Escuela Universitaria Politécnica - La Almunia
Centro adscrito
Universidad Zaragoza

ESCUELA UNIVERSITARIA POLITÉCNICA
DE LA ALMUNIA DE DOÑA GODINA (ZARAGOZA)

ANEXOS

Control de acceso y registro de horario en la empresa mediante reconocimiento facial

Business Access Control and Time Schedule Registration Using Face Recognition

424.20.17

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1. ANEXO 1 (PRESUPUESTO)

PROYECTO: Sistema de Control de Acceso y Registro Horario en la Empresa mediante Reconocimiento Facial.	**PRESUPUESTO**
Proyectista: Néstor Doñate Marqués	CIF: 72996228R

DATOS CLIENTE	Nº de presupuesto:	NDM202109107
Nombre: EUPLA	Fecha:	16/09/2021
CIF: Q5068031C	Forma de pago:	Según contrato
Domicilio: Calle Mayor, 5	Tipo de cliente:	Institución pública
50100 La Almunia de Doña Godina (Zaragoza)		
Teléfono: 976 600 813		

Cantidad	Concepto	Precio unitario	Precio total
	MATERIALES		
1	Sistema de Alimentación Ininterrumpida (SAI)	45	45,00 €
1	Controlador ESP32	42	42,00 €
Varios	Diodos, transistores, resistencias y componentes electrónicos		60,00 €
1	Abrepuertas eléctrico	55	55,00 €
Varios	Reguladores de tensión		25,00 €
1	Foco Aputure AL-F7	99	99,00 €
Varios	Relés		15,00 €
1	Expansor de E/S MCP23017	22	22,00 €
1	Convertidor USB-serie CH340	12	12,00 €
	DISEÑO Y MONTAJE		
Varios	Soportes de montaje, sistemas de apoyo, tornillería...		250,00 €
100	Horas Diseño del Equipo	50	5.000,00 €
	MANO DE OBRA		
20	Horas de montaje	40	800,00 €
6	Horas puesta en marcha y ajuste	50	300,00 €
5	5 horas de formación operario equipo e informes de registro	50	250,00 €
		Suma	6.975,00 €
		IVA 21%	1.464,75 €
		Total	8.439,75 €

CONFORME EL CLIENTE:	EL INGENIERO MECATRÓNICO
	
EUPLA	Néstor Doñate Marqués

2. ANEXO 2 (PLIEGO DE CONDICIONES)

El párrafo anterior tiene aplicado el estilo TFG_Título1

Debe intentar responder, junto con el resto de cláusulas del contrato, a las preguntas ¿Cuándo, cuánto, y qué ocurre si no se cumple?

2.1. DEFINICIÓN Y ALCANCE DEL PLIEGO

2.1.1. *Condiciones iniciales*

Las condiciones iniciales desde las cuales partirá la instalación serán las siguientes:

Se nos entregará la obra construida. El objeto de este Proyecto será únicamente el diseño, construcción y puesta en marcha del sistema de control de acceso y registro horario en la empresa mediante reconocimiento facial.

La instalación eléctrica, suministro, distribución, alumbrado, alimentación de red e instalación de puesta a tierra del sistema y cualquier coste derivado de posibles incidencias o factores no previstos, irán a cargo del propietario de la instalación.

El ordenador de control con las licencias de software para el control del equipo y el tratamiento de los ficheros de informes que contienen los registros horarios serán proporcionados por el propietario.

Es necesario que el propietario adecúe la iluminación de la zona a las necesidades del Equipo, dado que los sistemas de reconocimiento por imagen son muy sensibles a los cambios en la iluminación del entorno.

2.1.2. *Condiciones generales*

El presente Pliego de Condiciones tiene por objeto definir el alcance del trabajo y la ejecución cualitativa del mismo.

El trabajo consistirá en el diseño y construcción del sistema de control de acceso y registro horario en la empresa mediante reconocimiento facial. El alcance del trabajo incluye el diseño y preparación de todos los planos, diagramas, especificaciones, lista de material y requisitos para la adquisición e instalación del trabajo.

2.2. NORMAS, LEYES Y REGLAMENTOS

Programación

La norma de programación es la IEC 61131. (*IEC 61131-3*, 2010)

Electricidad

La instalación eléctrica se hará conforme al reglamento electrotécnico de baja tensión. (*Reglamento Electrotécnico para Baja Tensión de 2002*, 2002)

Medio ambiente

En cuanto a la ley de protección ambiental nos regiremos por el siguiente documento. (*Ley 6/2017, de 8 de mayo, de Protección del Medio Ambiente de la Comunidad Autónoma de La Rioja.*, 2017)

Normativa de seguridad

En normativa laboral, nos regiremos por la ley de prevención de riesgos laborales, LPRL. (*BOE.es - Prevención de riesgos laborales*, 2017)

2.3. MATERIALES Y CONDICIONES TÉCNICAS

Todos los materiales empleados serán de primera calidad. Cumplirán las especificaciones y tendrán las características indicadas en el proyecto y en las normas técnicas generales.

Toda especificación o característica de materiales que figuren en uno solo de los documentos del Proyecto, aún sin figurar en los otros es igualmente obligatoria.

Ejecución del Diseño y construcción del Equipo

COMIENZO: Según el plazo que figure en el contrato establecido, o en su defecto a los quince días de la adjudicación definitiva o de la firma del contrato.

PLAZO DE EJECUCIÓN: Se ejecutará en el plazo que se estipule en el contrato suscrito o en su defecto en el que figure en las condiciones de este pliego.

Interpretación y Desarrollo del Proyecto: La interpretación técnica de los documentos del Proyecto, corresponde al Ingeniero Mecatrónico.

Cualquier duda o aclaración que surja durante la ejecución o puesta en marcha del diseño será consultada con el Ingeniero Mecatrónico.

Obras complementarias: El propietario tiene la obligación de realizar todas las obras complementarias que sean indispensables para la puesta en marcha del Proyecto.

Conservación del Equipo: Es obligación del propietario la conservación en perfecto estado del equipo y corren a su cargo los gastos derivados de ello.

2.4. CONDICIONES ECONÓMICAS

Abono del equipo y la instalación

Este Proyecto no tiene en consideración las posibles subvenciones, ayudas o apoyos económicos obtenidos por el propietario para su ejecución.

En el contrato se deberá fijar detalladamente la forma y plazos que se abonarán el equipo y su instalación.

Terminada la puesta en marcha se procederá a la liquidación final que se efectuará de acuerdo con los criterios establecidos en el contrato.

Precios

El Ingeniero Mecatrónico presentará, al formalizarse el contrato, relación de los precios de las unidades que integran el proyecto, los cuales de ser aceptados tendrán valor contractual y se

aplicarán a las posibles variaciones que pueda haber.

Estos precios unitarios, se entiende que comprenden la ejecución total del equipo, incluyendo todos los trabajos aún los complementarios y los materiales así como la parte proporcional de imposición fiscal, las cargas laborales y otros gastos repercutibles.

En caso de tener que realizarse unidades no previstas en el proyecto, se fijará su precio entre el propietario y el Ingeniero Mecatrónico antes de iniciar la obra.

Revisión de Precios

En el contrato se establecerá si es posible la revisión de precios y la fórmula a aplicar para calcularla. En defecto de esta última, se aplicará a juicio del Ingeniero Mecatrónico alguno de los criterios oficiales aceptados.

Penalizaciones

Por retraso en los plazos de entrega del equipo, se podrán establecer tablas de penalización cuyas cuantías y demoras se fijarán en el contrato.

Contrato

El contrato se formalizará mediante documento privado, que podrá elevarse a escritura pública a petición de cualquiera de las partes. Comprenderá la adquisición de todos los materiales, transporte, mano de obra, medios auxiliares para la ejecución de la instalación proyectada en el plazo estipulado, así como la reconstrucción de las unidades defectuosas, la realización de los trabajos complementarias y los derivados de la Proyecto de automatización, modificaciones que se introduzcan durante la ejecución, éstas últimas en los términos previstos.

La totalidad de los documentos que componen el Proyecto Técnico serán incorporados al contrato y tanto el Ingeniero Mecatrónico como la Propiedad deberán firmarlos en testimonio de que los conocen y aceptan.

2.5. PLAZOS DE ENTREGA

Recepción del equipo

RECEPCIÓN PROVISIONAL: Una vez terminado el diseño y montaje, tendrá lugar la recepción provisional y para ello se practicará en ellas un detenido reconocimiento por el Ingeniero Mecatrónico y la Propiedad, levantando acta y empezando a correr desde ese día el plazo de garantía.

PLAZO DE GARANTÍA: El plazo de garantía será como mínimo de dos años, contado desde la fecha de la recepción provisional, o bien el que se establezca en el contrato también contado desde la misma fecha.

RECEPCIÓN DEFINITIVA: Se realizará después de transcurrido el plazo de garantía de igual forma que la provisional. A partir de esta fecha cesará la obligación de conservar y reparar a su cargo el equipo, si bien subsistirán las responsabilidades que pudiera tener por defectos ocultos y deficiencias de causa dudosa.

3. ANEXO 3 (CÓDIGO)

El párrafo anterior tiene aplicado el estilo TFG_Título1

Cualquier anexo susceptible de ser incluido.

Especificaciones del cliente, Estudio de necesidades, Cálculos, Plan de seguridad, De justificación de soluciones, De Dimensionamiento, Manual del usuario, Manual de mantenimiento, Al estudio económico, Diagramas UML, Programación, Scripts matemáticos complementarios…..

Código del teclado

```
#include <Keypad.h>; // Con esta linea llamamos a la librería Keypad para que arduino reconozca el teclado
char ClaveAcceso[] = "A35";// En esta linea creamos la constante de cadena llamada contraseña (el numero A35 puede ser cambiado)
char codigo[3]; // Creamos otra constante, en esta se guardaran los caracteres que presionemos en nuestro teclado matricial 4x4
int cont = 0;
const int LED_Cerradura_Abierta = 3;
bool Led_Cerradura_Abierta = LOW;

const byte ROWS = 4; //Este código se estable para definir que nuestro teclado tiene 4 filas
const byte COLS = 4; //Este código se estable para definir que nuestro teclado tiene 4 columnas

char hexaKeys[ROWS][COLS] = //En el siguiente matriz se agregan en orden las teclas que posee nuestro teclado
{
  {'1', '2', '3', 'A'},
  {'4', '5', '6', 'B'},
  {'7', '8', '9', 'C'},
  {'*', '0', '#', 'D'}
};

byte rowPins[ROWS] = {13, 12, 11, 10}; // Estos son los pines de conexión de Arduino de las columnas
byte colPins[COLS] = {9, 8, 7, 6}; //Estos son los pines de conexión de Arduino de las filas

Keypad customKeypad = Keypad(makeKeymap(hexaKeys), rowPins, colPins, ROWS, COLS); //En este punto el teclado se inicia y realiza el mapeo de sus teclas con respecto a la matriz colocada arriba

void setup() {
  Serial.begin(9600);
  pinMode(LED_Cerradura_Abierta, OUTPUT);
}
```

```
void loop() {
  char customKey = customKeypad.getKey(); //esta linea indica que el carácter presionado se guardara en la variable customKey
  if (customKey != NO_KEY) //Con este ciclo preguntamos si se presiono una tecla, si se presiono entonces el ciclo continua
  {
    codigo[cont] = customKey; //se guardaran los caracteres presionados en codigo[cont]
    Serial.print(codigo[cont]); //Se imprime en nuestro monitor serial lo que este guardado en codigo[cont]
    cont = cont + 1; //incrementamos la variable cont (esto con el fin de tener los 3 dígitos que requerimos)
    if (cont == 3) //Ahora comienza otro ciclo if, en el cual se pregunta si ya hay 3 datos guardados y si es así entonces el ciclo continua
    {
      if (codigo[0] == ClaveAcceso[0] && codigo[1] == ClaveAcceso[1] && codigo[2] == ClaveAcceso[2] )
      {
        Serial.println("  Puerta abierta");
        digitalWrite(LED_Cerradura_Abierta, HIGH);
        delay(5000);
        digitalWrite(LED_Cerradura_Abierta, LOW);
      }

      if (codigo[0] != ClaveAcceso[0] || codigo[1] != ClaveAcceso[1] || codigo[2] != ClaveAcceso[2]) //empieza un nuevo ciclo, esta vez indicamos si el código es diferente que los productos siga con el ciclo
      {
       Serial.println("  Código no válido");
       cont = 0;
      }
    }
  }
}
```

Código cámera Web Server – Pestaña principal

```
#include "esp_camera.h"
#include <WiFi.h>

//
// WARNING!!! Make sure that you have either selected ESP32 Wrover Module,
//            or another board which has PSRAM enabled
//

// Select camera model
//#define CAMERA_MODEL_T_JOURNAL
//#define CAMERA_MODEL_WROVER_KIT
//#define CAMERA_MODEL_ESP_EYE
//#define CAMERA_MODEL_M5STACK_PSRAM
//#define CAMERA_MODEL_M5STACK_WIDE
```

```
#define CAMERA_MODEL_WROVER_B //este modelo es el que se empleará para
el Modelo con reconocimiento facial

#include "camera_pins.h"

const char* ssid = "Mitelefono";
const char* password = "holahola";

void startCameraServer();

void setup() {
  Serial.begin(115200);
  Serial.setDebugOutput(true);
  Serial.println();

  camera_config_t config;
  config.ledc_channel = LEDC_CHANNEL_0;
  config.ledc_timer = LEDC_TIMER_0;
  config.pin_d0 = Y2_GPIO_NUM;
  config.pin_d1 = Y3_GPIO_NUM;
  config.pin_d2 = Y4_GPIO_NUM;
  config.pin_d3 = Y5_GPIO_NUM;
  config.pin_d4 = Y6_GPIO_NUM;
  config.pin_d5 = Y7_GPIO_NUM;
  config.pin_d6 = Y8_GPIO_NUM;
  config.pin_d7 = Y9_GPIO_NUM;
  config.pin_xclk = XCLK_GPIO_NUM;
  config.pin_pclk = PCLK_GPIO_NUM;
  config.pin_vsync = VSYNC_GPIO_NUM;
  config.pin_href = HREF_GPIO_NUM;
  config.pin_sscb_sda = SIOD_GPIO_NUM;
  config.pin_sscb_scl = SIOC_GPIO_NUM;
  config.pin_pwdn = PWDN_GPIO_NUM;
  config.pin_reset = RESET_GPIO_NUM;
  config.xclk_freq_hz = 20000000;
  config.pixel_format = PIXFORMAT_JPEG;
  //init with high specs to pre-allocate larger buffers
  if(psramFound()){
    config.frame_size = FRAMESIZE_UXGA;
    config.jpeg_quality = 10;
    config.fb_count = 2;
  } else {
    config.frame_size = FRAMESIZE_SVGA;
    config.jpeg_quality = 12;
    config.fb_count = 1;
  }

#if defined(CAMERA_MODEL_ESP_EYE)
  pinMode(13, INPUT_PULLUP);
  pinMode(14, INPUT_PULLUP);
#endif

  // camera init
  esp_err_t err = esp_camera_init(&config);
  if (err != ESP_OK) {
```

```
    Serial.printf("Camera init failed with error 0x%x", err);
    return;
  }

  sensor_t * s = esp_camera_sensor_get();
  //initial sensors are flipped vertically and colors are a bit saturated
  if (s->id.PID == OV3660_PID) {
    s->set_vflip(s, 1);//flip it back
    s->set_brightness(s, 1);//up the blightness just a bit
    s->set_saturation(s, -2);//lower the saturation
  }
  //drop down frame size for higher initial frame rate
  s->set_framesize(s, FRAMESIZE_QVGA);

#if defined(CAMERA_MODEL_M5STACK_WIDE)
  s->set_vflip(s, 1);
  s->set_hmirror(s, 1);
#endif

  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  startCameraServer();

  Serial.print("Camera Ready! Use 'http://");
  Serial.print(WiFi.localIP());
  Serial.println("' to connect");
}

void loop() {
  // put your main code here, to run repeatedly:
  delay(10000);
}
```

Código cámera Web Server – Pestaña app_httpd.cpp

```
// Copyright 2015-2016 Espressif Systems (Shanghai) PTE LTD
//
// Licensed under the Apache License, Version 2.0 (the "License");
// you may not use this file except in compliance with the License.
// You may obtain a copy of the License at
//
//     http://www.apache.org/licenses/LICENSE-2.0
//
// Unless required by applicable law or agreed to in writing, software
// distributed under the License is distributed on an "AS IS" BASIS,
// WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
implied.
```

```
// See the License for the specific language governing permissions and
// limitations under the License.
#include "esp_http_server.h"
#include "esp_timer.h"
#include "esp_camera.h"
#include "img_converters.h"
#include "camera_index.h"
#include "Arduino.h"

#include "fb_gfx.h"
#include "fd_forward.h"
#include "fr_forward.h"

#define ENROLL_CONFIRM_TIMES 5
#define FACE_ID_SAVE_NUMBER 7

#define FACE_COLOR_WHITE  0x00FFFFFF
#define FACE_COLOR_BLACK  0x00000000
#define FACE_COLOR_RED    0x000000FF
#define FACE_COLOR_GREEN  0x0000FF00
#define FACE_COLOR_BLUE   0x00FF0000
#define FACE_COLOR_YELLOW (FACE_COLOR_RED | FACE_COLOR_GREEN)
#define FACE_COLOR_CYAN   (FACE_COLOR_BLUE | FACE_COLOR_GREEN)
#define FACE_COLOR_PURPLE (FACE_COLOR_BLUE | FACE_COLOR_RED)

typedef struct {
        size_t size; //number of values used for filtering
        size_t index; //current value index
        size_t count; //value count
        int sum;
        int * values; //array to be filled with values
} ra_filter_t;

typedef struct {
        httpd_req_t *req;
        size_t len;
} jpg_chunking_t;

#define PART_BOUNDARY "123456789000000000000987654321"
static const char* _STREAM_CONTENT_TYPE = "multipart/x-mixed-
replace;boundary=" PART_BOUNDARY;
static const char* _STREAM_BOUNDARY = "\r\n--" PART_BOUNDARY "\r\n";
static const char* _STREAM_PART = "Content-Type: image/jpeg\r\nContent-
Length: %u\r\n\r\n";

static ra_filter_t ra_filter;
httpd_handle_t stream_httpd = NULL;
httpd_handle_t camera_httpd = NULL;

static mtmn_config_t mtmn_config = {0};
static int8_t detection_enabled = 0;
static int8_t recognition_enabled = 0;
static int8_t is_enrolling = 0;
static face_id_list id_list = {0};
```

```
static ra_filter_t * ra_filter_init(ra_filter_t * filter, size_t sample_size){
    memset(filter, 0, sizeof(ra_filter_t));

    filter->values = (int *)malloc(sample_size * sizeof(int));
    if(!filter->values){
        return NULL;
    }
    memset(filter->values, 0, sample_size * sizeof(int));

    filter->size = sample_size;
    return filter;
}

static int ra_filter_run(ra_filter_t * filter, int value){
    if(!filter->values){
        return value;
    }
    filter->sum -= filter->values[filter->index];
    filter->values[filter->index] = value;
    filter->sum += filter->values[filter->index];
    filter->index++;
    filter->index = filter->index % filter->size;
    if (filter->count < filter->size) {
        filter->count++;
    }
    return filter->sum / filter->count;
}

static void rgb_print(dl_matrix3du_t *image_matrix, uint32_t color, const char *
str){
    fb_data_t fb;
    fb.width = image_matrix->w;
    fb.height = image_matrix->h;
    fb.data = image_matrix->item;
    fb.bytes_per_pixel = 3;
    fb.format = FB_BGR888;
    fb_gfx_print(&fb, (fb.width - (strlen(str) * 14)) / 2, 10, color, str);
}

static int rgb_printf(dl_matrix3du_t *image_matrix, uint32_t color, const char
*format, ...){
    char loc_buf[64];
    char * temp = loc_buf;
    int len;
    va_list arg;
    va_list copy;
    va_start(arg, format);
    va_copy(copy, arg);
    len = vsnprintf(loc_buf, sizeof(loc_buf), format, arg);
    va_end(copy);
    if(len >= sizeof(loc_buf)){
        temp = (char*)malloc(len+1);
        if(temp == NULL) {
            return 0;
        }
```

```
        }
        vsnprintf(temp, len+1, format, arg);
        va_end(arg);
        rgb_print(image_matrix, color, temp);
        if(len > 64){
            free(temp);
        }
        return len;
    }

    static void draw_face_boxes(dl_matrix3du_t *image_matrix, box_array_t
*boxes, int face_id){
        int x, y, w, h, i;
        uint32_t color = FACE_COLOR_YELLOW;
        if(face_id < 0){
            color = FACE_COLOR_RED;
        } else if(face_id > 0){
            color = FACE_COLOR_GREEN;
        }
        fb_data_t fb;
        fb.width = image_matrix->w;
        fb.height = image_matrix->h;
        fb.data = image_matrix->item;
        fb.bytes_per_pixel = 3;
        fb.format = FB_BGR888;
        for (i = 0; i < boxes->len; i++){
            // rectangle box
            x = (int)boxes->box[i].box_p[0];
            y = (int)boxes->box[i].box_p[1];
            w = (int)boxes->box[i].box_p[2] - x + 1;
            h = (int)boxes->box[i].box_p[3] - y + 1;
            fb_gfx_drawFastHLine(&fb, x, y, w, color);
            fb_gfx_drawFastHLine(&fb, x, y+h-1, w, color);
            fb_gfx_drawFastVLine(&fb, x, y, h, color);
            fb_gfx_drawFastVLine(&fb, x+w-1, y, h, color);
    #if 0
            // landmark
            int x0, y0, j;
            for (j = 0; j < 10; j+=2) {
                x0 = (int)boxes->landmark[i].landmark_p[j];
                y0 = (int)boxes->landmark[i].landmark_p[j+1];
                fb_gfx_fillRect(&fb, x0, y0, 3, 3, color);
            }
    #endif
        }
    }

    static int run_face_recognition(dl_matrix3du_t *image_matrix, box_array_t
*net_boxes){
        dl_matrix3du_t *aligned_face = NULL;
        int matched_id = 0;

        aligned_face = dl_matrix3du_alloc(1, FACE_WIDTH, FACE_HEIGHT, 3);
        if(!aligned_face){
            Serial.println("Could not allocate face recognition buffer");
```

```
            return matched_id;
        }
        if (align_face(net_boxes, image_matrix, aligned_face) == ESP_OK){
            if (is_enrolling == 1){
                int8_t left_sample_face = enroll_face(&id_list, aligned_face);

                if(left_sample_face == (ENROLL_CONFIRM_TIMES - 1)){
                    Serial.printf("Enrolling Face ID: %d\n", id_list.tail);
                }
                Serial.printf("Enrolling Face ID: %d sample %d\n", id_list.tail,
ENROLL_CONFIRM_TIMES - left_sample_face);
                rgb_printf(image_matrix, FACE_COLOR_CYAN, "ID[%u] Sample[%u]",
id_list.tail, ENROLL_CONFIRM_TIMES - left_sample_face);
                if (left_sample_face == 0){
                    is_enrolling = 0;
                    Serial.printf("Enrolled Face ID: %d\n", id_list.tail);
                }
            } else {
                matched_id = recognize_face(&id_list, aligned_face);
                if (matched_id >= 0) {
                    Serial.printf("Match Face ID: %u\n", matched_id);
                    rgb_printf(image_matrix, FACE_COLOR_GREEN, "Hello Subject %u",
matched_id);
                } else {
                    Serial.println("No Match Found");
                    rgb_print(image_matrix, FACE_COLOR_RED, "Intruder Alert!");
                    matched_id = -1;
                }
            }
        } else {
            Serial.println("Face Not Aligned");
            //rgb_print(image_matrix, FACE_COLOR_YELLOW, "Human Detected");
        }

        dl_matrix3du_free(aligned_face);
        return matched_id;
    }

    static size_t jpg_encode_stream(void * arg, size_t index, const void* data,
size_t len){
        jpg_chunking_t *j = (jpg_chunking_t *)arg;
        if(!index){
            j->len = 0;
        }
        if(httpd_resp_send_chunk(j->req, (const char *)data, len) != ESP_OK){
            return 0;
        }
        j->len += len;
        return len;
    }

    static esp_err_t capture_handler(httpd_req_t *req){
        camera_fb_t * fb = NULL;
        esp_err_t res = ESP_OK;
        int64_t fr_start = esp_timer_get_time();
```

```
        fb = esp_camera_fb_get();
        if (!fb) {
            Serial.println("Camera capture failed");
            httpd_resp_send_500(req);
            return ESP_FAIL;
        }

        httpd_resp_set_type(req, "image/jpeg");
        httpd_resp_set_hdr(req, "Content-Disposition", "inline;
filename=capture.jpg");
        httpd_resp_set_hdr(req, "Access-Control-Allow-Origin", "*");

        size_t out_len, out_width, out_height;
        uint8_t * out_buf;
        bool s;
        bool detected = false;
        int face_id = 0;
        if(!detection_enabled || fb->width > 400){
            size_t fb_len = 0;
            if(fb->format == PIXFORMAT_JPEG){
                fb_len = fb->len;
                res = httpd_resp_send(req, (const char *)fb->buf, fb->len);
            } else {
                jpg_chunking_t jchunk = {req, 0};
                res = frame2jpg_cb(fb, 80, jpg_encode_stream,
&jchunk)?ESP_OK:ESP_FAIL;
                httpd_resp_send_chunk(req, NULL, 0);
                fb_len = jchunk.len;
            }
            esp_camera_fb_return(fb);
            int64_t fr_end = esp_timer_get_time();
            Serial.printf("JPG: %uB %ums\n", (uint32_t)(fb_len), (uint32_t)((fr_end -
fr_start)/1000));
            return res;
        }

        dl_matrix3du_t *image_matrix = dl_matrix3du_alloc(1, fb->width, fb-
>height, 3);
        if (!image_matrix) {
            esp_camera_fb_return(fb);
            Serial.println("dl_matrix3du_alloc failed");
            httpd_resp_send_500(req);
            return ESP_FAIL;
        }

        out_buf = image_matrix->item;
        out_len = fb->width * fb->height * 3;
        out_width = fb->width;
        out_height = fb->height;

        s = fmt2rgb888(fb->buf, fb->len, fb->format, out_buf);
        esp_camera_fb_return(fb);
        if(!s){
            dl_matrix3du_free(image_matrix);
```

```
        Serial.println("to rgb888 failed");
        httpd_resp_send_500(req);
        return ESP_FAIL;
    }

    box_array_t *net_boxes = face_detect(image_matrix, &mtmn_config);

    if (net_boxes){
        detected = true;
        if(recognition_enabled){
            face_id = run_face_recognition(image_matrix, net_boxes);
        }
        draw_face_boxes(image_matrix, net_boxes, face_id);
        free(net_boxes->score);
        free(net_boxes->box);
        free(net_boxes->landmark);
        free(net_boxes);
    }

    jpg_chunking_t jchunk = {req, 0};
    s = fmt2jpg_cb(out_buf, out_len, out_width, out_height,
PIXFORMAT_RGB888, 90, jpg_encode_stream, &jchunk);
    dl_matrix3du_free(image_matrix);
    if(!s){
        Serial.println("JPEG compression failed");
        return ESP_FAIL;
    }

    int64_t fr_end = esp_timer_get_time();
    Serial.printf("FACE: %uB %ums %s%d\n", (uint32_t)(jchunk.len),
(uint32_t)((fr_end - fr_start)/1000), detected?"DETECTED ":"", face_id);
    return res;
}

static esp_err_t stream_handler(httpd_req_t *req){
    camera_fb_t * fb = NULL;
    esp_err_t res = ESP_OK;
    size_t _jpg_buf_len = 0;
    uint8_t * _jpg_buf = NULL;
    char * part_buf[64];
    dl_matrix3du_t *image_matrix = NULL;
    bool detected = false;
    int face_id = 0;
    int64_t fr_start = 0;
    int64_t fr_ready = 0;
    int64_t fr_face = 0;
    int64_t fr_recognize = 0;
    int64_t fr_encode = 0;

    static int64_t last_frame = 0;
    if(!last_frame) {
        last_frame = esp_timer_get_time();
    }

    res = httpd_resp_set_type(req, _STREAM_CONTENT_TYPE);
```

```
        if(res != ESP_OK){
            return res;
        }

        httpd_resp_set_hdr(req, "Access-Control-Allow-Origin", "*");

        while(true){
            detected = false;
            face_id = 0;
            fb = esp_camera_fb_get();
            if (!fb) {
                Serial.println("Camera capture failed");
                res = ESP_FAIL;
            } else {
                fr_start = esp_timer_get_time();
                fr_ready = fr_start;
                fr_face = fr_start;
                fr_encode = fr_start;
                fr_recognize = fr_start;
                if(!detection_enabled || fb->width > 400){
                    if(fb->format != PIXFORMAT_JPEG){
                        bool jpeg_converted = frame2jpg(fb, 80, &_jpg_buf,
&_jpg_buf_len);
                        esp_camera_fb_return(fb);
                        fb = NULL;
                        if(!jpeg_converted){
                            Serial.println("JPEG compression failed");
                            res = ESP_FAIL;
                        }
                    } else {
                        _jpg_buf_len = fb->len;
                        _jpg_buf = fb->buf;
                    }
                } else {

                    image_matrix = dl_matrix3du_alloc(1, fb->width, fb->height, 3);

                    if (!image_matrix) {
                        Serial.println("dl_matrix3du_alloc failed");
                        res = ESP_FAIL;
                    } else {
                        if(!fmt2rgb888(fb->buf, fb->len, fb->format, image_matrix-
>item)){
                            Serial.println("fmt2rgb888 failed");
                            res = ESP_FAIL;
                        } else {
                            fr_ready = esp_timer_get_time();
                            box_array_t *net_boxes = NULL;
                            if(detection_enabled){
                                net_boxes = face_detect(image_matrix, &mtmn_config);
                            }
                            fr_face = esp_timer_get_time();
                            fr_recognize = fr_face;
                            if (net_boxes || fb->format != PIXFORMAT_JPEG){
                                if(net_boxes){
```

```
                        detected = true;
                        if(recognition_enabled){
                            face_id = run_face_recognition(image_matrix,
net_boxes);
                        }
                        fr_recognize = esp_timer_get_time();
                        draw_face_boxes(image_matrix, net_boxes, face_id);
                        free(net_boxes->score);
                        free(net_boxes->box);
                        free(net_boxes->landmark);
                        free(net_boxes);
                    }
                    if(!fmt2jpg(image_matrix->item, fb->width*fb->height*3,
fb->width, fb->height, PIXFORMAT_RGB888, 90, &_jpg_buf, &_jpg_buf_len)){
                        Serial.println("fmt2jpg failed");
                        res = ESP_FAIL;
                    }
                    esp_camera_fb_return(fb);
                    fb = NULL;
                } else {
                    _jpg_buf = fb->buf;
                    _jpg_buf_len = fb->len;
                }
                fr_encode = esp_timer_get_time();
            }
            dl_matrix3du_free(image_matrix);
        }
    }
}
if(res == ESP_OK){
    size_t hlen = snprintf((char *)part_buf, 64, _STREAM_PART,
_jpg_buf_len);
    res = httpd_resp_send_chunk(req, (const char *)part_buf, hlen);
}
if(res == ESP_OK){
    res = httpd_resp_send_chunk(req, (const char *)_jpg_buf,
_jpg_buf_len);
}
if(res == ESP_OK){
    res = httpd_resp_send_chunk(req, _STREAM_BOUNDARY,
strlen(_STREAM_BOUNDARY));
}
if(fb){
    esp_camera_fb_return(fb);
    fb = NULL;
    _jpg_buf = NULL;
} else if(_jpg_buf){
    free(_jpg_buf);
    _jpg_buf = NULL;
}
if(res != ESP_OK){
    break;
}
int64_t fr_end = esp_timer_get_time();
```

```
        int64_t ready_time = (fr_ready - fr_start)/1000;
        int64_t face_time = (fr_face - fr_ready)/1000;
        int64_t recognize_time = (fr_recognize - fr_face)/1000;
        int64_t encode_time = (fr_encode - fr_recognize)/1000;
        int64_t process_time = (fr_encode - fr_start)/1000;

        int64_t frame_time = fr_end - last_frame;
        last_frame = fr_end;
        frame_time /= 1000;
        uint32_t avg_frame_time = ra_filter_run(&ra_filter, frame_time);
        Serial.printf("MJPG: %uB %ums (%.1ffps), AVG: %ums (%.1ffps),
%u+%u+%u+%u=%u %s%d\n",
            (uint32_t)(_jpg_buf_len),
            (uint32_t)frame_time, 1000.0 / (uint32_t)frame_time,
            avg_frame_time, 1000.0 / avg_frame_time,
            (uint32_t)ready_time, (uint32_t)face_time, (uint32_t)recognize_time,
(uint32_t)encode_time, (uint32_t)process_time,
            (detected)?"DETECTED ":"", face_id
        );
    }

    last_frame = 0;
    return res;
}

static esp_err_t cmd_handler(httpd_req_t *req){
    char*  buf;
    size_t buf_len;
    char variable[32] = {0,};
    char value[32] = {0,};

    buf_len = httpd_req_get_url_query_len(req) + 1;
    if (buf_len > 1) {
        buf = (char*)malloc(buf_len);
        if(!buf){
            httpd_resp_send_500(req);
            return ESP_FAIL;
        }
        if (httpd_req_get_url_query_str(req, buf, buf_len) == ESP_OK) {
            if (httpd_query_key_value(buf, "var", variable, sizeof(variable)) ==
ESP_OK &&
                httpd_query_key_value(buf, "val", value, sizeof(value)) == ESP_OK)
{
            } else {
                free(buf);
                httpd_resp_send_404(req);
                return ESP_FAIL;
            }
        } else {
            free(buf);
            httpd_resp_send_404(req);
            return ESP_FAIL;
        }
        free(buf);
    } else {
```

```
            httpd_resp_send_404(req);
            return ESP_FAIL;
        }

        int val = atoi(value);
        sensor_t * s = esp_camera_sensor_get();
        int res = 0;

        if(!strcmp(variable, "framesize")) {
            if(s->pixformat == PIXFORMAT_JPEG) res = s->set_framesize(s,
(framesize_t)val);
        }
        else if(!strcmp(variable, "quality")) res = s->set_quality(s, val);
        else if(!strcmp(variable, "contrast")) res = s->set_contrast(s, val);
        else if(!strcmp(variable, "brightness")) res = s->set_brightness(s, val);
        else if(!strcmp(variable, "saturation")) res = s->set_saturation(s, val);
        else if(!strcmp(variable, "gainceiling")) res = s->set_gainceiling(s,
(gainceiling_t)val);
        else if(!strcmp(variable, "colorbar")) res = s->set_colorbar(s, val);
        else if(!strcmp(variable, "awb")) res = s->set_whitebal(s, val);
        else if(!strcmp(variable, "agc")) res = s->set_gain_ctrl(s, val);
        else if(!strcmp(variable, "aec")) res = s->set_exposure_ctrl(s, val);
        else if(!strcmp(variable, "hmirror")) res = s->set_hmirror(s, val);
        else if(!strcmp(variable, "vflip")) res = s->set_vflip(s, val);
        else if(!strcmp(variable, "awb_gain")) res = s->set_awb_gain(s, val);
        else if(!strcmp(variable, "agc_gain")) res = s->set_agc_gain(s, val);
        else if(!strcmp(variable, "aec_value")) res = s->set_aec_value(s, val);
        else if(!strcmp(variable, "aec2")) res = s->set_aec2(s, val);
        else if(!strcmp(variable, "dcw")) res = s->set_dcw(s, val);
        else if(!strcmp(variable, "bpc")) res = s->set_bpc(s, val);
        else if(!strcmp(variable, "wpc")) res = s->set_wpc(s, val);
        else if(!strcmp(variable, "raw_gma")) res = s->set_raw_gma(s, val);
        else if(!strcmp(variable, "lenc")) res = s->set_lenc(s, val);
        else if(!strcmp(variable, "special_effect")) res = s->set_special_effect(s, val);
        else if(!strcmp(variable, "wb_mode")) res = s->set_wb_mode(s, val);
        else if(!strcmp(variable, "ae_level")) res = s->set_ae_level(s, val);
        else if(!strcmp(variable, "face_detect")) {
            detection_enabled = val;
            if(!detection_enabled) {
                recognition_enabled = 0;
            }
        }
        else if(!strcmp(variable, "face_enroll")) is_enrolling = val;
        else if(!strcmp(variable, "face_recognize")) {
            recognition_enabled = val;
            if(recognition_enabled){
                detection_enabled = val;
            }
        }
        else {
            res = -1;
        }

        if(res){
            return httpd_resp_send_500(req);
```

```
    }

    httpd_resp_set_hdr(req, "Access-Control-Allow-Origin", "*");
    return httpd_resp_send(req, NULL, 0);
}

static esp_err_t status_handler(httpd_req_t *req){
    static char json_response[1024];

    sensor_t * s = esp_camera_sensor_get();
    char * p = json_response;
    *p++ = '{';

    p+=sprintf(p, "\"framesize\":%u,", s->status.framesize);
    p+=sprintf(p, "\"quality\":%u,", s->status.quality);
    p+=sprintf(p, "\"brightness\":%d,", s->status.brightness);
    p+=sprintf(p, "\"contrast\":%d,", s->status.contrast);
    p+=sprintf(p, "\"saturation\":%d,", s->status.saturation);
    p+=sprintf(p, "\"sharpness\":%d,", s->status.sharpness);
    p+=sprintf(p, "\"special_effect\":%u,", s->status.special_effect);
    p+=sprintf(p, "\"wb_mode\":%u,", s->status.wb_mode);
    p+=sprintf(p, "\"awb\":%u,", s->status.awb);
    p+=sprintf(p, "\"awb_gain\":%u,", s->status.awb_gain);
    p+=sprintf(p, "\"aec\":%u,", s->status.aec);
    p+=sprintf(p, "\"aec2\":%u,", s->status.aec2);
    p+=sprintf(p, "\"ae_level\":%d,", s->status.ae_level);
    p+=sprintf(p, "\"aec_value\":%u,", s->status.aec_value);
    p+=sprintf(p, "\"agc\":%u,", s->status.agc);
    p+=sprintf(p, "\"agc_gain\":%u,", s->status.agc_gain);
    p+=sprintf(p, "\"gainceiling\":%u,", s->status.gainceiling);
    p+=sprintf(p, "\"bpc\":%u,", s->status.bpc);
    p+=sprintf(p, "\"wpc\":%u,", s->status.wpc);
    p+=sprintf(p, "\"raw_gma\":%u,", s->status.raw_gma);
    p+=sprintf(p, "\"lenc\":%u,", s->status.lenc);
    p+=sprintf(p, "\"vflip\":%u,", s->status.vflip);
    p+=sprintf(p, "\"hmirror\":%u,", s->status.hmirror);
    p+=sprintf(p, "\"dcw\":%u,", s->status.dcw);
    p+=sprintf(p, "\"colorbar\":%u,", s->status.colorbar);
    p+=sprintf(p, "\"face_detect\":%u,", detection_enabled);
    p+=sprintf(p, "\"face_enroll\":%u,", is_enrolling);
    p+=sprintf(p, "\"face_recognize\":%u", recognition_enabled);
    *p++ = '}';
    *p++ = 0;
    httpd_resp_set_type(req, "application/json");
    httpd_resp_set_hdr(req, "Access-Control-Allow-Origin", "*");
    return httpd_resp_send(req, json_response, strlen(json_response));
}

static esp_err_t index_handler(httpd_req_t *req){
    httpd_resp_set_type(req, "text/html");
    httpd_resp_set_hdr(req, "Content-Encoding", "gzip");
    sensor_t * s = esp_camera_sensor_get();
    if (s->id.PID == OV3660_PID) {
        return httpd_resp_send(req, (const char *)index_ov3660_html_gz,
index_ov3660_html_gz_len);
```

```
    }
    return httpd_resp_send(req, (const char *)index_ov2640_html_gz,
index_ov2640_html_gz_len);
}

void startCameraServer(){
    httpd_config_t config = HTTPD_DEFAULT_CONFIG();

    httpd_uri_t index_uri = {
        .uri       = "/",
        .method    = HTTP_GET,
        .handler   = index_handler,
        .user_ctx  = NULL
    };

    httpd_uri_t status_uri = {
        .uri       = "/status",
        .method    = HTTP_GET,
        .handler   = status_handler,
        .user_ctx  = NULL
    };

    httpd_uri_t cmd_uri = {
        .uri       = "/control",
        .method    = HTTP_GET,
        .handler   = cmd_handler,
        .user_ctx  = NULL
    };

    httpd_uri_t capture_uri = {
        .uri       = "/capture",
        .method    = HTTP_GET,
        .handler   = capture_handler,
        .user_ctx  = NULL
    };

   httpd_uri_t stream_uri = {
        .uri       = "/stream",
        .method    = HTTP_GET,
        .handler   = stream_handler,
        .user_ctx  = NULL
    };


    ra_filter_init(&ra_filter, 20);

    mtmn_config.type = FAST;
    mtmn_config.min_face = 80;
    mtmn_config.pyramid = 0.707;
    mtmn_config.pyramid_times = 4;
    mtmn_config.p_threshold.score = 0.6;
    mtmn_config.p_threshold.nms = 0.7;
    mtmn_config.p_threshold.candidate_number = 20;
    mtmn_config.r_threshold.score = 0.7;
    mtmn_config.r_threshold.nms = 0.7;
```

```
    mtmn_config.r_threshold.candidate_number = 10;
    mtmn_config.o_threshold.score = 0.7;
    mtmn_config.o_threshold.nms = 0.7;
    mtmn_config.o_threshold.candidate_number = 1;

    face_id_init(&id_list, FACE_ID_SAVE_NUMBER, ENROLL_CONFIRM_TIMES);

    Serial.printf("Starting web server on port: '%d'\n", config.server_port);
    if (httpd_start(&camera_httpd, &config) == ESP_OK) {
        httpd_register_uri_handler(camera_httpd, &index_uri);
        httpd_register_uri_handler(camera_httpd, &cmd_uri);
        httpd_register_uri_handler(camera_httpd, &status_uri);
        httpd_register_uri_handler(camera_httpd, &capture_uri);
    }

    config.server_port += 1;
    config.ctrl_port += 1;
    Serial.printf("Starting stream server on port: '%d'\n", config.server_port);
    if (httpd_start(&stream_httpd, &config) == ESP_OK) {
        httpd_register_uri_handler(stream_httpd, &stream_uri);
    }
}
```

Código cámera Web Server – camera_index.h

```
//File: index_ov2640.html.gz, Size: 4316
#define index_ov2640_html_gz_len 4316
const uint8_t index_ov2640_html_gz[] = {
 0x1F, 0x8B, 0x08, 0x08, 0x50, 0x5C, 0xAE, 0x5C, 0x00, 0x03, 0x69, 0x6E,
0x64, 0x65, 0x78, 0x5F,
 0x6F, 0x76, 0x32, 0x36, 0x34, 0x30, 0x2E, 0x68, 0x74, 0x6D, 0x6C, 0x00,
0xE5, 0x5D, 0x7B, 0x73,
 0xD3, 0xC6, 0x16, 0xFF, 0x9F, 0x4F, 0x21, 0x04, 0x25, 0xF6, 0x34, 0x76,
0x6C, 0xC7, 0x84, 0xE0,
 0xDA, 0xE2, 0x42, 0x08, 0xD0, 0x19, 0x5E, 0x25, 0x2D, 0x74, 0xA6, 0xD3,
0x81, 0xB5, 0xB4, 0xB2,
 0x55, 0x64, 0xC9, 0x95, 0x56, 0x76, 0x52, 0x26, 0x9F, 0xE3, 0x7E, 0xA0,
0xFB, 0xC5, 0xEE, 0xD9,
 0x87, 0xA4, 0x95, 0xBC, 0x7A, 0xD8, 0x26, 0x36, 0x97, 0xEB, 0xCC, 0x14,
0xD9, 0xDA, 0x73, 0xF6,
 0x9C, 0xF3, 0x3B, 0xAF, 0x5D, 0x3D, 0x3A, 0xBC, 0x6D, 0xF9, 0x26, 0xB9,
0x9A, 0x63, 0x6D, 0x4A,
 0x66, 0xAE, 0x71, 0x6B, 0xC8, 0xFF, 0xD1, 0xE0, 0x33, 0x9C, 0x62, 0x64,
0xF1, 0x43, 0xF6, 0x75,
 0x86, 0x09, 0xD2, 0xCC, 0x29, 0x0A, 0x42, 0x4C, 0x46, 0x7A, 0x44, 0xEC,
0xD6, 0xA9, 0x9E, 0x3F,
 0xED, 0xA1, 0x19, 0x1E, 0xE9, 0x0B, 0x07, 0x2F, 0xE7, 0x7E, 0x40, 0x74,
0xCD, 0xF4, 0x3D, 0x82,
```

```
        0x3D, 0x18, 0xBE, 0x74, 0x2C, 0x32, 0x1D, 0x59, 0x78, 0xE1, 0x98, 0xB8,
0xC5, 0xBE, 0x1C, 0x3A,
        0x9E, 0x43, 0x1C, 0xE4, 0xB6, 0x42, 0x13, 0xB9, 0x78, 0xD4, 0x95, 0x79,
0x11, 0x87, 0xB8, 0xD8,
        0x38, 0xBF, 0x78, 0x7B, 0xDC, 0xD3, 0xDE, 0xBC, 0xEF, 0xF5, 0x4F, 0x3A,
0xC3, 0x23, 0xFE, 0x5B,
        0x3A, 0x26, 0x24, 0x57, 0xF2, 0x77, 0xFA, 0x19, 0xFB, 0xD6, 0x95, 0xF6,
0x25, 0xF3, 0x13, 0xFD,
        0xD8, 0x20, 0x44, 0xCB, 0x46, 0x33, 0xC7, 0xBD, 0x1A, 0x68, 0x8F, 0x03,
0x98, 0xF3, 0xF0, 0x05,
        0x76, 0x17, 0x98, 0x38, 0x26, 0x3A, 0x0C, 0x91, 0x17, 0xB6, 0x42, 0x1C,
0x38, 0xF6, 0x4F, 0x2B,
        0x84, 0x63, 0x64, 0x7E, 0x9E, 0x04, 0x7E, 0xE4, 0x59, 0x03, 0xED, 0x4E,
0xF7, 0x94, 0xFE, 0xAD,
        0x0E, 0x32, 0x7D, 0xD7, 0x0F, 0xE0, 0xFC, 0xF9, 0x33, 0xFA, 0xB7, 0x7A,
0x9E, 0xCD, 0x1E, 0x3A,
        0xFF, 0xE0, 0x81, 0xD6, 0x3D, 0x99, 0x5F, 0x66, 0xCE, 0x5F, 0xDF, 0xCA,
0x7C, 0x9D, 0xF6, 0x8A,
        0xA4, 0x17, 0xF4, 0xA7, 0xE5, 0xF4, 0x21, 0x36, 0x89, 0xE3, 0x7B, 0xED,
0x19, 0x72, 0x3C, 0x05,
        0x27, 0xCB, 0x09, 0xE7, 0x2E, 0x02, 0x1B, 0xD8, 0x2E, 0x2E, 0xE5, 0x73,
0x67, 0x86, 0xBD, 0xE8,
        0xB0, 0x82, 0x1B, 0x65, 0xD2, 0xB2, 0x9C, 0x80, 0x8F, 0x1A, 0x50, 0x3B,
0x44, 0x33, 0xAF, 0x92,
        0x6D, 0x99, 0x5C, 0x9E, 0xEF, 0x61, 0x85, 0x01, 0xE9, 0x44, 0xCB, 0x00,
0xCD, 0xE9, 0x00, 0xFA,
        0xEF, 0xEA, 0x90, 0x99, 0xE3, 0x71, 0xA7, 0x1A, 0x68, 0xC7, 0xFD, 0xCE,
0xFC, 0xB2, 0x02, 0xCA,
        0xE3, 0x13, 0xFA, 0xB7, 0x3A, 0x68, 0x8E, 0x2C, 0xCB, 0xF1, 0x26, 0x03,
0xED, 0x54, 0xC9, 0xC2,
        0x0F, 0x2C, 0x1C, 0xB4, 0x02, 0x64, 0x39, 0x51, 0x38, 0xD0, 0xFA, 0xAA,
0x31, 0x33, 0x14, 0x4C,
        0x40, 0x16, 0xE2, 0x83, 0xB0, 0xAD, 0xAE, 0x52, 0x12, 0x31, 0x24, 0x70,
0x26, 0x53, 0x02, 0x90,
        0xAE, 0x8C, 0xC9, 0x1B, 0x4D, 0x84, 0x50, 0x15, 0x9E, 0xA5, 0x76, 0x53,
0x5B, 0x0D, 0xB9, 0xCE,
        0xC4, 0x6B, 0x39, 0x04, 0xCF, 0x40, 0x9D, 0x90, 0x04, 0x98, 0x98, 0xD3,
0x32, 0x51, 0x6C, 0x67,
        0x12, 0x05, 0x58, 0x21, 0x48, 0x62, 0xB7, 0x12, 0x85, 0xE1, 0xE4, 0xEA,
0xA9, 0xD6, 0x12, 0x8F,
        0x3F, 0x3B, 0xA4, 0x25, 0x6C, 0x32, 0xC6, 0xB6, 0x1F, 0x60, 0xE5, 0xC8,
0x78, 0x84, 0xEB, 0x9B,
        0x9F, 0x5B, 0x21, 0x41, 0x01, 0xA9, 0xC3, 0x10, 0xD9, 0x04, 0x07, 0xD5,
0xFC, 0x30, 0xF5, 0x8A,
        0x6A, 0x6E, 0xC5, 0xD3, 0x8A, 0x01, 0x8E, 0xE7, 0x3A, 0x1E, 0xAE, 0x2F,
0x5E, 0xD1, 0xBC, 0x59,
        0x76, 0x7C, 0x54, 0x0D, 0x60, 0x9C, 0xD9, 0xA4, 0xCC, 0x4B, 0x98, 0xAE,
0xAB, 0x93, 0x89, 0xB8,
        0xE9, 0x76, 0x3A, 0x3F, 0xAC, 0x9E, 0x9C, 0x62, 0xEE, 0xA6, 0x28, 0x22,
0xFE, 0xF6, 0x11, 0xB1,
        0x12, 0x56, 0x39, 0x3D, 0xFE, 0x35, 0xC3, 0x96, 0x83, 0xB4, 0x86, 0x14,
0xCE, 0xA7, 0x1D, 0xF0,
        0xA9, 0xA6, 0x86, 0x3C, 0x4B, 0x6B, 0xF8, 0x81, 0x03, 0x81, 0x80, 0x58,
0xBA, 0x71, 0xE1, 0x17,
```

```
        0x28, 0x1C, 0x73, 0xDC, 0x54, 0xA8, 0x5C, 0x12, 0x33, 0xB2, 0x45, 0xD4,
0x61, 0x43, 0x3F, 0x35,
        0x52, 0x0E, 0xFD, 0x54, 0x06, 0x90, 0x42, 0x47, 0xC6, 0xBE, 0x0C, 0x2F,
0x59, 0xC2, 0x22, 0xCC,
        0xE8, 0x67, 0x86, 0x2E, 0x5B, 0xA5, 0xD8, 0xC5, 0x83, 0x62, 0x0C, 0xA1,
0xCC, 0x9A, 0x0D, 0x18,
        0xBA, 0x98, 0x6A, 0x2D, 0x8D, 0x66, 0xC9, 0xA6, 0x9A, 0x46, 0x30, 0x55,
0x43, 0x4E, 0x3F, 0xB2,
        0x53, 0xAC, 0xA1, 0xAE, 0x5A, 0xD5, 0x34, 0x77, 0xF0, 0x3F, 0x95, 0x0F,
0x71, 0x4D, 0x0A, 0xB3,
        0x08, 0xFD, 0xD4, 0xCF, 0x24, 0x29, 0xB3, 0xCA, 0x6C, 0xA2, 0x60, 0x5C,
0x9C, 0x51, 0x56, 0xF8,
        0x16, 0x45, 0xB7, 0x82, 0x6B, 0xB9, 0x08, 0x75, 0xB3, 0x8B, 0x82, 0x71,
0x99, 0x0C, 0x95, 0x59,
        0x86, 0x7E, 0xAE, 0x6B, 0xF4, 0x1B, 0x77, 0xC6, 0x11, 0x21, 0xBE, 0x17,
0x6E, 0x55, 0xA2, 0x8A,
        0xE2, 0xEC, 0xAF, 0x28, 0x24, 0x8E, 0x7D, 0xD5, 0x12, 0x21, 0x0D, 0x71,
0x36, 0x47, 0xD0, 0x42,
        0x8E, 0x31, 0x59, 0x62, 0x5C, 0xDE, 0x6E, 0x78, 0x68, 0x01, 0x79, 0x67,
0x32, 0x71, 0x55, 0xBE,
        0x67, 0x46, 0x41, 0x48, 0xFB, 0xB6, 0xB9, 0xEF, 0x00, 0xE3, 0x60, 0x75,
0xE2, 0x6C, 0x0C, 0xD6,
        0x9C, 0xA8, 0x65, 0x8E, 0x15, 0x73, 0xF9, 0x11, 0xA1, 0x36, 0x56, 0x22,
0xE1, 0x83, 0x3A, 0x0E,
        0xB9, 0x52, 0x9E, 0x13, 0x91, 0xA8, 0x38, 0x13, 0x87, 0x60, 0x69, 0x59,
0xC8, 0xCA, 0x35, 0x30,
        0xA7, 0xD8, 0xFC, 0x8C, 0xAD, 0x1F, 0x2B, 0xDB, 0xB0, 0xAA, 0xF6, 0xB0,
0xED, 0x78, 0xF3, 0x88,
        0xB4, 0x68, 0x3B, 0x35, 0xBF, 0x11, 0xCC, 0x99, 0x43, 0xC6, 0x2A, 0xF6,
0x7A, 0x65, 0x4D, 0xC5,
        0xFD, 0xF9, 0x65, 0xB9, 0x11, 0x64, 0x61, 0x0D, 0x17, 0x8D, 0xB1, 0x5B,
0x26, 0xB2, 0x08, 0x86,
        0x82, 0xB4, 0x2B, 0x72, 0x55, 0x71, 0xEF, 0xC6, 0x24, 0x4B, 0x8B, 0x57,
0xFF, 0xC1, 0x0F, 0xB5,
        0xED, 0xC8, 0x8E, 0x0F, 0x33, 0x3F, 0x85, 0xD8, 0x85, 0x00, 0x2B, 0x6A,
0xBD, 0x61, 0xCC, 0x12,
        0x64, 0x28, 0x9D, 0x20, 0x40, 0xDE, 0x04, 0x43, 0x2E, 0xB8, 0x3C, 0x8C,
0x0F, 0xCB, 0x17, 0x06,
        0xB5, 0xD4, 0xA7, 0xA9, 0xFA, 0x7E, 0xF9, 0x42, 0x84, 0x27, 0x84, 0x0D,
0x9A, 0x11, 0x09, 0xD6,
        0xD2, 0xF9, 0xBB, 0x4A, 0xA7, 0xE0, 0xFD, 0x88, 0x32, 0x60, 0xB2, 0x2E,
0xA5, 0xEC, 0xEF, 0x2B,
        0x33, 0x42, 0xBC, 0xD2, 0xB3, 0xED, 0xAA, 0xB5, 0xA2, 0x6D, 0x1F, 0x77,
0x8E, 0xFB, 0x95, 0x0D,
        0x93, 0x52, 0xCB, 0xDC, 0x7A, 0x51, 0x91, 0x31, 0x92, 0x6C, 0x52, 0x0D,
0xC1, 0x60, 0xEA, 0x2F,
        0x70, 0xA0, 0x00, 0x22, 0x27, 0x6E, 0xFF, 0x61, 0xDF, 0xAA, 0xC1, 0x0D,
0x41, 0xBE, 0x5F, 0xA8,
        0xB2, 0x69, 0x96, 0x5D, 0xAF, 0x6B, 0xF6, 0x4A, 0x1D, 0x93, 0xB3, 0x6B,
0x83, 0x37, 0xA0, 0xB1,
        0x8B, 0xAD, 0x92, 0xF4, 0x6C, 0x61, 0x1B, 0x45, 0x2E, 0xA9, 0xB0, 0x37,
0xEA, 0xD0, 0xBF, 0xB2,
        0x19, 0x59, 0x5C, 0xFD, 0x41, 0x37, 0x3A, 0x46, 0x2C, 0x12, 0xFE, 0x54,
0xCC, 0x19, 0xD7, 0x4E,
```

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        0x34, 0x9F, 0x63, 0x04, 0xA3, 0x4C, 0x5C, 0xB4, 0x24, 0xAD, 0xD5, 0x33,
0xAB, 0x13, 0x57, 0xAD,
        0x85, 0x68, 0xA5, 0x2B, 0x26, 0xDD, 0xD0, 0x5A, 0x3A, 0x0F, 0x6C, 0xDF,
0x8C, 0x54, 0x65, 0xBA,
        0x9E, 0x4B, 0xAD, 0xF2, 0x1B, 0xC4, 0x26, 0x0B, 0x5D, 0x87, 0x39, 0x76,
0xE4, 0x79, 0x14, 0xD1,
        0x16, 0x09, 0x40, 0x4D, 0xC5, 0x44, 0xF5, 0x0C, 0xB7, 0x51, 0x74, 0x66,
0x0C, 0x5B, 0xB4, 0x19,
        0x93, 0x0B, 0x40, 0x45, 0xA2, 0x48, 0x72, 0x88, 0x16, 0xFA, 0xA0, 0x54,
0xCC, 0x6A, 0x3B, 0xBB,
        0x90, 0x69, 0x34, 0x53, 0x35, 0x06, 0xF1, 0x64, 0x5D, 0xA8, 0x62, 0x7C,
0xBA, 0x60, 0x32, 0x46,
        0x8D, 0xCE, 0x61, 0xE7, 0xF0, 0x18, 0xFE, 0xA3, 0x68, 0xD0, 0xCB, 0x9D,
0x4B, 0x98, 0xB7, 0xC0,
        0xF3, 0x72, 0xC9, 0xA7, 0x7A, 0x9F, 0xA4, 0x28, 0x8D, 0x55, 0x62, 0x51,
0x3F, 0x92, 0xB2, 0x1B,
        0x26, 0xDD, 0x76, 0x45, 0x61, 0x29, 0x70, 0xE9, 0xF5, 0x1D, 0x51, 0xE1,
0x2D, 0xEB, 0x42, 0x3C,
        0xF3, 0xFF, 0x69, 0xF1, 0xAA, 0xFA, 0x7F, 0xEF, 0xED, 0x92, 0x29, 0xBE,
0x6B, 0x4F, 0x5F, 0xDB,
        0x2E, 0xE1, 0xBE, 0x7D, 0xA3, 0x53, 0x8C, 0x7A, 0x4B, 0xF4, 0x33, 0x20,
0xA1, 0x07, 0x8B, 0xAA,
        0x00, 0x56, 0x57, 0x85, 0x3D, 0x8F, 0x34, 0x66, 0x03, 0x1B, 0xD8, 0x8E,
0xEB, 0xB6, 0x5C, 0x7F,
        0x59, 0xDD, 0x89, 0x94, 0x7B, 0xF2, 0x8A, 0x9F, 0x56, 0xBB, 0xFC, 0xA6,
0xD2, 0x46, 0x90, 0xB9,
        0xFE, 0x27, 0xA4, 0xFD, 0xBE, 0x03, 0xAE, 0x34, 0x34, 0x36, 0x2B, 0x14,
0x1B, 0xF8, 0xE3, 0x76,
        0x13, 0xD5, 0x72, 0x25, 0xDE, 0x09, 0x96, 0x2E, 0xE6, 0xC2, 0xA5, 0x43,
0xCC, 0xE9, 0x06, 0x8B,
        0xAA, 0xB9, 0x1F, 0x3A, 0xFC, 0x1A, 0x4D, 0x80, 0x5D, 0x44, 0x3B, 0xF8,
0x8D, 0x96, 0xDC, 0x95,
        0x0B, 0x13, 0x99, 0xBC, 0x8E, 0x26, 0xCC, 0x74, 0xDF, 0xCE, 0x76, 0x49,
0x9B, 0xF7, 0x0E, 0xC5,
        0xB9, 0x5A, 0xED, 0xD6, 0x15, 0xED, 0x7E, 0x36, 0x32, 0xD4, 0x83, 0xD6,
0xC8, 0xE8, 0x71, 0xD2,
        0x9E, 0x04, 0xF8, 0xAA, 0x86, 0x32, 0x87, 0xE2, 0xDF, 0x01, 0xDF, 0x10,
0xDD, 0x7C, 0xED, 0xCF,
        0x0A, 0x80, 0xF0, 0xA2, 0x76, 0x3F, 0xAC, 0x31, 0x75, 0xF1, 0x94, 0x75,
0xFC, 0x31, 0xD9, 0xEE,
        0xD3, 0xF5, 0x1A, 0xE9, 0xA6, 0xA4, 0x84, 0xAA, 0x5D, 0x35, 0xAE, 0xBE,
0xCA, 0x93, 0x2E, 0xB6,
        0x49, 0xC1, 0xD5, 0x0C, 0xD6, 0xA7, 0x1E, 0x97, 0x67, 0xB7, 0x96, 0xB4,
0x4F, 0x50, 0x99, 0x39,
        0x92, 0x5D, 0xB9, 0x62, 0xEF, 0x53, 0x72, 0xA6, 0xD9, 0x73, 0x6D, 0xE6,
0xC5, 0x90, 0xC4, 0xED,
        0x33, 0x83, 0x19, 0xC6, 0xCC, 0x44, 0xC9, 0x07, 0x78, 0xF0, 0xEF, 0x8D,
0xDE, 0x89, 0xF2, 0x62,
        0x41, 0xC9, 0xE0, 0x32, 0xD1, 0x0A, 0xB7, 0xB5, 0x56, 0x4B, 0x56, 0xE1,
0x02, 0x59, 0xCE, 0x45,
        0x4A, 0xA0, 0xCA, 0xA3, 0xB2, 0x2C, 0xC3, 0xAC, 0xEE, 0xD1, 0x94, 0x3A,
0xBB, 0x33, 0x43, 0xD0,
        0xF6, 0x52, 0x77, 0x45, 0xC0, 0x51, 0x85, 0x5F, 0x1D, 0x77, 0x97, 0x36,
0x0D, 0xBB, 0x27, 0x9D,
```

```
        0x8A, 0x29, 0x4D, 0xD7, 0x0F, 0xCB, 0xE3, 0x0A, 0x8D, 0xC1, 0x7E, 0x11,
0x51, 0x4C, 0x24, 0xB6,
        0x2E, 0x95, 0x3B, 0x4F, 0xCC, 0xB9, 0x95, 0x67, 0x6A, 0x95, 0xEE, 0xD2,
0x98, 0x2A, 0x0F, 0xC7,
        0x9C, 0xCD, 0xBB, 0x1D, 0x65, 0xA6, 0x2D, 0xDD, 0x7F, 0x23, 0xF8, 0x12,
0xD6, 0x9B, 0xF4, 0x82,
        0xDC, 0x40, 0x33, 0xB1, 0x3A, 0x8D, 0x66, 0x8A, 0x5C, 0xB7, 0xCE, 0x26,
0x60, 0x29, 0x0E, 0x53,
        0xC7, 0xB2, 0x70, 0xE9, 0x2E, 0x27, 0x5D, 0xF3, 0xE6, 0x58, 0xC4, 0x47,
0xC3, 0x23, 0xE9, 0x06,
        0x96, 0xE1, 0x51, 0x7A, 0xAF, 0xCD, 0x90, 0xDE, 0xC5, 0x22, 0xDF, 0xE7,
0xC2, 0x2F, 0xB2, 0x68,
        0xA6, 0x8B, 0xC2, 0x70, 0xA4, 0xD3, 0xBB, 0x31, 0xF4, 0xEC, 0x6D, 0x2F,
0x43, 0xCB, 0x59, 0x68,
        0x8E, 0x35, 0xD2, 0x5D, 0x7F, 0xE2, 0xE7, 0xCE, 0xB1, 0xF3, 0x7C, 0xDB,
0x1B, 0x22, 0x75, 0xA4,
        0x67, 0x2E, 0x09, 0xE8, 0x8C, 0x2A, 0xFD, 0x49, 0x37, 0xEE, 0xDD, 0x79,
0xF8, 0xE0, 0xC1, 0xC9,
        0x4F, 0xF7, 0xBC, 0x71, 0x38, 0x17, 0xFF, 0xFD, 0x95, 0x5F, 0x41, 0x79,
0xF3, 0xBE, 0x77, 0xD2,
        0x87, 0x86, 0x16, 0x13, 0xE2, 0x78, 0x93, 0x70, 0x78, 0xC4, 0x98, 0xE6,
0x04, 0x39, 0x02, 0x49,
        0x0A, 0x64, 0x13, 0x09, 0x5D, 0x25, 0x5E, 0x3C, 0x24, 0x84, 0x1C, 0x35,
0x46, 0x81, 0x62, 0x08,
        0x1B, 0xC6, 0xDB, 0x05, 0xD6, 0x69, 0xE9, 0x2C, 0xB1, 0x8D, 0xFD, 0xCB,
0xBC, 0x06, 0x4C, 0x29,
        0x91, 0xF5, 0xC4, 0x28, 0x6C, 0x15, 0x31, 0x04, 0x32, 0x46, 0x4E, 0xAF,
0x87, 0x14, 0x8C, 0x49,
        0xE4, 0x13, 0xD6, 0x97, 0xB6, 0xE7, 0xF9, 0xD4, 0x76, 0x80, 0x66, 0x98,
0x26, 0x22, 0xF1, 0x63,
        0x31, 0x9B, 0x3C, 0x12, 0x09, 0xA5, 0x6E, 0xBC, 0xC3, 0x2C, 0x5C, 0x01,
0x65, 0xA5, 0x59, 0x57,
        0xB8, 0x88, 0x0C, 0x9A, 0x99, 0x5F, 0x8F, 0x45, 0x14, 0x3B, 0xA6, 0x2D,
0xC4, 0xDC, 0xA6, 0x42,
        0x20, 0xC6, 0xCE, 0x9F, 0x33, 0x07, 0x5B, 0x20, 0x37, 0x02, 0xD3, 0x76,
0x3B, 0xBA, 0xF1, 0xDB,
        0xEF, 0xCF, 0x1F, 0x37, 0x20, 0x11, 0x75, 0x2E, 0xBB, 0xBD, 0x4E, 0xA7,
0x39, 0x3C, 0xE2, 0x43,
        0xD6, 0xE6, 0xF5, 0x50, 0x37, 0x2E, 0x18, 0xAB, 0xDE, 0x29, 0xB0, 0xEA,
0xF4, 0xFA, 0x9B, 0xB3,
        0x3A, 0xD5, 0x0D, 0xC6, 0x09, 0x98, 0x5C, 0x3E, 0x38, 0x39, 0xDD, 0x9C,
0xD1, 0x03, 0x90, 0xE9,
        0x3D, 0x70, 0x3A, 0x05, 0xED, 0x4E, 0xB6, 0x51, 0xEE, 0x44, 0x37, 0x28,
0x1F, 0x88, 0x8A, 0xCB,
        0xFE, 0xE9, 0x16, 0x7C, 0xEE, 0xEB, 0xA2, 0x24, 0x52, 0x97, 0x8D, 0x8F,
0x74, 0xE3, 0xEC, 0xE7,
        0x67, 0x8D, 0x3E, 0xC8, 0xD8, 0x7B, 0x78, 0xB2, 0x39, 0xEF, 0xBE, 0x6E,
0xFC, 0x42, 0x85, 0x3C,
        0xEE, 0x01, 0xA3, 0xFE, 0x16, 0x42, 0x1E, 0xEB, 0xC6, 0x0B, 0xC6, 0x09,
0xB8, 0x5C, 0x76, 0x1F,
        0x6C, 0x21, 0x12, 0xB8, 0xD7, 0x2F, 0x8C, 0x13, 0xF8, 0x17, 0x75, 0xAF,
0x9A, 0x9C, 0x20, 0x5F,
        0x32, 0xD3, 0x94, 0xC4, 0xE9, 0x6A, 0xF6, 0xC9, 0x9C, 0x2E, 0x0B, 0xE3,
0xBF, 0x23, 0x28, 0x1D,
```

```
        0xE4, 0x6A, 0xED, 0x20, 0x16, 0x74, 0xA0, 0x12, 0x3F, 0xA8, 0x17, 0xBF,
0x92, 0x24, 0xC9, 0x65,
        0x39, 0xDD, 0xE8, 0x76, 0x2A, 0x34, 0x60, 0xB4, 0x72, 0x16, 0x64, 0xC4,
0x19, 0x05, 0x74, 0xDA,
        0x49, 0xB0, 0x18, 0xA6, 0xB7, 0x7E, 0x80, 0x8F, 0x1E, 0xEB, 0x52, 0x5C,
0x6F, 0x94, 0x22, 0x14,
        0xD2, 0xA2, 0x4B, 0xDD, 0x38, 0x39, 0xAE, 0xB2, 0xF7, 0x16, 0x70, 0x8C,
0x59, 0x9B, 0xE2, 0xE1,
        0x30, 0x5C, 0x1B, 0x91, 0x94, 0x54, 0x37, 0x9E, 0x24, 0xC7, 0xDB, 0xE0,
0xD2, 0xEA, 0x6D, 0x81,
        0x8B, 0x24, 0x0E, 0x87, 0xA6, 0xD5, 0x13, 0xD0, 0xF4, 0xF4, 0x34, 0x22,
0xBE, 0x26, 0x30, 0x55,
        0xD2, 0x6E, 0x83, 0x0B, 0x2D, 0xE2, 0x01, 0x0A, 0xC9, 0xDA, 0xA8, 0xC4,
0x84, 0x90, 0xD6, 0xC4,
        0xD1, 0xDE, 0x10, 0x49, 0x44, 0xF9, 0x0E, 0xF0, 0x08, 0x11, 0x89, 0x02,
0x76, 0x43, 0xDC, 0xDA,
        0x88, 0xA4, 0xA4, 0x50, 0x0F, 0x93, 0xE3, 0xBD, 0xA1, 0x22, 0x89, 0xF3,
0x3D, 0xE0, 0x32, 0xC7,
        0xA6, 0x83, 0xDC, 0x8F, 0xD8, 0xB6, 0xA1, 0x64, 0xAD, 0x8F, 0x4D, 0x86,
0x1C, 0xF0, 0xE1, 0xDF,
        0xB5, 0x73, 0xF6, 0x7D, 0xED, 0x1E, 0x31, 0xC7, 0xEE, 0x6B, 0x35, 0x8A,
0x1D, 0x75, 0xDF, 0xF2,
        0xDA, 0x4F, 0xE4, 0xDC, 0xB0, 0x43, 0xE8, 0x02, 0x13, 0x3C, 0x61, 0x2B,
0xE5, 0x8D, 0x79, 0xF4,
        0x74, 0xE3, 0x79, 0x80, 0xAE, 0xD8, 0xB3, 0x05, 0xDB, 0x34, 0x3D, 0xEF,
0xB0, 0xA5, 0xFD, 0x0A,
        0x4B, 0xC1, 0x6D, 0x3A, 0xB0, 0xE7, 0x01, 0x86, 0x65, 0xE2, 0x56, 0x5C,
0xEE, 0x43, 0x31, 0x83,
        0x83, 0xED, 0x98, 0x40, 0xC3, 0x7A, 0x81, 0xE7, 0x0E, 0xFA, 0x16, 0x1A,
0x2E, 0xB4, 0x1C, 0xAF,
        0x1D, 0x16, 0x40, 0xA3, 0x1B, 0x8F, 0x3F, 0x3C, 0x59, 0x3B, 0x49, 0xF1,
0xFD, 0xE6, 0x3A, 0x1E,
        0xCE, 0xB3, 0x93, 0x10, 0x50, 0x5F, 0x59, 0x6C, 0xAA, 0x23, 0xA7, 0xEE,
0x82, 0x53, 0xA1, 0x57,
        0x2C, 0x20, 0xDB, 0x9E, 0xD3, 0x25, 0x35, 0xEB, 0xE9, 0x78, 0x73, 0x19,
0x0C, 0x84, 0xF8, 0x38,
        0x41, 0xCE, 0xFA, 0x75, 0x25, 0x26, 0x64, 0x48, 0x69, 0xCF, 0xE1, 0x68,
0x57, 0x70, 0xF1, 0x69,
        0xF7, 0x86, 0x99, 0xD0, 0x7A, 0xDF, 0xC0, 0x81, 0x20, 0x33, 0xDF, 0x5A,
0x7F, 0x3B, 0x42, 0xD0,
        0xE9, 0x06, 0xA0, 0xF6, 0x0A, 0x0E, 0xD6, 0xAE, 0x32, 0x31, 0x83, 0x1B,
0x2E, 0x2F, 0x8F, 0x23,
        0xE2, 0x6F, 0x53, 0x59, 0x2E, 0x22, 0xCF, 0xBB, 0xDA, 0xA6, 0xAC, 0x9C,
0xB9, 0x7E, 0x64, 0x6D,
        0xCE, 0x01, 0x6A, 0xCA, 0x1B, 0xDB, 0x76, 0xCC, 0xCD, 0xAB, 0x12, 0x54,
0x94, 0x17, 0xFE, 0xAC,
        0x26, 0xFD, 0x0D, 0x67, 0x71, 0x6C, 0xAE, 0x9F, 0x20, 0xB0, 0x09, 0x28,
0x9E, 0x9F, 0x69, 0x17,
        0xE7, 0xAF, 0x2F, 0xDE, 0xBC, 0xDB, 0x4D, 0x76, 0x80, 0x39, 0xF7, 0x94,
0x18, 0xA8, 0xB6, 0xFB,
        0xCE, 0x09, 0x20, 0x44, 0x6F, 0x13, 0x9C, 0x7A, 0x1C, 0xA8, 0xA7, 0x17,
0x6F, 0x77, 0x85, 0x52,
        0x6F, 0x7F, 0x30, 0xF5, 0xBE, 0x05, 0x9C, 0x3E, 0xBA, 0x78, 0x81, 0xDD,
0x0D, 0xB0, 0xE2, 0x84,
```

```
        0x14, 0x2F, 0xED, 0x25, 0x3D, 0xDA, 0xDB, 0x42, 0x2E, 0x11, 0xE5, 0x3B,
0x58, 0xC6, 0x81, 0x57,
        0x7C, 0x64, 0x42, 0x6F, 0x12, 0x3C, 0x9C, 0x52, 0x37, 0xCE, 0x2F, 0xE7,
0x7E, 0x18, 0x05, 0x35,
        0x0B, 0xAA, 0x1A, 0x91, 0x6D, 0x76, 0x06, 0x53, 0x51, 0x38, 0x22, 0xF1,
0xD6, 0x20, 0xDD, 0xD9,
        0x4F, 0x30, 0xE9, 0x75, 0xFA, 0x5F, 0x15, 0x15, 0xCA, 0xFC, 0x26, 0x81,
0x99, 0x6C, 0x50, 0x77,
        0x26, 0xB4, 0xEE, 0x3C, 0x3F, 0xDB, 0x4D, 0x2A, 0x9B, 0xEC, 0xAD, 0xE0,
0x4C, 0xF6, 0x5A, 0x70,
        0x34, 0x7E, 0x51, 0x34, 0x81, 0x69, 0xC3, 0x45, 0x84, 0x20, 0x84, 0xB5,
0xF3, 0x26, 0x0B, 0x08,
        0x79, 0x53, 0xFD, 0x72, 0x9B, 0xD0, 0x89, 0xC5, 0xC8, 0x46, 0xCE, 0x71,
0x1A, 0x37, 0xF7, 0xBF,
        0x6A, 0xD4, 0x1C, 0x57, 0x4A, 0xBB, 0x4D, 0xD0, 0x50, 0x4D, 0x4C, 0xEC,
0xB8, 0xF4, 0x09, 0xA6,
        0x75, 0x01, 0x91, 0x68, 0x39, 0x26, 0xDA, 0x19, 0xFF, 0xB6, 0x0D, 0x36,
0xBD, 0x6D, 0xB0, 0x91,
        0x25, 0xCA, 0xC2, 0x73, 0x72, 0x43, 0x95, 0xA6, 0xDB, 0x3B, 0xBD, 0x49,
0x78, 0xC6, 0xF3, 0xF5,
        0x73, 0x1A, 0xD0, 0xE8, 0xC6, 0x93, 0xB7, 0xBB, 0xC9, 0x69, 0x74, 0xB2,
0x9A, 0x39, 0x6D, 0xAB,
        0x0C, 0xC6, 0x94, 0xDA, 0x77, 0x2B, 0xB6, 0xDC, 0x00, 0x8D, 0x25, 0x15,
0xFC, 0xC3, 0x8E, 0xD0,
        0x58, 0xD6, 0x47, 0xE3, 0x2B, 0x57, 0x98, 0xE5, 0xB7, 0x80, 0x4F, 0x80,
0x96, 0x1F, 0x27, 0x33,
        0xB4, 0x36, 0x46, 0x82, 0x4E, 0x37, 0xDE, 0xA1, 0xA5, 0xF6, 0xFC, 0xD5,
0xE3, 0x9D, 0x60, 0x15,
        0x4F, 0xBA, 0x1F, 0xBC, 0x12, 0x95, 0xF7, 0x8D, 0x99, 0x8B, 0xBD, 0xF5,
0x83, 0x8A, 0x12, 0xE9,
        0xC6, 0x4B, 0xEC, 0x85, 0xDA, 0x99, 0x1F, 0x88, 0xB7, 0xCD, 0xEC, 0x04,
0x35, 0x36, 0xF3, 0x7E,
        0x20, 0xE3, 0x4A, 0xEF, 0x1B, 0xAF, 0xE9, 0xCC, 0x09, 0x02, 0x3F, 0x58,
0x1B, 0x32, 0x41, 0xA7,
        0x1B, 0x2F, 0x5A, 0xAF, 0xD8, 0xD1, 0x4E, 0xE0, 0x8A, 0x67, 0xDD, 0x0F,
0x62, 0x89, 0xCE, 0xFB,
        0x06, 0x6D, 0x61, 0xBB, 0xCE, 0x7C, 0x6D, 0xC8, 0x18, 0x95, 0x6E, 0xBC,
0x6F, 0x3D, 0x83, 0x7F,
        0x77, 0x02, 0x17, 0x9F, 0x71, 0x3F, 0x60, 0x09, 0x6D, 0xF7, 0x0D, 0x95,
0x65, 0x2E, 0xD7, 0x06,
        0x0A, 0x68, 0x74, 0xE3, 0xE9, 0xD9, 0x07, 0xAD, 0xF1, 0xD4, 0x5F, 0x7A,
0xF4, 0xC6, 0x3F, 0xED,
        0xFC, 0x75, 0x73, 0x27, 0x88, 0xD1, 0xA9, 0xF7, 0x83, 0x17, 0x53, 0x7A,
0xDF, 0x68, 0xB1, 0xBB,
        0x8F, 0xC7, 0x68, 0xFD, 0x74, 0x18, 0x13, 0xD2, 0x7B, 0x5F, 0xE0, 0x48,
0x7B, 0x82, 0x76, 0x93,
        0x10, 0x93, 0x79, 0x77, 0xD1, 0xB4, 0xA7, 0x4A, 0xEE, 0x1B, 0x27, 0x1B,
0x99, 0xF8, 0xA3, 0x85,
        0xC9, 0x26, 0x37, 0x5E, 0x48, 0xB4, 0xBA, 0xF1, 0x0C, 0xBE, 0x68, 0x4F,
0xD9, 0x97, 0x5D, 0xB5,
        0x1C, 0xF2, 0xFC, 0xBB, 0x40, 0x2D, 0xA3, 0xEF, 0x37, 0x01, 0x1C, 0x34,
0x78, 0xFE, 0xC4, 0xDB,
        0xE8, 0x7E, 0xEA, 0x0C, 0xB9, 0x80, 0xEF, 0x1D, 0xFF, 0xBE, 0x5B, 0x00,
0x53, 0x21, 0x76, 0x86,
```

```
        0xA1, 0xA4, 0xF7, 0x2E, 0x60, 0x8C, 0x9F, 0x49, 0x60, 0xDB, 0x02, 0xFC,
0xE5, 0x4F, 0x55, 0x48,
        0x89, 0x57, 0xC2, 0xB0, 0xAD, 0x1B, 0x4C, 0x5A, 0x21, 0x71, 0x5C, 0x57,
0x37, 0x9E, 0x63, 0xA2,
        0x5D, 0xD0, 0xC3, 0xE1, 0x11, 0x1F, 0x50, 0x9F, 0x8B, 0xB8, 0xE1, 0x9F,
0xBE, 0x76, 0x0D, 0xCD,
        0x74, 0xE3, 0x82, 0xBE, 0x16, 0x0B, 0x78, 0xD1, 0x6F, 0xEB, 0x33, 0x63,
0x46, 0xC4, 0x5E, 0xE0,
        0x83, 0x50, 0x09, 0x48, 0xE2, 0xED, 0x24, 0xBA, 0x16, 0x1F, 0x49, 0xBF,
0x19, 0xE7, 0x6C, 0xB0,
        0x46, 0xBD, 0xAC, 0x7A, 0x3A, 0x7A, 0x15, 0xD6, 0x2C, 0xBE, 0x58, 0x3B,
0x3C, 0xF2, 0x90, 0xC2,
        0xDC, 0x05, 0x28, 0x0C, 0xF9, 0xFB, 0xD4, 0x0A, 0x58, 0x25, 0x0F, 0x53,
0x30, 0x4B, 0xA4, 0x0F,
        0x26, 0x25, 0x6A, 0xE5, 0x1F, 0x58, 0x12, 0x1B, 0xB6, 0xF5, 0x82, 0x96,
0x3D, 0x7A, 0x24, 0xEA,
        0x21, 0x3D, 0x4C, 0xCC, 0xFF, 0x9F, 0x7F, 0x57, 0xF9, 0x0C, 0x7D, 0xDB,
0x5D, 0x2A, 0x98, 0xAE,
        0x85, 0x81, 0x39, 0xD2, 0x8B, 0x1E, 0xCD, 0x28, 0xD0, 0xFC, 0x48, 0xA5,
0x7A, 0x6E, 0xB0, 0xC2,
        0xD6, 0xC3, 0xD0, 0x0C, 0x9C, 0x39, 0x31, 0x6E, 0x59, 0xBE, 0x19, 0xCD,
0xB0, 0x47, 0xDA, 0xC8,
        0xB2, 0xCE, 0x17, 0x70, 0xF0, 0xD2, 0x09, 0x09, 0x06, 0x2B, 0x34, 0x0E,
0x9E, 0xBE, 0x79, 0x75,
        0xC6, 0x1F, 0x51, 0x79, 0xE9, 0x23, 0x0B, 0x5B, 0x07, 0x87, 0x9A, 0x1D,
0x79, 0xDC, 0xCD, 0x1B,
        0x98, 0x8E, 0xE5, 0x6F, 0x1A, 0x5C, 0xA0, 0x40, 0x1B, 0xA3, 0x10, 0xBF,
0xF0, 0x43, 0xA2, 0x8D,
        0xB4, 0x84, 0xA3, 0xEB, 0x9B, 0xEC, 0xF6, 0xC5, 0xB6, 0x1F, 0x38, 0x13,
0xC7, 0x13, 0x23, 0xB9,
        0xB2, 0xBF, 0x05, 0x2E, 0x0C, 0x4D, 0xA8, 0x7E, 0xD4, 0x0E, 0x06, 0xA7,
0xDD, 0x03, 0xFA, 0x34,
        0x11, 0xC0, 0x00, 0x3F, 0x00, 0x04, 0x18, 0x06, 0x40, 0x80, 0x8F, 0x0C,
0xF1, 0x38, 0x11, 0x76,
        0xDB, 0xCC, 0xE4, 0x54, 0x40, 0x2A, 0x6D, 0xE3, 0x80, 0xE3, 0x74, 0x40,
0x1F, 0xAD, 0xBB, 0x4E,
        0x28, 0xC3, 0xA9, 0xBF, 0x2C, 0xA3, 0x0C, 0xF0, 0xCC, 0x5F, 0xE0, 0x1C,
0x71, 0x42, 0x2D, 0xBC,
        0xB9, 0x72, 0xEA, 0xD8, 0xEB, 0x0F, 0x9A, 0xF1, 0x80, 0xE4, 0xCD, 0x3D,
0x23, 0x8D, 0x04, 0x11,
        0xCE, 0xB2, 0xC5, 0x5E, 0x15, 0xD7, 0x58, 0xAC, 0x52, 0xC6, 0x36, 0x72,
0xC3, 0x1C, 0xE7, 0x68,
        0x6E, 0x21, 0x82, 0xDF, 0xD3, 0xDD, 0x5D, 0x18, 0xD0, 0xC0, 0xEE, 0x21,
0xDF, 0xEA, 0x3D, 0x14,
        0x67, 0xDE, 0x01, 0x5F, 0x82, 0x9B, 0xE9, 0xAC, 0xF2, 0xCF, 0x40, 0x91,
0xFD, 0x3A, 0xD2, 0xBC,
        0x08, 0x42, 0xF8, 0x11, 0x53, 0x41, 0x1B, 0x64, 0xCE, 0x32, 0x6A, 0x17,
0xB2, 0x93, 0x78, 0x4B,
        0x31, 0x9B, 0x93, 0xFD, 0xE8, 0xD8, 0x74, 0xE2, 0x36, 0x7B, 0x67, 0xF2,
0x08, 0x78, 0x1C, 0xC4,
        0xD9, 0xFD, 0x20, 0x7D, 0x15, 0xA5, 0x4C, 0xC4, 0xEC, 0xD0, 0x16, 0x7D,
0xB0, 0x38, 0xBF, 0x10,
        0x27, 0x6E, 0xDF, 0x5E, 0x24, 0x7C, 0x35, 0x69, 0x18, 0x9C, 0x4A, 0x4F,
0x5C, 0xC3, 0x09, 0xE9,
```

```
        0x79, 0xBF, 0x55, 0xDE, 0x39, 0x1E, 0x31, 0x73, 0x89, 0xC3, 0xAD, 0x44,
0xF2, 0x8C, 0x05, 0xEE,
        0xDD, 0xCB, 0x72, 0xBB, 0x3D, 0x12, 0x54, 0xA9, 0x26, 0x7C, 0x3C, 0x44,
0x06, 0x44, 0x1E, 0xA8,
        0x2D, 0x9E, 0x02, 0x15, 0x22, 0x39, 0x76, 0xE3, 0x76, 0xC6, 0xF0, 0x89,
0x8C, 0x36, 0x35, 0x91,
        0x63, 0x31, 0x03, 0xB1, 0x7B, 0x20, 0x9A, 0xE9, 0x53, 0x72, 0x5C, 0xBE,
0x47, 0xCC, 0xEB, 0x1B,
        0x58, 0x5C, 0x1D, 0x6D, 0x82, 0xFD, 0xA9, 0x33, 0xA7, 0x3F, 0x88, 0xF1,
0xE9, 0x54, 0x32, 0xC7,
        0x49, 0x86, 0x23, 0x55, 0x2C, 0x27, 0x37, 0xFD, 0x30, 0x7E, 0xF4, 0x3A,
0x81, 0xB8, 0x56, 0x21,
        0x3F, 0x95, 0xCA, 0x26, 0x07, 0x36, 0xF4, 0x5A, 0x46, 0xFA, 0x7B, 0xCE,
0xD4, 0xC9, 0xC0, 0x02,
        0x26, 0x6C, 0x82, 0x55, 0x26, 0xA5, 0x92, 0xC7, 0x37, 0x8A, 0x29, 0x0C,
0xC2, 0xD8, 0x2D, 0xC7,
        0xD4, 0x14, 0x6C, 0x56, 0x38, 0x2C, 0x63, 0x95, 0x2B, 0xFC, 0x0A, 0x86,
0x3C, 0x10, 0x1B, 0xBC,
        0xAE, 0x3D, 0x61, 0x35, 0x8A, 0x32, 0x17, 0x31, 0x96, 0xFD, 0xFD, 0x96,
0x2C, 0xFC, 0x75, 0x1C,
        0x76, 0x49, 0x0A, 0x94, 0xFD, 0x80, 0xFA, 0x7F, 0x6C, 0x69, 0x1A, 0x22,
0xA9, 0xA3, 0x89, 0x07,
        0xFB, 0xE3, 0xF8, 0x48, 0xE1, 0x30, 0x21, 0xF7, 0x49, 0x91, 0x32, 0xC8,
0x89, 0x2A, 0x87, 0x08,
        0xC8, 0xDD, 0xD5, 0xE4, 0x47, 0xF5, 0xC7, 0x90, 0x42, 0x3F, 0x67, 0xF8,
0xB0, 0x8B, 0x32, 0x09,
        0x13, 0xFE, 0x1B, 0xBF, 0xCD, 0xA9, 0xE5, 0x7B, 0x58, 0xCD, 0x5D, 0x0E,
0x12, 0x15, 0x4F, 0x5E,
        0xC2, 0xF3, 0x4C, 0xA3, 0xF1, 0xCC, 0x21, 0x0A, 0x86, 0x07, 0x90, 0xBE,
0x55, 0xBC, 0x44, 0x63,
        0x97, 0x12, 0x04, 0x98, 0x44, 0x81, 0x27, 0x47, 0x21, 0xCF, 0x64, 0x7F,
0x47, 0x38, 0xB8, 0x02,
        0x46, 0x9F, 0xEE, 0x7E, 0x89, 0xEB, 0xC2, 0xF5, 0x11, 0x7B, 0x34, 0xC1,
0x77, 0x1F, 0x41, 0xE5,
        0x18, 0xDD, 0xFD, 0xC2, 0xA0, 0xBE, 0xBE, 0x07, 0x53, 0xC2, 0x17, 0x36,
0xF1, 0xF5, 0x27, 0xCE,
        0xC2, 0xA6, 0x2F, 0x9A, 0x6D, 0x30, 0x16, 0x31, 0x6E, 0x6D, 0x32, 0xC5,
0x5E, 0x23, 0xC0, 0xE1,
        0x1C, 0xD8, 0xE3, 0x34, 0x01, 0xC6, 0x33, 0xFA, 0x2E, 0x86, 0x12, 0x35,
0x69, 0x7C, 0x0A, 0x30,
        0xD0, 0x81, 0x00, 0xC4, 0xD7, 0xEE, 0x7E, 0x61, 0x2C, 0xAE, 0x35, 0x1B,
0xB2, 0x40, 0x38, 0xC5,
        0xD6, 0x21, 0xD4, 0x2B, 0x44, 0xE8, 0x13, 0xB8, 0x77, 0xBF, 0xC4, 0xAC,
0xDA, 0xFC, 0xA7, 0xEB,
        0x4F, 0x89, 0x87, 0x24, 0x45, 0x24, 0xAE, 0x7D, 0xEC, 0x44, 0x9B, 0xF1,
0xBA, 0x60, 0x28, 0xF8,
        0xC1, 0x63, 0xD7, 0x6D, 0x1C, 0xF0, 0x07, 0x95, 0x45, 0x6E, 0x6F, 0x43,
0xB3, 0x7A, 0x8E, 0x40,
        0x6C, 0xB9, 0x28, 0xB0, 0x7C, 0xE5, 0x7B, 0xA6, 0xEB, 0x98, 0x9F, 0x69,
0x42, 0x6F, 0x66, 0x05,
        0xE7, 0x19, 0xC2, 0x6D, 0xF3, 0x17, 0xCF, 0xBC, 0xF6, 0x2D, 0x9C, 0x73,
0xD3, 0x26, 0x15, 0xE3,
        0xE8, 0x08, 0xAC, 0x8C, 0xAC, 0x38, 0x95, 0x71, 0x8C, 0xE8, 0x1B, 0x0A,
0xB8, 0x99, 0x32, 0x16,
```

```
        0xE6, 0xCA, 0x08, 0x5D, 0xB8, 0xCD, 0xD2, 0x2A, 0x1F, 0xAB, 0x9C, 0xBA,
0x2D, 0x47, 0x4F, 0x4B,
        0x6C, 0xF1, 0x57, 0xE8, 0x7B, 0x8D, 0xE6, 0xAD, 0xC4, 0x0C, 0xAB, 0x3C,
0xE8, 0x04, 0x12, 0x83,
        0x8C, 0x89, 0x8A, 0xCC, 0x94, 0x5D, 0x0D, 0x1C, 0xA4, 0x99, 0xA4, 0xC0,
0x66, 0xF4, 0x23, 0x55,
        0x42, 0x56, 0x06, 0xD9, 0xBC, 0x7F, 0x30, 0x97, 0xF9, 0xF3, 0x90, 0x97,
0x4E, 0x29, 0x23, 0x35,
        0x25, 0x73, 0x71, 0xFF, 0xA3, 0xAF, 0xE8, 0x97, 0xDB, 0x17, 0xE8, 0xC9,
0xCF, 0x5D, 0x4C, 0x0F,
        0x9F, 0x5C, 0xFD, 0x0C, 0x25, 0x9F, 0x37, 0x2E, 0x4C, 0x96, 0x94, 0xE0,
0x2C, 0x69, 0x1A, 0x2B,
        0x29, 0xD3, 0x06, 0x53, 0xE2, 0xC1, 0x9A, 0x7E, 0x9E, 0x6F, 0xCA, 0x38,
0x24, 0xEB, 0x83, 0x0C,
        0x29, 0xE5, 0x5A, 0x4D, 0x9B, 0x59, 0x15, 0x48, 0xF4, 0x72, 0xAE, 0x2B,
0xA3, 0x97, 0x16, 0x02,
        0x12, 0x35, 0x73, 0xE4, 0x6A, 0x62, 0xB9, 0x25, 0x3E, 0x90, 0x8C, 0x1D,
0x12, 0x7F, 0xCE, 0x57,
        0x26, 0x39, 0x27, 0x5F, 0x3A, 0x9E, 0xE5, 0x2F, 0xDB, 0xF4, 0x7C, 0x43,
0x94, 0x56, 0x59, 0xD1,
        0xB6, 0xE3, 0x81, 0x01, 0x5F, 0xFC, 0xFA, 0xEA, 0x25, 0x4D, 0x39, 0xF2,
0x0A, 0xE7, 0x20, 0xDB,
        0x17, 0xB1, 0x77, 0x02, 0x2B, 0x67, 0xA0, 0xB0, 0xB5, 0xA1, 0xD5, 0xE6,
0xA9, 0x26, 0x69, 0x47,
        0x69, 0x24, 0xD0, 0xC3, 0x4F, 0x7C, 0x4E, 0x5A, 0x78, 0x32, 0x00, 0x37,
0x2B, 0x65, 0xF1, 0xE7,
        0x79, 0x51, 0x20, 0x0E, 0x1F, 0x13, 0x02, 0xEE, 0xAA, 0x71, 0x47, 0x0E,
0x69, 0x8E, 0x11, 0xAB,
        0xC3, 0x5B, 0x9A, 0x0C, 0x7E, 0x41, 0xC8, 0xA7, 0x66, 0x12, 0x31, 0x96,
0x15, 0x5E, 0xCA, 0x93,
        0x68, 0x0E, 0x71, 0x89, 0x1F, 0x7D, 0x34, 0xC7, 0x90, 0x1A, 0x9F, 0x82,
0xE7, 0xB7, 0x3D, 0xD0,
        0xA0, 0x79, 0x5D, 0xA6, 0x0E, 0x37, 0x57, 0x0A, 0x64, 0x5D, 0x21, 0x58,
0x12, 0x52, 0x73, 0xCB,
        0xD8, 0x47, 0xCD, 0x4E, 0xF6, 0xDE, 0x73, 0x2F, 0x6E, 0x6D, 0x8B, 0x0C,
0x3B, 0x5A, 0x35, 0x2D,
        0xEF, 0x6E, 0x32, 0x0C, 0xD2, 0xF4, 0xB2, 0x22, 0x6C, 0xAE, 0x81, 0x91,
0xFC, 0x22, 0x1E, 0x10,
        0xCB, 0x2E, 0x07, 0x44, 0x81, 0xEC, 0xD9, 0xDE, 0x2F, 0xD7, 0x2C, 0xE4,
0x20, 0x17, 0x39, 0x4C,
        0xA3, 0x2F, 0x2A, 0x98, 0xD2, 0xF2, 0x2C, 0x9C, 0xA0, 0x4E, 0x99, 0x50,
0xE6, 0xBF, 0xD2, 0x7A,
        0xC1, 0x67, 0x88, 0xA5, 0xCD, 0xF7, 0xA8, 0xD9, 0xDA, 0x70, 0x16, 0x81,
0x95, 0x66, 0xB1, 0x4F,
        0xF2, 0xDF, 0x68, 0xC3, 0x96, 0x04, 0x0F, 0x34, 0x70, 0x65, 0x41, 0x0D,
0xA7, 0xA5, 0x4C, 0x20,
        0xBA, 0xBD, 0x0A, 0x02, 0xE9, 0xAE, 0x27, 0x89, 0x56, 0xEA, 0x22, 0x4B,
0xD3, 0x5F, 0xFE, 0x3E,
        0x1D, 0xC6, 0x02, 0xB8, 0xAE, 0x6A, 0xAE, 0xC0, 0x09, 0xC6, 0x35, 0x13,
0xB7, 0xA1, 0x44, 0xA2,
        0xAD, 0x92, 0x9C, 0xA6, 0xA0, 0x2D, 0x5E, 0x6D, 0x89, 0x73, 0xDE, 0x54,
0xD4, 0x0A, 0xAF, 0xB6,
        0xC1, 0xD7, 0x92, 0x83, 0xC4, 0xF7, 0x3F, 0xA6, 0x26, 0xC4, 0xE5, 0xF6,
0xC6, 0xB2, 0xBD, 0xE3,
```

```
        0xE5, 0x40, 0x05, 0x85, 0x7C, 0x9B, 0x26, 0x37, 0x17, 0xAE, 0x69, 0x2E,
0x2C, 0xCC, 0x45, 0x09,
        0xD2, 0x0E, 0xB4, 0x7A, 0x6D, 0x92, 0xF8, 0xFF, 0x87, 0x27, 0xA9, 0x66,
0xCB, 0x71, 0xA9, 0x9C,
        0xA2, 0xF7, 0x97, 0xD4, 0x2B, 0x27, 0xC8, 0x3C, 0xCB, 0xC1, 0xD5, 0x5A,
0x8E, 0xEB, 0xA9, 0x15,
        0xAF, 0x1D, 0x28, 0x41, 0xAA, 0x96, 0x7A, 0x85, 0x11, 0xAB, 0x92, 0xEC,
0x75, 0xB3, 0xFF, 0xDD,
        0x42, 0xF2, 0x66, 0x89, 0x44, 0x58, 0xBE, 0x51, 0x5C, 0x59, 0x3D, 0xF9,
0x30, 0x49, 0xC9, 0x64,
        0x8D, 0x52, 0x49, 0x9A, 0x8C, 0x94, 0xA8, 0x13, 0x39, 0x4A, 0xA9, 0xE3,
0x41, 0xBC, 0xEC, 0x26,
        0x5F, 0x6B, 0x19, 0x2B, 0x19, 0x9D, 0x06, 0x4E, 0xCA, 0x80, 0x77, 0xFC,
0x86, 0x76, 0x3F, 0xBF,
        0x26, 0xE6, 0xBD, 0x17, 0x57, 0x36, 0xD7, 0x71, 0xC9, 0x03, 0x12, 0x95,
0x32, 0x63, 0x92, 0x00,
        0xE1, 0xF4, 0x45, 0x62, 0x56, 0x8A, 0x82, 0x5C, 0x1C, 0x90, 0x86, 0xFE,
0xD6, 0xC5, 0x74, 0xBD,
        0x22, 0x9E, 0xC6, 0x39, 0xFB, 0xF9, 0x99, 0xE6, 0x07, 0x1A, 0x7F, 0xC1,
0x5D, 0x90, 0xBC, 0x5B,
        0x44, 0x13, 0x6F, 0x7F, 0x62, 0xAB, 0x42, 0x9A, 0x83, 0xC8, 0xD4, 0x09,
0xA1, 0x49, 0xA6, 0x4F,
        0xDE, 0xE2, 0xDB, 0x7A, 0xF2, 0x82, 0xA7, 0x4A, 0xF5, 0x78, 0x57, 0xFC,
0x53, 0xA2, 0x48, 0xCE,
        0x9C, 0x9C, 0x26, 0xB5, 0xE5, 0x6D, 0xA1, 0xE3, 0x4A, 0x22, 0x2A, 0x5B,
0x87, 0xAE, 0x61, 0xC2,
        0xE4, 0xF4, 0x37, 0x6B, 0x45, 0xB5, 0x02, 0x95, 0x86, 0x4C, 0xC8, 0x52,
0x5B, 0xA6, 0xBA, 0xAE,
        0x58, 0x53, 0xB5, 0xD8, 0x2F, 0x41, 0x94, 0xEE, 0x79, 0x29, 0xB3, 0x7C,
0x31, 0x2A, 0xDC, 0xE2,
        0xBC, 0xB0, 0xF2, 0xCF, 0xF0, 0x28, 0xDE, 0x59, 0xE5, 0xDF, 0xF8, 0xAB,
0x8B, 0x86, 0x47, 0xFC,
        0x7F, 0x22, 0xF6, 0x5F, 0x04, 0x9C, 0x39, 0x76, 0x5C, 0x6C, 0x00, 0x00
       };


       //File: index_ov3660.html.gz, Size: 4408
       #define index_ov3660_html_gz_len 4408
       const uint8_t index_ov3660_html_gz[] = {
        0x1F, 0x8B, 0x08, 0x08, 0x28, 0x5C, 0xAE, 0x5C, 0x00, 0x03, 0x69, 0x6E,
0x64, 0x65, 0x78, 0x5F,
        0x6F, 0x76, 0x33, 0x36, 0x36, 0x30, 0x2E, 0x68, 0x74, 0x6D, 0x6C, 0x00,
0xE5, 0x5D, 0xEB, 0x92,
        0xD3, 0xC6, 0x12, 0xFE, 0xCF, 0x53, 0x08, 0x41, 0x58, 0x6F, 0x65, 0xED,
0xF5, 0x6D, 0xCD, 0xE2,
        0xD8, 0xE6, 0xC0, 0xB2, 0x84, 0x54, 0x01, 0x49, 0x20, 0x21, 0xA9, 0x4A,
0xA5, 0x60, 0x2C, 0x8D,
        0xED, 0x09, 0xB2, 0xE4, 0x48, 0x23, 0x7B, 0x37, 0xD4, 0x3E, 0xC7, 0x79,
0xA0, 0xF3, 0x62, 0xA7,
        0xE7, 0x22, 0x69, 0x24, 0x8F, 0x2E, 0xB6, 0x59, 0x9B, 0xC3, 0x31, 0x55,
0x20, 0x5B, 0xD3, 0x3D,
        0xDD, 0xFD, 0xF5, 0x6D, 0x46, 0x17, 0x06, 0x77, 0x6D, 0xCF, 0xA2, 0xD7,
0x0B, 0x6C, 0xCC, 0xE8,
        0xDC, 0x19, 0xDD, 0x19, 0x88, 0x7F, 0x0C, 0xF8, 0x0C, 0x66, 0x18, 0xD9,
0xE2, 0x90, 0x7F, 0x9D,
```

```
        0x63, 0x8A, 0x0C, 0x6B, 0x86, 0xFC, 0x00, 0xD3, 0xA1, 0x19, 0xD2, 0x49,
0xFD, 0xDC, 0xCC, 0x9E,
        0x76, 0xD1, 0x1C, 0x0F, 0xCD, 0x25, 0xC1, 0xAB, 0x85, 0xE7, 0x53, 0xD3,
0xB0, 0x3C, 0x97, 0x62,
        0x17, 0x86, 0xAF, 0x88, 0x4D, 0x67, 0x43, 0x1B, 0x2F, 0x89, 0x85, 0xEB,
0xFC, 0xCB, 0x09, 0x71,
        0x09, 0x25, 0xC8, 0xA9, 0x07, 0x16, 0x72, 0xF0, 0xB0, 0xA5, 0xF2, 0xA2,
0x84, 0x3A, 0x78, 0x74,
        0xF9, 0xF6, 0xA7, 0x4E, 0xDB, 0xF8, 0xF1, 0x5D, 0xA7, 0xD7, 0x6B, 0x0E,
0x4E, 0xC5, 0x6F, 0xC9,
        0x98, 0x80, 0x5E, 0xAB, 0xDF, 0xD9, 0x67, 0xEC, 0xD9, 0xD7, 0xC6, 0xA7,
0xD4, 0x4F, 0xEC, 0x33,
        0x01, 0x21, 0xEA, 0x13, 0x34, 0x27, 0xCE, 0x75, 0xDF, 0x78, 0xE2, 0xC3,
0x9C, 0x27, 0x2F, 0xB0,
        0xB3, 0xC4, 0x94, 0x58, 0xE8, 0x24, 0x40, 0x6E, 0x50, 0x0F, 0xB0, 0x4F,
0x26, 0xDF, 0xAD, 0x11,
        0x8E, 0x91, 0xF5, 0x71, 0xEA, 0x7B, 0xA1, 0x6B, 0xF7, 0x8D, 0x7B, 0xAD,
0x73, 0xF6, 0x67, 0x7D,
        0x90, 0xE5, 0x39, 0x9E, 0x0F, 0xE7, 0x2F, 0x9F, 0xB3, 0x3F, 0xEB, 0xE7,
0xF9, 0xEC, 0x01, 0xF9,
        0x07, 0xF7, 0x8D, 0x56, 0x6F, 0x71, 0x95, 0x3A, 0x7F, 0x73, 0x27, 0xF5,
0x75, 0xD6, 0xCE, 0x93,
        0x5E, 0xD2, 0x9F, 0x17, 0xD3, 0x07, 0xD8, 0xA2, 0xC4, 0x73, 0x1B, 0x73,
0x44, 0x5C, 0x0D, 0x27,
        0x9B, 0x04, 0x0B, 0x07, 0x81, 0x0D, 0x26, 0x0E, 0x2E, 0xE4, 0x73, 0x6F,
0x8E, 0xDD, 0xF0, 0xA4,
        0x84, 0x1B, 0x63, 0x52, 0xB7, 0x89, 0x2F, 0x46, 0xF5, 0x99, 0x1D, 0xC2,
0xB9, 0x5B, 0xCA, 0xB6,
        0x48, 0x2E, 0xD7, 0x73, 0xB1, 0xC6, 0x80, 0x6C, 0xA2, 0x95, 0x8F, 0x16,
0x6C, 0x00, 0xFB, 0x77,
        0x7D, 0xC8, 0x9C, 0xB8, 0xC2, 0xA9, 0xFA, 0x46, 0xA7, 0xDB, 0x5C, 0x5C,
0x95, 0x40, 0xD9, 0xE9,
        0xB1, 0x3F, 0xEB, 0x83, 0x16, 0xC8, 0xB6, 0x89, 0x3B, 0xED, 0x1B, 0xE7,
0x5A, 0x16, 0x9E, 0x6F,
        0x63, 0xBF, 0xEE, 0x23, 0x9B, 0x84, 0x41, 0xDF, 0xE8, 0xEA, 0xC6, 0xCC,
0x91, 0x3F, 0x05, 0x59,
        0xA8, 0x07, 0xC2, 0xD6, 0x5B, 0x5A, 0x49, 0xE4, 0x10, 0x9F, 0x4C, 0x67,
0x14, 0x20, 0x5D, 0x1B,
        0x93, 0x35, 0x9A, 0x0C, 0xA1, 0x32, 0x3C, 0x0B, 0xED, 0xA6, 0xB7, 0x1A,
0x72, 0xC8, 0xD4, 0xAD,
        0x13, 0x8A, 0xE7, 0xA0, 0x4E, 0x40, 0x7D, 0x4C, 0xAD, 0x59, 0x91, 0x28,
0x13, 0x32, 0x0D, 0x7D,
        0xAC, 0x11, 0x24, 0xB6, 0x5B, 0x81, 0xC2, 0x70, 0x72, 0xFD, 0x54, 0x7D,
0x85, 0xC7, 0x1F, 0x09,
        0xAD, 0x4B, 0x9B, 0x8C, 0xF1, 0xC4, 0xF3, 0xB1, 0x76, 0x64, 0x34, 0xC2,
0xF1, 0xAC, 0x8F, 0xF5,
        0x80, 0x22, 0x9F, 0x56, 0x61, 0x88, 0x26, 0x14, 0xFB, 0xE5, 0xFC, 0x30,
0xF3, 0x8A, 0x72, 0x6E,
        0xF9, 0xD3, 0xCA, 0x01, 0xC4, 0x75, 0x88, 0x8B, 0xAB, 0x8B, 0x97, 0x37,
0x6F, 0x9A, 0x9D, 0x18,
        0x55, 0x01, 0x18, 0x32, 0x9F, 0x16, 0x79, 0x09, 0xD7, 0x75, 0x7D, 0x32,
0x19, 0x37, 0xAD, 0x66,
        0xF3, 0x9B, 0xF5, 0x93, 0x33, 0x2C, 0xDC, 0x14, 0x85, 0xD4, 0xDB, 0x3D,
0x22, 0xD6, 0xC2, 0x2A,
```

```
        0xA3, 0xC7, 0xBF, 0xE6, 0xD8, 0x26, 0xC8, 0xA8, 0x29, 0xE1, 0x7C, 0xDE,
0x04, 0x9F, 0x3A, 0x36,
        0x90, 0x6B, 0x1B, 0x35, 0xCF, 0x27, 0x10, 0x08, 0x88, 0xA7, 0x1B, 0x07,
0x7E, 0x81, 0xC2, 0xB1,
        0xC0, 0xC7, 0x1A, 0x95, 0x0B, 0x62, 0x46, 0xB5, 0x88, 0x3E, 0x6C, 0xD8,
0xA7, 0x42, 0xCA, 0x61,
        0x9F, 0xD2, 0x00, 0xD2, 0xE8, 0xC8, 0xD9, 0x17, 0xE1, 0xA5, 0x4A, 0x98,
0x87, 0x19, 0xFB, 0xCC,
        0xD1, 0x55, 0xBD, 0x10, 0xBB, 0x68, 0x50, 0x84, 0x21, 0x94, 0x59, 0xAB,
0x06, 0x43, 0x97, 0x33,
        0xA3, 0x6E, 0xB0, 0x2C, 0x79, 0xAC, 0xA7, 0x91, 0x4C, 0xF5, 0x90, 0xB3,
0x8F, 0xEA, 0x14, 0x1B,
        0xA8, 0xAB, 0x57, 0x35, 0xC9, 0x1D, 0xE2, 0x8F, 0xCE, 0x87, 0x84, 0x26,
0xB9, 0x59, 0x84, 0x7D,
        0xAA, 0x67, 0x92, 0x84, 0x59, 0x69, 0x36, 0xD1, 0x30, 0xCE, 0xCF, 0x28,
0x6B, 0x7C, 0xF3, 0xA2,
        0x5B, 0xC3, 0xB5, 0x58, 0x84, 0xAA, 0xD9, 0x45, 0xC3, 0xB8, 0x48, 0x86,
0xD2, 0x2C, 0xC3, 0x3E,
        0x37, 0x15, 0xFA, 0x8D, 0x7B, 0xE3, 0x90, 0x52, 0xCF, 0x0D, 0x76, 0x2A,
0x51, 0x79, 0x71, 0xF6,
        0x57, 0x18, 0x50, 0x32, 0xB9, 0xAE, 0xCB, 0x90, 0x86, 0x38, 0x5B, 0x20,
0x68, 0x21, 0xC7, 0x98,
        0xAE, 0x30, 0x2E, 0x6E, 0x37, 0x5C, 0xB4, 0x84, 0xBC, 0x33, 0x9D, 0x3A,
0x3A, 0xDF, 0xB3, 0x42,
        0x3F, 0x60, 0x7D, 0xDB, 0xC2, 0x23, 0xC0, 0xD8, 0x5F, 0x9F, 0x38, 0x1D,
0x83, 0x15, 0x27, 0xAA,
        0x5B, 0x63, 0xCD, 0x5C, 0x5E, 0x48, 0x99, 0x8D, 0xB5, 0x48, 0x78, 0xA0,
0x0E, 0xA1, 0xD7, 0xDA,
        0x73, 0x32, 0x12, 0x35, 0x67, 0xA2, 0x10, 0x2C, 0x2C, 0x0B, 0x69, 0xB9,
0xFA, 0xD6, 0x0C, 0x5B,
        0x1F, 0xB1, 0xFD, 0x6D, 0x69, 0x1B, 0x56, 0xD6, 0x1E, 0x36, 0x88, 0xBB,
0x08, 0x69, 0x9D, 0xB5,
        0x53, 0x8B, 0x5B, 0xC1, 0x9C, 0x3B, 0x64, 0xA4, 0x62, 0xBB, 0x5D, 0xD4,
0x54, 0x9C, 0x2D, 0xAE,
        0x8A, 0x8D, 0xA0, 0x0A, 0x3B, 0x72, 0xD0, 0x18, 0x3B, 0x45, 0x22, 0xCB,
0x60, 0xC8, 0x49, 0xBB,
        0x32, 0x57, 0xE5, 0xF7, 0x6E, 0x5C, 0xB2, 0xA4, 0x78, 0x75, 0x1F, 0x7E,
0x53, 0xD9, 0x8E, 0xFC,
        0xF8, 0x24, 0xF5, 0x53, 0x80, 0x1D, 0x08, 0xB0, 0xBC, 0xD6, 0x1B, 0xC6,
0xAC, 0x40, 0x86, 0xC2,
        0x09, 0x7C, 0xE4, 0x4E, 0x31, 0xE4, 0x82, 0xAB, 0x93, 0xE8, 0xB0, 0x78,
0x61, 0x50, 0x49, 0x7D,
        0x96, 0xAA, 0xCF, 0x8A, 0x17, 0x22, 0x22, 0x21, 0x6C, 0xD1, 0x8C, 0x28,
0xB0, 0x16, 0xCE, 0xDF,
        0xD2, 0x3A, 0x85, 0xE8, 0x47, 0xB4, 0x01, 0x93, 0x76, 0x29, 0x6D, 0x7F,
0x5F, 0x9A, 0x11, 0xA2,
        0x95, 0xDE, 0x64, 0x52, 0xB6, 0x56, 0x9C, 0x4C, 0x3A, 0xCD, 0x4E, 0xB7,
0xB4, 0x61, 0xD2, 0x6A,
        0x99, 0x59, 0x2F, 0x6A, 0x32, 0x46, 0x9C, 0x4D, 0xCA, 0x21, 0xE8, 0xCF,
0xBC, 0x25, 0xF6, 0x35,
        0x40, 0x64, 0xC4, 0xED, 0x3E, 0xEA, 0xDA, 0x15, 0xB8, 0x21, 0xC8, 0xF7,
0x4B, 0x5D, 0x36, 0x4D,
        0xB3, 0x6B, 0xB7, 0xAC, 0x76, 0xA1, 0x63, 0x0A, 0x76, 0x0D, 0xF0, 0x06,
0x34, 0x76, 0xB0, 0x5D,
```

```
        0x90, 0x9E, 0x6D, 0x3C, 0x41, 0xA1, 0x43, 0x4B, 0xEC, 0x8D, 0x9A, 0xEC,
0x4F, 0xD1, 0x8C, 0x3C,
        0xAE, 0xFE, 0x60, 0x1B, 0x1D, 0x43, 0x1E, 0x09, 0x7F, 0x6A, 0xE6, 0x8C,
0x6A, 0x27, 0x5A, 0x2C,
        0x30, 0x82, 0x51, 0x16, 0xCE, 0x5B, 0x92, 0x56, 0xEA, 0x99, 0xF5, 0x89,
0xAB, 0xD2, 0x42, 0xB4,
        0xD4, 0x15, 0xE3, 0x6E, 0x68, 0x23, 0x9D, 0xFB, 0x13, 0xCF, 0x0A, 0x75,
0x65, 0xBA, 0x9A, 0x4B,
        0xAD, 0xF3, 0xEB, 0x47, 0x26, 0x0B, 0x1C, 0xC2, 0x1D, 0x3B, 0x74, 0x5D,
0x86, 0x68, 0x9D, 0xFA,
        0xA0, 0xA6, 0x66, 0xA2, 0x6A, 0x86, 0xDB, 0x2A, 0x3A, 0x53, 0x86, 0xCD,
0xDB, 0x8C, 0xC9, 0x04,
        0xA0, 0x26, 0x51, 0xC4, 0x39, 0xC4, 0x08, 0x3C, 0x50, 0x2A, 0x62, 0xB5,
0x9B, 0x5D, 0xE8, 0x2C,
        0x9C, 0xEB, 0x1A, 0x83, 0x68, 0xB2, 0x16, 0x54, 0x31, 0x31, 0x9D, 0x3F,
0x1D, 0xA3, 0x5A, 0xF3,
        0xA4, 0x79, 0xD2, 0x81, 0xBF, 0x34, 0x0D, 0x7A, 0xB1, 0x73, 0x49, 0xF3,
0xE6, 0x78, 0x5E, 0x26,
        0xF9, 0x94, 0xEF, 0x93, 0xE4, 0xA5, 0xB1, 0x52, 0x2C, 0xAA, 0x47, 0x52,
0x7A, 0xC3, 0xA4, 0xD5,
        0x28, 0x29, 0x2C, 0x39, 0x2E, 0xBD, 0xB9, 0x23, 0x6A, 0xBC, 0x65, 0x53,
0x88, 0xE7, 0xDE, 0x3F,
        0x75, 0x51, 0x55, 0xFF, 0xEF, 0xBD, 0x5D, 0x31, 0xC5, 0x57, 0xED, 0xE9,
0x1B, 0xDB, 0x25, 0x38,
        0xB4, 0x6F, 0x34, 0xF3, 0x51, 0xAF, 0xCB, 0x7E, 0x06, 0x24, 0x74, 0x61,
0x51, 0xE5, 0xC3, 0xEA,
        0x2A, 0xB7, 0xE7, 0x51, 0xC6, 0x6C, 0x61, 0x83, 0x09, 0x71, 0x9C, 0xBA,
0xE3, 0xAD, 0xCA, 0x3B,
        0x91, 0x62, 0x4F, 0x5E, 0xF3, 0xD3, 0x72, 0x97, 0xDF, 0x56, 0xDA, 0x10,
0x32, 0xD7, 0xFF, 0x84,
        0xB4, 0x5F, 0x77, 0xC0, 0x15, 0x86, 0xC6, 0x76, 0x85, 0x62, 0x0B, 0x7F,
0xDC, 0x6D, 0xA2, 0x4A,
        0xAE, 0x24, 0x3A, 0xC1, 0xC2, 0xC5, 0x5C, 0xB0, 0x22, 0xD4, 0x9A, 0x6D,
0xB1, 0xA8, 0x5A, 0x78,
        0x01, 0x11, 0xD7, 0x68, 0x7C, 0xEC, 0x20, 0xD6, 0xC1, 0x6F, 0xB5, 0xE4,
0x2E, 0x5D, 0x98, 0xA8,
        0xE4, 0x55, 0x34, 0xE1, 0xA6, 0xFB, 0x72, 0xB6, 0x4B, 0x1A, 0xA2, 0x77,
0xC8, 0xCF, 0xD5, 0x7A,
        0xB7, 0x2E, 0x69, 0xF7, 0xD3, 0x91, 0xA1, 0x1F, 0xB4, 0x41, 0x46, 0x8F,
0x92, 0xF6, 0xD4, 0xC7,
        0xD7, 0x15, 0x94, 0x39, 0x91, 0xFF, 0xF6, 0xC5, 0x86, 0xE8, 0xF6, 0x6B,
0x7F, 0x5E, 0x00, 0xA4,
        0x17, 0x35, 0xBA, 0x41, 0x85, 0xA9, 0xF3, 0xA7, 0xAC, 0xE2, 0x8F, 0xF1,
0x76, 0x9F, 0x69, 0x56,
        0x48, 0x37, 0x05, 0x25, 0x54, 0xEF, 0xAA, 0x51, 0xF5, 0xD5, 0x9E, 0x74,
0xF0, 0x84, 0xE6, 0x5C,
        0xCD, 0xE0, 0x7D, 0x6A, 0xA7, 0x38, 0xBB, 0xD5, 0x95, 0x7D, 0x82, 0xD2,
0xCC, 0x11, 0xEF, 0xCA,
        0xE5, 0x7B, 0x9F, 0x96, 0x33, 0xCB, 0x9E, 0x1B, 0x33, 0xCF, 0x87, 0x24,
0x6A, 0x9F, 0x39, 0xCC,
        0x30, 0x66, 0x2E, 0x4B, 0x3E, 0xC0, 0x83, 0x7F, 0xAF, 0xB5, 0x7B, 0xDA,
0x8B, 0x05, 0x05, 0x83,
        0x8B, 0x44, 0xCB, 0xDD, 0xD6, 0x5A, 0x2F, 0x59, 0xB9, 0x0B, 0x64, 0x35,
0x17, 0x69, 0x81, 0x2A,
```

```
        0x8E, 0xCA, 0xA2, 0x0C, 0xB3, 0xBE, 0x47, 0x53, 0xE8, 0xEC, 0x64, 0x8E,
0xA0, 0xED, 0x65, 0xEE,
        0x8A, 0x80, 0xA3, 0x0E, 0xBF, 0x2A, 0xEE, 0xAE, 0x6C, 0x1A, 0xB6, 0x7A,
0xCD, 0x92, 0x29, 0x2D,
        0xC7, 0x0B, 0x8A, 0xE3, 0x0A, 0x8D, 0xC1, 0x7E, 0x21, 0xD5, 0x4C, 0x24,
0xB7, 0x2E, 0xB5, 0x3B,
        0x4F, 0xDC, 0xB9, 0xB5, 0x67, 0x2A, 0x95, 0xEE, 0xC2, 0x98, 0x2A, 0x0E,
0xC7, 0x8C, 0xCD, 0x5B,
        0x4D, 0x6D, 0xA6, 0x2D, 0xDC, 0x7F, 0xA3, 0xF8, 0x0A, 0xD6, 0x9B, 0xEC,
0x82, 0x5C, 0xDF, 0xB0,
        0xB0, 0x3E, 0x8D, 0xA6, 0x8A, 0x5C, 0xAB, 0xCA, 0x26, 0x60, 0x21, 0x0E,
0x33, 0x62, 0xDB, 0xB8,
        0x70, 0x97, 0x93, 0xAD, 0x79, 0x2B, 0x36, 0x0F, 0x4C, 0x7E, 0xDD, 0xA6,
0xD4, 0xAD, 0x04, 0x45,
        0xE1, 0x75, 0xFA, 0xD6, 0x6D, 0x47, 0x8C, 0x2C, 0x34, 0x79, 0x7B, 0xC4,
0xE9, 0x56, 0xA4, 0x50,
        0x54, 0x6D, 0x70, 0xC7, 0xDB, 0xC4, 0xCC, 0x64, 0x60, 0x07, 0x36, 0x6A,
0x3D, 0x9B, 0x2B, 0x52,
        0x0D, 0x4E, 0x95, 0x7B, 0x89, 0x06, 0xA7, 0xC9, 0x6D, 0x4F, 0x03, 0x76,
0x43, 0x91, 0x7A, 0xCB,
        0x91, 0xB8, 0xDE, 0x65, 0x58, 0x0E, 0x0A, 0x82, 0xA1, 0xC9, 0x6E, 0x8C,
0x31, 0xD3, 0x77, 0x20,
        0x0D, 0x6C, 0xB2, 0x34, 0x88, 0x3D, 0x34, 0x1D, 0x6F, 0xEA, 0x65, 0xCE,
0xF1, 0xF3, 0xE2, 0x0A,
        0x04, 0x24, 0xCD, 0xA1, 0x99, 0xBA, 0x3A, 0x63, 0x72, 0xAA, 0xE4, 0x27,
0x73, 0xF4, 0xE0, 0xDE,
        0xA3, 0x87, 0x0F, 0x7B, 0xDF, 0x3D, 0x70, 0xC7, 0xC1, 0x42, 0xFE, 0xFD,
0x8B, 0xB8, 0x98, 0x25,
        0xEE, 0x88, 0x82, 0x3C, 0x4A, 0x29, 0xE8, 0x19, 0x0C, 0x4E, 0x39, 0xD3,
0x8C, 0x20, 0xA7, 0x20,
        0x49, 0x8E, 0x6C, 0xB2, 0xB6, 0xEA, 0xC4, 0x8B, 0x86, 0x04, 0x50, 0x2E,
0xC6, 0xC8, 0xD7, 0x0C,
        0xE1, 0xC3, 0x44, 0xE7, 0xC6, 0xFD, 0xD6, 0xE4, 0x35, 0x66, 0xEC, 0x5D,
0x65, 0x35, 0xE0, 0x4A,
        0xC9, 0x02, 0x24, 0x47, 0x61, 0x3B, 0x8F, 0x21, 0x90, 0x71, 0x72, 0x76,
0x69, 0x2A, 0x67, 0x4C,
        0x2C, 0x9F, 0xB4, 0xBE, 0x72, 0xA5, 0x44, 0x4C, 0x3D, 0xF1, 0xD1, 0x1C,
0x33, 0xF7, 0x97, 0x3F,
        0xE6, 0xB3, 0xC9, 0x22, 0x11, 0x53, 0x9A, 0xA3, 0x37, 0x98, 0x67, 0x4E,
0x40, 0x59, 0x6B, 0xD6,
        0x35, 0x2E, 0xB2, 0x98, 0xA5, 0xE6, 0x37, 0x23, 0x11, 0xE5, 0xE6, 0x75,
0x1D, 0x71, 0xB7, 0x29,
        0x11, 0x88, 0xB3, 0xF3, 0x16, 0xDC, 0xC1, 0x96, 0xC8, 0x09, 0xC1, 0xB4,
0xAD, 0x96, 0x39, 0xFA,
        0xF9, 0xF7, 0xEF, 0x9F, 0xD4, 0xDA, 0xCD, 0xEE, 0xF9, 0x55, 0xEB, 0xAC,
0xD7, 0x3D, 0x1E, 0x9C,
        0x8A, 0x21, 0x9B, 0xF3, 0x6A, 0x9A, 0xA3, 0x5F, 0x19, 0x2F, 0xA8, 0x2F,
0xCD, 0xAB, 0x56, 0xBB,
        0xD9, 0xDC, 0x9E, 0xD7, 0x23, 0x73, 0xF4, 0x96, 0xB3, 0x6A, 0x9F, 0x03,
0xAB, 0x66, 0x7B, 0x07,
        0xB1, 0xCE, 0xCD, 0x11, 0xE7, 0x04, 0x4C, 0xAE, 0x1E, 0xF6, 0xCE, 0xB7,
0x67, 0xF4, 0x10, 0x64,
        0x7A, 0x07, 0x9C, 0xCE, 0x41, 0xBB, 0xDE, 0x2E, 0xCA, 0xF5, 0xCC, 0x11,
0xE3, 0xD3, 0xEB, 0x36,
```

```
        0xAF, 0xBA, 0xE7, 0x3B, 0xF0, 0x39, 0x33, 0x65, 0xA7, 0xC3, 0xDC, 0x3F,
0x3A, 0x32, 0x47, 0x17,
        0x3F, 0x3C, 0xAF, 0x75, 0x41, 0xC6, 0xF6, 0xA3, 0xDE, 0xF6, 0xBC, 0xBB,
0xE0, 0x17, 0x4C, 0xC8,
        0x4E, 0x1B, 0x18, 0x75, 0x77, 0x10, 0xB2, 0x63, 0x8E, 0x5E, 0x70, 0x4E,
0xC0, 0xE5, 0xAA, 0xF5,
        0x70, 0x07, 0x91, 0xC0, 0xBD, 0x7E, 0xE6, 0x9C, 0xC0, 0xBF, 0x98, 0x7B,
0x55, 0xE4, 0x04, 0xB9,
        0x97, 0x9B, 0xA6, 0x20, 0xE6, 0xD7, 0x33, 0x59, 0xEA, 0x74, 0x51, 0x4A,
0xF8, 0x3B, 0x84, 0x8E,
        0x80, 0x5E, 0x6F, 0x9C, 0x10, 0x24, 0x1D, 0xA8, 0x24, 0x0E, 0xAA, 0xE5,
0x02, 0x45, 0x92, 0xF8,
        0x6A, 0xAB, 0x39, 0xEA, 0x96, 0x28, 0xC0, 0x49, 0xD5, 0x84, 0xCA, 0x69,
0x53, 0xF2, 0x9B, 0xAC,
        0x3F, 0x64, 0xA8, 0xB3, 0xFB, 0x79, 0xC0, 0x43, 0x3B, 0xA6, 0x12, 0xD5,
0x5B, 0x25, 0x1B, 0x8D,
        0xAC, 0xE8, 0xCA, 0x1C, 0xF5, 0x3A, 0x65, 0xD6, 0xDE, 0x01, 0x8C, 0x31,
0xEF, 0x3D, 0x5D, 0x1C,
        0x04, 0x1B, 0xE3, 0x91, 0x90, 0x9A, 0xA3, 0xA7, 0xF1, 0xF1, 0x2E, 0xA8,
0xD4, 0xCB, 0x34, 0xE5,
        0xB4, 0x39, 0xB0, 0x28, 0xE2, 0x08, 0x64, 0xEA, 0x1D, 0x09, 0x4D, 0x82,
0xCC, 0xE7, 0x05, 0xE6,
        0x36, 0x71, 0x61, 0xED, 0x80, 0x8F, 0x02, 0xBA, 0x31, 0x2A, 0x11, 0x21,
0x24, 0x35, 0x79, 0x74,
        0x30, 0x44, 0x62, 0x51, 0xBE, 0x02, 0x3C, 0x02, 0x44, 0x43, 0x9F, 0xDF,
0xE5, 0xB8, 0x31, 0x22,
        0x09, 0x29, 0x54, 0xC3, 0xF8, 0x78, 0x27, 0x54, 0x76, 0x49, 0x5F, 0x8A,
0x38, 0x12, 0x97, 0x28,
        0x85, 0x75, 0x6F, 0x09, 0x97, 0x32, 0x69, 0x77, 0xC2, 0x65, 0x86, 0xFC,
0xC5, 0x56, 0xE9, 0x2B,
        0xA6, 0x04, 0x54, 0xA2, 0xC3, 0x83, 0x85, 0x4A, 0x22, 0xCC, 0x57, 0x10,
0x2B, 0xB0, 0xFE, 0xF6,
        0x48, 0xB0, 0x79, 0xC7, 0x2F, 0xE9, 0xCC, 0xD1, 0x33, 0x5C, 0x7F, 0xCD,
0x8E, 0x76, 0x81, 0xE3,
        0x49, 0x48, 0xBD, 0x1D, 0x00, 0x89, 0x64, 0x11, 0x70, 0x34, 0x25, 0x1A,
0xE7, 0xB7, 0x84, 0xC6,
        0xF9, 0x2D, 0xA2, 0x81, 0xF0, 0x7B, 0x07, 0x2F, 0xB1, 0xB3, 0x31, 0x1C,
0x11, 0xA1, 0x39, 0xBA,
        0xBC, 0x5A, 0x78, 0x01, 0xBB, 0x5B, 0xF8, 0x25, 0xFB, 0xBE, 0x53, 0x90,
0x9C, 0xED, 0x80, 0x49,
        0x2C, 0x90, 0x8C, 0x91, 0x33, 0x89, 0xCA, 0xD9, 0x2D, 0xA1, 0x52, 0x26,
0xEB, 0x2E, 0xA8, 0x4C,
        0x11, 0x71, 0x2D, 0x4C, 0x1C, 0x76, 0xE7, 0xE2, 0xA6, 0xC0, 0x28, 0xB4,
0xE6, 0xE8, 0xFB, 0xE4,
        0xCB, 0x2E, 0xC0, 0x34, 0x77, 0xC0, 0x45, 0x95, 0x27, 0x1D, 0x2F, 0x67,
0xB0, 0x58, 0xBE, 0x25,
        0x6C, 0x5A, 0xAD, 0xDB, 0xAC, 0x2A, 0x0B, 0x6C, 0x11, 0xE4, 0xBC, 0xC7,
0x93, 0x09, 0x2C, 0x83,
        0x36, 0x2F, 0x2D, 0x29, 0x72, 0xA8, 0x2F, 0xE2, 0xBB, 0x71, 0xC9, 0xBF,
0x6F, 0xBC, 0x87, 0x91,
        0x61, 0xF7, 0xB9, 0x36, 0x32, 0x9A, 0xFA, 0xB5, 0xF0, 0x6B, 0x2F, 0x96,
0x73, 0xDB, 0x5D, 0x0D,
        0x60, 0x82, 0xA7, 0x7C, 0x53, 0x7D, 0x6B, 0x1E, 0x6D, 0xF0, 0x6C, 0x1F,
0x5D, 0xF3, 0xC7, 0x10,
```

```
        0x77, 0x59, 0x48, 0xBF, 0xC1, 0xB6, 0xF1, 0x0B, 0x71, 0xB7, 0x57, 0xA6,
0xCB, 0x04, 0xC1, 0xD8,
        0xDD, 0x8D, 0xCB, 0x19, 0x2C, 0x91, 0xE0, 0x60, 0x37, 0x26, 0x3D, 0xF0,
0x24, 0xBC, 0x20, 0xE8,
        0x4B, 0x58, 0xC4, 0xA3, 0xD5, 0x78, 0xF3, 0x82, 0xB2, 0x1A, 0x43, 0x5D,
0xFE, 0xED, 0xA9, 0x71,
        0xC9, 0x6F, 0x03, 0xDB, 0x38, 0x5D, 0x89, 0x2B, 0xD4, 0x55, 0x1C, 0x5D,
0x24, 0x2A, 0x29, 0xA7,
        0xB9, 0xB6, 0x27, 0xAA, 0x0F, 0xA0, 0xAA, 0xFB, 0xA2, 0x1A, 0xF5, 0x22,
0x01, 0xF9, 0x05, 0x3D,
        0x53, 0xD1, 0xB6, 0x9A, 0x8E, 0xB7, 0xD8, 0x8A, 0x59, 0xAB, 0xCD, 0xDB,
0x30, 0x6B, 0x05, 0x30,
        0xD9, 0x4B, 0x76, 0x87, 0xA0, 0x6D, 0x00, 0x5E, 0x7B, 0x01, 0x8A, 0xCD,
0x7A, 0x18, 0xA0, 0xB8,
        0xBE, 0x87, 0x06, 0x0A, 0xBC, 0xE5, 0x3D, 0xAB, 0xA3, 0xDB, 0x04, 0x15,
0x27, 0x34, 0x47, 0xAF,
        0x90, 0x1B, 0x42, 0x91, 0xD9, 0x17, 0x60, 0xF1, 0xC4, 0x07, 0x0B, 0x2F,
0xA9, 0xF7, 0xA1, 0xA1,
        0x03, 0x41, 0xE6, 0x9E, 0xBD, 0xF9, 0x72, 0x47, 0xD2, 0x89, 0x94, 0xF8,
0x0A, 0x8E, 0x36, 0x6E,
        0x0C, 0x22, 0x0E, 0xB7, 0xDC, 0x11, 0x88, 0xA5, 0xD4, 0xF6, 0xCD, 0xC0,
0xDB, 0xD0, 0x75, 0xAF,
        0x77, 0xE9, 0x04, 0x2E, 0x1C, 0x2F, 0xB4, 0xB7, 0xE7, 0x00, 0x6D, 0xC0,
0x8F, 0x93, 0x09, 0xB1,
        0xB6, 0x6F, 0x24, 0xA0, 0x09, 0x78, 0xE1, 0xCD, 0x2B, 0xD2, 0xDF, 0x72,
0xE1, 0xC5, 0xD6, 0x16,
        0x2B, 0x39, 0x0B, 0x50, 0xBC, 0xBC, 0xD8, 0x6B, 0xE1, 0x85, 0x39, 0x0F,
0x94, 0x19, 0x98, 0xB6,
        0x87, 0x4E, 0x0A, 0x20, 0xC4, 0x7B, 0xEE, 0x3C, 0xDB, 0x80, 0x25, 0x28,
0xE3, 0x8C, 0x1E, 0x2D,
        0xBF, 0x0F, 0xB5, 0xBE, 0x4B, 0x24, 0x4A, 0xAF, 0xEE, 0x5A, 0x67, 0x9D,
0x5E, 0xBC, 0xBC, 0xEB,
        0xB4, 0x3F, 0xEF, 0x02, 0x8F, 0x31, 0xBF, 0x5D, 0x7C, 0xDA, 0xDB, 0x40,
0x03, 0xD9, 0xE8, 0x35,
        0xBB, 0xCE, 0xB0, 0x41, 0xC2, 0xDE, 0x3D, 0x90, 0xDA, 0x87, 0x8B, 0xA4,
0xF6, 0x17, 0x10, 0x4A,
        0xD3, 0x2D, 0x32, 0xDE, 0x94, 0x65, 0xBC, 0xEF, 0x2F, 0xF6, 0x83, 0xD0,
0xF4, 0x60, 0xA9, 0x6E,
        0x7A, 0xD0, 0x54, 0x67, 0x88, 0x9B, 0xAD, 0x62, 0x98, 0xB6, 0xEC, 0x60,
0x25, 0xA1, 0xD8, 0xCB,
        0xDA, 0x25, 0xC9, 0xB5, 0xAE, 0x76, 0xC9, 0x72, 0x91, 0x18, 0xE9, 0x24,
0xD7, 0x4B, 0xAE, 0x8A,
        0x9C, 0x7D, 0xDE, 0xCB, 0xBA, 0xDD, 0x32, 0x69, 0x77, 0x09, 0x1A, 0x1F,
0xAD, 0xDE, 0x4F, 0xE7,
        0x68, 0x63, 0x30, 0x24, 0x1D, 0x60, 0xF1, 0xEA, 0xC9, 0x3E, 0xDB, 0x85,
0x68, 0xDE, 0xC3, 0xC4,
        0x51, 0xAC, 0xF5, 0xA1, 0x73, 0x9D, 0x83, 0xDD, 0xCD, 0x93, 0x1D, 0x23,
0x32, 0x47, 0x2F, 0xB1,
        0x1B, 0x18, 0x17, 0x9E, 0x2F, 0xDF, 0xFD, 0xB4, 0x17, 0xD4, 0xF8, 0xCC,
0x87, 0x81, 0x4C, 0x28,
        0x7D, 0x68, 0xBC, 0x66, 0x73, 0xE2, 0xFB, 0x9E, 0xBF, 0x31, 0x64, 0x92,
0x0E, 0x96, 0x15, 0xF5,
        0x57, 0xFC, 0x68, 0x2F, 0x70, 0x45, 0xB3, 0x1E, 0x06, 0xB1, 0x58, 0xE7,
0x43, 0x83, 0xB6, 0x9C,
```

```
        0x38, 0x64, 0xB1, 0x31, 0x64, 0x9C, 0xCA, 0x1C, 0xBD, 0xAB, 0x3F, 0x87,
0x7F, 0xF7, 0x02, 0x97,
        0x98, 0xF1, 0x30, 0x60, 0x49, 0x6D, 0x0F, 0x0D, 0xD5, 0x78, 0xB1, 0x79,
0x3A, 0x04, 0x1A, 0x73,
        0xF4, 0xF4, 0xA7, 0xFD, 0xF4, 0x7E, 0x6C, 0xB2, 0x8A, 0x08, 0xED, 0x84,
0x07, 0x57, 0xEA, 0xD0,
        0x68, 0xAC, 0xB6, 0x40, 0x63, 0xC5, 0x04, 0xFF, 0x6D, 0x4F, 0x68, 0xAC,
0xAA, 0xA3, 0xF1, 0x99,
        0xE3, 0x65, 0xF5, 0x25, 0xE0, 0xC3, 0x9F, 0xC5, 0x18, 0xA3, 0xCD, 0xCB,
0x51, 0x44, 0xC8, 0x6E,
        0x1A, 0x83, 0x23, 0xE3, 0x29, 0xDA, 0x4F, 0x41, 0x8A, 0xE7, 0xDD, 0x47,
0x08, 0x25, 0x4A, 0x1E,
        0x1A, 0xA7, 0x09, 0xB2, 0xF0, 0x7B, 0x1B, 0xD3, 0x6D, 0xAE, 0x2D, 0x2B,
0xB4, 0xE6, 0xE8, 0x39,
        0x7C, 0x31, 0x9E, 0xF1, 0x2F, 0xFB, 0x6A, 0xF9, 0xD4, 0xF9, 0xF7, 0x81,
0x5A, 0x4A, 0xDF, 0x2F,
        0x02, 0x38, 0x68, 0xB0, 0xBD, 0xA9, 0xBB, 0xD5, 0x23, 0x0D, 0x29, 0x72,
0x09, 0xDF, 0x1B, 0xF1,
        0x7D, 0xBF, 0x00, 0x26, 0x42, 0xEC, 0x0D, 0x43, 0x45, 0xEF, 0x7D, 0xC0,
0x18, 0x3D, 0x16, 0xC4,
        0x8B, 0xB4, 0x78, 0x15, 0x5E, 0x19, 0x52, 0xF2, 0xE1, 0x27, 0x7E, 0x4B,
0x0B, 0xA6, 0xF5, 0x80,
        0x12, 0xC7, 0x81, 0x85, 0x30, 0xA6, 0xC6, 0x5B, 0x76, 0x38, 0x38, 0x15,
0x03, 0xAA, 0x73, 0x91,
        0xCF, 0xDC, 0xB0, 0x97, 0x50, 0xA2, 0xB9, 0x39, 0x7A, 0xCB, 0x5E, 0x12,
0x08, 0xBC, 0xD8, 0xB7,
        0xCD, 0x99, 0x71, 0x23, 0x62, 0xD7, 0xF7, 0x40, 0xA8, 0x18, 0x24, 0xF9,
0xAE, 0x26, 0xD3, 0x88,
        0x8E, 0x94, 0xDF, 0x46, 0x97, 0x7C, 0xB0, 0xC1, 0xBC, 0xAC, 0x7C, 0x3A,
0x76, 0xD5, 0xC2, 0xCA,
        0xBF, 0xB8, 0x31, 0x38, 0x75, 0x91, 0xC6, 0xDC, 0x39, 0x28, 0x0C, 0xC4,
0xDB, 0x25, 0x73, 0x58,
        0xC5, 0xCF, 0x33, 0x71, 0x4B, 0x24, 0x8F, 0x69, 0xC6, 0x6A, 0x65, 0x1F,
0xDF, 0x94, 0xDB, 0x4C,
        0xD5, 0x82, 0x96, 0x3F, 0x88, 0x29, 0xEB, 0x21, 0x3B, 0x8C, 0xCD, 0xFF,
0x9F, 0x7F, 0x97, 0xF9,
        0x0C, 0x7B, 0xF7, 0x67, 0x22, 0x98, 0x69, 0x04, 0xBE, 0x35, 0x34, 0xF3,
0x9E, 0x8E, 0xCA, 0xD1,
        0xFC, 0x54, 0xA7, 0x7A, 0x66, 0xB0, 0xC6, 0xD6, 0x83, 0xC0, 0xF2, 0xC9,
0x82, 0x8E, 0xEE, 0xD8,
        0x9E, 0x15, 0xCE, 0xB1, 0x4B, 0x1B, 0xC8, 0xB6, 0x2F, 0x97, 0x70, 0xF0,
0x92, 0x04, 0x14, 0x83,
        0x15, 0x6A, 0x47, 0xCF, 0x7E, 0x7C, 0x75, 0x21, 0x9E, 0x12, 0x7B, 0xE9,
0x21, 0x1B, 0xDB, 0x47,
        0x27, 0xC6, 0x24, 0x74, 0x85, 0x9B, 0xD7, 0x30, 0x1B, 0x2B, 0xDE, 0xBB,
0xBA, 0x44, 0xBE, 0x31,
        0x46, 0x01, 0x7E, 0xE1, 0x05, 0xD4, 0x18, 0x1A, 0x31, 0x47, 0xC7, 0xB3,
0xF8, 0x7D, 0xBF, 0x0D,
        0xCF, 0x27, 0x53, 0xE2, 0xCA, 0x91, 0x42, 0xD9, 0x5F, 0x7D, 0x07, 0x86,
0xC6, 0x54, 0xDF, 0x1A,
        0x47, 0xFD, 0xF3, 0xD6, 0x11, 0x7B, 0x1C, 0x0F, 0x60, 0x80, 0x1F, 0x00,
0x02, 0x0C, 0x03, 0x20,
        0xC0, 0x87, 0x23, 0xF9, 0x78, 0x20, 0x76, 0x1A, 0xDC, 0xE4, 0x4C, 0x40,
0x26, 0x6D, 0xED, 0x48,
```

```
        0xE0, 0x74, 0xC4, 0x1E, 0x34, 0xBE, 0x89, 0x29, 0x83, 0x99, 0xB7, 0x2A,
0xA2, 0xF4, 0xF1, 0xDC,
        0x5B, 0xE2, 0x0C, 0x71, 0x4C, 0x2D, 0xBD, 0xB9, 0x74, 0xEA, 0xC8, 0xEB,
0x8F, 0x8E, 0xA3, 0x01,
        0xF1, 0x7B, 0xCC, 0x86, 0x06, 0xF5, 0x43, 0x9C, 0x66, 0x8B, 0xDD, 0x32,
0xAE, 0x91, 0x58, 0x85,
        0x8C, 0x27, 0xC8, 0x09, 0x32, 0x9C, 0xC3, 0x85, 0x8D, 0x28, 0x7E, 0xC7,
0x76, 0x0C, 0x61, 0x40,
        0x0D, 0x3B, 0x27, 0x62, 0xFB, 0xF0, 0x44, 0x9E, 0x79, 0x03, 0x7C, 0x29,
0x3E, 0x4E, 0x66, 0x55,
        0x7F, 0x06, 0x8A, 0xF4, 0xD7, 0xA1, 0xE1, 0x86, 0x10, 0xC2, 0x8F, 0xB9,
0x0A, 0x46, 0x3F, 0x75,
        0x96, 0x53, 0x3B, 0x90, 0x9D, 0xE4, 0x3B, 0xDB, 0xF9, 0x9C, 0xFC, 0x47,
0x32, 0x61, 0x13, 0x37,
        0xF8, 0x1B, 0xE4, 0x87, 0xC0, 0xE3, 0x28, 0xCA, 0xEE, 0x47, 0xC9, 0x8B,
0x79, 0x55, 0x22, 0x6E,
        0x87, 0x86, 0xEC, 0x83, 0xE5, 0xF9, 0xA5, 0x3C, 0x71, 0xF7, 0xEE, 0x32,
0xE6, 0x6B, 0x28, 0xC3,
        0xE0, 0x54, 0x72, 0xE2, 0x06, 0x4E, 0x28, 0x4F, 0x3F, 0xAF, 0xF3, 0xCE,
0xF0, 0x88, 0x98, 0x2B,
        0x1C, 0xEE, 0xC4, 0x92, 0xA7, 0x2C, 0xF0, 0xE0, 0x41, 0x9A, 0xDB, 0xDD,
0xA1, 0xA4, 0x4A, 0x34,
        0x11, 0xE3, 0x21, 0x32, 0x20, 0xF2, 0x40, 0x6D, 0xF9, 0x4C, 0xBC, 0x14,
0x89, 0x4C, 0x6A, 0x77,
        0x53, 0x86, 0x8F, 0x65, 0x9C, 0x30, 0x13, 0x11, 0x9B, 0x1B, 0x88, 0x5F,
0x33, 0x3C, 0x4E, 0x9E,
        0x7A, 0x15, 0xF2, 0x3D, 0xE6, 0x5E, 0x5F, 0xC3, 0xF2, 0xF2, 0xDB, 0x31,
0xD8, 0x9F, 0x39, 0x73,
        0xF2, 0x83, 0x1C, 0x9F, 0x4C, 0xA5, 0x72, 0x9C, 0xA6, 0x38, 0x32, 0xC5,
0x32, 0x72, 0xB3, 0x0F,
        0x9F, 0x00, 0x86, 0xB2, 0x9D, 0xEF, 0xE4, 0xF9, 0xFC, 0x8C, 0x39, 0xD9,
0x87, 0x4F, 0xBC, 0x3E,
        0xB0, 0x50, 0x82, 0xE8, 0x0E, 0x09, 0x8D, 0x62, 0x9C, 0xDD, 0x6A, 0xCC,
0x54, 0xE2, 0x22, 0xC0,
        0x61, 0x11, 0xAB, 0x4C, 0x01, 0xD7, 0x30, 0x14, 0x01, 0x55, 0x13, 0xF5,
0xE9, 0x29, 0xAF, 0x35,
        0x8C, 0xB9, 0x8C, 0x95, 0xF4, 0xEF, 0x77, 0x54, 0xE1, 0x6F, 0xA2, 0xF0,
0x89, 0x53, 0x99, 0x8A,
        0x27, 0xF3, 0xE3, 0xC8, 0x62, 0xCC, 0xD5, 0x13, 0x87, 0x91, 0xAF, 0x2B,
0x89, 0xFC, 0x3C, 0x31,
        0xAB, 0x05, 0x39, 0x4C, 0xF1, 0xF8, 0x7E, 0x46, 0x54, 0xD5, 0xD5, 0x41,
0xEE, 0x96, 0xA1, 0xBE,
        0x80, 0x64, 0x0C, 0xA9, 0xF0, 0x63, 0x8A, 0x0F, 0xDF, 0xB0, 0x8F, 0x99,
0x88, 0xDF, 0xC4, 0xE5,
        0xFD, 0xBA, 0xE7, 0x62, 0x3D, 0x77, 0xD5, 0xD9, 0x75, 0x3C, 0x45, 0x29,
0xCE, 0x32, 0x0D, 0xC7,
        0x73, 0x42, 0x35, 0x0C, 0x8F, 0x20, 0x0D, 0xEB, 0x78, 0xC9, 0x06, 0x2D,
0x21, 0xF0, 0x31, 0x0D,
        0x7D, 0x57, 0x8D, 0x26, 0x91, 0x91, 0xFE, 0x0E, 0xB1, 0x7F, 0x0D, 0x8C,
0x3E, 0xDC, 0xFF, 0x14,
        0xE5, 0xF7, 0x9B, 0x53, 0xFE, 0x6C, 0x8E, 0xE7, 0x3C, 0x86, 0x0A, 0x30,
0xBC, 0xFF, 0x89, 0x43,
        0x7D, 0xF3, 0x00, 0xA6, 0x84, 0x2F, 0x7C, 0xE2, 0x9B, 0x0F, 0x82, 0xC5,
0x84, 0xBD, 0x3E, 0xBB,
```

```
        0xC6, 0x59, 0x44, 0xB8, 0x35, 0xE8, 0x0C, 0xBB, 0x35, 0x1F, 0x07, 0x0B,
0x60, 0x8F, 0x93, 0x44,
        0x16, 0xCD, 0xE8, 0x39, 0x18, 0x4A, 0xCD, 0xB4, 0xF6, 0xC1, 0xC7, 0x40,
0x07, 0x02, 0x50, 0xCF,
        0xB8, 0xFF, 0x89, 0xB3, 0xB8, 0x31, 0x26, 0x10, 0xCD, 0xC1, 0x0C, 0xDB,
0x27, 0x50, 0x77, 0x10,
        0x65, 0x4F, 0xA6, 0xDF, 0xFF, 0x14, 0xB1, 0x6A, 0x88, 0x9F, 0x6E, 0x3E,
0xC4, 0x1E, 0x12, 0x17,
        0x83, 0xA8, 0x86, 0xF1, 0x13, 0x0D, 0xCE, 0xEB, 0x2D, 0x47, 0xC1, 0xF3,
0x9F, 0x38, 0x4E, 0xED,
        0x48, 0xBC, 0x7E, 0x41, 0xE6, 0xE8, 0x06, 0x34, 0x9D, 0x97, 0x08, 0xC4,
0x56, 0x93, 0x3B, 0xCF,
        0x3B, 0x9E, 0x6B, 0x39, 0xC4, 0xFA, 0xC8, 0x12, 0xF3, 0x71, 0x5A, 0x70,
0x11, 0xE9, 0x4E, 0x43,
        0xBC, 0x4E, 0xEB, 0xB5, 0x67, 0xE3, 0x8C, 0x9B, 0x1E, 0x33, 0x31, 0x4E,
0x4F, 0xC1, 0xCA, 0xC8,
        0x8E, 0x52, 0x92, 0xC0, 0x88, 0xBD, 0x77, 0x45, 0x98, 0x29, 0x65, 0x61,
0xA1, 0x8C, 0xD4, 0x45,
        0xD8, 0x2C, 0xA9, 0xD6, 0x91, 0xCA, 0x89, 0xDB, 0x0A, 0xF4, 0x8C, 0xD8,
0x16, 0x7F, 0x05, 0x9E,
        0x5B, 0x3B, 0xBE, 0x13, 0x9B, 0x61, 0x9D, 0x07, 0x9B, 0x40, 0x61, 0x90,
0x32, 0x51, 0x9E, 0x99,
        0xD2, 0x5D, 0xFD, 0x51, 0x92, 0x49, 0x72, 0x6C, 0x26, 0x3E, 0x4A, 0x4D,
0xE3, 0x05, 0x8D, 0xCF,
        0xFC, 0x07, 0x77, 0x9A, 0x3F, 0x4F, 0x44, 0x11, 0x54, 0x72, 0xD2, 0xB1,
0x62, 0x30, 0xE1, 0x81,
        0xEC, 0xBF, 0x1E, 0x51, 0x1B, 0x11, 0xE8, 0xAE, 0x2F, 0x1D, 0xCC, 0x0E,
0x9F, 0x5E, 0xFF, 0x00,
        0xC5, 0x5B, 0xB4, 0x20, 0x5C, 0x9A, 0x84, 0xE0, 0x22, 0x6E, 0xFF, 0x4A,
0x29, 0x93, 0x56, 0x51,
        0xE1, 0xC1, 0xDB, 0x77, 0x91, 0x71, 0x8A, 0x38, 0xC4, 0x9D, 0x7E, 0x8A,
0x94, 0x71, 0x2D, 0xA7,
        0x4D, 0xF5, 0xF7, 0x0A, 0xBD, 0x9A, 0xED, 0x8A, 0xE8, 0x95, 0x96, 0x5E,
0xA1, 0xE6, 0xAE, 0x5C,
        0x4E, 0xAC, 0x36, 0xB7, 0x47, 0x8A, 0xB1, 0x03, 0xEA, 0x2D, 0xC4, 0x1A,
0x23, 0xE3, 0xE6, 0x2B,
        0xE2, 0xDA, 0xDE, 0xAA, 0xC1, 0xCE, 0xD7, 0x64, 0x91, 0x54, 0x15, 0x6D,
0x10, 0x17, 0x0C, 0xF8,
        0xE2, 0x97, 0x57, 0x2F, 0x59, 0xD2, 0x51, 0xD7, 0x2A, 0x47, 0xE9, 0x0E,
0x87, 0xBF, 0xEB, 0x5C,
        0x3B, 0x03, 0x83, 0xAD, 0x01, 0x4D, 0xB3, 0x48, 0x36, 0x71, 0x63, 0xC9,
0x62, 0x81, 0x1D, 0x7E,
        0x10, 0x73, 0xB2, 0xD2, 0x93, 0x02, 0xF8, 0xB8, 0x54, 0x16, 0x6F, 0x91,
0x15, 0x05, 0x22, 0xF1,
        0x09, 0xA5, 0xE0, 0xB0, 0x86, 0x70, 0xE5, 0x80, 0x65, 0x19, 0xB9, 0xCE,
0xBB, 0x63, 0xA8, 0xE0,
        0xE7, 0x04, 0x7D, 0x62, 0x26, 0x19, 0x65, 0x69, 0xE1, 0x95, 0x4C, 0x89,
0x16, 0x10, 0x99, 0xF8,
        0xF1, 0x7B, 0x6B, 0x0C, 0xC9, 0xF1, 0x19, 0x78, 0x7E, 0xC3, 0x05, 0x0D,
0x8E, 0x6F, 0x8A, 0xD4,
        0x11, 0xE6, 0x4A, 0x80, 0xAC, 0x2A, 0x04, 0x4F, 0x43, 0x7A, 0x6E, 0x29,
0xFB, 0xE8, 0xD9, 0xA9,
        0xDE, 0x2B, 0xAE, 0xDD, 0xB2, 0x36, 0x2D, 0xCF, 0xB0, 0xC3, 0x75, 0xD3,
0x8A, 0x3E, 0x25, 0xC5,
```

```
        0x20, 0x49, 0x30, 0x6B, 0xC2, 0x66, 0xDA, 0x14, 0xC5, 0x2F, 0xA2, 0x01,
0x91, 0xEC, 0x6A, 0x40,
        0xE4, 0xC8, 0x9E, 0xEE, 0xE2, 0x32, 0xED, 0x42, 0x06, 0x72, 0x99, 0xC5,
0x0C, 0xF6, 0xD6, 0x8F,
        0x19, 0x2B, 0xD0, 0xD2, 0x09, 0xAA, 0x14, 0x0A, 0x6D, 0x06, 0x2C, 0xAC,
0x18, 0x62, 0x86, 0x48,
        0xDA, 0x6C, 0xB7, 0x99, 0xAE, 0x0E, 0x17, 0x21, 0x58, 0x69, 0x1E, 0xF9,
0xA4, 0xF8, 0x8D, 0xB5,
        0x6C, 0x71, 0xF0, 0x40, 0x0B, 0x57, 0x14, 0xD4, 0x70, 0x5A, 0xC9, 0x04,
0xB2, 0xDF, 0x2B, 0x21,
        0x50, 0xEE, 0xBA, 0xE0, 0xB4, 0xF0, 0xD3, 0xBA, 0xD8, 0x1A, 0x23, 0xC3,
0xB8, 0xE3, 0x18, 0x73,
        0x46, 0x24, 0xBB, 0xA2, 0x04, 0xF1, 0xF5, 0xEE, 0x34, 0x0B, 0xF9, 0x5A,
0x57, 0x7A, 0xA3, 0xA0,
        0x15, 0xDD, 0xB7, 0x96, 0xE8, 0x83, 0x8B, 0x95, 0xC7, 0xAA, 0xF2, 0x51,
0x97, 0x5D, 0x42, 0xA1,
        0xDE, 0x65, 0x27, 0xD4, 0xC7, 0x15, 0xD5, 0xC7, 0x52, 0x7D, 0x46, 0x90,
0x34, 0x84, 0xE5, 0x2D,
        0x7F, 0xEC, 0x8C, 0xBF, 0x3D, 0x4D, 0x34, 0x5B, 0x8D, 0x0B, 0xE5, 0x94,
0xAD, 0xB8, 0xA2, 0x5E,
        0x31, 0x41, 0xEA, 0x9E, 0x62, 0xA1, 0xD6, 0x6A, 0x5C, 0x4D, 0xAD, 0xA8,
0x95, 0x67, 0x04, 0x89,
        0x5A, 0xFA, 0x86, 0x3F, 0x52, 0x25, 0xDE, 0x42, 0xE6, 0xFF, 0xA7, 0x4B,
0xFC, 0xCE, 0x94, 0x58,
        0x58, 0xB1, 0xFF, 0x5A, 0x5A, 0xCA, 0xC4, 0x30, 0x45, 0xC9, 0x78, 0xC9,
0x50, 0x4A, 0x1A, 0x8F,
        0x54, 0xA8, 0x63, 0x39, 0x0A, 0xA9, 0xA3, 0x41, 0xA2, 0x06, 0xC6, 0x5F,
0x2B, 0x19, 0x2B, 0x1E,
        0x9D, 0x04, 0x42, 0xC2, 0x40, 0x34, 0xE0, 0x23, 0xE3, 0x2C, 0xBB, 0xD4,
0x14, 0x8D, 0x90, 0x50,
        0x36, 0xD3, 0xFE, 0xA8, 0x03, 0x62, 0x95, 0x52, 0x63, 0xE2, 0x00, 0x11,
0xF4, 0x79, 0x62, 0x96,
        0x8A, 0x82, 0x1C, 0xEC, 0xD3, 0x9A, 0xF9, 0x93, 0x83, 0xD9, 0xF2, 0x41,
0xDE, 0x14, 0x7E, 0xF1,
        0xC3, 0x73, 0xC3, 0xF3, 0x0D, 0xF1, 0x16, 0x4D, 0x3F, 0x7E, 0x6B, 0x8E,
0x21, 0x5F, 0x31, 0xC7,
        0x17, 0x69, 0xC4, 0x9D, 0x1A, 0x74, 0x46, 0x02, 0xE8, 0x59, 0xD9, 0x93,
0xE0, 0xF8, 0xAE, 0x19,
        0xBF, 0x45, 0xAE, 0x54, 0x3D, 0xD1, 0xA4, 0x7E, 0x17, 0x2B, 0x92, 0x31,
0xA7, 0xA0, 0x49, 0x6C,
        0x79, 0x57, 0xEA, 0xB8, 0x96, 0x58, 0x8A, 0x96, 0x85, 0x1B, 0x98, 0x30,
0x3E, 0xFD, 0xC5, 0x5A,
        0x51, 0xAF, 0x40, 0xA9, 0x21, 0x63, 0xB2, 0xC4, 0x96, 0x89, 0xAE, 0x6B,
0xD6, 0xD4, 0xAD, 0xBD,
        0x0B, 0x10, 0x65, 0x5B, 0x49, 0xDA, 0x6C, 0x9E, 0x8F, 0x8A, 0xB0, 0xB8,
0xA8, 0x72, 0xE2, 0x33,
        0x38, 0x8D, 0x36, 0x2C, 0xC5, 0x37, 0xF1, 0x52, 0xAE, 0xC1, 0xA9, 0xF8,
0x9F, 0x0A, 0xFF, 0x0B,
        0x9B, 0xFC, 0x8E, 0x51, 0xC1, 0x70, 0x00, 0x00
      };
```

Código cámera Web Server – camera_pins.h

```
#if defined(CAMERA_MODEL_WROVER_KIT)
#define PWDN_GPIO_NUM    -1
#define RESET_GPIO_NUM   -1
#define XCLK_GPIO_NUM    21
#define SIOD_GPIO_NUM    26
#define SIOC_GPIO_NUM    27

#define Y9_GPIO_NUM      35
#define Y8_GPIO_NUM      34
#define Y7_GPIO_NUM      39
#define Y6_GPIO_NUM      36
#define Y5_GPIO_NUM      19
#define Y4_GPIO_NUM      18
#define Y3_GPIO_NUM       5
#define Y2_GPIO_NUM       4
#define VSYNC_GPIO_NUM   25
#define HREF_GPIO_NUM    23
#define PCLK_GPIO_NUM    22

#elif defined(CAMERA_MODEL_ESP_EYE)
#define PWDN_GPIO_NUM    -1
#define RESET_GPIO_NUM   -1
#define XCLK_GPIO_NUM    4
#define SIOD_GPIO_NUM    18
#define SIOC_GPIO_NUM    23

#define Y9_GPIO_NUM      36
#define Y8_GPIO_NUM      37
#define Y7_GPIO_NUM      38
#define Y6_GPIO_NUM      39
#define Y5_GPIO_NUM      35
#define Y4_GPIO_NUM      14
#define Y3_GPIO_NUM      13
#define Y2_GPIO_NUM      34
#define VSYNC_GPIO_NUM   5
#define HREF_GPIO_NUM    27
#define PCLK_GPIO_NUM    25

#elif defined(CAMERA_MODEL_M5STACK_PSRAM)
#define PWDN_GPIO_NUM     -1
#define RESET_GPIO_NUM    15
#define XCLK_GPIO_NUM     27
#define SIOD_GPIO_NUM     25
#define SIOC_GPIO_NUM     23

#define Y9_GPIO_NUM       19
#define Y8_GPIO_NUM       36
#define Y7_GPIO_NUM       18
#define Y6_GPIO_NUM       39
#define Y5_GPIO_NUM        5
#define Y4_GPIO_NUM       34
#define Y3_GPIO_NUM       35
#define Y2_GPIO_NUM       32
```

```
#define VSYNC_GPIO_NUM    22
#define HREF_GPIO_NUM     26
#define PCLK_GPIO_NUM     21

#elif defined(CAMERA_MODEL_M5STACK_WIDE)
#define PWDN_GPIO_NUM     -1
#define RESET_GPIO_NUM    15
#define XCLK_GPIO_NUM     27
#define SIOD_GPIO_NUM     22
#define SIOC_GPIO_NUM     23

#define Y9_GPIO_NUM       19
#define Y8_GPIO_NUM       36
#define Y7_GPIO_NUM       18
#define Y6_GPIO_NUM       39
#define Y5_GPIO_NUM        5
#define Y4_GPIO_NUM       34
#define Y3_GPIO_NUM       35
#define Y2_GPIO_NUM       32
#define VSYNC_GPIO_NUM    25
#define HREF_GPIO_NUM     26
#define PCLK_GPIO_NUM     21

#elif defined(CAMERA_MODEL_WROVER_B)
#define PWDN_GPIO_NUM -1
#define RESET_GPIO_NUM -1
#define XCLK_GPIO_NUM 32
#define SIOD_GPIO_NUM 13
#define SIOC_GPIO_NUM 12
#define Y9_GPIO_NUM 39
#define Y8_GPIO_NUM 36
#define Y7_GPIO_NUM 23
#define Y6_GPIO_NUM 18
#define Y5_GPIO_NUM 15
#define Y4_GPIO_NUM 4
#define Y3_GPIO_NUM 14
#define Y2_GPIO_NUM 5
#define VSYNC_GPIO_NUM 27
#define HREF_GPIO_NUM 25
#define PCLK_GPIO_NUM 19

#elif defined(CAMERA_MODEL_T_JOURNAL)
#define PWDN_GPIO_NUM     32
#define RESET_GPIO_NUM    -1
#define XCLK_GPIO_NUM     27
#define SIOD_GPIO_NUM     25
#define SIOC_GPIO_NUM     23

#define Y9_GPIO_NUM       19
#define Y8_GPIO_NUM       36
#define Y7_GPIO_NUM       18
#define Y6_GPIO_NUM       39
#define Y5_GPIO_NUM       5
#define Y4_GPIO_NUM       34
#define Y3_GPIO_NUM       35
```

```
#define Y2_GPIO_NUM       17
#define VSYNC_GPIO_NUM    22
#define HREF_GPIO_NUM     26
#define PCLK_GPIO_NUM     21

#else
#error "Camera model not selected"
#endif
```

4. ANEXO 4 (HOJAS DE CARACTERÍSTICAS)

Diodo 1N4001

WTE
POWER SEMICONDUCTORS

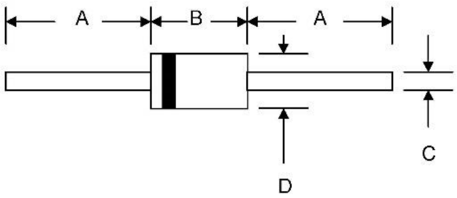
1N4001 – 1N4007

RoHS Pb

1.0A STANDARD DIODE

Features

- Diffused Junction
- Low Forward Voltage Drop
- High Current Capability
- High Reliability
- High Surge Current Capability



Mechanical Data

- Case: DO-41, Molded Plastic
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Weight: 0.35 grams (approx.)
- Mounting Position: Any
- Marking: Type Number
- **Lead Free: For RoHS / Lead Free Version, Add "-LF" Suffix to Part Number, See Page 4**

DO-41		
Dim	**Min**	**Max**
A	25.4	—
B	4.06	5.21
C	0.71	0.864
D	2.00	2.72
All Dimensions in mm		

Maximum Ratings and Electrical Characteristics @T_A=25°C unless otherwise specified

Single Phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N 4001	1N 4002	1N 4003	1N 4004	1N 4005	1N 4006	1N 4007	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 1) @T_A = 75°C	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms Single half sine-wave superimposed on rated load (JEDEC Method)	I_{FSM}	30							A
Forward Voltage @I_F = 1.0A	V_{FM}	1.0							V
Peak Reverse Current @T_A = 25°C At Rated DC Blocking Voltage @T_A = 100°C	I_{RM}	5.0 50							µA
Typical Junction Capacitance (Note 2)	C_j	15							pF
Typical Thermal Resistance Junction to Ambient (Note 1)	$R_{\theta JA}$	50							°C/W
Operating Temperature Range	T_j	-65 to +125							°C
Storage Temperature Range	T_{STG}	-65 to +150							°C

Note: 1. Leads maintained at ambient temperature at a distance of 9.5mm from the case
2. Measured at 1.0 MHz and Applied Reverse Voltage of 4.0V D.C.

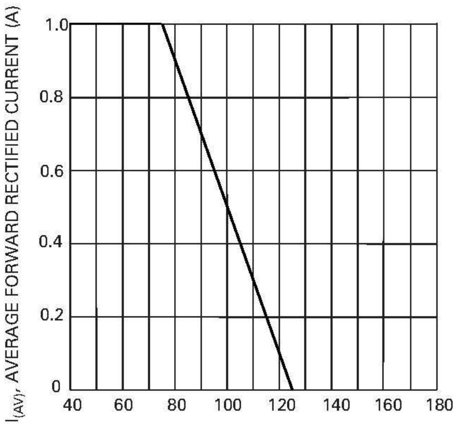


Fig. 1 Forward Current Derating Curve

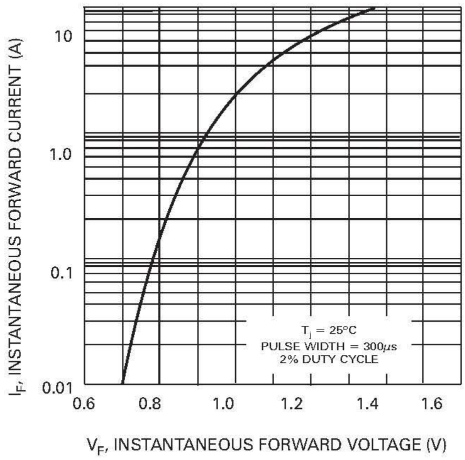


Fig. 2 Typical Forward Characteristics

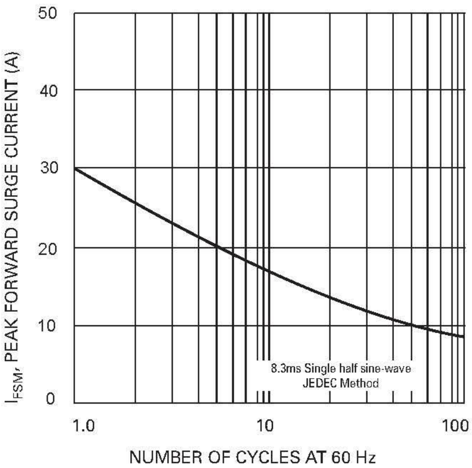


Fig. 3 Max Non-Repetitive Peak Fwd Surge Current

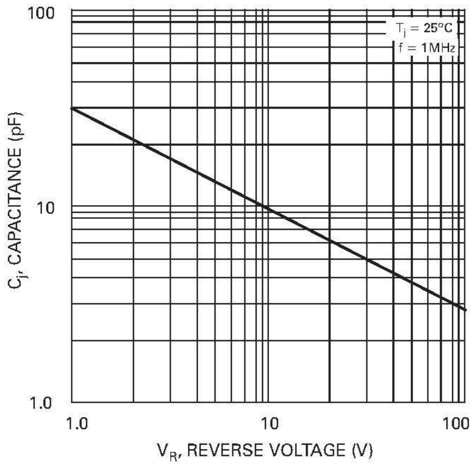
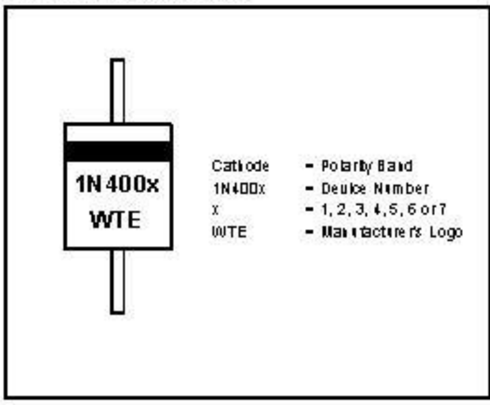


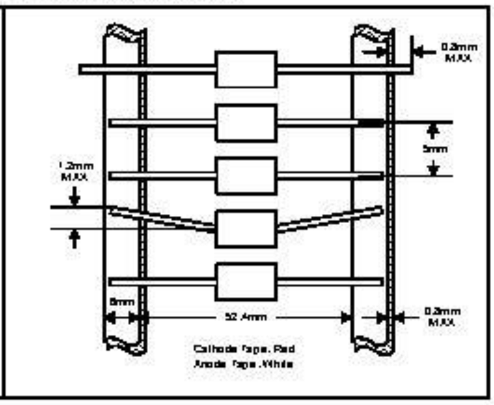
Fig. 4 Typical Junction Capacitance

1N4001 – 1N4007 2 of 4 © 2006 Won-Top Electronics

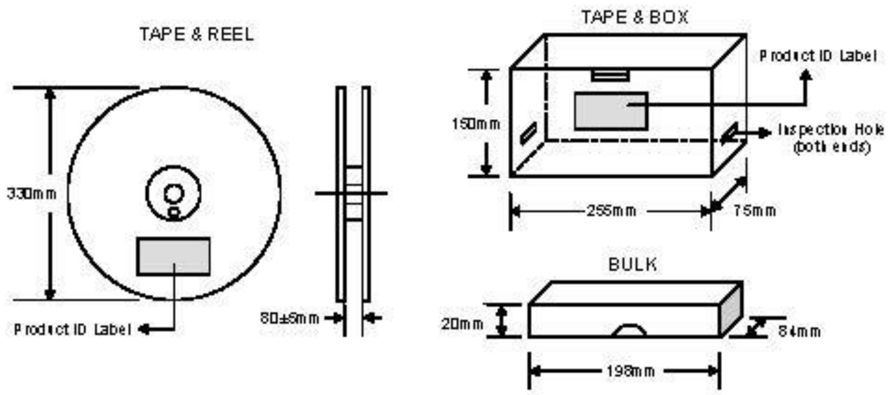
MARKING INFORMATION



TAPING SPECIFICATIONS



PACKAGING INFORMATION



Packaging	Reel Diameter / Box Size (mm)	Quantity (PCS)	Carton Size (mm)	Quantity (PCS)	Approx. Gross Weight (KG)
TAPE & REEL	330	5,000	370 x 370 x 420	25,000	13.0
TAPE & BOX	255 x 75 x 150	5,000	400 x 273 x 415	50,000	21.0
BULK	198 x 84 x 20	1,000	459 x 214 x 256	50,000	19.5

Note: 1. Paper reel, white or gray color. Core material: plastic or metal.
2. Components are packed in accordance with EIA standard RS-296-E.

ORDERING INFORMATION

Product No.	Package Type	Shipping Quantity
1N4001-T3	DO-41	5000/Tape & Reel
1N4001-TB	DO-41	5000/Tape & Box
1N4001	DO-41	1000 Units/Box
1N4002-T3	DO-41	5000/Tape & Reel
1N4002-TB	DO-41	5000/Tape & Box
1N4002	DO-41	1000 Units/Box
1N4003-T3	DO-41	5000/Tape & Reel
1N4003-TB	DO-41	5000/Tape & Box
1N4003	DO-41	1000 Units/Box
1N4004-T3	DO-41	5000/Tape & Reel
1N4004-TB	DO-41	5000/Tape & Box
1N4004	DO-41	1000 Units/Box
1N4005-T3	DO-41	5000/Tape & Reel
1N4005-TB	DO-41	5000/Tape & Box
1N4005	DO-41	1000 Units/Box
1N4006-T3	DO-41	5000/Tape & Reel
1N4006-TB	DO-41	5000/Tape & Box
1N4006	DO-41	1000 Units/Box
1N4007-T3	DO-41	5000/Tape & Reel
1N4007-TB	DO-41	5000/Tape & Box
1N4007	DO-41	1000 Units/Box

1. Products listed in **bold** are WTE **Preferred** devices.
2. Shipping quantity given is for minimum packing quantity only. For minimum order quantity, please consult the Sales Department.
3. **To order RoHS / Lead Free version (with Lead Free finish), add "-LF" suffix to part number above. For example, 1N4001-TB-LF**.

Won-Top Electronics Co., Ltd.
No. 44 Yu Kang North 3rd Road, Chine Chen Dist., Kaohsiung, Taiwan
Phone: 886-7-822-5408 or 886-7-822-5410
Fax: 886-7-822-5417
Email: sales@wontop.com
Internet: http://www.wontop.com

We power your everyday.

Diodo 1N5822 schotky

Zibo Seno Electronic Engineering Co., Ltd.

ME 淄博圣诺

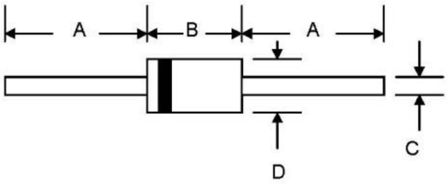
1N5820 – 1N5822

Pb lead-free RoHS

3.0A SCHOTTKY BARRIER RECTIFIER

Features

- Schottky Barrier Chip
- Guard Ring Die Construction for Transient Protection
- High Current Capability
- Low Power Loss, High Efficiency
- High Surge Current Capability
- For Use in Low Voltage, High Frequency Inverters, Free Wheeling, and Polarity Protection Applications



Mechanical Data

- Case: Molded Plastic
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Weight: 1.2 grams (approx.)
- Mounting Position: Any
- Marking: Type Number
- **Lead Free: For RoHS / Lead Free Version**

DO-201AD		
Dim	**Min**	**Max**
A	24.5	—
B	7.20	9.50
C	1.10	1.30
D	5.00	5.60
All Dimensions in mm		

Maximum Ratings and Electrical Characteristics @T_A=25°C unless otherwise specified

Single Phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N5820	1N5821	1N5822	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	V
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	V
Average Rectified Output Current (Note 1) @T_L = 90°C	I_O	3.0			A
Non-Repetitive Peak Forward Surge Current 8.3ms Single half sine-wave superimposed on rated load (JEDEC Method) @T_L = 75°C	I_{FSM}	80			A
Forward Voltage @I_F = 3.0A	V_{FM}	0.475	0.50	0.525	V
Peak Reverse Current @T_A = 25°C At Rated DC Blocking Voltage @T_A = 100°C	I_{RM}	2.0 20			mA
Typical Junction Capacitance (Note 2)	C_j	250			pF
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	20			K/W
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +150			°C

Note: 1. Valid provided that leads are kept at ambient temperature at a distance of 9.5mm from the case.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V D.C.

Zibo Seno Electronic Engineering Co., Ltd.

淄博圣诺

1N5820 – 1N5822

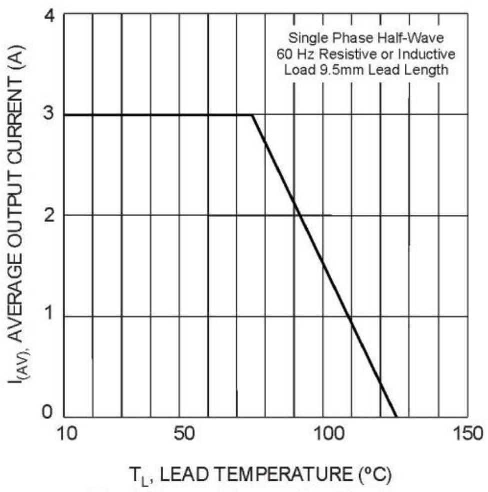


Fig. 1 Forward Current Derating Curve

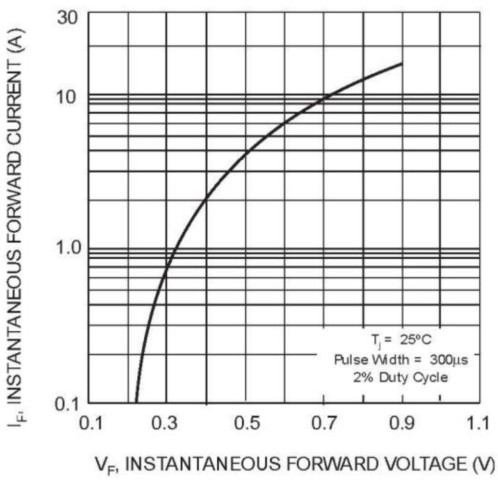


Fig. 2 Typical Forward Voltage Characteristics

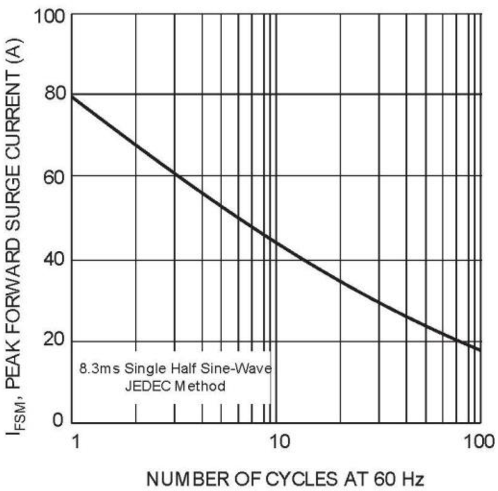


Fig. 3 Peak Forward Surge Current

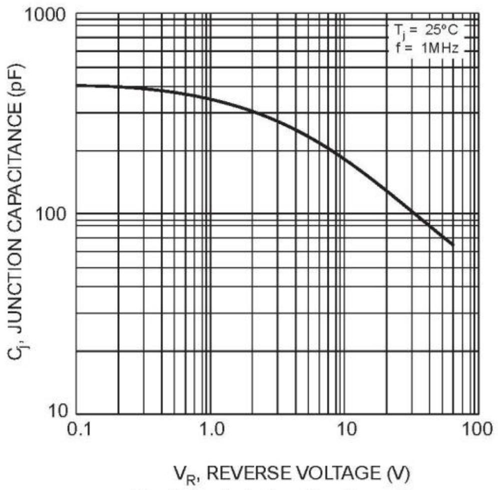


Fig. 4 Typical Junction Capacitance

Abrepuertas – Cerradura eléctrica

14/9/21 23:22 Abrepuertas Dorcas Series 30/58 - Dorcas

DORCAS

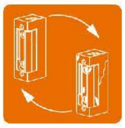
Abrepuertas Dorcas Series 30/58 Usted está aquí Inicio / CIERRAPUERTAS / Abrepuertas Dorcas Series 30/58

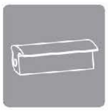
Ver descargas

https://www.dorcas.com/productos/abrepuertas-dorcas-series-30-58/ 1/6

La Serie 30 posee una gran implantación en el mercado y es una buena opción para la reposición de abrepuertas ya instalados. Disponible en versión monoblock y en versión ajustable o flex.
La Serie 58 difiere de la anterior en que su pestillo gira de forma radial.

- **REPOSICIÓN**
- **VERSIONES REGULABLE Y MONOBLOCK**

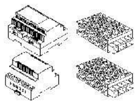




CARACTERÍSTICAS TÉCNICAS	Serie 30				Serie 58			
Alto	90,8 mm				90,8 mm			
Ancho	20 mm				20 mm			
Profundo	28 mm				28 mm			
Ajuste de la aleta Flex	+4				-1+2			
Profundidad de pestillo	8,1 mm				5 mm			
Ciclos testados con excitación eléctrica	300.000				300.000			
Fuerza de retención	2.950 N / 300 Kg-f				2.950 N / 300 kg-f			
Rango de temperatura de trabajo	-15 ºC a +40ºC				-15 ºC a +40ºC			
Diodo o varistor	Opcional				Opcional			
Microswitch	Opcional							
	8-12 V			24 V	12 VDC (412)	24 VDC (424)	12 VDC (512)	24 VDC (524)
Resistencia de la bobina (Ω)	8	17	30	58	68	132	70	230
Consumo de corriente alterna (mA)	800(8V) 1200(12V)	370(8V) 560(12V)		330				
Consumo de corriente continua estabilizada (mA)	1000(8V) 1500(12V)	470(8V) 700(12V)	260(8V) 400(12V)		180 VDC directa	180 VDC directa	150 VDC directa	120 VDC directa
Rango de trabajo mantenido en corriente continua (V)				-	11-12	23-24	11-12	23-24
Precarga de pestillo máxima para apertura AC (N)	Serie 30 100 (12V) Serie 58 100 (12V)	-	-	-	-	-	-	-

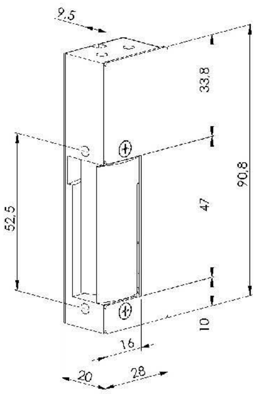
TRANSFORMADORES

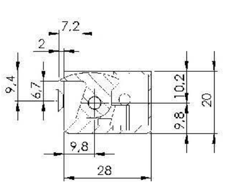
Para un idóneo funcionamiento recomendamos: AC 12V TF3, AC 24V TF8

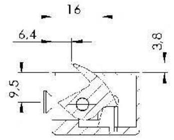


TF5 DC 12V, TF7 DC 24V Sección accesorios pág.106

CAJA DE MECANISMOS

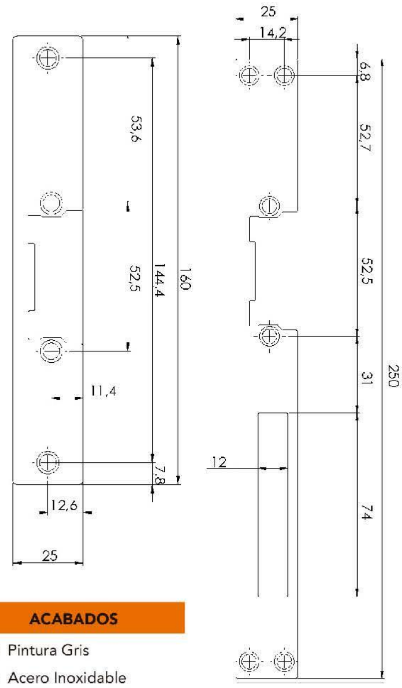






ARMADURAS RECOMENDADAS

S (10) G (21)



ACABADOS

- **G** Pintura Gris
- **X** Acero Inoxidable

Puede solicitar cualquier otro acabado no estándar.
Por favor, consulte plazo de entrega.

CÓDIGO	DESCRIPCIÓN	NORMAL	AUTOMÁTICO ESTANDAR	AUTOMÁTICO INVISIBLE	AUTOMÁTICO TEMPORIZADO	AUTOMÁTICO DESLIZANTE	INVERTIDO	CONMUTACIÓN	DESBLOQUEO	AJUSTABLE con tornillos de regulación en el pestillo	TENSIÓN **
3001	30NF	●								●	V AC
3002	30NDF	●							●	●	V AC
3003	30AF		●							●	V AC
3004	30ADF		●						●	●	V AC
3005	30AAF			●						●	V AC
3006	30AADF			●					●	●	V AC
3007	30NF 412	●								●	12V DC
3008	30NDF 412	●							●	●	12V DC
3009	30AF 412		●							●	12V DC
3010	30ADF 412		●						●	●	12V DC
3013	30NF 512						●			●	12V DC
3015	30N	●									V AC
3016	30ND	●							●		V AC
3017	30A		●								V AC
3018	30AD		●						●		V AC
3019	30AA			●							V AC
3020	30AAD			●					●		V AC
3021	30N 412	●									12V DC
3022	30ND 412	●							●		12V DC
3023	30A 412		●								12V DC
3024	30AD 412		●						●		12V DC
3027	30N 512						●				12V DC
3029	30N 305	●						●			V AC
3030	30N 305 412	●						●			12V DC
3031	30N 305 512						●	●			12V DC

**Disponible opcionalmente en 24V; sencillamente, anote 24 tras el código. *Ejemplo: 3029 24*
Si desea solicitar la caja de mecanismos de 104 mm de altura, indíquelo con una B detrás del código. *Ejemplo: 3015 B*
En versión ajustable, existe la opción de incorporar el pestillo radial. Debe escribir 58_ _ en lugar de 30 _ _. *Ejemplo: 5806*
La bobina estándar es de 8Ω, si desea alguna otra por favor indíquelo.

EJEMPLO DE CODIFICACIÓN: 3001/10G **EJEMPLO DE DESCRIPCIÓN:** 30 NF/SG	Caja de mecanismos de la serie 30 con función normal y aleta regulable con armadura corta 10 ("S" según la descripción) con acabado en color gris
EJEMPLO DE CODIFICACIÓN: 5804/21X **EJEMPLO DE DESCRIPCIÓN:** 58 ADF/GX	Caja de mecanismos de la serie 58 con función automática, desbloqueo y aleta regulable, con armadura 21 ("G" según la descripción) con acabado en acero inoxidable

Regulador ADP3338

ANALOG DEVICES

High Accuracy, Ultralow I_Q, 1 A, anyCAP® Low Dropout Regulator

ADP3338

FEATURES

High accuracy over line and load: ±0.8% @ 25°C, ±1.4% over temperature
Ultralow dropout voltage: 190 mV (typ) @ 1 A
Requires only C_O = 1.0 µF for stability
anyCAP is stable with any type of capacitor (including MLCC)
Current and thermal limiting
Low noise
2.7 V to 8 V supply range
−40°C to +85°C ambient temperature range
SOT-223 package

FUNCTIONAL BLOCK DIAGRAM

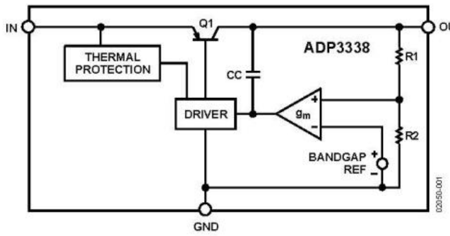


Figure 1.

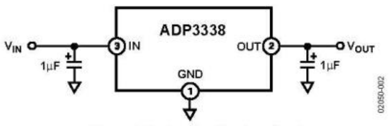


Figure 2. Typical Application Circuit

APPLICATIONS

Notebook, palmtop computers
SCSI terminators
Battery-powered systems
Bar code scanners
Camcorders, cameras
Home entertainment systems
Networking systems
DSP/ASIC supplies

GENERAL DESCRIPTION

The ADP3338 is a member of the ADP33xx family of precision, low dropout (LDO), anyCAP voltage regulators. The ADP3338 operates with an input voltage range of 2.7 V to 8 V and delivers a load current up to 1 A. The ADP3338 stands out from conventional LDOs with a novel architecture and an enhanced process that offers performance advantages and higher output current than its competition. Its patented design requires only a 1 µF output capacitor for stability. This device is insensitive to output capacitor equivalent series resistance (ESR), and is stable with any good quality capacitor, including ceramic (MLCC) types for space-restricted applications. The ADP3338 achieves exceptional accuracy of ±0.8% at room temperature and ±1.4% over temperature, line, and load variations. The dropout voltage of the ADP3338 is only 190 mV (typical) at 1 A. The device also includes a safety current limit and thermal overload protection. The ADP3338 has ultralow quiescent current: 110 µA (typical) in light load situations.

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 www.analog.com
Fax: 781.461.3113

TABLE OF CONTENTS

REVISION HISTORY

6/05—Data Sheet Changed from Rev. A to Rev. B

Added Pin Function Descriptions Table ... 5
Changes to Ordering Guide ... 13

6/04—Data Sheet Changed from Rev. 0 to Rev. A

Updated Format ... Universal
Changes to Figures 5, 11, 12, 13, 14, 15 ... 6
Updated Outline Dimensions ... 12
Changes to Ordering Guide ... 12

6/01—Rev. 0: Initial Version

SPECIFICATIONS

V_{IN} = 6.0 V, C_{IN} = C_{OUT} = 1 μF, T_J = −40°C to +125°C, unless otherwise noted.

Table 1.

Parameter[1, 2, 3]	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT						
Voltage Accuracy	V_{OUT}	V_{IN} = V_{OUTNOM} + 0.4 V to 8 V, I_L = 0.1 mA to 1 A, T_J = 25°C	−0.8		+0.8	%
		V_{IN} = V_{OUTNOM} + 0.4 V to 8 V, I_L = 0.1 mA to 1 A, T_J = −40°C to +125°C	−1.4		+1.4	%
		V_{IN} = V_{OUTNOM} + 0.4 V to 8 V, I_L = 50 mA to 1 A, T_J = 150°C	−1.6		+1.6	%
Line Regulation		V_{IN} = V_{OUTNOM} + 0.4 V to 8 V, T_J = 25°C		0.04		mV/V
Load Regulation		I_L = 0.1 mA to 1 A, T_J = 25°C		0.006		mV/mA
Dropout Voltage	V_{DROP}	V_{OUT} = 98% of V_{OUTNOM}				
		I_L = 1 A		190	400	mV
		I_L = 500 mA		125	200	mV
		I_L = 100 mA		70	150	mV
Peak Load Current	I_{LDPK}	V_{IN} = V_{OUTNOM} + 1 V		1.6		A
Output Noise	V_{NOISE}	f = 10 Hz to 100 kHz, C_L = 10 μF, I_L = 1 A		95		μV rms
GROUND CURRENT						
In Regulation	I_{GND}	I_L = 1 A		9	30	mA
		I_L = 500 mA		4.5	15	mA
		I_L = 100 mA		0.9	3	mA
		I_L = 0.1 mA		110	190	μA
In Dropout	I_{GND}	V_{IN} = V_{OUTNOM} − 100 mV, I_L = 0.1 mA		190	600	μA

[1] All limits at temperature extremes are guaranteed via correlation using standard statistical quality control (SQC) methods.
[2] Application stable with no load.
[3] V_{IN} = 2.7 V for models with V_{OUTNOM} ≤ 2.2 V.

ADP3338

ABSOLUTE MAXIMUM RATINGS

Unless otherwise specified, all voltages are referenced to GND.

Table 2.

Parameter	Rating
Input Supply Voltage	−0.3 V to +8.5 V
Power Dissipation	Internally limited
Operating Ambient Temperature Range	−40°C to +85°C
Operating Junction Temperature Range	−40°C to +150°C
θ_{JA}	62.3°C/W
θ_{JC}	26.8°C/W
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering 10 sec)	300°C
Vapor Phase (60 sec)	215°C
Infrared (15 sec)	220°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

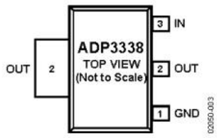
Only one absolute maximum rating may be applied at any one time.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

Rev. B | Page 4 of 16

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS



NOTE: PIN 2 AND TAB ARE INTERNALLY CONNECTED

Figure 3. Pin Configuration

Table 3. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	GND	Ground Pin.
2	OUT	Regulator Output. Bypass to ground with a 1 µF or larger capacitor.
3	IN	Regulator Input. Bypass to ground with a 1 µF or larger capacitor.

ADP3338

TYPICAL PERFORMANCE CHARACTERISTICS

T_A = 25°C, unless otherwise noted.

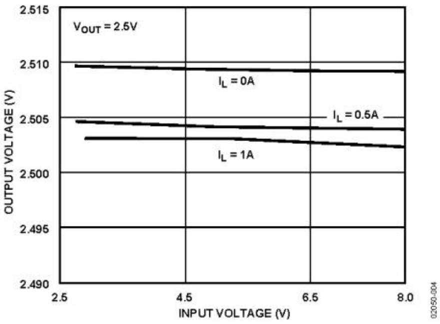


Figure 4. Line Regulation Output Voltage vs. Input Voltage

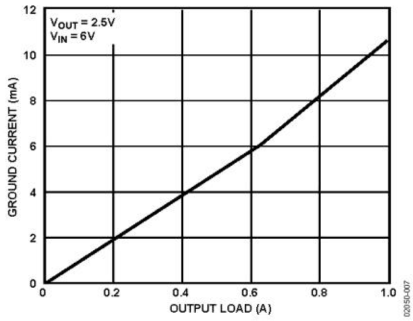


Figure 7. Ground Current vs. Load Current

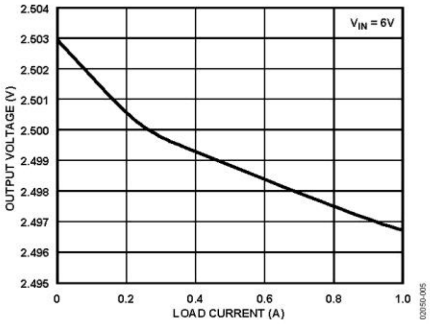


Figure 5. Output Voltage vs. Load Current

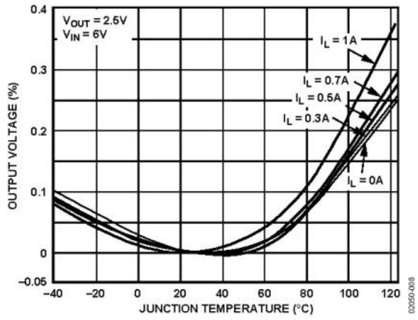


Figure 8. Output Voltage Variation % vs. Junction Temperature

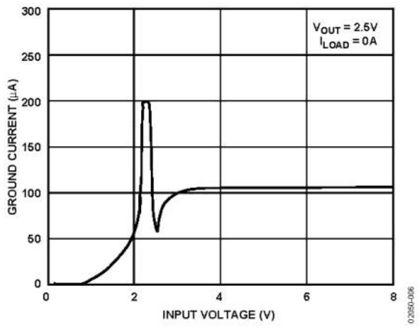


Figure 6. Ground Current vs. Supply Voltage

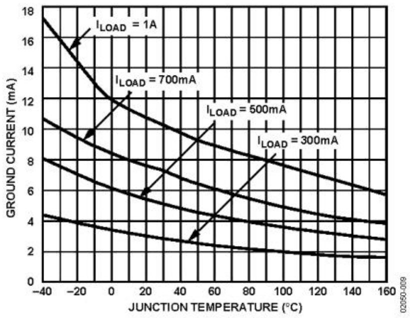


Figure 9. Ground Current vs. Junction Temperature

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ADP3338

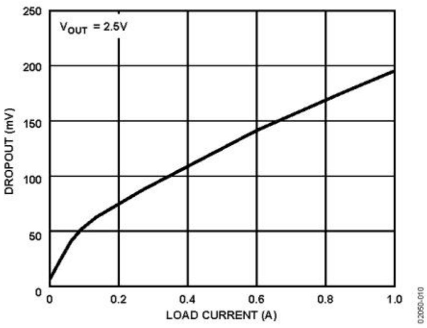

Figure 10. Dropout Voltage vs. Load Current

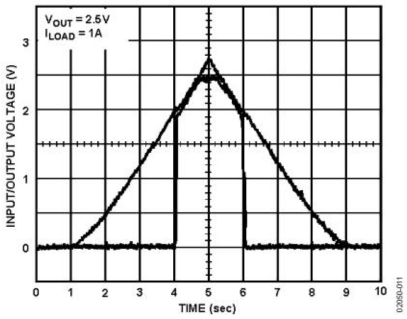

Figure 11. Power-Up/Power-Down

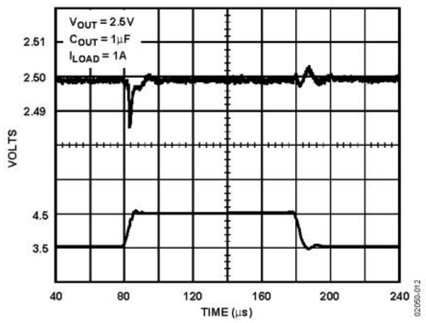

Figure 12. Line Transient Response

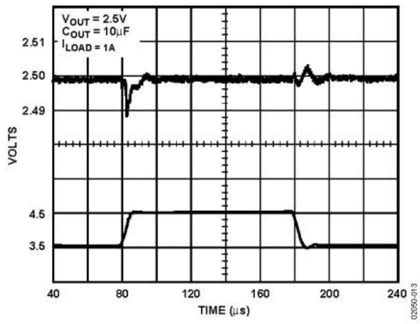

Figure 13. Line Transient Response

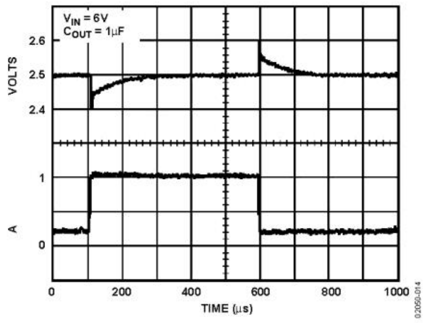

Figure 14. Load Transient Response

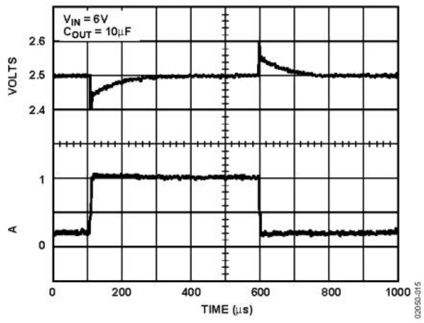

Figure 15. Load Transient Response

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ADP3338

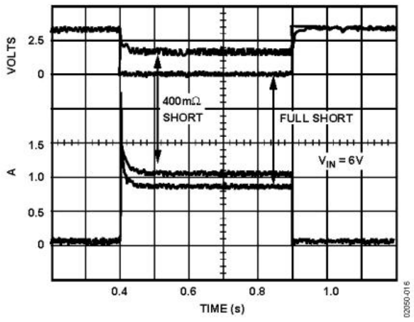

Figure 16. Short-Circuit Current

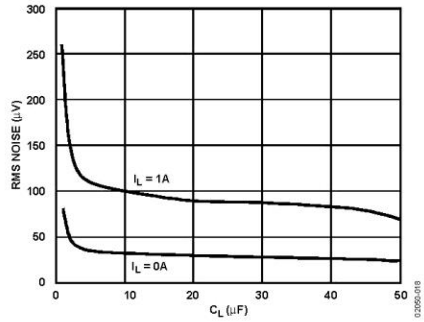

Figure 18. RMS Noise vs. C_L

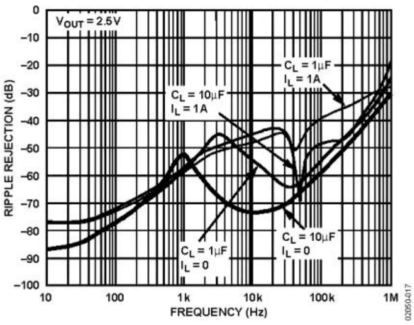

Figure 17. Power Supply Ripple Rejection

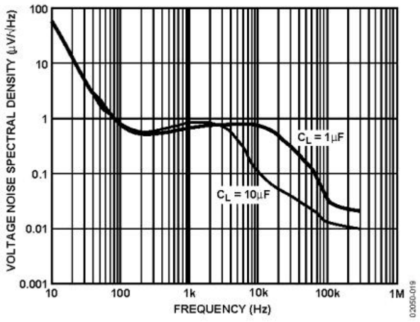

Figure 19. Output Noise Density (10 Hz to 100 kHz)

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THEORY OF OPERATION

The ADP3338 anyCAP LDO uses a single control loop for regulation and reference functions. The output voltage is sensed by a resistive voltage divider, consisting of R1 and R2, which is varied to provide the available output voltage option. Feedback is taken from this network by way of a series diode (D1) and a second resistor divider (R3 and R4) to the input of an amplifier.

A very high gain error amplifier is used to control this loop. The amplifier is constructed in such a way that equilibrium produces a large, temperature-proportional input offset voltage that is repeatable and very well controlled. The temperature-proportional offset voltage is combined with the complementary diode voltage to form a virtual band gap voltage that is implicit in the network, although it never appears explicitly in the circuit. Ultimately, this patented design makes it possible to control the loop with only one amplifier. This technique also improves the noise characteristics of the amplifier by providing more flexibility on the trade off of noise sources that leads to a low noise design.

The R1, R2 divider is chosen in the same ratio as the band gap voltage to the output voltage. Although the R1, R2 resistor divider is loaded by Diode D1 and a second divider consisting of R3 and R4, the values can be chosen to produce a temperature-stable output. This unique arrangement specifically corrects for the loading of the divider, thus avoiding the error resulting from base current loading in conventional circuits.

The patented amplifier controls a new and unique noninverting driver that drives the pass transistor, Q1. The use of this special noninverting driver enables the frequency compensation to include the load capacitor in a pole-splitting arrangement to achieve reduced sensitivity to the value, type, and ESR of the load capacitance.

Most LDOs place very strict requirements on the range of ESR values for the output capacitor because they are difficult to stabilize due to the uncertainty of load capacitance and resistance. Moreover, the ESR value required to keep conventional LDOs stable changes depending on load and temperature. These ESR limitations make designing with LDOs more difficult because of their unclear specifications and extreme variations over temperature.

With the ADP3338 anyCAP LDO, this is no longer true. It can be used with virtually any good quality capacitor, with no constraint on the minimum ESR. This innovative design provides circuit stability with just a small 1 µF capacitor on the output. Additional advantages of the pole-splitting scheme include superior line noise rejection and very high regulator gain to achieve excellent line and load regulation. An impressive ±1.4% accuracy is guaranteed over line, load, and temperature.

Additional features of the circuit include current limit and thermal shutdown.

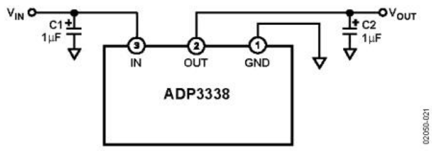

Figure 20. Typical Application Circuit

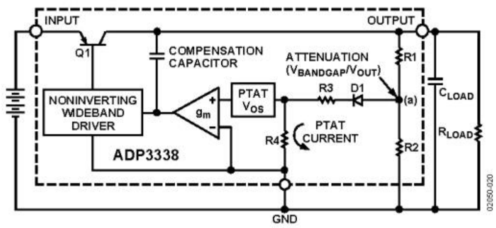

Figure 21. Functional Block Diagram

APPLICATION INFORMATION

CAPACITOR SELECTION

Output Capacitor

The stability and transient response of the LDO is a function of the output capacitor. The ADP3338 is stable with a wide range of capacitor values, types, and ESR (anyCAP). A capacitor as low as 1 µF is the only requirement for stability. A higher capacitance may be necessary if high output current surges are anticipated, or if the output capacitor cannot be located near the output and ground pins. The ADP3338 is stable with extremely low ESR capacitors (ESR ≈ 0) such as multilayer ceramic capacitors (MLCC) or OSCON. Note that the effective capacitance of some capacitor types falls below the minimum over temperature or with dc voltage.

Input Capacitor

An input bypass capacitor is not strictly required, but is recommended in any application involving long input wires or high source impedance. Connecting a 1 µF capacitor from the input to ground reduces the sensitivity of the circuit to PC board layout and input transients. If a larger output capacitor is necessary, a larger value input capacitor is recommended.

OUTPUT CURRENT LIMIT

The ADP3338 is short-circuit protected by limiting the pass transistor's base drive current. The maximum output current is limited to approximately 2 A (see Figure 16).

THERMAL OVERLOAD PROTECTION

The ADP3338 is protected against damage due to excessive power dissipation by its thermal overload protection circuit. Thermal protection limits the die temperature to a maximum of 160°C. Under extreme conditions, such as high ambient temperature and power dissipation where the die temperature starts to rise above 160°C, the output current is reduced until the die temperature has dropped to a safe level.

Current and thermal limit protections are intended to protect the device against accidental overload conditions. For normal operation, externally limit the power dissipation of the device so the junction temperature does not exceed 150°C.

CALCULATING POWER DISSIPATION

Device power dissipation is calculated as

$$P_D = (V_{IN} - V_{OUT}) \times I_{LOAD} + (V_{IN} \times I_{GND})$$

Where I_{LOAD} and I_{GND} are load current and ground current, and V_{IN} and V_{OUT} are the input and output voltages, respectively. Assuming the worst-case operating conditions are I_{LOAD} = 1.0 A, I_{GND} = 10 mA, V_{IN} = 3.3 V, and V_{OUT} = 2.5 V, the device power dissipation is

$$P_D = (3.3\text{ V} - 2.5\text{ V}) \times 1000\text{ mA} + (3.3\text{ V} \times 10\text{ mA}) = 833\text{ mW}$$

So, for a junction temperature of 125°C and a maximum ambient temperature of 85°C, the required thermal resistance from junction to ambient is

$$\theta_{JA} = \frac{125°C - 85°C}{0.833\text{ W}} = 48°C/W$$

PRINTED CIRCUIT BOARD LAYOUT CONSIDERATIONS

The thermal resistance, θ_{JA}, of the SOT-223 is determined by the sum of the junction-to-case and the case-to-ambient thermal resistances. The junction-to-case thermal resistance, θ_{JC}, is determined by the package design and is specified at 26.8°C/W. However, the case-to-ambient thermal resistance is determined by the printed circuit board design.

As shown in Figure 22, the amount of copper to which the ADP3338 is mounted affects thermal performance. When mounted to the minimal pads of 2 oz. copper, as shown in Figure 22 (a), θ_{JA} is 126.6°C/W. Adding a small copper pad under the ADP3338, as shown in Figure 22 (b), reduces the θ_{JA} to 102.9°C/W. Increasing the copper pad to one square inch, as shown in Figure 22 (c), reduces the θ_{JA} even further to 52.8°C/W.

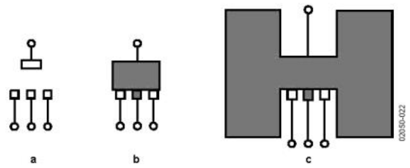

Figure 22. PCB Layouts

Use the following general guidelines when designing printed circuit boards:

- Keep the output capacitor as close as possible to the output and ground pins.
- Keep the input capacitor as close as possible to the input and ground pins.
- Specify thick copper and use wide traces for optimum heat transfer. PC board traces with larger cross sectional areas remove more heat from the ADP3338.
- Decrease thermal resistance by adding a copper pad under the ADP3338, as shown in Figure 22 (b).
- Use the adjacent area to the ADP3338 to add more copper around it. Connecting the copper area to the output of the ADP3338, as shown in Figure 22 (c), is best, but thermal performance will be improved even if it is connected to other signals.
- Use additional copper layers or planes to reduce the thermal resistance. Again, connecting the other layers to the output of the ADP3338 is best, but is not necessary. When connecting the output pad to other layers, use multiple vias.

OUTLINE DIMENSIONS

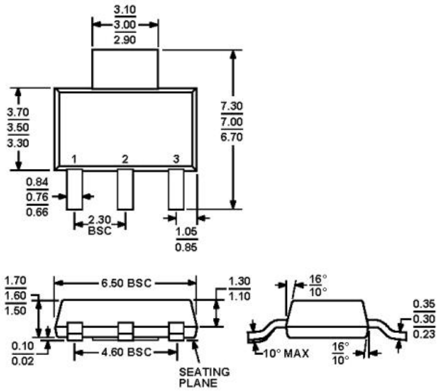

Figure 23. 3-Lead Small Outline Transistor Package [SOT-223] (KC-3)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Output Voltage (V)	Package Option	Package Description
ADP3338AKC-1.5-RL	−40°C to +85°C	1.5	KC-3	3-Lead SOT-223
ADP3338AKC-1.5-RL7	−40°C to +85°C	1.5	KC-3	3-Lead SOT-223
ADP3338AKCZ-1.5-RL[1]	−40°C to +85°C	1.5	KC-3	3-Lead SOT-223
ADP3338AKCZ-1.5-RL7[1]	−40°C to +85°C	1.5	KC-3	3-Lead SOT-223
ADP3338AKC-1.8-RL	−40°C to +85°C	1.8	KC-3	3-Lead SOT-223
ADP3338AKC-1.8-RL7	−40°C to +85°C	1.8	KC-3	3-Lead SOT-223
ADP3338AKCZ-1.8-RL[1]	−40°C to +85°C	1.8	KC-3	3-Lead SOT-223
ADP3338AKCZ-1.8-R7[1]	−40°C to +85°C	1.8	KC-3	3-Lead SOT-223
ADP3338AKC-2.5-RL	−40°C to +85°C	2.5	KC-3	3-Lead SOT-223
ADP3338AKC-2.5-RL7	−40°C to +85°C	2.5	KC-3	3-Lead SOT-223
ADP3338AKCZ-2.5-RL[1]	−40°C to +85°C	2.5	KC-3	3-Lead SOT-223
ADP3338AKCZ-2.5RL7[1]	−40°C to +85°C	2.5	KC-3	3-Lead SOT-223
ADP3338AKC-2.85-RL	−40°C to +85°C	2.85	KC-3	3-Lead SOT-223
ADP3338AKC-2.85-RL7	−40°C to +85°C	2.85	KC-3	3-Lead SOT-223
ADP3338AKCZ-2.85R7[1]	−40°C to +85°C	2.85	KC-3	3-Lead SOT-223
ADP3338AKC-3-RL	−40°C to +85°C	3.0	KC-3	3-Lead SOT-223
ADP3338AKC-3-RL7	−40°C to +85°C	3.0	KC-3	3-Lead SOT-223
ADP3338AKCZ-3-RL7[1]	−40°C to +85°C	3.0	KC-3	3-Lead SOT-223
ADP3338AKC-3.3-RL	−40°C to +85°C	3.3	KC-3	3-Lead SOT-223
ADP3338AKC-3.3-RL7	−40°C to +85°C	3.3	KC-3	3-Lead SOT-223
ADP3338AKCZ-3.3-RL[1]	−40°C to +85°C	3.3	KC-3	3-Lead SOT-223
ADP3338AKCZ-3.3RL7[1]	−40°C to +85°C	3.3	KC-3	3-Lead SOT-223
ADP3338AKC-5-REEL	−40°C to +85°C	5	KC-3	3-Lead SOT-223
ADP3338AKC-5-REEL7	−40°C to +85°C	5	KC-3	3-Lead SOT-223
ADP3338AKCZ-5-REEL[1]	−40°C to +85°C	5	KC-3	3-Lead SOT-223
ADP3338AKCZ-5-R7[1]	−40°C to +85°C	5	KC-3	3-Lead SOT-223

[1] Z = Pb-free part.

NOTES

NOTES

NOTES

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✓ Ángulo del haz: 45°
✓ 14000 lux a 0,3 m
✓ CRI 95 / TLCI 95+
✓ La temperatura de color y el brillo se pueden aumentar o disminuir con solo presionar un botón
✓ Salida de luz máxima a 5500 K
✓ La función de memoria guarda automáticamente los últimos ajustes
✓ Fuente de alimentación: Batería NP-F (no incluida) o USB (tipo C)
✓ Rosca de 1/4" en tres lados
✓ Dimensiones: 158 x 87 x 34 mm
✓ Peso: 260 g
✓ Batería adecuada (artículo nº496754) no incluida
✓ Cargador adecuado (artículo nº496757) no incluido

Más información

Construcción	Panel LED
Potencia [W]	15 W
Color de LED	CW/WW
Temperatura (K)	3200 – 9500
Óptica	No
CRI	95
del	45 °
DMX	No
Control remoto	No
Sin ventilador	Si
Panel	No
Batería	Opcional

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- ✓ 2 difusores
- ✓ Rótula Coldshoe
- ✓ Bolsa de transporte
- ✓ Cable USB
- ✓ Instrucciones de funcionamiento

Anclaje	1/4"
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Certificación IP	IP20
Incluye bolsa / estuche	Sí
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Color del chasis	Negro

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Capacidad (W)	25W
Forma de onda	Corriente continua
Batería	Lithium-ion Voltaje Nominal 3.7VDC
Gama	Hogar y empresa
Conexiones	Schuko macho
Peso	280 Gramos
Garantía	2 Años

MÁS

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Características

- Entrada de voltaje Rango 90 VAC ~ 264 VAC
- Frequencia 50 or 60 Hz
- Salida de voltaje Voltaje 12VDC ± 5% Max.
- Consumo 25W (2.1A)

Batería

- Tipo Batería Lithium-ion Voltaje Nominal 3.7VDC
- Capacidad 2600mAh

- Tiempo de carga típico 3 horas para una carga del 90%

Datos Físicos

- Entrada: Schuko
- Cable de salida 1m de largo (Jack DC macho, DE 5.5mm, DI 2.5mm), viene con tres puntas intercambiables

Dimensiones

- D X W X H (mm) 68 x 42 x 74 Peso 280g

Tiempo de autonomía aproximado

Carga Tiempo de autonomía @ 12Vdc (min)

- 12V/1.0A Router: 150 min
- 12V/1.5A Router: 120 min
- 120 12V/2.0A Router: 90 min

OPINIONES

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Jesús A. el día 28/06/2018

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1 opinión

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2 opiniones

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ATS SWITCH DE TRANSFERENCIA

0 opinión

Añadir al carrito

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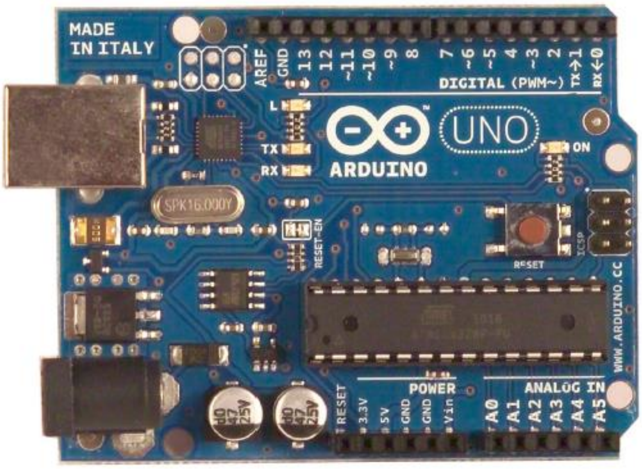
Datasheet Arduino Uno Rev3

Arduino UNO



Product Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Index

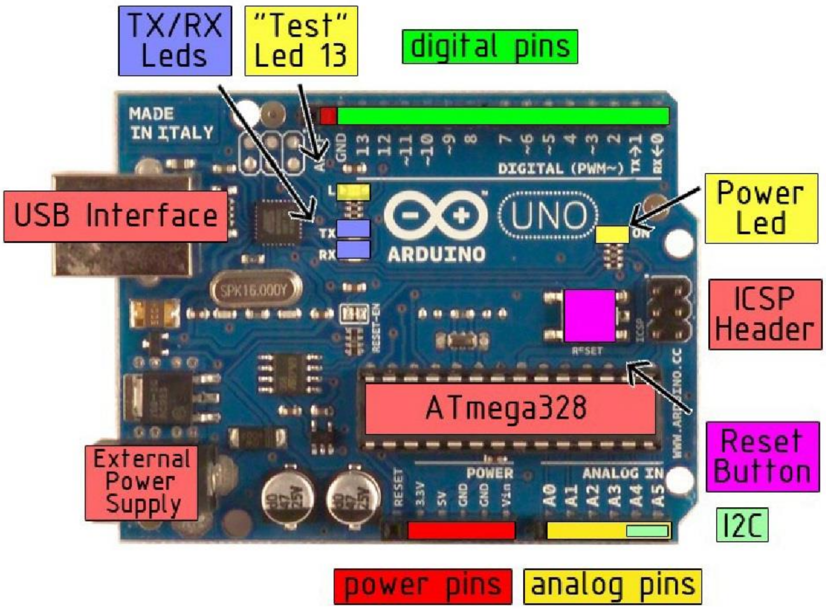
Technical Specification

EAGLE files: arduino-duemilanove-uno-design.zip Schematic: arduino-uno-schematic.pdf

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

the board



Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. TThese pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- **I^{2}C: 4 (SDA) and 5 (SCL).** Support I^{2}C (TWI) communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and Atmega328 ports.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an *.inf file is required..

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.

The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega328 datasheet.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno w/ ATmega328" from the **Tools > Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega8U2 firmware source code is available . The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader).

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Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

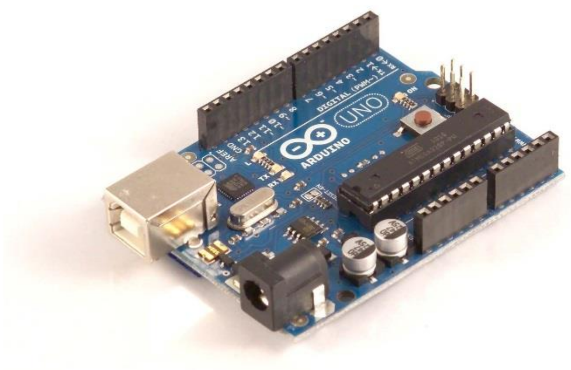
The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.



How to use Arduino

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

Arduino is a cross-platoform program. You'll have to follow different instructions for your personal OS. Check on the Arduino site for the latest instructions. *http://arduino.cc/en/Guide/HomePage*

Linux Install **Windows Install** **Mac Install**

Once you have downloaded/unzipped the arduino IDE, you can Plug the Arduino to your PC via USB cable.

Blink led

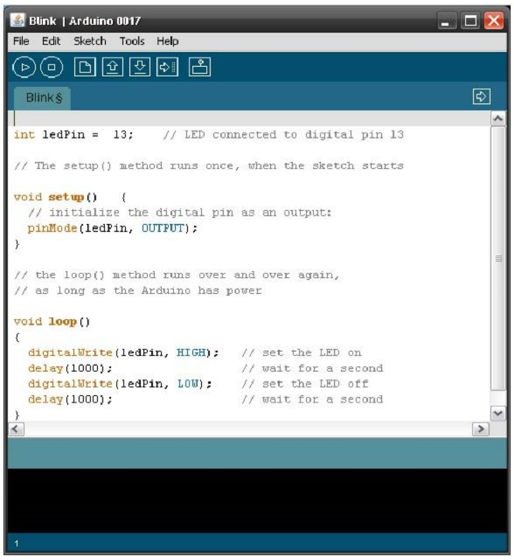
Now you're actually ready to "burn" your first program on the arduino board. To select "blink led", the physical translation of the well known programming "hello world", select

**File>Sketchbook>
Arduino-0017>Examples>
Digital>Blink**

Once you have your skecth you'll see something very close to the screenshot on the right.

In **Tools>Board** select

Now you have to go to
Tools>SerialPort
and select the right serial port, the one arduino is attached to.



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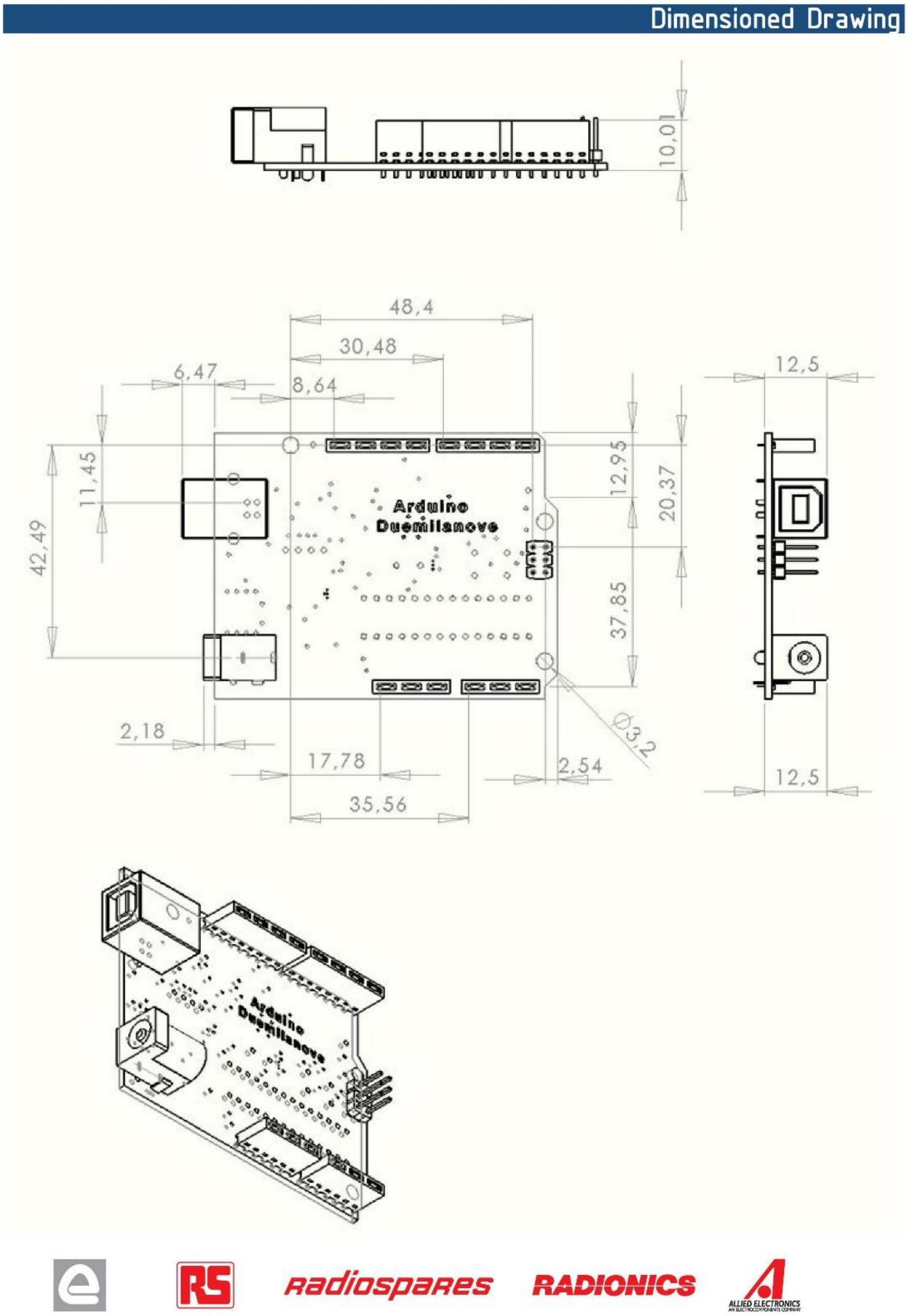
Dimensioned Drawing
10,01
48,4
30,48
6,47
8,64
12,5
11,45
42,49
12,95
20,37
37,85
Arduino
Duemilanove
2,18
17,78
35,56
2,54
Ø3,2
12,5
RS
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Terms & Conditions

1. Warranties

1.1 The producer warrants that its products will conform to the Specifications. This warranty lasts for one (1) years from the date of the sale. The producer shall not be liable for any defects that are caused by neglect, misuse or mistreatment by the Customer, including improper installation or testing, or for any products that have been altered or modified in any way by a Customer. Moreover, The producer shall not be liable for any defects that result from Customer's design, specifications or instructions for such products. Testing and other quality control techniques are used to the extent the producer deems necessary.

1.2 If any products fail to conform to the warranty set forth above, the producer's sole liability shall be to replace such products. The producer's liability shall be limited to products that are determined by the producer not to conform to such warranty. If the producer elects to replace such products, the producer shall have a reasonable time to replacements. Replaced products shall be warranted for a new full warranty period.

1.3 EXCEPT AS SET FORTH ABOVE, PRODUCTS ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." THE PRODUCER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING PRODUCTS, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE

1.4 Customer agrees that prior to using any systems that include the producer products, Customer will test such systems and the functionality of the products as used in such systems. The producer may provide technical, applications or design advice, quality characterization, reliability data or other services. Customer acknowledges and agrees that providing these services shall not expand or otherwise alter the producer's warranties, as set forth above, and no additional obligations or liabilities shall arise from the producer providing such services.

1.5 The Arduino™ products are not authorized for use in safety-critical applications where a failure of the product would reasonably be expected to cause severe personal injury or death. Safety-Critical Applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Arduino™ products are neither designed nor intended for use in military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Arduino™ products which is solely at the Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

1.6 Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products and any use of Arduino™ products in Customer's applications, notwithstanding any applications-related information or support that may be provided by the producer.

2. Indemnification

The Customer acknowledges and agrees to defend, indemnify and hold harmless the producer from and against any and all third-party losses, damages, liabilities and expenses it incurs to the extent directly caused by: (i) an actual breach by a Customer of the representation and warranties made under this terms and conditions or (ii) the gross negligence or willful misconduct by the Customer.

3. Consequential Damages Waiver

In no event the producer shall be liable to the Customer or any third parties for any special, collateral, indirect, punitive, incidental, consequential or exemplary damages in connection with or arising out of the products provided hereunder, regardless of whether the producer has been advised of the possibility of such damages. This section will survive the termination of the warranty period.

4. Changes to specifications

The producer may make changes to specifications and product descriptions at any time, without notice. The Customer must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." The producer reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The product information on the Web Site or Materials is subject to change without notice. Do not finalize a design with this information.

Enviromental Policies

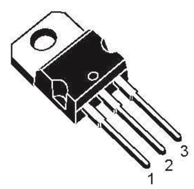
The producer of Arduino™ has joined the Impatto Zero® policy of LifeGate.it. For each Arduino board produced is created / looked after half squared Km of Costa Rica's forest's.

Transistor Darlington TIP112

TIP110/112
TIP115/117

COMPLEMENTARY SILICON POWER DARLINGTON TRANSISTORS

- STMicroelectronics PREFERRED SALESTYPES
- COMPLEMENTARY PNP - NPN DEVICES
- MONOLITHIC DARLINGTON CONFIGURATION
- INTEGRATED ANTIPARALLEL COLLECTOR-EMITTER DIODE



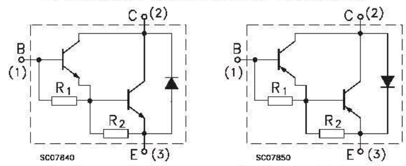
TO-220

APPLICATIONS
- LINEAR AND SWITCHING INDUSTRIAL EQUIPMENT

DESCRIPTION
The TIP110 and TIP112 are silicon Epitaxial-Base NPN transistors in monolithic Darlington configuration mounted in Jedec TO-220 plastic package. They are intented for use in medium power linear and switching applications.

The complementary PNP types are TIP115 and TIP117.

INTERNAL SCHEMATIC DIAGRAM



R_1 Typ.= 7K Ω R_2 Typ.= 230

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value		Unit
		NPN	TIP110	TIP112	
		PNP	TIP115	TIP117	
V_{CBO}	Collector-Base Voltage (I_E = 0)		60	100	V
V_{CEO}	Collector-Emitter Voltage (I_B = 0)		60	100	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)		5		V
I_C	Collector Current		2		A
I_{CM}	Collector Peak Current		4		A
I_B	Base Current		50		mA
P_{tot}	Total Dissipation at $T_{case} \leq 25$ °C $T_{amb} \leq 25$ °C		50 2		W W
T_{stg}	Storage Temperature		-65 to 150		°C
T_j	Max. Operating Junction Temperature		150		°C

* For PNP types voltage and current values are negative

June 1999 1/6

THERMAL DATA

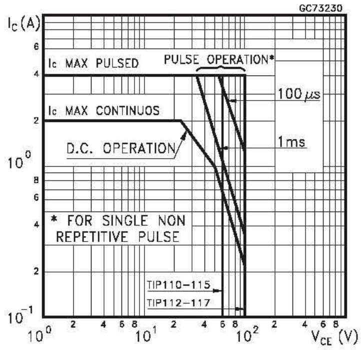
$R_{thj-case}$	Thermal Resistance Junction-case	Max	2.5	°C/W
$R_{thj-amb}$	Thermal Resistance Junction-ambient	Max	62.5	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

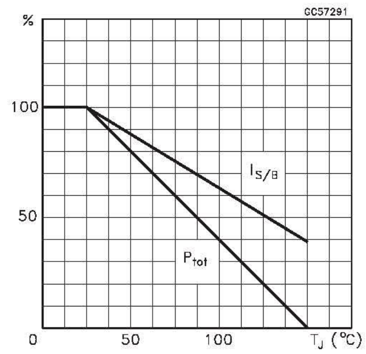
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CEO}	Collector Cut-off Current (I_B = 0)	V_{CE} = Half Rated V_{CEO}			2	mA
I_{CBO}	Collector Cut-off Current (I_E = 0)	V_{CB} = Rated V_{CBO}			1	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage (I_B = 0)	I_C = 30 mA for **TIP110/115** for **TIP112/117**	 60 100			 V V
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 2 A I_B = 8 mA			2.5	V
V_{BE}*	Base-Emitter Voltage	I_C = 2 A V_{CE} = 4 V			2.8	V
h_{FE}*	DC Current Gain	I_C = 1 A V_{CE} = 4 V I_C = 2 A V_{CE} = 4 V	1000 500			

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
For PNP types voltage and current values are negative.

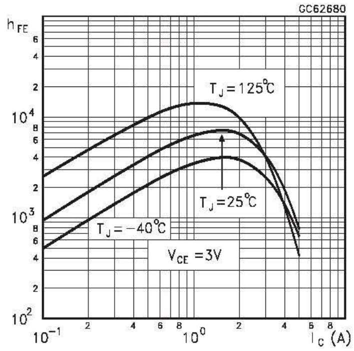
Safe Operating Areas



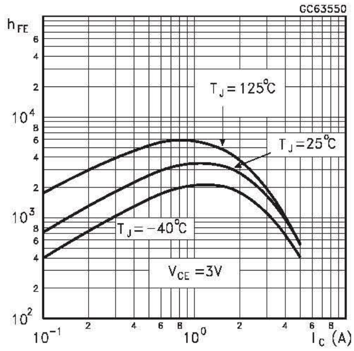
Derating Curve



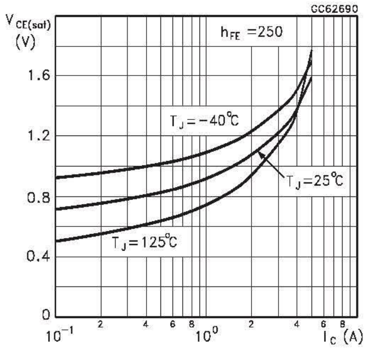
DC Current Gain (NPN type)



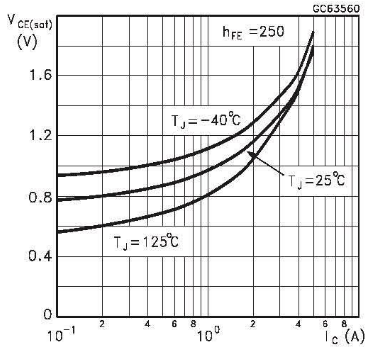
DC Current Gain (PNP type)



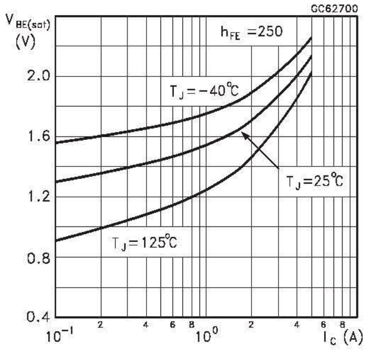
Collector-Emitter Saturation Voltage (NPN type)



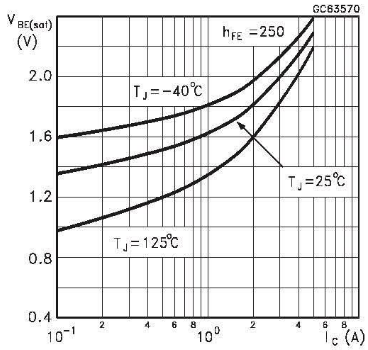
Collector-Emitter Saturation Voltage (PNP type)



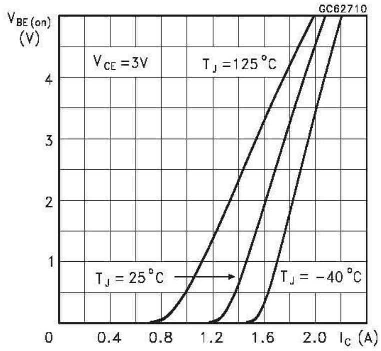
Base-Emitter Saturation Voltage (NPN type)



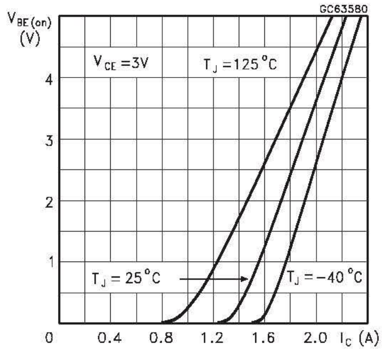
Base-Emitter Saturation Voltage (PNP type)



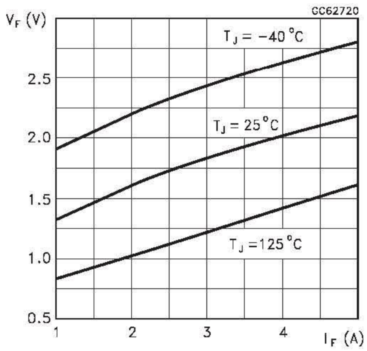
Base-Emitter On Voltage (NPN type)



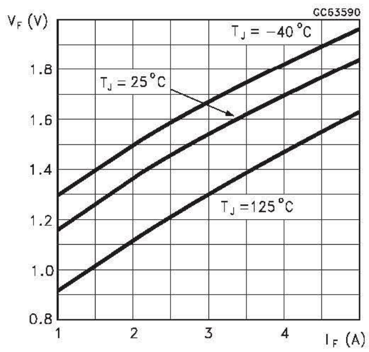
Base-Emitter On Voltage (PNP type)



Freewheel Diode Forward Voltage (NPN types)

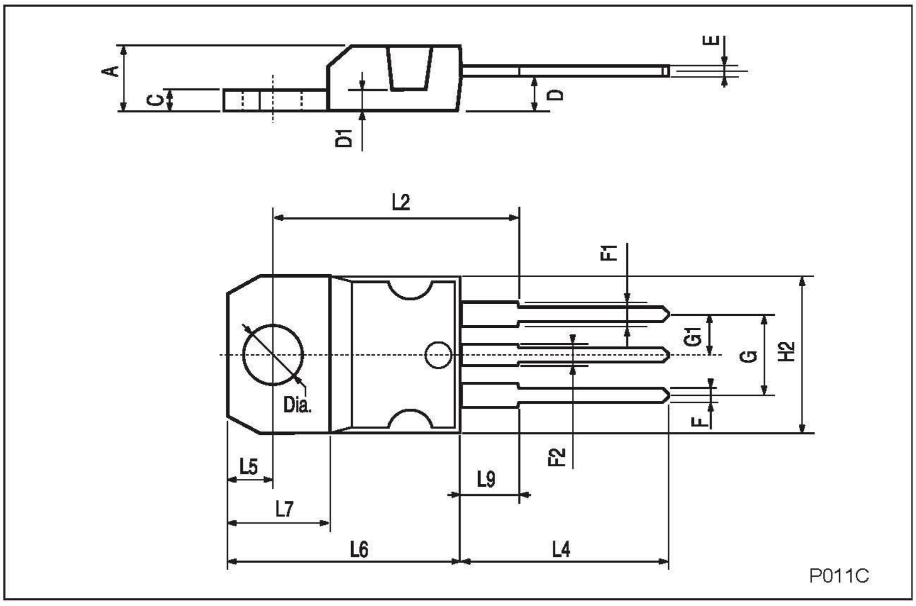


Freewheel Diode Forward Voltage (PNP types)



TO-220 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
C	1.23		1.32	0.048		0.051
D	2.40		2.72	0.094		0.107
D1		1.27			0.050	
E	0.49		0.70	0.019		0.027
F	0.61		0.88	0.024		0.034
F1	1.14		1.70	0.044		0.067
F2	1.14		1.70	0.044		0.067
G	4.95		5.15	0.194		0.203
G1	2.4		2.7	0.094		0.106
H2	10.0		10.40	0.393		0.409
L2		16.4			0.645	
L4	13.0		14.0	0.511		0.551
L5	2.65		2.95	0.104		0.116
L6	15.25		15.75	0.600		0.620
L7	6.2		6.6	0.244		0.260
L9	3.5		3.93	0.137		0.154
DIA.	3.75		3.85	0.147		0.151



Relé

Panasonic Automation Controls Catalog

1 Form A 8A/16A, Small Polarized Power Relays (latching type)

DW RELAYS (ADW1)

Low profile type
(Inrush type)

Reflow
compatible type
(Standard type)

IEC60335-1
compliant type
(Standard & Inrush type)

RoHS compliant

Protective construction: Flux-resistant type

FEATURES

1. Low profile type available (h = 15.8 mm .622 inch)
2. Inrush type available (TV-8 UL/C-UL approved)
3. IEC60335-1* compliant type available (PTI 325V VDE approved)
4. Reflow possible (pin-in-paste)
5. Certified by UL/C-UL, VDE

* Common safety standard for major electrical appliance

TYPICAL APPLICATIONS

1. Lighting control equipment
2. Smart meters
3. Industrial equipment
4. Security equipment
5. Home appliances
6. Various power supplies

ORDERING INFORMATION

ADW 1 ☐ ☐ ☐ ☐ W

Contact arrangement
1: 1 Form A

Operating function
1: 1 coil latching type
2: 2 coil latching type

Nominal coil voltage (DC)
03: 3V, 05: 5V, 06: 6V, 09: 9V, 12: 12V, 24: 24V

Contact capacity
Nil: Standard type (8A)
H: Inrush type (16A, Inrush current 100A)

Type classification
Nil: Reflow compatible type
L: Low profile type
T: IEC60335-1 compliant type

Notes: 1. "L" and "T" type are non-compliant reflow soldering.
2. Low profile type is available (inrush type only).
3. The suffix "W" on the part number is only displayed on the inner and outer packaging. It is not displayed on the relay.

2016.03 | industrial.panasonic.com/ac/e/ –1– ASCTB8E 201603-T

DW (ADW1)

TYPES

1. Standard type (8A) (Reflow compatible type)

Contact arrangement	Nominal coil voltage	Part No.	
		1 coil latching type	2 coil latching type
1 Form A	3V DC	ADW1103W	ADW1203W
	5V DC	ADW1105W	ADW1205W
	6V DC	ADW1106W	ADW1206W
	9V DC	ADW1109W	ADW1209W
	12V DC	ADW1112W	ADW1212W
	24V DC	ADW1124W	ADW1224W

Standard packing: Carton: 100 pcs.; Case: 500 pcs.
Note: Carton packing is standard. Tube packing type is also available. Please consult us for details.

2. Standard type (8A) (IEC60335-1 compliant type)

Contact arrangement	Nominal coil voltage	Part No.	
		1 coil latching type	2 coil latching type
1 Form A	3V DC	ADW1103TW	ADW1203TW
	5V DC	ADW1105TW	ADW1205TW
	6V DC	ADW1106TW	ADW1206TW
	9V DC	ADW1109TW	ADW1209TW
	12V DC	ADW1112TW	ADW1212TW
	24V DC	ADW1124TW	ADW1224TW

Standard packing: Carton: 100 pcs.; Case: 500 pcs.
Note: Carton packing is standard. Tube packing type is also available. Please consult us for details.

3. Inrush type (16A, Inrush current 100A · IEC60335-1 compliant type)*1, *2

Contact arrangement	Nominal coil voltage	Part No.	
		1 coil latching type	2 coil latching type
1 Form A	3V DC	ADW1103HTW	ADW1203HTW
	5V DC	ADW1105HTW	ADW1205HTW
	6V DC	ADW1106HTW	ADW1206HTW
	9V DC	ADW1109HTW	ADW1209HTW
	12V DC	ADW1112HTW	ADW1212HTW
	24V DC	ADW1124HTW	ADW1224HTW

Standard packing: 100 pcs.; Case: 500 pcs.
Notes: *1. Carton packing is standard. Tube packing type is also available. Please contact us for details.
*2. Please contact us for the reflow compatible type of inrush type (16A, Inrush current 100A · IEC60335-1 compliant type).

4. Inrush type (16A, Inrush current 100A · Low profile type)

Contact arrangement	Nominal coil voltage	Part No.	
		1 coil latching type	2 coil latching type
1 Form A	3V DC	ADW1103HLW	ADW1203HLW
	5V DC	ADW1105HLW	ADW1205HLW
	6V DC	ADW1106HLW	ADW1206HLW
	9V DC	ADW1109HLW	ADW1209HLW
	12V DC	ADW1112HLW	ADW1212HLW
	24V DC	ADW1124HLW	ADW1224HLW

Standard packing: 100 pcs.; Case: 500 pcs.

DW (ADW1)

RATING

1. Coil data

1) 1 coil latching type

Nominal coil voltage	Set voltage (at 20°C 68°F)	Reset voltage (at 20°C 68°F)	Nominal operating current [±10%] (at 20°C 68°F)	Coil resistance [±10%] (at 20°C 68°F)	Nominal operating power	Max. applied voltage (at 20°C 68°F)
3V DC	*80%V or less of nominal voltage (Initial)	*80%V or less of nominal voltage (Initial)	66.7mA	45Ω	200mW	110%V of nominal voltage
5V DC			40.0mA	125Ω		
6V DC			33.3mA	180Ω		
9V DC			22.2mA	405Ω		
12V DC			16.7mA	720Ω		
24V DC			8.3mA	2,880Ω		

2) 2 coil latching type

Nominal coil voltage	Set voltage (at 20°C 68°F)	Reset voltage (at 20°C 68°F)	Nominal operating current [±10%] (at 20°C 68°F)		Coil resistance [±10%] (at 20°C 68°F)		Nominal operating power		Max. applied voltage (at 20°C 68°F)
			Set coil	Reset coil	Set coil	Reset coil	Set coil	Reset coil	
3V DC	*80%V or less of nominal voltage (Initial)	*80%V or less of nominal voltage (Initial)	133.3mA	133.3mA	22.5Ω	22.5Ω	400mW	400mW	110%V of nominal voltage
5V DC			80.0mA	80.0mA	62.5Ω	62.5Ω			
6V DC			66.7mA	66.7mA	90 Ω	90 Ω			
9V DC			44.4mA	44.4mA	202.5Ω	202.5Ω			
12V DC			33.3mA	33.3mA	360 Ω	360 Ω			
24V DC			16.7mA	16.7mA	1,440 Ω	1,440 Ω			

*Square, pulse drive

2. Specifications

Characteristics	Item		Specifications	
			Standard type	Inrush type
Contact	Arrangement		1 Form A	
	Contact resistance (Initial)		Max. 100 mΩ (By voltage drop 6 V DC 1A)	
	Contact material		$AgSnO_2$ type	
Rating	Nominal switching capacity (resistive load)		8A 250V AC	16A 277V AC
	Max. switching power (resistive load)		2,000VA	4,432VA
	Max. switching voltage		250V AC	277V AC
	Max. switching current		8A AC	16A AC
	Nominal operating power		200mW (1 coil latching type), 400mW (2 coil latching type)	
	Min. switching capacity (Reference value)*1		100mA 5 V DC	
Electrical characteristics	Insulation resistance (Initial)		Min. 1,000MΩ (at 500V DC, Measurement at same location as "Breakdown voltage" section)	
	Breakdown voltage (Initial)	Between open contacts	1,000 Vrms for 1min. (Detection current: 10mA)	
		Between contact and coil	5,000 Vrms for 1min. (Detection current: 10mA)	
	Surge breakdown voltage*2 (Between contact and coil)		12,000 V (Initial)	
	Set time (at 20°C 68°F) (Initial)		Max. 15 ms (Nominal voltage applied to the coil, excluding contact bounce time)	
	Reset time (at 20°C 68°F) (Initial)		Max. 15 ms (Nominal voltage applied to the coil, excluding contact bounce time)	
Mechanical characteristics	Shock resistance	Functional	100 m/s² (Half-wave pulse of sine wave: 11 ms; detection time: 10µs)	
		Destructive	1,000 m/s² (Half-wave pulse of sine wave: 6 ms)	
	Vibration resistance	Functional	10 to 55 Hz at double amplitude of 2 mm (Detection time: 10µs)	
		Destructive	10 to 55 Hz at double amplitude of 3 mm	
Expected life	Mechanical		Min. 10^6 (at 180 times/min.)	
	Electrical	Resistive load	Min. 5×10^4 (at 8A 250V AC, at 20 times/min.) Min. 10^5 (at 5A 250V AC, at 20 times/min.) (IEC60335-1 type only)	Min. 2×10^4 (at 16A 277V AC, ON:OFF = 1s:5s) Min. 5×10^4 (at 8A 250V AC, at 20 times/min.)
		Inrush current	—	Min. 2.5×10^4 [Inrush 100A 600W (120V AC) Tungsten] Cycle rate ON:OFF = 1s:59s
Conditions	Conditions for operation, transport and storage*3 *4		Temperature: –40°C to +85°C –40°F to +185°F Humidity: 5 to 85% R.H. (Not freezing and condensing at low temperature)	Temperature: –40°C to +85°C –40°F to +185°F (8A or less), –40°C to +70°C –40°F to +158°F (Over 8A to 16A) Humidity: 5 to 85% R.H. (Not freezing and condensing at low temperature)
Unit weight			Approx. 8 g .28 oz (Low profile type: Approx. 7.5 g .26 oz)	

Notes: *1. Minimum switching load is a guide to the lower current limit of switching under the micro-load. This parameter is changed by the condition, such as switching times, environment condition, and expected reliability. Therefore, Panasonic Corporation cannot assure the reliability. When the relay is used lower than minimum switching load, reliability is attrition. Please use the relay over minimum switching load.

*2. Wave is standard shock voltage of ±1.2×50µs according to JEC-212-1981

*3. The upper limit of the ambient temperature is the maximum temperature that can satisfy the coil temperature rise value. Refer to Usage, transport and storage conditions in NOTES.

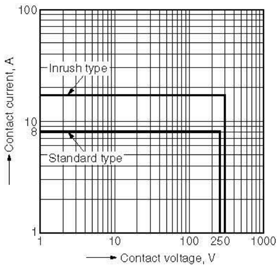
*4. Allowable range when in original packaging is –40°C to +70°C –40°F to +158°F.

DW (ADW1)

REFERENCE DATA

■ Standard type and Inrush type

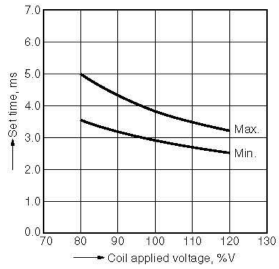
1. Max. switching capacity (AC resistive load)



■ Standard type

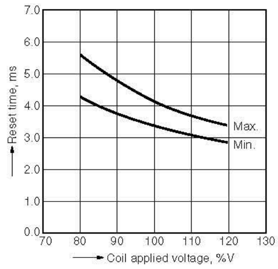
1. Set time (1 coil latching type)

Tested sample: ADW1106, 15 pcs
Ambient temperature: 28°C 82.4°F
Contact load: 5V DC, 10mA



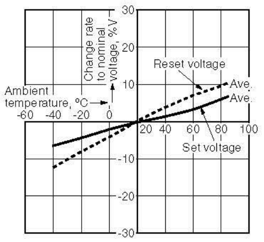
2. Reset time (1 coil latching type)

Tested sample: ADW1106, 15 pcs
Ambient temperature: 28°C 82.4°F
Contact load: 5V DC, 10mA



3. Ambient temperature characteristics

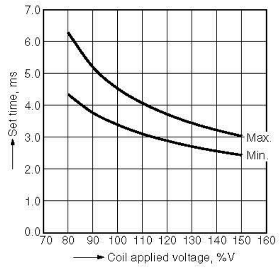
Tested sample: ADW1106, 6pcs
Ambient temperature: –40°C to +85°C
–40°F to +185°F



■ Inrush type

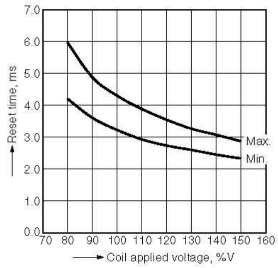
1. Set time (1 coil latching type)

Tested sample: ADW1112HL, 30 pcs
Ambient temperature: 28°C 82.4°F
Contact load: 5V DC, 10mA



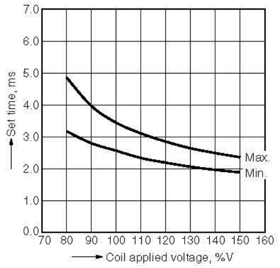
2. Reset time (1 coil latching type)

Tested sample: ADW1112HL, 30 pcs
Ambient temperature: 28°C 82.4°F
Contact load: 5V DC, 10mA



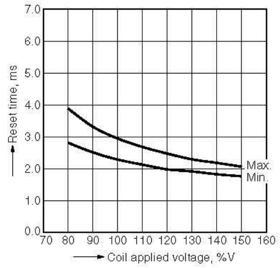
3. Set time (2 coil latching type)

Tested sample: ADW1212HL, 30 pcs
Ambient temperature: 28°C 82.4°F
Contact load: 5V DC, 10mA



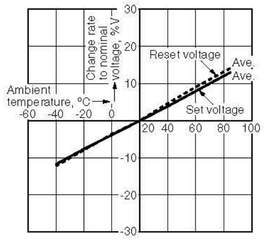
4. Reset time (2 coil latching type)

Tested sample: ADW1212HL, 30 pcs
Ambient temperature: 28°C 82.4°F
Contact load: 5V DC, 10mA



5. Ambient temperature characteristics

Tested sample: ADW1105HL, 6pcs
Ambient temperature: –40°C to +85°C
–40°F to +185°F

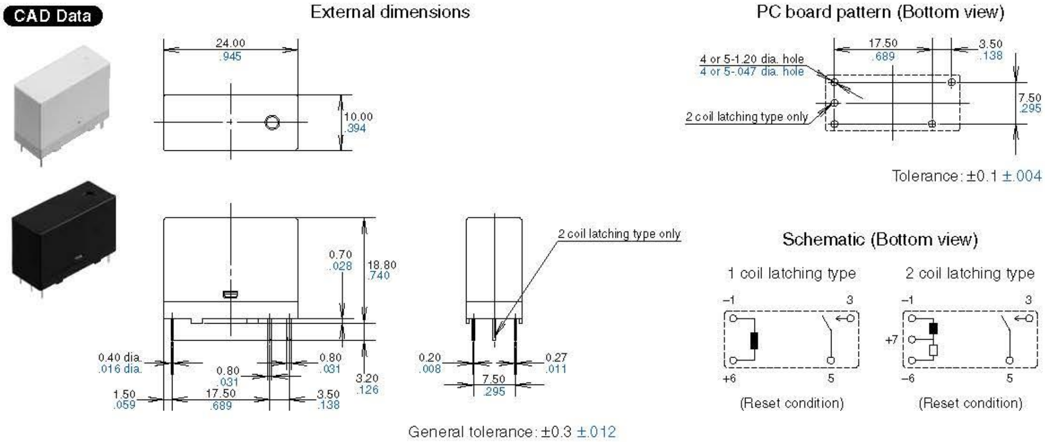


DW (ADW1)

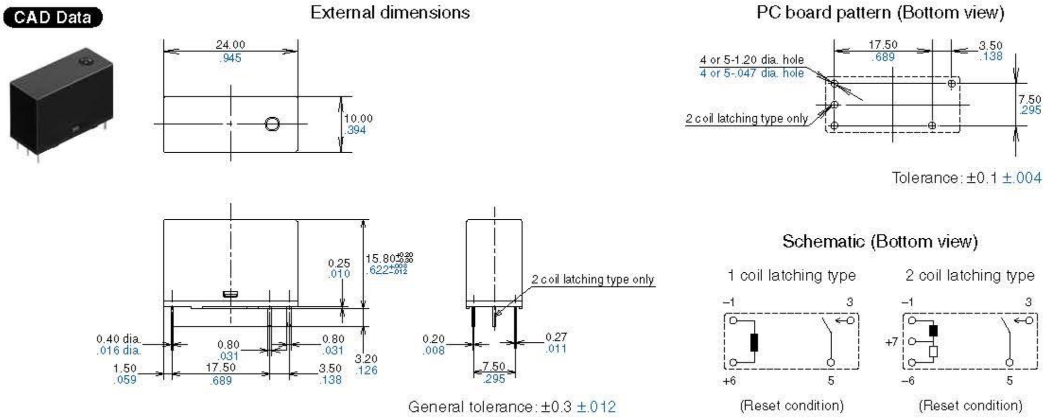
DIMENSIONS (mm inch)

The CAD data of the products with a CAD Data mark can be downloaded from: http://industrial.panasonic.com/ac/e/

1. Standard height type



2. Low profile type



SAFETY STANDARDS

Item	UL/C-UL (Recognized)		VDE (Recognized)		TV rating (UL/C-UL)	
	File No.	Contact rating	File No.	Contact rating	File No.	Contact rating
Standard type (8A)	E43149	8A 250V AC R 85°C 185°F 5×10⁴ 5A 30V DC R 85°C 185°F 5×10⁴	40032254	8A 250V AC (cosϕ=1.0) 85°C 185°F 5×10⁴ 5A 30V DC (0ms) 85°C 185°F 5×10⁴	—	—
Inrush type (16A)	E43149	16A 277V AC R 60°C 140°F 5×10⁴ 8A 250V AC R 85°C 185°F 5×10⁴ 5A 30V DC R 85°C 185°F 5×10⁴ 1200W Standard ballast 277V AC 50°C 122°F 6×10³ 1200W Tungsten, 240V AC 50°C 122°F 6×10³ 600W Tungsten, 120V AC 50°C 122°F 2.5×10⁴ 5A 347V AC R 85°C 185°F (UL standards only) 5×10⁴	40032254	16A 277V AC (cosϕ=1.0) 70°C 158°F 5×10⁴ 8A 250V AC (cosϕ=1.0) 85°C 185°F 5×10⁴ 5A 30V DC (0ms) 85°C 185°F 5×10⁴	E43149	TV-8 rating 240V AC 40°C 104°F 2.5×10⁴

Notes: 1. CSA standards: Certified by C-UL
2. CQC standard: Application pending, Please contact us.

DW (ADW1)

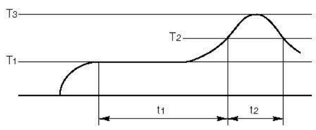
NOTES

1. For cautions for use, please read "GENERAL APPLICATION GUIDELINES".

2. Solder and cleaning conditions

1) Flow solder mounting conditions
Please obey the following conditions when soldering automatically.
(1) Preheating: within 120°C 248°F (solder surface terminal portion) and within 120 seconds
(2) Soldering iron: 260°C±5°C 500°F±41°F (solder temperature) and within 6 seconds (soldering time)
*Furthermore, because the type of PC board used and other factors may influence the relays, test that the relays function properly on the actual PC board on which they are mounted.

2) Reflow solder mounting (Pin-in-Paste mounting) conditions



T_1 = 150 to 180°C 302 to 356°F
T_2 = 230°C 446°F or more
T_3 = 250°C 482°F or less
t_1 = 60 to 120 seconds
t_2 = within 30 seconds

- Cautions to observe when mounting temperature increases in the relay are greatly dependent on the way different parts are located a PC board and the heating method of the reflow device. Therefore, please conduct testing on the actual device beforehand after making sure the parts soldered on the relay terminals and the top of the relay case are within the temperature conditions given above.

3) Since this is not a sealed type relay, do not clean it as is. Also, be careful not to allow flux to overflow above the PC board or enter the inside of the relay.

3. Max. applied voltage

It is not allowed to apply the continuous maximum voltage to the coil.
In order to obtain the specified performance, please apply nominal coil voltage.

4. Set/reset pulse time of latching type relay

Regarding the set/reset pulse time of the latching type relay, it is recommended to apply nominal coil voltage for minimum 30ms pulse across the coil to secure the sure operation considering the ambient temperature and condition change through service life.

Please contact ....

Panasonic Corporation
Electromechanical Control Business Division
■ 1006, Oaza Kadoma, Kadoma-shi, Osaka 571-8506, Japan
industrial.panasonic.com/ac/e/

ASCTB8E-2 201603-2YKN

Specifications are subject to change without notice.

LILYGO TTGO T-Journal ESP32 Camera Module Development Board

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- Communication distance 300m

Bluetooth

- Bluetooth protocol v4.2BR / EDR and BLE standard
- Radiofrequency with -98dBm sensitivity NZIF receiver Class-1,Class-2&Class-3 emitter AFH
- Audio frequency CVSD&SBC audio frequency

Software Specifications

- Wifi Mode Station / SoftAP / SoftAP+Station / P2P
- Security mechanism WPA / WPA2 / WPA2-Enterprise/WPS
- Encryption Type AES / RSA / ECC / SHA
- Firmware upgrade UART download/OTA (Through network/host to download and write firmware)
- Software Development Support cloud server development /SDK for user firmware development
- Networking protocol IPv4 / IPv6 / SSL / TCP / UDP / HTTP / FTP / MQTT
- User Configuration AT + Instruction set, cloud server, android / iOS

Specifications

SKU	19353
Manufacturer	LILYGO

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Details

Hardware

- Chipset ESPRESSIF-ESP32-PCIO-D4 240MHz Xtensa® single-/dual-core 32-bit LX6 microprocessor
- FLASH QSPI flash / SRAM, up to 4 x 16 MB
- SRAM 520 kB SRAM
- KEY reset，IO32
- 0.91 inch SSD1306 OLED display
- Power indicator red LED
- USB to TTL CP2104
- Camera OV2640 2 Megapixel
- Steering engine analog servo
- On-board clock 40 MHz crystal oscillator
- Working voltage 2.3 V - 3.6 V
- Working current about 160 mA
- Working temperature range -40℃ ~ +85℃
- Size 64.57 mm x 23.98 mm
- Power Supply Specifications
- Power Supply USB 5 V / 1 A
- Charging current 1 A
- Battery 3.7 V lithium battery

WiFi

- Standard FCC / CE / TELEC / KCC / SRRC / NCC (esp32 chip)
- Protocol 802.11 b/g/n/e/i (802.11n，speed up to150Mbps)A-MPDU and A-MSDU polymerization，
- Support 0.4μS Protection interval
- Frequency range 2.4GHz~2.5GHz(2400M~2483.5M)
- Transmit Power 22dBm

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Amplificador operacional LM741

Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (October 2004) to Revision D — **Page**

- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
- Removed NAD 10-Pin CLGA pinout 3
- Removed obselete M (S0-8) package from the data sheet 4
- Added recommended operating supply voltage spec 4
- Added recommended operating temperature spec 4

Changes from Revision C (March 2013) to Revision D — **Page**

- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
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- Added recommended operating temperature spec 4

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TEXAS INSTRUMENTS

LM741

SNOSC25D – MAY 1998 – REVISED OCTOBER 2015

LM741 Operational Amplifier

1 Features

- Overload Protection on the Input and Output
- No Latch-Up When the Common-Mode Range is Exceeded

2 Applications

- Comparators
- Multivibrators
- DC Amplifiers
- Summing Amplifiers
- Integrator or Differentiators
- Active Filters

3 Description

The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common-mode range is exceeded, as well as freedom from oscillations.

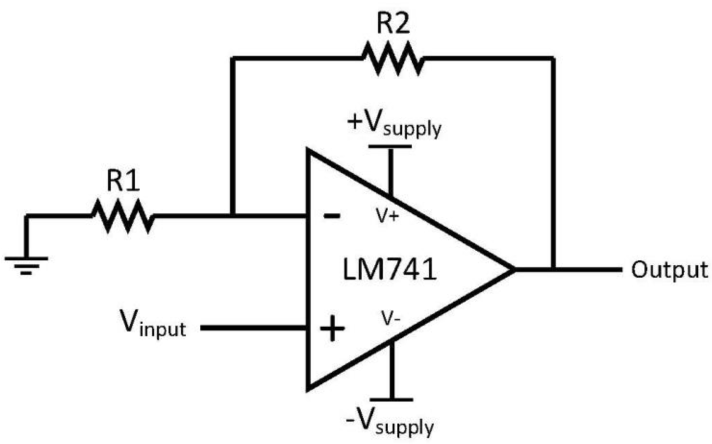
The LM741C is identical to the LM741 and LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM741	TO-99 (8)	9.08 mm × 9.08 mm
	CDIP (8)	10.16 mm × 6.502 mm
	PDIP (8)	9.81 mm × 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)(3)

		MIN	MAX	UNIT
Supply voltage	LM741, LM741A		±22	V
	LM741C		±18	
Power dissipation (4)			500	mW
Differential input voltage			±30	V
Input voltage (5)			±15	V
Output short circuit duration		Continuous		
Operating temperature	LM741, LM741A	–50	125	°C
	LM741C	0	70	
Junction temperature	LM741, LM741A		150	°C
	LM741C		100	
Soldering information	PDIP package (10 seconds)		260	°C
	CDIP or TO-99 package (10 seconds)		300	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) For military specifications see RETS741X for LM741 and RETS741AX for LM741A.
(3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4) For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{jA} P_D)$.
(5) For supply voltages less than ±15 V, the absolute maximum input voltage is equal to the supply voltage.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±400	V

(1) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Supply voltage (VDD-GND)	LM741, LM741A	±10	±15	±22	V
	LM741C	±10	±15	±18	
Temperature	LM741, LM741A	–55		125	°C
	LM741C	0		70	

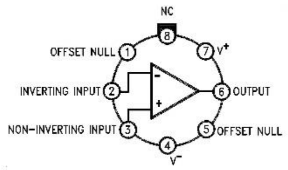
6.4 Thermal Information

THERMAL METRIC(1)		LM741			UNIT
		LMC (TO-99)	NAB (CDIP)	P (PDIP)	
		8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	100	100	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	25	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

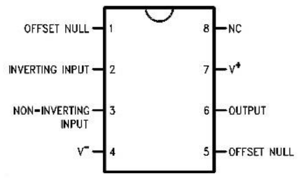
5 Pin Configuration and Functions

LMC Package
8-Pin TO-99
Top View



LM741H is available per JM38510/10101

NAB Package
8-Pin CDIP or PDIP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
INVERTING INPUT	2	I	Inverting signal input
NC	8	N/A	No Connect, should be left floating
NONINVERTING INPUT	3	I	Noninverting signal input
OFFSET NULL OFFSET NULL	1, 5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
OUTPUT	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V–	4	I	Negative supply voltage

Electrical Characteristics, LM741A[(1)] (continued)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output voltage swing		V_S = ±20 V	R_L ≥ 10 kΩ	±16			V
			R_L ≥ 2 kΩ	±15			
Output short circuit current		T_A = 25°C		10	25	35	mA
		$T_{AMIN} \le T_A \le T_{AMAX}$		10		40	
Common-mode rejection ratio		R_S ≤ 50 Ω, V_{CM} = ±12 V, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 50 Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response	Rise time	T_A = 25°C, unity gain			0.25	0.8	µs
	Overshoot				6%	20%	
Bandwidth [(2)]		T_A = 25°C		0.437	1.5		MHz
Slew rate		T_A = 25°C, unity gain		0.3	0.7		V/µs
Power consumption		V_S = ±20 V	T_A = 25°C		80	150	mW
			$T_A = T_{AMIN}$			165	
			$T_A = T_{AMAX}$			135	

(2) Calculated value from: BW (MHz) = 0.35/Rise Time (µs).

6.7 Electrical Characteristics, LM741C[(1)]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		R_S ≤ 10 kΩ	T_A = 25°C		2	6	mV
			$T_{AMIN} \le T_A \le T_{AMAX}$			7.5	mV
Input offset voltage adjustment range		T_A = 25°C, V_S = ±20 V			±15		mV
Input offset current		T_A = 25°C			20	200	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				300	
Input bias current		T_A = 25°C			80	500	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				0.8	µA
Input resistance		T_A = 25°C, V_S = ±20 V		0.3	2		MΩ
Input voltage range		T_A = 25°C		±12	±13		V
Large signal voltage gain		V_S = ±15 V, V_O = ±10 V, R_L ≥ 2 kΩ	T_A = 25°C	20	200		V/mV
			$T_{AMIN} \le T_A \le T_{AMAX}$	15			
Output voltage swing		V_S = ±15 V	R_L ≥ 10 kΩ	±12	±14		V
			R_L ≥ 2 kΩ	±10	±13		
Output short circuit current		T_A = 25°C			25		mA
Common-mode rejection ratio		R_S ≤ 10 kΩ, V_{CM} = ±12 V, $T_{AMIN} \le T_A \le T_{AMAX}$		70	90		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 10 Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		77	96		dB
Transient response	Rise time	T_A = 25°C, Unity Gain			0.3		µs
	Overshoot				5%		
Slew rate		T_A = 25°C, Unity Gain			0.5		V/µs
Supply current		T_A = 25°C			1.7	2.8	mA
Power consumption		V_S = ±15 V, T_A = 25°C			50	85	mW

(1) Unless otherwise specified, these specifications apply for V_S = ±15 V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

6.5 Electrical Characteristics, LM741 (1)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		$R_S \le 10$ kΩ	T_A = 25°C		1	5	mV
			$T_{AMIN} \le T_A \le T_{AMAX}$			6	mV
Input offset voltage adjustment range		T_A = 25°C, V_S = ±20 V			±15		mV
Input offset current		T_A = 25°C			20	200	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$			85	500	nA
Input bias current		T_A = 25°C			80	500	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				1.5	µA
Input resistance		T_A = 25°C, V_S = ±20 V		0.3	2		MΩ
Input voltage range		$T_{AMIN} \le T_A \le T_{AMAX}$		±12	±13		V
Large signal voltage gain		V_S = ±15 V, V_O = ±10 V, $R_L \ge 2$ kΩ	T_A = 25°C	50	200		V/mV
			$T_{AMIN} \le T_A \le T_{AMAX}$	25			V/mV
Output voltage swing		V_S = ±15 V	$R_L \ge 10$ kΩ	±12	±14		V
			$R_L \ge 2$ kΩ	±10	±13		V
Output short circuit current		T_A = 25°C			25		mA
Common-mode rejection ratio		$R_S \le 10$ Ω, V_{CM} = ±12 V, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, $R_S \le 10$ Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response	Rise time	T_A = 25°C, unity gain			0.3		µs
	Overshoot				5%		
Slew rate		T_A = 25°C, unity gain			0.5		V/µs
Supply current		T_A = 25°C			1.7	2.8	mA
Power consumption		V_S = ±15 V	T_A = 25°C		50	85	mW
			$T_A = T_{AMIN}$		60	100	mW
			$T_A = T_{AMAX}$		45	75	mW

(1) Unless otherwise specified, these specifications apply for V_S = ±15 V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

6.6 Electrical Characteristics, LM741A (1)

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage	$R_S \le 50$ Ω	T_A = 25°C		0.8	3	mV
		$T_{AMIN} \le T_A \le T_{AMAX}$			4	mV
Average input offset voltage drift					15	µV/°C
Input offset voltage adjustment range	T_A = 25°C, V_S = ±20 V		±10			mV
Input offset current	T_A = 25°C			3	30	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				70	nA
Average input offset current drift					0.5	nA/°C
Input bias current	T_A = 25°C			30	80	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				0.21	µA
Input resistance	T_A = 25°C, V_S = ±20 V		1	6		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, V_S = ±20 V		0.5			MΩ
Large signal voltage gain	V_S = ±20 V, V_O = ±15 V, $R_L \ge 2$ kΩ	T_A = 25°C	50			V/mV
		$T_{AMIN} \le T_A \le T_{AMAX}$	32			V/mV
	V_S = ±5 V, V_O = ±2 V, $R_L \ge 2$ kΩ, $T_{AMIN} \le T_A \le T_{AMAX}$		10			V/mV

(1) Unless otherwise specified, these specifications apply for V_S = ±15 V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

Regulador de Tensión LM2576

Ordering & quality | Technical documentation | Design & development | Support & training

TEXAS INSTRUMENTS

LM2576, LM2576HV
SNVS107F – JUNE 1999 – REVISED MAY 2021

LM2576xx Series SIMPLE SWITCHER® 3-A Step-Down Voltage Regulator

1 Features

- Newer products available:
  - LMR33630 36-V, 3-A, 400-kHz synchronous converter
  - LM76003 60-V, 3.5-A, 2.2-MHz synchronous converter
- 3.3-V, 5-V, 12-V, 15-V, and adjustable output versions
- Adjustable version output voltage range,1.23 V to 37 V (57 V for HV version) ±4% maximum over line and load conditions
- Specified 3-A output current
- Wide input voltage range: 40 V Up to 60 V for HV version
- Requires only four external components
- 52-kHz fixed-frequency internal oscillator
- TTL-shutdown capability, low-power standby mode
- High efficiency
- Uses readily available standard inductors
- Create a custom design using the LMR33630 or LM76003 with the WEBENCH® Power Designer

2 Applications

- Motor drives
- Merchant network and server PSU
- Appliances
- Test and measurement equipment

3 Description

The LM2576 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, 15 V, and an adjustable output version.

Requiring a minimum number of external components, these regulators are simple to use and include fault protection and a fixed-frequency oscillator.

The LM2576 series offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially reduces the size of the heat sink, and in some cases no heat sink is required.

A standard series of inductors optimized for use with the LM2576 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

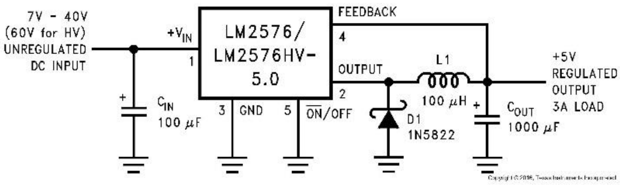
Other features include a ±4% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency. External shutdown is included, featuring 50-µA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

The new product, LMR33630, offers reduced BOM cost, higher efficiency, and an 85% reduction in solution size among many other features. The LM76003 requires very few external components and has a pinout designed for simple, optimum PCB layout for EMI and thermal performance. See the device comparison table to compare specs.

Device Information

PART NUMBER(1)	PACKAGE	BODY SIZE (NOM)
LM2576 LM2576HV	TO-220 (5)	10.16 mm × 8.51 mm
	DDPAK/TO-263 (5)	10.16 mm × 8.42 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Fixed Output Voltage Version Typical Application Diagram

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision E (June 2020) to Revision F (May 2021)	Page
• Added information for the LM76003 promotion	1
• Updated the numbering format for tables, figures, and cross-references throughout the document.	1

Changes from Revision D (January 2016) to Revision E (June 2020)	Page
• Added information about the LMR33630	1

Changes from Revision C (April 2013) to Revision D (January 2016)	Page
• Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1
• Moved the thermal resistance data from the *Electrical Characteristics: All Output Voltage Versions* table to the *Thermal Information* table	4

Changes from Revision B (April 2013) to Revision C (April 2013)	Page
• Changed layout of National Data Sheet to TI format	3

5 Pin Configuration and Functions

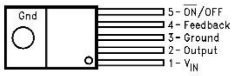


Figure 5-1. KC Package 5-Pin TO-220 Top View

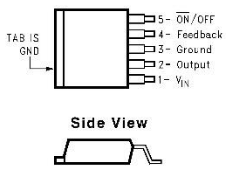


Figure 5-2. KTT Package 5-PIN DDPAK/TO-263 Top View

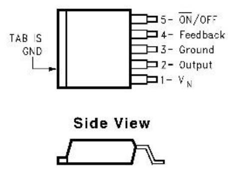


Figure 5-3. DDPAK/TO-263 (S) Package 5-Lead Surface-Mount Package Top View

Table 5-1. Pin Functions

PIN		I/O(1)	DESCRIPTION
NO.	NAME		
1	V_{IN}	I	Supply input pin to collector pin of high-side transistor. Connect to power supply and input bypass capacitors CIN. Path from V_{IN} pin to high frequency bypass C_{IN} and GND must be as short as possible.
2	OUTPUT	O	Emitter pin of the power transistor. This is a switching node. Attached this pin to an inductor and the cathode of the external diode.
3	GROUND	—	Ground pin. Path to C_{IN} must be as short as possible.
4	FEEDBACK	I	Feedback sense input pin. Connect to the midpoint of feedback divider to set VOUT for ADJ version or connect this pin directly to the output capacitor for a fixed output version.
5	$\overline{ON}$/OFF	I	Enable input to the voltage regulator. High = OFF and low = ON. Connect to GND to enable the voltage regulator. Do not leave this pin float.
—	TAB	—	Connected to GND. Attached to heatsink for thermal relief for TO-220 package or put a copper plane connected to this pin as a thermal relief for DDPAK package.

(1) I = INPUT, O = OUTPUT

6 Specifications

6.1 Absolute Maximum Ratings

over the recommended operating junction temperature range of -40°C to 125°C (unless otherwise noted)(1) (2)

		MIN	MAX	UNIT
Maximum supply voltage	LM2576		45	V
	LM2576HV		63	
ON /OFF pin input voltage		$-0.3V \le V \le +V_{IN}$		V
Output voltage to ground	(Steady-state)	−1		V
Power dissipation		Internally Limited		
Maximum junction temperature, T_J			150	°C
Storage temperature, T_{stg}		−65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over the recommended operating junction temperature range of -40°C to 125°C (unless otherwise noted)

		MIN	MAX	UNIT
Temperature	LM2576, LM2576HV	−40	125	°C
Supply voltage	LM2576		40	V
	LM2576HV		60	

6.4 Thermal Information

THERMAL METRIC(1) (2) (3)		LM2576, LM2576HV		UNIT
		KTT (TO-263)	KC (TO-220)	
		5 PINS	5 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	42.6	32.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	43.3	41.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	22.4	17.6	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	10.7	7.8	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	21.3	17	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	0.4	0.4	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953 and the *Using New Thermal Metrics* applications report, SBVA025.
(2) The package thermal impedance is calculated in accordance with JESD 51-7
(3) Thermal Resistances were simulated on a 4-layer, JEDEC board.

6.5 Electrical Characteristics: 3.3 V

Specifications are for T_J = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SYSTEM PARAMETERS TEST CIRCUIT Figure 8-3 **and** Figure 8-9[(1)]							
V_{OUT}	Output Voltage	V_{IN} = 12 V, I_{LOAD} = 0.5 A Circuit of Figure 8-3 and Figure 8-9		3.234	3.3	3.366	V
V_{OUT}	Output Voltage: LM2576	6 V ≤ V_{IN} ≤ 40 V, 0.5 A ≤ I_{LOAD} ≤ 3 A Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	3.168	3.3	3.432	V
			Applies over full operating temperature range	3.135		3.465	
V_{OUT}	Output Voltage: LM2576HV	6 V ≤ V_{IN} ≤ 60 V, 0.5 A ≤ I_{LOAD} ≤ 3 A Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	3.168	3.3	3.45	V
			Applies over full operating temperature range	3.135		3.482	
η	Efficiency	V_{IN} = 12 V, I_{LOAD} = 3 A			75%		

(1) External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/LM2576HV is used as shown in Figure 8-3 and Figure 8-9, system performance is as shown in *Section 6.10*.

6.6 Electrical Characteristics: 5 V

Specifications are for T_J = 25°C for the Figure 8-3 and Figure 8-9 (unless otherwise noted).

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SYSTEM PARAMETERS TEST CIRCUIT Figure 8-3 **and** Figure 8-9[(1)]							
V_{OUT}	Output Voltage	V_{IN} = 12 V, I_{LOAD} = 0.5 A Circuit of Figure 8-3 and Figure 8-9		4.9	5	5.1	V
V_{OUT}	Output Voltage LM2576	0.5 A ≤ I_{LOAD} ≤ 3 A, 8 V ≤ V_{IN} ≤ 40 V Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	4.8	5	5.2	V
			Applies over full operating temperature range	4.75		5.25	
V_{OUT}	Output Voltage LM2576HV	0.5 A ≤ I_{LOAD} ≤ 3 A, 8 V ≤ V_{IN} ≤ 60 V Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	4.8	5	4.75	V
			Applies over full operating temperature range	5.225		5.275	
η	Efficiency	V_{IN} = 12 V, I_{LOAD} = 3 A			77%		

(1) External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/LM2576HV is used as shown in Figure 8-3 and Figure 8-9, system performance is as shown in *Section 6.10*.

6.7 Electrical Characteristics: 12 V

Specifications are for T_J = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SYSTEM PARAMETERS TEST CIRCUIT Figure 8-3 **and** Figure 8-9[(1)]							
V_{OUT}	Output Voltage	V_{IN} = 25 V, I_{LOAD} = 0.5 A Circuit of Figure 8-3 and Figure 8-9		11.76	12	12.24	V
V_{OUT}	Output Voltage LM2576	0.5 A ≤ I_{LOAD} ≤ 3 A, 15 V ≤ V_{IN} ≤ 40 V Circuit of Figure 8-3 and Figure 8-9 and	T_J = 25°C	11.52	12	12.48	V
			Applies over full operating temperature range	11.4		12.6	
V_{OUT}	Output Voltage LM2576HV	0.5 A ≤ I_{LOAD} ≤ 3 A, 15 V ≤ V_{IN} ≤ 60 V Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	11.52	12	12.54	V
			Applies over full operating temperature range	11.4		12.66	

Specifications are for T_J = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
η	Efficiency	V_{IN} = 15 V, I_{LOAD} = 3 A		88%		

(1) External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/LM2576HV is used as shown in Figure 8-3 and Figure 8-9, system performance is as shown in *Section 6.10*.

6.8 Electrical Characteristics: 15 V

over operating free-air temperature range (unless otherwise noted).

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SYSTEM PARAMETERS TEST CIRCUIT Figure 8-3 **and** Figure 8-9[(1)]							
V_{OUT}	Output Voltage	V_{IN} = 25 V, I_{LOAD} = 0.5 A Circuit of Figure 8-3 and Figure 8-9		14.7	15	15.3	V
V_{OUT}	Output Voltage LM2576	0.5 A ≤ I_{LOAD} ≤ 3 A, 18 V ≤ V_{IN} ≤ 40 V Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	14.4	15	15.6	V
			Applies over full operating temperature range	14.25		15.75	
V_{OUT}	Output Voltage LM2576HV	0.5 A ≤ I_{LOAD} ≤ 3 A, 18 V ≤ V_{IN} ≤ 60 V Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	14.4	15	14.25	V
			Applies over full operating temperature range	15.68		15.83	
η	Efficiency	V_{IN} = 18 V, I_{LOAD} = 3 A			88%		

(1) External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/LM2576HV is used as shown in Figure 8-3 and Figure 8-9, system performance is as shown in *Section 6.10*.

6.9 Electrical Characteristics: Adjustable Output Voltage

over operating free-air temperature range (unless otherwise noted).

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SYSTEM PARAMETERS TEST CIRCUIT Figure 8-3 **and** Figure 8-9[(1)]							
V_{OUT}	Feedback voltage	V_{IN} = 12 V, I_{LOAD} = 0.5 A V_{OUT} = 5 V, Circuit of Figure 8-3 and Figure 8-9		1.217	1.23	1.243	V
V_{OUT}	Feedback Voltage LM2576	0.5 A ≤ I_{LOAD} ≤ 3 A, 8 V ≤ V_{IN} ≤ 40 V V_{OUT} = 5 V, Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	1.193	1.23	1.267	V
			Applies over full operating temperature range	1.18		1.28	
V_{OUT}	Feedback Voltage LM2576HV	0.5 A ≤ I_{LOAD} ≤ 3 A, 8 V ≤ V_{IN} ≤ 60 V V_{OUT} = 5 V, Circuit of Figure 8-3 and Figure 8-9	T_J = 25°C	1.193	1.23	1.273	V
			Applies over full operating temperature range	1.18		1.286	
η	Efficiency	V_{IN} = 12 V, I_{LOAD} = 3 A, V_{OUT} = 5 V			77%		

(1) External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/LM2576HV is used as shown in Figure 8-3 and Figure 8-9, system performance is as shown in *Section 6.10*.

6.10 Electrical Characteristics: All Output Voltage Versions

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP[(1)]	MAX	UNIT
SYSTEM PARAMETERS TEST CIRCUIT Figure 8-3 **and** Figure 8-9[(2)]							
I_b	Feedback Bias Current	V_{OUT} = 5 V (Adjustable Version Only)	T_J = 25°C	100	50		nA
			Applies over full operating temperature range	500			
f_O	Oscillator Frequency[(7)]	T_J = 25°C		47	52	58	kHz
		Applies over full operating temperature range		42		63	

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP[1]	MAX	UNIT
V_{SAT}	Saturation Voltage	I_{OUT} = 3 A [3]	T_J = 25°C		1.4	1.8	V
			Applies over full operating temperature range			2	
DC	Max Duty Cycle (ON)[4]			93%	98%		
I_{CL}	Current Limit[3] [7]	T_J = 25°C		4.2	5.8	6.9	A
		Applies over full operating temperature range		3.5		7.5	
I_L	Output Leakage Current	Output = 0 V Output = −1 V Output = −1 V [5] [6]		2	7.5	30	mA
I_Q	Quiescent Current[5]				5	10	mA
I_{STBY}	Standby Quiescent Current	$\overline{ON}$ /OFF Pin = 5 V (OFF)			50	200	μA
$\overline{ON}$ /OFF CONTROL TEST CIRCUIT Figure 8-3 **and** Figure 8-9							
V_{IH}	$\overline{ON}$ /OFF Pin Logic Input Level	V_{OUT} = 0 V	T_J = 25°C	2.2	1.4		V
			Applies over full operating temperature range	2.4			
V_{IL}		V_{OUT} = Nominal Output Voltage	T_J = 25°C		1.2	1	V
			Applies over full operating temperature range			0.8	
I_{IH}	$\overline{ON}$ /OFF Pin Input Current	$\overline{ON}$ /OFF Pin = 5 V (OFF)			12	30	μA
I_{IL}		$\overline{ON}$ /OFF Pin = 0 V (ON)			0	10	μA

(1) All limits specified at room temperature (25°C) unless otherwise noted. All room temperature limits are 100% production tested. All limits at temperature extremes are specified through correlation using standard Statistical Quality Control (SQC) methods.
(2) External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/LM2576HV is used as shown in Figure 8-3 and Figure 8-9, system performance is as shown in *Section 6.10*.
(3) Output pin sourcing current. No diode, inductor or capacitor connected to output.
(4) Feedback pin removed from output and connected to 0V.
(5) Feedback pin removed from output and connected to +12 V for the Adjustable, 3.3-V, and 5-V versions, and +25 V for the 12-V and 15-V versions, to force the output transistor OFF.
(6) V_{IN} = 40 V (60 V for high voltage version).
(7) The oscillator frequency reduces to approximately 11 kHz in the event of an output short or an overload which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self protection feature lowers the average power dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.

6.11 Typical Characteristics

(Circuit of Figure 8-3 and Figure 8-9)

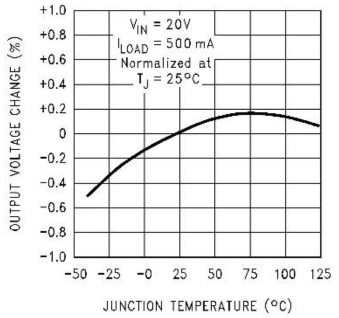


Figure 6-1. Normalized Output Voltage

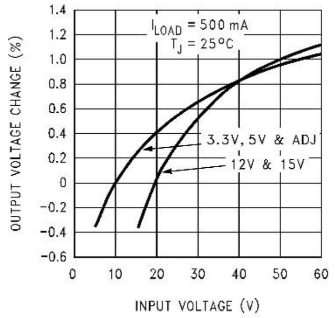


Figure 6-2. Line Regulation

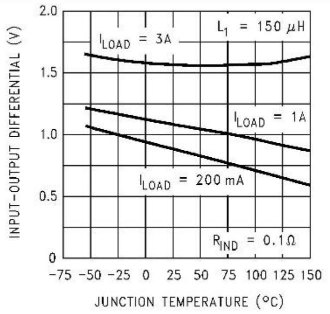


Figure 6-3. Dropout Voltage

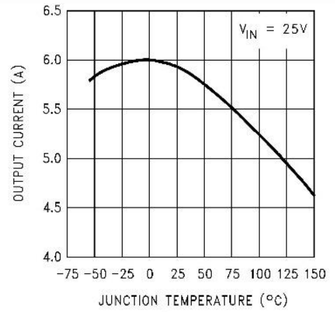


Figure 6-4. Current Limit

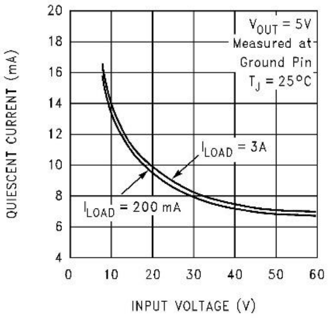


Figure 6-5. Quiescent Current

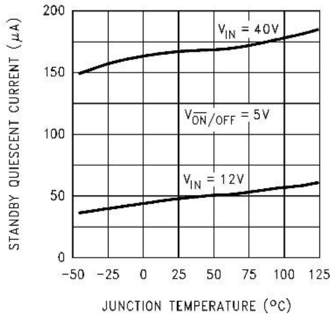


Figure 6-6. Standby Quiescent Current

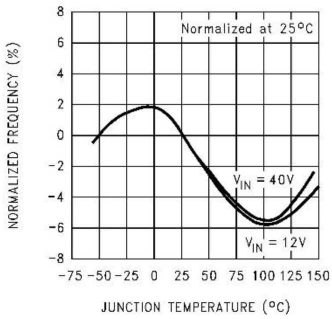


Figure 6-7. Oscillator Frequency

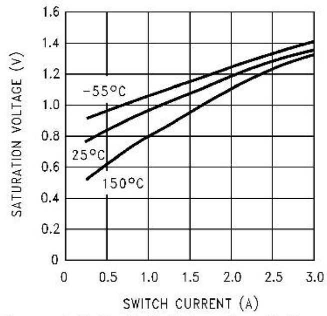


Figure 6-8. Switch Saturation Voltage

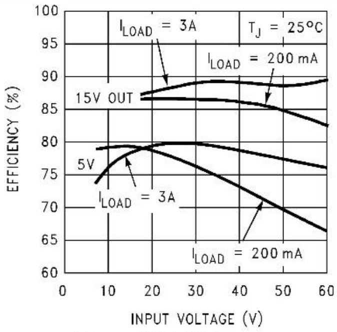


Figure 6-9. Efficiency

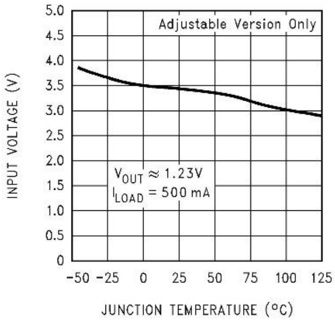


Figure 6-10. Minimum Operating Voltage

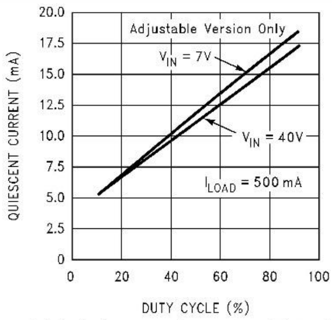


Figure 6-11. Quiescent Current vs Duty Cycle

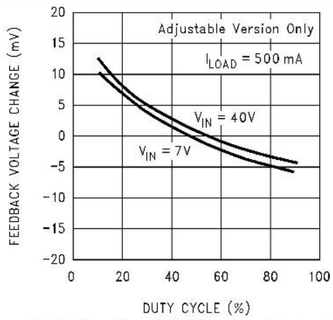


Figure 6-12. Feedback Voltage vs Duty Cycle

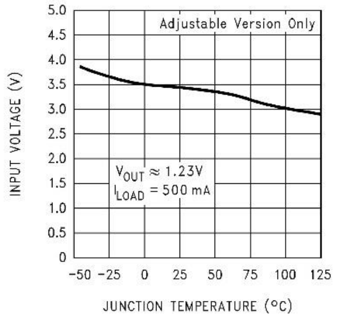


Figure 6-13. Minimum Operating Voltage

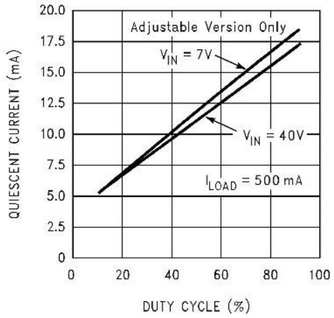


Figure 6-14. Quiescent Current vs Duty Cycle

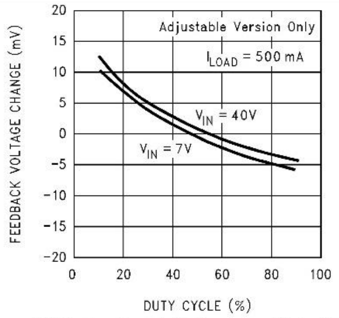


Figure 6-15. Feedback Voltage vs Duty Cycle

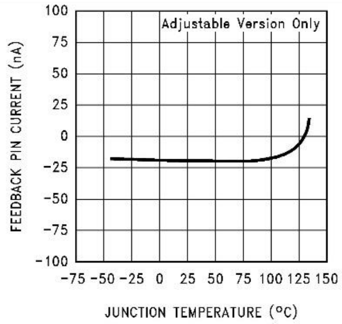
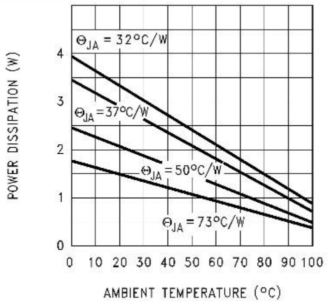
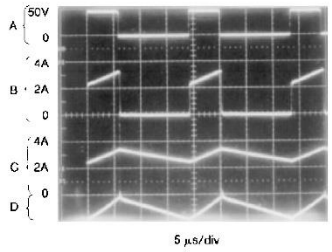


Figure 6-16. Feedback Pin Current



If the DDPAK/TO-263 package is used, the thermal resistance can be reduced by increasing the PCB copper area thermally connected to the package. Using 0.5 square inches of copper area, θ_{JA} is 50°C/W, with 1 square inch of copper area, θ_{JA} is 37°C/W, and with 1.6 or more square inches of copper area, θ_{JA} is 32°C/W.

Figure 6-17. Maximum Power Dissipation (DDPAK/ TO-263)



V_{OUT} = 15 V A: Output Pin Voltage, 50 V/div B: Output Pin Current, 2 A/div C: Inductor Current, 2 A/div D: Output Ripple Voltage, 50 mV/div, AC-Coupled**Horizontal Time Base: 5 µs/div**

Figure 6-18. Switching Waveforms

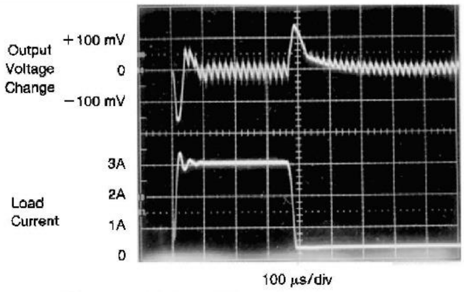


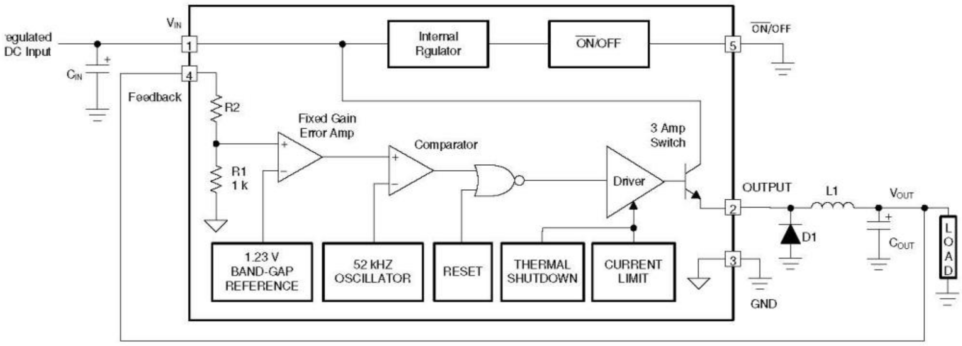
Figure 6-19. Load Transient Response

7 Detailed Description

7.1 Overview

The LM2576 SIMPLE SWITCHER® regulator is an easy-to-use, non-synchronous step-down DC-DC converter with a wide input voltage range from 40 V to up to 60 V for a HV version. It is capable of delivering up to 3-A DC load current with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, 15 V, and an adjustable output version. The family requires few external components, and the pin arrangement was designed for simple, optimum PCB layout.

7.2 Functional Block Diagram



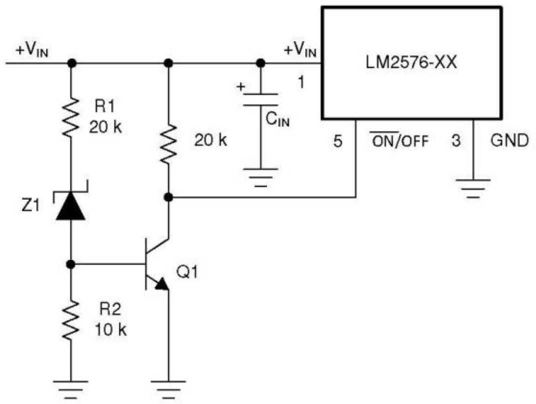
3.3 V R2 = 1.7 k 5 V, R2 = 3.1 k 12 V, R2 = 8.84 k 15 V, R2 = 11.3 k For ADJ. Version R1 = Open, R2 = 0 Ω Patent Pending

7.3 Feature Description

7.3.1 Undervoltage Lockout

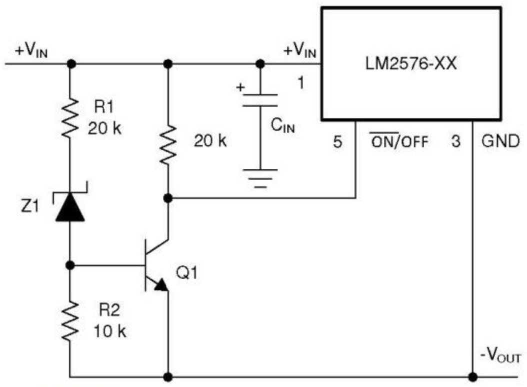
In some applications it is desirable to keep the regulator off until the input voltage reaches a certain threshold. Figure 7-1 shows an undervoltage lockout circuit that accomplishes this task, while Figure 7-2 shows the same circuit applied to a buck-boost configuration. These circuits keep the regulator off until the input voltage reaches a predetermined level.

$$V_{TH} \approx V_{Z1} + 2V_{BE}(Q1) \quad (1)$$



Complete circuit not shown.

Figure 7-1. Undervoltage Lockout for Buck Circuit



Complete circuit not shown (see Figure 8-1).

Figure 7-2. Undervoltage Lockout for Buck-Boost Circuit

7.3.2 Delayed Start-Up

The $\overline{ON}$ /OFF pin can be used to provide a delayed start-up feature as shown in Figure 7-3. With an input voltage of 20 V and for the part values shown, the circuit provides approximately 10 ms of delay time before the circuit begins switching. Increasing the RC time constant can provide longer delay times. But excessively large RC time constants can cause problems with input voltages that are high in 60-Hz or 120-Hz ripple, by coupling the ripple into the $\overline{ON}$ /OFF pin.

7.3.3 Adjustable Output, Low-Ripple Power Supply

Figure 7-4 shows a 3-A power supply that features an adjustable output voltage. An additional LC filter that reduces the output ripple by a factor of 10 or more is included in this circuit.

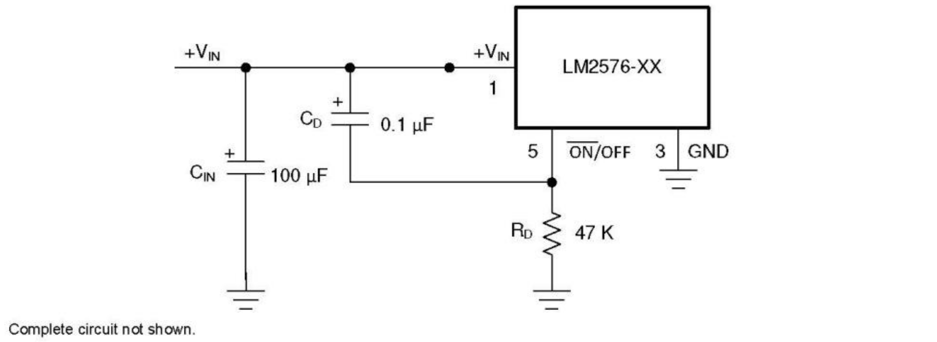


Figure 7-3. Delayed Start-Up

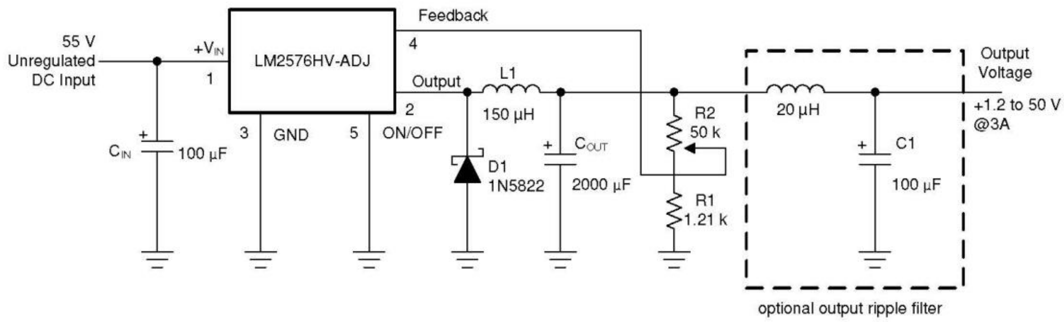


Figure 7-4. 1.2-V to 55-V Adjustable 3-A Power Supply With Low Output Ripple

7.4 Device Functional Modes

7.4.1 Shutdown Mode

The $\overline{\text{ON}}$/OFF pin provides electrical ON and OFF control for the LM2576. When the voltage of this pin is higher than 1.4 V, the device is in shutdown mode. The typical standby current in this mode is 50 µA.

7.4.2 Active Mode

When the voltage of the $\overline{\text{ON}}$/OFF pin is below 1.2 V, the device starts switching, and the output voltage rises until it reaches the normal regulation voltage.

7.4.3 Current Limit

The LM2576 device has current limiting to prevent the switch current from exceeding safe values during an accidental overload on the output. This current limit value can be found in *Section 6.10* under the heading of I_{CL}.

The LM2576 uses cycle-by-cycle peak current limit for overload protection. This helps to prevent damage to the device and external components. The regulator operates in current limit mode whenever the inductor current exceeds the value of I_{CL} given in *Section 6.10*. This occurs if the load current is greater than 3 A, or the converter is starting up. Keep in mind that the maximum available load current depends on the input voltage, output voltage, and inductor value. The regulator also incorporates short-circuit protection to prevent inductor current run-away. When the voltage on the FB pin (ADJ) falls below about 0.58 V the switching frequency is dropped to about 11 kHz. This allows the inductor current to ramp down sufficiently during the switch OFF-time to prevent saturation.

8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

8.1.1 Input Capacitor (C_{IN})

To maintain stability, the regulator input pin must be bypassed with at least a 100-μF electrolytic capacitor. The capacitor's leads must be kept short, and placed near the regulator.

If the operating temperature range includes temperatures below −25°C, the input capacitor value may need to be larger. With most electrolytic capacitors, the capacitance value decreases and the ESR increases with lower temperatures and age. Paralleling a ceramic or solid tantalum capacitor increases the regulator stability at cold temperatures. For maximum capacitor operating lifetime, the RMS ripple current rating of the capacitor must be greater than:

$$1.2 \times \left(\frac{t_{ON}}{T}\right) \times I_{LOAD}$$

$$\text{where } \frac{t_{ON}}{T} = \frac{V_{OUT}}{V_{IN}} \text{ for a buck regulator}$$

$$\text{and } \frac{t_{ON}}{T} = \frac{|V_{OUT}|}{|V_{OUT}| + V_{IN}} \text{ for a buck-boost regulator.} \quad (2)$$

8.1.2 Inductor Selection

All switching regulators have two basic modes of operation: continuous and discontinuous. The difference between the two types relates to the inductor current, whether it is flowing continuously, or if it drops to zero for a period of time in the normal switching cycle. Each mode has distinctively different operating characteristics, which can affect the regulator performance and requirements.

The LM2576 (or any of the SIMPLE SWITCHER® family can be used for both continuous and discontinuous modes of operation.

The inductor value selection guides in Figure 8-4 through Figure 8-8 are designed for buck regulator designs of the continuous inductor current type. When using inductor values shown in the inductor selection guide, the peak-to-peak inductor ripple current is approximately 20% to 30% of the maximum DC current. With relatively heavy load currents, the circuit operates in the continuous mode (inductor current always flowing), but under light load conditions, the circuit is forced to the discontinuous mode (inductor current falls to zero for a period of time). This discontinuous mode of operation is perfectly acceptable. For light loads (less than approximately 300 mA), it may be desirable to operate the regulator in the discontinuous mode, primarily because of the lower inductor values required for the discontinuous mode.

The selection guide chooses inductor values suitable for continuous mode operation, but if the inductor value chosen is prohibitively high, the designer should investigate the possibility of discontinuous operation.

Inductors are available in different styles such as pot core, toriod, E-frame, bobbin core, and so on, as well as different core materials, such as ferrites and powdered iron. The bobbin core is the least expensive type, and consists of wire wrapped on a ferrite rod core. This type of construction makes for an inexpensive inductor; however, because the magnetic flux is not completely contained within the core, the bobbin core generates more electromagnetic interference (EMI). This EMI can cause problems in sensitive circuits, or can give incorrect scope readings because of induced voltages in the scope probe.

The inductors listed in the selection chart include ferrite pot core construction for AIE, powdered iron toroid for Pulse Engineering, and ferrite bobbin core for Renco.

An inductor must not operate beyond its maximum-rated current because it may saturate. When an inductor begins to saturate, the inductance decreases rapidly, and the inductor begins to look mainly resistive (the DC resistance of the winding), causing the switch current to rise very rapidly. Different inductor types have different saturation characteristics, and this must be considered when selecting an inductor.

The inductor manufacturer's data sheets include current and energy limits to avoid inductor saturation.

8.1.3 Inductor Ripple Current

When the switcher is operating in the continuous mode, the inductor current waveform ranges from a triangular to a sawtooth type of waveform (depending on the input voltage). For a given input voltage and output voltage, the peak-to-peak amplitude of this inductor current waveform remains constant. As the load current rises or falls, the entire sawtooth current waveform also rises or falls. The average DC value of this waveform is equal to the DC load current (in the buck regulator configuration).

If the load current drops to a low enough level, the bottom of the sawtooth current waveform reaches zero, and the switcher changes to a discontinuous mode of operation. This is a perfectly acceptable mode of operation. Any buck switching regulator (no matter how large the inductor value is) is forced to run discontinuous if the load current is light enough.

8.1.4 Output Capacitor

An output capacitor is required to filter the output voltage and is needed for loop stability. The capacitor must be placed near the LM2576 using short PCB traces. Standard aluminum electrolytics are usually adequate, but TI recommends low ESR types for low output ripple voltage and good stability. The ESR of a capacitor depends on many factors, including: the value, the voltage rating, physical size, and the type of construction. In general, low value or low voltage (less than 12 V) electrolytic capacitors usually have higher ESR numbers.

The amount of output ripple voltage is primarily a function of the ESR (Equivalent Series Resistance) of the output capacitor and the amplitude of the inductor ripple current (ΔI_{IND}). See *Section 8.1.3*.

The lower capacitor values (220 µF to 1000 µF) allows typically 50 mV to 150 mV of output ripple voltage, while larger-value capacitors reduces the ripple to approximately 20 mV to 50 mV.

$$\text{Output Ripple Voltage} = (\Delta I_{IND})\ (\text{ESR of } C_{OUT}) \quad (3)$$

To further reduce the output ripple voltage, several standard electrolytic capacitors may be paralleled, or a higher-grade capacitor may be used. Such capacitors are often called *high-frequency*, *low-inductance*, or *low-ESR*. These reduces the output ripple to 10 mV or 20 mV. However, when operating in the continuous mode, reducing the ESR below 0.03 Ω can cause instability in the regulator.

Tantalum capacitors can have a very low ESR, and must be carefully evaluated if it is the only output capacitor. Because of their good low temperature characteristics, a tantalum can be used in parallel with aluminum electrolytics, with the tantalum making up 10% or 20% of the total capacitance.

The ripple current rating of the capacitor at 52 kHz should be at least 50% higher than the peak-to-peak inductor ripple current.

8.1.5 Catch Diode

Buck regulators require a diode to provide a return path for the inductor current when the switch is off. This diode must be placed close to the LM2576 using short leads and short printed-circuit traces.

Because of their fast switching speed and low forward voltage drop, Schottky diodes provide the best efficiency, especially in low output voltage switching regulators (less than 5 V). Fast-recovery, high-efficiency, or ultra-fast recovery diodes are also suitable, but some types with an abrupt turnoff characteristic may cause instability and EMI problems. A fast-recovery diode with soft recovery characteristics is a better choice. Standard 60-Hz diodes (for example, 1N4001 or 1N5400, and so on) are also *not suitable*. See Table 8-3 for Schottky and *soft* fast-recovery diode selection guide.

8.1.6 Output Voltage Ripple and Transients

The output voltage of a switching power supply contains a sawtooth ripple voltage at the switcher frequency, typically about 1% of the output voltage, and may also contain short voltage spikes at the peaks of the sawtooth waveform.

The output ripple voltage is due mainly to the inductor sawtooth ripple current multiplied by the ESR of the output capacitor (see *Section 8.1.2*).

The voltage spikes are present because of the fast switching action of the output switch, and the parasitic inductance of the output filter capacitor. To minimize these voltage spikes, special low inductance capacitors can be used, and their lead lengths must be kept short. Wiring inductance, stray capacitance, as well as the scope probe used to evaluate these transients, all contribute to the amplitude of these spikes.

An additional small LC filter (20 µH and 100 µF) can be added to the output (as shown in Figure 7-4) to further reduce the amount of output ripple and transients. A 10 × reduction in output ripple voltage and transients is possible with this filter.

8.1.7 Feedback Connection

The LM2576 (fixed voltage versions) feedback pin must be wired to the output voltage point of the switching power supply. When using the adjustable version, physically locate both output voltage programming resistors near the LM2576 to avoid picking up unwanted noise. Avoid using resistors greater than 100 kΩ because of the increased chance of noise pickup.

8.1.8 $\overline{\text{ON}}$ /OFF INPUT

For normal operation, the $\overline{\text{ON}}$ /OFF pin must be grounded or driven with a low-level TTL voltage (typically below 1.6 V). To put the regulator into standby mode, drive this pin with a high-level TTL or CMOS signal. The $\overline{\text{ON}}$ /OFF pin can be safely pulled up to $+V_{IN}$ without a resistor in series with it. The $\overline{\text{ON}}$ /OFF pin must not be left open.

8.1.9 Inverting Regulator

Figure 8-1 shows a LM2576-12 in a buck-boost configuration to generate a negative 12-V output from a positive input voltage. This circuit bootstraps the ground pin of the regulator to the negative output voltage, then by grounding the feedback pin, the regulator senses the inverted output voltage and regulates it to −12 V.

For an input voltage of 12 V or more, the maximum available output current in this configuration is approximately 700 mA. At lighter loads, the minimum input voltage required drops to approximately 4.7 V.

The switch currents in this buck-boost configuration are higher than in the standard buck-mode design, thus lowering the available output current. Also, the start-up input current of the buck-boost converter is higher than the standard buck-mode regulator, and this may overload an input power source with a current limit less than 5 A. Using a delayed turn-on or an undervoltage lockout circuit (described in *Section 8.1.10*) would allow the input voltage to rise to a high enough level before the switcher would be allowed to turn on.

Because of the structural differences between the buck and the buck-boost regulator topologies, the buck regulator design procedure section can not be used to select the inductor or the output capacitor. The recommended range of inductor values for the buck-boost design is between 68 µH and 220 µH, and the output capacitor values must be larger than what is normally required for buck designs. Low input voltages or high output currents require a large value output capacitor (in the thousands of micro Farads).

The peak inductor current, which is the same as the peak switch current, can be calculated in Equation 4:

$$I_p \approx \frac{I_{LOAD}\,(V_{IN} + |V_O|)}{V_{IN}} + \frac{V_{IN}\,|V_O|}{V_{IN} + |V_O|} \times \frac{1}{2L_1\, f_{osc}} \quad (4)$$

where

- f_{osc} = 52 kHz

Under normal continuous inductor current operating conditions, the minimum V_{IN} represents the worst case. Select an inductor that is rated for the peak current anticipated.

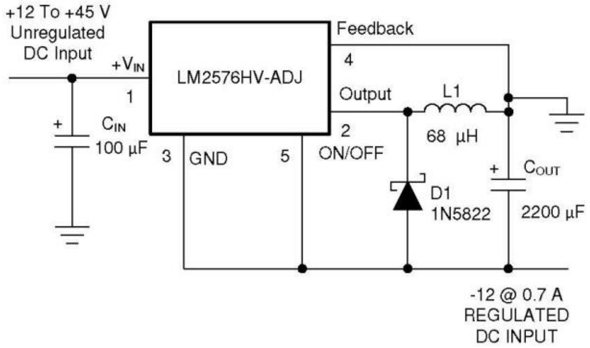
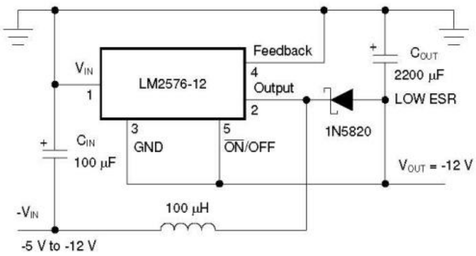


Figure 8-1. Inverting Buck-Boost Develops −12 V

Also, the maximum voltage appearing across the regulator is the absolute sum of the input and output voltage. For a −12-V output, the maximum input voltage for the LM2576 is +28 V, or +48 V for the LM2576HV.

8.1.10 Negative Boost Regulator

Another variation on the buck-boost topology is the negative boost configuration. The circuit in Figure 8-2 accepts an input voltage ranging from −5 V to −12 V and provides a regulated −12-V output. Input voltages greater than −12 V causes the output to rise above −12 V, but does not damage the regulator.



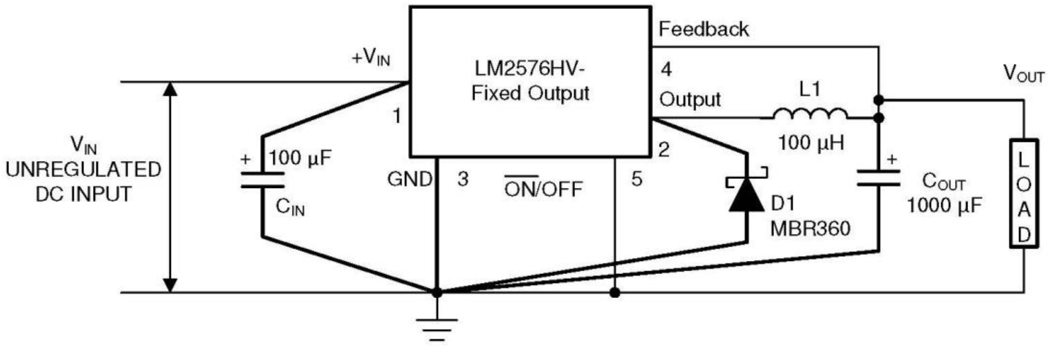
Typical Load Current 400 mA for V_{IN} = −5.2 V 750 mA for V_{IN} = −7 V Heat sink may be required.

Figure 8-2. Negative Boost

Because of the boosting function of this type of regulator, the switch current is relatively high, especially at low input voltages. Output load current limitations are a result of the maximum current rating of the switch. Also, boost regulators can not provide current-limiting load protection in the event of a shorted load, so some other means (such as a fuse) may be necessary.

8.2 Typical Applications

8.2.1 Fixed Output Voltage Version



C_{IN} — 100-µF, 75-V, Aluminum Electrolytic C_{OUT} — 1000-µF, 25-V, Aluminum Electrolytic D_1 — Schottky, MBR360 L_1 — 100 µH, Pulse Eng. PE-92108 R_1 — 2 k, 0.1% R_2 — 6.12 k, 0.1%

Figure 8-3. Fixed Output Voltage Versions

8.2.1.1 Design Requirements

Table 8-1 lists the design parameters of this example.

Table 8-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Regulated Output Voltage (3.3 V, 5 V, 12 V, or 15 V), V_{OUT}	5 V
Maximum Input Voltage, V_{IN}(Max)	15 V
Maximum Load Current, I_{LOAD}(Max)	3 A

8.2.1.2 Detailed Design Procedure

8.2.1.2.1 Custom Design with WEBENCH Tools

Click here to create a custom design using the WEBENCH® Power Designer.

1. Start by entering your V_{IN}, V_{OUT} and I_{OUT} requirements.
2. Optimize your design for key parameters like efficiency, footprint and cost using the optimizer dial and compare this design with other possible solutions from Texas Instruments.
3. WEBENCH Power Designer provides you with a customized schematic along with a list of materials with real time pricing and component availability.
4. In most cases, you will also be able to:
   - Run electrical simulations to see important waveforms and circuit performance,
   - Run thermal simulations to understand the thermal performance of your board,
   - Export your customized schematic and layout into popular CAD formats,
   - Print PDF reports for the design, and share your design with colleagues.

8.2.1.2.2 Inductor Selection (L1)

1. Select the correct Inductor value selection guide from Figure 8-4, Figure 8-5, Figure 8-6, or Figure 8-7. (Output voltages of 3.3 V, 5 V, 12 V or 15 V respectively). For other output voltages, see the design procedure for the adjustable version. Use the selection guide shown in Figure 8-5.

2. From the inductor value selection guide, identify the inductance region intersected by V_{IN}(Max) and I_{LOAD}(Max), and note the inductor code for that region. From the selection guide, the inductance area intersected by the 15-V line and 3-A line is L100.
3. Identify the inductor value from the inductor code, and select an appropriate inductor from the table shown in Figure 8-4. Part numbers are listed for three inductor manufacturers. The inductor chosen must be rated for operation at the LM2576 switching frequency (52 kHz) and for a current rating of 1.15 × I_{LOAD}. For additional inductor information, see *Section 8.1.2*. Inductor value required is 100 µH from the table in Figure 8-4. Choose AIE 415-0930, Pulse Engineering PE92108, or Renco RL2444.

8.2.1.2.3 Output Capacitor Selection (C_{OUT})

1. The value of the output capacitor together with the inductor defines the dominate pole-pair of the switching regulator loop. For stable operation and an acceptable output ripple voltage, (approximately 1% of the output voltage) TI recommends a value between 100 µF and 470 µF. We choose C_{OUT} = 680-µF to 2000-µF standard aluminum electrolytic.
2. The voltage rating of the capacitor must be at least 1.5 times greater than the output voltage. For a 5-V regulator, a rating of at least 8 V is appropriate, and a 10-V or 15-V rating is recommended. Capacitor voltage rating = 20 V. Higher voltage electrolytic capacitors generally have lower ESR numbers, and for this reason it may be necessary to select a capacitor rated for a higher voltage than would normally be needed.

8.2.1.2.4 Catch Diode Selection (D1)

1. The catch-diode current rating must be at least 1.2 times greater than the maximum load current. Also, if the power supply design must withstand a continuous output short, the diode should have a current rating equal to the maximum current limit of the LM2576. The most stressful condition for this diode is an overload or shorted output condition. For this example, a 3-A current rating is adequate.
2. The reverse voltage rating of the diode should be at least 1.25 times the maximum input voltage. Use a 20-V 1N5823 or SR302 Schottky diode, or any of the suggested fast-recovery diodes shown in Table 8-3.

8.2.1.2.5 Input Capacitor (C_{IN})

An aluminum or tantalum electrolytic bypass capacitor located close to the regulator is needed for stable operation. A 100-µF, 25-V aluminum electrolytic capacitor located near the input and ground pins provides sufficient bypassing.

8.2.1.3 Application Curves

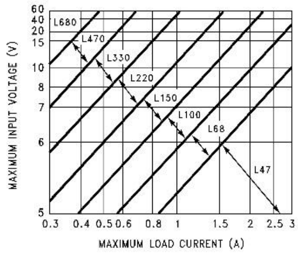


Figure 8-4. LM2576(HV)-3.3

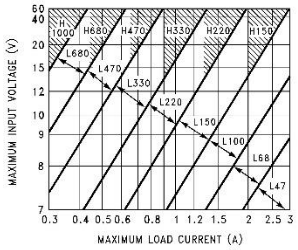


Figure 8-5. LM2576(HV)-5.0

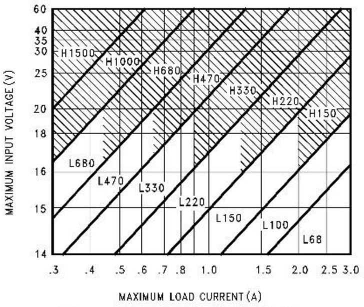


Figure 8-6. LM2576(HV)-12

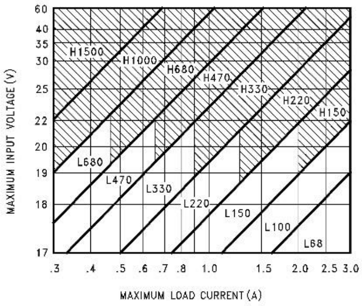


Figure 8-7. LM2576(HV)-15

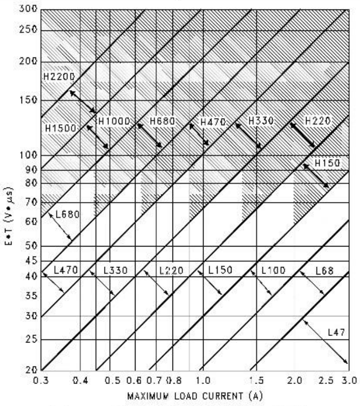
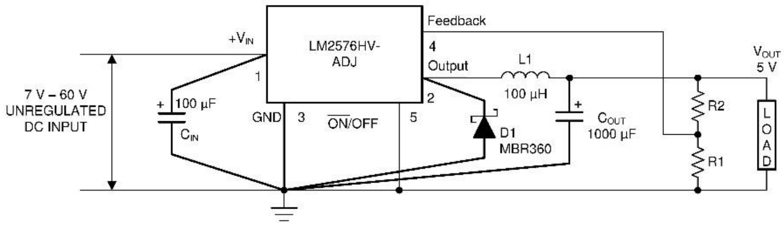


Figure 8-8. LM2576(HV)-ADJ

8.2.2 Adjusted Output Voltage Version



$V_{OUT} = V_{REF}\left(1 + \frac{R_2}{R_1}\right)$

$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right)$ where V_{REF} = 1.23 V, R1 between 1 k and 5 k

Figure 8-9. Adjustable Output Voltage Version

8.2.2.1 Design Requirements

Table 8-2 lists the design parameters of this example.

Table 8-2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Regulated Output Voltage, V_{OUT}	10 V
Maximum Input Voltage, V_{IN}(Max)	25 V
Maximum Load Current, I_{LOAD}(Max)	3 A
Switching Frequency, F	Fixed at 52 kHz

8.2.2.2 Detailed Design Procedure

8.2.2.2.1 Programming Output Voltage

Select R1 and R2, as shown in Figure 8-9.

Use Equation 5 to select the appropriate resistor values.

$$V_{OUT} = V_{REF}\left(1 + \frac{R_2}{R_1}\right) \quad \text{where } V_{REF} = 1.23\text{V} \tag{5}$$

R_1 can be between 1k and 5k. *(For best temperature coefficient and stability with time, use 1% metal film resistors)*

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right) \tag{6}$$

$$V_{OUT} = 1.23\left(1 + \frac{R_2}{R_1}\right) \quad \text{Select R1} = 1\text{k}$$

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right) = 1\text{k}\left(\frac{10\text{V}}{1.23\text{V}} - 1\right) \tag{7}$$

R_2 = 1 k (8.13 − 1) = 7.13 k, closest 1% value is 7.15 k

8.2.2.2.2 Inductor Selection (L1)

1. Calculate the inductor Volt • microsecond constant, E • T (V • µs), from Equation 8:

$$E \times T = \left(V_{IN} - V_{OUT}\right)\frac{V_{OUT}}{V_{IN}} \times \frac{1000}{F(\text{in kHz})}(V \times \mu s) \quad (8)$$

Calculate E • T (V • µs)

$$E \times T = (25 - 10) \times \frac{10}{25} \times \frac{1000}{52} = 115\ V \times \mu s \quad (9)$$

2. Use the E • T value from the previous formula and match it with the E • T number on the vertical axis of the Inductor value selection guide shown in Figure 8-8.

   E • T = 115 V • µs
3. On the horizontal axis, select the maximum load current.

   I_{LOAD}(Max) = 3 A
4. Identify the inductance region intersected by the E • T value and the maximum load current value, and note the inductor code for that region.

   Inductance Region = H150
5. Identify the inductor value from the inductor code, and select an appropriate inductor from the table shown in Table 8-4. Part numbers are listed for three inductor manufacturers. The inductor chosen must be rated for operation at the LM2576 switching frequency (52 kHz) and for a current rating of 1.15 × I_{LOAD}. For additional inductor information, see *Section 8.1.2*.

   Inductor Value = 150 µH

   Choose from *AIE part #415-0936*, *Pulse Engineering part #PE-531115*, or *Renco part #RL2445*.

8.2.2.2.3 Output Capacitor Selection (C_{OUT})

1. The value of the output capacitor together with the inductor defines the dominate pole-pair of the switching regulator loop. For stable operation, the capacitor must satisfy Equation 10:

$$C_{OUT} \geq 13{,}300 \frac{V_{IN(Max)}}{V_{OUT} \times L(\mu H)}(\mu F)$$

   Equation 10 yields capacitor values between 10 µF and 2200 µF that satisfies the loop requirements for stable operation. But to achieve an acceptable output ripple voltage, (approximately 1% of the output voltage) and transient response, the output capacitor may need to be several times larger than Equation 10 yields.

$$COUT \geq 13{,}300 \frac{25}{10 \times 150} = 22.2\ \mu F$$

   However, for acceptable output ripple voltage select

   C_{OUT} ≥ 680 µF

   C_{OUT} = 680-µF electrolytic capacitor
2. The capacitor's voltage rating must be at last 1.5 times greater than the output voltage. For a 10-V regulator, a rating of at least 15 V or more is recommended. Higher voltage electrolytic capacitors generally have lower ESR numbers, and for this reason it may be necessary to select a capacitor rate for a higher voltage than would normally be needed.

8.2.2.2.4 Catch Diode Selection (D1)

1. The catch-diode current rating must be at least 1.2 times greater than the maximum load current. Also, if the power supply design must withstand a continuous output short, the diode must have a current rating equal to the maximum current limit of the LM2576. The most stressful condition for this diode is an overload or shorted output. See Table 8-3. For this example, a 3.3-A current rating is adequate.

2. The reverse voltage rating of the diode should be at least 1.25 times the maximum input voltage. Use a 30-V 31DQ03 Schottky diode, or any of the suggested fast-recovery diodes in Table 8-3.

8.2.2.2.5 Input Capacitor (C_{IN})

An aluminum or tantalum electrolytic bypass capacitor located close to the regulator is needed for stable operation. A 100-µF aluminum electrolytic capacitor located near the input and ground pins provides sufficient bypassing.

Table 8-3. Diode Selection Guide

V_R	SCHOTTKY		FAST RECOVERY	
	3 A	4 A to 6 A	3 A	4 A to 6 A
20 V	1N5820 MBR320P SR302	1N5823	The following diodes are all rated to 100-V 31DF1 HER302	The following diodes are all rated to 100-V 50WF10 MUR410 HER602
30 V	1N5821 MBR330 31DQ03 SR303	50WQ03 1N5824		
40 V	1N5822 MBR340 31DQ04 SR304	MBR340 50WQ04 1N5825		
50 V	MBR350 31DQ05 SR305	50WQ05		
60 V	MBR360 DQ06 SR306	50WR06 50SQ060		

Table 8-4. Inductor Selection by Manufacturer's Part Number

INDUCTOR CODE	INDUCTOR VALUE	SCHOTT[(1)]	PULSE ENG.[(2)]	RENCO[(3)]
L47	47 µH	671 26980	PE-53112	RL2442
L68	68 µH	671 26990	PE-92114	RL2443
L100	100 µH	671 27000	PE-92108	RL2444
L150	150 µH	671 27010	PE-53113	RL1954
L220	220 µH	671 27020	PE-52626	RL1953
L330	330 µH	671 27030	PE-52627	RL1952
L470	470 µH	671 27040	PE-53114	RL1951
L680	680 µH	671 27050	PE-52629	RL1950
H150	150 µH	671 27060	PE-53115	RL2445
H220	220 µH	671 27070	PE-53116	RL2446
H330	330 µH	671 27080	PE-53117	RL2447
H470	470 µH	671 27090	PE-53118	RL1961
H680	680 µH	671 27100	PE-53119	RL1960
H1000	1000 µH	671 27110	PE-53120	RL1959
H1500	1500 µH	671 27120	PE-53121	RL1958
H2200	2200 µH	671 27130	PE-53122	RL2448

(1) Schott Corporation, (612) 475-1173, 1000 Parkers Lake Road, Wayzata, MN 55391.
(2) Pulse Engineering, (619) 674-8100, P.O. Box 12235, San Diego, CA 92112.
(3) Renco Electronics Incorporated, (516) 586-5566, 60 Jeffryn Blvd. East, Deer Park, NY 11729.

9 Power Supply Recommendations

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance generate voltage transients which can cause problems. For minimal inductance and ground loops, the length of the leads indicated by heavy lines should be kept as short as possible. Single-point grounding (as indicated) or ground plane construction should be used for best results. When using the adjustable version, physically locate the programming resistors near the regulator, to keep the sensitive feedback wiring short.

10 Layout

10.1 Layout Guidelines

Board layout is critical for the proper operation of switching power supplies. First, the ground plane area must be sufficient for thermal dissipation purposes. Second, appropriate guidelines must be followed to reduce the effects of switching noise. Switch mode converters are very fast switching devices. In such cases, the rapid increase of input current combined with the parasitic trace inductance generates unwanted L di/dt noise spikes. The magnitude of this noise tends to increase as the output current increases. This noise may turn into electromagnetic interference (EMI) and can also cause problems in device performance. Therefore, take care in layout to minimize the effect of this switching noise. The most important layout rule is to keep the AC current loops as small as possible. Figure 10-1 shows the current flow in a buck converter. The top schematic shows a dotted line which represents the current flow during the top-switch ON-state. The middle schematic shows the current flow during the top-switch OFF-state. The bottom schematic shows the currents referred to as AC currents. These AC currents are the most critical because they are changing in a very short time period. The dotted lines of the bottom schematic are the traces to keep as short and wide as possible. This also yields a small loop area reducing the loop inductance. To avoid functional problems due to layout, review the PCB layout example. Best results are achieved if the placement of the LM2576 device, the bypass capacitor, the Schottky diode, RFBB, RFBT, and the inductor are placed as shown in Figure 10-2.TI also recommends using 2-oz copper boards or heavier to help thermal dissipation and to reduce the parasitic inductances of board traces. See application note *AN-1229 SIMPLE SWITCHER® PCB Layout Guidelines* (SNVA054) for more information.

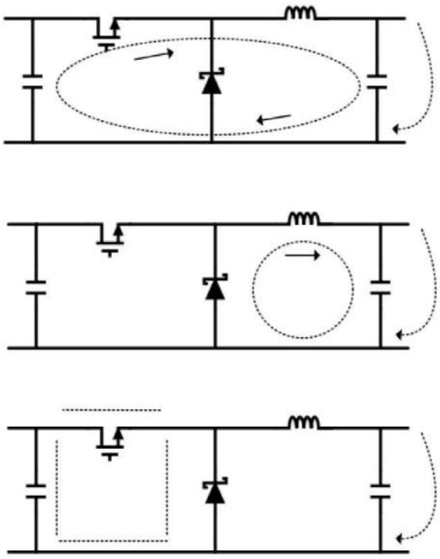


Figure 10-1. Current Flow in Buck Application

10.2 Layout Example

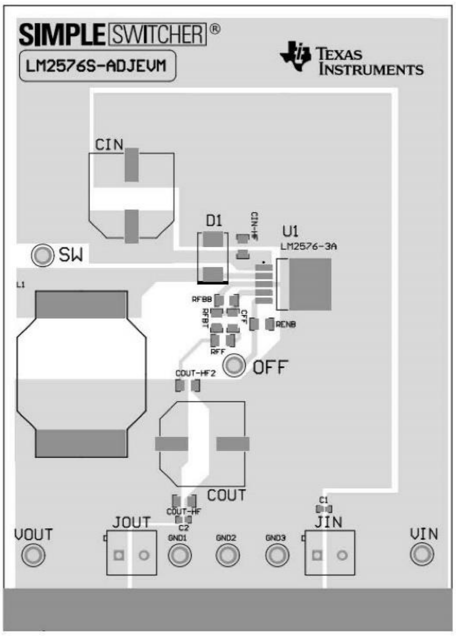


Figure 10-2. LM2576xx Layout Example

10.3 Grounding

To maintain output voltage stability, the power ground connections must be low-impedance (see Figure 8-3 and Figure 8-9). For the 5-lead TO-220 and DDPAK/TO-263 style package, both the tab and pin 3 are ground and either connection may be used, as they are both part of the same copper lead frame.

10.4 Heat Sink and Thermal Considerations

In many cases, only a small heat sink is required to keep the LM2576 junction temperature within the allowed operating range. For each application, to determine whether or not a heat sink is required, the following must be identified:

1. Maximum ambient temperature (in the application).
2. Maximum regulator power dissipation (in application).
3. Maximum allowed junction temperature (125°C for the LM2576). For a safe, conservative design, a temperature approximately 15°C cooler than the maximum temperatures must be selected.
4. LM2576 package thermal resistances θ_{JA} and θ_{JC}.

Total power dissipated by the LM2576 can be estimated in Equation 10:

$$P_D = (V_{IN})(I_Q) + (V_O/V_{IN})(I_{LOAD})(V_{SAT}) \quad (12)$$

where

- I_Q (quiescent current) and V_{SAT} can be found in *Section 6.11* shown previously,
- V_{IN} is the applied minimum input voltage, V_O is the regulated output voltage,

- and I_{LOAD} is the load current.

The dynamic losses during turnon and turnoff are negligible if a Schottky type catch diode is used.

When no heat sink is used, the junction temperature rise can be determined by Equation 11:

$$\Delta T_J = (P_D)\ (\theta_{JA}) \tag{13}$$

To arrive at the actual operating junction temperature, add the junction temperature rise to the maximum ambient temperature.

$$T_J = \Delta T_J + T_A \tag{14}$$

If the actual operating junction temperature is greater than the selected safe operating junction temperature determined in step 3, then a heat sink is required.

When using a heat sink, the junction temperature rise can be determined by Equation 12:

$$\Delta T_J = (P_D)\ (\theta_{JC} + \theta_{interface} + \theta_{Heat\ sink}) \tag{15}$$

The operating junction temperature is:

$$T_J = T_A + \Delta T_J \tag{16}$$

As in Equation 14, if the actual operating junction temperature is greater than the selected safe operating junction temperature, then a larger heat sink is required (one that has a lower thermal resistance).

11 Device and Documentation Support

11.1 Device Support

11.1.1 Device Nomenclature

11.1.1.1 Definition of Terms

BUCK REGULATOR A switching regulator topology in which a higher voltage is converted to a lower voltage. Also known as a step-down switching regulator.

BUCK-BOOST REGULATOR A switching regulator topology in which a positive voltage is converted to a negative voltage without a transformer.

DUTY CYCLE (D) Ratio of the output switch's on-time to the oscillator period.

$$\text{for buck regulator} \quad D = \frac{t_{ON}}{T} = \frac{V_{OUT}}{V_{IN}}$$

$$\text{for buck-boost regulator} \quad D = \frac{t_{ON}}{T} = \frac{|V_O|}{|V_O| + V_{IN}} \tag{17}$$

CATCH DIODE OR CURRENT STEERING DIODE The diode which provides a return path for the load current when the LM2576 switch is OFF.

EFFICIENCY (η) The proportion of input power actually delivered to the load.

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{P_{OUT}}{P_{OUT} + P_{LOSS}} \tag{18}$$

CAPACITOR EQUIVALENT SERIES RESISTANCE (ESR) The purely resistive component of a real capacitor's impedance (see Figure 11-1). It causes power loss resulting in capacitor heating, which directly affects the capacitor's operating lifetime. When used as a switching regulator output filter, higher ESR values result in higher output ripple voltages.

Figure 11-1. Simple Model of a Real Capacitor

Most standard aluminum electrolytic capacitors in the 100 µF–1000 µF range have 0.5Ω to 0.1Ω ESR. Higher-grade capacitors (low-ESR, high-frequency, or low-inductance) in the 100 µF to 1000 µF range generally have ESR of less than 0.15Ω.

EQUIVALENT SERIES INDUCTANCE (ESL) The pure inductance component of a capacitor (see Figure 11-1). The amount of inductance is determined to a large extent on the capacitor's construction. In a buck regulator, this unwanted inductance causes voltage spikes to appear on the output.

OUTPUT RIPPLE VOLTAGE The AC component of the switching regulator's output voltage. It is usually dominated by the output capacitor's ESR multiplied by the inductor's ripple current (ΔI_{IND}). The peak-to-peak value of this sawtooth ripple current can be determined by reading *Section 8.1.3*.

CAPACITOR RIPPLE CURRENT RMS value of the maximum allowable alternating current at which a capacitor can be operated continuously at a specified temperature.

STANDBY QUIESCENT CURRENT (I_{STBY}) Supply current required by the LM2576 when in the standby mode ($\overline{ON}$ /OFF pin is driven to TTL-high voltage, thus turning the output switch OFF).

INDUCTOR RIPPLE CURRENT (ΔI_{IND}) The peak-to-peak value of the inductor current waveform, typically a sawtooth waveform when the regulator is operating in the continuous mode (vs. discontinuous mode).

CONTINUOUS/ DISCONTINUOUS MODE OPERATION Relates to the inductor current. In the continuous mode, the inductor current is always flowing and never drops to zero, vs. the discontinuous mode, where the inductor current drops to zero for a period of time in the normal switching cycle.

INDUCTOR SATURATION The condition which exists when an inductor cannot hold any more magnetic flux. When an inductor saturates, the inductor appears less inductive and the resistive component dominates. Inductor current is then limited only by the DC resistance of the wire and the available source current.

OPERATING VOLT MICROSECOND CONSTANT ($E•T_{op}$) The product (in Volt•μs) of the voltage applied to the inductor and the time the voltage is applied. This $E•T_{op}$ constant is a measure of the energy handling capability of an inductor and is dependent upon the type of core, the core area, the number of turns, and the duty cycle.

11.1.2 Custom Design with WEBENCH Tools

Create a Custom Design with WEBENCH Tools

11.2 Documentation Support

11.2.1 Related Documentation

For related documentation, see the following:

AN-1229 SIMPLE SWITCHER® PCB Layout Guidelines (SNVA054)

11.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

11.4 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.5 Trademarks

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11.6 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.7 Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

TEXAS INSTRUMENTS
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PACKAGE OPTION ADDENDUM

8-Jul-2021

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM2576HVS-12	NRND	DDPAK/ TO-263	KTT	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576 HVS-12 P+	
LM2576HVS-12/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-12 P+	Samples
LM2576HVS-3.3/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-3.3 P+	Samples
LM2576HVS-5.0	NRND	DDPAK/ TO-263	KTT	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576 HVS-5.0 P+	
LM2576HVS-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-5.0 P+	Samples
LM2576HVS-ADJ	NRND	DDPAK/ TO-263	KTT	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576 HVS-ADJ P+	
LM2576HVS-ADJ/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-ADJ P+	Samples
LM2576HVSX-12	NRND	DDPAK/ TO-263	KTT	5	500	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576 HVS-12 P+	
LM2576HVSX-12/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-12 P+	Samples
LM2576HVSX-3.3/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-3.3 P+	Samples
LM2576HVSX-5.0	NRND	DDPAK/ TO-263	KTT	5	500	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576 HVS-5.0 P+	
LM2576HVSX-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-5.0 P+	Samples
LM2576HVSX-ADJ	NRND	DDPAK/ TO-263	KTT	5	500	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576 HVS-ADJ P+	
LM2576HVSX-ADJ/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576 HVS-ADJ P+	Samples
LM2576HVT-12	NRND	TO-220	KC	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576HVT -12 P+	
LM2576HVT-12/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576HVT -12 P+	Samples
LM2576HVT-12/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576HVT	Samples

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PACKAGE OPTION ADDENDUM

8-Jul-2021

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
										-12 P+	
LM2576HVT-15/LB03	NRND	TO-220	NDH	5	45	Non-RoHS & Green	Call TI	Call TI		LM2576HVT -15 P+	
LM2576HVT-15/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576HVT -15 P+	Samples
LM2576HVT-15/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576HVT -15 P+	Samples
LM2576HVT-5.0	NRND	TO-220	KC	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576HVT -5.0 P+	
LM2576HVT-5.0/LB03	NRND	TO-220	NDH	5	45	Non-RoHS & Green	Call TI	Call TI		LM2576HVT -5.0 P+	
LM2576HVT-5.0/LF02	ACTIVE	TO-220	NEB	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576HVT -5.0 P+	Samples
LM2576HVT-5.0/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576HVT -5.0 P+	Samples
LM2576HVT-5.0/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576HVT -5.0 P+	Samples
LM2576HVT-ADJ	NRND	TO-220	KC	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576HVT -ADJ P+	
LM2576HVT-ADJ/LB03	NRND	TO-220	NDH	5	45	Non-RoHS & Green	Call TI	Call TI		LM2576HVT -ADJ P+	
LM2576HVT-ADJ/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576HVT -ADJ P+	Samples
LM2576HVT-ADJ/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576HVT -ADJ P+	Samples
LM2576S-12	NRND	DDPAK/ TO-263	KTT	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576S -12 P+	
LM2576S-12/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576S -12 P+	Samples
LM2576S-3.3/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576S -3.3 P+	Samples
LM2576S-5.0	NRND	DDPAK/ TO-263	KTT	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576S -5.0 P+	
LM2576S-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576S -5.0 P+	Samples

Addendum-Page 2

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM2576S-ADJ/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	45	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576S -ADJ P+	Samples
LM2576SX-3.3/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576S -3.3 P+	Samples
LM2576SX-5.0/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576S -5.0 P+	Samples
LM2576SX-ADJ/NOPB	ACTIVE	DDPAK/ TO-263	KTT	5	500	RoHS-Exempt & Green	SN	Level-3-245C-168 HR	-40 to 125	LM2576S -ADJ P+	Samples
LM2576T-12	NRND	TO-220	KC	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576T -12 P+	
LM2576T-12/LB03	NRND	TO-220	NDH	5	45	Non-RoHS & Green	Call TI	Call TI		LM2576T -12 P+	
LM2576T-12/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576T -12 P+	Samples
LM2576T-12/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576T -12 P+	Samples
LM2576T-15/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576T -15 P+	Samples
LM2576T-15/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576T -15 P+	Samples
LM2576T-3.3/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576T -3.3 P+	Samples
LM2576T-3.3/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576T -3.3 P+	Samples
LM2576T-5.0	NRND	TO-220	KC	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576T -5.0 P+	
LM2576T-5.0/LB03	NRND	TO-220	NDH	5	45	Non-RoHS & Green	Call TI	Call TI		LM2576T -5.0 P+	
LM2576T-5.0/LF02	ACTIVE	TO-220	NEB	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576T -5.0 P+	Samples
LM2576T-5.0/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576T -5.0 P+	Samples
LM2576T-5.0/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576T -5.0 P+	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM2576T-ADJ	NRND	TO-220	KC	5	45	Non-RoHS & Green	Call TI	Call TI	-40 to 125	LM2576T -ADJ P+	
LM2576T-ADJ/LB03	NRND	TO-220	NDH	5	45	Non-RoHS & Green	Call TI	Call TI		LM2576T -ADJ P+	
LM2576T-ADJ/LF02	ACTIVE	TO-220	NEB	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576T -ADJ P+	Samples
LM2576T-ADJ/LF03	ACTIVE	TO-220	NDH	5	45	RoHS & Green	SN	Level-1-NA-UNLIM		LM2576T -ADJ P+	Samples
LM2576T-ADJ/NOPB	ACTIVE	TO-220	KC	5	45	RoHS & Green	SN	Level-1-NA-UNLIM	-40 to 125	LM2576T -ADJ P+	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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PACKAGE MATERIALS INFORMATION

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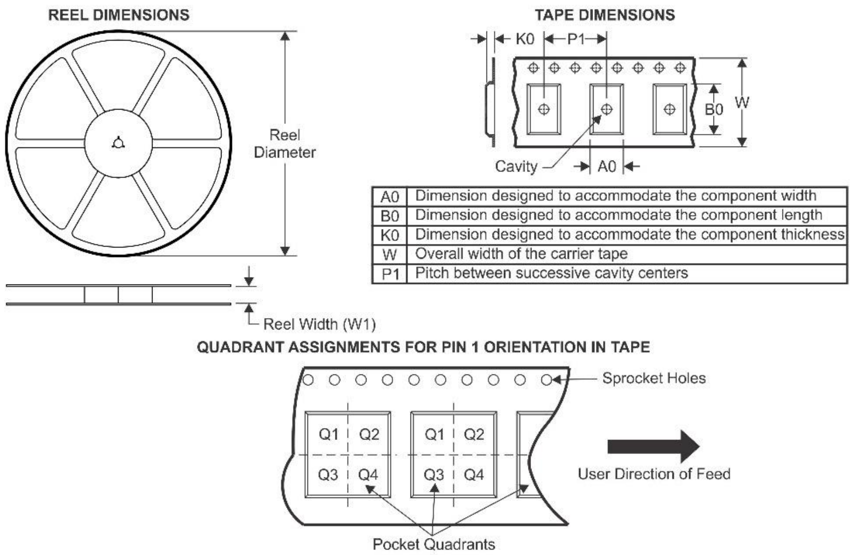
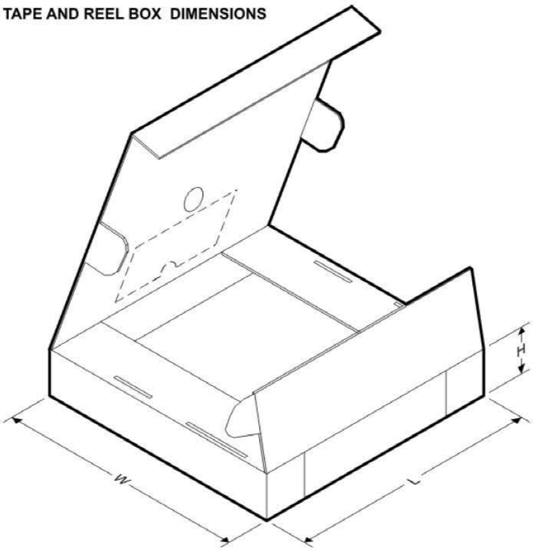
TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM2576HVSX-12	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576HVSX-12/NOPB	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576HVSX-3.3/NOPB	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576HVSX-5.0	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576HVSX-5.0/NOPB	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576HVSX-ADJ	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576HVSX-ADJ/NOPB	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576SX-3.3/NOPB	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576SX-5.0/NOPB	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM2576SX-ADJ/NOPB	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2

TAPE AND REEL BOX DIMENSIONS



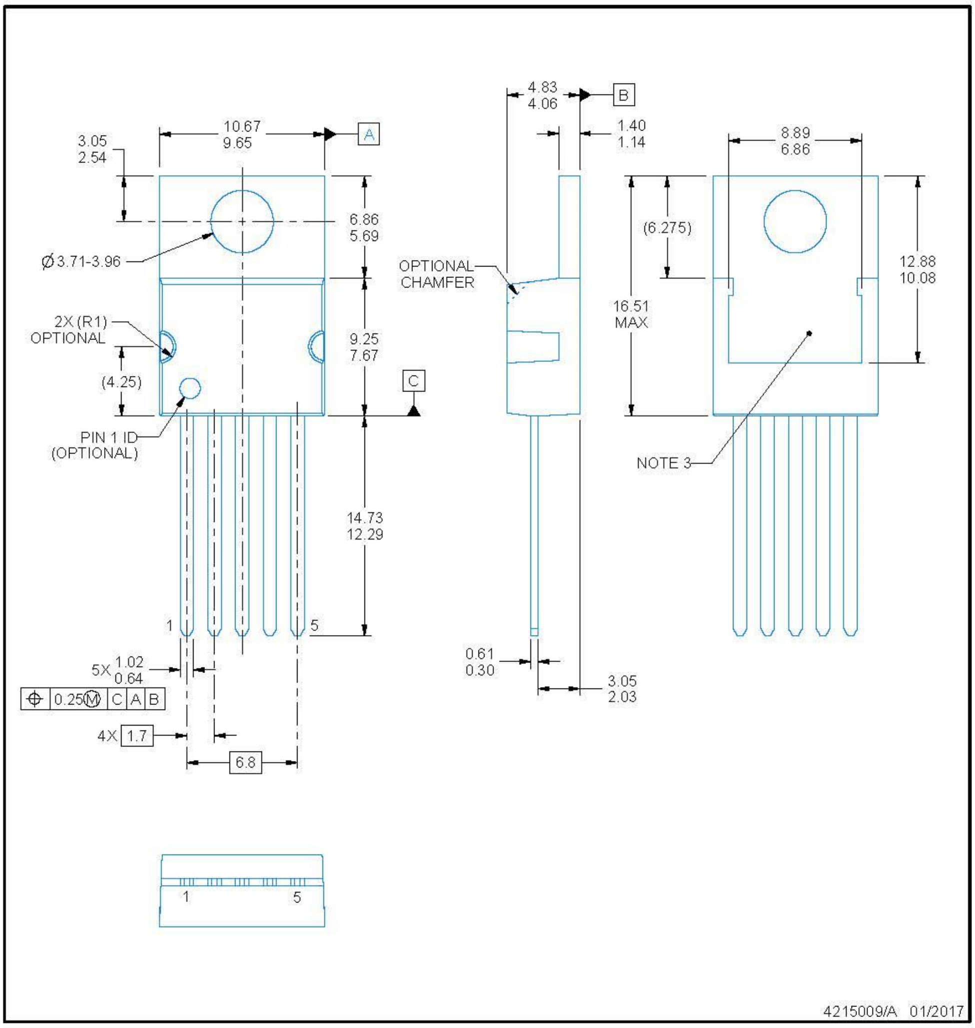
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM2576HVSX-12	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576HVSX-12/NOPB	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576HVSX-3.3/NOPB	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576HVSX-5.0	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576HVSX-5.0/NOPB	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576HVSX-ADJ	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576HVSX-ADJ/NOPB	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576SX-3.3/NOPB	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576SX-5.0/NOPB	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
LM2576SX-ADJ/NOPB	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0

PACKAGE OUTLINE

KC0005A **TO-220 - 16.51 mm max height**

TO-220



NOTES:

1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Shape may vary per different assembly sites.

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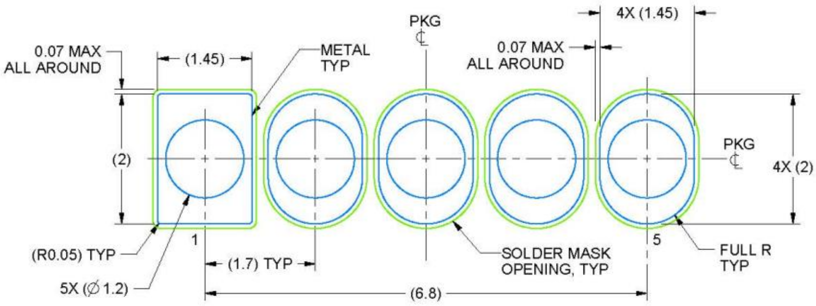
EXAMPLE BOARD LAYOUT

KC0005A

TO-220 - 16.51 mm max height

TO-220



LAND PATTERN
NON-SOLDER MASK DEFINED
SCALE:12X

4215009/A 01/2017

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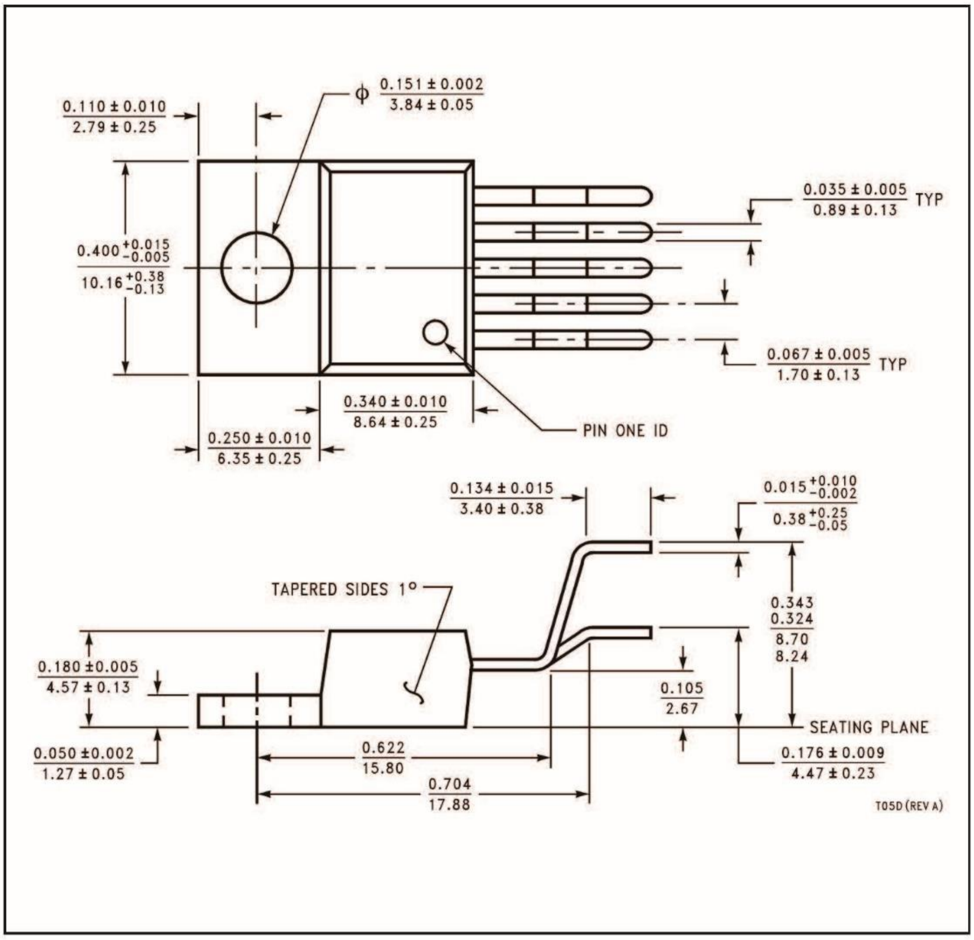
MECHANICAL DATA

NDH0005D



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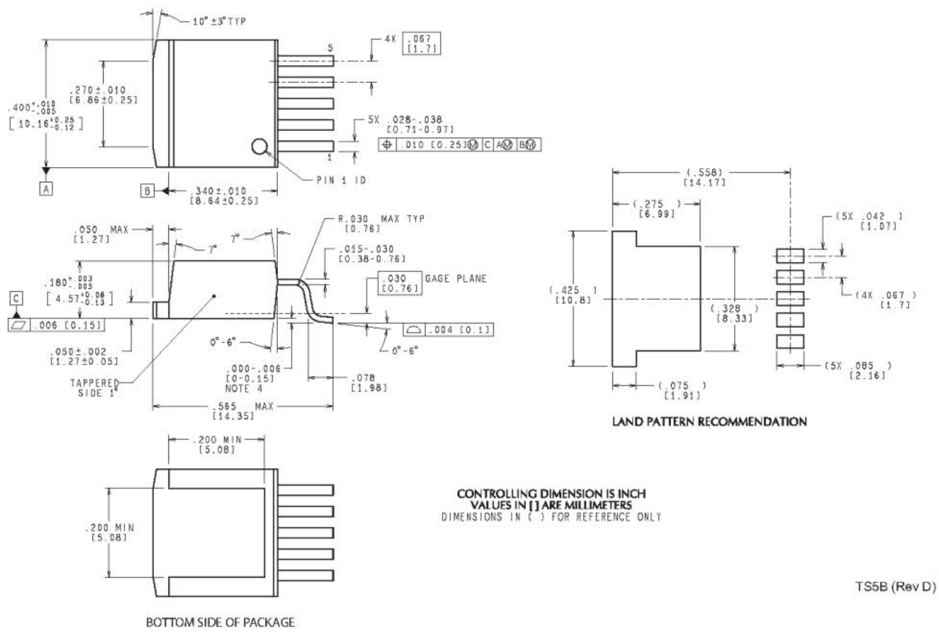
MECHANICAL DATA

KTT0005B



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MECHANICAL DATA

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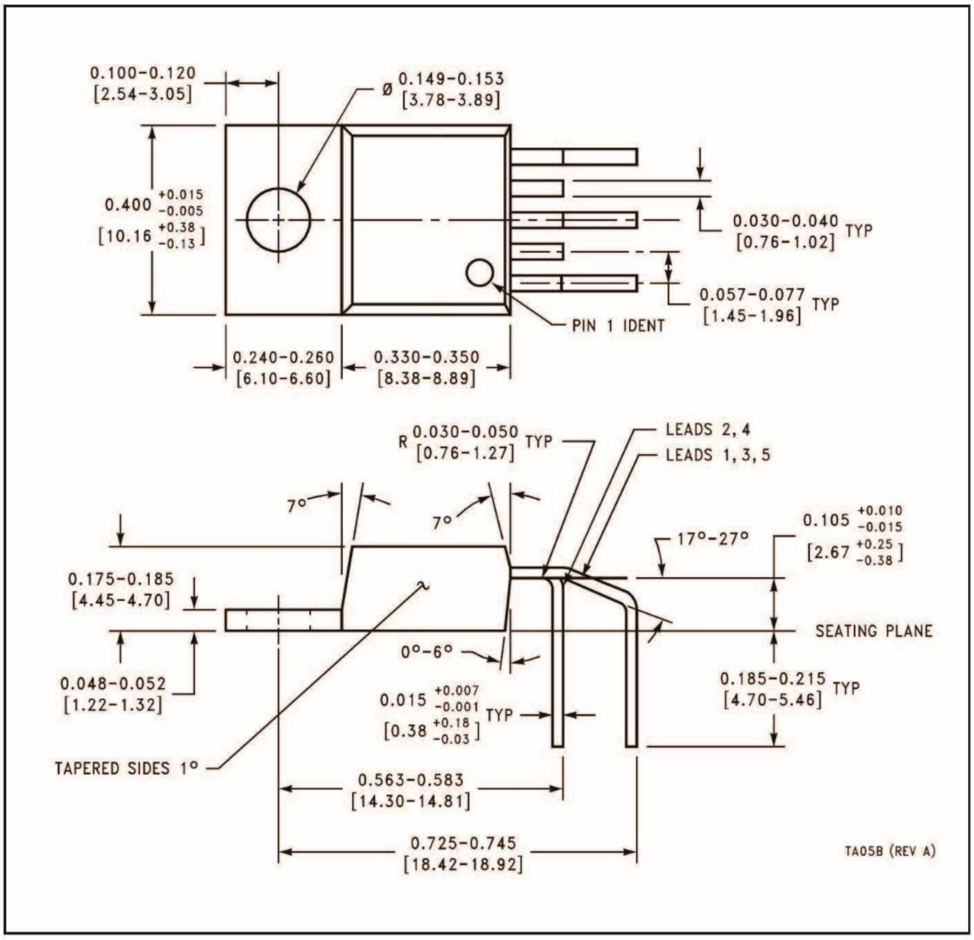

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Expansor de entradas/salidas

MICROCHIP

MCP23017/MCP23S17

16-Bit I/O Expander with Serial Interface

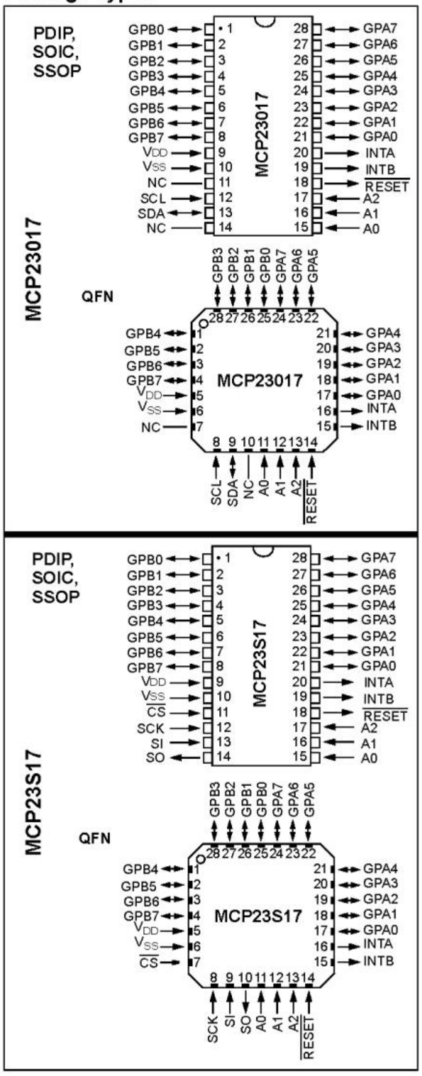
Features

- 16-bit remote bidirectional I/O port
  - I/O pins default to input
- High-speed I2C™ interface (**MCP23017**)
  - 100 kHz
  - 400 kHz
  - 1.7 MHz
- High-speed SPI interface (**MCP23S17**)
  - 10 MHz (max.)
- Three hardware address pins to allow up to eight devices on the bus
- Configurable interrupt output pins
  - Configurable as active-high, active-low or open-drain
- INTA and INTB can be configured to operate independently or together
- Configurable interrupt source
  - Interrupt-on-change from configured register defaults or pin changes
- Polarity Inversion register to configure the polarity of the input port data
- External Reset input
- Low standby current: 1 µA (max.)
- Operating voltage:
  - 1.8V to 5.5V @ -40°C to +85°C
  - 2.7V to 5.5V @ -40°C to +85°C
  - 4.5V to 5.5V @ -40°C to +125°C

Packages

- 28-pin PDIP (300 mil)
- 28-pin SOIC (300 mil)
- 28-pin SSOP
- 28-pin QFN

Package Types



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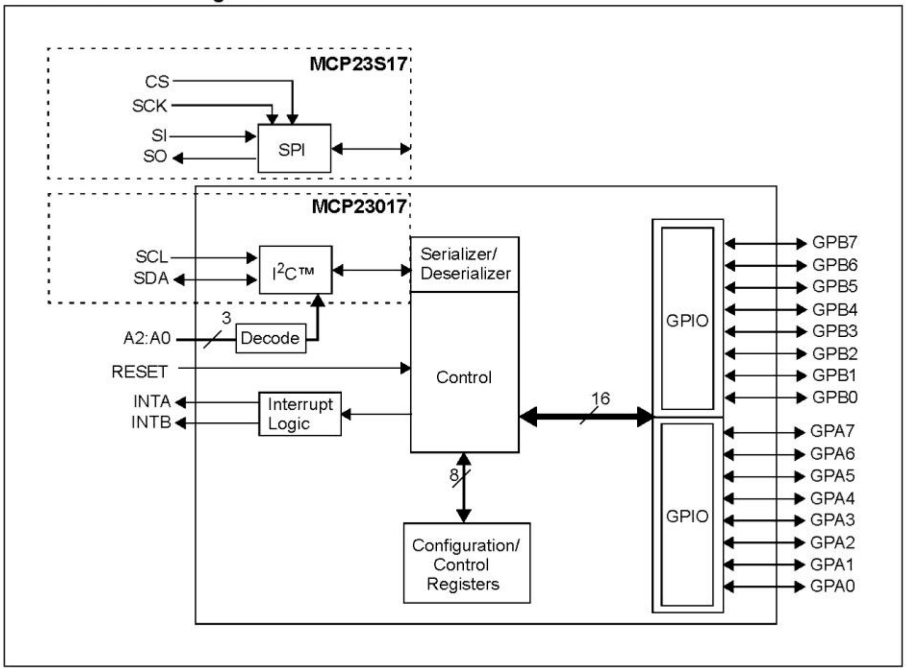
MCP23017

MCP23017/MCP23S17

Functional Block Diagram



1.0 DEVICE OVERVIEW

The MCP23017/MCP23S17 (MCP23X17) device family provides 16-bit, general purpose parallel I/O expansion for I^2C bus or SPI applications. The two devices differ only in the serial interface.

- MCP23017 – I^2C interface
- MCP23S17 – SPI interface

The MCP23X17 consists of multiple 8-bit configuration registers for input, output and polarity selection. The system master can enable the I/Os as either inputs or outputs by writing the I/O configuration bits (IODIRA/B). The data for each input or output is kept in the corresponding input or output register. The polarity of the Input Port register can be inverted with the Polarity Inversion register. All registers can be read by the system master.

The 16-bit I/O port functionally consists of two 8-bit ports (PORTA and PORTB). The MCP23X17 can be configured to operate in the 8-bit or 16-bit modes via IOCON.BANK.

There are two interrupt pins, INTA and INTB, that can be associated with their respective ports, or can be logically OR'ed together so that both pins will activate if either port causes an interrupt.

The interrupt output can be configured to activate under two conditions (mutually exclusive):

1. When any input state differs from its corresponding Input Port register state. This is used to indicate to the system master that an input state has changed.
2. When an input state differs from a preconfigured register value (DEFVAL register).

The Interrupt Capture register captures port values at the time of the interrupt, thereby saving the condition that caused the interrupt.

The Power-on Reset (POR) sets the registers to their default values and initializes the device state machine.

The hardware address pins are used to determine the device address.

MCP23017/MCP23S17

1.1 Pin Descriptions

TABLE 1-1: PINOUT DESCRIPTION

Pin Name	PDIP/ SOIC/ SSOP	QFN	Pin Type	Function
GPB0	1	25	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPB1	2	26	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPB2	3	27	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPB3	4	28	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPB4	5	1	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPB5	6	2	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPB6	7	3	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPB7	8	4	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
V_{DD}	9	5	P	Power
V_{SS}	10	6	P	Ground
NC/$\overline{CS}$	11	7	I	NC (MCP23017), Chip Select (MCP23S17)
SCL/SCK	12	8	I	Serial clock input
SDA/SI	13	9	I/O	Serial data I/O (MCP23017), Serial data input (MCP23S17)
NC/SO	14	10	O	NC (MCP23017), Serial data out (MCP23S17)
A0	15	11	I	Hardware address pin. Must be externally biased.
A1	16	12	I	Hardware address pin. Must be externally biased.
A2	17	13	I	Hardware address pin. Must be externally biased.
$\overline{RESET}$	18	14	I	Hardware reset. Must be externally biased.
INTB	19	15	O	Interrupt output for PORTB. Can be configured as active-high, active-low or open-drain.
INTA	20	16	O	Interrupt output for PORTA. Can be configured as active-high, active-low or open-drain.
GPA0	21	17	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPA1	22	18	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPA2	23	19	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPA3	24	20	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPA4	25	21	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPA5	26	22	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPA6	27	23	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.
GPA7	28	24	I/O	Bidirectional I/O pin. Can be enabled for interrupt-on-change and/or internal weak pull-up resistor.

1.2 Power-on Reset (POR)

The on-chip POR circuit holds the device in reset until VDD has reached a high enough voltage to deactivate the POR circuit (i.e., release the device from reset). The maximum VDD rise time is specified in **Section 2.0 "Electrical Characteristics"**.

When the device exits the POR condition (releases reset), device operating parameters (i.e., voltage, temperature, serial bus frequency, etc.) must be met to ensure proper operation.

1.3 Serial Interface

This block handles the functionality of the I^2C (MCP23017) or SPI (MCP23S17) interface protocol. The MCP23X17 contains 22 individual registers (11 register pairs) that can be addressed through the Serial Interface block, as shown in Table 1-2.

TABLE 1-2: REGISTER ADDRESSES

Address IOCON.BANK = 1	Address IOCON.BANK = 0	Access to:
00h	00h	IODIRA
10h	01h	IODIRB
01h	02h	IPOLA
11h	03h	IPOLB
02h	04h	GPINTENA
12h	05h	GPINTENB
03h	06h	DEFVALA
13h	07h	DEFVALB
04h	08h	INTCONA
14h	09h	INTCONB
05h	0Ah	IOCON
15h	0Bh	IOCON
06h	0Ch	GPPUA
16h	0Dh	GPPUB
07h	0Eh	INTFA
17h	0Fh	INTFB
08h	10h	INTCAPA
18h	11h	INTCAPB
09h	12h	GPIOA
19h	13h	GPIOB
0Ah	14h	OLATA
1Ah	15h	OLATB

1.3.1 BYTE MODE AND SEQUENTIAL MODE

The MCP23X17 family has the ability to operate in Byte mode or Sequential mode (IOCON.SEQOP).

Byte Mode disables automatic Address Pointer incrementing. When operating in Byte mode, the MCP23X17 family does not increment its internal address counter after each byte during the data transfer. This gives the ability to continually access the same address by providing extra clocks (without additional control bytes). This is useful for polling the GPIO register for data changes or for continually writing to the output latches.

A special mode **(Byte mode with IOCON.BANK = 0)** causes the address pointer to toggle between associated A/B register pairs. For example, if the BANK bit is cleared and the Address Pointer is initially set to address 12h (GPIOA) or 13h (GPIOB), the pointer will toggle between GPIOA and GPIOB. Note that the Address Pointer can initially point to either address in the register pair.

Sequential mode enables automatic address pointer incrementing. When operating in Sequential mode, the MCP23X17 family increments its address counter after each byte during the data transfer. The Address Pointer automatically rolls over to address 00h after accessing the last register.

These two modes are not to be confused with single writes/reads and continuous writes/reads that are serial protocol sequences. For example, the device may be configured for Byte mode and the master may perform a continuous read. In this case, the MCP23X17 would not increment the Address Pointer and would repeatedly drive data from the same location.

1.3.2 I^2C INTERFACE

1.3.2.1 I^2C Write Operation

The I^2C write operation includes the control byte and register address sequence, as shown in the bottom of Figure 1-1. This sequence is followed by eight bits of data from the master and an Acknowledge (ACK) from the MCP23017. The operation is ended with a Stop (P) or Restart (SR) condition being generated by the master.

Data is written to the MCP23017 after every byte transfer. If a Stop or Restart condition is generated during a data transfer, the data will not be written to the MCP23017.

Both "byte writes" and "sequential writes" are supported by the MCP23017. If Sequential mode is enabled (IOCON, SEQOP = 0) (default), the MCP23017 increments its address counter after each ACK during the data transfer.

1.3.2.2 I2C Read Operation

I2C Read operations include the control byte sequence, as shown in the bottom of Figure 1-1. This sequence is followed by another control byte (including the Start condition and ACK) with the R/W bit set (R/W = 1). The MCP23017 then transmits the data contained in the addressed register. The sequence is ended with the master generating a Stop or Restart condition.

1.3.2.3 I2C Sequential Write/Read

For sequential operations (Write or Read), instead of transmitting a Stop or Restart condition after the data transfer, the master clocks the next byte pointed to by the address pointer (see **Section 1.3.1 "Byte Mode and Sequential Mode"** for details regarding sequential operation control).

The sequence ends with the master sending a Stop or Restart condition.

The MCP23017 Address Pointer will roll over to address zero after reaching the last register address.

Refer to Figure 1-1.

1.3.3 SPI INTERFACE

1.3.3.1 SPI Write Operation

The SPI write operation is started by lowering $\overline{CS}$. The Write command (slave address with R/W bit cleared) is then clocked into the device. The opcode is followed by an address and at least one data byte.

1.3.3.2 SPI Read Operation

The SPI read operation is started by lowering $\overline{CS}$. The SPI read command (slave address with R/W bit set) is then clocked into the device. The opcode is followed by an address, with at least one data byte being clocked out of the device.

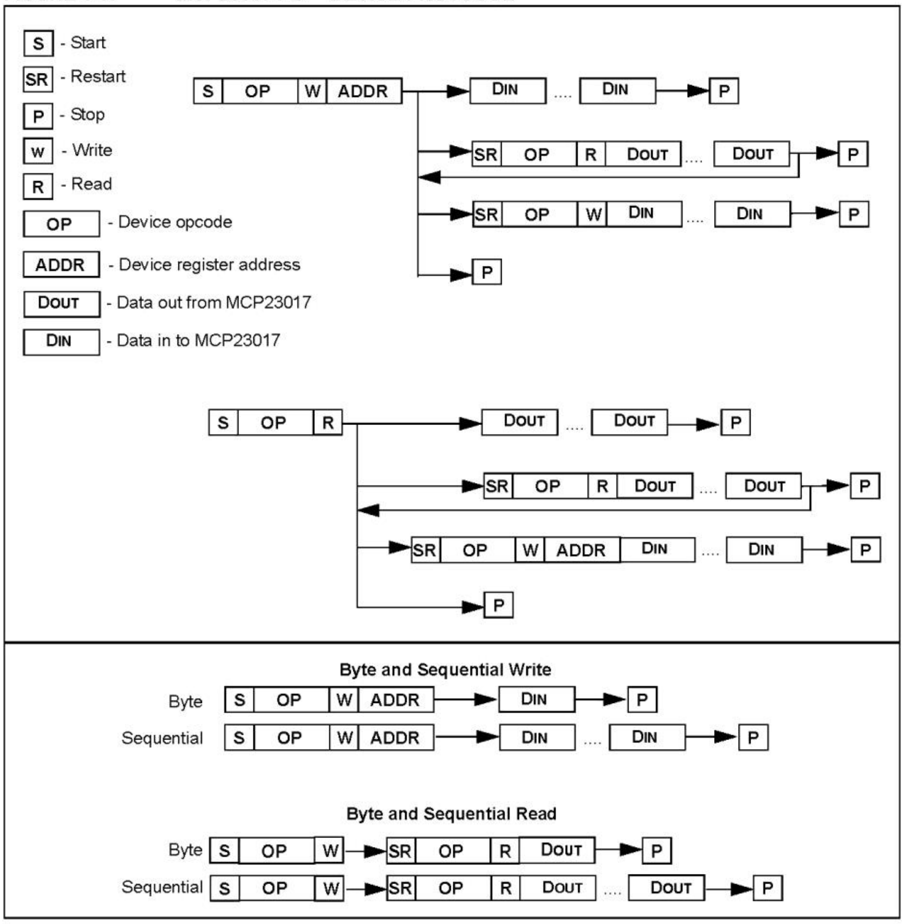
1.3.3.3 SPI Sequential Write/Read

For sequential operations, instead of deselecting the device by raising $\overline{CS}$, the master clocks the next byte pointed to by the Address Pointer. (see **Section 1.3.1 "Byte Mode and Sequential Mode"** for details regarding sequential operation control).

The sequence ends by the raising of $\overline{CS}$.

The MCP23S17 Address Pointer will roll over to address zero after reaching the last register address.

FIGURE 1-1: MCP23017 I²C™ DEVICE PROTOCOL



MCP23017/MCP23S17

1.4 Hardware Address Decoder

The hardware address pins are used to determine the device address. To address a device, the corresponding address bits in the control byte must match the pin state. The pins must be biased externally.

1.4.1 ADDRESSING I²C DEVICES (MCP23017)

The MCP23017 is a slave I²C interface device that supports 7-bit slave addressing, with the read/write bit filling out the control byte. The slave address contains four fixed bits and three user-defined hardware address bits (pins A2, A1 and A0). Figure 1-2 shows the control byte format.

1.4.2 ADDRESSING SPI DEVICES (MCP23S17)

The MCP23S17 is a slave SPI device. The slave address contains four fixed bits and three user-defined hardware address bits (if enabled via IOCON.HAEN) (pins A2, A1 and A0) with the read/write bit filling out the control byte. Figure 1-3 shows the control byte format. The address pins should be externally biased even if disabled (IOCON.HAEN = 0).

FIGURE 1-2: I²C™ CONTROL BYTE FORMAT

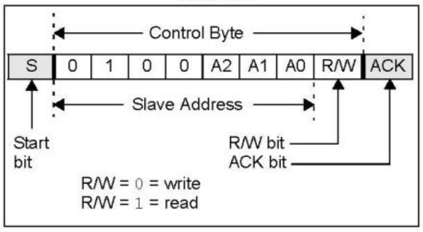


FIGURE 1-3: SPI CONTROL BYTE FORMAT

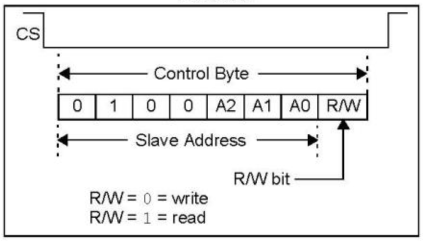


FIGURE 1-4: I²C™ ADDRESSING REGISTERS

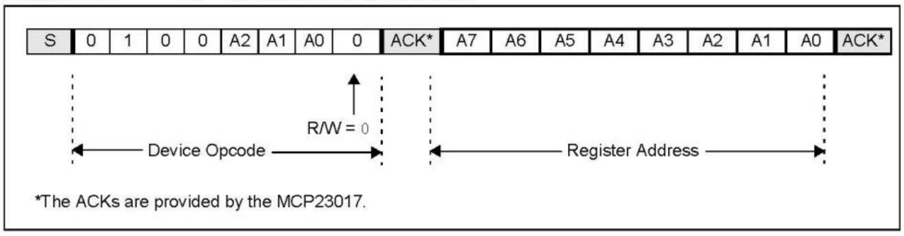
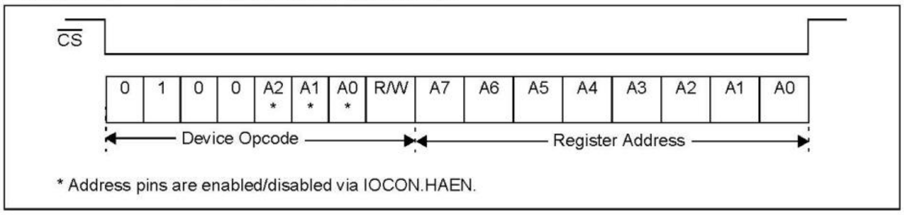


FIGURE 1-5: SPI ADDRESSING REGISTERS



1.5 GPIO Port

The GPIO module is a general purpose, 16-bit wide, bidirectional port that is functionally split into two 8-bit wide ports.

The GPIO module contains the data ports (GPIOn), internal pull-up resistors and the output latches (OLATn).

Reading the GPIOn register reads the value on the port. Reading the OLATn register only reads the latches, not the actual value on the port.

Writing to the GPIOn register actually causes a write to the latches (OLATn). Writing to the OLATn register forces the associated output drivers to drive to the level in OLATn. Pins configured as inputs turn off the associated output driver and put it in high-impedance.

TABLE 1-3: SUMMARY OF REGISTERS ASSOCIATED WITH THE GPIO PORTS (BANK = 1)

Register Name	Address (hex)	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	POR/RST value
IODIRA	00	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IPOLA	01	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
GPINTENA	02	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
GPPUA	06	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
GPIOA	09	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
OLATA	0A	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000
IODIRB	10	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IPOLB	11	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
GPINTENB	12	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
GPPUB	16	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
GPIOB	19	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
OLATB	1A	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000

TABLE 1-4: SUMMARY OF REGISTERS ASSOCIATED WITH THE GPIO PORTS (BANK = 0)

Register Name	Address (hex)	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	POR/RST value
IODIRA	00	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IODIRB	01	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IPOLA	02	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
IPOLB	03	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
GPINTENA	04	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
GPINTENB	05	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
GPPUA	0C	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
GPPUB	0D	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
GPIOA	12	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
GPIOB	13	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
OLATA	14	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000
OLATB	15	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000

1.6 Configuration and Control Registers

There are 21 registers associated with the MCP23X17, as shown in Table 1-5 and Table 1-6. The two tables show the register mapping with the two BANK bit values. Ten registers are associated with PortA and ten are associated with PortB. One register (IOCON) is shared between the two ports. The PortA registers are identical to the PortB registers, therefore, they will be referred to without differentiating between the port designation (i.e., they will not have the "A" or "B" designator assigned) in the register tables.

TABLE 1-5: CONTROL REGISTER SUMMARY (IOCON.BANK = 1)

Register Name	Address (hex)	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	POR/RST value
IODIRA	00	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IPOLA	01	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
GPINTENA	02	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
DEFVALA	03	DEF7	DEF6	DEF5	DEF4	DEF3	DEF2	DEF1	DEF0	0000 0000
INTCONA	04	IOC7	IOC6	IOC5	IOC4	IOC3	IOC2	IOC1	IOC0	0000 0000
IOCON	05	BANK	MIRROR	SEQOP	DISSLW	HAEN	ODR	INTPOL	—	0000 0000
GPPUA	06	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
INTFA	07	INT7	INT6	INT5	INT4	INT3	INT2	INT1	INTO	0000 0000
INTCAPA	08	ICP7	ICP6	ICP5	ICP4	ICP3	ICP2	ICP1	ICP0	0000 0000
GPIOA	09	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
OLATA	0A	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000
IODIRB	10	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IPOLB	11	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
GPINTENB	12	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
DEFVALB	13	DEF7	DEF6	DEF5	DEF4	DEF3	DEF2	DEF1	DEF0	0000 0000
INTCONB	14	IOC7	IOC6	IOC5	IOC4	IOC3	IOC2	IOC1	IOC0	0000 0000
IOCON	15	BANK	MIRROR	SEQOP	DISSLW	HAEN	ODR	INTPOL	—	0000 0000
GPPUB	16	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
INTFB	17	INT7	INT6	INT5	INT4	INT3	INT2	INT1	INTO	0000 0000
INTCAPB	18	ICP7	ICP6	ICP5	ICP4	ICP3	ICP2	ICP1	ICP0	0000 0000
GPIOB	19	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
OLATB	1A	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000

TABLE 1-6: CONTROL REGISTER SUMMARY (IOCON.BANK = 0)

Register Name	Address (hex)	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	POR/RST value
IODIRA	00	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IODIRB	01	IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0	1111 1111
IPOLA	02	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
IPOLB	03	IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0	0000 0000
GPINTENA	04	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
GPINTENB	05	GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0	0000 0000
DEFVALA	06	DEF7	DEF6	DEF5	DEF4	DEF3	DEF2	DEF1	DEF0	0000 0000
DEFVALB	07	DEF7	DEF6	DEF5	DEF4	DEF3	DEF2	DEF1	DEF0	0000 0000
INTCONA	08	IOC7	IOC6	IOC5	IOC4	IOC3	IOC2	IOC1	IOC0	0000 0000
INTCONB	09	IOC7	IOC6	IOC5	IOC4	IOC3	IOC2	IOC1	IOC0	0000 0000
IOCON	0A	BANK	MIRROR	SEQOP	DISSLW	HAEN	ODR	INTPOL	—	0000 0000
IOCON	0B	BANK	MIRROR	SEQOP	DISSLW	HAEN	ODR	INTPOL	—	0000 0000
GPPUA	0C	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
GPPUB	0D	PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0	0000 0000
INTFA	0E	INT7	INT6	INT5	INT4	INT3	INT2	INT1	INTO	0000 0000
INTFB	0F	INT7	INT6	INT5	INT4	INT3	INT2	INT1	INTO	0000 0000
INTCAPA	10	ICP7	ICP6	ICP5	ICP4	ICP3	ICP2	ICP1	ICP0	0000 0000
INTCAPB	11	ICP7	ICP6	ICP5	ICP4	ICP3	ICP2	ICP1	ICP0	0000 0000
GPIOA	12	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
GPIOB	13	GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0	0000 0000
OLATA	14	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000
OLATB	15	OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0	0000 0000

1.6.1 I/O DIRECTION REGISTER

Controls the direction of the data I/O.

When a bit is set, the corresponding pin becomes an input. When a bit is clear, the corresponding pin becomes an output.

REGISTER 1-1: IODIR – I/O DIRECTION REGISTER (ADDR 0x00)

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
IO7	IO6	IO5	IO4	IO3	IO2	IO1	IO0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0 **IO7:IO0:** These bits control the direction of data I/O <7:0>
1 = Pin is configured as an input.
0 = Pin is configured as an output.

1.6.2 INPUT POLARITY REGISTER

This register allows the user to configure the polarity on the corresponding GPIO port bits.

If a bit is set, the corresponding GPIO register bit will reflect the inverted value on the pin.

REGISTER 1-2: IPOL – INPUT POLARITY PORT REGISTER (ADDR 0x01)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
IP7	IP6	IP5	IP4	IP3	IP2	IP1	IP0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’	
-n = Value at POR	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 7-0 **IP7:IP0:** These bits control the polarity inversion of the input pins <7:0>
1 = GPIO register bit will reflect the opposite logic state of the input pin.
0 = GPIO register bit will reflect the same logic state of the input pin.

1.6.3 INTERRUPT-ON-CHANGE CONTROL REGISTER

The GPINTEN register controls the interrupt-on-change feature for each pin.

If a bit is set, the corresponding pin is enabled for interrupt-on-change. The DEFVAL and INTCON registers must also be configured if any pins are enabled for interrupt-on-change.

REGISTER 1-3: GPINTEN – INTERRUPT-ON-CHANGE PINS (ADDR 0x02)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
GPINT7	GPINT6	GPINT5	GPINT4	GPINT3	GPINT2	GPINT1	GPINT0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’	
-n = Value at POR	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 7-0 **GPINT7:GPINT0:** General purpose I/O interrupt-on-change bits <7:0>
1 = Enable GPIO input pin for interrupt-on-change event.
0 = Disable GPIO input pin for interrupt-on-change event.

Refer to INTCON and GPINTEN.

1.6.4 DEFAULT COMPARE REGISTER FOR INTERRUPT-ON-CHANGE

The default comparison value is configured in the DEFVAL register. If enabled (via GPINTEN and INTCON) to compare against the DEFVAL register, an opposite value on the associated pin will cause an interrupt to occur.

REGISTER 1-4: DEFVAL – DEFAULT VALUE REGISTER (ADDR 0x03)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
DEF7	DEF6	DEF5	DEF4	DEF3	DEF2	DEF1	DEF0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’	
-n = Value at POR	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 7-0 **DEF7:DEF0:** These bits set the compare value for pins configured for interrupt-on-change from defaults <7:0>. Refer to INTCON.
If the associated pin level is the opposite from the register bit, an interrupt occurs.

Refer to INTCON and GPINTEN.

1.6.5 INTERRUPT CONTROL REGISTER

The INTCON register controls how the associated pin value is compared for the interrupt-on-change feature. If a bit is set, the corresponding I/O pin is compared against the associated bit in the DEFVAL register. If a bit value is clear, the corresponding I/O pin is compared against the previous value.

REGISTER 1-5: INTCON – INTERRUPT-ON-CHANGE CONTROL REGISTER (ADDR 0x04)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
IOC7	IOC6	IOC5	IOC4	IOC3	IOC2	IOC1	IOC0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0 **IOC7:IOC0:** These bits control how the associated pin value is compared for interrupt-on-change <7:0>

1 = Controls how the associated pin value is compared for interrupt-on-change.
0 = Pin value is compared against the previous pin value.

Refer to INTCON and GPINTEN.

1.6.6 CONFIGURATION REGISTER

The IOCON register contains several bits for configuring the device:

The **BANK** bit changes how the registers are mapped (see Table 1-5 and Table 1-6 for more details).

- If BANK = 1, the registers associated with each port are segregated. Registers associated with PORTA are mapped from address 00h - 0Ah and registers associated with PORTB are mapped from 10h - 1Ah.
- If BANK = 0, the A/B registers are paired. For example, IODIRA is mapped to address 00h and IODIRB is mapped to the next address (address 01h). The mapping for all registers is from 00h - 15h.

It is important to take care when changing the BANK bit as the address mapping changes after the byte is clocked into the device. The address pointer may point to an invalid location after the bit is modified.

For example, if the device is configured to automatically increment its internal Address Pointer, the following scenario would occur:

- BANK = 0
- Write 80h to address 0Ah (IOCON) to set the BANK bit
- Once the write completes, the internal address now points to 0Bh which is an invalid address when the BANK bit is set.

For this reason, it is advised to only perform byte writes to this register when changing the BANK bit.

The **MIRROR** bit controls how the INTA and INTB pins function with respect to each other.

- When MIRROR = 1, the INTn pins are functionally OR'ed so that an interrupt on either port will cause both pins to activate.
- When MIRROR = 0, the INT pins are separated. Interrupt conditions on a port will cause its respective INT pin to activate.

The Sequential Operation (**SEQOP**) controls the incrementing function of the Address Pointer. If the address pointer is disabled, the Address Pointer does not automatically increment after each byte is clocked during a serial transfer. This feature is useful when it is desired to continuously poll (read) or modify (write) a register.

The Slew Rate (**DISSLW**) bit controls the slew rate function on the SDA pin. If enabled, the SDA slew rate will be controlled when driving from a high to low.

The Hardware Address Enable (**HAEN**) bit enables/disables hardware addressing on the MCP23S17 only. The address pins (A2, A1 and A0) must be externally biased, regardless of the HAEN bit value.

If enabled (HAEN = 1), the device's hardware address matches the address pins.

If disabled (HAEN = 0), the device's hardware address is A2 = A1 = A0 = 0.

The Open-Drain (**ODR**) control bit enables/disables the INT pin for open-drain configuration. Erasing this bit overrides the INTPOL bit.

The Interrupt Polarity (**INTPOL**) sets the polarity of the INT pin. This bit is functional only when the ODR bit is cleared, configuring the INT pin as active push-pull.

REGISTER 1-6: IOCON – I/O EXPANDER CONFIGURATION REGISTER (ADDR 0x05)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0
BANK	MIRROR	SEQOP	DISSLW	HAEN	ODR	INTPOL	—
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7 **BANK:** Controls how the registers are addressed
1 = The registers associated with each port are separated into different banks
0 = The registers are in the same bank (addresses are sequential)

bit 6 **MIRROR:** INT Pins Mirror bit
1 = The INT pins are internally connected
0 = The INT pins are not connected. INTA is associated with PortA and INTB is associated with PortB

bit 5 **SEQOP:** Sequential Operation mode bit.
1 = Sequential operation disabled, address pointer does not increment.
0 = Sequential operation enabled, address pointer increments.

bit 4 **DISSLW:** Slew Rate control bit for SDA output.
1 = Slew rate disabled.
0 = Slew rate enabled.

bit 3 **HAEN:** Hardware Address Enable bit (MCP23S17 only).
Address pins are always enabled on MCP23017.
1 = Enables the MCP23S17 address pins.
0 = Disables the MCP23S17 address pins.

bit 2 **ODR:** This bit configures the INT pin as an open-drain output.
1 = Open-drain output (overrides the INTPOL bit).
0 = Active driver output (INTPOL bit sets the polarity).

bit 1 **INTPOL:** This bit sets the polarity of the INT output pin.
1 = Active-high.
0 = Active-low.

bit 0 **Unimplemented:** Read as '0'.

1.6.7 PULL-UP RESISTOR CONFIGURATION REGISTER

The GPPU register controls the pull-up resistors for the port pins. If a bit is set and the corresponding pin is configured as an input, the corresponding port pin is internally pulled up with a 100 kΩ resistor.

REGISTER 1-7: GPPU – GPIO PULL-UP RESISTOR REGISTER (ADDR 0x06)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
PU7	PU6	PU5	PU4	PU3	PU2	PU1	PU0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0 **PU7:PU0:** These bits control the weak pull-up resistors on each pin (when configured as an input) <7:0>.
1 = Pull-up enabled.
0 = Pull-up disabled.

1.6.8 INTERRUPT FLAG REGISTER

The INTF register reflects the interrupt condition on the port pins of any pin that is enabled for interrupts via the GPINTEN register. A 'set' bit indicates that the associated pin caused the interrupt.

This register is 'read-only'. Writes to this register will be ignored.

REGISTER 1-8: INTF – INTERRUPT FLAG REGISTER (ADDR 0x07)

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
INT7	INT6	INT5	INT4	INT3	INT2	INT1	INT0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0 **INT7:INT0:** These bits reflect the interrupt condition on the port. Will reflect the change only if interrupts are enabled (GPINTEN) <7:0>.
1 = Pin caused interrupt.
0 = Interrupt not pending.

1.6.9 INTERRUPT CAPTURE REGISTER

The INTCAP register captures the GPIO port value at the time the interrupt occurred. The register is 'read only' and is updated only when an interrupt occurs. The register will remain unchanged until the interrupt is cleared via a read of INTCAP or GPIO.

REGISTER 1-9: INTCAP – INTERRUPT CAPTURED VALUE FOR PORT REGISTER (ADDR 0x08)

R-x	R-x	R-x	R-x	R-x	R-x	R-x	R-x
ICP7	ICP6	ICP5	ICP4	ICP3	ICP2	ICP1	ICP0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0 **ICP7:ICP0:** These bits reflect the logic level on the port pins at the time of interrupt due to pin change <7:0>
1 = Logic-high.
0 = Logic-low.

1.6.10 PORT REGISTER

The GPIO register reflects the value on the port. Reading from this register reads the port. Writing to this register modifies the Output Latch (OLAT) register.

REGISTER 1-10: GPIO – GENERAL PURPOSE I/O PORT REGISTER (ADDR 0x09)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
GP7	GP6	GP5	GP4	GP3	GP2	GP1	GP0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0 **GP7:GP0:** These bits reflect the logic level on the pins <7:0>
1 = Logic-high.
0 = Logic-low.

1.6.11 OUTPUT LATCH REGISTER (OLAT)

The OLAT register provides access to the output latches. A read from this register results in a read of the OLAT and not the port itself. A write to this register modifies the output latches that modifies the pins configured as outputs.

REGISTER 1-11: OLAT – OUTPUT LATCH REGISTER 0 (ADDR 0x0A)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
OL7	OL6	OL5	OL4	OL3	OL2	OL1	OL0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0 **OL7:OL0:** These bits reflect the logic level on the output latch <7:0>
1 = Logic-high.
0 = Logic-low.

1.7 Interrupt Logic

If enabled, the MCP23X17 activates the INTn interrupt output when one of the port pins changes state or when a pin does not match the preconfigured default. Each pin is individually configurable as follows:

- Enable/disable interrupt via GPINTEN
- Can interrupt on either pin change or change from default as configured in DEFVAL

Both conditions are referred to as Interrupt-on-Change (IOC).

The interrupt control module uses the following registers/bits:

- IOCON.MIRROR – controls if the two interrupt pins mirror each other
- GPINTEN – Interrupt enable register
- INTCON – Controls the source for the IOC
- DEFVAL – Contains the register default for IOC operation

1.7.1 INTA AND INTB

There are two interrupt pins: INTA and INTB. By default, INTA is associated with GPAn pins (PortA) and INTB is associated with GPBn pins (PortB). Each port has an independent signal which is cleared if its associated GPIO or INTCAP register is read.

1.7.1.1 Mirroring the INT pins

Additionally, the INTn pins can be configured to mirror each other so that any interrupt will cause both pins to go active. This is controlled via IOCON.MIRROR.

If IOCON.MIRROR = 0, the internal signals are routed independently to the INTA and INTB pads.

If IOCON.MIRROR = 1, the internal signals are OR'ed together and routed to the INTn pads. In this case, the interrupt will only be cleared if the associated GPIO or INTCAP is read (see Table 1-7).

TABLE 1-7: INTERRUPT OPERATION (IOCON.MIRROR = 1)

Interrupt Condition	Read Portn *	Interupt Result
GPIOA	PortA	Clear
	PortB	Unchanged
GPIOB	PortA	Unchanged
	PortB	Clear
GPIOA and GPIOB	PortA	Unchanged
	PortB	Unchanged
	Both PortA and PortB	Clear

* Port n = GPIOn or INTCAPn

1.7.2 IOC FROM PIN CHANGE

If enabled, the MCP23X17 will generate an interrupt if a mismatch condition exists between the current port value and the previous port value. Only IOC enabled pins will be compared. Refer to Register 1-3 and Register 1-5.

1.7.3 IOC FROM REGISTER DEFAULT

If enabled, the MCP23X17 will generate an interrupt if a mismatch occurs between the DEFVAL register and the port. Only IOC enabled pins will be compared. Refer to Register 1-3, Register 1-5 and Register 1-4.

1.7.4 INTERRUPT OPERATION

The INTn interrupt output can be configured as active-low, active-high or open-drain via the IOCON register.

Only those pins that are configured as an input (IODIR register) with Interrupt-On-Change (IOC) enabled (IOINTEN register) can cause an interrupt. Pins defined as an output have no effect on the interrupt output pin.

Input change activity on a port input pin that is enabled for IOC will generate an internal device interrupt and the device will capture the value of the port and copy it into INTCAP. The interrupt will remain active until the INTCAP or GPIO register is read. Writing to these registers will not affect the interrupt. The interrupt condition will be cleared after the LSb of the data is clocked out during a read command of GPIO or INTCAP.

The first interrupt event will cause the port contents to be copied into the INTCAP register. Subsequent interrupt conditions on the port will not cause an interrupt to occur as long as the interrupt is not cleared by a read of INTCAP or GPIO.

> **Note:** The value in INTCAP can be lost if GPIO is read before INTCAP while another IOC is pending. After reading GPIO, the interrupt will clear and then set due to the pending IOC, causing the INTCAP register to update.

1.7.5 INTERRUPT CONDITIONS

There are two possible configurations that cause interrupts (configured via INTCON):

1. Pins configured for **interrupt-on-pin change** will cause an interrupt to occur if a pin changes to the opposite state. The default state is reset after an interrupt occurs and after clearing the interrupt condition (i.e., after reading GPIO or INTCAP). For example, an interrupt occurs by an input changing from '1' to '0'. The new initial state for the pin is a logic 0 after the interrupt is cleared.
2. Pins configured for **interrupt-on-change from register value** will cause an interrupt to occur if the corresponding input pin differs from the register bit. The interrupt condition will remain as long as the condition exists, regardless if the INTCAP or GPIO is read.

See Figure 1-6 and Figure 1-7 for more information on interrupt operations.

FIGURE 1-6: INTERRUPT-ON-PIN CHANGE

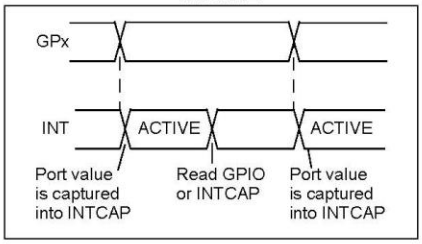
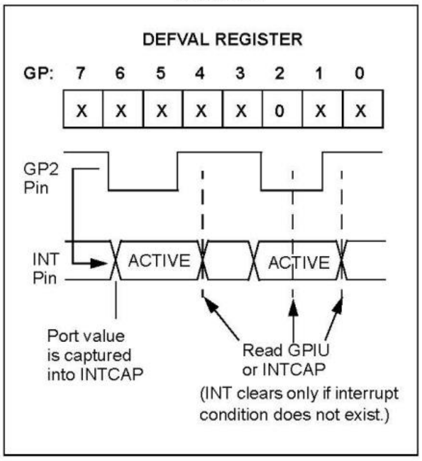


FIGURE 1-7: INTERRUPT-ON-CHANGE FROM REGISTER DEFAULT



NOTES:

2.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Ambient temperature under bias .... -40°C to +125°C
Storage temperature .... -65°C to +150°C
Voltage on V_{DD} with respect to V_{SS} .... -0.3V to +5.5V
Voltage on all other pins with respect to V_{SS} (except V_{DD}) .... -0.6V to (V_{DD} + 0.6V)
Total power dissipation (**Note**) .... 700 mW
Maximum current out of V_{SS} pin .... 150 mA
Maximum current into V_{DD} pin .... 125 mA
Input clamp current, I_{IK} ($V_I < 0$ or $V_I > V_{DD}$) .... ±20 mA
Output clamp current, I_{OK} ($V_O < 0$ or $V_O > V_{DD}$) .... ±20 mA
Maximum output current sunk by any output pin .... 25 mA
Maximum output current sourced by any output pin .... 25 mA

Note: Power dissipation is calculated as follows:
$P_{DIS} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$

† **NOTE:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

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2.1 DC Characteristics

DC Characteristics	Operating Conditions (unless otherwise indicated): 1.8V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +85°C (I-Temp) 4.5V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +125°C (E-Temp) **(Note 1)**						
Param No.	**Characteristic**	**Sym**	**Min**	**Typ (Note 1(**	**Max**	**Units**	**Conditions**
D001	Supply Voltage	VDD	1.8	—	5.5	V	
D002	VDD Start Voltage to Ensure Power-on Reset	VPOR	—	VSS	—	V	
D003	VDD Rise Rate to Ensure Power-on Reset	SVDD	0.05	—	—	V/ms	Design guidance only. Not tested.
D004	Supply Current	IDD	—	—	1	mA	SCL/SCK = 1 MHz
D005	Standby current	IDDS	—	—	1	µA	
			—	—	3	µA	4.5V-5.5V @ +125°C **(Note 1)**
	Input Low Voltage						
D030	A0, A1 (TTL buffer)	VIL	VSS	—	0.15 VDD	V	
D031	CS, GPIO, SCL/SCK, SDA, A2, RESET (Schmitt Trigger)		VSS	—	0.2 VDD	V	
	Input High Voltage						
D040	A0, A1 (TTL buffer)	VIH	0.25 VDD + 0.8	—	VDD	V	
D041	CS, GPIO, SCL/SCK, SDA, A2, RESET (Schmitt Trigger)		0.8 VDD	—	VDD	V	For entire VDD range
	Input Leakage Current						
D060	I/O port pins	IIL	—	—	±1	µA	VSS ≤ VPIN ≤ VDD
	Output Leakage Current						
D065	I/O port pins	ILO	—	—	±1	µA	VSS ≤ VPIN ≤ VDD
D070	GPIO weak pull-up current	IPU	40	75	115	µA	VDD = 5V, GP Pins = VSS –40°C ≤ TA ≤ +85°C
	Output Low-Voltage						
D080	GPIO	VOL	—	—	0.6	V	IOL = 8.0 mA, VDD = 4.5V
	INT		—	—	0.6	V	IOL = 1.6 mA, VDD = 4.5V
	SO, SDA		—	—	0.6	V	IOL = 3.0 mA, VDD = 1.8V
	SDA		—	—	0.8	V	IOL = 3.0 mA, VDD = 4.5V
	Output High-Voltage						
D090	GPIO, INT, SO	VOH	VDD – 0.7	—	—	V	IOH = -3.0 mA, VDD = 4.5V
			VDD – 0.7	—	—		IOH = -400 µA, VDD = 1.8V
	Capacitive Loading Specs on Output Pins						
D101	GPIO, SO, INT	CIO	—	—	50	pF	
D102	SDA	CB	—	—	400	pF	

Note 1: This parameter is characterized, not 100% tested.

FIGURE 2-1: LOAD CONDITIONS FOR DEVICE TIMING SPECIFICATIONS

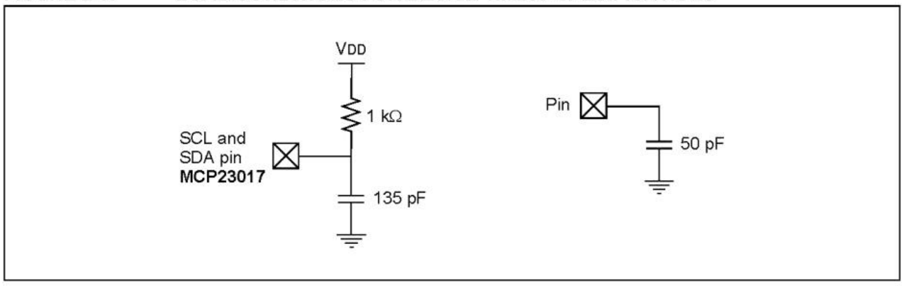
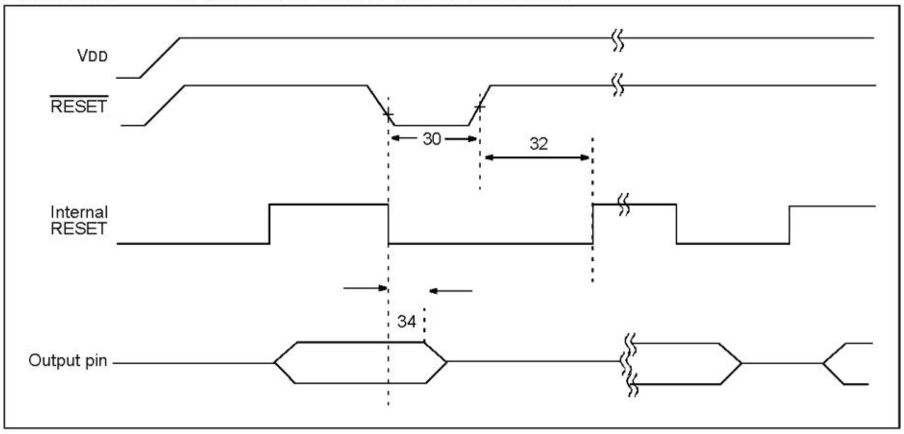


FIGURE 2-2: RESET AND DEVICE RESET TIMER TIMING



MCP23017/MCP23S17

TABLE 2-1: DEVICE RESET SPECIFICATIONS

AC Characteristics		Operating Conditions (unless otherwise indicated): 1.8V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +85°C (I-Temp) 4.5V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +125°C (E-Temp) (Note 1)					
Param No.	Characteristic	Sym	Min	Typ(1)	Max	Units	Conditions
30	RESET Pulse Width (Low)	TRSTL	1	—	—	µs	
32	Device Active After Reset high	THLD	—	0	—	ns	VDD = 5.0V
34	Output High-Impedance From RESET Low	TIOZ	—	—	1	µs	

Note 1: This parameter is characterized, not 100% tested.

FIGURE 2-3: I²C™ BUS START/STOP BITS TIMING

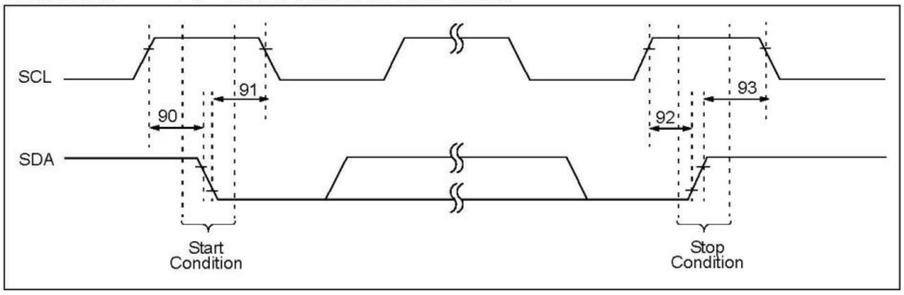


FIGURE 2-4: I²C™ BUS DATA TIMING

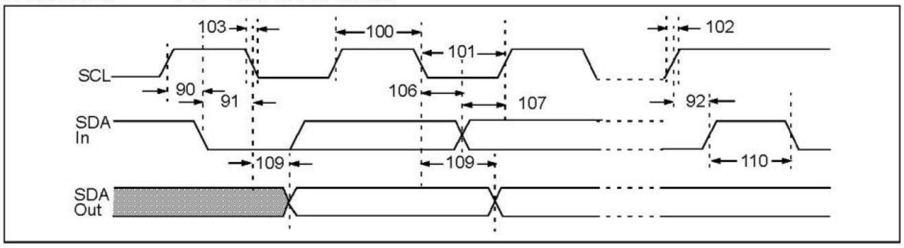


TABLE 2-2: I²C™ BUS DATA REQUIREMENTS

I²C™ AC Characteristics		Operating Conditions (unless otherwise indicated): 1.8V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +85°C (I-Temp) 4.5V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +125°C (E-Temp) **(Note 1)** RPU (SCL, SDA) = 1 kΩ, CL (SCL, SDA) = 135 pF					
Param No.	**Characteristic**	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
100	Clock High Time:	THIGH					
	100 kHz mode		4.0	—	—	μs	1.8V–5.5V (I-Temp)
	400 kHz mode		0.6	—	—	μs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		0.12	—	—	μs	4.5V–5.5V (E-Temp)
101	Clock Low Time:	TLOW					
	100 kHz mode		4.7	—	—	μs	1.8V–5.5V (I-Temp)
	400 kHz mode		1.3	—	—	μs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		0.32	—	—	μs	4.5V–5.5V (E-Temp)
102	SDA and SCL Rise Time:	TR (Note 1)					
	100 kHz mode		—	—	1000	ns	1.8V–5.5V (I-Temp)
	400 kHz mode		20 + 0.1 CB(2)	—	300	ns	2.7V–5.5V (I-Temp)
	1.7 MHz mode		20	—	160	ns	4.5V–5.5V (E-Temp)
103	SDA and SCL Fall Time:	TF (Note 1)					
	100 kHz mode		—	—	300	ns	1.8V–5.5V (I-Temp)
	400 kHz mode		20 + 0.1 CB(2)	—	300	ns	2.7V–5.5V (I-Temp)
	1.7 MHz mode		20	—	80	ns	4.5V–5.5V (E-Temp)
90	START Condition Setup Time:	TSU:STA					
	100 kHz mode		4.7	—	—	μs	1.8V–5.5V (I-Temp)
	400 kHz mode		0.6	—	—	μs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		0.16	—	—	μs	4.5V–5.5V (E-Temp)
91	START Condition Hold Time:	THD:STA					
	100 kHz mode		4.0	—	—	μs	1.8V–5.5V (I-Temp)
	400 kHz mode		0.6	—	—	μs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		0.16	—	—	μs	4.5V–5.5V (E-Temp)
106	Data Input Hold Time:	THD:DAT					
	100 kHz mode		0	—	3.45	μs	1.8V–5.5V (I-Temp)
	400 kHz mode		0	—	0.9	μs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		0	—	0.15	μs	4.5V–5.5V (E-Temp)
107	Data Input Setup Time:	TSU:DAT					
	100 kHz mode		250	—	—	ns	1.8V–5.5V (I-Temp)
	400 kHz mode		100	—	—	ns	2.7V–5.5V (I-Temp)
	1.7 MHz mode		0.01	—	—	μs	4.5V–5.5V (E-Temp)
92	Stop Condition Setup Time:	TSU:STO					
	100 kHz mode		4.0	—	—	μs	1.8V–5.5V (I-Temp)
	400 kHz mode		0.6	—	—	μs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		0.16	—	—	μs	4.5V–5.5V (E-Temp)

Note 1: This parameter is characterized, not 100% tested.
2: CB is specified to be from 10 to 400 pF.

TABLE 2-2: I²C™ BUS DATA REQUIREMENTS (CONTINUED)

I²C™ AC Characteristics		Operating Conditions (unless otherwise indicated): 1.8V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +85°C (I-Temp) 4.5V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +125°C (E-Temp) **(Note 1)** RPU (SCL, SDA) = 1 kΩ, CL (SCL, SDA) = 135 pF					
Param No.	**Characteristic**	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
109	Output Valid From Clock:	TAA					
	100 kHz mode		—	—	3.45	µs	1.8V–5.5V (I-Temp)
	400 kHz mode		—	—	0.9	µs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		—	—	0.18	µs	4.5V–5.5V (E-Temp)
110	Bus Free Time:	TBUF					
	100 kHz mode		4.7	—	—	µs	1.8V–5.5V (I-Temp)
	400 kHz mode		1.3	—	—	µs	2.7V–5.5V (I-Temp)
	1.7 MHz mode		N/A	—	N/A	µs	4.5V – 5.5V (E-Temp)
	Bus Capacitive Loading:	CB					
	100 kHz and 400 kHz		—	—	400	pF	**Note 1**
	1.7 MHz		—	—	100	pF	**Note 1**
	Input Filter Spike Suppression (SDA and SCL)	TSP					
	100 kHz and 400 kHz		—	—	50	ns	
	1.7 MHz		—	—	10	ns	Spike suppression off

Note 1: This parameter is characterized, not 100% tested.
2: CB is specified to be from 10 to 400 pF.

FIGURE 2-5: SPI INPUT TIMING

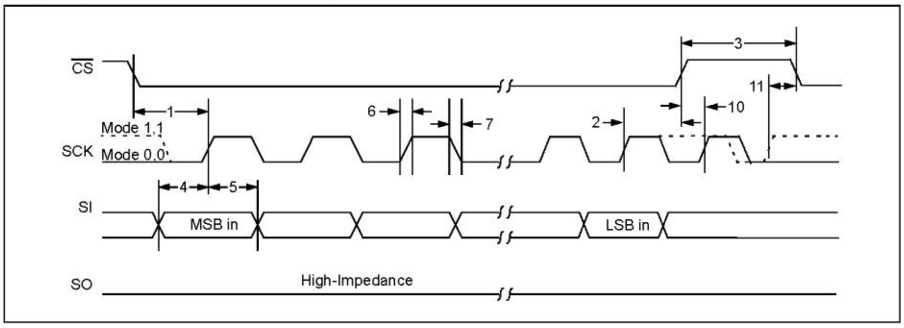


FIGURE 2-6: SPI OUTPUT TIMING

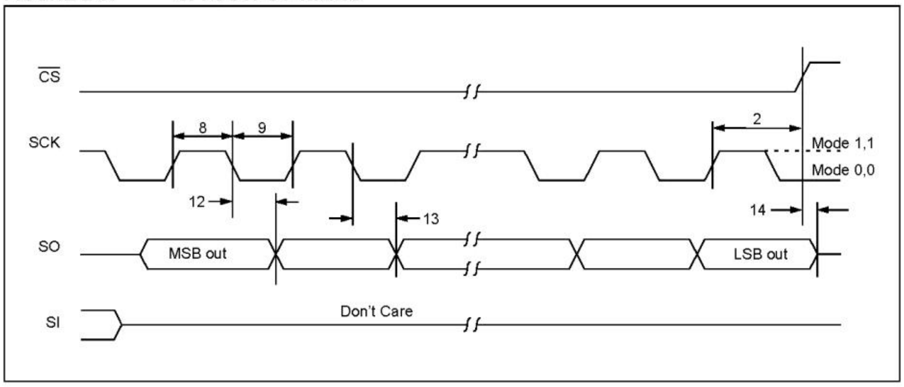


TABLE 2-3: SPI INTERFACE AC CHARACTERISTICS

SPI Interface AC Characteristics		Operating Conditions (unless otherwise indicated): 1.8V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +85°C (I-Temp) 4.5V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +125°C (E-Temp) (Note 1)					
Param No.	Characteristic	Sym	Min	Typ	Max	Units	Conditions
	Clock Frequency	FCLK	—	—	5	MHz	1.8V–5.5V (I-Temp)
			—	—	10	MHz	2.7V–5.5V (I-Temp)
			—	—	10	MHz	4.5V–5.5V (E-Temp)
1	$\overline{CS}$ Setup Time	TCSS	50	—	—	ns	
2	$\overline{CS}$ Hold Time	TCSH	100	—	—	ns	1.8V–5.5V (I-Temp)
			50	—	—	ns	2.7V–5.5V (I-Temp)
			50	—	—	ns	4.5V–5.5V (E-Temp)
3	$\overline{CS}$ Disable Time	TCSD	100	—	—	ns	1.8V–5.5V (I-Temp)
			50	—	—	ns	2.7V–5.5V (I-Temp)
			50	—	—	ns	4.5V–5.5V (E-Temp)
4	Data Setup Time	TSU	20	—	—	ns	1.8V–5.5V (I-Temp)
			10	—	—	ns	2.7V–5.5V (I-Temp)
			10	—	—	ns	4.5V–5.5V (E-Temp)
5	Data Hold Time	THD	20	—	—	ns	1.8V–5.5V (I-Temp)
			10	—	—	ns	2.7V–5.5V (I-Temp)
			10	—	—	ns	4.5V–5.5V (E-Temp)
6	CLK Rise Time	TR	—	—	2	µs	**Note 1**
7	CLK Fall Time	TF	—	—	2	µs	**Note 1**
8	Clock High Time	THI	90	—	—	ns	1.8V–5.5V (I-Temp)
			45	—	—	ns	2.7V–5.5V (I-Temp)
			45	—	—	ns	4.5V–5.5V (E-Temp)

Note 1: This parameter is characterized, not 100% tested.

TABLE 2-3: SPI INTERFACE AC CHARACTERISTICS (CONTINUED)

SPI Interface AC Characteristics		Operating Conditions (unless otherwise indicated): 1.8V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +85°C (I-Temp) 4.5V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +125°C (E-Temp) (Note 1)					
Param No.	Characteristic	Sym	Min	Typ	Max	Units	Conditions
9	Clock Low Time	TLO	90	—	—	ns	1.8V–5.5V (I-Temp)
			45	—	—	ns	2.7V–5.5V (I-Temp)
			45	—	—	ns	4.5V–5.5V (E-Temp)
10	Clock Delay Time	TCLD	50	—	—	ns	
11	Clock Enable Time	TCLE	50	—	—	ns	
12	Output Valid from Clock Low	TV	—	—	90	ns	1.8V–5.5V (I-Temp)
			—	—	45	ns	2.7V–5.5V (I-Temp)
			—	—	45	ns	4.5V–5.5V (E-Temp)
13	Output Hold Time	THO	0	—	—	ns	
14	Output Disable Time	TDIS	—	—	100	ns	

Note 1: This parameter is characterized, not 100% tested.

FIGURE 2-7: GPIO AND INT TIMING

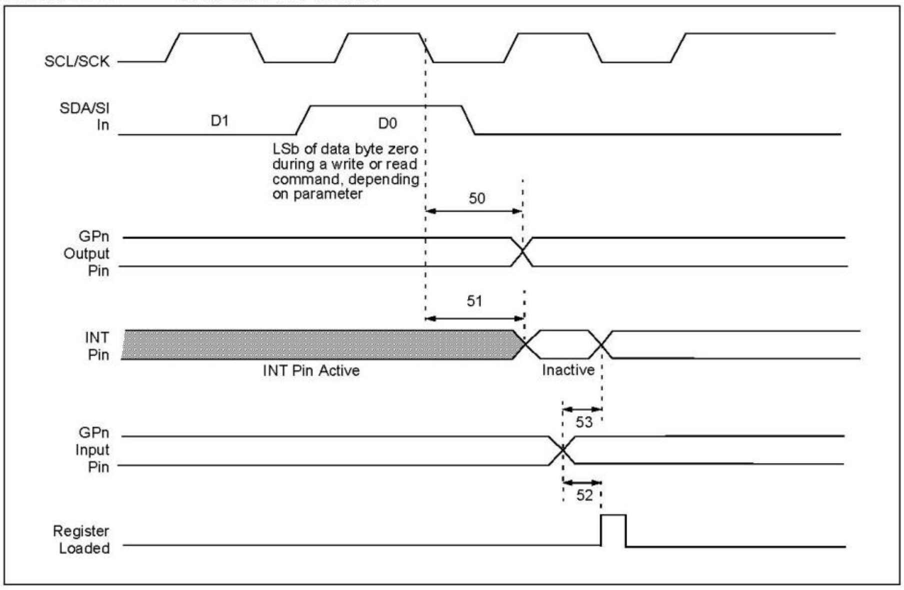


TABLE 2-4: GP AND INT PINS

AC Characteristics		Operating Conditions (unless otherwise indicated): 1.8V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +85°C (I-Temp) 4.5V ≤ VDD ≤ 5.5V at -40°C ≤ TA ≤ +125°C (E-Temp) **(Note 1)**					
Param No.	**Characteristic**	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
50	Serial Data to Output Valid	TGPOV	—	—	500	ns	
51	Interrupt Pin Disable Time	TINTD	—	—	600	ns	
52	GP Input Change to Register Valid	TGPIV	—	—	450	ns	
53	IOC Event to INT Active	TGPINT	—	—	600	ns	
	Glitch Filter on GP Pins	TGLITCH	—	—	150	ns	**Note 1**

Note 1: This parameter is characterized, not 100% tested

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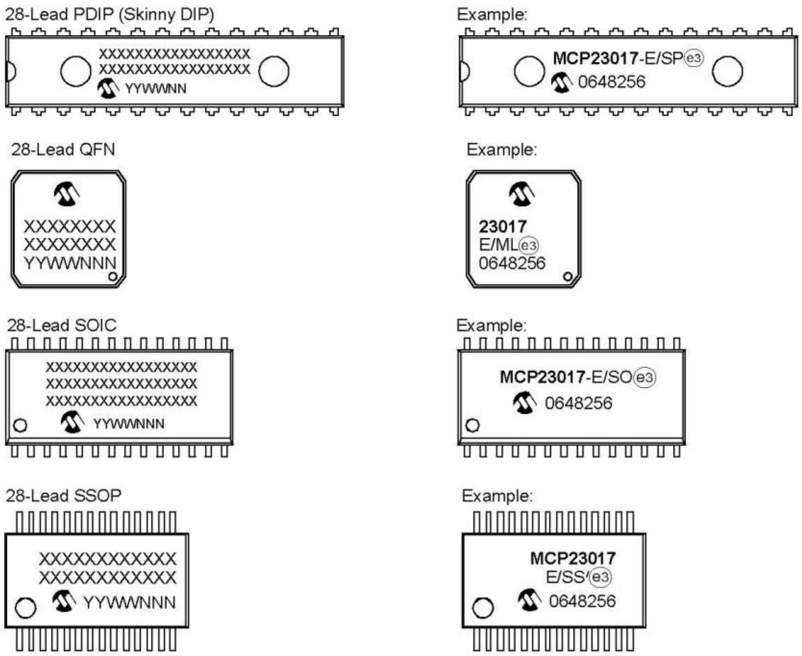
NOTES:

3.0 PACKAGING INFORMATION

3.1 Package Marking Information

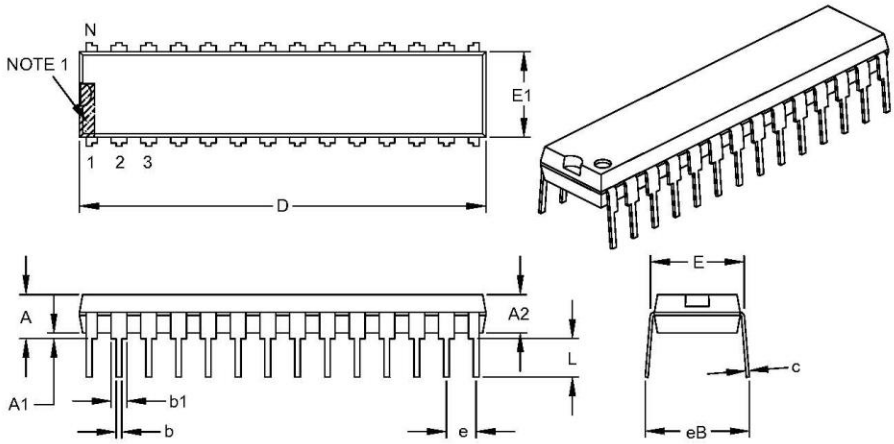


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

28-Lead Skinny Plastic Dual In-Line (SP) – 300 mil Body [SPDIP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



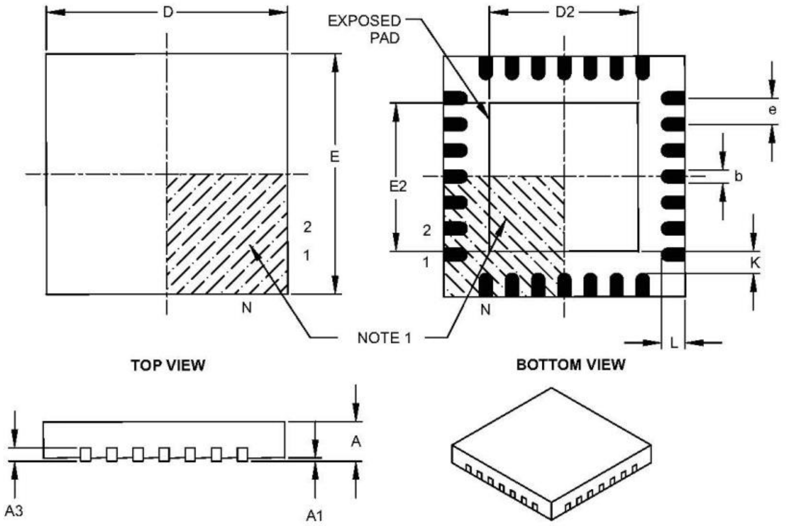
	Units	INCHES		
	Dimension Limits	MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		.100 BSC	
Top to Seating Plane	A	–	–	.200
Molded Package Thickness	A2	.120	.135	.150
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.290	.310	.335
Molded Package Width	E1	.240	.285	.295
Overall Length	D	1.345	1.365	1.400
Tip to Seating Plane	L	.110	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.040	.050	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	–	–	.430

Notes:
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic.
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M.
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-070B

28-Lead Plastic Quad Flat, No Lead Package (ML) – 6x6 mm Body [QFN] with 0.55 mm Contact Length

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



	Units	MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		0.65 BSC	
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3		0.20 REF	
Overall Width	E		6.00 BSC	
Exposed Pad Width	E2	3.65	3.70	4.20
Overall Length	D		6.00 BSC	
Exposed Pad Length	D2	3.65	3.70	4.20
Contact Width	b	0.23	0.30	0.35
Contact Length	L	0.50	0.55	0.70
Contact-to-Exposed Pad	K	0.20	–	–

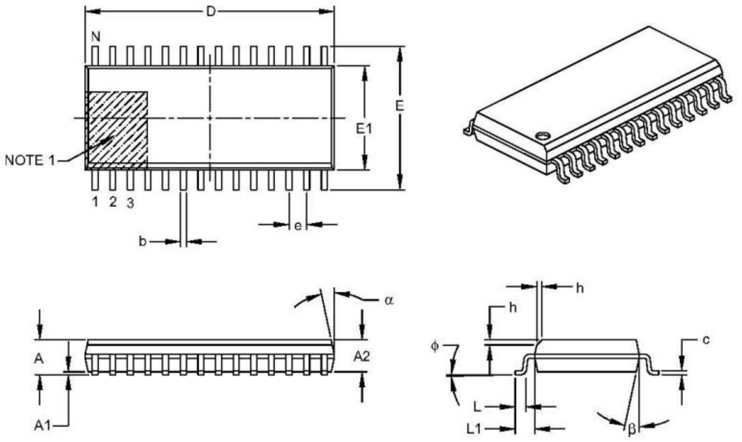
Notes:
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated.
3. Dimensioning and tolerancing per ASME Y14.5M.
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-105B

MCP23017/MCP23S17

28-Lead Plastic Small Outline (SO) – Wide, 7.50 mm Body [SOIC]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		1.27 BSC	
Overall Height	A	–	–	2.65
Molded Package Thickness	A2	2.05	–	–
Standoff §	A1	0.10	–	0.30
Overall Width	E		10.30 BSC	
Molded Package Width	E1		7.50 BSC	
Overall Length	D		17.90 BSC	
Chamfer (optional)	h	0.25	–	0.75
Foot Length	L	0.40	–	1.27
Footprint	L1		1.40 REF	
Foot Angle Top	φ	0°	–	8°
Lead Thickness	c	0.18	–	0.33
Lead Width	b	0.31	–	0.51
Mold Draft Angle Top	α	5°	–	15°
Mold Draft Angle Bottom	β	5°	–	15°

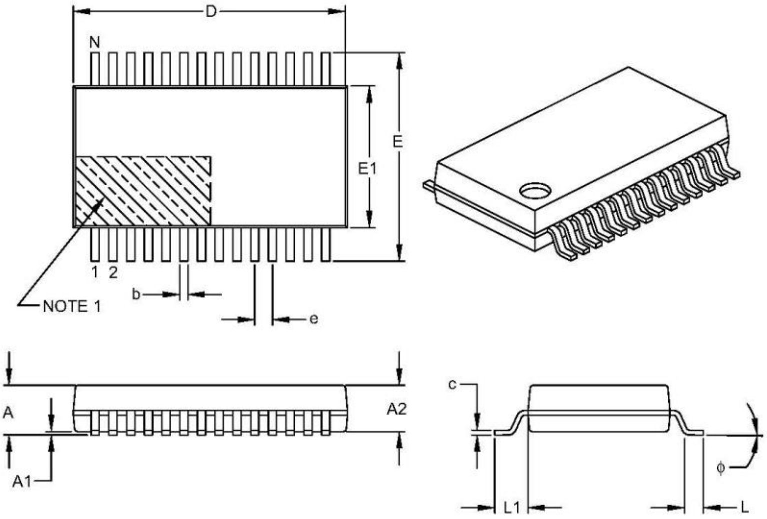
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic.
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M.
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-052B

28-Lead Plastic Shrink Small Outline (SS) – 5.30 mm Body [SSOP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



	Units	MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		0.65 BSC	
Overall Height	A	–	–	2.00
Molded Package Thickness	A2	1.65	1.75	1.85
Standoff	A1	0.05	–	–
Overall Width	E	7.40	7.80	8.20
Molded Package Width	E1	5.00	5.30	5.60
Overall Length	D	9.90	10.20	10.50
Foot Length	L	0.55	0.75	0.95
Footprint	L1		1.25 REF	
Lead Thickness	c	0.09	–	0.25
Foot Angle	φ	0°	4°	8°
Lead Width	b	0.22	–	0.38

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.20 mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-073B

MCP23017/MCP23S17

NOTES:

APPENDIX A: REVISION HISTORY

Revision B (February 2007)

1. Changed Byte and Sequential Read in Figure 1-1 from "R" to "W".
2. Table 2-4, Param No. 51 and 53: Changed from 450 to 600 and 500 to 600, respecively.
3. Added disclaimers to package outline drawings.
4. Updated package outline drawings.

Revision A (June 2005)

- Original Release of this Document.

MCP23017/MCP23S17

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	– X	/XX
Device	Temperature Range	Package

Device	MCP23017:	16-Bit I/O Expander w/I^{2}C™ Interface
	MCP23017T:	16-Bit I/O Expander w/I^{2}C Interface (Tape and Reel)
	MCP23S17:	16-Bit I/O Expander w/SPI Interface
	MCP23S17T:	16-Bit I/O Expander w/SPI Interface (Tape and Reel)
Temperature Range	E =	-40°C to +125°C (Extended)
Package	ML =	Plastic Quad, Flat No Leads (QFN), 28-lead
	SP =	Plastic DIP (300 mil Body), 28-Lead
	SO =	Plastic SOIC (300 mil Body), 28-Lead
	SS =	SSOP, (209 mil Body, 5.30 mm), 28-Lead

Examples:

a) MCP23017-E/SP: Extended Temp., 28LD PDIP package.
b) MCP23017-E/SO: Extended Temp., 28LD SOIC package.
c) MCP23017T-E/SO: Tape and Reel, Extended Temp., 28LD SOIC package.
d) MCP23017-E/SS: Extended Temp., 28LD SSOP package.
e) MCP23017T-E/SS: Tape and Reel, Extended Temp., 28LD SSOP package.

a) MCP23S17-E/SP: Extended Temp., 28LD PDIP package.
b) MCP23S17-E/SO: Extended Temp., 28LD SOIC package.
c) MCP23S17T-E/SO: Tape and Reel, Extended Temp., 28LD SOIC package.
d) MCP23S17-E/SS: Extended Temp., 28LD SSOP package.
e) MCP23S17T-E/SS: Tape and Reel, Extended Temp., 28LD SSOP package.

MCP23017/MCP23S17

NOTES:

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12/08/06

Regulador LM25

LM2576

3.0 A, 15 V, Step-Down Switching Regulator

The LM2576 series of regulators are monolithic integrated circuits ideally suited for easy and convenient design of a step−down switching regulator (buck converter). All circuits of this series are capable of driving a 3.0 A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5.0 V, 12 V, 15 V, and an adjustable output version.

These regulators were designed to minimize the number of external components to simplify the power supply design. Standard series of inductors optimized for use with the LM2576 are offered by several different inductor manufacturers.

Since the LM2576 converter is a switch−mode power supply, its efficiency is significantly higher in comparison with popular three−terminal linear regulators, especially with higher input voltages. In many cases, the power dissipated is so low that no heatsink is required or its size could be reduced dramatically.

A standard series of inductors optimized for use with the LM2576 are available from several different manufacturers. This feature greatly simplifies the design of switch−mode power supplies.

The LM2576 features include a guaranteed ±4% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency (±2% over 0°C to 125°C). External shutdown is included, featuring 80 μA (typical) standby current. The output switch includes cycle−by−cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

Features

- 3.3 V, 5.0 V, 12 V, 15 V, and Adjustable Output Versions
- Adjustable Version Output Voltage Range, 1.23 to 37 V ±4% Maximum Over Line and Load Conditions
- Guaranteed 3.0 A Output Current
- Wide Input Voltage Range
- Requires Only 4 External Components
- 52 kHz Fixed Frequency Internal Oscillator
- TTL Shutdown Capability, Low Power Standby Mode
- High Efficiency
- Uses Readily Available Standard Inductors
- Thermal Shutdown and Current Limit Protection
- Moisture Sensitivity Level (MSL) Equals 1
- Pb−Free Packages are Available

Applications

- Simple High−Efficiency Step−Down (Buck) Regulator
- Efficient Pre−Regulator for Linear Regulators
- On−Card Switching Regulators
- Positive to Negative Converter (Buck−Boost)
- Negative Step−Up Converters
- Power Supply for Battery Chargers

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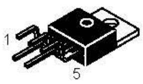
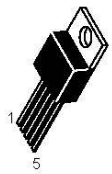


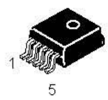
TO−220
TV SUFFIX
CASE 314B

Heatsink surface connected to Pin 3



TO−220
T SUFFIX
CASE 314D

Pin 1. V_{in}
2. Output
3. Ground
4. Feedback
5. $\overline{ON}$/OFF



D^2PAK
D2T SUFFIX
CASE 936A

Heatsink surface (shown as terminal 6 in case outline drawing) is connected to Pin 3

ORDERING INFORMATION

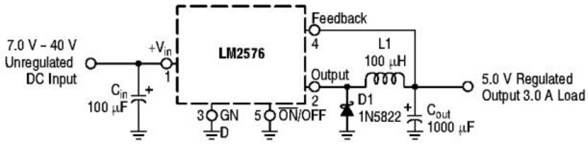
See detailed ordering and shipping information in the package dimensions section on page 24 of this data sheet.

DEVICE MARKING INFORMATION

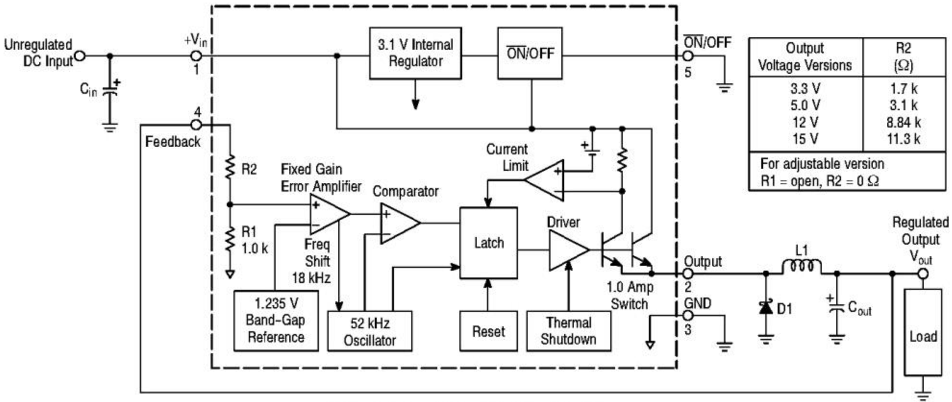
See general marking information in the device marking section on page 25 of this data sheet.

LM2576

Typical Application (Fixed Output Voltage Versions)



Representative Block Diagram and Typical Application



This device contains 162 active transistors.

Figure 1. Block Diagram and Typical Application

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Maximum Supply Voltage	V_{in}	45	V
$\overline{\text{ON}}$/OFF Pin Input Voltage	–	$-0.3\ V \le V \le +V_{in}$	V
Output Voltage to Ground (Steady–State)	–	−1.0	V
Power Dissipation			
Case 314B and 314D (TO–220, 5–Lead)	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	65	°C/W
Thermal Resistance, Junction–to–Case	$R_{\theta JC}$	5.0	°C/W
Case 936A (D^2PAK)	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	70	°C/W
Thermal Resistance, Junction–to–Case	$R_{\theta JC}$	5.0	°C/W
Storage Temperature Range	T_{stg}	−65 to +150	°C
Minimum ESD Rating (Human Body Model: C = 100 pF, R = 1.5 kΩ)	–	2.0	kV
Lead Temperature (Soldering, 10 seconds)	–	260	°C
Maximum Junction Temperature	T_J	150	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

LM2576

OPERATING RATINGS (Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	−40 to +125	°C
Supply Voltage	V_{in}	40	V

SYSTEM PARAMETERS (Note 1 Test Circuit Figure 15)

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, V_{in} = 12 V for the 3.3 V, 5.0 V, and Adjustable version, V_{in} = 25 V for the 12 V version, and V_{in} = 30 V for the 15 V version. I_{Load} = 500 mA. For typical values T_J = 25°C, for min/max values T_J is the operating junction temperature range that applies Note 2, unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
LM2576−3.3 (Note 1 Test Circuit Figure 15)					
Output Voltage (V_{in} = 12 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	3.234	3.3	3.366	V
Output Voltage (6.0 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A)	V_{out}				V
T_J = 25°C		3.168	3.3	3.432	
T_J = −40 to +125°C		3.135	−	3.465	
Efficiency (V_{in} = 12 V, I_{Load} = 3.0 A)	η	−	75	−	%
LM2576−5 (Note 1 Test Circuit Figure 15)					
Output Voltage (V_{in} = 12 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	4.9	5.0	5.1	V
Output Voltage (8.0 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A)	V_{out}				V
T_J = 25°C		4.8	5.0	5.2	
T_J = −40 to +125°C		4.75	−	5.25	
Efficiency (V_{in} = 12 V, I_{Load} = 3.0 A)	η	−	77	−	%
LM2576−12 (Note 1 Test Circuit Figure 15)					
Output Voltage (V_{in} = 25 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	11.76	12	12.24	V
Output Voltage (15 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A)	V_{out}				V
T_J = 25°C		11.52	12	12.48	
T_J = −40 to +125°C		11.4	−	12.6	
Efficiency (V_{in} = 15 V, I_{Load} = 3.0 A)	η	−	88	−	%
LM2576−15 (Note 1 Test Circuit Figure 15)					
Output Voltage (V_{in} = 30 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	14.7	15	15.3	V
Output Voltage (18 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A)	V_{out}				V
T_J = 25°C		14.4	15	15.6	
T_J = −40 to +125°C		14.25	−	15.75	
Efficiency (V_{in} = 18 V, I_{Load} = 3.0 A)	η	−	88	−	%
LM2576 ADJUSTABLE VERSION (Note 1 Test Circuit Figure 15)					
Feedback Voltage (V_{in} = 12 V, I_{Load} = 0.5 A, V_{out} = 5.0 V, T_J = 25°C)	V_{out}	1.217	1.23	1.243	V
Feedback Voltage (8.0 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A, V_{out} = 5.0 V)	V_{out}				V
T_J = 25°C		1.193	1.23	1.267	
T_J = −40 to +125°C		1.18	−	1.28	
Efficiency (V_{in} = 12 V, I_{Load} = 3.0 A, V_{out} = 5.0 V)	η	−	77	−	%

1. External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576 is used as shown in the Figure 15 test circuit, system performance will be as shown in system parameters section.
2. Tested junction temperature range for the LM2576: T_{low} = −40°C T_{high} = +125°C

DEVICE PARAMETERS

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, V_{in} = 12 V for the 3.3 V, 5.0 V, and Adjustable version, V_{in} = 25 V for the 12 V version, and V_{in} = 30 V for the 15 V version. I_{Load} = 500 mA. For typical values T_J = 25°C, for min/max values T_J is the operating junction temperature range that applies [Note 2], unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
ALL OUTPUT VOLTAGE VERSIONS					
Feedback Bias Current (V_{out} = 5.0 V Adjustable Version Only)	I_b				nA
T_J = 25°C		–	25	100	
T_J = −40 to +125°C		–	–	200	
Oscillator Frequency Note 3	f_{osc}				kHz
T_J = 25°C		–	52	–	
T_J = 0 to +125°C		47	–	58	
T_J = −40 to +125°C		42	–	63	
Saturation Voltage (I_{out} = 3.0 A Note 4)	V_{sat}				V
T_J = 25°C		–	1.5	1.8	
T_J = −40 to +125°C		–	–	2.0	
Max Duty Cycle ("on") Note 5	DC	94	98	–	%
Current Limit (Peak Current Notes 3 and 4)	I_{CL}				A
T_J = 25°C		4.2	5.8	6.9	
T_J = −40 to +125°C		3.5	–	7.5	
Output Leakage Current Notes 6 and 7, T_J = 25°C	I_L				mA
Output = 0 V		–	0.8	2.0	
Output = −1.0 V		–	6.0	20	
Quiescent Current Note 6	I_Q				mA
T_J = 25°C		–	5.0	9.0	
T_J = −40 to +125°C		–	–	11	
Standby Quiescent Current ($\overline{ON}$/OFF Pin = 5.0 V ("off"))	I_{stby}				μA
T_J = 25°C		–	80	200	
T_J = −40 to +125°C		–	–	400	
$\overline{ON}$/OFF Pin Logic Input Level (Test Circuit Figure 15)					V
V_{out} = 0 V	V_{IH}				
T_J = 25°C		2.2	1.4	–	
T_J = −40 to +125°C		2.4	–	–	
V_{out} = Nominal Output Voltage	V_{IL}				
T_J = 25°C		–	1.2	1.0	
T_J = −40 to +125°C		–	–	0.8	
$\overline{ON}$/OFF Pin Input Current (Test Circuit Figure 15)					μA
$\overline{ON}$/OFF Pin = 5.0 V ("off"), T_J = 25°C	I_{IH}	–	15	30	
$\overline{ON}$/OFF Pin = 0 V ("on"), T_J = 25°C	I_{IL}	–	0	5.0	

3. The oscillator frequency reduces to approximately 18 kHz in the event of an output short or an overload which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self protection feature lowers the average dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.
4. Output (Pin 2) sourcing current. No diode, inductor or capacitor connected to output pin.
5. Feedback (Pin 4) removed from output and connected to 0 V.
6. Feedback (Pin 4) removed from output and connected to +12 V for the Adjustable, 3.3 V, and 5.0 V versions, and +25 V for the 12 V and 15 V versions, to force the output transistor "off".
7. V_{in} = 40 V.

LM2576

TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of Figure 15)

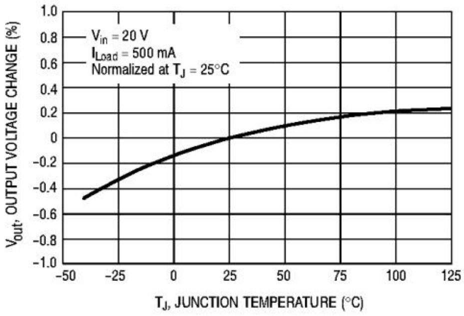


Figure 2. Normalized Output Voltage

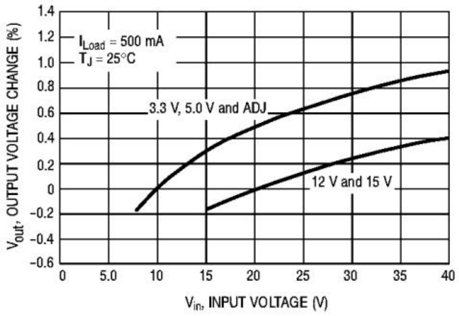


Figure 3. Line Regulation

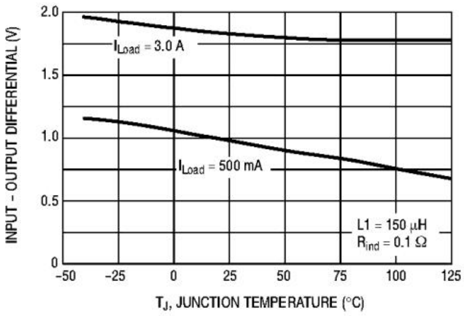


Figure 4. Dropout Voltage

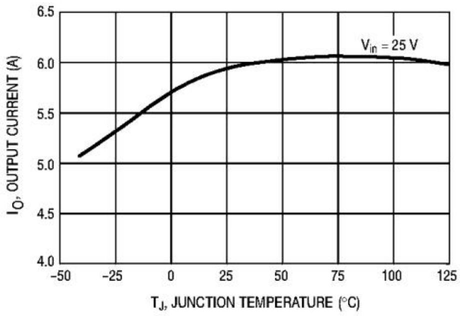


Figure 5. Current Limit

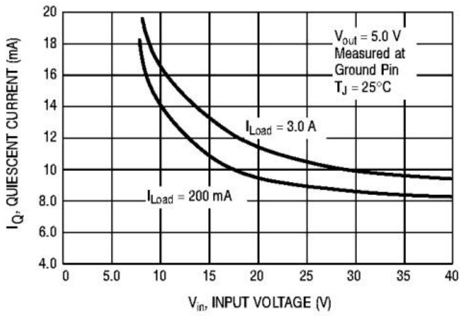


Figure 6. Quiescent Current

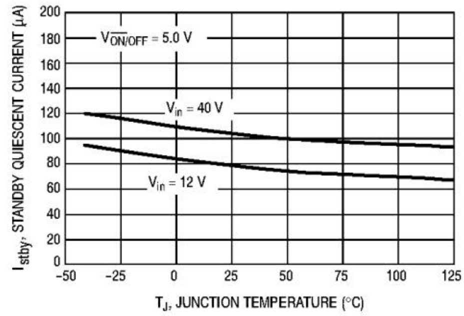


Figure 7. Standby Quiescent Current

LM2576

TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of Figure 15)

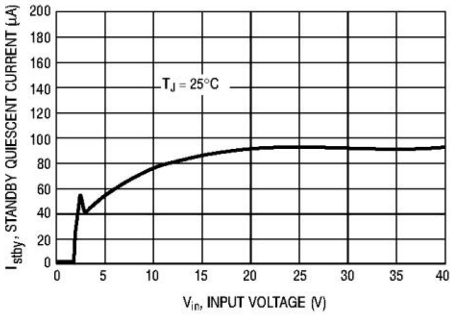


Figure 8. Standby Quiescent Current

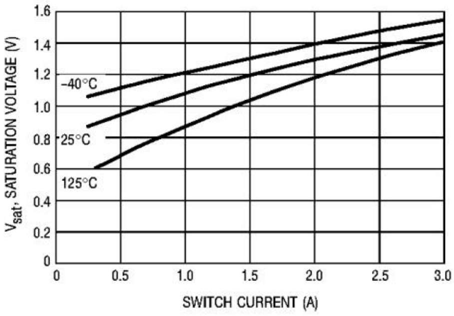


Figure 9. Switch Saturation Voltage

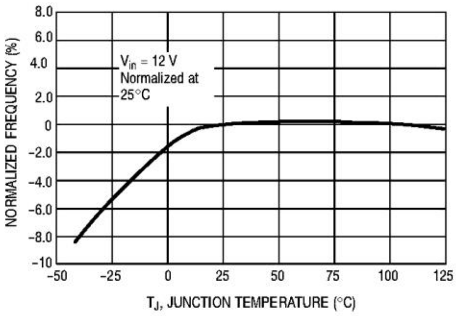


Figure 10. Oscillator Frequency

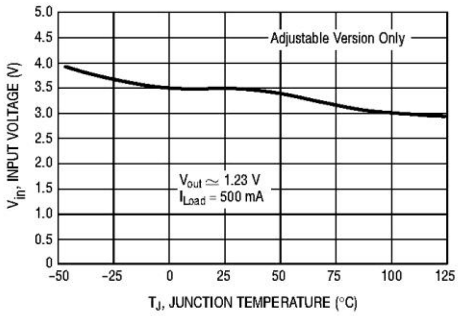


Figure 11. Minimum Operating Voltage

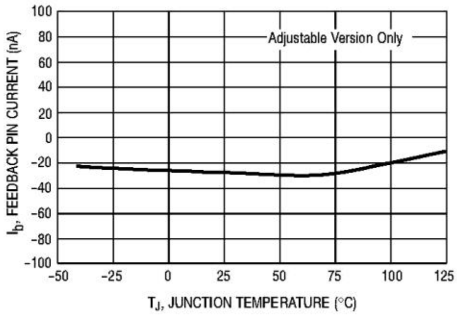


Figure 12. Feedback Pin Current

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TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of Figure 15)

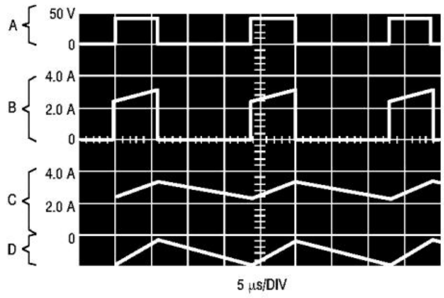

Figure 13. Switching Waveforms

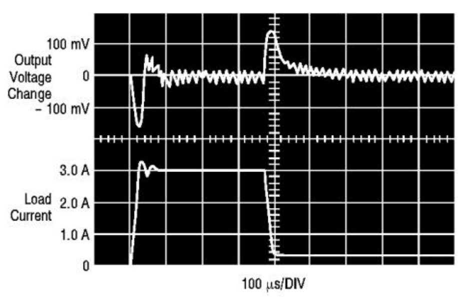

Figure 14. Load Transient Response

Vout = 15 V
A: Output Pin Voltage, 10 V/DIV
B: Inductor Current, 2.0 A/DIV
C: Inductor Current, 2.0 A/DIV, AC−Coupled
D: Output Ripple Voltage, 50 mV/dDIV, AC−Coupled
Horizontal Time Base: 5.0 μs/DIV

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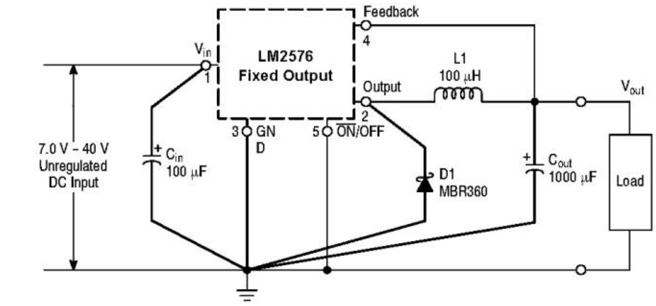
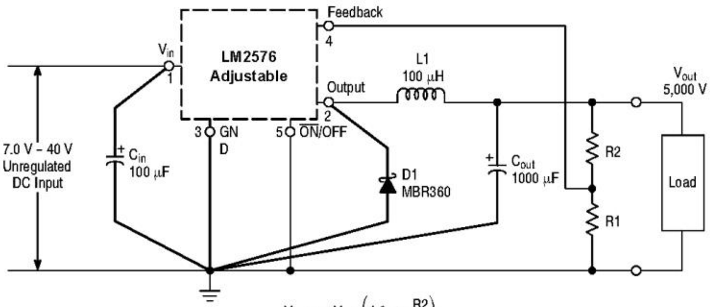
Fixed Output Voltage Versions



C_{in}	–	100 µF, 75 V, Aluminium Electrolytic
C_{out}	–	1000 µF, 25 V, Aluminium Electrolytic
D1	–	Schottky, MBR360
L1	–	100 µH, Pulse Eng. PE−92108
R1	–	2.0 k, 0.1%
R2	–	6.12 k, 0.1%

Adjustable Output Voltage Versions



$$V_{out} = V_{ref}\left(1.0 + \frac{R2}{R1}\right)$$

$$R2 = R1\left(\frac{V_{out}}{V_{ref}} - 1.0\right)$$

Where V_{ref} = 1.23 V, R1 between 1.0 k and 5.0 k

Figure 15. Typical Test Circuit

PCB LAYOUT GUIDELINES

As in any switching regulator, the layout of the printed circuit board is very important. Rapidly switching currents associated with wiring inductance, stray capacitance and parasitic inductance of the printed circuit board traces can generate voltage transients which can generate electromagnetic interferences (EMI) and affect the desired operation. As indicated in the Figure 15, to minimize inductance and ground loops, the length of the leads indicated by heavy lines should be kept as short as possible.

For best results, single−point grounding (as indicated) or ground plane construction should be used.

On the other hand, the PCB area connected to the Pin 2 (emitter of the internal switch) of the LM2576 should be kept to a minimum in order to minimize coupling to sensitive circuitry.

Another sensitive part of the circuit is the feedback. It is important to keep the sensitive feedback wiring short. To assure this, physically locate the programming resistors near to the regulator, when using the adjustable version of the LM2576 regulator.

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PIN FUNCTION DESCRIPTION

Pin	Symbol	Description (Refer to Figure 1)
1	V_{in}	This pin is the positive input supply for the LM2576 step−down switching regulator. In order to minimize voltage transients and to supply the switching currents needed by the regulator, a suitable input bypass capacitor must be present (C_{in} in Figure 1).
2	Output	This is the emitter of the internal switch. The saturation voltage V_{sat} of this output switch is typically 1.5 V. It should be kept in mind that the PCB area connected to this pin should be kept to a minimum in order to minimize coupling to sensitive circuitry.
3	GND	Circuit ground pin. See the information about the printed circuit board layout.
4	Feedback	This pin senses regulated output voltage to complete the feedback loop. The signal is divided by the internal resistor divider network R2, R1 and applied to the non−inverting input of the internal error amplifier. In the Adjustable version of the LM2576 switching regulator this pin is the direct input of the error amplifier and the resistor network R2, R1 is connected externally to allow programming of the output voltage.
5	$\overline{ON}$/OFF	It allows the switching regulator circuit to be shut down using logic level signals, thus dropping the total input supply current to approximately 80 μA. The threshold voltage is typically 1.4 V. Applying a voltage above this value (up to $+V_{in}$) shuts the regulator off. If the voltage applied to this pin is lower than 1.4 V or if this pin is left open, the regulator will be in the "on" condition.

DESIGN PROCEDURE

Buck Converter Basics

The LM2576 is a "Buck" or Step−Down Converter which is the most elementary forward−mode converter. Its basic schematic can be seen in Figure 16.

The operation of this regulator topology has two distinct time periods. The first one occurs when the series switch is on, the input voltage is connected to the input of the inductor.

The output of the inductor is the output voltage, and the rectifier (or catch diode) is reverse biased. During this period, since there is a constant voltage source connected across the inductor, the inductor current begins to linearly ramp upwards, as described by the following equation:

$$I_{L(on)} = \frac{\left(V_{in} - V_{out}\right) t_{on}}{L}$$

During this "on" period, energy is stored within the core material in the form of magnetic flux. If the inductor is properly designed, there is sufficient energy stored to carry the requirements of the load during the "off" period.

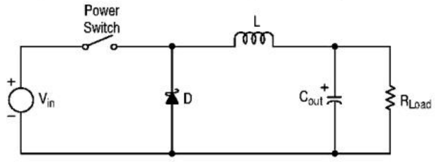

Figure 16. Basic Buck Converter

The next period is the "off" period of the power switch. When the power switch turns off, the voltage across the inductor reverses its polarity and is clamped at one diode voltage drop below ground by the catch diode. The current now flows through the catch diode thus maintaining the load current loop. This removes the stored energy from the inductor. The inductor current during this time is:

$$I_{L(off)} = \frac{\left(V_{out} - V_D\right) t_{off}}{L}$$

This period ends when the power switch is once again turned on. Regulation of the converter is accomplished by varying the duty cycle of the power switch. It is possible to describe the duty cycle as follows:

$$d = \frac{t_{on}}{T}, \text{ where T is the period of switching.}$$

For the buck converter with ideal components, the duty cycle can also be described as:

$$d = \frac{V_{out}}{V_{in}}$$

Figure 17 shows the buck converter, idealized waveforms of the catch diode voltage and the inductor current.

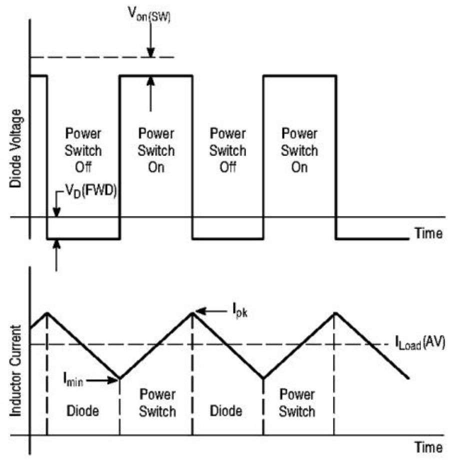

Figure 17. Buck Converter Idealized Waveforms

Procedure (Fixed Output Voltage Version) In order to simplify the switching regulator design, a step−by−step design procedure and some examples are provided.

Procedure	Example
Given Parameters: V_{out} = Regulated Output Voltage (3.3 V, 5.0 V, 12 V or 15 V) $V_{in(max)}$ = Maximum Input Voltage $I_{Load(max)}$ = Maximum Load Current	**Given Parameters:** V_{out} = 5.0 V $V_{in(max)}$ = 15 V $I_{Load(max)}$ = 3.0 A
1. Controller IC Selection According to the required input voltage, output voltage and current, select the appropriate type of the controller IC output voltage version.	**1. Controller IC Selection** According to the required input voltage, output voltage, current polarity and current value, use the LM2576−5 controller IC
2. Input Capacitor Selection (C_{in}) To prevent large voltage transients from appearing at the input and for stable operation of the converter, an aluminium or tantalum electrolytic bypass capacitor is needed between the input pin $+V_{in}$ and ground pin GND. This capacitor should be located close to the IC using short leads. This capacitor should have a low ESR (Equivalent Series Resistance) value.	**2. Input Capacitor Selection (C_{in})** A 100 μF, 25 V aluminium electrolytic capacitor located near to the input and ground pins provides sufficient bypassing.
3. Catch Diode Selection (D1) **A.** Since the diode maximum peak current exceeds the regulator maximum load current the catch diode current rating must be at least 1.2 times greater than the maximum load current. For a robust design the diode should have a current rating equal to the maximum current limit of the LM2576 to be able to withstand a continuous output short **B.** The reverse voltage rating of the diode should be at least 1.25 times the maximum input voltage.	**3. Catch Diode Selection (D1)** **A.** For this example the current rating of the diode is 3.0 A. **B.** Use a 20 V 1N5820 Schottky diode, or any of the suggested fast recovery diodes shown in Table 1.
4. Inductor Selection (L1) **A.** According to the required working conditions, select the correct inductor value using the selection guide from Figures 18 to 22. **B.** From the appropriate inductor selection guide, identify the inductance region intersected by the Maximum Input Voltage line and the Maximum Load Current line. Each region is identified by an inductance value and an inductor code. **C.** Select an appropriate inductor from the several different manufacturers part numbers listed in Table 2. The designer must realize that the inductor current rating must be higher than the maximum peak current flowing through the inductor. This maximum peak current can be calculated as follows: $I_{p(max)} = I_{Load(max)} + \frac{(V_{in} - V_{out})\, t_{on}}{2L}$ where t_{on} is the “on” time of the power switch and $t_{on} = \frac{V_{out}}{V_{in}} \times \frac{1.0}{f_{osc}}$ For additional information about the inductor, see the inductor section in the “Application Hints” section of this data sheet.	**4. Inductor Selection (L1)** **A.** Use the inductor selection guide shown in Figures 19. **B.** From the selection guide, the inductance area intersected by the 15 V line and 3.0 A line is L100. **C.** Inductor value required is 100 μH. From Table 2, choose an inductor from any of the listed manufacturers.

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Procedure (Fixed Output Voltage Version) (continued) In order to simplify the switching regulator design, a step−by−step design procedure and some examples are provided.

Procedure	Example
5. Output Capacitor Selection (C_{out}) **A.** Since the LM2576 is a forward−mode switching regulator with voltage mode control, its open loop 2−pole−1−zero frequency characteristic has the dominant pole−pair determined by the output capacitor and inductor values. For stable operation and an acceptable ripple voltage, (approximately 1% of the output voltage) a value between 680 μF and 2000 μF is recommended. **B.** Due to the fact that the higher voltage electrolytic capacitors generally have lower ESR (Equivalent Series Resistance) numbers, the output capacitor's voltage rating should be at least 1.5 times greater than the output voltage. For a 5.0 V regulator, a rating at least 8.0 V is appropriate, and a 10 V or 16 V rating is recommended.	**5. Output Capacitor Selection (C_{out})** **A.** C_{out} = 680 μF to 2000 μF standard aluminium electrolytic. **B.** Capacitor voltage rating = 20 V.

Procedure (Adjustable Output Version: LM2576−ADJ)

Procedure	Example
Given Parameters: V_{out} = Regulated Output Voltage $V_{in(max)}$ = Maximum DC Input Voltage $I_{Load(max)}$ = Maximum Load Current	**Given Parameters:** V_{out} = 8.0 V $V_{in(max)}$ = 25 V $I_{Load(max)}$ = 2.5 A
1. Programming Output Voltage To select the right programming resistor R1 and R2 value (see Figure 2) use the following formula: $V_{out} = V_{ref}\left(1.0 + \frac{R2}{R1}\right)$ where V_{ref} = 1.23 V Resistor R1 can be between 1.0 k and 5.0 kΩ. (For best temperature coefficient and stability with time, use 1% metal film resistors). $R2 = R1\left(\frac{V_{out}}{V_{ref}} - 1.0\right)$	**1. Programming Output Voltage** (selecting R1 and R2) Select R1 and R2: $V_{out} = 1.23\left(1.0 + \frac{R2}{R1}\right)$ Select R1 = 1.8 kΩ $R2 = R1\left(\frac{V_{out}}{V_{ref}} - 1.0\right) = 1.8\,k\left(\frac{8.0\,V}{1.23\,V} - 1.0\right)$ R2 = 9.91 kΩ, choose a 9.88 k metal film resistor.
2. Input Capacitor Selection (C_{in}) To prevent large voltage transients from appearing at the input and for stable operation of the converter, an aluminium or tantalum electrolytic bypass capacitor is needed between the input pin $+V_{in}$ and ground pin GND This capacitor should be located close to the IC using short leads. This capacitor should have a low ESR (Equivalent Series Resistance) value. For additional information see input capacitor section in the "Application Hints" section of this data sheet.	**2. Input Capacitor Selection (C_{in})** A 100 μF, 150 V aluminium electrolytic capacitor located near the input and ground pin provides sufficient bypassing.
3. Catch Diode Selection (D1) **A.** Since the diode maximum peak current exceeds the regulator maximum load current the catch diode current rating must be at least 1.2 times greater than the maximum load current. For a robust design, the diode should have a current rating equal to the maximum current limit of the LM2576 to be able to withstand a continuous output short. **B.** The reverse voltage rating of the diode should be at least 1.25 times the maximum input voltage.	**3. Catch Diode Selection (D1)** **A.** For this example, a 3.0 A current rating is adequate. **B.** Use a 30 V 1N5821 Schottky diode or any suggested fast recovery diode in the Table 1.

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Procedure (Adjustable Output Version: LM2576−ADJ) (continued)

Procedure	Example
4. Inductor Selection (L1) **A.** Use the following formula to calculate the inductor Volt x microsecond [V x µs] constant: $E \times T = (V_{in} - V_{out}) \frac{V_{out}}{V_{in}} \times \frac{10^6}{F[Hz]}$ [V x µs] **B.** Match the calculated E x T value with the corresponding number on the vertical axis of the Inductor Value Selection Guide shown in Figure 22. This E x T constant is a measure of the energy handling capability of an inductor and is dependent upon the type of core, the core area, the number of turns, and the duty cycle. **C.** Next step is to identify the inductance region intersected by the E x T value and the maximum load current value on the horizontal axis shown in Figure 25. **D.** From the inductor code, identify the inductor value. Then select an appropriate inductor from Table 2. The inductor chosen must be rated for a switching frequency of 52 kHz and for a current rating of 1.15 x I_{Load}. The inductor current rating can also be determined by calculating the inductor peak current: $I_{p(max)} = I_{Load(max)} + \frac{(V_{in} - V_{out})t_{on}}{2L}$ where t_{on} is the "on" time of the power switch and $t_{on} = \frac{V_{out}}{V_{in}} \times \frac{1.0}{f_{osc}}$ For additional information about the inductor, see the inductor section in the "External Components" section of this data sheet.	**4. Inductor Selection (L1)** **A.** Calculate E x T [V x µs] constant: $E \times T = (25 - 8.0) \times \frac{8.0}{25} \times \frac{1000}{52} = 80$ [V x µs] **B.** E x T = 80 [V x µs] **C.** $I_{Load(max)} = 2.5$ A Inductance Region = H150 **D.** Proper inductor value = 150 µH Choose the inductor from Table 2.
5. Output Capacitor Selection (C_{out}) **A.** Since the LM2576 is a forward−mode switching regulator with voltage mode control, its open loop 2−pole−1−zero frequency characteristic has the dominant pole−pair determined by the output capacitor and inductor values. For stable operation, the capacitor must satisfy the following requirement: $C_{out} \geq 13,300 \frac{V_{in(max)}}{V_{out} \times L[\mu H]}$ [µF] **B.** Capacitor values between 10 µF and 2000 µF will satisfy the loop requirements for stable operation. To achieve an acceptable output ripple voltage and transient response, the output capacitor may need to be several times larger than the above formula yields. **C.** Due to the fact that the higher voltage electrolytic capacitors generally have lower ESR (Equivalent Series Resistance) numbers, the output capacitor's voltage rating should be at least 1.5 times greater than the output voltage. For a 5.0 V regulator, a rating of at least 8.0 V is appropriate, and a 10 V or 16 V rating is recommended.	**5. Output Capacitor Selection (C_{out})** **A.** $C_{out} \geq 13,300 \times \frac{25}{8 \times 150} = 332.5$ µF To achieve an acceptable ripple voltage, select C_{out} = 680 µF electrolytic capacitor.

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LM2576 Series Buck Regulator Design Procedures (continued)

Indicator Value Selection Guide (For Continuous Mode Operation)

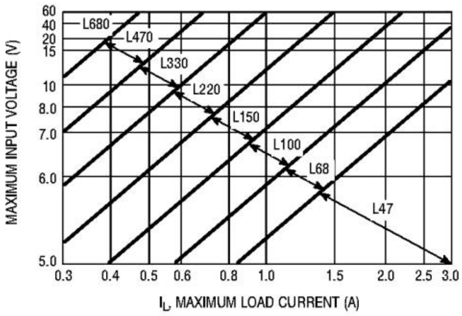

Figure 18. LM2576−3.3

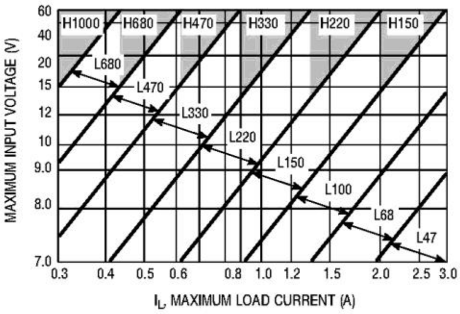

Figure 19. LM2576−5

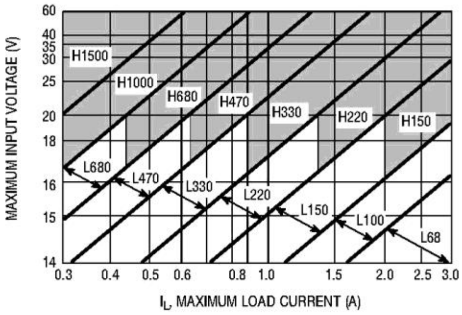

Figure 20. LM2576−12

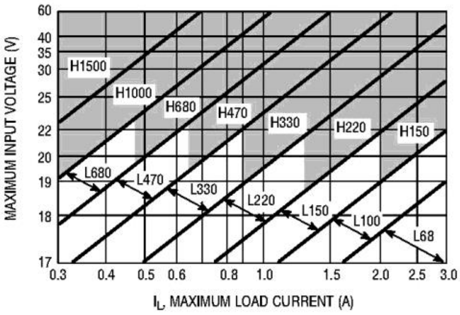

Figure 21. LM2576−15

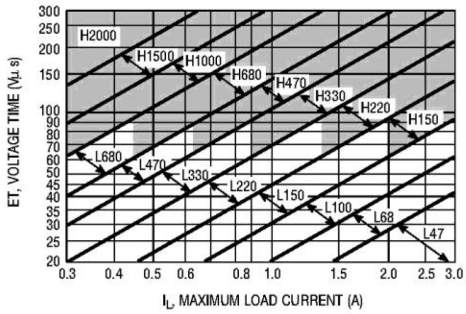

Figure 22. LM2576−ADJ

http://onsemi.com
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Table 1. Diode Selection Guide

V_R	Schottky 3.0 A Through Hole	Schottky 3.0 A Surface Mount	Schottky 4.0 – 6.0 A Through Hole	Schottky 4.0 – 6.0 A Surface Mount	Fast Recovery 3.0 A Through Hole	Fast Recovery 3.0 A Surface Mount	Fast Recovery 4.0 – 6.0 A Through Hole	Fast Recovery 4.0 – 6.0 A Surface Mount
20 V	**1N5820** MBR320P SR302	SK32	**1N5823** SR502 SB520		MUR320 31DF1 HER302 (all diodes rated to at least 100 V)	**MURS320T3** **MURD320** 30WF10 (all diodes rated to at least 100 V)	**MUR420** HER602 (all diodes rated to at least 100 V)	**MURD620CT** 50WF10 (all diodes rated to at least 100 V)
30 V	**1N5821** MBR330 SR303 31DQ03	SK33 30WQ03	**1N5824** SR503 SB530	50WQ03				
40 V	**1N5822** **MBR340** SR304 31DQ04	SK34 30WQ04 **MBRS340T3** **MBRD340**	**1N5825** SR504 SB540	**MBRD640CT** 50WQ04				
50 V	MBR350 31DQ05 SR305	SK35 30WQ05	SB550	50WQ05				
60 V	**MBR360** DQ06 SR306	**MBRS360T3** **MBRD360**	50SQ080	**MBRD660CT**				

NOTE: Diodes listed in bold are available from ON Semiconductor.

Table 2. Inductor Selection by Manufacturer's Part Number

Inductor Code	Inductor Value	Tech 39	Schott Corp.	Pulse Eng.	Renco
L47	47 μH	77 212	671 26980	PE-53112	RL2442
L68	68 μH	77 262	671 26990	PE-92114	RL2443
L100	100 μH	77 312	671 27000	PE-92108	RL2444
L150	150 μH	77 360	671 27010	PE-53113	RL1954
L220	220 μH	77 408	671 27020	PE-52626	RL1953
L330	330 μH	77 456	671 27030	PE-52627	RL1952
L470	470 μH	*	671 27040	PE-53114	RL1951
L680	680 μH	77 506	671 27050	PE-52629	RL1950
H150	150 μH	77 362	671 27060	PE-53115	RL2445
H220	220 μH	77 412	671 27070	PE-53116	RL2446
H330	330 μH	77 462	671 27080	PE-53117	RL2447
H470	470 μH	*	671 27090	PE-53118	RL1961
H680	680 μH	77 508	671 27100	PE-53119	RL1960
H1000	1000 μH	77 556	671 27110	PE-53120	RL1959
H1500	1500 μH	*	671 27120	PE-53121	RL1958
H2200	2200 μH	*	671 27130	PE-53122	RL2448

NOTE: *Contact Manufacturer

Table 3. Example of Several Inductor Manufacturers Phone/Fax Numbers

Pulse Engineering, Inc.	Phone Fax	+ 1−619−674−8100 + 1−619−674−8262
Pulse Engineering, Inc. Europe	Phone Fax	+ 353−9324−107 + 353−9324−459
Renco Electronics, Inc.	Phone Fax	+ 1−516−645−5828 + 1−516−586−5562
Tech 39	Phone Fax	+ 33−1−4115−1681 + 33−1−4709−5051
Schott Corporation	Phone Fax	+ 1−612−475−1173 + 1−612−475−1786

EXTERNAL COMPONENTS

Input Capacitor (C_{in})

The Input Capacitor Should Have a Low ESR

For stable operation of the switch mode converter a low ESR (Equivalent Series Resistance) aluminium or solid tantalum bypass capacitor is needed between the input pin and the ground pin, to prevent large voltage transients from appearing at the input. It must be located near the regulator and use short leads. With most electrolytic capacitors, the capacitance value decreases and the ESR increases with lower temperatures. For reliable operation in temperatures below −25°C larger values of the input capacitor may be needed. Also paralleling a ceramic or solid tantalum capacitor will increase the regulator stability at cold temperatures.

RMS Current Rating of C_{in}

The important parameter of the input capacitor is the RMS current rating. Capacitors that are physically large and have large surface area will typically have higher RMS current ratings. For a given capacitor value, a higher voltage electrolytic capacitor will be physically larger than a lower voltage capacitor, and thus be able to dissipate more heat to the surrounding air, and therefore will have a higher RMS current rating. The consequence of operating an electrolytic capacitor beyond the RMS current rating is a shortened operating life. In order to assure maximum capacitor operating lifetime, the capacitor's RMS ripple current rating should be:

$$I_{rms} > 1.2 \times d \times I_{Load}$$

where d is the duty cycle, for a buck regulator

$$d = \frac{t_{on}}{T} = \frac{V_{out}}{V_{in}}$$

$$\text{and } d = \frac{t_{on}}{T} = \frac{|V_{out}|}{|V_{out}| + V_{in}} \text{ for a buck−boost regulator.}$$

Output Capacitor (C_{out})

For low output ripple voltage and good stability, low ESR output capacitors are recommended. An output capacitor has two main functions: it filters the output and provides regulator loop stability. The ESR of the output capacitor and the peak−to−peak value of the inductor ripple current are the main factors contributing to the output ripple voltage value. Standard aluminium electrolytics could be adequate for some applications but for quality design, low ESR types are recommended.

An aluminium electrolytic capacitor's ESR value is related to many factors such as the capacitance value, the voltage rating, the physical size and the type of construction. In most cases, the higher voltage electrolytic capacitors have lower ESR value. Often capacitors with much higher voltage ratings may be needed to provide low ESR values that, are required for low output ripple voltage.

The Output Capacitor Requires an ESR Value That Has an Upper and Lower Limit

As mentioned above, a low ESR value is needed for low output ripple voltage, typically 1% to 2% of the output voltage. But if the selected capacitor's ESR is extremely low (below 0.05 Ω), there is a possibility of an unstable feedback loop, resulting in oscillation at the output. This situation can occur when a tantalum capacitor, that can have a very low ESR, is used as the only output capacitor.

At Low Temperatures, Put in Parallel Aluminium Electrolytic Capacitors with Tantalum Capacitors

Electrolytic capacitors are not recommended for temperatures below −25°C. The ESR rises dramatically at cold temperatures and typically rises 3 times at −25°C and as much as 10 times at −40°C. Solid tantalum capacitors have much better ESR spec at cold temperatures and are recommended for temperatures below −25°C. They can be also used in parallel with aluminium electrolytics. The value of the tantalum capacitor should be about 10% or 20% of the total capacitance. The output capacitor should have at least 50% higher RMS ripple current rating at 52 kHz than the peak−to−peak inductor ripple current.

Catch Diode

Locate the Catch Diode Close to the LM2576

The LM2576 is a step–down buck converter; it requires a fast diode to provide a return path for the inductor current when the switch turns off. This diode must be located close to the LM2576 using short leads and short printed circuit traces to avoid EMI problems.

Use a Schottky or a Soft Switching Ultra–Fast Recovery Diode

Since the rectifier diodes are very significant sources of losses within switching power supplies, choosing the rectifier that best fits into the converter design is an important process. Schottky diodes provide the best performance because of their fast switching speed and low forward voltage drop.

They provide the best efficiency especially in low output voltage applications (5.0 V and lower). Another choice could be Fast–Recovery, or Ultra–Fast Recovery diodes. It has to be noted, that some types of these diodes with an abrupt turnoff characteristic may cause instability or EMI troubles.

A fast–recovery diode with soft recovery characteristics can better fulfill some quality, low noise design requirements. Table 1 provides a list of suitable diodes for the LM2576 regulator. Standard 50/60 Hz rectifier diodes, such as the 1N4001 series or 1N5400 series are **NOT** suitable.

Inductor

The magnetic components are the cornerstone of all switching power supply designs. The style of the core and the winding technique used in the magnetic component's design has a great influence on the reliability of the overall power supply.

Using an improper or poorly designed inductor can cause high voltage spikes generated by the rate of transitions in current within the switching power supply, and the possibility of core saturation can arise during an abnormal operational mode. Voltage spikes can cause the semiconductors to enter avalanche breakdown and the part can instantly fail if enough energy is applied. It can also cause significant RFI (Radio Frequency Interference) and EMI (Electro–Magnetic Interference) problems.

Continuous and Discontinuous Mode of Operation

The LM2576 step–down converter can operate in both the continuous and the discontinuous modes of operation. The regulator works in the continuous mode when loads are relatively heavy, the current flows through the inductor continuously and never falls to zero. Under light load conditions, the circuit will be forced to the discontinuous mode when inductor current falls to zero for certain period of time (see Figure 23 and Figure 24). Each mode has distinctively different operating characteristics, which can affect the regulator performance and requirements. In many cases the preferred mode of operation is the continuous mode. It offers greater output power, lower peak currents in the switch, inductor and diode, and can have a lower output ripple voltage. On the other hand it does require larger inductor values to keep the inductor current flowing continuously, especially at low output load currents and/or high input voltages.

To simplify the inductor selection process, an inductor selection guide for the LM2576 regulator was added to this data sheet (Figures 18 through 22). This guide assumes that the regulator is operating in the continuous mode, and selects an inductor that will allow a peak–to–peak inductor ripple current to be a certain percentage of the maximum design load current. This percentage is allowed to change as different design load currents are selected. For light loads (less than approximately 300 mA) it may be desirable to operate the regulator in the discontinuous mode, because the inductor value and size can be kept relatively low. Consequently, the percentage of inductor peak–to–peak current increases. This discontinuous mode of operation is perfectly acceptable for this type of switching converter. Any buck regulator will be forced to enter discontinuous mode if the load current is light enough.

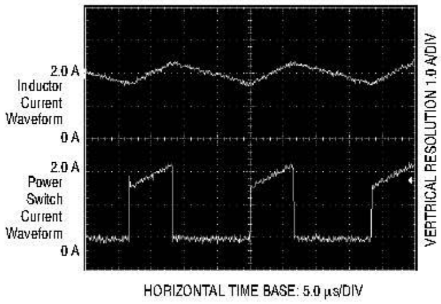


Figure 23. Continuous Mode Switching Current Waveforms

Selecting the Right Inductor Style

Some important considerations when selecting a core type are core material, cost, the output power of the power supply, the physical volume the inductor must fit within, and the amount of EMI (Electro–Magnetic Interference) shielding that the core must provide. The inductor selection guide covers different styles of inductors, such as pot core, E–core, toroid and bobbin core, as well as different core materials such as ferrites and powdered iron from different manufacturers.

For high quality design regulators the toroid core seems to be the best choice. Since the magnetic flux is contained within the core, it generates less EMI, reducing noise problems in sensitive circuits. The least expensive is the bobbin core type, which consists of wire wound on a ferrite rod core. This type of inductor generates more EMI due to the fact that its core is open, and the magnetic flux is not contained within the core.

When multiple switching regulators are located on the same printed circuit board, open core magnetics can cause interference between two or more of the regulator circuits, especially at high currents due to mutual coupling. A toroid, pot core or E−core (closed magnetic structure) should be used in such applications.

Do Not Operate an Inductor Beyond its Maximum Rated Current

Exceeding an inductor's maximum current rating may cause the inductor to overheat because of the copper wire losses, or the core may saturate. Core saturation occurs when the flux density is too high and consequently the cross sectional area of the core can no longer support additional lines of magnetic flux.

This causes the permeability of the core to drop, the inductance value decreases rapidly and the inductor begins to look mainly resistive. It has only the DC resistance of the winding. This can cause the switch current to rise very rapidly and force the LM2576 internal switch into cycle−by−cycle current limit, thus reducing the DC output load current. This can also result in overheating of the inductor and/or the LM2576. Different inductor types have different saturation characteristics, and this should be kept in mind when selecting an inductor.

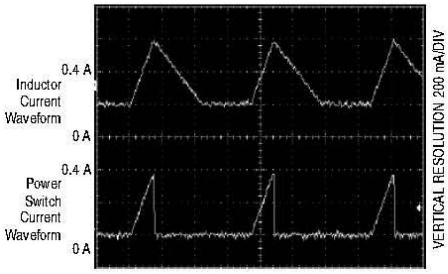


Figure 24. Discontinuous Mode Switching Current Waveforms

GENERAL RECOMMENDATIONS

Output Voltage Ripple and Transients

Source of the Output Ripple

Since the LM2576 is a switch mode power supply regulator, its output voltage, if left unfiltered, will contain a sawtooth ripple voltage at the switching frequency. The output ripple voltage value ranges from 0.5% to 3% of the output voltage. It is caused mainly by the inductor sawtooth ripple current multiplied by the ESR of the output capacitor.

Short Voltage Spikes and How to Reduce Them

The regulator output voltage may also contain short voltage spikes at the peaks of the sawtooth waveform (see Figure 25). These voltage spikes are present because of the fast switching action of the output switch, and the parasitic inductance of the output filter capacitor. There are some other important factors such as wiring inductance, stray capacitance, as well as the scope probe used to evaluate these transients, all these contribute to the amplitude of these spikes. To minimize these voltage spikes, low inductance capacitors should be used, and their lead lengths must be kept short. The importance of quality printed circuit board layout design should also be highlighted.

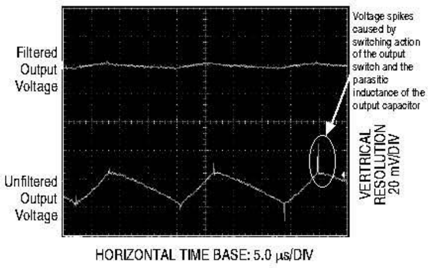


Figure 25. Output Ripple Voltage Waveforms

Minimizing the Output Ripple

In order to minimize the output ripple voltage it is possible to enlarge the inductance value of the inductor L1 and/or to use a larger value output capacitor. There is also another way to smooth the output by means of an additional LC filter (20 μH, 100 μF), that can be added to the output (see Figure 34) to further reduce the amount of output ripple and transients. With such a filter it is possible to reduce the output ripple voltage transients 10 times or more. Figure 25 shows the difference between filtered and unfiltered output waveforms of the regulator shown in Figure 34.

The lower waveform is from the normal unfiltered output of the converter, while the upper waveform shows the output ripple voltage filtered by an additional LC filter.

Heatsinking and Thermal Considerations

The Through−Hole Package TO−220

The LM2576 is available in two packages, a 5−pin TO−220(T, TV) and a 5−pin surface mount D^2PAK(D2T). Although the TO−220(T) package needs a heatsink under most conditions, there are some applications that require no heatsink to keep the LM2576 junction temperature within the allowed operating range. Higher ambient temperatures require some heat sinking, either to the printed circuit (PC) board or an external heatsink.

The Surface Mount Package D^2PAK and its Heatsinking

The other type of package, the surface mount D^2PAK, is designed to be soldered to the copper on the PC board. The copper and the board are the heatsink for this package and the other heat producing components, such as the catch diode and inductor. The PC board copper area that the package is soldered to should be at least 0.4 in^2 (or 260 mm^2) and ideally should have 2 or more square inches (1300 mm^2) of 0.0028 inch copper. Additional increases of copper area beyond approximately 6.0 in^2 (4000 mm^2) will not improve heat dissipation significantly. If further thermal improvements are needed, double sided or multilayer PC boards with large copper areas should be considered. In order to achieve the best thermal performance, it is highly recommended to use wide copper traces as well as large areas of copper in the printed circuit board layout. The only exception to this is the OUTPUT (switch) pin, which should not have large areas of copper (see page 8 'PCB Layout Guideline').

Thermal Analysis and Design

The following procedure must be performed to determine whether or not a heatsink will be required. First determine:

1. $P_{D(max)}$ maximum regulator power dissipation in the application.
2. $T_{A(max)}$ maximum ambient temperature in the application.
3. $T_{J(max)}$ maximum allowed junction temperature (125°C for the LM2576). For a conservative design, the maximum junction temperature should not exceed 110°C to assure safe operation. For every additional +10°C temperature rise that the junction must withstand, the estimated operating lifetime of the component is halved.
4. $R_{\theta JC}$ package thermal resistance junction−case.
5. $R_{\theta JA}$ package thermal resistance junction−ambient.

(Refer to Maximum Ratings on page 2 of this data sheet or $R_{\theta JC}$ and $R_{\theta JA}$ values).

The following formula is to calculate the approximate total power dissipated by the LM2576:

$$P_D = (V_{in} \times I_Q) + d \times I_{Load} \times V_{sat}$$

where d is the duty cycle and for buck converter

$$d = \frac{t_{on}}{T} = \frac{V_O}{V_{in}},$$

I_Q (quiescent current) and V_{sat} can be found in the LM2576 data sheet,
V_{in} is minimum input voltage applied,
V_O is the regulator output voltage,
I_{Load} is the load current.

The dynamic switching losses during turn−on and turn−off can be neglected if proper type catch diode is used.

Packages Not on a Heatsink (Free−Standing)

For a free−standing application when no heatsink is used, the junction temperature can be determined by the following expression:

$$T_J = (R_{\theta JA}) (P_D) + T_A$$

where $(R_{\theta JA})(P_D)$ represents the junction temperature rise caused by the dissipated power and T_A is the maximum ambient temperature.

Packages on a Heatsink

If the actual operating junction temperature is greater than the selected safe operating junction temperature determined in step 3, than a heatsink is required. The junction temperature will be calculated as follows:

$$T_J = P_D (R_{\theta JA} + R_{\theta CS} + R_{\theta SA}) + T_A$$

where $R_{\theta JC}$ is the thermal resistance junction−case,
$R_{\theta CS}$ is the thermal resistance case−heatsink,
$R_{\theta SA}$ is the thermal resistance heatsink−ambient.

If the actual operating temperature is greater than the selected safe operating junction temperature, then a larger heatsink is required.

Some Aspects That can Influence Thermal Design

It should be noted that the package thermal resistance and the junction temperature rise numbers are all approximate, and there are many factors that will affect these numbers, such as PC board size, shape, thickness, physical position, location, board temperature, as well as whether the surrounding air is moving or still.

Other factors are trace width, total printed circuit copper area, copper thickness, single− or double−sided, multilayer board, the amount of solder on the board or even color of the traces.

The size, quantity and spacing of other components on the board can also influence its effectiveness to dissipate the heat.

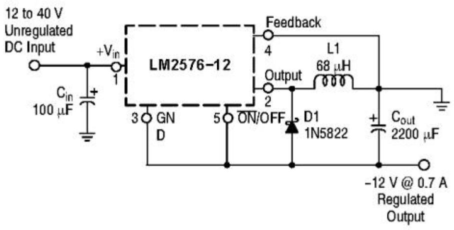


Figure 26. Inverting Buck−Boost Develops −12 V

ADDITIONAL APPLICATIONS

Inverting Regulator

An inverting buck−boost regulator using the LM2576−12 is shown in Figure 26. This circuit converts a positive input voltage to a negative output voltage with a common ground by bootstrapping the regulators ground to the negative output voltage. By grounding the feedback pin, the regulator senses the inverted output voltage and regulates it.

In this example the LM2576−12 is used to generate a −12 V output. The maximum input voltage in this case cannot exceed +28 V because the maximum voltage appearing across the regulator is the absolute sum of the input and output voltages and this must be limited to a maximum of 40 V.

LM2576

This circuit configuration is able to deliver approximately 0.7 A to the output when the input voltage is 12 V or higher. At lighter loads the minimum input voltage required drops to approximately 4.7 V, because the buck–boost regulator topology can produce an output voltage that, in its absolute value, is either greater or less than the input voltage.

Since the switch currents in this buck–boost configuration are higher than in the standard buck converter topology, the available output current is lower.

This type of buck–boost inverting regulator can also require a larger amount of startup input current, even for light loads. This may overload an input power source with a current limit less than 5.0 A.

Such an amount of input startup current is needed for at least 2.0 ms or more. The actual time depends on the output voltage and size of the output capacitor.

Because of the relatively high startup currents required by this inverting regulator topology, the use of a delayed startup or an undervoltage lockout circuit is recommended.

Using a delayed startup arrangement, the input capacitor can charge up to a higher voltage before the switch–mode regulator begins to operate.

The high input current needed for startup is now partially supplied by the input capacitor C_{in}.

It has been already mentioned above, that in some situations, the delayed startup or the undervoltage lockout features could be very useful. A delayed startup circuit applied to a buck–boost converter is shown in Figure 27, Figure 33 in the "Undervoltage Lockout" section describes an undervoltage lockout feature for the same converter topology.

Design Recommendations:

The inverting regulator operates in a different manner than the buck converter and so a different design procedure has to be used to select the inductor L1 or the output capacitor C_{out}.

The output capacitor values must be larger than what is normally required for buck converter designs. Low input voltages or high output currents require a large value output capacitor (in the range of thousands of μF).

The recommended range of inductor values for the inverting converter design is between 68 μH and 220 μH. To select an inductor with an appropriate current rating, the inductor peak current has to be calculated.

The following formula is used to obtain the peak inductor current:

$$I_{peak} \approx \frac{I_{Load}\,(V_{in} + |V_O|)}{V_{in}} + \frac{V_{in} \times t_{on}}{2L_1}$$

$$\text{where } t_{on} = \frac{|V_O|}{V_{in} + |V_O|} \times \frac{1.0}{f_{osc}}, \text{ and } f_{osc} = 52\ \text{kHz}.$$

Under normal continuous inductor current operating conditions, the worst case occurs when V_{in} is minimal.

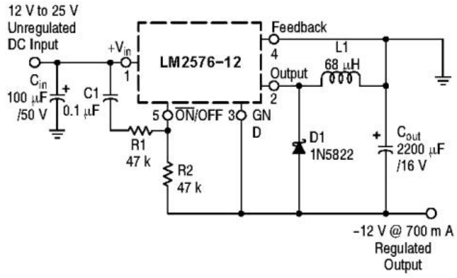
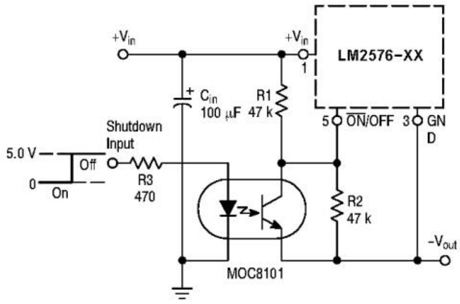


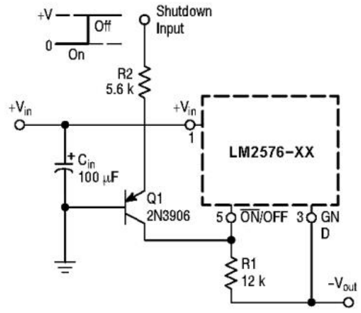
Figure 27. Inverting Buck–Boost Regulator with Delayed startup



NOTE: This picture does not show the complete circuit.

Figure 28. Inverting Buck–Boost Regulator Shutdown Circuit Using an Optocoupler

With the inverting configuration, the use of the $\overline{ON}$/OFF pin requires some level shifting techniques. This is caused by the fact, that the ground pin of the converter IC is no longer at ground. Now, the $\overline{ON}$/OFF pin threshold voltage (1.3 V approximately) has to be related to the negative output voltage level. There are many different possible shut down methods, two of them are shown in Figures 28 and 29.



NOTE: This picture does not show the complete circuit.

Figure 29. Inverting Buck−Boost Regulator Shutdown Circuit Using a PNP Transistor

Negative Boost Regulator

This example is a variation of the buck−boost topology and it is called negative boost regulator. This regulator experiences relatively high switch current, especially at low input voltages. The internal switch current limiting results in lower output load current capability.

The circuit in Figure 30 shows the negative boost configuration. The input voltage in this application ranges from −5.0 V to −12 V and provides a regulated −12 V output. If the input voltage is greater than −12 V, the output will rise above −12 V accordingly, but will not damage the regulator.

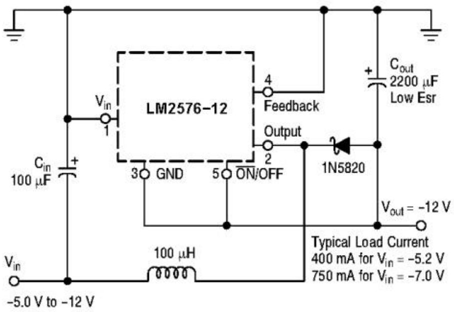


Figure 30. Negative Boost Regulator

Design Recommendations:

The same design rules as for the previous inverting buck−boost converter can be applied. The output capacitor C_{out} must be chosen larger than would be required for a what standard buck converter. Low input voltages or high output currents require a large value output capacitor (in the range of thousands of μF). The recommended range of inductor values for the negative boost regulator is the same as for inverting converter design.

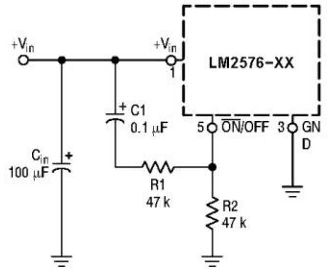
Another important point is that these negative boost converters cannot provide current limiting load protection in the event of a short in the output so some other means, such as a fuse, may be necessary to provide the load protection.

Delayed Startup

There are some applications, like the inverting regulator already mentioned above, which require a higher amount of startup current. In such cases, if the input power source is limited, this delayed startup feature becomes very useful.

To provide a time delay between the time when the input voltage is applied and the time when the output voltage comes up, the circuit in Figure 31 can be used. As the input voltage is applied, the capacitor C1 charges up, and the voltage across the resistor R2 falls down. When the voltage on the $\overline{\text{ON}}$/OFF pin falls below the threshold value 1.3 V, the regulator starts up. Resistor R1 is included to limit the maximum voltage applied to the $\overline{\text{ON}}$/OFF pin. It reduces the power supply noise sensitivity, and also limits the capacitor C1 discharge current, but its use is not mandatory.

When a high 50 Hz or 60 Hz (100 Hz or 120 Hz respectively) ripple voltage exists, a long delay time can cause some problems by coupling the ripple into the $\overline{\text{ON}}$/OFF pin, the regulator could be switched periodically on and off with the line (or double) frequency.



NOTE: This picture does not show the complete circuit.

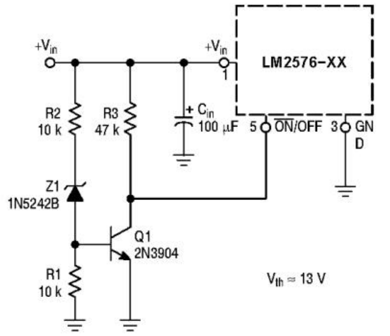
Figure 31. Delayed Startup Circuitry

Undervoltage Lockout

Some applications require the regulator to remain off until the input voltage reaches a certain threshold level. Figure 32 shows an undervoltage lockout circuit applied to a buck regulator. A version of this circuit for buck−boost converter is shown in Figure 33. Resistor R3 pulls the $\overline{\text{ON}}$/OFF pin high and keeps the regulator off until the input voltage reaches a predetermined threshold level with respect to the ground Pin 3, which is determined by the following expression:

$$V_{th} \approx V_{Z1} + \left(1.0 + \frac{R2}{R1}\right) V_{BE} \,(Q1)$$

LM2576



NOTE: This picture does not show the complete circuit.

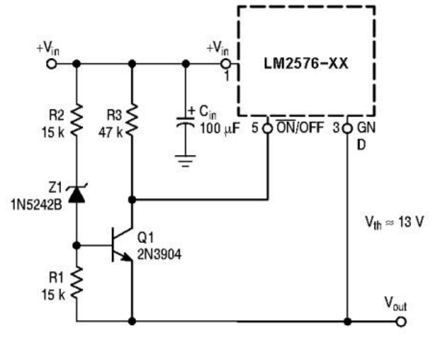
Figure 32. Undervoltage Lockout Circuit for Buck Converter

The following formula is used to obtain the peak inductor current:

$$I_{peak} \approx \frac{I_{Load}(V_{in} + |V_O|)}{V_{in}} + \frac{V_{in} \times t_{on}}{2L_1}$$

$$\text{where } t_{on} = \frac{|V_O|}{V_{in} + |V_O|} \times \frac{1.0}{f_{osc}}, \text{ and } f_{osc} = 52 \text{ kHz.}$$

Under normal continuous inductor current operating conditions, the worst case occurs when V_{in} is minimal.



NOTE: This picture does not show the complete circuit.

Figure 33. Undervoltage Lockout Circuit for Buck−Boost Converter

Adjustable Output, Low−Ripple Power Supply

A 3.0 A output current capability power supply that features an adjustable output voltage is shown in Figure 34.

This regulator delivers 3.0 A into 1.2 V to 35 V output. The input voltage ranges from roughly 3.0 V to 40 V. In order to achieve a 10 or more times reduction of output ripple, an additional L−C filter is included in this circuit.

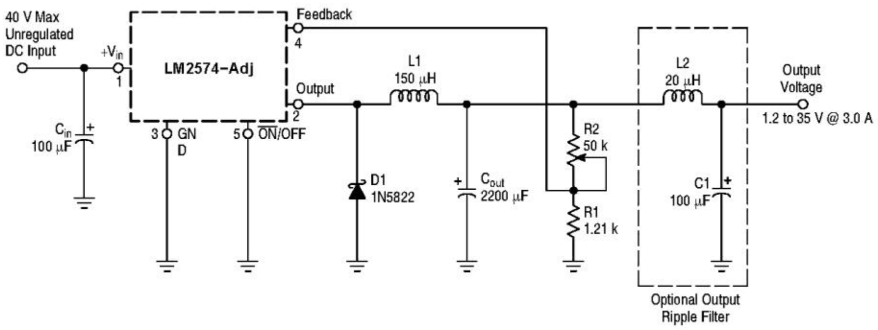
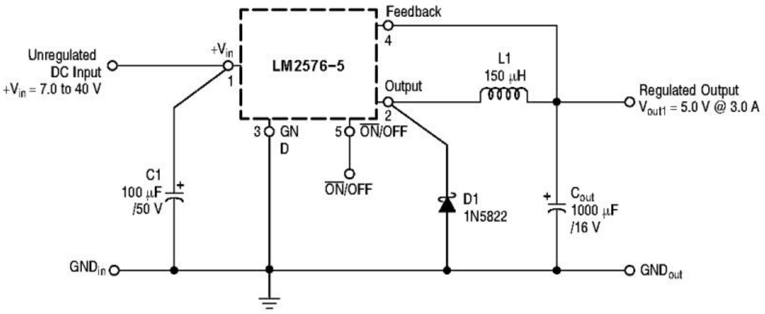


Figure 34. 1.2 to 35 V Adjustable 3.0 A Power Supply with Low Output Ripple

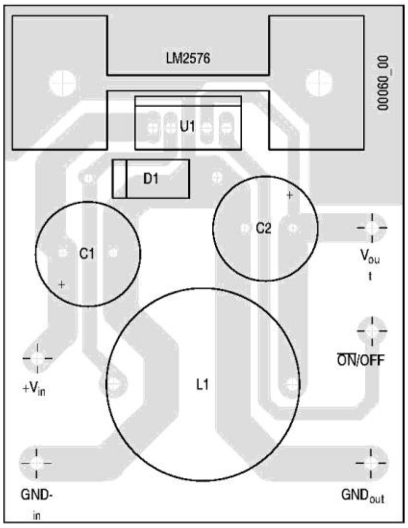
LM2576

THE LM2576−5 STEP−DOWN VOLTAGE REGULATOR WITH 5.0 V @ 3.0 A OUTPUT POWER CAPABILITY. TYPICAL APPLICATION WITH THROUGH−HOLE PC BOARD LAYOUT



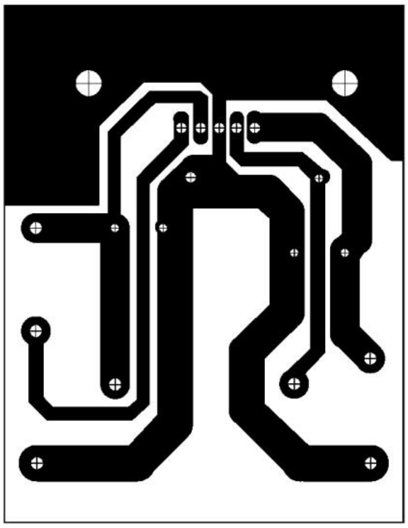
C1	−	100 μF, 50 V, Aluminium Electrolytic
C2	−	1000 μF, 16 V, Aluminium Electrolytic
D1	−	3.0 A, 40 V, Schottky Rectifier, 1N5822
L1	−	150 μH, RL2444, Renco Electronics

Figure 35. Schematic Diagram of the LM2576−5 Step−Down Converter



NOTE: Not to scale.

Figure 36. Printed Circuit Board Layout Component Side



NOTE: Not to scale.

Figure 37. Printed Circuit Board Layout Copper Side

LM2576

THE LM2576−ADJ STEP−DOWN VOLTAGE REGULATOR WITH 8.0 V @ 1.0 A OUTPUT POWER CAPABILITY. TYPICAL APPLICATION WITH THROUGH−HOLE PC BOARD LAYOUT

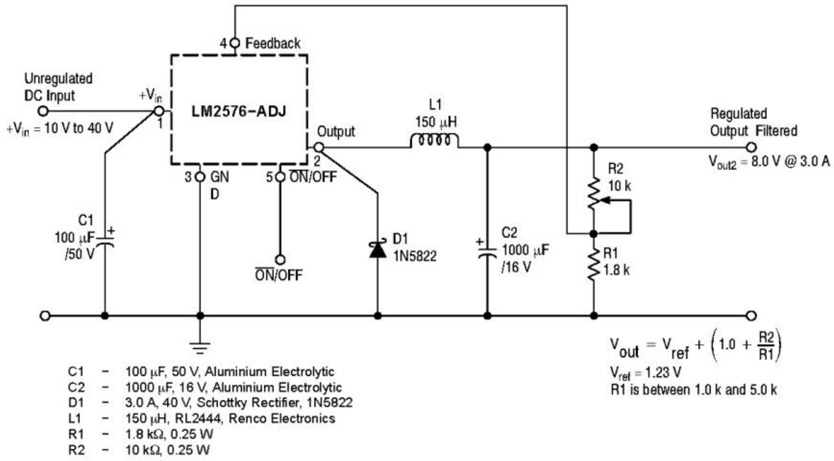
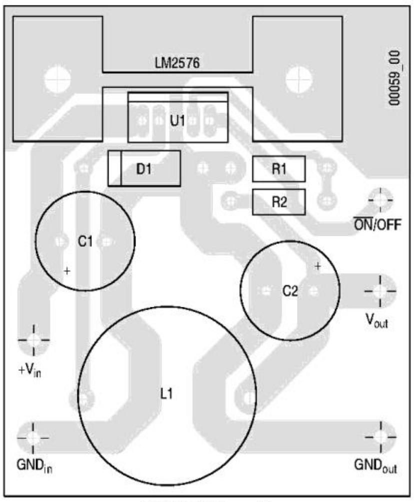
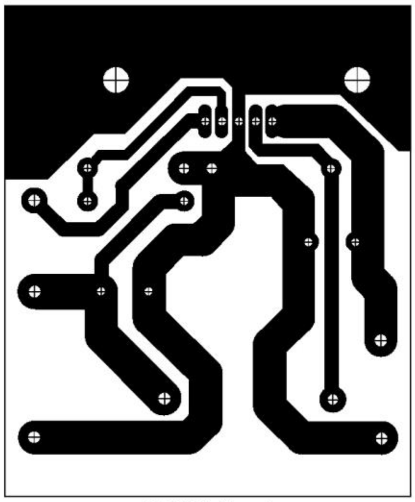


Figure 38. Schematic Diagram of the 8.0 V @ 3.0 A Step−Down Converter Using the LM2576−ADJ



NOTE: Not to scale.

Figure 39. Printed Circuit Board Layout Component Side



NOTE: Not to scale.

Figure 40. Printed Circuit Board Layout Copper Side

References

- National Semiconductor LM2576 Data Sheet and Application Note
- National Semiconductor LM2595 Data Sheet and Application Note
- Marty Brown "Practical Switching Power Supply Design", Academic Press, Inc., San Diego 1990
- Ray Ridley "High Frequency Magnetics Design", Ridley Engineering, Inc. 1995

ORDERING INFORMATION

Device	Nominal Output Voltage	Operating Temperature Range	Package	Shipping†
LM2576TV−ADJ	1.23 V to 37 V	T_J = −40° to +125°C	TO−220 (Vertical Mount)	50 Units/Rail
LM2576TV−ADJG			TO−220 (Vertical Mount) (Pb−Free)	
LM2576T−ADJ			TO−220 (Straight Lead)	
LM2576T−ADJG			TO−220 (Straight Lead) (Pb−Free)	
LM2576D2T−ADJ			D^2PAK (Surface Mount)	
LM2576D2T−ADJG			D^2PAK (Surface Mount) (Pb−Free)	
LM2576D2T−ADJR4			D^2PAK (Surface Mount)	2500 Tape & Reel
LM2576D2T−ADJR4G			D^2PAK (Surface Mount) (Pb−Free)	
LM2576TV−3.3	3.3 V	T_J = −40° to +125°C	TO−220 (Vertical Mount)	50 Units/Rail
LM2576TV−3.3G			TO−220 (Vertical Mount) (Pb−Free)	
LM2576T−3.3			TO−220 (Straight Lead)	
LM2576T−3.3G			TO−220 (Straight Lead) (Pb−Free)	
LM2576D2T−3.3			D^2PAK (Surface Mount)	
LM2576D2T−3.3G			D^2PAK (Surface Mount) (Pb−Free)	
LM2576D2TR4−3.3			D^2PAK (Surface Mount)	2500 Tape & Reel
LM2576D2TR4−3.3G			D^2PAK (Surface Mount) (Pb−Free)	
LM2576TV−005	5.0 V	T_J = −40° to +125°C	TO−220 (Vertical Mount)	50 Units/Rail
LM2576TV−5G			TO−220 (Vertical Mount) (Pb−Free)	
LM2576T−005			TO−220 (Straight Lead)	
LM2576T−005G			TO−220 (Straight Lead) (Pb−Free)	
LM2576D2T−005			D^2PAK (Surface Mount)	
LM2576D2T−005G			D^2PAK (Surface Mount) (Pb−Free)	
LM2576D2TR4−005			D^2PAK (Surface Mount)	2500 Tape & Reel
LM2576D2TR4−5G			D^2PAK (Surface Mount) (Pb−Free)	
LM2576TV−012	12 V	T_J = −40° to +125°C	TO−220 (Vertical Mount)	50 Units/Rail
LM2576TV−012G			TO−220 (Vertical Mount) (Pb−Free)	
LM2576T−012			TO−220 (Straight Lead)	
LM2576T−012G			TO−220 (Straight Lead) (Pb−Free)	
LM2576D2T−012			D^2PAK (Surface Mount)	
LM2576D2T−012G			D^2PAK (Surface Mount) (Pb−Free)	
LM2576D2TR4−012			D^2PAK (Surface Mount)	2500 Tape & Reel
LM2576D2TR4−012G			D^2PAK (Surface Mount) (Pb−Free)	

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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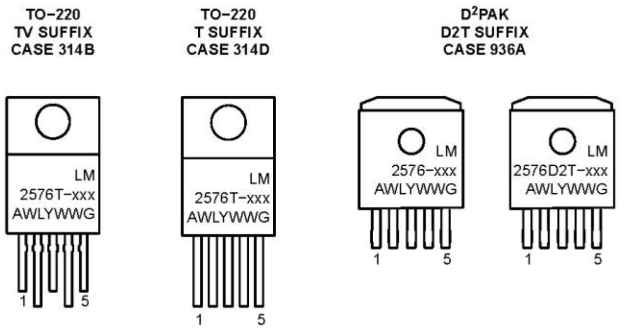
ORDERING INFORMATION

Device	Nominal Output Voltage	Operating Temperature Range	Package	Shipping†
LM2576TV−015	15 V	T_J = −40° to +125°C	TO−220 (Vertical Mount)	50 Units/Rail
LM2576TV−015G			TO−220 (Vertical Mount) (Pb−Free)	
LM2576T−015			TO−220 (Straight Lead)	
LM2576T−15G			TO−220 (Straight Lead) (Pb−Free)	
LM2576D2T−015			D^2PAK (Surface Mount)	
LM2576D2T−15G			D^2PAK (Surface Mount) (Pb−Free)	

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

MARKING DIAGRAMS

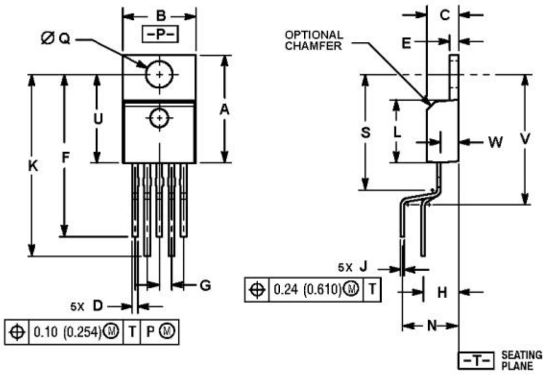


xxx = 3.3, 5.0, 12, 15, or ADJ
A = Assembly Location
WL = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free Package

LM2576

PACKAGE DIMENSIONS

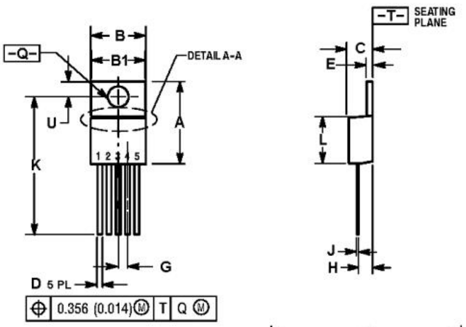
TO−220
TV SUFFIX
CASE 314B−05
ISSUE L



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION D DOES NOT INCLUDE INTERCONNECT BAR (DAMBAR) PROTRUSION. DIMENSION D INCLUDING PROTRUSION SHALL NOT EXCEED 0.043 (1.092) MAXIMUM.

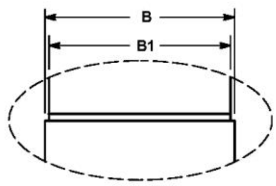
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.572	0.613	14.529	15.570
B	0.390	0.415	9.906	10.541
C	0.170	0.180	4.318	4.572
D	0.025	0.038	0.635	0.965
E	0.048	0.055	1.219	1.397
F	0.850	0.935	21.590	23.749
G	0.067 BSC		1.702 BSC	
H	0.166 BSC		4.216 BSC	
J	0.015	0.025	0.381	0.635
K	0.900	1.100	22.860	27.940
L	0.320	0.365	8.128	9.271
N	0.320 BSC		8.128 BSC	
Q	0.140	0.153	3.556	3.886
S	---	0.620	---	15.748
U	0.468	0.505	11.888	12.827
V	---	0.735	---	18.669
W	0.090	0.110	2.286	2.794

TO−220
T SUFFIX
CASE 314D−04
ISSUE F



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION D DOES NOT INCLUDE INTERCONNECT BAR (DAMBAR) PROTRUSION. DIMENSION D INCLUDING PROTRUSION SHALL NOT EXCEED 10.92 (0.043) MAXIMUM.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.572	0.613	14.529	15.570
B	0.390	0.415	9.906	10.541
B1	0.375	0.415	9.525	10.541
C	0.170	0.180	4.318	4.572
D	0.025	0.038	0.635	0.965
E	0.048	0.055	1.219	1.397
G	0.067 BSC		1.702 BSC	
H	0.087	0.112	2.210	2.845
J	0.015	0.025	0.381	0.635
K	0.977	1.045	24.810	26.543
L	0.320	0.365	8.128	9.271
Q	0.140	0.153	3.556	3.886
U	0.105	0.117	2.667	2.972



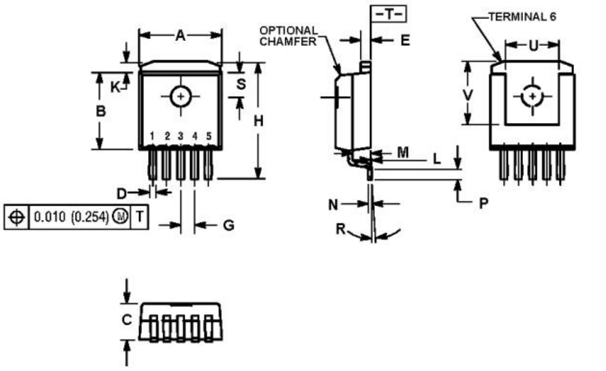
DETAIL A−A

http://onsemi.com
26

LM2576

PACKAGE DIMENSIONS

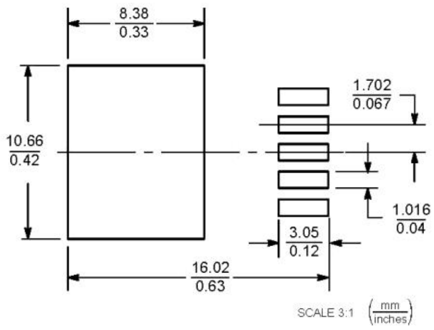
D²PAK
D2T SUFFIX
CASE 936A−02
ISSUE C



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 6.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.386	0.403	9.804	10.236
B	0.356	0.368	9.042	9.347
C	0.170	0.180	4.318	4.572
D	0.026	0.036	0.660	0.914
E	0.045	0.055	1.143	1.397
G	0.067 BSC		1.702 BSC	
H	0.539	0.579	13.691	14.707
K	0.050 REF		1.270 REF	
L	0.000	0.010	0.000	0.254
M	0.088	0.102	2.235	2.591
N	0.018	0.026	0.457	0.660
P	0.058	0.078	1.473	1.981
R	5° REF		5° REF	
S	0.116 REF		2.946 REF	
U	0.200 MIN		5.080 MIN	
V	0.250 MIN		6.350 MIN	

SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
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ON Semiconductor Website: http://onsemi.com

Order Literature: http://www.onsemi.com/litorder

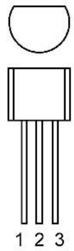
For additional information, please contact your local Sales Representative.

LM2576/D

Transistor SP8050

S8050 TRANSISTOR (PNP)

TO-92



FEATURES

Power dissipation

P_{CM} : 0.625 W (Tamb=25℃)

Collector current

I_{CM} : 0.5 A

Collector-base voltage

$V_{(BR)CBO}$: 40 V

1. EMITTER
2. BASE
3. COLLECTOR

ELECTRICAL CHARACTERISTICS (Tamb=25℃ unless otherwise specified)

Parameter	Symbol	Test conditions	MIN	TYP	MAX	UNIT
Collector-base breakdown voltage	$V(BR)_{CBO}$	Ic= 100 μA , I_E=0	40			V
Collector-emitter breakdown voltage	$V(BR)_{CEO}$	Ic= 0.1 mA , I_B=0	25			V
Emitter-base breakdown voltage	$V(BR)_{EBO}$	I_E= 100 μA , I_C=0	5			V
Collector cut-off current	I_{CBO}	V_{CB}= 40 V , I_E=0			0.1	μA
Collector cut-off current	I_{CEO}	V_{CE}= 20 V , I_B=0			0.1	μA
Emitter cut-off current	I_{EBO}	V_{EB}= 5 V , I_C=0			0.1	μA
DC current gain(note)	$H_{FE(1)}$	V_{CE}= 1 V, I_C= 50mA	85		300	
	$H_{FE(2)}$	V_{CE}= 1 V, I_C= 500mA	50			
Collector-emitter saturation voltage	V_{CE}(sat)	I_C= 500mA, I_B= 50 mA			0.6	V
Base-emitter saturation voltage	V_{BE}(sat)	I_C= 500mA, I_B= 50 mA			1.2	V
Base-emitter voltage	V_{BE}	I_E= 100mA			1.4	V
Transition frequency	f_T	V_{CE}= 6 V, I_C= 20mA f = 30MHz	150			MHz

CLASSIFICATION OF $H_{FE(1)}$

Rank	B	C	D
Range	85-160	120-200	160-300

Wing Shing Computer Components Co., (H.K.)Ltd. Tel:(852)2341 9276 Fax:(852)2797 8153
Homepage: http://www.wingshing.com E-mail: wsccltd@hkstar.com

Convertidor USB-Serie CH340

USB to serial chip CH340

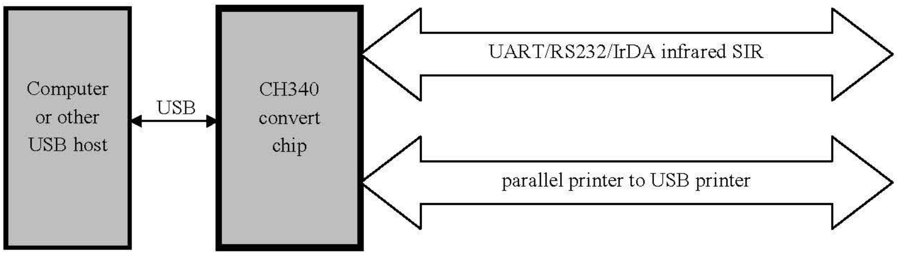
English DataSheet
Version: 1D
http://wch.cn

1. Introduction

CH340 is a USB bus convert chip and it can realize USB convert to serial interface, USB convert to IrDA infrared or USB convert to printer interface.

In serial interface mode, CH340 supplies common MODEM liaison signal, used to enlarge asynchronous serial interface of computer or upgrade the common serial device to USB bus directly. More detail about USB convert to printer interface please referring to the second manual CH340DS2.

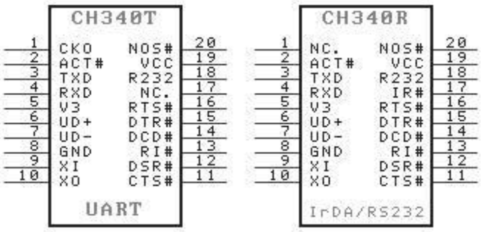
In infrared mode, add infrared transceiver to CH340 can compose USB infrared adapter, realize SIR infrared communication.



2. Features

- Full speed USB device interface, conforms to USB Specification Version 2.0, only needs crystal and capacitance external.
- Emulate standard serial interface, used to upgrade the former peripheral device, or add excess serial interface through USB.
- Totally compatible with serial application program in computer endpoint Windows operation system.
- Hardware full duplex serial interface, set transceiver buffer, supports communication baud rate varies from 50bps to 2Mbps.
- Supports common MODEM liaison signal RTS, DTR, DCD, RI, DSR and CTS.
- Through adding level converter equipment to supply RS232, RS485, RS422 and other interface.
- Supports IrDA criterion SIR infrared communication, supports baud rate varies from 2400bps to 115200bps.
- For it is through USB converts to serial interface, only compatible with application layer not totally.
- Software compatible with CH341, using drive of CH341 directly.
- Support 5V and 3.3V source voltage.
- Supply SSOP-20 package without lead, compatible with RoHS.

3. Package



Package shape	Width of plastic		Pitch of Pin		Instruction of package	Ordering type
SSOP-20	5.30mm	209mil	0.65mm	25mil	Shrink small outline package of 20-pin	CH340T
SSOP-20	5.30mm	209mil	0.65mm	25mil	Shrink small outline package of 20-pin	CH340R

4. Pins

Pin No.	Pin Name	Pin Type	Pin Description(description in bracket is only about CH340R)
19	VCC	POWER	Positive power input port, requires an external 0.1uF power decoupling capacitance
8	GND	POWER	Public ground, ground connection for USB
5	V3	POWER	connects of VCC to input outside power while 3.3V, connects of 0.01uF decoupling capacitance outside while 5V
9	XI	IN	Input of crystal oscillator, attachment of crystal and crystal oscillator capacitance outside
10	XO	OUT	Opposite output of crystal oscillator, attachment of crystal and crystal oscillator capacitance outside
6	UD+	USB signal	Directly connect to D+ data wire of USB bus, set up pull-up resistor internal
7	UD-	USB signal	Directly connect to D- data wire of USB bus
20	NOS#	IN	Forbid USB device suspending, active with low, set up pull-up resistor internal
3	TXD	OUT	Serial data output(opposite phasic output of CH340R)
4	RXD	IN	Serial data input, set up controlled pull-up and pull-down resistor
11	CTS#	IN	MODEM liaison input signal, clear sending, active with low(high)
12	DSR#	IN	MODEM liaison input signal, data equipment is ready, active with low(high)
13	RI#	IN	MODEM liaison input signal, oscillate ring to prompt, active with low(high)

14	DCD#	OUT	MODEM liaison input signal, carrier wave detection, active with low(high)
15	DTR#	OUT	MODEM liaison output signal, data endpoint is ready, active with low(high)
16	RTS#	OUT	MODEM liaison output signal, request to send, active with low(high)
2	ACT#	OUT	CH340T:negative phasic clock output (CH340R:USB configuration is finished state output, active with low)
18	R232	IN	Assistant RS232 enable, active with high, set up pull-down resistor internal
17	NC.	NC.	CH340T: unconnected, must be suspended
	IR#	IN	CH340R:Serial interface mode set input, set up pull-up resistor internal, low level is SIR infrared serial interface, high level is common serial interface
1	CKO.	OUT(NC.)	CH340T: clock output
	NC		CH340R:unconnected, must be suspend

5. Function description

CH340 chip set up USB pull-up resistor internal, UD+ and UD- pins must be connected to USB bus directly.

CH340 chip set up power up reset circuit internal.

When CH340 chip is working normally, the outside must supply 12MHz clock signal to XI pin. In generally, clock signal is generated by inverter in CH340 through oscillating of crystal keeping frequency. A crystal of 12MHz between XI and XO, XI and XO connect a high frequency oscillator capacitance to ground respectively can compose the peripheral circuit.

CH340 chip supports 5V and 3.3V power voltage. When using 5V source power, the VCC input 5V power and the pin of V3 must connect with 4700pF or 0.01uF decoupling capacitance. When using 3.3V power voltage, connects V3 with VCC, and input 3.3V power voltage. And the other circuit voltage which is connected with CH340 is no more than 3.3V.

CH340 automatically supports USB device suspending to save power consume. NOS# is low–level can forbid USB device suspending.

In asynchronous serial interface mode, CH340 chip contains these pins: data transfer pin, MODEM liaison signal pin and assistant pin.

Data transfer pin contains: TXD pin and RXD pin. When serial interface is idle, RXD must be high-level. If R232 is high-level, use assistant RS232 function, then RXD pin automatically inserts a inverter internal, and low-level is in default. When serial interface output is free, the TXD in CH340H and CH340T is high level, TXD in CH340R is low-level.

MODEM liaison signal pin contains: CTS#, DSR#, RI#, DCD# and RTS#. All these MODEM liaison signal are controlled by computer application program and application program defines function.

Assistant pin contains: IR#, R232, CKOH, CKOL and ACT#. When IR# is low-level, starts infrared serial interface mode. R232 is used to control assistant RS232 function. When R232 is high-level, RXD pin automatically insert a inverter internal, and output opposite phase clock from CKOH and CKOL. ACT# is USB device configuration finished state output (such as USB infrared adapter is ready) when R232 is low-level. IR# and R232 only be detected once a time after power reset.

CH340 set separate transceiver buffer internal and supports simplex, semiduplex and full duplex asynchronous serial communication. Serial data contains one low-level start bit , eight or nine data bit and one high-level stop bit. Supporting odd check/even check/flag check/blank check. CH340 supports common baud rate: 50,75,100,110,134.5,150,300,600,900,1200,1800,2400,3600,4800,9600,14400,19200,28800, 33600,38400, 56000,57600,76800,115200,128000,153600,230400,460800,921600,1500000,2000000 and so on. The baud rate error of serial transfer signal is less than 0.3%, and permission baud rate error of serial receive signal is not less than 0.2%.

In the WINDOWS operation system of computer endpoint, drive program of CH340 can communicate standard serial interface. So the mostly original serial interface application program is totally compatible, and without any modify.

CH340 can be used to upgrade the former serial interface peripheral equipment, or add extra serial interface for computer via USB bus. Supply RS232, RS485, RS422 and other interface via adding level change device.

Only add infrared transceiver, CH340 can add SIR infrared adapter for computer via USB bus, realize infrared communication between computer and peripheral equipment which is according to IrDA criterion.

6. Parameter

6.1. Absolute maximum rating (Stresses above those listed can cause permanent damage to the device. Exposure to maximum rated conditions can affect device operation and reliability.)

Name	Parameter note	Min.	Max.	Units
TA	Ambient operating temperature	-40	85	℃
TS	Storage temperature	-55	125	℃
VCC	Voltage source (VCC connects to power, GND to ground)	-0.5	6.5	V
VIO	The voltage of input or output pin	-0.5	VCC+0.5	V

6.2. Electrical parameter (test conditions: TA=25℃, VCC=5V, exclude pin connection of USB bus)
(The every current parameter must multiply the coefficient of 40% when the power is 3.3V)

Name	Parameter note		Min.	Typical	Max.	Units
VCC	Source voltage	V3 doesn't connect to VCC	4.5	5	5.3	V
		V3 connect to VCC	3.3	3.3	3.8	
ICC	Total source current when working			12	30	mA
ISLP	Total source current when USB suspending	VCC=5V		0.15	0.2	mA
		VCC=3.3V		0.05	0.08	mA
VIL	Input Voltage LOW		-0.5		0.7	V
VIH	Input Voltage HIGH		2.0		VCC+0.5	V
VOL	Output Voltage LOW (draw 4mA current)				0.5	V
VOH	Output Voltage HIGH (output 3mA current) (Output 100uA current during chip reset)		VCC-0.5			V
IUP	Input current with pull-up resistor internal		3	150	300	uA
IDN	Input current with pull-down resistor internal		-50	-150	-300	uA
VR	Restrict voltage when power-up reset		2.3	2.6	2.9	V

6.3. sequence parameter (test conditions: TA=25℃,VCC=5V)

Name	Parameter note	Min.	Typical	Max.	Units
FCLK	Frequency of input clock in XI	11.98	12.00	12.02	MHz
TPR	Reset time of power-up		20	50	mS

7. Application

7.1. USB convert 9-wire serial interface (the following image)

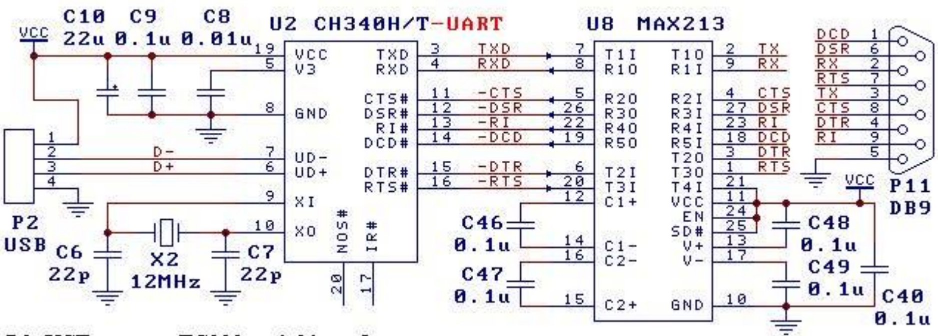
The following image is using CH340T to realize USB convert RS232 serial interface. CH340 supplies common serial interface signal and MODEM signal, changes TTL serial interface to RS232 serial interface through level convert circuit U8. Endpoint P11 is DB9 needle, the pin and its function is the same as common nine needles serial interface of computer. The similar with U8 is MAX213/ADM213/SP213 etc.

Take the U8 and C46/C47/C48.C49/C40 out when only realize USB convert to TTL serial interface. The signal wire in the image can only connect RXD、TXD and public ground, the other signal wire can suspend when not use.

P2 is USB endpoint. USB bus contains a pair of 5V power wire and a pair of data signal wire. Usually, the +5V power wire is red, the black is ground. D+ signal wire is green and the D- signal wire is white. The max source current of USB bus is up to 500mA. In generally, CH340 and low power exhaust USB product can directly use the 5V power supplied by USB bus. If the USB product supplies stock power by other manner, CH340 must use this stock power. If the USB bus power and stock power are necessary at the same time, connect a 1Ω resistor between USB bus 5V power wire and USB product 5V stock power, and connect the two power wires' ground wire directly.

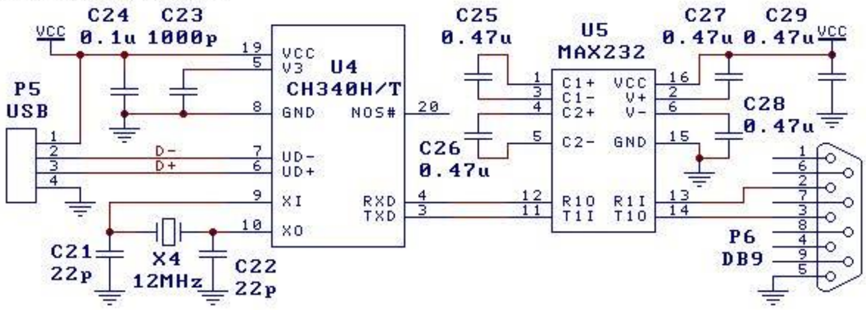
The capacitance of C8 varies from 4700pF to 0.02uF, used to internal power node decoupling of CH340. The C9 is 0.1uF, used to external power decoupling. Crystal X2、capacitance C6 and C7 are used to clock surge circuit. The X2 is 12MHz quartz crystal, C6 and C7 are monolithic or high frequency stoneware capacitance with 22pF. If X2 is ceramic with low cost, C6 and C7 must use the recommend value of crystal manufacturer and generally is 47pF.

When designing the PCB, pay much attention to some notes: decoupling capacitance C8 and C9 must keep near to connection pin of CH340; makes sure D+ and D- are parallel and supply ground net or pour copper beside them to decrease the disturbance from outside signal; the relevant signal between XI and XO must be kept as short as possible. In order to lessen the high frequency disturbance, play ground net or pour copper to the relative equipment.



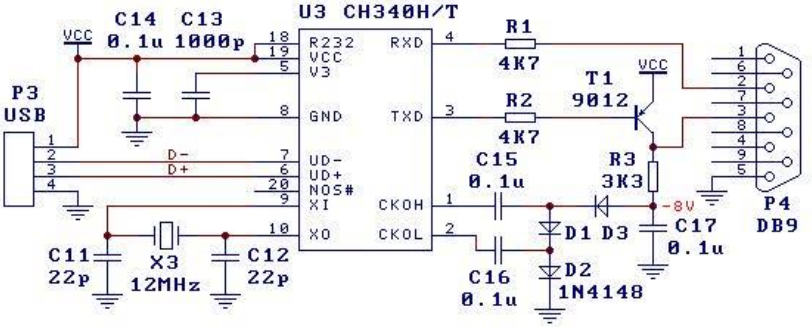
7.2. USB convert RS232 serial interface (the following image)

The image is USB converts to basic and common three wires RS232 serial interface, and U5 is MAX232/ICL232/SP232 etc.



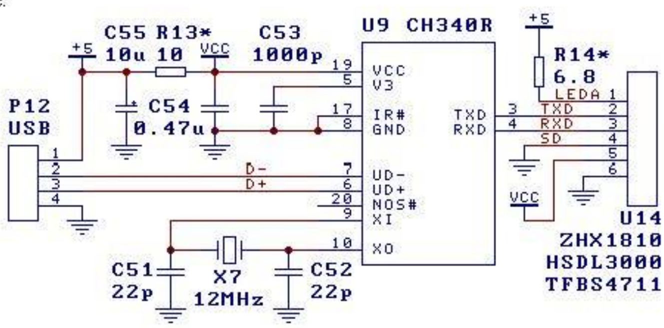
7.3. USB convert RS232 serial interface, handing edition (the following image)

The following image also is USB convert three RS232 serial interface, the function of this circuit is the same with 7.2. except the range of output RS232 is low. R232 in CH340 is high-level starts assistant RS232 function, only add diode、audion、resistor and capacitance can replace the special level convert circuit U5 in 7.2.. So the hardware cost is lower.

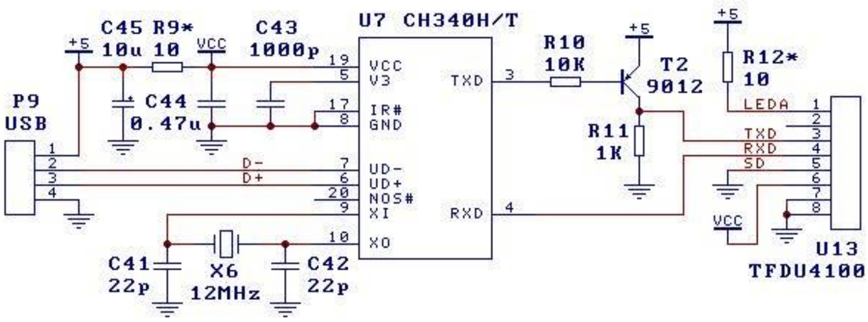


7.4. USB infrared adapter (the following image)

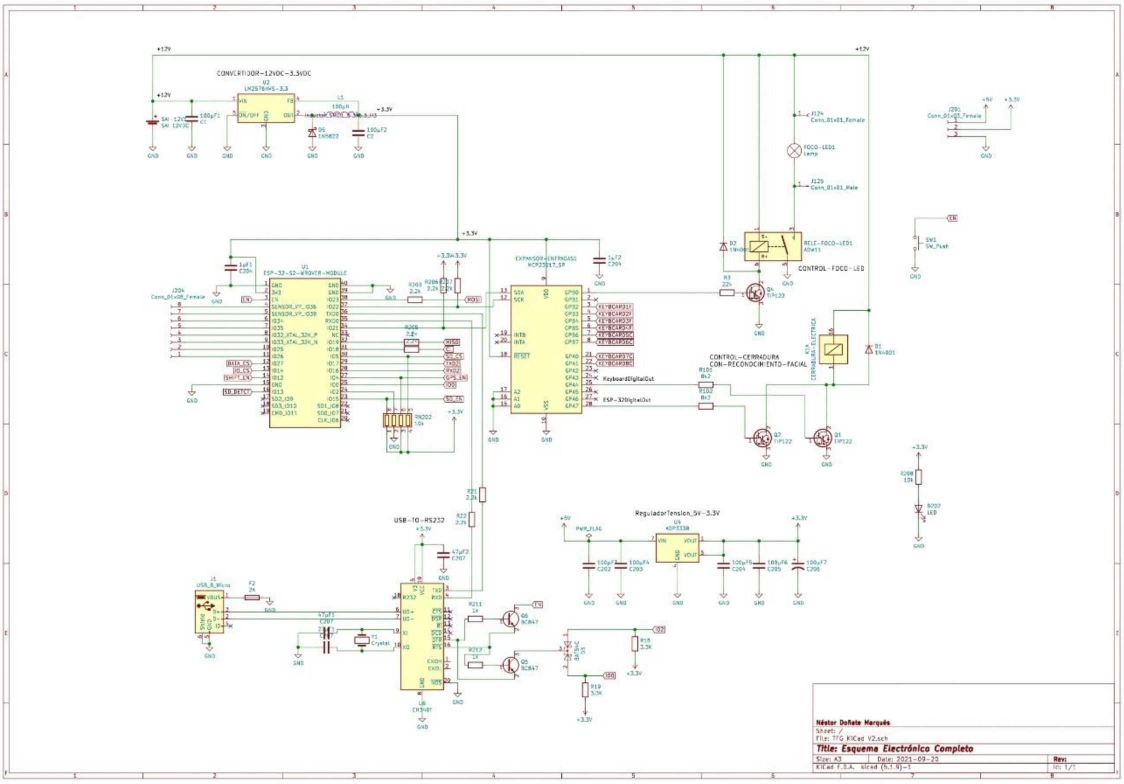
The following USB infrared adapter image is composed with USB convert IrDA infrared chip CH340R and infrared transceiver U14 (ZHX1810/HSDL3000 etc). The resistor R13 is used to weaken influence of large current when infrared transferring. R13 can be ignored when the request is low. The limited current resistor R14 can be adjusted according recommended value supplied by the infrared transceiver U14's manufacture.



Consulting the following image, if selecting CH340H or CH340T chip, only to insert a inverter in TXD signal wire can realize the similar infrared function of the upper image.(the converter circuit in the following is composed of audion T12 and two resistors R10 and R11).



5. ANEXO 5 (PLANOS)

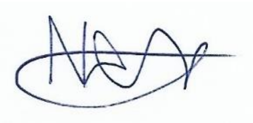


Se añade tras este anexo el PDF con el plano completo en DIN-A3

Relación de documentos

(_) Memoria	114	páginas
(X) Anexos	243	páginas

La Almunia, a 22 de Septiembre de 2021



Firmado: Néstor Doñate Marqués