

## Anexos

### Anexo I. Script Matlab, relación temperatura tensión del sensor

```
1. close all
2. clear all
3.
4. hold all
5. format long
6.
7. syms Vcc Rtc B Tc To Ro T;
8.
9. %Introducimos los diferentes parametros del termistor NTC
10.    %y de la alimentación
11.    To = 25;
12.    Tc = 25;
13.    Vcc = 1.5;
14.    B = 4450;
15.    Ro = 100000
16.    Rl = 75000;
17.    %Pasamos las temperaturas de celsius a kelvin
18.    To = To + 273;
19.    Tc = Tc + 273;
20.    %Calculamos el valor de la R del termistor a Tc = 25 °C
21.    Rtc = Ro*exp(B*(1/Tc-1/To));
22.    %Planteamos las ecuaciones simbólicas de la resistencia
23.    %del termistor y de la tensión entre el termistor
24.    %y la resistencia en serie.
25.    Rt = Ro*exp(B*(1/T-1/To));
26.    Vo = Vcc*Rl/(Rl+Rt);
27.
28.    %Calculamos la ecuación y representamos la recta que
29.    %se corresponde con el modelo ideal del sensor.
30.    %Para ello se sustituye en el la zona lineal de la
31.    %ecuacion la temperatura por dos valores muy próximos
32.    uno=subs(Vo,T,Tc);
33.    dos = subs(Vo,T, Tc+1);
34.    pendiente = dos - uno
35.    offset = uno - pendiente*Tc
36.    X = linspace(273, 273 + (Tc-273)*2);
37.    recta = pendiente*X + offset;
38.    plot(X-273, recta)
39.
40.
41.    %representamos la tensión para distintas temperaturas
42.    %kelvin comprendidas entre 273 y 323 kelvin
43.    Ti=linspace(273,273 + (Tc-273)*2);
44.    VO=subs(Vo,T,Ti);
45.    plot(Ti-273,VO)
46.    %Dibujamos las gráficas
47.    xlabel('Temperatura (°C)')
48.    ylabel('Tensión (V)')
49.    title('Relación entre temperatura y tensión')
```

## Anexo II Script Matlab, errores del sensor

```
1. close all
2. clear all
3.
4. syms T;
5. R1 = 75000;
6. Beta = 4450;
7. %Ecuación simbólica de la R del termistor en función
8. %de la temperatura
9. Rt = 100000*exp(Beta*(1/T-1/298));
10.
11.
12.
13.     %cálculos hechos para valores de temperatura entre
14.     %0 y 25 grados
15.
16.     %Ecuaciones simbólicas de la R máxima y la R mínima
17.     %que puede alcanzar el termistor teniendo en cuenta
18.     %las tolerancias.
19. RtMax = (1.01*100000)*exp((1.01*Beta)*(1/T-1/298));
20. RtMin = (0.99*100000)*exp((0.99*Beta)*(1/T-1/298));
21. Vi = 1.5;
22.
23.
24.     %Calculamos la ecuación simbólica de la salida de tensión
25.     %ideal del sensor en función de la temperatura.
26. Vo = Vi*R1/(Rt + R1);
27.
28.     %VoMin y VoMax son las ecuaciones simbólicas que
29.     %representan
30.     %la tensión máxima y mínima que puede haber en el sensor
31.     %para cada temperatura
32.     VoMin = (Vi * 0.995)*(0.99 * R1)/(0.99 * R1 +
33.             RtMax) - 0.00015;
34.     VoMax = (Vi * 1.005)*(1.01 * R1)/(1.01 * R1 +
35.             RtMin) + 0.00015;
36.
37.     %Restandole a la tensión ideal la tensión mínima y la
38.     %tensión
39.     %máxima posibles, obtenemos el error máximo y mínimo en
40.     %tensión.
41.     %Dividiendo la tensión por los voltios por grado
42.     %centígrado,
43.     %obtenemos el error en grados centígrados.
44. ErrMin = (Vo - VoMin)/0.018408;
45. ErrMax = (Vo - VoMax)/0.018408;
46.
47.     %representacion estos errores para las temperaturas
48.     %comprendidas
```

```

49. ErrMaxRep = subs(ErrMax, T, Ti);
50. plot(Ti-273,ErrMaxRep, 'r')
51. xlabel('Temperatura (°C)')
52. ylabel('Error (°C)')
53. title('Error máximo de temperatura')
54.
55. RtMax = (1.01*100000)*exp((0.99*Beta)*(1/T-1/298));
56. RtMin = (0.99*100000)*exp((1.01*Beta)*(1/T-1/298));
57. Vi = 1.5;
58.
59.
60.
61. %Realizamos el mismo proceso para las temperaturas mayores
62. %de 25 grados, en nuestro caso para las que están
63. %entre 25 y 35 grados centígrados.
64.
65. %Calculamos la ecuación simbólica de la salida de tensión
66. %ideal del sensor en función de la temperatura.
67. Vo = Vi*R1/(Rt + R1);
68.
69. %VoMin y VoMax son las ecuaciones simbólicas que
   representan
70. %la tensión máxima y mínima que puede haber en el sensor
71. %para cada temperatura
72. VoMin = (Vi * 0.995)*(0.99 * R1)/(0.99 * R1 +
   RtMax) - 0.00015;
73. VoMax = (Vi * 1.005)*(1.01 * R1)/(1.01 * R1 +
   RtMin) + 0.00015;
74.
75. %Restandole a la tensión ideal la tensión mínima y la
   tensión
76. %máxima posibles, obtenemos el error máximo y mínimo en
   tensión.
77. %Dividiendo la tensión por los voltios por grado
   centígrado,
78. %obtenemos el error en grados centígrados.
79. ErrMin = (Vo - VoMin)/0.018408;
80. ErrMax = (Vo - VoMax)/0.018408;
81.
82. %representacion estos errores pra temperaturas entre
83. %25 y 35 grados centígrados.
84. Ti=linspace(273 + 25,273 + 35);
85. ErrMinRep=subs(ErrMin,T,Ti);
86. plot(Ti-273,ErrMinRep, 'b')
87.
88. hold all
89.
90. ErrMaxRep = subs(ErrMax, T, Ti);
91. plot(Ti-273,ErrMaxRep, 'r')
92. xlabel('Temperatura (°C)')
93. ylabel('Error (°C)')
94. title('Error máximo de temperatura')

```

## Anexo III. Firmware del nodo central

```
1. #define _DISABLE_TLS_
2.
3. #include <ESP8266WiFi.h>
4. #include <FS.h>
5. #include <ESP8266WebServer.h>
6. #include <WiFiI udp.h>
7. #include <ESP8266mDNS.h>
8. #include <SPI.h>
9. #include <ThingerESP8266.h>
10.
11.
12. //-----
13. //-----VARIABLES GLOBALES-----
14. //-----
15. ThingerWifi thing("fran_hans", "esp8266", "E@0VVsqUV94p");
16.
17. //Ficheros
18. byte
19. numeroElementos[9] = {0, 0, 0, 0, 0, 0, 0, 0, 0}; //Número de
elementos escritos en el fichero desde el inicio del programa o
"desde la última desconexión".
20. unsigned long ultimoEpoch[9] = {0UL,0UL,0UL,0UL,0UL,0UL,0UL,
,0UL,0UL}; //Último tiempo epoch en el que se ha tomado o se ha
recibido una medida.
21. float ultimaTemperatura[8] = {0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
.0}; //Última temperatura tomada.
22. File ficheroDatos; //Variable auxiliar para manejar
ficheros.
23. byte numeroFicherosUsados; //Ficheros existentes
24. unsigned long bytesMaximosFichero; //Número máximo de bytes
disponible para cada fichero.
25. //Tiempo
26. unsigned long tiempoAnterior = 0UL; //Variables empleadas
para contabilizar 5 minutos entre medidas.
27. unsigned long tiempoActual = 0UL;
28. unsigned long epoch; //En la variable epoch se almacenan
los segundos transcurridos desde el 1 de enero de 1970 a las
00:00 horas.
29.
30. //Sensor
31. float temperatura;
32.
33. //Comunicaciones con protocolo NTP para obtener el tiempo
epoch.
34. IPAddress timeServerIP(150,214,94,5); // Objeto de la IP
del Real Instituto y Observatorio de la Armada, San Fernando
(Cádiz) 150.214.94.5
35. const byte NTP_PACKET_SIZE = 48; //El NTP time stamp es los
primeros 48 bytes del mensaje.
36. //Buffers para guardar los paquetes de entrada y salida de
la solicitud NTP.
37. byte packetBuffer[ NTP_PACKET_SIZE];
```

```

38.     char incomingPacket[5];
39.     unsigned int localPort = 2390; //Puerto elegido para
    realizar la comunicación
40.
41.     //Objetos IPAddress para definir la IP estática.
42.     IPAddress ip(192,168,0,250); //IP estatica
43.     IPAddress gateway(192,168,0,1); //Puerta de enlace
44.     IPAddress subnet(255,255,255,0); //Subnet
45.
46.     //Objeto WiFiUDP para realizar la comunicación mediante el
    protocolo UDP.
47.     WiFiUDP udp;
48.
49.     //Objeto webserver para gestionar el servidor local.
50.     ESP8266WebServer server(80);
51.
52.
53.
54.     //-----
-----DECLARACIÓN FUNCIONES-----
-----
55.
56.     //funciones inicializacion
57.     void inicializarWifi();
58.     inline void inicializarServidor();
59.     inline void incializacionUDP();
60.
61.     //Funciones manejo ficheros
62.     void acortarFichero( byte numeroElementosEliminar, String
    direccion );
63.     void mostrarFichero(String direccion);
64.     void guardarTemperatura(String mensajeString);
65.
66.     //Funciones servidor
67.     bool enviarFichero(String path);
68.     void borrarFichero();
69.     void cambiarNombres();
70.
71.     //Funciones servidor ntp
72.     bool obtenerFechaHora();
73.     unsigned long sendNTPpacket(IPAddress& address);
74.
75.
76.     //-----
-----SETUP-----
-----
77.
78.     void setup(void) {
79.
80.         Serial.begin(115200); //Establecemos comunicación serie
    para depurar errores.
81.         pinMode(5, OUTPUT); //led verde
82.         pinMode(4, OUTPUT); //led rojo
83.         inicializarWifi(); //Se establece conexión Wi-Fi
84.         inicializarServidor(); //Se inicia el servidor
85.         incializacionUDP(); //Se inicia la conexión mediante el
    protocolo UDP
86.

```

```

87.          //Se intenta obtener la fecha y hora actuales, si el
     proceso falla 20 veces, se entiende que la conexión falla y se
     llamará a la función inicializarWifi() para reconectarse.
88.          byte z = 0;
89.          while (!obtenerFechaHora()) {
90.              z++;
91.              Serial.println("Volviendlo a intentar...");
92.              if (z > 20) {
93.                  inicializarWifi();
94.                  ficheroDatos.println(" ");
95.              }
96.              z = 0;
97.          }
98.      }
99.
100.
101.
102.      //-----
-----LOOP-----
-----
```

103.

```

104.      void loop() {
105.          //Puesto que el contador de tiempo del programa podría
     saturar, al principio de cada iteración del bucle se comprueba
     que esto no haya sucedido.
106.          if (tiempoActual <= millis()) {
107.              tiempoActual = millis();
108.          } else {
109.              //Si millis() ha saturado, se le suma a la variable
     epoch el tiempo transcurrido.
110.              epoch += (0xFFFFUL - tiempoActual + millis());
111.              tiempoActual = tiempoAnterior = millis();
112.          }
113.
114.
115.          //Cada 5 minutos o 300000 milisegundos, se cumplirá esta
     condición.
116.          if (tiempoActual - tiempoAnterior > 300000UL) {
117.              tiempoAnterior = tiempoActual;
118.              epoch += 300UL; //Se actualiza el tiempo transcurrido
     en la variable epoch.
119.
120.          //Se comprueba si el módulo Wi-Fi sigue conectado a la
     red, en caso contrario se llama a la función inicializarWifi para
     reconectar.
121.          if (!WiFi.isConnected())
122.              inicializarWifi();
123.
124.          ficheroDatos = SPIFFS.open("/datos0.csv", "a");
125.          //Si el módulo se ha desconectado durante más de 650
     segundos o el módulo se ha reiniciado, se escribirá un espacio
     para que valores consecutivos en el fichero no aparezcan unidos
     en la representación de los datos.
126.          if (((epoch - ultimoEpoch[0]) > 650) || (ultimoEpoch[0]
     == 0UL))
127.              ficheroDatos.println(" ");
128.          ultimoEpoch[0] = epoch;
129.          //Si ha pasado una hora o lo que es lo mismo 12
     elementos sin haberse actualizado la hora, se obtiene la hora a
     través del servidor NTP y se escribe en el fichero.
```

```

130.         if (numeroElementos[0] % 12 == 0) {
131.             byte z = 0;
132.             while (!obtenerFechaHora()) {
133.                 z++;
134.                 Serial.println("Volviendlo a intentar..."); 
135.                 if (z > 20) {
136.                     inicializarWifi();
137.                     ficheroDatos.println(" ");
138.                 }
139.             }
140.             z = 0;
141.             ficheroDatos.print(epoch);
142.             ficheroDatos.write(',');
143.         }
144.
145.         //Se lee el sensor y se hacen las conversiones
146.         //necesarias para hallar la temperatura.
146.         //Aunque hay muy poco ruido se ha un filtrado por
147.         //software tomando varias medidas para obtener una medida sin el
148.         //más mínimo ruido.
149.         float sumaVoltios = 0.0;
150.         for (int i=0 ; i<10; i++) {
151.             int lecturaADC = analogRead(A0);
152.             Serial.println("");
153.             Serial.print("lectura ADC: ");
154.             Serial.println(lecturaADC);
155.             float voltios = (float) (lecturaADC) * 0.962 / 1024.0;
156.             Serial.print("voltios: ");
157.             Serial.println(voltios, 5);
158.             sumaVoltios = sumaVoltios + voltios;
159.         }
160.         sumaVoltios = sumaVoltios / 10.0;
161.         Serial.print("Media voltios: ");
162.         Serial.println(sumaVoltios, 5);
163.         temperatura = (sumaVoltios - 0.1827) / 0.0184;
164.         Serial.print("Media temperatura: ");
165.         Serial.println(temperatura);
166.         //Se escribe la temperatura en el fichero con un
167.         //decimal e incrementamos el número de elemntos en 1.
168.         ficheroDatos.println(temperatura, 1);
169.         ++numeroElementos[0];
170.         ficheroDatos.close();
171.         Serial.println("Dato introducido en el fichero");
172.
173.         //Actualizamos las temperaturas en la nube
174.         thing["Temperaturas"] >> [] (pson &out) {
175.             String temp;
176.             out["T0"] = temperatura;
177.             for (int i = 0 ; i < 8 ; i++) {
178.                 temp = "T" + String(i + 1);
179.                 //Si la ultima temperatura se tomó hace más de 330
180.                 //segundos, corresponde con una muestra pasada y se deduce que ese
181.                 //sensor no está funcionando o no existe.
182.                 if (epoch - ultimoEpoch[i + 1] < 330) {
183.                     Serial.print("epoch - último epoch: ");
184.                     Serial.println(epoch - ultimoEpoch[i + 1]);
185.                     out[temp.c_str()] = ultimaTemperatura[i];
186.                 }
187.             }
188.             else out[temp.c_str()] = 0;

```

```

185.         }
186.     };
187.     thing.handle();
188.     thing.write_bucket("esp8266Temp", "Temperaturas");
189.
190.
191.     //Borramos datos de ficheros si así es necesario.
192.     //Primero detectamos qué sensores están usándose.
193.     for (int i = 0; i < 9; i++) {
194.         if (SPIFFS.exists("/datos" + String(i) + ".csv"))
195.             numeroFicherosUsados++;
196.     }
197.     //2822196 Bytes = ((3MB * 1024KB/MB * 1024B/KB) - 10 KB
198.     // (página web) *0.9
199.     //Sabiendo el número máximo de bytes, calculamos el
200.     //número máximo de bytes por archivo, teniendo en cuenta que al
201.     //copiar un archivo en otro nuevo, generamos un archivo más de los
202.     //almacenados.
203.     bytesMaximosFichero = 2822196UL / (numeroFicherosUsados +
204.     1);
205.     Serial.println(numeroFicherosUsados);
206.     numeroFicherosUsados = 0;
207.     //Borramos 500 datos de aquel fichero que supere el
208.     //máximo de bytes.
209.     Dir dir = SPIFFS.openDir("/datos");
210.     Serial.println(bytesMaximosFichero);
211.     //Se repasan todos los ficheros guardados en la
212.     //memoria, si algún fichero supera el máximo, se llama a la
213.     //función acortar fichero.
214.     while (dir.next()) {
215.         Serial.print(dir.fileName());
216.         Serial.print(dir.fileSize());
217.         if (dir.fileSize() > bytesMaximosFichero) {
218.             Serial.print(dir.fileName());
219.             acortarFichero(500, dir.fileName()); //Con esta
220.             //función eliminamos las 500 últimas muestras del fichero.
221.         }
222.     }
223. }
224.
225. //Esta parte del código se usa únicamente durante el
226. //desarrollo, para poder observar los datos almacenados y
227. //formatear la memoria desde el ordenador.
228. if (Serial.available() > 0){
229.     char caracter = Serial.read();
230.     Serial.println("Has pulsado el carácter
231.     " + String(caracter));
232.     if (caracter == 'b') {
233.         Serial.println("Se va a formatear la memoria");
234.         if (SPIFFS.format()) Serial.println("Se ha formateado
235.         la memoria.");
236.     } else if (caracter == 'n') {
237.         mostrarFichero("/nombres");
238.     } else {
239.         Serial.println("Se va a mostrar el fichero
240.         /datos" + String(caracter) + ".csv");
241.         mostrarFichero("/datos" + String(caracter) + ".csv");
242.     }

```

```

232.         Serial.read();
233.     }
234.
235.
236.
237.
238.     //Comprobamos si ha llegado algún paquete mediante
comunicación UDP y en casi afirmativo lo leemos.
239.     int packetSize = udp.parsePacket(); //Esta función
devuelve el tamaño del paquete. Devuelve 0 si no hay paquetes
disponibles.
240.     while (packetSize) {
241.         // receive incoming UDP packets
242.         Serial.printf("Recibidos %d bytes de %s, puerto %d\n",
packetSize, udp.remoteIP().toString().c_str(),
udp.remotePort());
243.         int len = udp.read(incomingPacket, 5); //Lee del Buffer
el paquete y lo introduce en incomingPacket. Devuelve el número
de caracteres del paquete.
244.         if (len > 0)
245.         {
246.             incomingPacket[len] = '\0'; //Se añade al final del
paquete el carácter de fin de cadena.
247.         }
248.         Serial.printf("UDP packet contents: %s\n",
incomingPacket);
249.
250.         //El primer carácter recibido se corresponde con el
número de sensor y de fichero.
251.         char primerCaracter = incomingPacket[0];
252.         Serial.println(primerCaracter - 48);
253.         //Se comprueba que no ha habido fallos en la
transmisión y el primer carácter está entre el 1 y el 8.
254.         if ((primerCaracter - 48 > 0) and (primerCaracter - 48
< 9)) {
255.             //Se almacena en nombreFichero el fichero donde se
debe guardar la temperatura.
256.             String
nombreFichero = "/datos" + String(primerCaracter) + ".csv";
257.             //Se almacena en temperaturaMedida la temperatura
recibida.
258.             String temperaturaMedida;
259.             for (int i = 1; incomingPacket[i] != '\0' ; i++) {
260.                 temperaturaMedida += String(incomingPacket[i]);
261.             }
262.
263.             //Se actualiza el epoch.
264.             unsigned long epochActualizado = epoch + (unsigned lo
ng) ((millis() - tiempoAnterior)/1000);
265.
266.             //Detectamos si hay algun fallo en el envío de la
información. Si hay un error escribe "E".
267.             //Consideramos que hay error cuando:
268.             //La temperatura se sale del rango del sensor 15 a 35
grados centígrados.
269.             if (temperaturaMedida.toFloat() < 14.0 or temperatura
Medida.toFloat() > 36.0){ //Si hay error convirtiendo a float el
resultado arrojado es 0.0 que es menor que 5.0
270.                 temperaturaMedida = "E";
271.                 ultimaTemperatura[primerCaracter-49] = -1.0;

```

```

272.          //No han pasado más de 650 segundos ni se ha
    reiniciado el sistema entre medidas ni la medida viene precedida
    por un error en la medida anterior y la temperatura ha variado
    más de 5 grados.
273.          } else if (!((epochActualizado - ultimoEpoch[primerCaracter-48]) > 650) and !(ultimoEpoch[primerCaracter-48] == OUL) and (ultimaTemperatura[primerCaracter-49] != -1.0) and (abs(temperaturaMedida.toFloat() - ultimaTemperatura[primerCaracter-49]) > 5.0)) {
274.              temperaturaMedida = "E";
275.              ultimaTemperatura[primerCaracter-49] = -1.0;
276.          } else ultimaTemperatura[primerCaracter-49] = temperaturaMedida.toFloat();
277.
278.
279.          if (SPIFFS.exists(nombreFichero)){
280.              ficheroDatos = SPIFFS.open(nombreFichero, "a");
281.              //Si el fichero ya existe, se comprueba si se ha
    reiniciado el sistema o han pasado más de 350 segundos entre
    medidas o si hace 12 elementos (1 hora) que no se escribe el
    epoch.
282.              if ((numeroElementos[primerCaracter-48]%12 == 0) || ((epochActualizado - ultimoEpoch[primerCaracter-48]) > 350) || (ultimoEpoch[primerCaracter-48] == OUL)){
283.                  if (((epochActualizado - ultimoEpoch[primerCaracter-48]) > 350) || (ultimoEpoch[primerCaracter-48] == OUL)){
284.                      //Si se ha reiniciado el sistema o han pasado
    mas de 350 segundos entre medidas, se escribe un espacio en el
    fichero.
285.                      ficheroDatos.println(" ");
286.                      numeroElementos[primerCaracter-48] = 0;
287.                  }
288.                  //Si esto sucede, se escribe en el fichero el
    epoch.
289.                  ficheroDatos.print(epochActualizado);
290.                  ficheroDatos.write(',');
291.              }
292.              //Finalmente se escribe la temperatura separada por
    una coma.
293.              ficheroDatos.println(temperaturaMedida);
294.              ultimoEpoch[primerCaracter-48] = epochActualizado;
295.              ++numeroElementos[primerCaracter-48];
296.          } else {
297.              //Si el fichero no existe, se escribe el epoch en
    primer lugar y luego la temperatura separada por una coma.
298.              ultimoEpoch[primerCaracter-48] = epochActualizado;
299.              ficheroDatos = SPIFFS.open(nombreFichero, "a");
300.              ficheroDatos.print(epochActualizado);

301.              ficheroDatos.write(',');
302.              ficheroDatos.println(temperaturaMedida);
303.              ficheroDatos.close();
304.              ++numeroElementos[primerCaracter-48];
305.          }
306.
307.      }
308.      //Se envía un 1 como respuesta al emisor del paquete.
    Esto solo sirve para depurar fallos, el módulo periférico no
    comprueba que haya respuesta.
309.      udp.beginPacket(udp.remoteIP(), udp.remotePort());
310.      udp.write('1');

```

```

311.         udp.endPacket();
312.
313.         //Se comprueba si siguen quedando paquetes por leer.
314.         packetSize = udp.parsePacket();
315.
316.     }
317.     //Se comprueba si alguien ha hecho alguna petición al
318.     //servidor.
319.     server.handleClient();
320.
321.
322.
323.     //-----
324.     -----DEFINICIÓN FUNCIONES-----
325.     -----
326.     //-----
327.     -----funciones manejo de ficheros-----
328.
329.     void acortarFichero(byte numeroElementosEliminar, String
330.     direccion) {
331.         String linea;
332.         int k = 0;
333.         int l = 0;
334.         byte j = direccion.charAt(6); //En dirección está
335.         almacenado el nombre del fichero. El sexto carácter de dirección
336.         se corresponde con el número del fichero.
337.         Serial.println(j);
338.         //Renombramos el fichero original para poder abrir una
339.         copia con el mismo nombre.
340.         String direccion1 = direccion + "1";
341.         SPIFFS.rename(direccion, direccion1);
342.         File fichero = SPIFFS.open(direccion1, "r"); //Abrimos el
343.         fichero original para leerlo
344.         File copia = SPIFFS.open(direccion, "w"); //Abrimos la
345.         copia para escribir
346.
347.         //Leemos del fichero original tantas líneas
348.         (linea=elemento) como elementos se deban despreciar para luego
349.         copiar el resto.
350.         Serial.print("numero de elementos a eliminar: ");
351.         Serial.println(numeroElementosEliminar);
352.         for (int i = 0; i < numeroElementosEliminar; i++) {
353.             linea = fichero.readStringUntil('\n');
354.             Serial.println(linea);
355.         }
356.         Serial.println("hasta aquí elementos eliminados \n");
357.         //Seguimos despreciando elementos hasta que encontremos
358.         uno que contenga una coma, es decir, que tenga un epoch
359.         do{
360.             linea = fichero.readStringUntil('\n');
361.             Serial.println(linea);
362.             Serial.print(++l);
363.             Serial.print(": ");
364.             } while(linea.indexOf(',') == -1);
365.             Serial.println("hasta aquí elementos hasta elemento con
366.             fecha");
367.             Serial.print("elemento con fecha: ");

```

```

357.          //Ese elemento con fecha y hora es el primero que
            copiamos en el nuevo fichero.
358.          Serial.println(linea);
359.          copia.println(linea);
360.          //Copiamos el resto de elementos hasta que ya no queden
            elementos en el fichero original.
361.          while(fichero.available() > 0) {
362.              linea = fichero.readStringUntil('\n');
363.              k++;
364.              copia.println(linea);
365.              Serial.print(k);
366.              Serial.print(": ");
367.              Serial.println(linea);
368.          }
369.          Serial.println("hasta aqui elementos copiados en el nuevo
            fichero");
370.          copia.close();
371.          fichero.close();
372.          SPIFFS.remove(direccion1);
373.
374.          numeroElementos[j-48] = k + 1; //Actualizamos el número
            de elementos
375.      }
376.
377.      //En esta función enviamos por puerto serie el fichero
            elegido para mostrarlo por pantalla. Es una función es usada
            para depurar el programa y encontrar errores únicamente.
378.      void mostrarFichero(String direccion){
379.          if (SPIFFS.exists(direccion)){ //Primero se comprueba que
            existe el fichero
380.          File fichero = SPIFFS.open(direccion, "r");
381.          //mientras el fichero siga conteniendo elementos se lee
            el siguiente elemento y se muestra por pantalla.
382.          while(fichero.available() > 0){
383.              Serial.write(fichero.read());
384.          }
385.          fichero.close();
386.      } else
387.          Serial.println("el fichero que se esta intentando
            mostrar no existe");
388.      }
389.
390.
391.
392.      void guardarTemperatura(String mensaje) {
393.
394.          //char mensaje[6];
395.          char primerCaracter = mensaje.charAt(0);
396.          //Se almacena en nombreFichero el fichero donde se debe
            guardar la temperatura.
397.          String
            nombreFichero = "/datos" + String(primerCaracter) + ".csv";
398.          //Se almacena en temperaturaMedida la tempeartura
            recibida.
399.          String temperaturaMedida = mensaje.substring(1);
400.
401.          //Se almacena la temperatura en el array para que se
            envíe a la nube.
402.          ultimaTemperatura[primerCaracter-
            49] = temperaturaMedida.toFloat();
403.          //Se actualiza el epoch.

```

```

404.         unsigned long epochActualizado = epoch + (unsigned long) (
405.             millis() - tiempoAnterior) /1000);
406.         Serial.print("millis - tiempoAnterior: ");
407.         Serial.println((unsigned long) ((millis() -
408.             tiempoAnterior)/1000));
409.     if (SPIFFS.exists(nombreFichero)) {
410.         ficheroDatos = SPIFFS.open(nombreFichero, "a");
411.         //Si el fichero ya existe, se comprueba si se ha
412.         //reiniciado el sistema o han pasado más de 350 segundos entre
413.         //medidas o si hace 12 elementos (1 hora) que no se escribe el
414.         //epoch.
415.         if ((numeroElementos[primerCaracter-
416.             48] %12 == 0) || ((epochActualizado - ultimoEpoch[primerCaracter-
417.                 48]) > 350) || (ultimoEpoch[primerCaracter-48] == 0UL)){
418.             if (((epochActualizado - ultimoEpoch[primerCaracter-
419.                 48]) > 350) || (ultimoEpoch[primerCaracter-48] == 0UL)){
420.                 //Si se ha reiniciado el sistema o han pasado mas
421.                 //de 350 segundos entre medidas, se escribe un espacio en el
422.                 //fichero.
423.                 ficheroDatos.println(" ");
424.             }
425.             //Si esto sucede, se escribe en el fichero el epoch.
426.             ficheroDatos.print(epochActualizado);
427.             ficheroDatos.write(',');
428.             numeroElementos[primerCaracter-48] = 0;
429.         }
430.         //Finalmente se escribe la temperatura separada por una
431.         //coma.
432.         ficheroDatos.println(temperaturaMedida);
433.         ultimoEpoch[primerCaracter-48] = epochActualizado;
434.         ++numeroElementos[primerCaracter-48];
435.     } else {
436.         //Si el fichero no existe, se escribe el epoch en
437.         //primer lugar y luego la temperatura separada por una coma.
438.         ultimoEpoch[primerCaracter-48] = epochActualizado;
439.         ficheroDatos = SPIFFS.open(nombreFichero, "a");
440.         ficheroDatos.print(epochActualizado);
441.         ficheroDatos.write(',');
442.         ficheroDatos.println(temperaturaMedida);
443.         ficheroDatos.close();
444.         ++numeroElementos[primerCaracter-48];
445.     }
446. }
447. }
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999. }

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446.         File
447.         file = SPIFFS.open("/nombres", "a");
448.         for (i ; i < 9 ; i++){
449.             String campo = server.arg(String(i));
450.             if (campo != "") { //Se comprueba si hay
451.                 escrito algo en cada uno de los campos de cada sensor
452.                 file.println(server.arg(String(i))); //Si hay
453.                 algo escrito, se guarda en el fichero
454.             } else
455.                 file.println(i); //Si no hay
456.             nada escrito, se mantiene el número que había antes
457.         }
458.
459.         //Esta función elimina el fichero correspondiente al sensor
460.         seleccionado.
461.         void borrarFichero(){
462.             String
463.             direccion = "/datos" + server.arg("sensor") + ".csv";
464.             Serial.println(direccion);
465.             if (SPIFFS.exists(direccion))
466.                 SPIFFS.remove(direccion);
467.             server.sendHeader("Location","/");
468.             // Añade un
469.             //encabezado que le proporciona una nueva localización al
470.             //navegador para ir a la página principal otra vez
471.             server.send(303); //Se envía el
472.             código de estatus 303
473.             numeroElementos[server.arg("sensor").toInt()] = 0; ///
474.             Se pone a 0 el número de elementos
475.         }
476.
477.         //Esta función se encarga de enviar un fichero del servidor
478.         //al cliente cuando este lo reclame.
479.         //El parámetro path de la función contiene el URI
480.         //solicitado por el navegador.
481.         bool enviarFichero(String path){
482.             bool exito;
483.             if (path == "/")
484.                 //Si el URI
485.                 es simplemente "/", se enviará al cliente la página principal
486.                 "/index.html"
487.                 path += "index.html";
488.             String tipoArchivo = getContentType(path); //Esta
489.             función devuelve una cadena disinta en función del tipo de
490.             archivo enviado
491.             String pathConGz = path + ".gz"; //La variable
492.             pathConGZ, contiene el nombre del archivo comprimido en formato
493.             ".gz"
494.             //Se comprueba si existe o bien el archivo o bien el
495.             //archivo comprimido. Si ninguno de los dos existe, se devuelve
496.             //"false".
497.             if (SPIFFS.exists(path) || SPIFFS.exists(pathConGz)){
498.                 if (SPIFFS.exists(pathConGz)) //Si existe
499.                     el archivo comprimido se enviará ese, si no existe, se envía el
500.                     no comprimido

```

```

482.         path = pathConGz;
483.         File archivo = SPIFFS.open(path, "r");
484.         size_t enviado = server.streamFile(archivo,
485.                                         tipoArchivo); //Se envía el archivo al cliente
486.         archivo.close(); //Se devulve "true".
487.         Serial.println(String("\tSent file: ") + path);
488.         exito = true;
489.     } else exito = false;
490. }
491.
492.
493. //Esta función devuelve una cadena en función del tipo de
494. //archivo (de su terminación) que se esté enviando al cliente.
495. String getContentType(String filename) { // determine the
496.     filetype of a given filename, based on the extension
497.     if (filename.endsWith(".html")) return "text/html";
498.     else if (filename.endsWith(".css")) return "text/css";
499.     else if (filename.endsWith(".js")) return "application/ja-
500.         vascript";
501.     else if (filename.endsWith(".ico")) return "image/x-
502.         icon";
503.     else if (filename.endsWith(".gz")) return "application/x-
504.         gzip";
505.     return "text/plain";
506. }
507.
508. //-----
509. -----Funciones comunicación NTP-----
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526.          //El "timestamp" empieza en el byte 40 del paquete
      recibido y ocupa 4 bytes
527.          //o lo que es lo mismo dos unsigned long.
528.          unsigned long highWord = word(packetBuffer[40],
      packetBuffer[41]);
529.          unsigned long lowWord = word(packetBuffer[42],
      packetBuffer[43]);
530.          // Combinamos los 4 bytes en un long integer.
531.          // Esto es el tiempo NTP (segundos desde el 1 de enero
      de 1900):
532.          unsigned long segundosDesde1900 = highWord << 16 | lowW
      ord;
533.          Serial.print("Segundos desde el 1 de enero de 1900 =
      " );
534.          Serial.println(segundosDesde1900);
535.
536.          // Ahora convertimos el formato NTP en UNIX.
537.          Serial.print("Unix time = ");
538.          // El "Unix time" empieza el 1 de enero de 1970. 70
      años en segundos es 2208988800.
539.          const unsigned long setentaAnnos = 2208988800UL;
540.          // Le restamos 70 años:
541.          epoch = segundosDesde1900 - setentaAnnos;
542.          Serial.println(epoch);
543.
544.          exito = true;
545.      }
546.      return exito;
547.  }
548.
549.
550.  // Envía una solicitud NTP al servidor NTP a la dirección
      IP dada.
551.  unsigned long sendNTPpacket(IPAddress& address) {
552.      Serial.println("Enviando paquete NTP...");
553.      // Pone todos los bytes del buffer a 0.
554.      memset(packetBuffer, 0, NTP_PACKET_SIZE);
555.      // Se inicializan los valores necesarios para formular
      una solicitud NTP.
556.      packetBuffer[0] = 0b00100011;    // LI, Version, Mode
      0b11100011;
557.
558.      // you can send a packet requesting a timestamp:
559.      udp.beginPacket(address, 123);           //Las
      solicitudes NTP se realizan mediante el puerto 123
560.      udp.write(packetBuffer, NTP_PACKET_SIZE);
561.      udp.endPacket();
562.  }
563.
564.
565.
566.  //-----
-----Funciones inicialización-----
-----
567.
568.  void inicializarWifi() {
569.      String ssid;           // Almacena el SSID de la red Wi-Fi.
570.      String password;       // Almacena la contraseña de la red
      Wi-Fi.
571.      int i = 0;

```

```

572.
573.         digitalWrite(5, LOW);
574.
575.
576.
577.         SPIFFS.begin();
578.         //Se emplea para las pruebas.
579.         /*
580.             SPIFFS.remove("credenciales");
581.             ficheroDatos = SPIFFS.open("credenciales","a");
582.             ficheroDatos.println("vodafone68FF");
583.             ficheroDatos.println("UDUGMX3TPWAVHJ");
584.             //ficheroDatos.println("Redmi");
585.             //ficheroDatos.println("francompartewifi");
586.             ficheroDatos.close();*/
587.
588.         //Si el fichero con las credenciales Wi-Fi existe, se lee
589.         //de esta el SSID y la contraseña de la red Wi-Fi.
590.         if (SPIFFS.exists("credenciales")) {
591.             ficheroDatos = SPIFFS.open("credenciales","r");
592.             ssid = ficheroDatos.readStringUntil('\n');
593.             ssid.remove(ssid.length()-1);
594.             password = ficheroDatos.readStringUntil('\n');
595.             password.remove(password.length()-1);
596.             ficheroDatos.close();
597.             WiFi.mode(WIFI_AP_STA);    //Se inicia la conexión como
598.             //estación y como punto de acceso
599.             WiFi.softAP("esp8266", "", 1, false, 8);    //Se
600.             //establece el nombre, la contraseña, el canal y el número máximo
601.             //de elementos de la red Wi-Fi.
602.             WiFi.begin(ssid.c_str(), password.c_str());
603.             WiFi.config(ip, gateway, subnet);    //Se establece una
604.             //ip fija y se deshabilita la asignación dinámica de IPs por parte
605.             //del router.
606.             Serial.print("Connecting to ");
607.             Serial.print(ssid);
608.             Serial.print("/");
609.             Serial.print(password);
610.             Serial.println("...");
611.
612.             //Se intenta establecer conexión hasta que se haya
613.             //establecido o hayan pasado 20 segundos.
614.             while (WiFi.status() != WL_CONNECTED and i < 20) {
615.                 if (i%2 == 0){
616.                     digitalWrite(4, HIGH); //Se apaga y se enciende el
617.                     //led rojo mientras se intenta establecer conexión.
618.                     } else {
619.                         digitalWrite(4, LOW);
620.                         }
621.                         delay(1000);
622.                         Serial.print(++i);
623.                         Serial.print(' ');
624.             }
625.             digitalWrite(4, LOW); //Se apaga el led rojo.
626.
627.             if (i < 20){
628.                 Serial.println('\n');
629.                 Serial.println("Connection established!");
630.                 Serial.print("IP address:\t");
631.                 Serial.println(WiFi.localIP());

```

```

624.          //Si se ha establecido conexión antes de 20 segundos,
   se enciende el luz verde.
625.          digitalWrite(5, HIGH);
626.      }
627.  }
628.  //Si no se ha conseguido establecer conexión se inicia el
   modo WPS.
629.  if (i == 20 || !SPIFFS.exists("credenciales")){
630.      WiFi.mode(WIFI_STA);
631.      Serial.println("Pulsa el boton de tu modem");
632.      digitalWrite(4, HIGH);           //El led rojo se enciende
   y permanece encendido mientras se intenta establecer la conexión
   mediante WPS.
633.      //Se intenta establecer conexión WPS hasta que se
   obtenga la SSID y la contraseña de la red y estas sean válidas.
634.      do {
635.          if (WiFi.beginWPSConfig()){
636.              Serial.println("exito conexión WPS");
637.              Serial.println(WiFi.SSID());
638.              Serial.println(WiFi.psk());
639.          } else ESP.reset();        //Si se produce un error, el
   sistema se resetea
640.          }while(WiFi.SSID() == "");
641.          while (WiFi.status() != WL_CONNECTED) {
642.              delay(1000);
643.              Serial.print(++i);
644.              Serial.print(' ');
645.          }
646.          Serial.println("primera conexión realizada");
647.          //Se obtiene la contraseña y la SSID de la red y se
   guardan en el fichero credenciales para futuras conexiones.
648.          ssid = WiFi.SSID();
649.          password = WiFi.psk();
650.          if(SPIFFS.exists("credenciales"))
651.              SPIFFS.remove("credenciales");
652.          ficheroDatos = SPIFFS.open("credenciales", "a");
653.          Serial.print("la ssid es: ");
654.          Serial.println(WiFi.SSID());
655.          ficheroDatos.println(WiFi.SSID());
656.          ficheroDatos.println(WiFi.psk());
657.          ficheroDatos.close();
658.
659.          //Es necesario desconectarse y volverse a conectar a la
   red Wi-Fi para poder hacer en modo estación y punto de acceso a
   la vez.
660.          Serial.println("Se procede a desconectarse");
661.          WiFi.disconnect(true);
662.          Serial.println("Se ha desconectado con éxito");
663.          delay(500);
664.          WiFi.mode(WIFI_AP_STA);
665.          WiFi.softAP("esp8266", "", 1, false, 8);
666.          WiFi.begin(ssid.c_str(),
   password.c_str());           // Connect to the network
667.          WiFi.config(ip, gateway, subnet);
668.          Serial.print("Connecting to ");
669.          Serial.print(ssid);
670.          Serial.println(" ...");
671.
672.          while (WiFi.status() != WL_CONNECTED) { // Wait for the
   Wi-Fi to connect
673.              if (i%2 == 0){

```

```

674.         digitalWrite(4, HIGH);
675.     } else {
676.         digitalWrite(4, LOW);
677.     }
678.     delay(1000);
679.     Serial.print(++i);
680.     Serial.print(' ');
681. }
682. digitalWrite(4, LOW);
683.
684. Serial.println('\n');
685. Serial.println("Connection established!");
686. Serial.print("IP address:\t");
687. Serial.println(WiFi.localIP());
688. digitalWrite(5, HIGH); //Cuando está conectado se
    enciende el led verde
689. }
690.
691.     thing.add_wifi(ssid.c_str(), password.c_str()); //Esto es
    necesario para que el módulo se pueda conectar a la nube
692. }
693.
694. //Esta función inicializa el servidor.
695. inline void inicializarServidor() {
696.     server.on("/action_cambiarNombres", HTTP_POST,
    cambiarNombres); // Llama a la función "cambiarNombres" cuando
    un cliente solicita la URI "/action_cambiarNombres"
697.     server.on("/action_borrar", HTTP_POST,
    borrarFichero); // Llama a la función "borrarFichero"
    cuando un cliente solicita la URI "/action_borrar"
698.     server.onNotFound([]() {
    // Si un cliente solicita cualquier otro URI...
699.         if (!enviarFichero(server.uri())) {
    // Se llena a la función enviarFichero
700.             String posibleMedida = server.uri().substring(1);
701.             Serial.println(posibleMedida);
702.             if (posibleMedida.toFloat() != 0.0) {
    Serial.println("La posible medida se intenta
    guardar");
704.                 guardarTemperatura(posibleMedida);
705.             } else
706.                 server.send(404, "text/plain", "404: File Not
    Found"); // Si ese fichero no se encuentra se responde con el
    código de estado 404.
707.             }
708.         });
709.
710.     server.begin(); // Inicia el servidor
711.     Serial.println("HTTP server started");
712. }
713.
714.
715. inline void inicializacionUDP() {
716.     Serial.println("Starting UDP");
717.     udp.begin(localPort);
718.     Serial.print("Local port: ");
719.     Serial.println(udp.localPort());
720. }

```

## Anexo IV. Firmware del nodo periférico HTTP

```
1. #include <ESP8266WiFi.h>
2.
3. //Se define la IP fija a la que se enviará la temperatura
4. //IPAddress IPStation(192,168,0,29); //casa
5. IPAddress IPStation(192,168,43,234); //móvil
6.
7. //Se crea un objeto WiFiUDP y un array de 6 chars para realizar
   la comunicación
8. char mensaje[6];
9.
10.    //Mediante esta función se conecta a la red Wi-Fi del nodo
    central.
11.    inline void inicializarWifi();
12.
13.    WiFiClient client;
14.
15.
16.    void setup() {
17.
18.        //se lee la tensión en el conversor analógico digital y
    se obtiene a partir de esta medida la temperatura.
19.        int lecturaADC = analogRead(A0);
20.        float voltios = (float) (lecturaADC)*0.9836/1024.0;
21.        float temperatura = round((voltios - 0.1827)/0.018408*10)
    /10.0;
22.
23.        inicializarWifi();
24.
25.        //Se envia la temperatura mediante protocolo HTTP.
26.        (String(1) + String(temperatura)).toCharArray(mensaje, 6)
    ; //Se le añade un 1 a la temperatura que respresenta el
    número de sensor
27.        if (client.connect("192.168.43.234", 80)) {
28.            //Se intenta conectar por el puerto 80 al nodo central, el
    servidor
29.            client.print(String("GET /") + mensaje + "
    HTTP/1.1\r\n")); //Se le manda al servidor una petición "GET" con
    la temperatura medida
30.        }
31.        else {
32.            ESP.deepSleep(15e6,
    WAKE_RF_DEFAULT); //Si no se consigue
    establecer conexión se entra en modo deep-sleep nuevamente
33.        }
34.        delay(25); //Se espera a que acabe la conexión
35.        //El módulo permanecerá en modo deep sleep durante 298e6
    microsegundos.
36.        ESP.deepSleep(298e6, WAKE_RF_DEFAULT);
37.    }
38.
39.    void loop() {
40.    }
41.
42.    inline void inicializarWifi(){
43.        WiFi.begin("esp8266");
```

```
44.          //Si el módulo no se ha conectado al nodo central en 10
        segundos, el módulo Wi-Fi entrará en deep sleep para no
        malgastar batería.
45.          int i = 0;
46.          while (WiFi.status() != WL_CONNECTED) { // Wait for the
        Wi-Fi to connect
47.              delay(200);
48.              i++;
49.              if (i > 50)
50.                  ESP.deepSleep(298e6, WAKE_RF_DEFAULT);
51.
52.      }
```

## Anexo V. Firmware del nodo periférico UDP

```
1. #include <ESP8266WiFi.h>
2. #include <WiFiUdp.h>
3.
4. //Se define la IP fija a la que se enviará la temperatura
5. IPAddress IPStation(192,168,0,234);
6.
7. //Se crea un objeto WiFiUDP y un array de 6 chars para realizar
   la comunicación
8. WiFiUDP udp;
9. char mensaje[6];
10.
11.      //Mediante esta función se conecta a la red Wi-Fi del nodo
      central.
12.      inline void inicializarWifi();
13.
14.
15. void setup() {
16.
17.      //se lee la tensión en el conversor analógico digital y
      se obtiene a partir de esta medida la temperatura.
18.      int lecturaADC = analogRead(A0);
19.      float voltios = (float) (lecturaADC)*0.9836/1024.0;
20.      float temperatura = round((voltios - 0.1827)/0.018408*10)
      /10.0;
21.
22.      inicializarWifi();
23.      udp.begin(2390); //Se inicializa la comunicación mediante
      el protocolo UDP.
24.
25.      //Se envia la temperatura mediante protocolo UDP.
26.      (String(1) + String(temperatura)).toCharArray(mensaje, 6)
      ; //Se le añade un 1 a la temperatura que respresenta el número
      de sensor.
27.      udp.beginPacket(IPStation, 2390); //El puerto empleado
      para la comunicación es el 2390
28.      udp.write(mensaje, 6);
29.      udp.endPacket();
30.      delay(10);
31.
32.      //El módulo permanecerá en modo deep sleep durante 298e6
      microsegundos.
33.      ESP.deepSleep(298e6, WAKE_RF_DEFAULT);
34.  }
35.
36. void loop() {
37.  }
38.
39. inline void inicializarWifi(){
40.     WiFi.begin("esp8266");
41.     //Si el módulo no se ha conectado al nodo central en 10
      segundos, el módulo Wi-Fi entrará en deep sleep para no
      malgastar batería.
42.     int i = 0;
43.     while (WiFi.status() != WL_CONNECTED) { // Wait for the
      Wi-Fi to connect
44.         delay(200);
45.         i++;
46.         if (i > 50)
```

```
47.           ESP.deepSleep(298e6, WAKE_RF_DEFAULT);  
48.       }  
49.   }
```

## Anexo VI. Archivo HTML de la página web principal

```
1. <!DOCTYPE html>
2. <html>
3.
4. <head>
5.   <title>Gráfica de temperatura</title>
6.   <link href='https://fonts.googleapis.com/css?family=Roboto:300'
      rel='stylesheet' type='text/css'>
7.   <link rel="icon" type="image/png" sizes="144x144" href="/favicon-
n-144x144.png">
8.   <link rel="icon" type="image/png" sizes="96x96" href="/favicon.
ico">
9.   <link rel="manifest" href="/manifest.json">
10.  <meta charset="UTF-8"/>
11.  <meta name="theme-color" content="#00878f">
12.  <meta content='width=device-width, initial-scale=1.0,
      maximum-scale=1.0, user-scalable=0' name='viewport'>
13.  <script type="text/javascript" src="https://www.gstatic.co
m/charts/loader.js"></script>
14. </head>
15.
16. <body>
17.   <center>
18.     <h1>Gráfica de temperatura</h1>
19.     <div id="chart_div"></div>
20.     <div id="loading">Cargando ...</div>
21.     <div id="dateselect" style="visibility: hidden;">
22.       <div id="date"></div>
23.       <button id="prev">&lt;</button>
24.       <button id="next">&gt;></button><br>
25.       <button id="zoomout">&lt;-</button>
26.       <button id="zoomin">&gt;+</button><br>
27.       <button id="reset" style="width:
      4.4em;">Reset</button><br>
28.       <div style="margin: 4px; margin-top: 15px;"> Selecciona
      el sensor que quieras visualizar:</div>
29.       <form action="/action_borrar" method="post">
30.         <select id="selectSensor" name="sensor" style="font-
      size: 12pt; margin: 8px">
31.           <option id="0" value="0">0</option>
32.           <option id="1" value="1">1</option>
33.           <option id="2" value="2">2</option>
34.           <option id="3" value="3">3</option>
35.           <option id="4" value="4">4</option>
36.           <option id="5" value="5">5</option>
37.           <option id="6" value="6">6</option>
38.           <option id="7" value="7">7</option>
39.           <option id="8" value="8">8</option>
40.         </select><br>
41.         <input type="submit" value="Borrar" style="font-size:
      12pt; width: 4.4em;">
42.       </form>
43.       <button id="refresh" style="width:
      4.4em;">Cargar</button><br>
44.       <form action="/cambiarNombre.html" method="get"><br>
45.         <input type="submit" value="Cambiar
      nombres" style="font-size: 12pt;">
46.       </form>
```

```

47.          <p id="notFoundText" style="visibility: hidden;">El
    archivo que estás intentando visualizar no existe.</p>
48.
49.      </div>
50.      </center>
51.
52.      <script src="temperatureGraph.js"></script>
53.
54.      <style>
55.      body {
56.          font-family: 'Roboto', sans-serif;
57.          font-size: 18pt;
58.          margin: 0;
59.          margin-top: 6px;
60.      }
61.
62.      h1 {
63.          font-size: 1.5em;
64.          font-weight: normal;
65.          margin: 0px 0px 12px 0px;
66.      }
67.
68.      button {
69.          font-size: 12pt;
70.          width: 2em;
71.      }
72.
73.      center {
74.          padding: 1em;
75.          margin: auto;
76.          width: 90%;
77.          box-shadow: #777 2px 2px 5px;
78.          box-sizing: border-box;
79.      }
80.
81.      #loading {
82.          margin-bottom: 12px;
83.      }
84.
85.      @media only screen and (max-device-width: 700px) {
86.          center {
87.              width: 100%;
88.              height: 100vh;
89.              overflow: auto;
90.          }
91.      }
92.      </style>
93.  </body>
94.
95. </html>

```

## Anexo VII. Archivo HTML de la página para cambiar los nombres de los sensores

```
1. <!DOCTYPE html>
2. <html>
3.
4. <head>
5.   <title>Cambio nombre</title>
6.   <meta charset="UTF-8" />
7. </head>
8.
9. <body>
10.   <center>
11.     <form action="/action_cambiarNombres" method="post">
12.       Sensor 0 -->
13.       <input type="text" name="0"><br>
14.       Sensor 1 -->
15.       <input type="text" name="1"><br>
16.       Sensor 2 -->
17.       <input type="text" name="2"><br>
18.       Sensor 3 -->
19.       <input type="text" name="3"><br>
20.       Sensor 4 -->
21.       <input type="text" name="4"><br>
22.       Sensor 5 -->
23.       <input type="text" name="5"><br>
24.       Sensor 6 -->
25.       <input type="text" name="6"><br>
26.       Sensor 7 -->
27.       <input type="text" name="7"><br>
28.       Sensor 8 -->
29.       <input type="text" name="8"><br><br>
30.       <input type="submit" value="Guardar">
31.     </form>
32.   </center>
33.
34.
35. </html>
36.
```

## Anexo VIII. Archivo JavaScript de la página web

```
1. var dataArray = [];
2.
3. var defaultZoomTime = 24*60*60*1000; // 1 day
4. var minZoom = -6; // 22 minutes 30 seconds
5. var maxZoom = 8; // ~ 8.4 months
6.
7. var zoomLevel = 0;
8. var viewportEndTime = new Date();
9. var viewportStartTime = new Date();
10.
11.     loadCSV(); // Download the CSV data, load Google Charts,
   parse the data, and draw the chart
12.
13.
14.     /*
15.         Structure:
16.
17.             loadCSV
18.                 callback:
19.                     parseCSV
20.                         load Google Charts (anonymous)
21.                             callback:
22.                                 updateViewport
23.                                     displayDate
24.                                         drawChart
25.             */
26.
27.         /*
28.             |
29.             |                                CHART
30.             |                                |
31.             |                                |                                VIEW
32.             PORT                            |                                |
33.             invisible                      |                                visible
34.             |                                invisible
35.             -----
36.             --|-----> time
37.             |                                |                                viewp
38.             |                                |                                ortEndTime
39.             |                                |                                |
40.             |                                |                                |
41.             |                                |                                |
42.             |                                |                                |
43.             |                                |                                |
44.             |                                |                                |
45.             |                                |                                |
46.             |                                |                                |
47.             |                                |                                |
48.             |                                |                                |
```

viewportStartTime

viewportEndTime

viewportWidthTime

viewportWidthTime = 1 day \* 2^zoomLevel = viewportEndTime - viewportStartTime

\*/

function loadCSV() {

var csvName;

var errorText = document.getElementById("notFoundTe  
xt");

var loadingdiv = document.getElementById("loading");

var xmlhttp = new XMLHttpRequest();

var xmlhttp2 = new XMLHttpRequest();

xmlhttp.onreadystatechange = function() {

if (this.readyState == 4 && this.status == 200) {

errorText.style.visibility = "hidden";

dataArray = parseCSV(this.responseText);

```

49.          google.charts.load('current', { 'packages': ['line', 'corechart'] });
50.          google.charts.setOnLoadCallback(updateViewport)
51.      ;
52.      } else {
53.          loadingdiv.style.visibility = "hidden";
54.      }
55.      if (this.readyState == 4 && this.status != 200) {
56.          errorText.style.visibility = "visible";
57.      }
58.  };
59.  xmlhttp.onreadystatechange = function() {
60.      var names = [];
61.      if (this.readyState == 4 && this.status == 200) {
62.          names = this.responseText.split("\n");
63.          for (var i = 0; i < 9; i++) {
64.              document.getElementById(i.toString()).innerHTML = names[i];
65.          }
66.      }
67.  };
68.  xmlhttp.open("GET", "nombres", true);
69.  xmlhttp.send();
70.  csvName = "datos" + document.getElementById("selectSensor").value + ".csv";
71.  xmlhttp.open("GET", csvName, true);
72.  xmlhttp.send();
73.  loadingdiv.style.visibility = "visible";
74. }
75. }
76.
77. function parseCSV(string) {
78.     var array = [];
79.     var lines = string.split("\n");
80.     var lastDate = new Date();
81.     for (var i = 0; i < (lines.length - 1); i++) {
82.         if (lines[i].indexOf(',') == -1) {
83.             if (lines[i].indexOf('E') == -1) {
84.                 var data = [];
85.                 lastDate = new Date(lastDate.getTime() + 30000);
86.                 data[0] = new Date(lastDate.getTime());
87.                 data[1] = parseFloat(lines[i]);
88.                 array.push(data);
89.             } else {
90.                 lastDate = new Date(lastDate.getTime() + 30000);
91.             }
92.         } else {
93.             var data = lines[i].split(", ", 2);
94.             data[0] = new Date(parseInt(data[0]) * 1000);
95.             lastDate = data[0];
96.             if (data[1].indexOf('E') == -1) {
97.                 data[1] = parseFloat(data[1]);
98.                 array.push(data);
99.             }
100.        }
101.    }
102.    return array;
103. }

```

```

104.
105.     function drawChart() {
106.       var data = new google.visualization.DataTable();
107.       data.addColumn('datetime', 'UNIX');
108.       data.addColumn('number', 'temperature');
109.
110.       data.addRows(dataArray);
111.
112.       var options = {
113.         curveType: 'function',
114.
115.         height: 360,
116.
117.         legend: { position: 'none' },
118.
119.         hAxis: {
120.           viewWindow: {
121.             min: viewportStartTime,
122.             max: viewportEndTime
123.           },
124.           gridlines: {
125.             count: -1,
126.             units: {
127.               days: { format: ['MMM dd'] },
128.               hours: { format: ['HH:mm', 'ha'] },
129.             }
130.           },
131.           minorGridlines: {
132.             units: {
133.               hours: { format: ['hh:mm:ss
134.                 a', 'ha'] },
135.               minutes: { format: ['HH:mm a
136.                 Z', ':mm'] }
137.             }
138.           },
139.           vAxis: {
140.             title: "temperatura (Celsius)"
141.           };
142.
143.       var chart = new google.visualization.LineChart(document
144.         .getElementById('chart_div'));
145.       chart.draw(data, options);
146.
147.       var dateselectdiv = document.getElementById("dateselect
148.         ");
149.       dateselectdiv.style.visibility = "visible";
150.
151.       var loadingdiv = document.getElementById("loading");
152.       loadingdiv.style.visibility = "hidden";
153.
154.       function displayDate() { // Display the start and end date
155.         on the page
156.         var dateDiv = document.getElementById("date");
157.
158.         var endDay = viewportEndTime.getDate();
159.         var endMonth = viewportEndTime.getMonth();

```

```

160.         var startMonth = viewportStartTime.getMonth()
161.         if (endDay == startDay && endMonth == startMonth) {
162.             dateDiv.textContent = (endDay).toString() + "/" + (
163.                 endMonth + 1).toString();
164.             } else {
165.                 dateDiv.textContent = (startDay).toString() + "/" +
166.                     (startMonth + 1).toString() + " - "
167.                     + (endDay).toString() + "/" + (endMonth + 1).toString();
168.             }
169.         }
170.     }
171.     document.getElementById("prev").onclick = function() {
172.         viewportEndTime = new Date(viewportEndTime.getTime() -
173.             getViewportWidthTime()/3); // move the viewport to the left for
174.             one third of its width (e.g. if the viewport width is 3 days,
175.             move one day back in time)
176.             updateViewport();
177.     }
178.     document.getElementById("next").onclick = function() {
179.         viewportEndTime = new Date(viewportEndTime.getTime() +
180.             getViewportWidthTime()/3); // move the viewport to the right for
181.             one third of its width (e.g. if the viewport width is 3 days,
182.             move one day into the future)
183.             updateViewport();
184.     }
185.     document.getElementById("zoomout").onclick = function() {
186.         zoomLevel += 1; // increment the zoom level (zoom out)
187.         if(zoomLevel > maxZoom) zoomLevel = maxZoom;
188.         else updateViewport();
189.     }
190.     document.getElementById("zoomin").onclick = function() {
191.         zoomLevel -= 1; // decrement the zoom level (zoom in)
192.         if(zoomLevel < minZoom) zoomLevel = minZoom;
193.         else updateViewport();
194.     }
195.     document.getElementById("reset").onclick = function() {
196.         viewportEndTime = new Date(); // the end time of the
197.             viewport is the current time
198.             zoomLevel = 0; // reset the zoom level to the default
199.             (one day)
200.             updateViewport();
201.     }
202.     document.getElementById("refresh").onclick = function() {
203.         viewportEndTime = new Date(); // the end time of the
204.             viewport is the current time
205.             loadCSV(); // download the latest data and re-draw the
206.             chart
207.     }
208.     document.body.onresize = drawChart;
209.
210.     function updateViewport() {
211.         viewportStartTime = new Date(viewportEndTime.getTime() -
212.             getViewportWidthTime());
213.         displayDate();
214.         drawChart();
215.     }
216.     function getViewportWidthTime() {

```

```
206.         return defaultZoomTime*(2**zoomLevel); // exponential
  relation between zoom level and zoom time span
207.                                         // every time
  you zoom, you double or halve the time scale
208.     }
```

## Anexo IX. Presupuestos

Nodo central				
Componente	Referencia	Fabricante	Uds.	Precio
Jack de alimentación	-	RS PRO	1	0,28 €
Referencia de tensión	ISL21080CIH315Z-TK	RENESAS	1	1,36 €
Termistor NTC	B57891S0104F008	EPCOS	1	1,37 €
Módulo Wi-Fi	ESP-12E	ESPRESSIF	1	1,21 €
Componentes pasivos	-	-	-	1 € aprox.
Total:				5,22 €

Nodo periférico				
Componente	Referencia	Fabricante	Uds.	Precio
Micro USB tipo B	10103594-0001LF	Amphenol FCI	1	0,74 €
Integrado de carga	MCP73833-FCI/MF	MICROCHIP	1	0,75 €
Regulador lineal 3,3 V	NCP700BSN33T1G	ON Semiconductor	1	0,67 €
Referencia de tensión	ISL21080CIH315Z-TK	RENESAS	1	1,36 €
Termistor NTC	B57891S0104F008	EPCOS	1	1,37 €
Módulo Wi-Fi	ESP-12E	ESPRESSIF	1	1,21 €
Componentes pasivos	-	-	-	2 € aprox.
Total:				8,10 €

La batería no ha sido incluida en el nodo periférico. El precio de la batería empleada en el diseño es de 22,12 €. Sin embargo, se puede encontrar una batería de una celda de iones de litio de 3000 mAh hasta por 2,86 € en Ali Express. También podría escogerse una batería de menor capacidad 400 -1000 mAh.

Los componentes pasivos no han sido comprados, sino que han sido proporcionados por la universidad. El precio de los componentes pasivos es una estimación.

## Anexo X. Hoja de características del SoC ESP8266

# ESP8266EX

## Datasheet



Version 6.0  
Espressif Systems  
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# About This Guide

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This document introduces the specifications of ESP8266EX.

## Release Notes

Date	Version	Release Notes
2015.12	V4.6	Updated Chapter 3.
2016.02	V4.7	Updated Section 3.6 and Section 4.1.
2016.04	V4.8	Updated Chapter 1.
2016.08	V4.9	Updated Chapter 1.
2016.11	V5.0	Added Appendix II “Learning Resources”.
2016.11	V5.1	Changed the power consumption during Deep-sleep from 10 $\mu$ A to 20 $\mu$ A in Table 5-2.
2016.11	V5.2	Changed the crystal frequency range from “26 MHz to 52 MHz” to “24 MHz to 52 MHz” in Section 3.3.
2016.12	V5.3	Changed the minimum working voltage from 3.0V to 2.5V.
2017.04	V5.4	Changed chip input and output impedance from $50\Omega$ to $39+j6\ \Omega$ .
2017.10	V5.5	Updated Chapter 3 regarding the range of clock amplitude to 0.8 ~ 1.5V.
2017.11	V5.6	Updated VDDPST from 1.8V ~ 3.3V to 1.8V ~ 3.6V.
2017.11	V5.7	<ul style="list-style-type: none"><li>• Corrected a typo in the description of SDIO_DATA_0 in Table 2-1;</li><li>• Added the testing conditions for the data in Table 5-2.</li></ul>

Date	Version	Release Notes
2018.02	V5.8	<ul style="list-style-type: none"> <li>• Updated Wi-Fi protocols in Section 1.1;</li> <li>• Updated description of the integrated Tensilica processor in 3.1.</li> </ul>
2018.09	V5.9	<ul style="list-style-type: none"> <li>• Update document cover;</li> <li>• Added a note for Table 1-1;</li> <li>• Updated Wi-Fi key features in Section 1.1;</li> <li>• Updated description of the Wi-Fi function in 3.5;</li> <li>• Updated pin layout diagram;</li> <li>• Fixed a typo in Table 2-1;</li> <li>• Removed Section AHB and AHB module;</li> <li>• Restructured Section Power Management;</li> <li>• Fixed a typo in Section UART;</li> <li>• Removed description of transmission angle in Section IR Remote Control;</li> <li>• Other optimization (wording).</li> </ul>
2018.11	V6.0	<ul style="list-style-type: none"> <li>• Added an SPI pin in Table 4-2;</li> <li>• Updated the diagram of packing information.</li> </ul>

## Documentation Change Notification

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# 1.

# Overview

---

Espressif's ESP8266EX delivers highly integrated Wi-Fi SoC solution to meet users' continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry.

With the complete and self-contained Wi-Fi networking capabilities, ESP8266EX can perform either as a standalone application or as the slave to a host MCU. When ESP8266EX hosts the application, it promptly boots up from the flash. The integrated high-speed cache helps to increase the system performance and optimize the system memory. Also, ESP8266EX can be applied to any microcontroller design as a Wi-Fi adaptor through SPI/SDIO or UART interfaces.

ESP8266EX integrates antenna switches, RF balun, power amplifier, low noise receive amplifier, filters and power management modules. The compact design minimizes the PCB size and requires minimal external circuitries.

Besides the Wi-Fi functionalities, ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor and on-chip SRAM. It can be interfaced with external sensors and other devices through the GPIOs. Software Development Kit (SDK) provides sample codes for various applications.

Espressif Systems' Smart Connectivity Platform (ESCP) enables sophisticated features including:

- Fast switch between sleep and wakeup mode for energy-efficient purpose;
- Adaptive radio biasing for low-power operation
- Advance signal processing
- Spur cancellation and RF co-existence mechanisms for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation

## 1.1. Wi-Fi Key Features

- 802.11 b/g/n support
- 802.11n support (2.4 GHz), up to 72.2 Mbps
- Defragmentation
- 2 x virtual Wi-Fi interface
- Automatic beacon monitoring (hardware TSF)
- Support Infrastructure BSS Station mode/SoftAP mode/Promiscuous mode
- Antenna diversity



## 1.2. Specifications

Table 1-1. Specifications

Categories	Items	Parameters
Wi-Fi	Certification	Wi-Fi Alliance
	Protocols	802.11 b/g/n (HT20)
	Frequency Range	2.4G ~ 2.5G (2400M ~ 2483.5M)
	TX Power	802.11 b: +20 dBm
		802.11 g: +17 dBm
		802.11 n: +14 dBm
	Rx Sensitivity	802.11 b: -91 dbm (11 Mbps)
		802.11 g: -75 dbm (54 Mbps)
		802.11 n: -72 dbm (MCS7)
	Antenna	PCB Trace, External, IPEX Connector, Ceramic Chip
Hardware	CPU	Tensilica L106 32-bit processor
	Peripheral Interface	UART/SDIO/SPI/I2C/I2S/IR Remote Control
		GPIO/ADC/PWM/LED Light & Button
	Operating Voltage	2.5V ~ 3.6V
	Operating Current	Average value: 80 mA
	Operating Temperature Range	-40°C ~ 125°C
	Package Size	QFN32-pin (5 mm x 5 mm)
Software	External Interface	-
	Wi-Fi Mode	Station/SoftAP/SoftAP+Station
	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware Upgrade	UART Download / OTA (via network)
	Software Development	Supports Cloud Server Development / Firmware and SDK for fast on-chip programming
	Network Protocols	IPv4, TCP/UDP/HTTP
	User Configuration	AT Instruction Set, Cloud Server, Android/iOS App

**Note:**

The TX power can be configured based on the actual user scenarios.



### 1.3. Applications

- Home appliances
- Home automation
- Smart plugs and lights
- Industrial wireless control
- Baby monitors
- IP cameras
- Sensor networks
- Wearable electronics
- Wi-Fi location-aware devices
- Security ID tags
- Wi-Fi position system beacons



## 2.

# Pin Definitions

Figure 2-1 shows the pin layout for 32-pin QFN package.

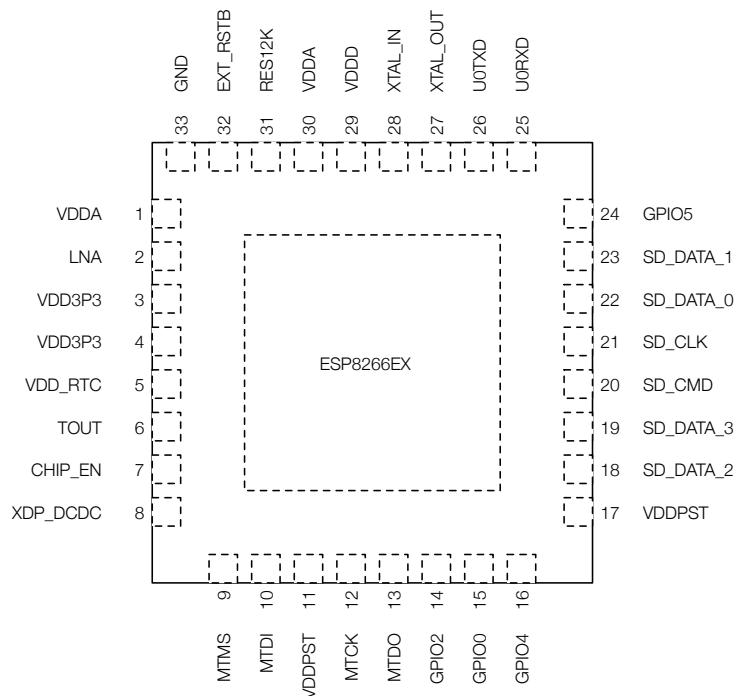


Figure 2-1. Pin Layout (Top View)

Table 2-1 lists the definitions and functions of each pin.

Table 2-1. ESP8266EX Pin Definitions

Pin	Name	Type	Function
1	VDDA	P	Analog Power 2.5V ~ 3.6V
2	LNA	I/O	RF antenna interface Chip output impedance=39+j6 Ω. It is suggested to retain the π-type matching network to match the antenna.
3	VDD3P3	P	Amplifier Power 2.5V ~ 3.6V
4	VDD3P3	P	Amplifier Power 2.5V ~ 3.6V
5	VDD_RTC	P	NC (1.1V)
6	TOUT	I	ADC pin. It can be used to test the power-supply voltage of VDD3P3 (Pin3 and Pin4) and the input power voltage of TOUT (Pin 6). However, these two functions cannot be used simultaneously.



Pin	Name	Type	Function
7	CHIP_EN	I	Chip Enable High: On, chip works properly Low: Off, small current consumed
8	XPD_DCDC	I/O	Deep-sleep wakeup (need to be connected to EXT_RSTB); GPIO16
9	MTMS	I/O	GPIO 14; HSPI_CLK
10	MTDI	I/O	GPIO 12; HSPI_MISO
11	VDDPST	P	Digital/IO Power Supply (1.8V ~ 3.6V)
12	MTCK	I/O	GPIO 13; HSPI莫斯; UART0_CTS
13	MTDO	I/O	GPIO 15; HSPI_CS; UART0_RTS
14	GPIO2	I/O	UART TX during flash programming; GPIO2
15	GPIO0	I/O	GPIO0; SPI_CS2
16	GPIO4	I/O	GPIO4
17	VDDPST	P	Digital/IO Power Supply (1.8V ~ 3.6V)
18	SDIO_DATA_2	I/O	Connect to SD_D2 (Series R: 200Ω); SPIHD; HSPIHD; GPIO9
19	SDIO_DATA_3	I/O	Connect to SD_D3 (Series R: 200Ω); SPIWP; HSPIWP; GPIO10
20	SDIO_CMD	I/O	Connect to SD_CMD (Series R: 200Ω); SPI_CS0; GPIO11
21	SDIO_CLK	I/O	Connect to SD_CLK (Series R: 200Ω); SPI_CLK; GPIO6
22	SDIO_DATA_0	I/O	Connect to SD_D0 (Series R: 200Ω); SPI_MISO; GPIO7
23	SDIO_DATA_1	I/O	Connect to SD_D1 (Series R: 200Ω); SPI_MOSI; GPIO8
24	GPIO5	I/O	GPIO5
25	U0RXD	I/O	UART Rx during flash programming; GPIO3
26	U0TXD	I/O	UART TX during flash programming; GPIO1; SPI_CS1
27	XTAL_OUT	I/O	Connect to crystal oscillator output, can be used to provide BT clock input
28	XTAL_IN	I/O	Connect to crystal oscillator input
29	VDDD	P	Analog Power 2.5V ~ 3.6V
30	VDDA	P	Analog Power 2.5V ~ 3.6V
31	RES12K	I	Serial connection with a 12 kΩ resistor and connect to the ground
32	EXT_RSTB	I	External reset signal (Low voltage level: active)

**Note:**

1. GPIO2, GPIO0, and MTDO are used to select booting mode and the SDIO mode;
2. U0TXD should not be pulled externally to a low logic level during the powering-up.



# 3. Functional Description

The functional diagram of ESP8266EX is shown as in Figure 3-1.

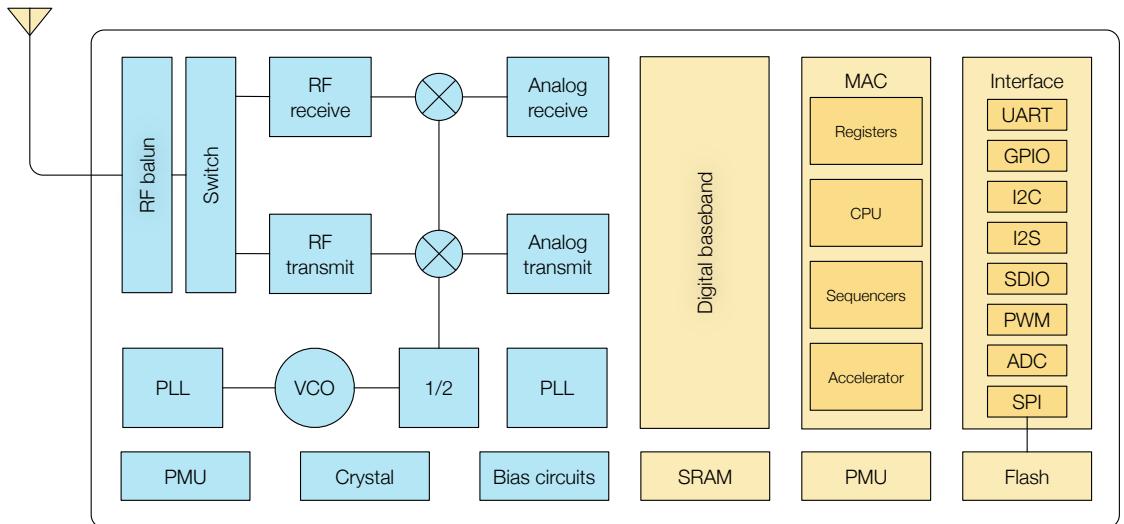


Figure 3-1. Functional Block Diagram

## 3.1. CPU, Memory, and Flash

### 3.1.1. CPU

The ESP8266EX integrates a Tensilica L106 32-bit RISC processor, which achieves extra-low power consumption and reaches a maximum clock speed of 160 MHz. The Real-Time Operating System (RTOS) and Wi-Fi stack allow 80% of the processing power to be available for user application programming and development. The CPU includes the interfaces as below:

- Programmable RAM/ROM interfaces (iBus), which can be connected with memory controller, and can also be used to visit flash.
- Data RAM interface (dBus), which can be connected with memory controller.
- AHB interface which can be used to visit the register.

### 3.1.2. Memory

ESP8266EX Wi-Fi SoC integrates memory controller and memory units including SRAM and ROM. MCU can access the memory units through iBus, dBus, and AHB interfaces. All memory units can be accessed upon request, while a memory arbiter will decide the running sequence according to the time when these requests are received by the processor.

According to our current version of SDK, SRAM space available to users is assigned as below.



- RAM size < 50 kB, that is, when ESP8266EX is working under the Station mode and connects to the router, the maximum programmable space accessible in Heap + Data section is around 50 kB.
- There is no programmable ROM in the SoC. Therefore, user program must be stored in an external SPI flash.

### 3.1.3. External Flash

ESP8266EX uses external SPI flash to store user programs, and supports up to 16 MB memory capacity theoretically.

The minimum flash memory of ESP8266EX is shown below:

- OTA disabled: 512 kB at least
- OTA enabled: 1 MB at least

**⚠️ Notice:**

*SPI mode supported: Standard SPI, Dual SPI and Quad SPI. The correct SPI mode should be selected when flashing bin files to ESP8266. Otherwise, the downloaded firmware/program may not be working properly.*

## 3.2. Clock

### 3.2.1. High Frequency Clock

The high frequency clock on ESP8266EX is used to drive both transmit and receive mixers. This clock is generated from internal crystal oscillator and external crystal. The crystal frequency ranges from 24 MHz to 52 MHz.

The internal calibration inside the crystal oscillator ensures that a wide range of crystals can be used, nevertheless the quality of the crystal is still a factor to consider to have reasonable phase noise and good Wi-Fi sensitivity. Refer to Table 3-1 to measure the frequency offset.

Table 3-1. High Frequency Clock Specifications

Parameter	Symbol	Min	Max	Unit
Frequency	FXO	24	52	MHz
Loading capacitance	CL	-	32	pF
Motional capacitance	CM	2	5	pF
Series resistance	RS	0	65	Ω
Frequency tolerance	ΔFXO	-15	15	ppm
Frequency vs temperature (-25°C ~ 75°C)	ΔFXO,Temp	-15	15	ppm



### 3.2.2. External Clock Requirements

An externally generated clock is available with the frequency ranging from 24 MHz to 52 MHz. The following characteristics are expected to achieve good performance of radio.

Table 3-2. External Clock Reference

Parameter	Symbol	Min	Max	Unit
Clock amplitude	V <sub>XO</sub>	0.8	1.5	V <sub>pp</sub>
External clock accuracy	ΔF <sub>XO,EXT</sub>	-15	15	ppm
Phase noise @1-kHz offset, 40-MHz clock	-	-	-120	dBc/Hz
Phase noise @10-kHz offset, 40-MHz clock	-	-	-130	dBc/Hz
Phase noise @100-kHz offset, 40-MHz clock	-	-	-138	dBc/Hz

## 3.3. Radio

ESP8266EX radio consists of the following blocks.

- 2.4 GHz receiver
- 2.4 GHz transmitter
- High speed clock generators and crystal oscillator
- Bias and regulators
- Power management

### 3.3.1. Channel Frequencies

The RF transceiver supports the following channels according to IEEE802.11b/g/n standards.

Table 3-3. Frequency Channel

Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442	14	2484



### 3.3.2. 2.4 GHz Receiver

The 2.4 GHz receiver down-converts the RF signals to quadrature baseband signals and converts them to the digital domain with 2 high resolution high speed ADCs. To adapt to varying signal channel conditions, RF filters, automatic gain control (AGC), DC offset cancelation circuits and baseband filters are integrated within ESP8266EX.

### 3.3.3. 2.4 GHz Transmitter

The 2.4 GHz transmitter up-converts the quadrature baseband signals to 2.4 GHz, and drives the antenna with a high-power CMOS power amplifier. The function of digital calibration further improves the linearity of the power amplifier, enabling a state of art performance of delivering +19.5 dBm average TX power for 802.11b transmission and +18 dBm for 802.11n (MCS0) transmission.

Additional calibrations are integrated to offset any imperfections of the radio, such as:

- Carrier leakage
- I/Q phase matching
- Baseband nonlinearities

These built-in calibration functions reduce the product test time and make the test equipment unnecessary.

### 3.3.4. Clock Generator

The clock generator generates quadrature 2.4 GHz clock signals for the receiver and transmitter. All components of the clock generator are integrated on the chip, including all inductors, varactors, loop filters, linear voltage regulators and dividers.

The clock generator has built-in calibration and self test circuits. Quadrature clock phases and phase noise are optimized on-chip with patented calibration algorithms to ensure the best performance of the receiver and transmitter.

## 3.4. Wi-Fi

ESP8266EX implements TCP/IP and full 802.11 b/g/n WLAN MAC protocol. It supports Basic Service Set (BSS) STA and SoftAP operations under the Distributed Control Function (DCF). Power management is handled with minimum host interaction to minimize active-duty period.

### 3.4.1. Wi-Fi Radio and Baseband

The ESP8266EX Wi-Fi Radio and Baseband support the following features:

- 802.11b and 802.11g
- 802.11n MCS0-7 in 20 MHz bandwidth
- 802.11n 0.4 µs guard-interval
- up to 72.2 Mbps of data rate



- Receiving STBC 2x1
- Up to 20.5 dBm of transmitting power
- Adjustable transmitting power
- Antenna diversity

### 3.4.2. Wi-Fi MAC

The ESP8266EX Wi-Fi MAC applies low-level protocol functions automatically, as follows:

- 2 × virtual Wi-Fi interfaces
- Infrastructure BSS Station mode/SoftAP mode/Promiscuous mode
- Request To Send (RTS), Clear To Send (CTS) and Immediate Block ACK
- Defragmentation
- CCMP (CBC-MAC, counter mode), TKIP (MIC, RC4), WEP (RC4) and CRC
- Automatic beacon monitoring (hardware TSF)
- Dual and single antenna Bluetooth co-existence support with optional simultaneous receive (Wi-Fi/Bluetooth) capability

## 3.5. Power Management

ESP8266EX is designed with advanced power management technologies and intended for mobile devices, wearable electronics and the Internet of Things applications.

The low-power architecture operates in the following modes:

- Active mode: The chip radio is powered on. The chip can receive, transmit, or listen.
- Modem-sleep mode: The CPU is operational. The Wi-Fi and radio are disabled.
- Light-sleep mode: The CPU and all peripherals are paused. Any wake-up events (MAC, host, RTC timer, or external interrupts) will wake up the chip.
- Deep-sleep mode: Only the RTC is operational and all other part of the chip are powered off.

Table 3-4. Power Consumption by Power Modes

Power Mode	Description	Power Consumption
Active (RF working)	Wi-Fi TX packet	Please refer to 5-2.
	Wi-Fi RX packet	
Modem-sleep <sup>①</sup>	CPU is working	15 mA
Light-sleep <sup>②</sup>	-	0.9 mA
Deep-sleep <sup>③</sup>	Only RTC is working	20 uA
Shut down	-	0.5 uA

A small blue icon of a book or document with a pencil, indicating a note or important information.**Notes:**

- ① **Modem-sleep** mode is used in the applications that require the CPU to be working, as in PWM or I2S applications. According to 802.11 standards (like U-APSD), it shuts down the Wi-Fi Modem circuit while maintaining a Wi-Fi connection with no data transmission to optimize power consumption. E.g. in DTIM3, maintaining a sleep of 300 ms with a wakeup of 3 ms cycle to receive AP's Beacon packages at interval requires about 15 mA current.
- ② During **Light-sleep** mode, the CPU may be suspended in applications like Wi-Fi switch. Without data transmission, the Wi-Fi Modem circuit can be turned off and CPU suspended to save power consumption according to the 802.11 standards (U-APSD). E.g. in DTIM3, maintaining a sleep of 300 ms with a wakeup of 3ms to receive AP's Beacon packages at interval requires about 0.9 mA current.
- ③ During **Deep-sleep** mode, Wi-Fi is turned off. For applications with long time lags between data transmission, e.g. a temperature sensor that detects the temperature every 100s, sleeps for 300s and wakes up to connect to the AP (taking about 0.3 ~ 1s), the overall average current is less than 1mA. The current of 20  $\mu$ A is acquired at the voltage of 2.5V.



# 4. Peripheral Interface

## 4.1. General Purpose Input/Output Interface (GPIO)

ESP8266EX has 17 GPIO pins which can be assigned to various functions by programming the appropriate registers.

Each GPIO PAD can be configured with internal pull-up or pull-down (XPD\_DCDC can only be configured with internal pull-down, other GPIO PAD can only be configured with internal pull-up), or set to high impedance. When configured as an input, the data are stored in software registers; the input can also be set to edge-trigger or level trigger CPU interrupts. In short, the IO pads are bi-directional, non-inverting and tristate, which includes input and output buffer with tristate control inputs.

These pins, when working as GPIOs, can be multiplexed with other functions such as I2C, I2S, UART, PWM, and IR Remote Control, etc.

For low power operations, the GPIOs can also be set to hold their state. For instance, when the IOs are not driven by internal and external circuits, all outputs will hold their states before the chip entered the low power modes.

The required drive strength is small— 5  $\mu$ A or more is enough to pull apart the latch.

## 4.2. Secure Digital Input/Output Interface (SDIO)

ESP8266EX has one Slave SDIO, the definitions of which are described as Table 4-1, which supports 25 MHz SDIO v1.1 and 50 MHz SDIO v2.0, and 1 bit/4 bit SD mode and SPI mode.

Table 4-1. Pin Definitions of SDIOs

Pin Name	Pin Num	IO	Function Name
SDIO_CLK	21	IO6	SDIO_CLK
SDIO_DATA0	22	IO7	SDIO_DATA0
SDIO_DATA1	23	IO8	SDIO_DATA1
SDIO_DATA_2	18	IO9	SDIO_DATA_2
SDIO_DATA_3	19	IO10	SDIO_DATA_3
SDIO_CMD	20	IO11	SDIO_CMD



## 4.3. Serial Peripheral Interface (SPI/HSPI)

ESP8266EX has two SPIs.

- One general Slave/Master SPI
- One general Slave HSPI

Functions of all these pins can be implemented via hardware.

### 4.3.1. General SPI (Master/Slave)

Table 4-2. Pin Definitions of SPIs

Pin Name	Pin Num	IO	Function Name
SDIO_CLK	21	IO6	SPICLK
SDIO_DATA0	22	IO7	SPIQ/MISO
SDIO_DATA1	23	IO8	SPIID/MOSI
SDIO_DATA_2	18	IO9	SPIHD
SDIO_DATA_3	19	IO10	SPIWP
U0TXD	26	IO1	SPICS1
GPIO0	15	IO0	SPICS2
SDIO_CMD	20	IO11	SPICS0

**Note:**

*SPI mode can be implemented via software programming. The clock frequency is 80 MHz at maximum when working as a master, 20 MHz at maximum when working as a slave.*

### 4.3.2. HSPI (Slave)

Table 4-3. Pin Definitions of HSPI (Slave)

Pin Name	Pin Num	IO	Function Name
MTMS	9	IO14	HSPICLK
MTDI	10	IO12	HSPIQ/MISO
MTCK	12	IO13	HSPID/MOSI
MTDO	13	IO15	HPSICS

**Note:**

*SPI mode can be implemented via software programming. The clock frequency is 20 MHz at maximum.*



## 4.4. I2C Interface

ESP8266EX has one I2C, which is realized via software programming, used to connect with other microcontrollers and other peripheral equipments such as sensors. The pin definition of I2C is as below.

Table 4-4. Pin Definitions of I2C

Pin Name	Pin Num	IO	Function Name
MTMS	9	IO14	I2C_SCL
GPIO2	14	IO2	I2C_SDA

Both I2C Master and I2C Slave are supported. I2C interface functionality can be realized via software programming, and the clock frequency is 100 kHz at maximum.

## 4.5. I2S Interface

ESP8266EX has one I2S data input interface and one I2S data output interface, and supports the linked list DMA. I2S interfaces are mainly used in applications such as data collection, processing, and transmission of audio data, as well as the input and output of serial data. For example, LED lights (WS2812 series) are supported. The pin definition of I2S is shown in Table 4-5.

Table 4-5. Pin Definitions of I2S

I2S Data Input			
Pin Name	Pin Num	IO	Function Name
MTDI	10	IO12	I2SI_DATA
MTCK	12	IO13	I2SI_BCK
MTMS	9	IO14	I2SI_WS
MTDO	13	IO15	I2SO_BCK
U0RXD	25	IO3	I2SO_DATA
GPIO2	14	IO2	I2SO_WS

## 4.6. Universal Asynchronous Receiver Transmitter (UART)

ESP8266EX has two UART interfaces UART0 and UART1, the definitions are shown in Table 4-6.



Table 4-6. Pin Definitions of UART

Pin Type	Pin Name	Pin Num	IO	Function Name
UART0	U0RXD	25	IO3	U0RXD
	U0TXD	26	IO1	U0TXD
	MTDO	13	IO15	U0RTS
	MTCK	12	IO13	U0CTS
UART1	GPIO2	14	IO2	U1TXD
	SD_D1	23	IO8	U1RXD

Data transfers to/from UART interfaces can be implemented via hardware. The data transmission speed via UART interfaces reaches 115200 × 40 (4.5 Mbps).

UART0 can be used for communication. It supports flow control. Since UART1 features only data transmit signal (TX), it is usually used for printing log.

**Note:**

*By default, UART0 outputs some printed information when the device is powered on and booting up. The baud rate of the printed information is relevant to the frequency of the external crystal oscillator. If the frequency of the crystal oscillator is 40 MHz, then the baud rate for printing is 115200; if the frequency of the crystal oscillator is 26 MHz, then the baud rate for printing is 74880. If the printed information exerts any influence on the functionality of the device, it is suggested to block the printing during the power-on period by changing (U0TXD, U0RXD) to (MTDO, MTCK).*

## 4.7. Pulse-Width Modulation (PWM)

ESP8266EX has four PWM output interfaces. They can be extended by users themselves. The pin definitions of the PWM interfaces are defined as below.

Table 4-7. Pin Definitions of PWM

Pin Name	Pin Num	IO	Function Name
MTDI	10	IO12	PWM0
MTDO	13	IO15	PWM1
MTMS	9	IO14	PWM2
GPIO4	16	IO4	PWM3

The functionality of PWM interfaces can be implemented via software programming. For example, in the LED smart light demo, the function of PWM is realized by interruption of the timer, the minimum resolution reaches as high as 44 ns. PWM frequency range is adjustable from 1000 µs to 10000 µs, i.e., between 100 Hz and 1 kHz. When the PWM frequency is 1 kHz, the duty ratio will be 1/22727, and a resolution of over 14 bits will be achieved at 1 kHz refresh rate.



## 4.8. IR Remote Control

ESP8266EX currently supports one infrared remote control interface. For detailed pin definitions, please see Table 4-8 below.

Table 4-8. Pin Definitions of IR Remote Control

Pin Name	Pin Num	IO	Function Name
MTMS	9	IO14	IR TX
GPIO5	24	IO 5	IR Rx

The functionality of Infrared remote control interface can be implemented via software programming. NEC coding, modulation, and demodulation are supported by this interface. The frequency of modulated carrier signal is 38 kHz, while the duty ratio of the square wave is 1/3. The transmission range is around 1m which is determined by two factors: one is the maximum current drive output, the other is internal current-limiting resistance value in the infrared receiver. The larger the resistance value, the lower the current, so is the power, and vice versa.

## 4.9. ADC (Analog-to-Digital Converter)

ESP8266EX is embedded with a 10-bit precision SAR ADC. TOUT (Pin6) is defined as below:

Table 4-9. Pin Definition of ADC

Pin Name	Pin Num	Function Name
TOUT	6	ADC Interface

The following two measurements can be implemented using ADC (Pin6). However, they cannot be implemented at the same time.

- Measure the power supply voltage of VDD3P3 (Pin3 and Pin4).

Hardware Design	TOUT must be floating.
RF Initialization Parameter	The 107th byte of <code>esp_init_data_default.bin</code> (0 ~ 127 bytes), vdd33_const must be set to 0xFF.
RF Calibration Process	Optimize the RF circuit conditions based on the testing results of VDD3P3 (Pin3 and Pin4).
User Programming	Use <code>system_get_vdd33</code> instead of <code>system_adc_read</code> .

- Measure the input voltage of TOUT (Pin6).

Hardware Design	The input voltage range is 0 to 1.0V when TOUT is connected to external circuit.
-----------------	----------------------------------------------------------------------------------



RF Initialization Parameter	The value of the 107th byte of <b><i>esp_init_data_default.bin</i></b> (0 ~ 127 bytes), vdd33_const must be set to the real power supply voltage of Pin3 and Pin4. The unit and effective value range of vdd33_const is 0.1V and 18 to 36, respectively, thus making the working power voltage range of ESP8266EX between 1.8V and 3.6V,
RF Calibration Process	Optimize the RF circuit conditions based on the value of vdd33_const. The permissible error is $\pm 0.2V$ .
User Programming	Use <code>system_adc_read</code> instead of <code>system_get_vdd33</code> .

**Notes:**

***esp\_init\_data\_default.bin*** is provided in SDK package which contains RF initialization parameters (0 ~ 127 bytes). The name of the 107th byte in ***esp\_init\_data\_default.bin*** is vdd33\_const, which is defined as below:

- When  $vdd33\_const = 0xff$ , the power voltage of Pin3 and Pin4 will be tested by the internal self-calibration process of ESP8266EX itself. RF circuit conditions should be optimized according to the testing results.
- When  $18 \leq vdd33\_const \leq 36$ , ESP8266EX RF Calibration and optimization process is implemented via  $(vdd33\_const/10)$ .
- When  $vdd33\_const < 18$  or  $36 < vdd33\_const < 255$ ,  $vdd33\_const$  is invalid. ESP8266EX RF Calibration and optimization process is implemented via the default value 3.3V.



# 5. Electrical Specifications

## 5.1. Electrical Characteristics

Table 5-1. Electrical Characteristics

Parameters	Conditions	Min	Typical	Max	Unit
Operating Temperature Range	-	-40	Normal	125	°C
Maximum Soldering Temperature	IPC/JEDEC J-STD-020	-	-	260	°C
Working Voltage Value	-	2.5	3.3	3.6	V
I/O	$V_{IL}$	-0.3	-	0.25 $V_{IO}$	
	$V_{IH}$	0.75 $V_{IO}$		3.6	
	$V_{OL}$	-	-	0.1 $V_{IO}$	V
	$V_{OH}$	0.8 $V_{IO}$		-	
	$I_{MAX}$	-	-	12	mA
Electrostatic Discharge (HBM)	TAMB=25°C	-	-	2	kV
Electrostatic Discharge (CDM)	TAMB=25°C	-	-	0.5	kV

## 5.2. RF Power Consumption

Unless otherwise specified, the power consumption measurements are taken with a 3.0V supply at 25°C of ambient temperature. All transmitters' measurements are based on a 50% duty cycle.

Table 5-2. Power Consumption

Parameters	Min	Typical	Max	Unit
TX 802.11b, CCK 11Mbps, $P_{OUT}=+17$ dBm	-	170	-	mA
TX 802.11g, OFDM 54Mbps, $P_{OUT}=+15$ dBm	-	140	-	mA
TX 802.11n, MCS7, $P_{OUT}=+13$ dBm	-	120	-	mA
Rx 802.11b, 1024 bytes packet length, -80 dBm	-	50	-	mA
Rx 802.11g, 1024 bytes packet length, -70 dBm	-	56	-	mA
Rx 802.11n, 1024 bytes packet length, -65 dBm	-	56	-	mA



## 5.3. Wi-Fi Radio Characteristics

The following data are from tests conducted at room temperature, with a 3.3V power supply.

Table 5-3. Wi-Fi Radio Characteristics

Parameters	Min	Typical	Max	Unit
Input frequency	2412	-	2484	MHz
Output impedance	-	39+j6	-	$\Omega$
Output power of PA for 72.2 Mbps	15.5	16.5	17.5	dBm
Output power of PA for 11b mode	19.5	20.5	21.5	dBm
Sensitivity				
DSSS, 1 Mbps	-	-98	-	dBm
CCK, 11 Mbps	-	-91	-	dBm
6 Mbps (1/2 BPSK)	-	-93	-	dBm
54 Mbps (3/4 64-QAM)	-	-75	-	dBm
HT20, MCS7 (65 Mbps, 72.2 Mbps)	-	-72	-	dBm
Adjacent Channel Rejection				
OFDM, 6 Mbps	-	37	-	dB
OFDM, 54 Mbps	-	21	-	dB
HT20, MCS0	-	37	-	dB
HT20, MCS7	-	20	-	dB



# 6. Package Information

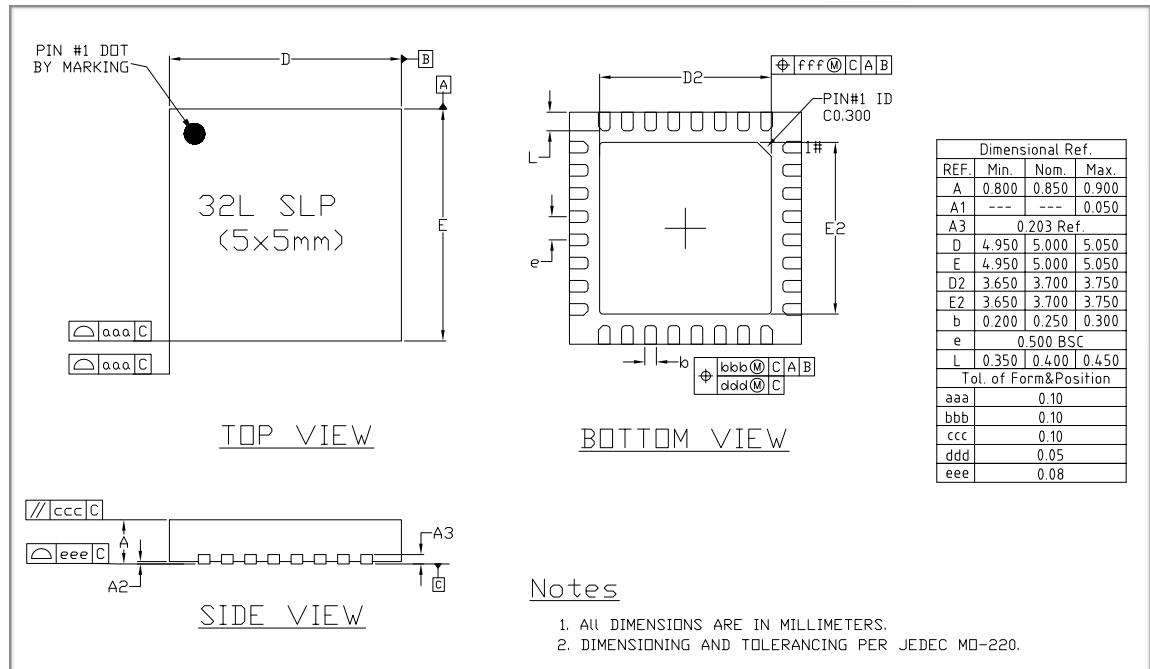


Figure 6-1. ESP8266EX Package



## I.

# Appendix - Pin List

For detailed pin information, please see [ESP8266 Pin List](#).

- Digital Die Pin List
- Buffer Sheet
- Register List
- Strapping List

**Notes:**

- *INST\_NAME* refers to the *IO\_MUX REGISTER* defined in **eagle\_soc.h**, for example *MTDI\_U* refers to *PERIPHS\_IO\_MUX\_MTDI\_U*.
- *Net Name* refers to the pin name in schematic.
- *Function* refers to the multifunction of each pin pad.
- *Function number 1 ~ 5* correspond to *FUNCTION 0 ~ 4* in *SDK*. For example, set *MTDI* to *GPIO12* as follows.
  - `#define FUNC_GPIO12 3 //defined in eagle_soc.h`
  - `PIN_FUNC_SELECT(PERIPHS_IO_MUX_MTDI_U, FUNC_GPIO12)`



## II. Appendix - Learning Resources

### II.1. Must-Read Documents

- [\*ESP8266 Quick Start Guide\*](#)

Description: This document is a quick user guide to getting started with ESP8266. It includes an introduction to the ESP-LAUNCHER, instructions on how to download firmware to the board and run it, how to compile the AT application, as well as the structure and debugging method of RTOS SDK. Basic documentation and other related resources for the ESP8266 are also provided.

- [\*ESP8266 SDK Getting Started Guide\*](#)

Description: This document takes ESP-LAUNCHER and ESP-WROOM-02 as examples of how to use the ESP8266 SDK. The contents include preparations before compilation, SDK compilation and firmware download.

- [\*ESP8266 Pin List\*](#)

Description: This link directs you to a list containing the type and function of every ESP8266 pin.

- [\*ESP8266 Hardware Design Guideline\*](#)

Description: This document provides a technical description of the ESP8266 series of products, including ESP8266EX, ESP-LAUNCHER and ESP-WROOM.

- [\*ESP8266 Hardware Matching Guide\*](#)

Description: This document introduces the frequency offset tuning and antenna impedance matching for ESP8266 in order to achieve optimal RF performance.

- [\*ESP8266 Technical Reference\*](#)

Description: This document provides an introduction to the interfaces integrated on ESP8266. Functional overview, parameter configuration, function description, application demos and other pieces of information are included.

- [\*ESP8266 Hardware Resources\*](#)

Description: This zip package includes manufacturing BOMs, schematics and PCB layouts of ESP8266 boards and modules.

- [\*FAQ\*](#)

### II.2. Must-Have Resources

- [\*ESP8266 SDKs\*](#)



Description: This webpage provides links both to the latest version of the ESP8266 SDK and the older ones.

- [ESP8266 Tools](#)

Description: This webpage provides links to both the ESP8266 flash download tools and the ESP8266 performance evaluation tools.

- [ESP8266 Apps](#)
- [ESP8266 Certification and Test Guide](#)
- [ESP8266 BBS](#)
- [ESP8266 Resources](#)



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## Anexo XI. Hoja de características del ESP-12E



# ESP-12E WiFi Module

**Version 1.0**

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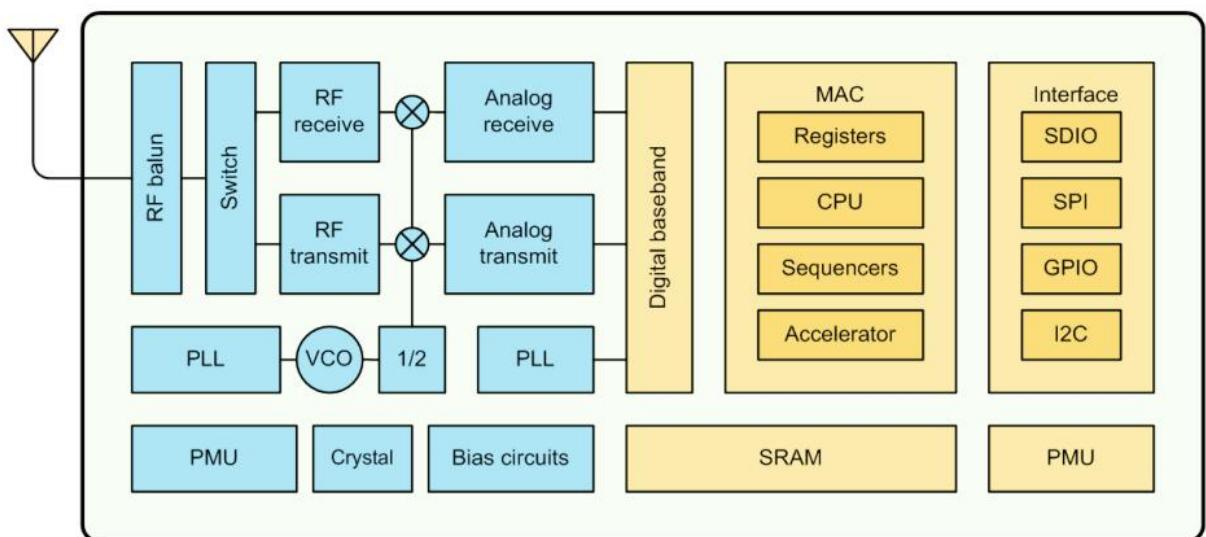


## 1. Preambles

ESP-12E WiFi module is developed by Ai-thinker Team. core processor ESP8266 in smaller sizes of the module encapsulates Tensilica L106 integrates industry-leading ultra low power 32-bit MCU micro, with the 16-bit short mode, Clock speed support 80 MHz, 160 MHz, supports the RTOS, integrated Wi-Fi MAC/BB/RF/PA/LNA, on-board antenna.

The module supports standard IEEE802.11 b/g/n agreement, complete TCP/IP protocol stack. Users can use the add modules to an existing device networking, or building a separate network controller.

ESP8266 is high integration wireless SOCs, designed for space and power constrained mobile platform designers. It provides unsurpassed ability to embed Wi-Fi capabilities within other systems, or to function as a standalone application, with the lowest cost, and minimal space requirement.



**Figure 1 ESP8266EX Block Diagram**

ESP8266EX offers a complete and self-contained Wi-Fi networking solution; it can be used to host the application or to offload Wi-Fi networking functions from another application processor.

When ESP8266EX hosts the application, it boots up directly from an external flash. It has integrated cache to improve the performance of the system in such applications.

Alternately, serving as a Wi-Fi adapter, wireless internet access can be added to any micro controllerbased design with simple connectivity (SPI/SDIO or I2C/UART interface).

ESP8266EX is among the most integrated WiFi chip in the industry; it integrates the antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.



ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the Wi-Fi functionalities. ESP8266EX is often integrated with external sensors and other application specific devices through its GPIOs; codes for such applications are provided in examples in the SDK.

Espressif Systems' Smart Connectivity Platform (ESCP) demonstrates sophisticated system-level features include fast sleep/wake context switching for energy-efficient VoIP, adaptive radio biasing, for low-power operation, advance signal processing, and spur cancellation and radio co-existence features for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation.

## 1.1. Features

- 802.11 b/g/n
- Integrated low power 32-bit MCU
- Integrated 10-bit ADC
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLL, regulators, and power management units
- Supports antenna diversity
- Wi-Fi 2.4 GHz, support WPA/WPA2
- Support STA/AP/STA+AP operation modes
- Support Smart Link Function for both Android and iOS devices
- Support Smart Link Function for both Android and iOS devices
- SDIO 2.0, (H) SPI, UART, I2C, I2S, IRDA, PWM, GPIO
- STBC, 1x1 MIMO, 2x1 MIMO
- A-MPDU & A-MSDU aggregation and 0.4s guard interval



- Deep sleep power <10uA, Power down leakage current < 5uA
- Wake up and transmit packets in < 2ms
- Standby power consumption of < 1.0mW (DTIM3)
- +20dBm output power in 802.11b mode
- Operating temperature range -40C ~ 125C



## 1.2. Parameters

Table 1 below describes the major parameters.

**Table 1 Parameters**

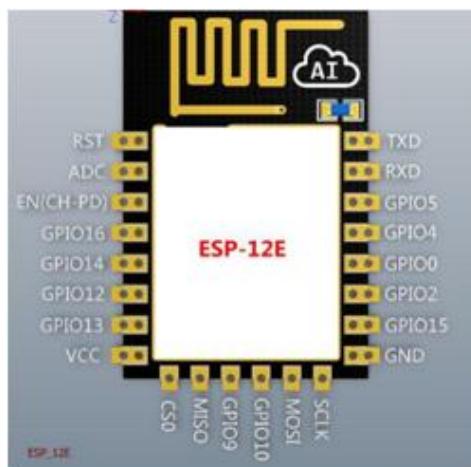
Categories	Items	Values
WiFi Paramters	WiFi Protocols	802.11 b/g/n
	Frequency Range	2.4GHz-2.5GHz (2400M-2483.5M)
Hardware Parameters	Peripheral Bus	UART/HSPI/I2C/I2S/Ir Remote Control GPIO/PWM
	Operating Voltage	3.0~3.6V
	Operating Current	Average value: 80mA
	Operating Temperature Range	-40°~125°
	Ambient Temperature Range	Normal temperature
	Package Size	16mm*24mm*3mm
	External Interface	N/A
	Wi-Fi mode	station/softAP/SoftAP+station
Software Parameters	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware Upgrade	UART Download / OTA (via network) / download and write firmware via host
	Software Development	Supports Cloud Server Development / SDK for custom firmware development
	Network Protocols	IPv4, TCP/UDP/HTTP/FTP
	User Configuration	AT Instruction Set, Cloud Server, Android/iOS App



## 2. Pin Descriptions

There are altogether 22 pin counts, the definitions of which are described in Table 2 below.

**Table 2 ESP-12E Pin design**



**Table 3 Pin Descriptions**

NO.	Pin Name	Function
1	RST	Reset the module
2	ADC	A/D Conversion result. Input voltage range 0-1v, scope: 0-1024
3	EN	Chip enable pin. Active high
4	IO16	GPIO16; can be used to wake up the chipset from deep sleep mode.
5	IO14	GPIO14; HSPI_CLK
6	IO12	GPIO12; HSPI_MISO
7	IO13	GPIO13; HSPI_MOSI; UART0_CTS
8	VCC	3.3V power supply (VDD)
9	CS0	Chip selection
10	MISO	Slave output Main input



11	IO9	GPIO9
12	IO10	GPIO10
13	MOSI	Main output slave input
14	SCLK	Clock
15	GND	GND
16	IO15	GPIO15; MTDO; HSPICS; UART0_RTS
17	IO2	GPIO2; UART1_RXD
18	IO0	GPIO0
19	IO4	GPIO4
20	IO5	GPIO5
21	RXD	UART0_RXD; GPIO3
22	TXD	UART0_TXD; GPIO1

**Table 4 Pin Mode**

Mode	GPIO15	GPIO0	GPIO2
UART	Low	Low	High
Flash Boot	Low	High	High



**Table 5 Receiver Sensitivity**

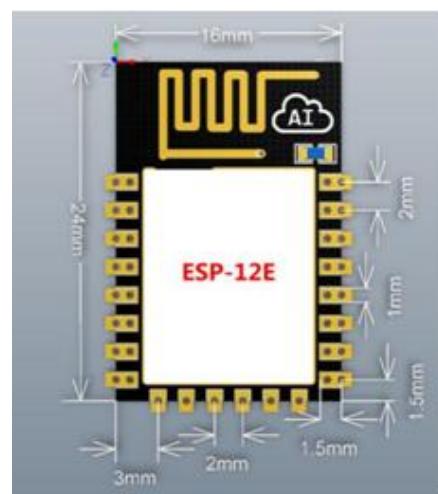
Parameters	Min	Typical	Max	Unit
Input frequency	2412		2484	MHz
Input impedance		50		$\Omega$
Input reflection			-10	dB
Output power of PA for 72.2Mbps	15.5	16.5	17.5	dBm
Output power of PA for 11b mode	19.5	20.5	21.5	dBm
Sensitivity				
DSSS, 1Mbps		-98		dBm
CCK, 11Mbps		-91		dBm
6Mbps (1/2 BPSK)		-93		dBm
54Mbps (3/4 64-QAM)		-75		dBm
HT20, MCS7 (65Mbps, 72.2Mbps)		-72		dBm
<b>Adjacent Channel Rejection</b>				
OFDM, 6Mbps		37		dB
OFDM, 54Mbps		21		dB
HT20, MCS0		37		dB
HT20, MCS7		20		dB

### 3. Packaging and Dimension

The external size of the module is 16mm\*24mm\*3mm, as is illustrated in Figure 3 below. The type of flash integrated in this module is an SPI flash, the capacity of which is 4 MB, and the package size of which is SOP-210mil. The antenna applied on this module is a 3DBi PCB-on-board antenna.



**Figure 3 [Module Pin Counts, 22 pin, 16 mm \*24 mm \*3 mm]**



**Figure 4 Top View of ESP-12E WiFi Module**



**Table 5 Dimension of ESP-12E WiFi Modul**

Length	Width	Height	PAD Size(Bottom)	Pin Pitch
16 mm	24mm	3 mm	0.9 mm x 1.7 mm	2mm

## 4. Functional Descriptions

### 4.1. MCU

ESP8266EX is embedded with Tensilica L106 32-bit micro controller (MCU), which features extra low power consumption and 16-bit RSIC. The CPU clock speed is 80MHz. It can also reach a maximum value of 160MHz. ESP8266EX is often integrated with external sensors and other specific devices through its GPIOs; codes for such applications are provided in examples in the SDK.

### 4.2. Memory Organization

#### 4.2.1. Internal SRAM and ROM

ESP8266EX WiFi SoC is embedded with memory controller, including SRAM and ROM. MCU can visit the memory units through iBus, dBus, and AHB interfaces. All memory units can be visited upon request, while a memory arbiter will decide the running sequence according to the time when these requests are received by the processor.

According to our current version of SDK provided, SRAM space that is available to users is assigned as below:

- RAM size < 36kB, that is to say, when ESP8266EX is working under the station mode and is connected to the router, programmable space accessible to user in heap and data section is around 36kB.)
- There is no programmable ROM in the SoC, therefore, user program must be stored in an external SPI flash.

#### 4.2.2. External SPI Flash

This module is mounted with an 4 MB external SPI flash to store user programs. If larger definable storage space is required, a SPI flash with larger memory size is preferred. Theoretically speaking, up to 16 MB memory capacity can be supported.

##### Suggested SPI Flash memory capacity:

- OTA is disabled: the minimum flash memory that can be supported is 512 kB;
  - OTA is enabled: the minimum flash memory that can be supported is 1 MB.
- Several SPI modes can be supported, including Standard SPI, Dual SPI, and Quad SPI.



Therefore, please choose the correct SPI mode when you are downloading into the flash, otherwise firmwares/programs that you downloaded may not work in the right way.

### 4.3. Crystal

Currently, the frequency of crystal oscillators supported include 40MHz, 26MHz and 24MHz. The accuracy of crystal oscillators applied should be  $\pm 10\text{PPM}$ , and the operating temperature range should be between -20°C and 85°C.

When using the downloading tools, please remember to select the right crystal oscillator type. In circuit design, capacitors C1 and C2, which are connected to the earth, are added to the input and output terminals of the crystal oscillator respectively. The values of the two capacitors can be flexible, ranging from 6pF to 22pF, however, the specific capacitive values of C1 and C2 depend on further testing and adjustment on the overall performance of the whole circuit. Normally, the capacitive values of C1 and C2 are within 10pF if the crystal oscillator frequency is 26MHz, while the values of C1 and C2 are 10pF<C1, C2<22pF if the crystal oscillator frequency is 40MHz.

### 4.4. Interfaces

**Table 6 Descriptions of Interfaces**

Interface	Pin Name	Description
HSPI	IO12(MISO) IO13(MOSI) IO14(CLK) IO15(CS)	SPI Flash 2, display screen, and MCU can be connected using HSPI interface.
PWM	IO12(R) IO15(G) IO13(B)	Currently the PWM interface has four channels, but users can extend the channels according to their own needs. PWM interface can be used to control LED lights, buzzers, relays, electronic machines, and so on.
IR Remote Control	IO14(IR_T) IO5(IR_R)	The functionality of Infrared remote control interface can be implemented via software programming. NEC coding, modulation, and demodulation are used by this interface. The frequency of modulated carrier signal is 38KHz.
ADC	TOUT	ESP8266EX integrates a 10-bit analog ADC. It can be used to test the power-supply voltage of VDD3P3 (Pin3 and Pin4) and the input power voltage of TOUT (Pin 6). However, these two functions cannot be used simultaneously. This interface is typically used in sensor products.
I2C	IO14(SCL) IO2(SDA)	I2C interface can be used to connect external sensor products and display screens, etc.



Interface	Pin Name	Description
UART	<b>UART0:</b> TXD (U0TXD) RXD (U0RXD) IO15 (RTS) IO13 (CTS) <b>UART1:</b> IO2(TXD)	Devices with UART interfaces can be connected with the module. Downloading: U0TXD+U0RXD or GPIO2+U0RXD Communicating: UART0: U0TXD, U0RXD, MTDO (U0RTS), MTCK (U0CTS) Debugging: UART1_TXD (GPIO2) can be used to print debugging information.  By default, UART0 will output some printed information when the device is powered on and is booting up. If this issue exerts influence on some specific applications, users can exchange the inner pins of UART when initializing, that is to say, exchange U0TXD, U0RXD with U0RTS, U0CTS.
I2S	<b>I2S Input:</b> IO12 (I2SI_DATA); IO13 (I2SI_BCK); IO14 (I2SI_WS); <b>I2S Output:</b> IO15 (I2SO_BCK); IO3 (I2SO_DATA); IO2 (I2SO_WS).	I2S interface is mainly used for collecting, processing, and transmission of audio data.



## 4.5. Absolute Maximum Ratings

**Table 7 Absolute Maximum Ratings**

Rating	Condition	Value	Unit
Storage Temperature		-40 to 125	°C
Maximum Soldering Temperature		260	°C
Supply Voltage	IPC/JEDEC J-STD-020	+3.0 to +3.6	V

## 4.6. Recommended Operating Conditions

**Table 8 Recommended Operating Conditions**

Operating Condition	Symbol	Min	Typ	Max	Unit
Operating Temperature		-40	20	125	°C
Supply voltage	VDD	3.0	3.3	3.6	V

## 4.7. Digital Terminal Characteristics

**Table 9 Digital Terminal Characteristics**

Terminals	Symbol	Min	Typ	Max	Unit
Input logic level low	V <sub>IL</sub>	-0.3		0.25VDD	V
Input logic level high	V <sub>IH</sub>	0.75VDD		VDD+0.3	V
Output logic level low	V <sub>OL</sub>	N		0.1VDD	V
Output logic level high	V <sub>OH</sub>	0.8VDD		N	V

Note: Test conditions: VDD = 3.3V, Temperature = 20 °C, if nothing special is stated.



## 5. RF Performance

Description	Min.	Typ.	Max	Unit
Input frequency	2400		2483.5	MHz
Input impedance		50		ohm
Input reflection			-10	dB
Output power of PA for 72.2Mbps	15.5	16.5	17.5	dBm
Output power of PA for 11b mode	19.5	20.5	21.5	dBm
<b>Sensitivity</b>				
CCK, 1Mbps		-98		dBm
CCK, 11Mbps		-91		dBm
6Mbps (1/2 BPSK)		-93		dBm
54Mbps (3/4 64-QAM)		-75		dBm
HT20, MCS7 (65Mbps, 72.2Mbps)		-72		dBm
<b>Adjacent Channel Rejection</b>				
OFDM, 6Mbps		37		dB
OFDM, 54Mbps		21		dB
HT20, MCS0		37		dB
HT20, MCS7		20		dB

**Table 10 RF Performance**



## 6. Power Consumption

Parameters	Min	Typical	Max	Unit
Tx802.11b, CCK 11Mbps, P OUT=+17dBm		170		mA
Tx 802.11g, OFDM 54Mbps, P OUT =+15dBm		140		mA
Tx 802.11n, MCS7, P OUT =+13dBm		120		mA
Rx 802.11b, 1024 bytes packet length , -80dBm		50		mA
Rx 802.11g, 1024 bytes packet length, -70dBm		56		mA
Rx 802.11n, 1024 bytes packet length, -65dBm		56		mA
Modem-Sleep①		15		mA
Light-Sleep②		0.9		mA
Deep-Sleep③		10		uA

**Table 11 Power Consumption**

① Modem-Sleep requires the CPU to be working, as in PWM or I2S applications. According to 802.11 standards (like U-APSD), it saves power to shut down the Wi-Fi Modem circuit while maintaining a Wi-Fi connection with no data transmission. E.g. in DTIM3, to maintain a sleep 300ms-wake 3ms cycle to receive AP's Beacon packages, the current is about 15mA.

② During Light-Sleep, the CPU may be suspended in applications like Wi-Fi switch. Without data transmission, the Wi-Fi Modem circuit can be turned off and CPU suspended to save power according to the 802.11 standard (U-APSD). E.g. in DTIM3, to maintain a sleep 300ms-wake 3ms cycle to receive AP's Beacon packages, the current is about 0.9mA.

③ Deep-Sleep does not require Wi-Fi connection to be maintained. For application with long time lags between data transmission, e.g. a temperature sensor that checks the temperature every 100s ,sleep 300s and waking up to connect to the AP (taking about 0.3~1s), the overall average current is less than 1mA.



## 7. Reflow Profile

**Table 12 Instructions**

T <sub>S</sub> max to T <sub>L</sub> (Ramp-up Rate)	3°C/second max
Preheat	
Temperature Min.(T <sub>S</sub> Min.)	150°C
Temperature Typical.(T <sub>S</sub> Typ.)	175°C
Temperature Min.(T <sub>S</sub> Max.)	200°C
Time(T <sub>S</sub> )	60~180 seconds
Ramp-up rate (T <sub>L</sub> to T <sub>P</sub> )	3°C/second max
Time Maintained Above: --Temperature(T <sub>L</sub> )/Time(T <sub>L</sub> )	217°C/60~150 seconds
Peak Temperature(T <sub>P</sub> )	260°C max. for 10 seconds
Target Peak Temperature (T <sub>P</sub> Target)	260°C +0/-5°C
Time within 5°C of actual peak(t <sub>P</sub> )	20~40 seconds
T <sub>S</sub> max to T <sub>L</sub> (Ramp-down Rate)	6°C/second max
Tune 25°C to Peak Temperature (t)	8 minutes max



## 8. Schematics

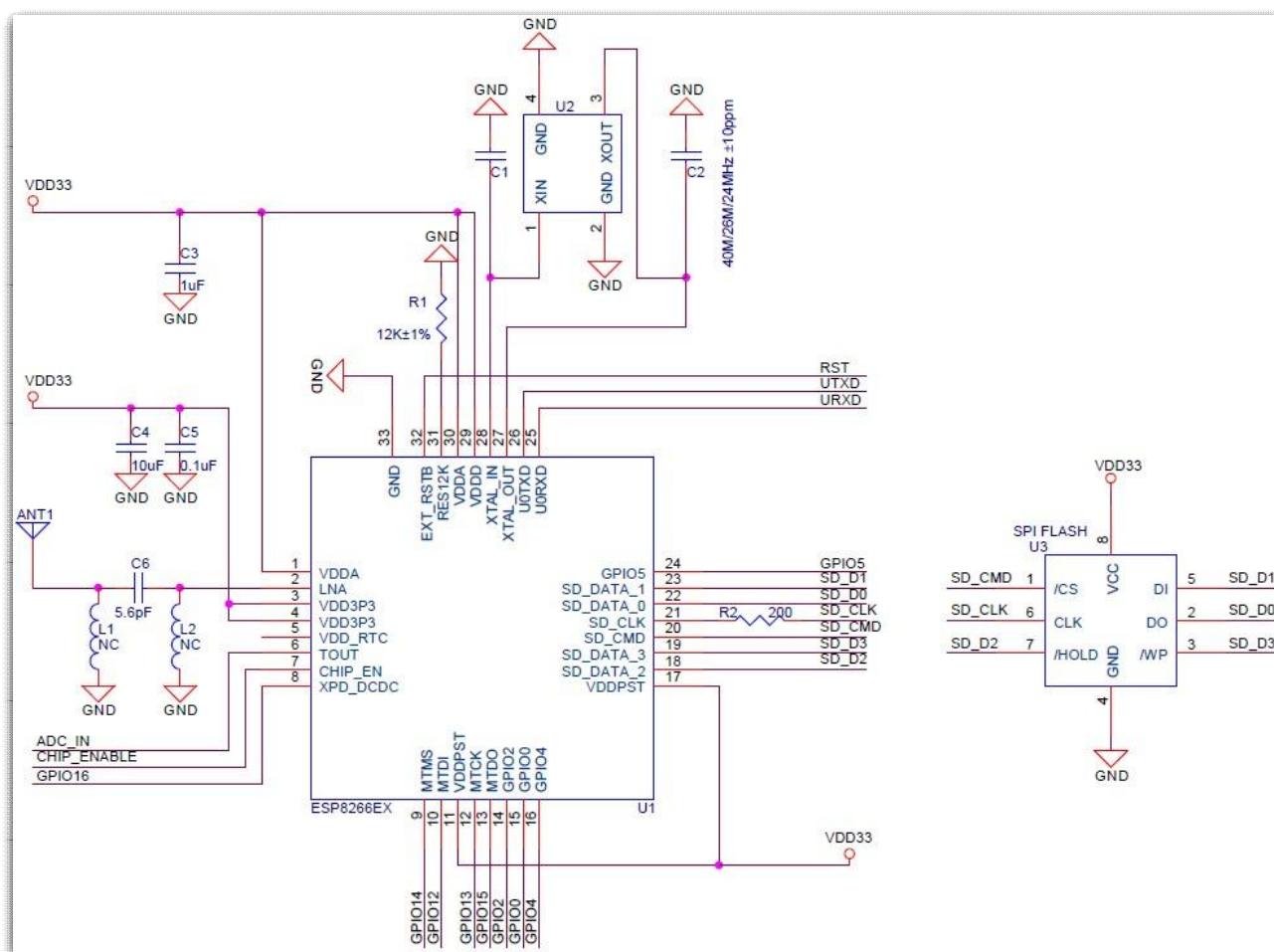


Figure 4 Schematics of Esp-12E WiFi Module

## Anexo XII. Hoja de características del termistor NTC



# **NTC thermistors for temperature measurement**

Leaded NTC thermistors,  
lead spacing 2.5 mm

**Series/Type:** B57891S

**Date:** March 2013

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**Applications**

- Temperature measurement and compensation

**Features**

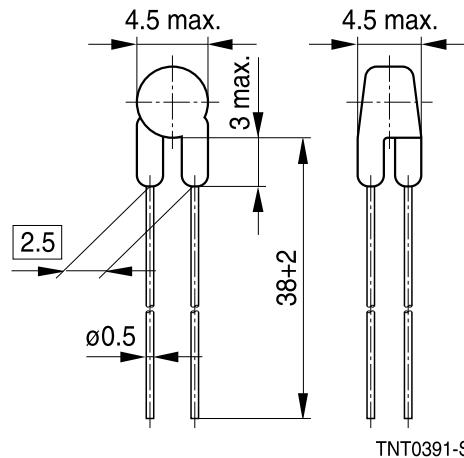
- Favorable price/ performance ratio
- Rugged design, epoxy resin encapsulation
- Leads: copper-clad Fe wire, tinned
- UL approval (E69802)

**Options**

- Lead spacing 5 mm available on request

**Delivery mode**

Bulk (standard), cardboard tape, reeled or in  
Ammo pack on request

**Dimensional drawing**

TNT0391-S

Dimensions in mm

Approx. weight 0.2 g

**General technical data**

Climatic category	(IEC 60068-1)		55/155/56	
Max. power	(at 25 °C)	P <sub>25</sub>	200	mW
Resistance tolerance		ΔR <sub>R</sub> /R <sub>R</sub>	±1, ±3, ±5	%
Rated temperature		T <sub>R</sub>	25	°C
Dissipation factor	(in air)	δ <sub>th</sub>	approx. 4	mW/K
Thermal cooling time constant	(in air)	τ <sub>c</sub>	approx. 15	s
Heat capacity		C <sub>th</sub>	approx. 60	mJ/K

**Electrical specification and ordering codes**

R <sub>25</sub> Ω	No. of R/T characteristic	B <sub>25/100</sub> K	Ordering code
2.2 k	1008	3560 ±1.5%	B57891S0222+008
5 k	2003	3980 ±1%	B57891S0502+008
10 k	4901	3950 ±1%	B57891S0103+008
20 k	2904	4300 ±1%	B57891S0203+008
100 k	4003	4450 ±1%	B57891S0104+008

+ = Resistance tolerance

F = ±1%

H = ±3%

J = ±5%

**Reliability data**

Test	Standard	Test conditions	$\Delta R_{25}/R_{25}$ (typical)	Remarks
Storage in dry heat	IEC 60068-2-2	Storage at upper category temperature T: 155 °C t: 1000 h	< 3%	No visible damage
Storage in damp heat, steady state	IEC 60068-2-78	Temperature of air: 40 °C Relative humidity of air: 93% Duration: 56 days	< 1%	No visible damage
Rapid temperature cycling	IEC 60068-2-14	Lower test temperature: -55 °C Upper test temperature: 155 °C Number of cycles: 100	< 2%	No visible damage
Endurance		P <sub>max</sub> : 200 mW t: 1000 h	< 3%	No visible damage
Long-term stability (empirical value)		Temperature: 70 °C t: 10000 h	< 3%	No visible damage

**Note**

- Contact of NTC thermistors with any liquids and solvents shall be prevented. It must be ensured that no water enters the NTC thermistors (e.g. through plug terminals).
- Avoid dewing and condensation unless thermistor is specified for these conditions.

**R/T characteristics**

R/T No.	<b>1008</b>		<b>2003</b>		<b>2904</b>	
T (°C)	B <sub>25/100</sub> = 3560 K		B <sub>25/100</sub> = 3980 K		B <sub>25/100</sub> = 4300 K	
	R <sub>T</sub> /R <sub>25</sub>	α (%/K)	R <sub>T</sub> /R <sub>25</sub>	α (%/K)	R <sub>T</sub> /R <sub>25</sub>	α (%/K)
-55.0	53.104	6.1	97.578	7.5	121.46	7.4
-50.0	39.318	6.0	67.65	7.2	84.439	7.2
-45.0	29.325	5.8	47.538	7.0	59.243	7.1
-40.0	22.03	5.7	33.831	6.7	41.938	6.9
-35.0	16.666	5.5	24.359	6.5	29.947	6.7
-30.0	12.696	5.4	17.753	6.3	21.567	6.6
-25.0	9.7251	5.2	13.067	6.0	15.641	6.3
-20.0	7.5171	5.1	9.7228	5.8	11.466	6.2
-15.0	5.8353	4.9	7.3006	5.6	8.451	6.0
-10.0	4.5686	4.8	5.5361	5.5	6.2927	5.9
-5.0	3.605	4.7	4.2332	5.3	4.7077	5.7
0.0	2.8665	4.5	3.266	5.1	3.5563	5.5
5.0	2.2907	4.4	2.5392	5.0	2.7119	5.3
10.0	1.8438	4.3	1.9902	4.8	2.086	5.1
15.0	1.492	4.1	1.5709	4.7	1.6204	5.0
20.0	1.2154	4.0	1.2492	4.5	1.2683	4.8
25.0	1.0000	3.9	1.0000	4.4	1.0000	4.7
30.0	0.82976	3.8	0.80575	4.3	0.7942	4.6
35.0	0.68635	3.7	0.65326	4.1	0.63268	4.5
40.0	0.57103	3.6	0.5329	4.0	0.5074	4.3
45.0	0.48015	3.5	0.43715	3.9	0.41026	4.2
50.0	0.40545	3.4	0.36064	3.8	0.33363	4.1
55.0	0.3417	3.3	0.29908	3.7	0.27243	4.0
60.0	0.28952	3.2	0.24932	3.6	0.2237	3.9
65.0	0.24714	3.1	0.20886	3.5	0.18459	3.8
70.0	0.21183	3.1	0.17578	3.4	0.15305	3.7
75.0	0.18194	3.0	0.14863	3.3	0.12755	3.6
80.0	0.1568	2.9	0.12621	3.2	0.10677	3.5
85.0	0.13592	2.8	0.10763	3.1	0.089928	3.4
90.0	0.11822	2.8	0.092159	3.1	0.076068	3.3
95.0	0.1034	2.7	0.079225	3.0	0.064524	3.3
100.0	0.090741	2.6	0.068356	2.9	0.054941	3.2
105.0	0.079642	2.6	0.059247	2.8	0.047003	3.1
110.0	0.070102	2.5	0.051531	2.8	0.040358	3.0
115.0	0.061889	2.4	0.044921	2.7	0.034743	3.0
120.0	0.054785	2.4	0.039282	2.7	0.030007	2.9
125.0	0.048706	2.3	0.034387	2.6	0.026006	2.8
130.0	0.043415	2.3	0.030186	2.5	0.022609	2.8
135.0	0.038722	2.2	0.02665	2.5	0.01972	2.7
140.0	0.034615	2.2	0.023594	2.4	0.017251	2.6
145.0	0.031048	2.1	0.020931	2.4	0.015139	2.6
150.0	0.02791	2.1	0.018616	2.3	0.013321	2.5
155.0	0.025193	2.0	0.016612	2.3	0.011754	2.5

R/T No.	<b>1008</b>		<b>2003</b>		<b>2904</b>	
T (°C)	$B_{25/100} = 3560 \text{ K}$		$B_{25/100} = 3980 \text{ K}$		$B_{25/100} = 4300 \text{ K}$	
	$R_T/R_{25}$	$\alpha (\%/\text{K})$	$R_T/R_{25}$	$\alpha (\%/\text{K})$	$R_T/R_{25}$	$\alpha (\%/\text{K})$
160.0	0.02279	2.0	—	—	—	—
165.0	0.020667	2.0	—	—	—	—
170.0	0.01878	1.9	—	—	—	—
175.0	0.01709	1.9	—	—	—	—
180.0	0.015582	1.8	—	—	—	—
185.0	0.014227	1.8	—	—	—	—
190.0	0.013012	1.8	—	—	—	—
195.0	0.011934	1.7	—	—	—	—
200.0	0.010964	1.7	—	—	—	—
205.0	0.0101	1.7	—	—	—	—
210.0	0.0093191	1.6	—	—	—	—
215.0	0.0085949	1.6	—	—	—	—
220.0	0.0079384	1.6	—	—	—	—
225.0	0.0073411	1.5	—	—	—	—
230.0	0.006798	1.5	—	—	—	—
235.0	0.0063087	1.5	—	—	—	—
240.0	0.0058623	1.5	—	—	—	—
245.0	0.0054487	1.4	—	—	—	—
250.0	0.0050705	1.4	—	—	—	—

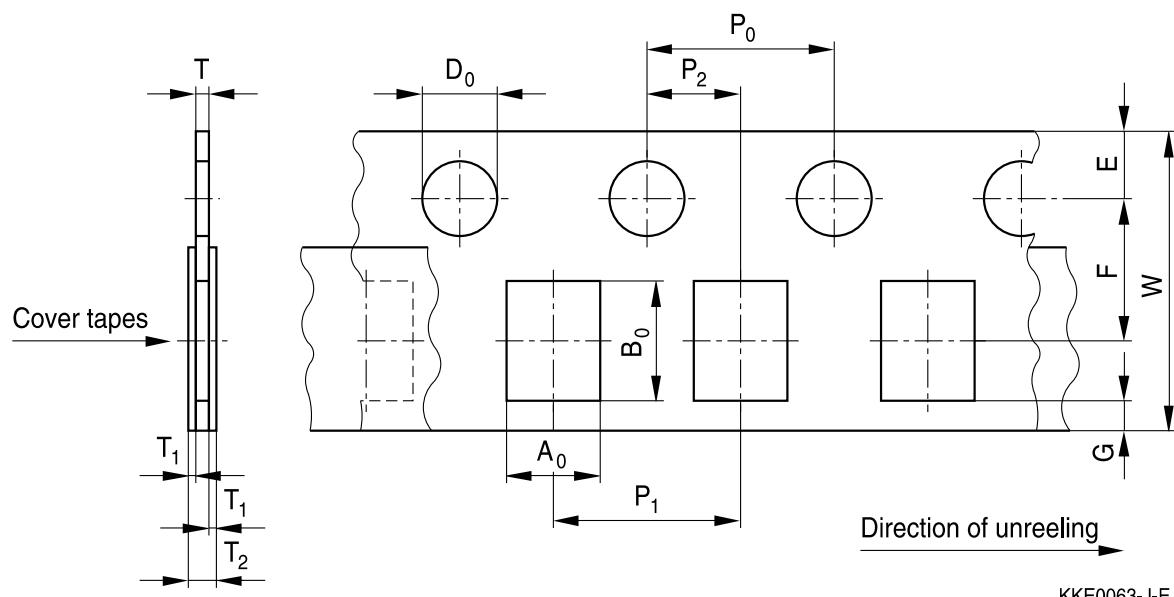
**R/T characteristics**

R/T No.	4003		4901	
T (°C)	$B_{25/100} = 4450\text{ K}$		$B_{25/100} = 3950\text{ K}$	
	$R_T/R_{25}$	$\alpha\text{ (%/K)}$	$R_T/R_{25}$	$\alpha\text{ (%/K)}$
-55.0	103.81	6.8	87.89	7.1
-50.0	73.707	6.7	61.759	6.9
-45.0	52.723	6.6	43.934	6.7
-40.0	37.988	6.5	31.618	6.5
-35.0	27.565	6.4	23.006	6.3
-30.0	20.142	6.2	16.915	6.1
-25.0	14.801	6.1	12.555	5.9
-20.0	10.976	5.9	9.4143	5.7
-15.0	8.1744	5.8	7.1172	5.5
-10.0	6.1407	5.7	5.4308	5.4
-5.0	4.6331	5.5	4.1505	5.2
0.0	3.5243	5.4	3.2014	5.0
5.0	2.6995	5.3	2.5011	4.9
10.0	2.0831	5.1	1.9691	4.7
15.0	1.6189	5.0	1.5618	4.6
20.0	1.2666	4.9	1.2474	4.5
25.0	1.0000	4.7	1.0000	4.3
30.0	0.78351	4.6	0.808	4.2
35.0	0.62372	4.5	0.6569	4.1
40.0	0.49937	4.4	0.5372	4.0
45.0	0.40218	4.3	0.44235	3.9
50.0	0.32557	4.2	0.3661	3.8
55.0	0.26402	4.1	0.30393	3.7
60.0	0.21527	4.0	0.25359	3.6
65.0	0.17693	3.9	0.21283	3.5
70.0	0.14616	3.8	0.17942	3.4
75.0	0.12097	3.7	0.15183	3.3
80.0	0.10053	3.7	0.12901	3.2
85.0	0.083761	3.6	0.11002	3.1
90.0	0.070039	3.5	0.094179	3.1
95.0	0.058937	3.4	0.080896	3.0
100.0	0.049777	3.4	0.069722	2.9
105.0	0.042146	3.3	0.060397	2.9
110.0	0.035803	3.2	0.052493	2.8
115.0	0.030504	3.2	0.045733	2.7
120.0	0.026067	3.1	0.039963	2.7
125.0	0.022332	3.0	0.035059	2.6
130.0	0.019186	3.0	0.030844	2.6
135.0	0.016515	2.9	0.027192	2.5
140.0	0.014253	2.9	0.024034	2.4
145.0	0.012367	2.8	0.021285	2.4
150.0	0.010758	2.8	0.018895	2.4
155.0	0.0093933	2.7	0.016813	2.3

## Taping and packing

### 1 Taping of SMD NTC thermistors

#### 1.1 Cardboard tape for case size 0402 and 0603 (taping to IEC 60286-3)

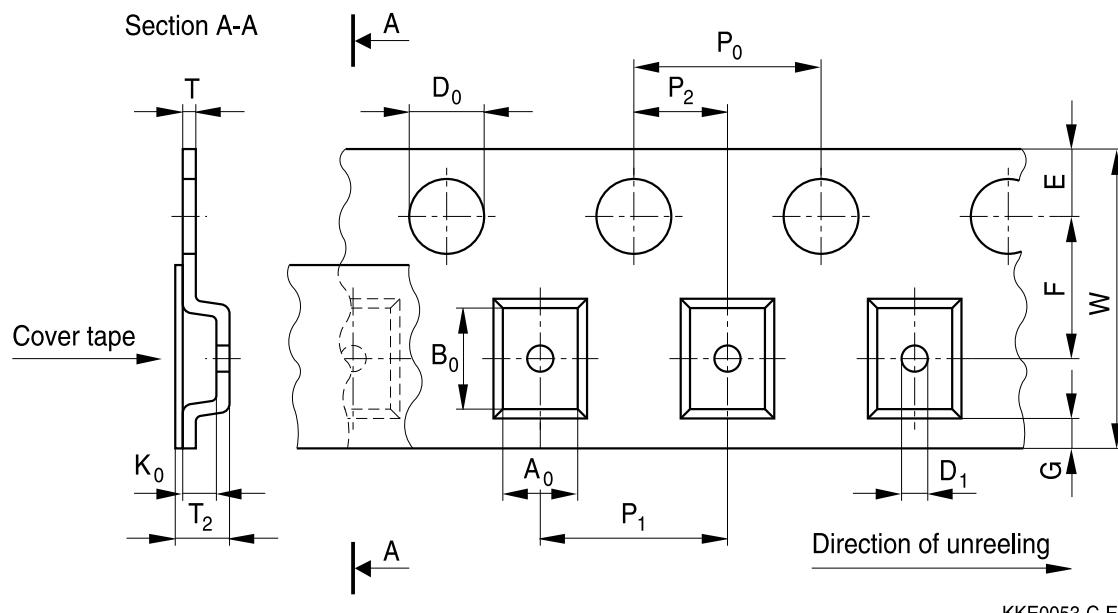


### Dimensions (mm)

	Case size 0402 (8-mm tape)	Case size 0603 (8-mm tape)	Tolerance
A <sub>0</sub> × B <sub>0</sub>	0.60 × 1.15	0.95 × 1.80	±0.2
T <sub>2</sub>	0.70	1.10	
T	0.60	0.90	max.
D <sub>0</sub>	1.50	1.50	±0.10
P <sub>0</sub>	4.00	4.00	±0.10 <sup>1)</sup>
P <sub>2</sub>	2.00	2.00	±0.05
P <sub>1</sub>	2.00	4.00	±0.10
W	8.00	8.00	±0.30
E	1.75	1.75	±0.10
F	3.50	3.50	±0.05
G	0.75	0.75	min.

1) ≤0.2 mm over 10 sprocket holes.

### 1.2 Blister tape for case size 0805 and 1206 (taping to IEC 60286-3)

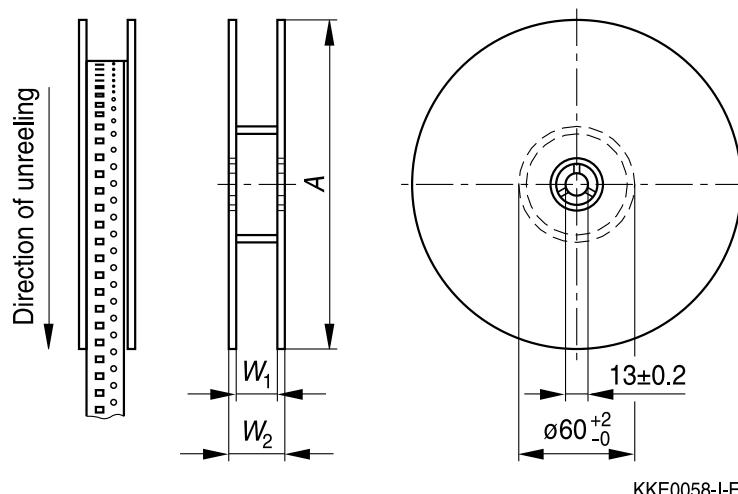


#### Dimensions (mm)

	Case size 0805 (8-mm tape)	Case size 1206 (8-mm tape)	Tolerance
A <sub>0</sub> × B <sub>0</sub>	1.60 × 2.40	1.90 × 3.50	±0.2
K <sub>0</sub>	1.40	1.40	max.
T <sub>2</sub>	2.5	2.5	max.
D <sub>0</sub>	1.50	1.50	+0.10/-0
D <sub>1</sub>	1.00	1.00	min.
P <sub>0</sub>	4.00	4.00	±0.10 <sup>2)</sup>
P <sub>2</sub>	2.00	2.00	±0.05
P <sub>1</sub>	4.00	4.00	±0.10
W	8.00	8.00	±0.30
E	1.75	1.75	±0.10
F	3.50	3.50	±0.05
G	0.75	0.75	min.

2) ≤0.2 mm over 10 sprocket holes.

### 1.3 Reel packing



### Packing survey

Case size	Chip thick- ness <sup>3)</sup> mm	8-mm tape		Reel dimensions mm						Packing units pcs./reel	
		Blister	Card- board	A	Tol.	W1	Tol.	W2	180-mm reel	330-mm reel	
0402	0.5		x	180	-3/+0	8.4	+1.5/-0	14.4 max.	10000	—	
0603	0.8		x	180	-3/+0	8.4	+1.5/-0	14.4 max.	4000	—	
				330	±2.0	12.4	+1.5/-0	18.4 max.	—	16000	
0805	0.8	x		180	-3/+0	8.4	+1.5/-0	14.4 max.	4000	16000	
	1.2	x		330	±2.0	12.4	+1.5/-0	18.4 max.	3000	12000	
1206	0.8	x		180	-2/+0	8.4	+1.5/-0	14.4 max.	4000	—	
	1.2	x		180	-2/+0	8.4	+1.5/-0	14.4 max.	2000	—	

### 2 Packing codes

The last two digits of the complete ordering code state the packing mode:

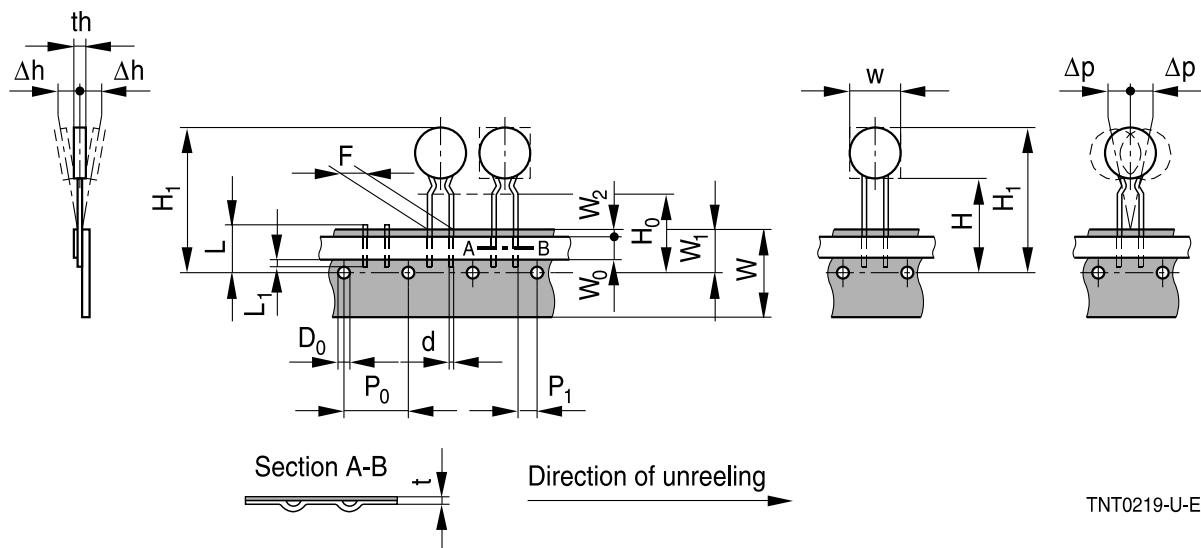
Last two digits			
60	SMD	Cardboard tape	180-mm reel packing
62	SMD	Blister tape	180-mm reel packing
70	SMD	Cardboard tape	330-mm reel packing
72	SMD	Blister tape	330-mm reel packing

3) Chip thickness depends on the resistance value.

### 3 Taping of radial leaded NTC thermistors

#### Dimensions and tolerances

Lead spacing F = 2.5 mm and 5.0 mm (taping to IEC 60286-2)

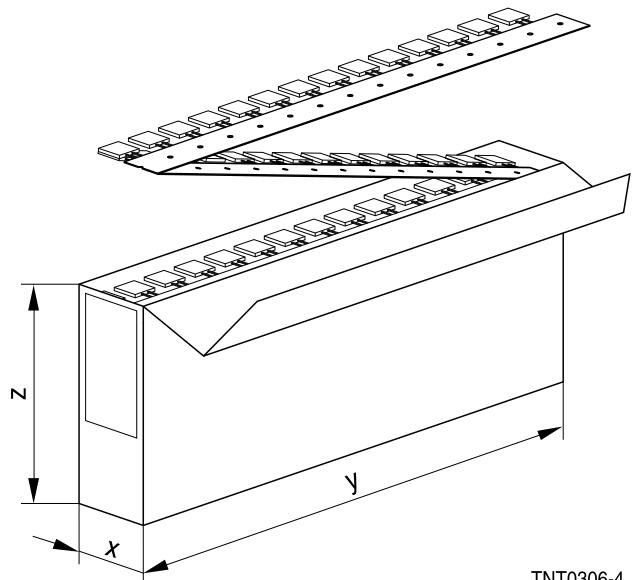


#### Dimensions (mm)

	Lead spacing 2.5 mm	Lead spacing 5 mm	Tolerance of lead spacing 2.5/5 mm	Remarks
w	11.0	11.5	max.	
th	5.0	6.0	max.	
d	0.5/0.6	0.5/0.6	±0.05	
P <sub>0</sub>	12.7	12.7	±0.3	±1 mm / 20 sprocket holes
P <sub>1</sub>	5.1	3.85	±0.7	
F	2.5	5.0	+0.6/-0.1	
Δh	0	0	±2.0	measured at top of component body
Δp	0	0	±1.3	
W	18.0	18.0	±0.5	
W <sub>0</sub>	5.5	5.5	min.	peel-off force ≥5 N
W <sub>1</sub>	9.0	9.0	+0.75/-0.5	
W <sub>2</sub>	3.0	3.0	max.	
H	18.0	18.0	+2.0/-0	
H <sub>0</sub>	16.0	16.0	±0.5	
H <sub>1</sub>	32.2	32.2	max.	
D <sub>0</sub>	4.0	4.0	±0.2	
t	0.9	0.9	max.	without wires
L	11.0	11.0	max.	
L <sub>1</sub>	4.0	4.0	max.	

### Types of packing

Ammo packing

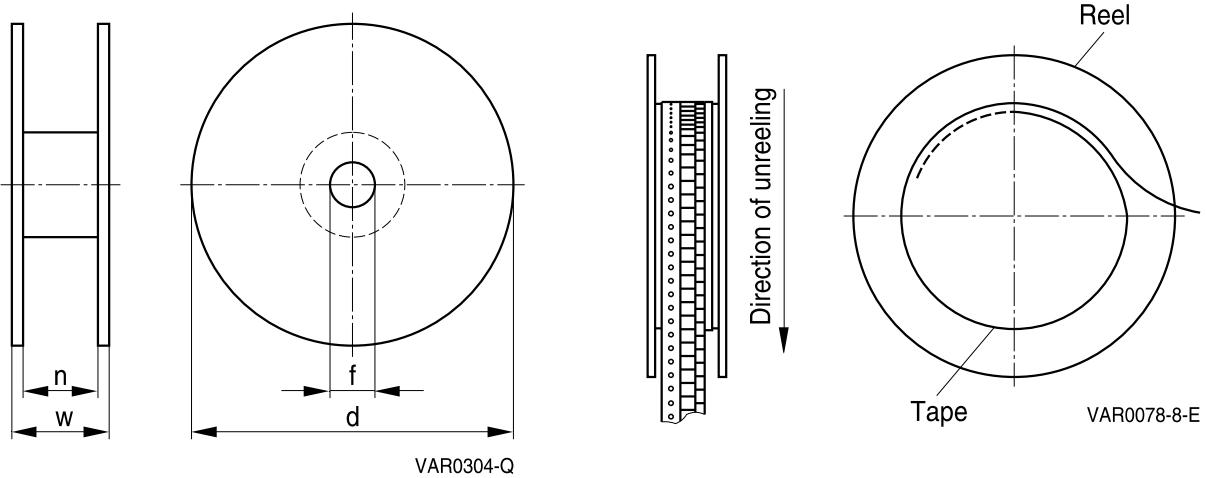


TNT0306-4

Ammo type	x	y	z
I	80	240	210

**Packing unit:** 1000 - 2000 pcs./reel

Reel packing

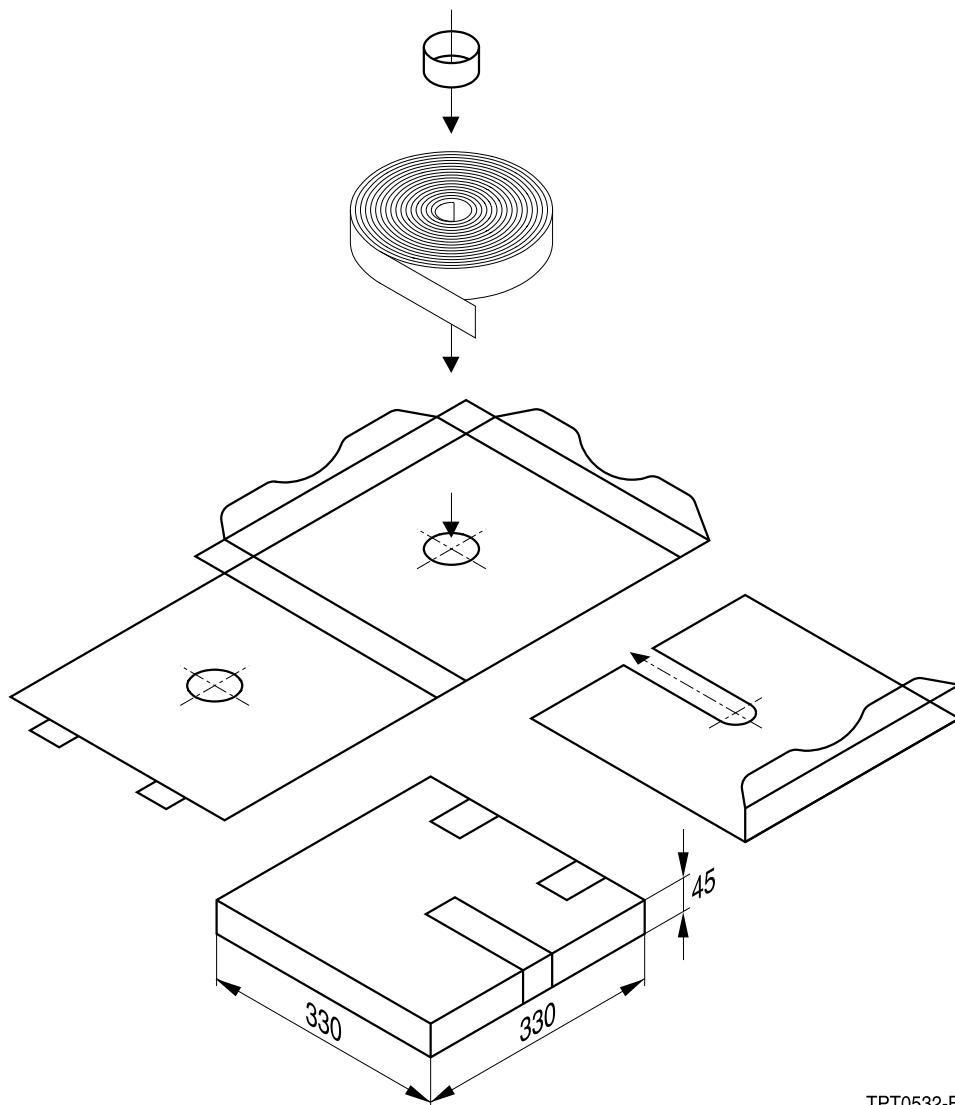


**Packing unit:** 1000 - 2000 pcs./reel

**Reel dimensions (in mm)**

Reel type	d	f	n	w
I	360 max.	$31 \pm 1$	approx. 45	54 max.
II	500 max.	$23 \pm 1$	approx. 59	72 max.

Cassette packing



**Packing unit:** 1000 - 2000 pcs./cassette

**Bulk packing**

The components are packed in cardboard boxes, the size of which depends on the order quantity.

#### 4 Packing codes

The last two digits of the complete ordering code state the packing mode:

Last two digits			
00, 01, 02, 03, 04, 05, 06, 07, 08	—	Bulk	—
40	—	Bulk	—
45	—	Bulk	—
50	Radial leads, kinked	Cardboard tape	Cassette packing
51	Radial leads, kinked	Cardboard tape	360 or 500-mm reel packing
52	Radial leads, straight	Cardboard tape	Cassette packing
53	Radial leads, straight	Cardboard tape	360 or 500-mm reel packing
54	Radial leads, kinked	Cardboard tape	AMMO packing
55	Radial leads, straight	Cardboard tape	AMMO packing

(If no packing code is indicated, this corresponds to 40)

Example 1: B57164K0102J000      Bulk  
              B57164K0102J052      Cardboard tape, cassette packing

Example 2: B57881S0103F002      Bulk  
              B57881S0103F251      Cardboard tape, reel packing

## Mounting instructions

### 1 Soldering

#### 1.1 Leaded NTC thermistors

Leaded thermistors comply with the solderability requirements specified by CECC.

When soldering, care must be taken that the NTC thermistors are not damaged by excessive heat. The following maximum temperatures, maximum time spans and minimum distances have to be observed:

	Dip soldering	Iron soldering
Bath temperature	max. 260 °C	max. 360 °C
Soldering time	max. 4 s	max. 2 s
Distance from thermistor	min. 6 mm	min. 6 mm

Under more severe soldering conditions the resistance may change.

#### 1.2 Leadless NTC thermistors

In case of NTC thermistors without leads, soldering is restricted to devices which are provided with a solderable metallization. The temperature shock caused by the application of hot solder may produce fine cracks in the ceramic, resulting in changes in resistance.

To prevent leaching of the metallization, solder with silver additives or with a low tin content should be used. In addition, soldering methods should be employed which permit short soldering times.

#### 1.3 SMD NTC thermistors

SMD NTC thermistors can be provided with a nickel barrier termination or on special request with silver-palladium termination. The usage of mild, non-activated fluxes for soldering is recommended as well as a proper cleaning of the PCB.

##### ■ Nickel barrier termination

The nickel barrier layer of the silver/nickel/tin termination (see figure 1) prevents leaching of the silver base metalization layer. This allows great flexibility in the selection of soldering parameters.

The tin prevents the nickel layer from oxidizing and thus ensures better wetting by the solder. The nickel barrier termination is suitable for all commonly-used soldering methods.

**Note:** SMD NTCs with AgPd termination are not approved for lead-free soldering.

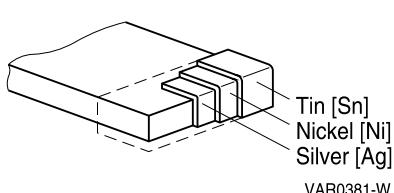


Figure 1

SMD NTC thermistors, structure of nickel barrier termination

### 1.3.1 Solderability (test to IEC 60068-2-58)

Preconditioning: Immersion into flux F-SW 32.

Evaluation criterion: Wetting of soldering areas  $\geq 95\%$ .

Solder	Bath temperature (°C)	Dwell time (s)
SnPb 60/40	215 $\pm 3$	3 $\pm 0.3$
SnAg (3.0 ... 4.0), Cu (0.5 ... 0.9)	245 $\pm 3$	3 $\pm 0.3$

### 1.3.2 Resistance to soldering heat (test to IEC 60068-2-58)

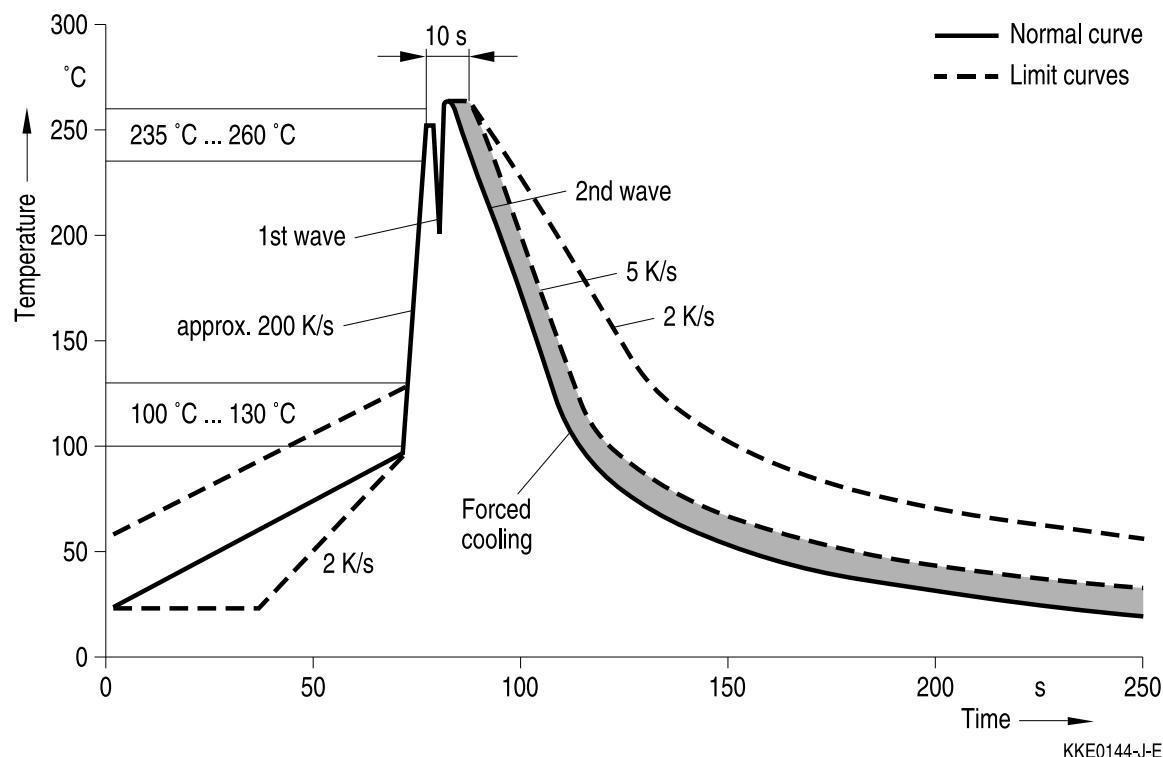
Preconditioning: Immersion into flux F-SW 32.

Evaluation criterion: Leaching of side edges  $\leq 1/3$ .

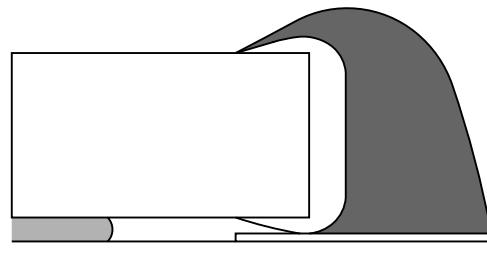
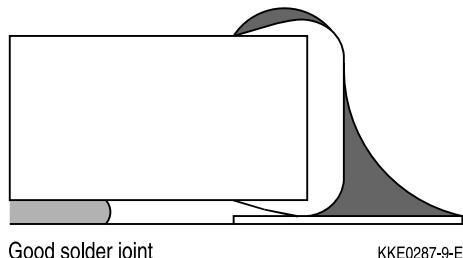
Solder	Bath temperature (°C)	Dwell time (s)
SnPb 60/40	260 $\pm 5$	10 $\pm 1$
SnAg (3.0 ... 4.0), Cu (0.5 ... 0.9)	260 $\pm 5$	10 $\pm 1$

## Wave soldering

Temperature characteristic at component terminal with dual wave soldering

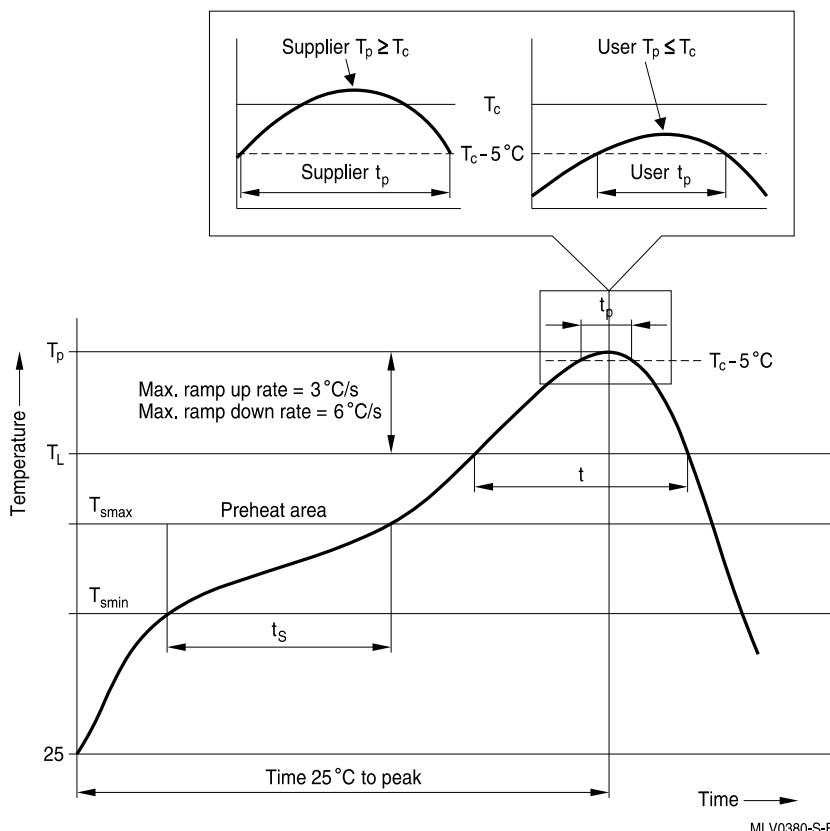


Solder joint profiles for silver/nickel/tin terminations



## Reflow soldering

Recommended temperature characteristic for reflow soldering following JEDEC J-STD-020D



Profile feature		Sn-Pb eutectic assembly	Pb-free assembly
Preheat and soak			
- Temperature min	$T_{smin}$	100 °C	150 °C
- Temperature max	$T_{smax}$	150 °C	200 °C
- Time	$t_{smin}$ to $t_{smax}$	60 ... 120 s	60 ... 180 s
Average ramp-up rate	$T_{smax}$ to $T_p$	3 °C/ s max.	3 °C/ s max.
Liquidous temperature	$T_L$	183 °C	217 °C
Time at liquidous	$t_L$	60 ... 150 s	60 ... 150 s
Peak package body temperature	$T_p$ <sup>1)</sup>	220 °C ... 235 °C <sup>2)</sup>	245 °C ... 260 °C <sup>2)</sup>
Time ( $t_p$ ) <sup>3)</sup> within 5 °C of specified classification temperature ( $T_c$ )		20 s <sup>3)</sup>	30 s <sup>3)</sup>
Average ramp-down rate	$T_p$ to $T_{smax}$	6 °C/ s max.	6 °C/ s max.
Time 25 °C to peak temperature		maximum 6 min	maximum 8 min

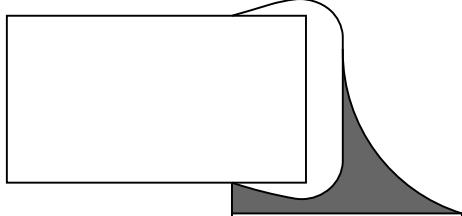
1) Tolerance for peak profile temperature ( $T_p$ ) is defined as a supplier minimum and a user maximum.

2) Depending on package thickness. For details please refer to JEDEC J-STD-020D.

3) Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum.

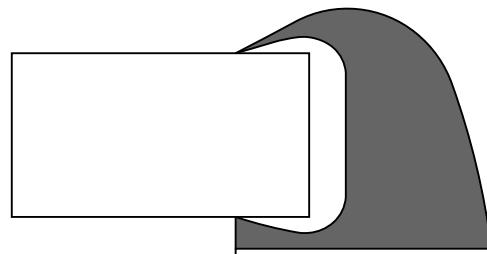
**Note:** All temperatures refer to topside of the package, measured on the package body surface.  
Number of reflow cycles: 3

Solder joint profiles for silver/nickel/tin terminations



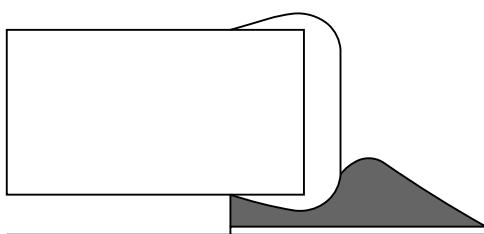
Good solder joint

TNT0565-G-E



Too much solder  
Pad geometry too large

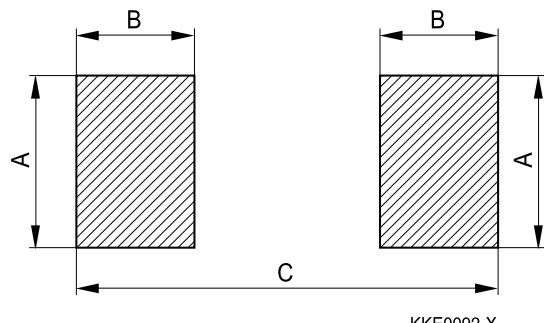
KKE0071-A-E



Poor wetting

KKE0072-I-E

### 1.3.3 Recommended geometry of solder pads



KKE0092-X

Recommended maximum dimensions (mm)

Case size inch/mm	A	B	C
0402/1005	0.6	0.6	1.7
0603/1608	1.0	1.0	3.0
0805/2012	1.3	1.2	3.4
1206/3216	1.8	1.2	4.5

### 1.3.4 Notes

Iron soldering should be avoided, hot air methods are recommended for repair purposes.

## 2 Conductive adhesion

An alternative to soldering is the gluing of thermistors with conductive adhesives. The benefit of this method is that it involves no thermal stress. The adhesives used must be chemically inert.

## 3 Clamp contacting

Pressure contacting by means of clamps is particularly suitable for applications involving frequent switching and high turn-on powers.

## 4 Robustness of terminations (leaded types)

The leads meet the requirements of IEC 60068-2-21. They may not be bent closer than 4 mm from the solder joint on the thermistor body or from the point at which they leave the feed-throughs. During bending, any mechanical stress at the outlet of the leads must be removed. The bending radius should be at least 0.75 mm.

Tensile strength: Test Ua1:

Leads	$\emptyset \leq 0.25 \text{ mm}$ =	1.0 N
	$0.25 < \emptyset \leq 0.35 \text{ mm}$ =	2.5 N
	$0.35 < \emptyset \leq 0.50 \text{ mm}$ =	5.0 N
	$0.50 < \emptyset \leq 0.80 \text{ mm}$ =	10.0 N
	$0.80 < \emptyset \leq 1.25 \text{ mm}$ =	20.0 N

Bending strength: Test Ub:

Two 90°-bends in opposite directions at a weight of 0.25 kg.

Torsional strength: Test Uc: severity 2

The lead is bent by 90° at a distance of 6 to 6.5 mm from the thermistor body.

The bending radius of the leads should be approx. 0.75 mm. Two torsions of 180° each (severity 2).

When subjecting leads to mechanical stress, the following should be observed:

### *Tensile stress on leads*

During mounting and operation tensile forces on the leads are to be avoided.

### *Bending of leads*

Bending of the leads directly on the thermistor body is not permissible.

A lead may be bent at a minimum distance of twice the wire's diameter +2 mm from the solder joint on the thermistor body. During bending the wire must be mechanically relieved at its outlet. The bending radius should be at least 0.75 mm.

### *Twisting of leads*

The twisting (torsion) by 180° of a lead bent by 90° is permissible at 6 mm from the bottom of the thermistor body.

## 5 Sealing and potting

When thermistors are sealed, potted or overmolded, there must be no mechanical stress caused by thermal expansion during the production process (curing / overmolding process) and during later operation. The upper category temperature of the thermistor must not be exceeded. Ensure that the materials used (sealing / potting compound and plastic material) are chemically neutral.

## 6 Cleaning

Washing processes may damage the product due to the possible static or cyclic mechanical loads (e.g. ultrasonic cleaning). They may cause cracks to develop on the product and its parts, which might lead to reduced reliability or lifetime.

## 7 Storage

In order to maintain their solderability, thermistors must be stored in a non-corrosive atmosphere. Humidity, temperature and container materials are critical factors.

Do not store SMDs where they are exposed to heat or direct sunlight. Otherwise, the packing material may be deformed or SMDs may stick together, causing problems during mounting. After opening the factory seals, such as polyvinyl-sealed packages, use the SMDs as soon as possible.

The components should be left in the original packing. Touching the metallization of unsoldered thermistors may change their soldering properties.

Storage temperature: -25 °C up to 45 °C

Relative humidity (without condensation): ≤75% annual mean

<95%, maximum 30 days per annum

Solder the thermistors listed in this data book after shipment from EPCOS within the time specified:

SMDs with nickel barrier termination: 12 months

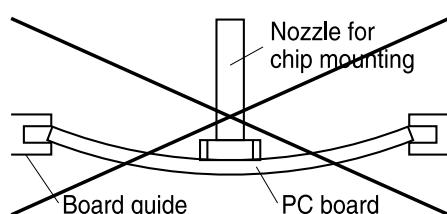
SMDs with AgPd termination: 6 months

Leaded components: 24 months

## 8 Placement and orientation of SMD NTC thermistors on PCB

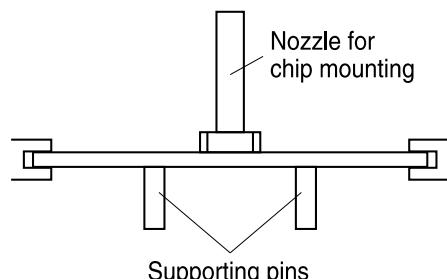
### a) Component placement

**Incorrect**



It is recommended that the PC board should be held by means of some adequate supporting pins such as shown left to prevent the SMDs from being damaged or cracked.

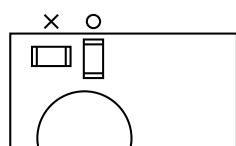
**Correct**



KKE0267-U-E

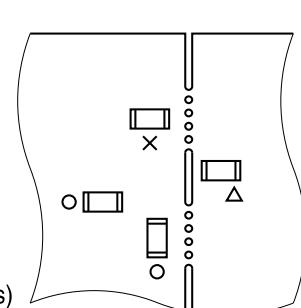
### b) Cracks

SMDs located near an easily warped area



○ = correct  
X = incorrect  
△ = incorrect  
(under certain conditions)

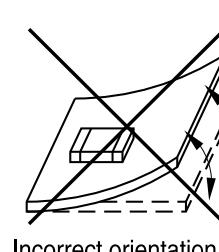
SMD breakage probability due to stress at a breakaway



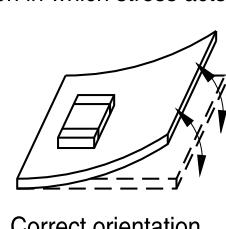
KKE0268-3-E

When placing a component near an area which is apt to bend or a grid groove on the PC board, it is advisable to have both electrodes subjected to uniform stress, or to position the component's electrodes at right angles to the grid groove or bending line (see c) Component orientation).

### c) Component orientation



Locate chip horizontal to the direction in which stress acts



KKE0269-B-E

Choose a mounting position that minimizes the stress imposed on the chip during flexing or bending of the board.

## Cautions and warnings

See "Important notes".

### Storage

- Store thermistors only in original packaging. Do not open the package prior to storage.
- Storage conditions in original packaging: storage temperature  $-25^{\circ}\text{C}$  ...  $+45^{\circ}\text{C}$ , relative humidity  $\leq 75\%$  annual mean,  $< 95\%$  maximum 30 days per annum, dew precipitation is inadmissible.
- Do not store thermistors where they are exposed to heat or direct sunlight. Otherwise, the packing material may be deformed or components may stick together, causing problems during mounting.
- Avoid contamination of thermistor surface during storage, handling and processing.
- Avoid storage of thermistors in harmful environments like corrosive gases ( $\text{SO}_x$ ,  $\text{Cl}$  etc.).
- Use the components as soon as possible after opening the factory seals, i.e. the polyvinyl-sealed packages.
- Solder thermistors within the time specified after shipment from EPCOS.  
For leaded components this is 24 months, for SMD components with nickel barrier termination 12 months, for SMD components with AgPd termination 6 months.

### Handling

- NTC thermistors must not be dropped. Chip-offs or any other damage must not be caused during handling of NTCs.
- Do not touch components with bare hands. Gloves are recommended.
- Avoid contamination of thermistor surface during handling.
- Washing processes may damage the product due to the possible static or cyclic mechanical loads (e.g. ultrasonic cleaning). They may cause cracks to develop on the product and its parts, which might lead to reduced reliability or lifetime.

### Bending / twisting leads

- A lead (wire) may be bent at a minimum distance of twice the wire's diameter plus 4 mm from the component head or housing. When bending ensure the wire is mechanically relieved at the component head or housing. The bending radius should be at least 0.75 mm.
- Twisting (torsion) by  $180^{\circ}$  of a lead bent by  $90^{\circ}$  is permissible at 6 mm from the bottom of the thermistor body.

### Soldering

- Use resin-type flux or non-activated flux.
- Insufficient preheating may cause ceramic cracks.
- Rapid cooling by dipping in solvent is not recommended.
- Complete removal of flux is recommended.

## Mounting

- Ensure that no thermo-mechanical stress occurs due to production processes (curing or overmolding processes) when thermistors are sealed, potted or overmolded or during their subsequent operation. The maximum temperature of the thermistor must not be exceeded. Ensure that the materials used (sealing/potting compound and plastic material) are chemically neutral.
- Electrodes/contacts must not be scratched or damaged before/during/after the mounting process.
- Contacts and housing used for assembly with the thermistor must be clean before mounting.
- Ensure that adjacent materials are designed for operation at temperatures comparable to the surface temperature of the thermistor. Be sure that surrounding parts and materials can withstand the temperature.
- Avoid contamination of the thermistor surface during processing.
- The connections of sensors (e.g. cable end, wire end, plug terminal) may only be exposed to an environment with normal atmospheric conditions.
- Tensile forces on cables or leads must be avoided during mounting and operation.
- Bending or twisting of cables or leads directly on the thermistor body is not permissible.
- Avoid using chemical substances as mounting aids. It must be ensured that no water or other liquids enter the NTC thermistors (e.g. through plug terminals). In particular, water based substances (e.g. soap suds) must not be used as mounting aids for sensors.

## Operation

- Use thermistors only within the specified operating temperature range.
- Use thermistors only within the specified power range.
- Environmental conditions must not harm the thermistors. Only use the thermistors under normal atmospheric conditions or within the specified conditions.
- Contact of NTC thermistors with any liquids and solvents shall be prevented. It must be ensured that no water enters the NTC thermistors (e.g. through plug terminals). For measurement purposes (checking the specified resistance vs. temperature), the component must not be immersed in water but in suitable liquids (e.g. Galden).
- Avoid dewing and condensation unless thermistor is specified for these conditions.
- Bending or twisting of cables and/or wires is not permissible during operation of the sensor in the application.
- Be sure to provide an appropriate fail-safe function to prevent secondary product damage caused by malfunction.

This listing does not claim to be complete, but merely reflects the experience of EPCOS AG.

## Symbols and terms

Symbol	English	German
A	Area	Fläche
AWG	American Wire Gauge	Amerikanische Norm für Drahtquerschnitte
B	B value	B-Wert
$B_{25/100}$	B value determined by resistance measurement at 25 °C and 100 °C	B-Wert, ermittelt durch Widerstandsmessungen bei 25 °C und 100 °C
$C_{th}$	Heat capacitance	Wärmekapazität
I	Current	Strom
N	Number (integer)	Anzahl (ganzzahliger Wert)
$P_{25}$	Maximum power at 25 °C	Maximale Leistung bei 25 °C
$P_{diss}$	Power dissipation	Verlustleistung
$P_{el}$	Electrical power	Elektrische Leistung
$P_{max}$	Maximum power within stated temperature range	Maximale Leistung im angegebenen Temperaturbereich
$\Delta R_B/R_B$	Resistance tolerance caused by spread of B value	Widerstandstoleranz, die durch die Streuung des B-Wertes verursacht wird
$R_{ins}$	Insulation resistance	Isolationswiderstand
$R_P$	Parallel resistance	Parallelwiderstand
$R_R$	Rated resistance	Nennwiderstand
$\Delta R_R/R_R$	Resistance tolerance	Widerstandstoleranz
$R_S$	Series resistance	Serienwiderstand
$R_T$	Resistance at temperature T (e.g. $R_{25}$ = resistance at 25 °C)	Widerstand bei Temperatur T (z.B. $R_{25}$ = Widerstand bei 25 °C)
T	Temperature	Temperatur
$\Delta T$	Temperature tolerance	Temperaturtoleranz
t	Time	Zeit
$T_A$	Ambient temperature	Umgebungstemperatur
$T_{max}$	Upper category temperature	Obere Grenztemperatur (Kategorietemperatur)
$T_{min}$	Lower category temperature	Untere Grenztemperatur (Kategorietemperatur)
$T_{op}$	Operating temperature	Betriebstemperatur
$T_R$	Rated temperature	Nenntemperatur
$T_{surf}$	Surface temperature	Oberflächentemperatur
V	Voltage	Spannung
$V_{ins}$	Insulation test voltage	Isolationsprüfungsspannung
$V_{op}$	Operating voltage	Betriebsspannung
$V_{test}$	Test voltage	Prüfspannung

Symbol	English	German
$\alpha$	Temperature coefficient	Temperaturkoeffizient
$\Delta$	Tolerance, change	Toleranz, Änderung
$\delta_{th}$	Dissipation factor	Wärmeleitwert
$\tau_c$	Thermal cooling time constant	Thermische Abkühlzeitkonstante
$\tau_a$	Thermal time constant	Thermische Zeitkonstante

**Abbreviations / Notes**

Symbol	English	German
<b>SMD</b>	Surface-mounted devices	Oberflächenmontierbares Bauelement
*	To be replaced by a number in ordering codes, type designations etc.	Platzhalter für Zahl im Bestellnummerncode oder für die Typenbezeichnung.
+	To be replaced by a letter. All dimensions are given in mm. The commas used in numerical values denote decimal points.	Platzhalter für einen Buchstaben. Alle Maße sind in mm angegeben. Verwendete Kommas in Zahlenwerten bezeichnen Dezimalpunkte.

## Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out that **such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application**. As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether an EPCOS product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified**. In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or lifesaving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed.**
4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet ([www.epcos.com/material](http://www.epcos.com/material)). Should you have any more detailed questions, please contact our sales offices.
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**Anexo XIII. Hoja de características del integrado  
de carga MCP73833**



# MCP73833/4

## Stand-Alone Linear Li-Ion / Li-Polymer Charge Management Controller

### Features

- Complete Linear Charge Management Controller
  - Integrated Pass Transistor
  - Integrated Current Sense
  - Integrated Reverse Discharge Protection
- Constant Current / Constant Voltage Operation with Thermal Regulation
- High Accuracy Preset Voltage Regulation:
  - 4.2V, 4.35V, 4.4V, or 4.5V,  $\pm 0.75\%$
- Programmable Charge Current: 1A Maximum
- Preconditioning of Deeply Depleted Cells
  - Selectable Current Ratio
  - Selectable Voltage Threshold
- Automatic End-of-Charge Control
  - Selectable Current Threshold
  - Selectable Safety Time Period
- Automatic Recharge
  - Selectable Voltage Threshold
- Two Charge Status Outputs
- Cell Temperature Monitor
- Low-Dropout Linear Regulator Mode
- Automatic Power-Down when Input Power Removed
- Under Voltage Lockout
- Numerous Selectable Options Available for a Variety of Applications:
  - Refer to **Section 1.0 “Electrical Characteristics”** for Selectable Options
  - Refer to the Product Identification System for Standard Options
- Available Packages:
  - DFN-10 (3 mm x 3 mm)
  - MSOP-10

### Applications

- Lithium-Ion / Lithium-Polymer Battery Chargers
- Personal Data Assistants
- Cellular Telephones
- Digital Cameras
- MP3 Players
- Bluetooth Headsets
- USB Chargers

### Description

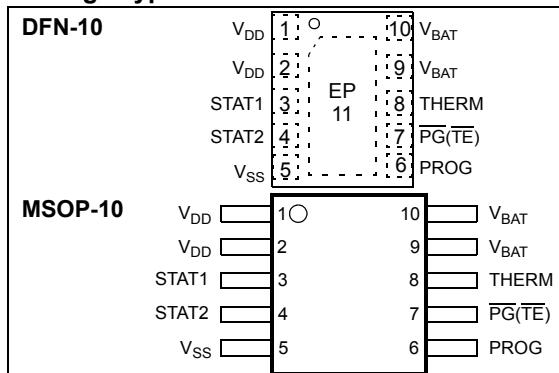
The MCP73833/4 is a highly advanced linear charge management controller for use in space-limited, cost sensitive applications. The MCP73833/4 is available in a 10-Lead, 3 mm x 3 mm DFN package or a 10-Lead, MSOP package. Along with its small physical size, the low number of external components required makes the MCP73833/4 ideally suited for portable applications. For applications charging from a USB port, the MCP73833/4 can adhere to all the specifications governing the USB power bus.

The MCP73833/4 employs a constant current/constant voltage charge algorithm with selectable preconditioning and charge termination. The constant voltage regulation is fixed with four available options: 4.20V, 4.35V, 4.40V, or 4.50V, to accomodate new, emerging battery charging requirements. The constant current value is set with one external resistor. The MCP73833/4 limits the charge current based on die temperature during high power or high ambient conditions. This thermal regulation optimizes the charge cycle time while maintaining device reliability.

Several options are available for the preconditioning threshold, preconditioning current value, charge termination value, and automatic recharge threshold. The preconditioning value and charge termination value are set as a ratio, or percentage, of the programmed constant current value. Preconditioning can be set to 100%. Refer to **Section 1.0 “Electrical Characteristics”** for available options and the **“Product Identification System”** for standard options.

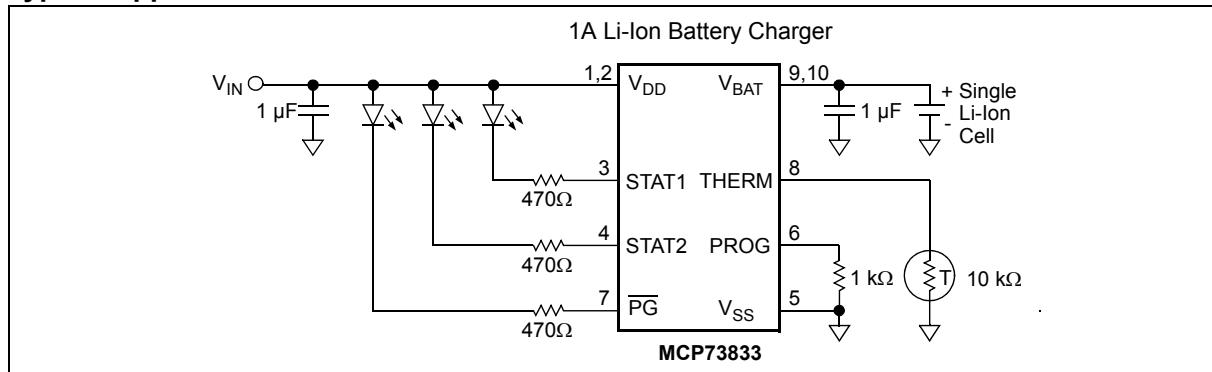
The MCP73833/4 is fully specified over the ambient temperature range of -40°C to +85°C.

### Package Types

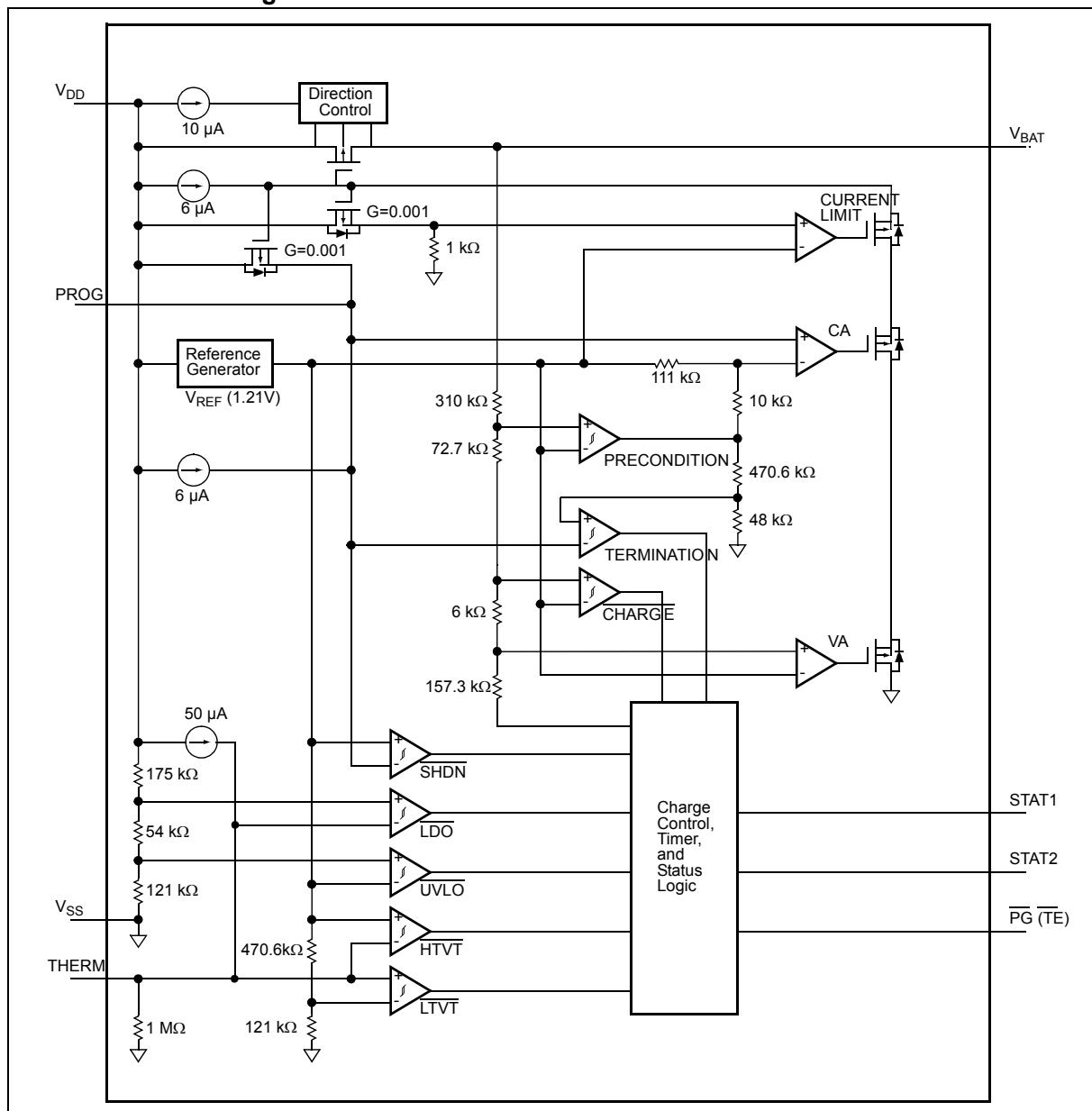


# MCP73833/4

## Typical Application



## Functional Block Diagram



# MCP73833/4

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings

$V_{DD}$	.....	7.0V
All Inputs and Outputs w.r.t. $V_{SS}$	.....	-0.3 to $(V_{DD}+0.3)V$
Maximum Junction Temperature, $T_J$	. Internally Limited	
Storage temperature	.....	-65°C to +150°C
ESD protection on all pins:		
Human Body Model (HBM)		
(1.5 kΩ in Series with 100 pF).....		$\geq 4\text{ kV}$
Machine Model (MM)		
(200 pF, No Series Resistance) .....		300V

**\*Notice:** Stresses above those listed under "Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

## DC CHARACTERISTICS

**Electrical Specifications:** Unless otherwise specified, all limits apply for  $V_{DD} = [V_{REG(Typical)}+0.3V]$  to 6V,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ . Typical values are at  $+25^\circ\text{C}$ ,  $V_{DD} = [V_{REG(Typical)}+1.0V]$

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Supply Input</b>						
Supply Voltage	$V_{DD}$	3.75	—	6	V	Charging
		$V_{REG(Typical)}+0.3V$	—	6	V	Charge Complete, Standby
Supply Current	$I_{SS}$	—	2000	3000	μA	Charging
		—	150	300	μA	Charge Complete
		—	100	300	μA	Standby (No Battery or PROG Floating)
		—	50	100	μA	Shutdown ( $V_{DD} \leq V_{BAT}$ , or $V_{DD} < V_{STOP}$ )
UVLO Start Threshold	$V_{START}$	3.4	3.55	3.7	V	$V_{DD}$ Low-to-High
UVLO Stop Threshold	$V_{STOP}$	3.3	3.45	3.6	V	$V_{DD}$ High-to-Low
UVLO Hysteresis	$V_{HYS}$	—	100	—	mV	
<b>Voltage Regulation (Constant Voltage Mode, System Test Mode)</b>						
Regulated Output Voltage	$V_{REG}$	4.168	4.20	4.232	V	$V_{DD} = [V_{REG(Typical)}+1V]$
		4.318	4.35	4.382	V	$I_{OUT} = 10\text{ mA}$
		4.367	4.40	4.433	V	$T_A = -5^\circ\text{C}$ to $+55^\circ\text{C}$
		4.467	4.50	4.533	V	
Line Regulation	$ (\Delta V_{BAT}/V_{BAT}) / \Delta V_{DD} $	—	0.10	0.30	%/V	$V_{DD} = [V_{REG(Typical)}+1V]$ to 6V, $I_{OUT} = 10\text{ mA}$
Load Regulation	$ \Delta V_{BAT}/V_{BAT} $	—	0.10	0.30	%	$I_{OUT} = 10\text{ mA}$ to $100\text{ mA}$ $V_{DD} = [V_{REG(Typical)}+1V]$
Supply Ripple Attenuation	$PSRR$	—	58	—	dB	$I_{OUT} = 10\text{ mA}$ , 10Hz to 1 kHz
		—	47	—	dB	$I_{OUT} = 10\text{ mA}$ , 10Hz to 10 kHz
		—	25	—	dB	$I_{OUT} = 10\text{ mA}$ , 10Hz to 1 MHz
<b>Current Regulation (Fast Charge Constant Current Mode)</b>						
Fast Charge Current Regulation	$I_{REG}$	90	100	110	mA	$PROG = 10\text{ k}\Omega$
		900	1000	1100	mA	$PROG = 1.0\text{ k}\Omega$
Maximum Output Current Limit	$I_{MAX}$	—	1200	—	mA	$PROG < 833\Omega$

# MCP73833/4

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## DC CHARACTERISTICS (CONTINUED)

**Electrical Specifications:** Unless otherwise specified, all limits apply for  $V_{DD} = [V_{REG}(\text{Typical})+0.3\text{V}]$  to 6V,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ . Typical values are at  $+25^\circ\text{C}$ ,  $V_{DD} = [V_{REG}(\text{Typical})+1.0\text{V}]$

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Preconditioning Current Regulation (Trickle Charge Constant Current Mode)</b>						
Precondition Current Ratio	$I_{PREG} / I_{REG}$	7.5 15 30 —	10 20 40 100	12.5 25 50 —	% % % %	PROG = 1.0 kΩ to 10 kΩ $T_A = -5^\circ\text{C}$ to $+55^\circ\text{C}$
Precondition Voltage Threshold Ratio	$V_{PTH} / V_{REG}$	64 69	66.5 71.5	70 75	% %	$V_{BAT}$ Low-to-High
Precondition Hysteresis	$V_{PHYS}$	—	100	—	mV	$V_{BAT}$ High-to-Low
<b>Charge Termination</b>						
Charge Termination Current Ratio	$I_{TERM} / I_{REG}$	3.75 5.6 7.5 15	5 7.5 10 20	6.25 9.4 12.5 25	% % % %	PROG = 1.0 kΩ to 10 kΩ $T_A = -5^\circ\text{C}$ to $+55^\circ\text{C}$
<b>Automatic Recharge</b>						
Recharge Voltage Threshold Ratio	$V_{RTH} / V_{REG}$	— —	94.0 96.5	— —	% %	$V_{BAT}$ High-to-Low
<b>Pass Transistor ON-Resistance</b>						
ON-Resistance	$R_{DSON}$	—	300	—	mΩ	$V_{DD} = 3.75\text{V}$ $T_J = 105^\circ\text{C}$
<b>Battery Discharge Current</b>						
Output Reverse Leakage Current	$I_{DISCHARGE}$	— — — —	0.15 0.25 0.15 -5.5	2 2 2 -15	μA μA μA μA	PROG Floating $V_{DD} \leq V_{BAT}$ $V_{DD} < V_{STOP}$ Charge Complete
<b>Status Indicators - STAT1, STAT2, PG</b>						
Sink Current	$I_{SINK}$	—	15	25	mA	
Low Output Voltage	$V_{OL}$	—	0.4	1	V	$I_{SINK} = 4 \text{ mA}$
Input Leakage Current	$I_{LK}$	—	0.01	1	μA	High Impedance, 6V on pin
<b>PROG Input</b>						
Charge Impedance Range	$R_{PROG}$	1	—	20	kΩ	
Standy Impedance	$R_{PROG}$	70	—	200	kΩ	Minimum Impedance for Standby
<b>Thermistor Bias</b>						
Thermistor Current Source	$I_{THERM}$	47	50	53	μA	$2 \text{ k}\Omega < R_{THERM} < 50 \text{ k}\Omega$
<b>Thermistor Comparator</b>						
Upper Trip Threshold	$V_{T1}$	1.20	1.23	1.26	V	$V_{THERM}$ Low-to-High
Upper Trip Point Hysteresis	$V_{T1HYS}$	—	-50	—	mV	
Lower Trip Threshold	$V_{T2}$	0.235	0.25	0.265	V	$V_{THERM}$ High-to-Low
Lower Trip Point Hysteresis	$V_{T2HYS}$	—	50	—	mV	
<b>System Test (LDO) Mode</b>						
Input High Voltage Level	$V_{IH}$	( $V_{DD}-0.1$ )	—	—	V	
THERM Input Sink Current	$I_{SINK}$	3	6	20	μA	Stand-by or system test mode
Bypass Capacitance	$C_{BAT}$	1 4.7	— —	— —	μF μF	$I_{OUT} < 250 \text{ mA}$ $I_{OUT} > 250 \text{ mA}$

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## DC CHARACTERISTICS (CONTINUED)

**Electrical Specifications:** Unless otherwise specified, all limits apply for  $V_{DD} = [V_{REG(Typical)} + 0.3V]$  to 6V,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ . Typical values are at  $+25^\circ\text{C}$ ,  $V_{DD} = [V_{REG(Typical)} + 1.0V]$

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Automatic Power Down</b>						
Automatic Power Down Entry Threshold	$V_{PD}$	—	$V_{BAT} + 50 \text{ mV}$	—	V	$2.3V \leq V_{BAT} \leq V_{REG}$ $V_{DD}$ Falling
Automatic Power Down Exit Threshold	$V_{PDEXIT}$	—	$V_{BAT} + 150 \text{ mV}$	—	V	$2.3V \leq V_{BAT} \leq V_{REG}$ $V_{DD}$ Rising
<b>Timer Enable Input (TE)</b>						
Input High Voltage Level	$V_{IH}$	2.0	—	—	V	
Input Low Voltage Level	$V_{IL}$	—	—	0.6	V	
Input Leakage Current	$I_{LK}$	—	0.01	1	$\mu\text{A}$	$V_{TE} = 6V$
<b>Thermal Shutdown</b>						
Die Temperature	$T_{SD}$	—	150	—	$^\circ\text{C}$	
Die Temperature Hysteresis	$T_{SDHYS}$	—	10	—	$^\circ\text{C}$	

## AC CHARACTERISTICS

**Electrical Specifications:** Unless otherwise specified, all limits apply for  $V_{DD} = [V_{REG(Typical)} + 0.3V]$  to 6V,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ . Typical values are at  $+25^\circ\text{C}$ ,  $V_{DD} = [V_{REG(Typical)} + 1.0V]$

Parameters	Sym	Min	Typ	Max	Units	Conditions
UVLO Start Delay	$t_{START}$	—	—	5	ms	$V_{DD}$ Low-to-High
<b>Current Regulation</b>						
Transition Time Out of Preconditioning	$t_{DELAY}$	—	—	1	ms	$V_{BAT} < V_{PTH}$ to $V_{BAT} > V_{PTH}$
Current Rise Time Out of Preconditioning	$t_{RISE}$	—	—	1	ms	$I_{OUT}$ Rising to 90% of $I_{REG}$
Preconditioning Comparator Filter Time	$t_{PRECON}$	0.4	1.3	3.2	ms	Average $V_{BAT}$ Rise/Fall
Termination Comparator Filter Time	$t_{TERM}$	0.4	1.3	3.2	ms	Average $I_{OUT}$ Falling
Charge Comparator Filter Time	$t_{CHARGE}$	0.4	1.3	3.2	ms	Average $V_{BAT}$ Falling
Thermistor Comparator Filter Time	$t_{THERM}$	0.4	1.3	3.2	ms	Average THERM Rise/Fall
<b>Elapsed Timer</b>						
Elapsed Timer Period	$t_{ELAPSED}$	0 3.6 5.4 7.2	0 4.0 6.0 8.0	0 4.4 6.6 8.8	Hours Hours Hours Hours	Timer Disabled
<b>Status Indicators</b>						
Status Output turn-off	$t_{OFF}$	—	—	200	$\mu\text{s}$	$I_{SINK} = 1 \text{ mA}$ to 0 mA
Status Output turn-on	$t_{ON}$	—	—	200	$\mu\text{s}$	$I_{SINK} = 0 \text{ mA}$ to 1 mA

## TEMPERATURE SPECIFICATIONS

**Electrical Specifications:** Unless otherwise specified, all limits apply for  $V_{DD} = [V_{REG(Typical)} + 0.3V]$  to 6V. Typical values are at  $+25^\circ\text{C}$ ,  $V_{DD} = [V_{REG(Typical)} + 1.0V]$

Parameters	Symbol	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Specified Temperature Range	$T_A$	-40	—	+85	$^\circ\text{C}$	
Operating Temperature Range	$T_A$	-40	—	+125	$^\circ\text{C}$	
Storage Temperature Range	$T_A$	-65	—	+150	$^\circ\text{C}$	
<b>Thermal Package Resistances</b>						
Thermal Resistance, MSOP-10	$\theta_{JA}$	—	113	—	$^\circ\text{C/W}$	4-Layer JC51-7 Standard Board, Natural Convection
Thermal Resistance, DFN-10, 3 mm x 3 mm	$\theta_{JA}$	—	41	—	$^\circ\text{C/W}$	4-Layer JC51-7 Standard Board, Natural Convection

# **MCP73833/4**

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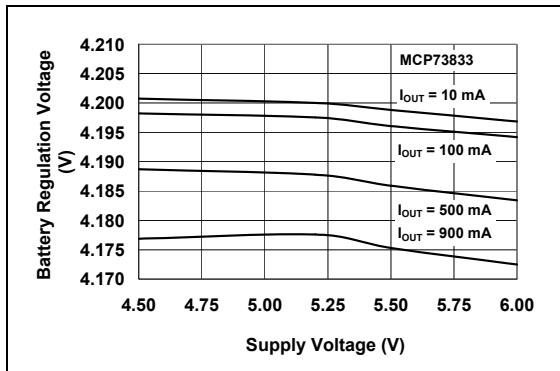
**NOTES:**

# MCP73833/4

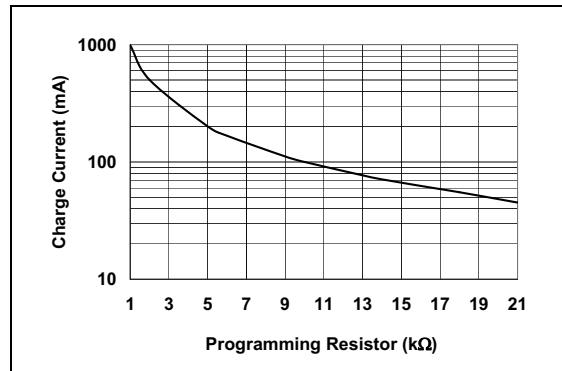
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

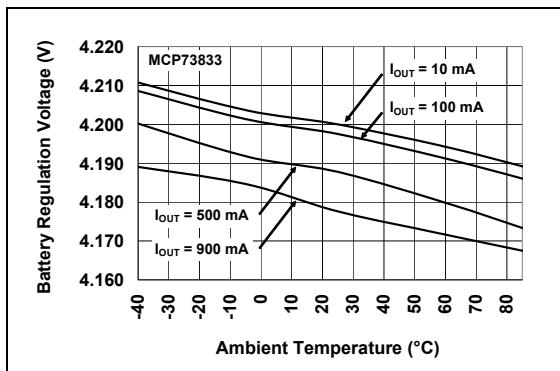
**Note:** Unless otherwise indicated,  $V_{DD} = 5.2V$ ,  $V_{REG} = 4.20V$ ,  $I_{OUT} = 10 \text{ mA}$  and  $T_A = +25^\circ\text{C}$ , Constant-voltage mode.



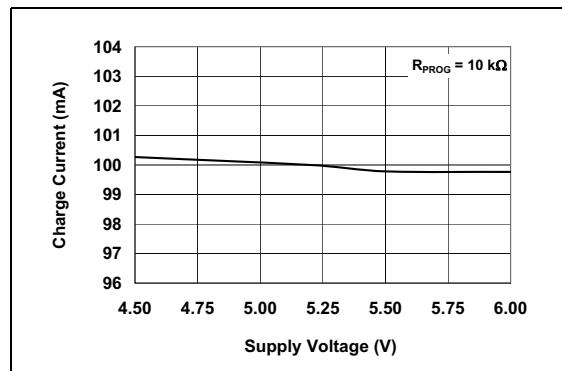
**FIGURE 2-1:** Battery Regulation Voltage ( $V_{BAT}$ ) vs. Supply Voltage ( $V_{DD}$ ).



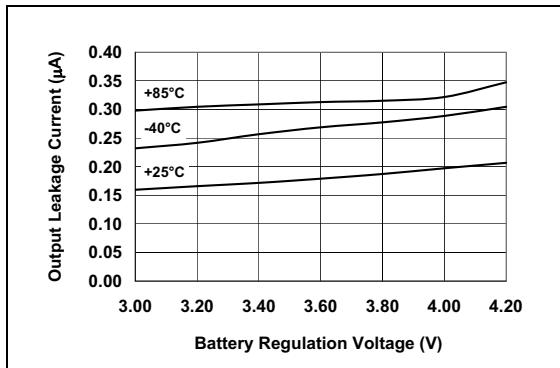
**FIGURE 2-4:** Charge Current ( $I_{OUT}$ ) vs. Programming Resistor ( $R_{PROG}$ ).



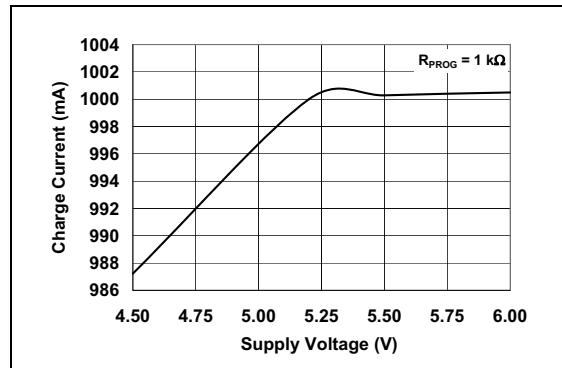
**FIGURE 2-2:** Battery Regulation Voltage ( $V_{BAT}$ ) vs. Ambient Temperature ( $T_A$ ).



**FIGURE 2-5:** Charge Current ( $I_{OUT}$ ) vs. Supply Voltage ( $V_{DD}$ ).



**FIGURE 2-3:** Output Leakage Current ( $I_{DISCHARGE}$ ) vs. Battery Regulation Voltage ( $V_{BAT}$ ).

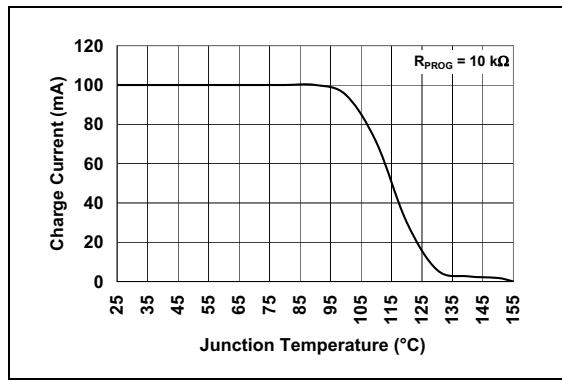


**FIGURE 2-6:** Charge Current ( $I_{OUT}$ ) vs. Supply Voltage ( $V_{DD}$ ).

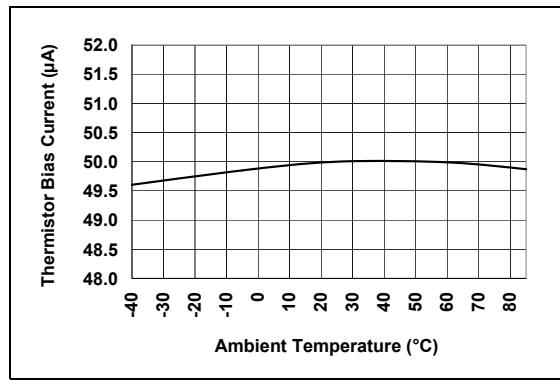
# MCP73833/4

## TYPICAL PERFORMANCE CURVES (Continued)

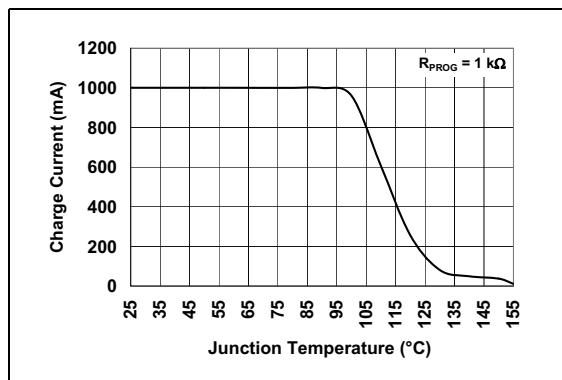
Note: Unless otherwise indicated,  $V_{DD} = 5.2V$ ,  $V_{REG} = 4.20V$ ,  $I_{OUT} = 10\text{ mA}$  and  $T_A = +25^\circ\text{C}$ , Constant-voltage mode.



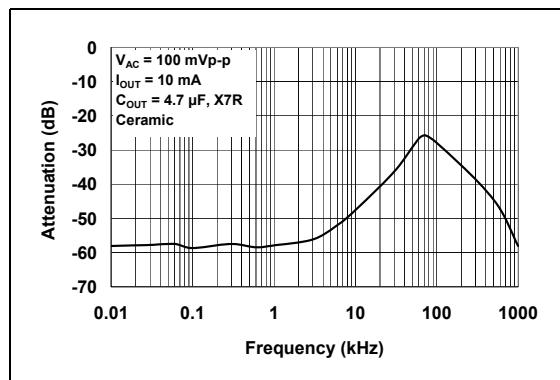
**FIGURE 2-7:** Charge Current ( $I_{OUT}$ ) vs. Junction Temperature ( $T_J$ ).



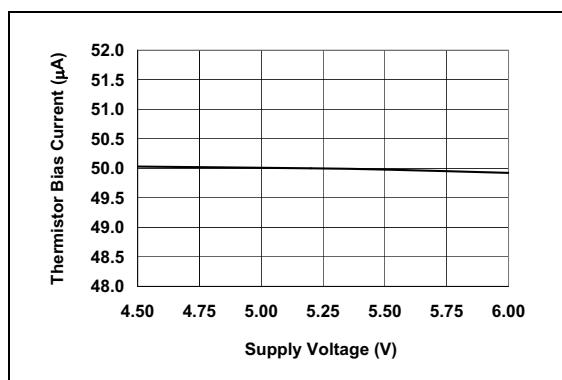
**FIGURE 2-10:** Thermistor Bias Current ( $I_{THRERM}$ ) vs. Ambient Temperature ( $T_A$ ).



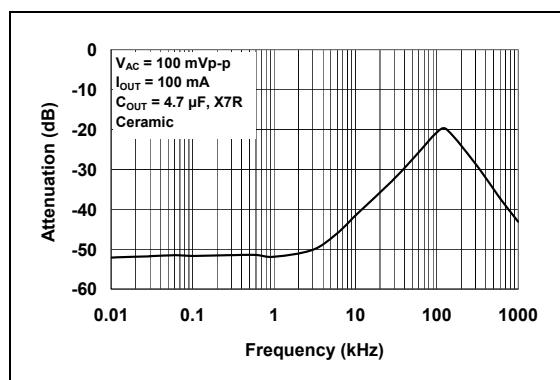
**FIGURE 2-8:** Charge Current ( $I_{OUT}$ ) vs. Junction Temperature ( $T_J$ ).



**FIGURE 2-11:** Power Supply Ripple Rejection (PSRR).



**FIGURE 2-9:** Thermistor Bias Current ( $I_{THRERM}$ ) vs. Supply Voltage ( $V_{DD}$ ).



**FIGURE 2-12:** Power Supply Ripple Rejection (PSRR).

# MCP73833/4

## TYPICAL PERFORMANCE CURVES (Continued)

Note: Unless otherwise indicated,  $V_{DD} = 5.2V$ ,  $V_{REG} = 4.20V$ ,  $I_{OUT} = 10 \text{ mA}$  and  $T_A = +25^\circ\text{C}$ , Constant-voltage mode.

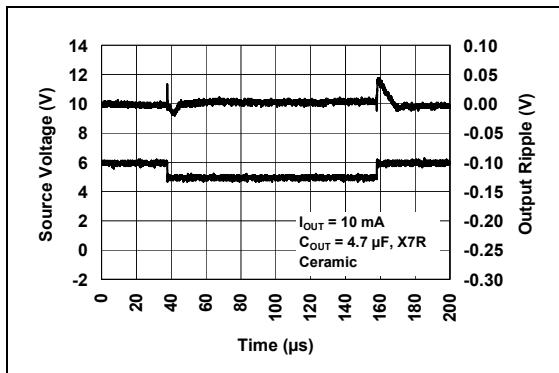


FIGURE 2-13: Line Transient Response.

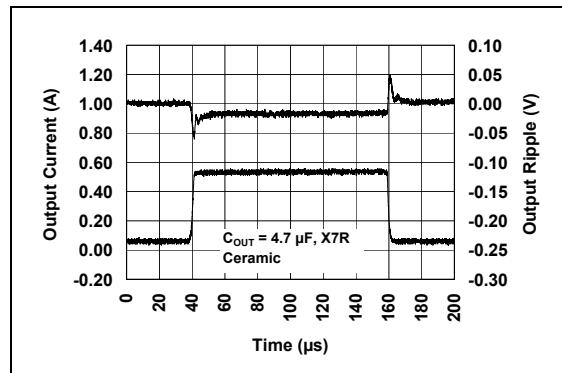


FIGURE 2-16: Load Transient Response.

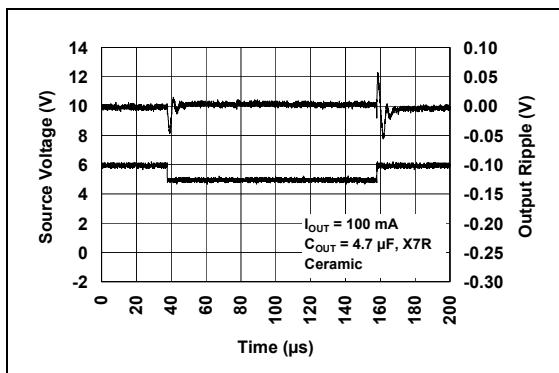


FIGURE 2-14: Line Transient Response.

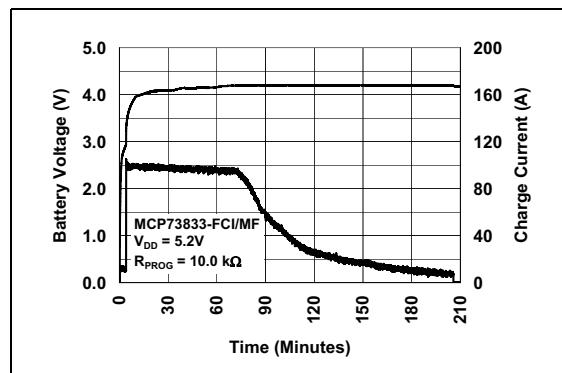


FIGURE 2-17: Complete Charge Cycle (180 mA Li-Ion Battery).

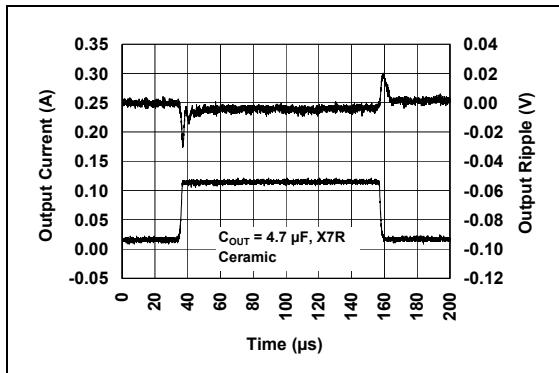


FIGURE 2-15: Load Transient Response.

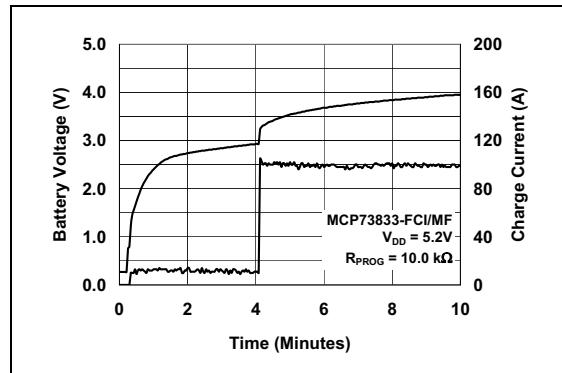


FIGURE 2-18: Charge Cycle Start - Preconditioning (180 mAh Li-Ion Battery).

# **MCP73833/4**

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**NOTES:**

## 3.0 PIN DESCRIPTIONS

Descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

Pin No.		Symbol	Function
DFN-10	MSOP-10		
1	1	V <sub>DD</sub>	Battery Management Input Supply
2	2	V <sub>DD</sub>	Battery Management Input Supply
3	3	STAT1	Charge Status Output
4	4	STAT2	Charge Status Output
5	5	V <sub>SS</sub>	Battery Management 0V Reference
6	6	PROG	Current Regulation Set and Charge Control Enable
7	7	PG, TE	<b>MCP73833:</b> Power Good output, <b>MCP73834:</b> Timer Enable input
8	8	THERM	Thermistor input
9	9	V <sub>BAT</sub>	Battery Charge Control Output
10	10	V <sub>BAT</sub>	Battery Charge Control Output
11	—	EP	Exposed Thermal Pad (EP); must be connected to V <sub>SS</sub> .

### 3.1 Battery Management Input Supply (V<sub>DD</sub>)

A supply voltage of [V<sub>REG</sub> (typical) + 0.3V] to 6V is recommended. Bypass to V<sub>SS</sub> with a minimum of 1  $\mu$ F.

### 3.2 Charge Status Outputs (STAT1, STAT2)

STAT1 and STAT2 are open-drain logic outputs for connection to a LED for charge status indication. Alternatively, a pull-up resistor can be applied for interfacing to a host microcontroller.

### 3.3 Battery Management 0V Reference (V<sub>SS</sub>)

Connect to negative terminal of battery and input supply.

### 3.4 Current Regulation Set (PROG)

Preconditioning, fast charge, and termination currents are scaled by placing a resistor from PROG to V<sub>SS</sub>.

The charge management controller can be disabled by allowing the PROG input to float.

### 3.5 Power Good Indication (PG) **MCP73833 Only**

The power good (PG) option is a pseudo open-drain output. The PG output can sink current, but not source current. However, there is a diode path back to the input, and, as such, the PG output should only be pulled up to the input. The PG output is low whenever the input to the MCP73833 is above the UVLO threshold and greater than the battery voltage.

### 3.6 Timer Enable Input (TE) **MCP73834 Only**

The timer enable (TE) input option is used to enable or disable the internal timer. A low signal on this pin enables the internal timer and a high signal disables the internal timer. The TE input can be used to disable the timer when the charger is supplying current to charge the battery and power the system load. The TE input is compatible with 1.8V logic.

### 3.7 Thermistor Input (THERM)

An internal 50  $\mu$ A current source provides the bias for most common 10 k $\Omega$  negative-temperature coefficient thermistors (NTC). The MCP73833/4 compares the voltage at the THERM pin to factory set thresholds of 1.20V and 0.25V, typically.

### 3.8 Battery Charge Control Output (V<sub>BAT</sub>)

Connect to positive terminal of battery. Drain terminal of internal P-channel MOSFET pass transistor. Bypass to V<sub>SS</sub> with a minimum of 1  $\mu$ F to ensure loop stability when the battery is disconnected.

### 3.9 Exposed Thermal Pad (EP)

There is an internal electrical connection between the Exposed Thermal Pad (EP) and the V<sub>SS</sub> pin; they must be connected to the same potential.

# **MCP73833/4**

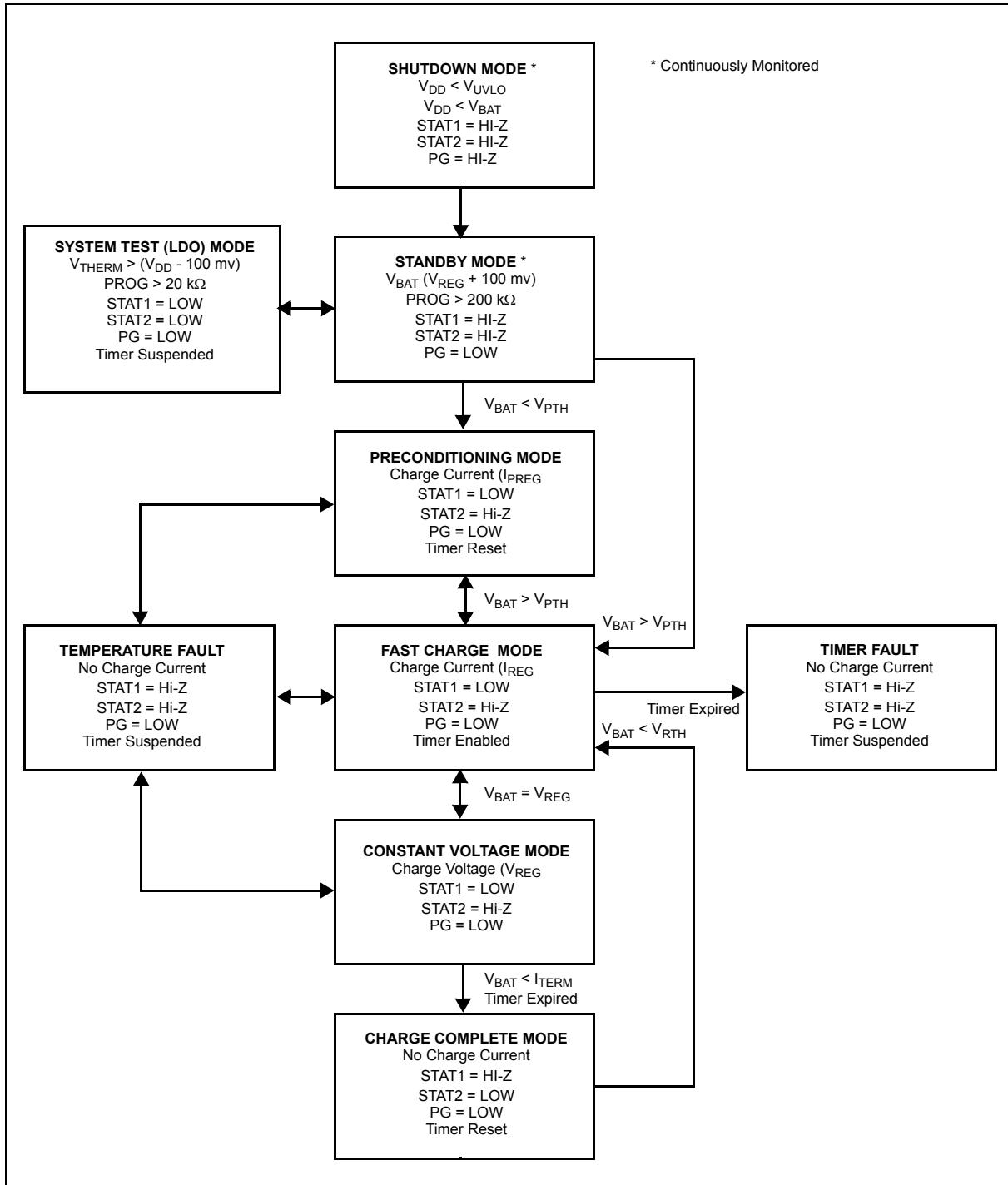
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**NOTES:**

## 4.0 FUNCTIONAL DESCRIPTION

The MCP73833/4 is a highly advanced linear charge management controller. Refer to the functional block diagram and [Figure 4-1](#) that depicts the operational flow algorithm from charge initiation to completion and automatic recharge.



**FIGURE 4-1:** Flow Chart.

# MCP73833/4

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## 4.1 Under Voltage Lockout (UVLO)

An internal under voltage lockout (UVLO) circuit monitors the input voltage and keeps the charger in shutdown mode until the input supply rises above the UVLO threshold. The UVLO circuitry has a built-in hysteresis of 100 mV.

In the event a battery is present when the input power is applied, the input supply must rise +150 mV above the battery voltage before the MCP73833/4 becomes operational.

The UVLO circuit places the device in shutdown mode if the input supply falls to within +50 mV of the battery voltage.

The UVLO circuit is always active. At any time the input supply is below the UVLO threshold or within +50 mV of the voltage at the  $V_{BAT}$  pin, the MCP73833/4 is placed in a shutdown mode.

During any UVLO condition, the battery reverse discharge current shall be less than 2  $\mu$ A.

## 4.2 Charge Qualification

For a charge cycle to begin, all UVLO conditions must be met and a battery or output load must be present.

A charge current programming resistor must be connected from PROG to  $V_{SS}$ . If the PROG pin is open or floating, the MCP73833/4 is disabled and the battery reverse discharge current is less than 2  $\mu$ A. In this manner, the PROG pin acts as a charge enable and can be used as a manual shutdown.

If the input supply voltage is above the UVLO threshold, but below  $V_{REG}(\text{Typical})+0.3V$ , the MCP73833/4 will pulse the STAT1 and PG outputs as the device determines if a battery is present.

## 4.3 Preconditioning

If the voltage at the  $V_{BAT}$  pin is less than the preconditioning threshold, the MCP73833/4 enters a preconditioning or trickle charge mode. The preconditioning threshold is factory set. Refer to **Section 1.0 “Electrical Characteristics”** for preconditioning threshold options.

In this mode, the MCP73833/4 supplies a percentage of the charge current (established with the value of the resistor connected to the PROG pin) to the battery. The percentage or ratio of the current is factory set. Refer to **Section 1.0 “Electrical Characteristics”** for preconditioning current options.

When the voltage at the  $V_{BAT}$  pin rises above the preconditioning threshold, the MCP73833/4 enters the constant current or fast charge mode.

## 4.4 Constant Current - Fast Charge Mode

During the constant current mode, the programmed charge current is supplied to the battery or load. The charge current is established using a single resistor from PROG to  $V_{SS}$ . The program resistor and the charge current are calculated using [Equation 4-1](#):

### EQUATION 4-1:

$$\text{Where: } I_{REG} = \frac{1000V}{R_{PROG}}$$
$$R_{PROG} = \text{kilo-ohms}$$
$$I_{REG} = \text{milliampere}$$

Constant current mode is maintained until the voltage at the  $V_{BAT}$  pin reaches the regulation voltage,  $V_{REG}$ .

When constant current mode is invoked, the internal timer is reset.

### 4.4.1 TIMER EXPIRED DURING CONSTANT CURRENT - FAST CHARGE MODE

If the internal timer expires before the recharge voltage threshold is reached, a timer fault is indicated and the charge cycle terminates. The MCP73833/4 remains in this condition until the battery is removed, the input power is removed, or the PROG pin is opened. If the battery is removed or the PROG pin is opened, the MCP73833/4 enters the Standby mode where it remains until a battery is reinserted or the PROG pin is reconnected. If the input power is removed, the MCP73833/4 is in Shutdown. When the input power is reapplied, a normal start-up sequence ensues.

## 4.5 Constant Voltage Mode

When the voltage at the  $V_{BAT}$  pin reaches the regulation voltage,  $V_{REG}$ , constant voltage regulation begins. The regulation voltage is factory set to 4.20V, 4.35V, 4.40V, or 4.50V with a tolerance of  $\pm 0.75\%$ .

## 4.6 Charge Termination

The charge cycle is terminated when, during constant voltage mode, the average charge current diminishes below a percentage of the programmed charge current (established with the value of the resistor connected to the PROG pin) or the internal timer has expired. A 1 ms filter time on the termination comparator ensures that transient load conditions do not result in premature charge cycle termination. The percentage or ratio of the current is factory set. The timer period is factory set and can be disabled. Refer to **Section 1.0 “Electrical Characteristics”** for charge termination current ratio and timer period options.

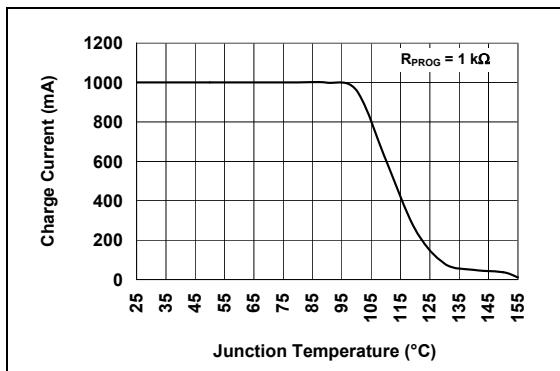
The charge current is latched off and the MCP73833/4 enters a charge complete mode.

## 4.7 Automatic Recharge

The MCP73833/4 continuously monitors the voltage at the  $V_{BAT}$  pin in the charge complete mode. If the voltage drops below the recharge threshold, another charge cycle begins and current is once again supplied to the battery or load. The recharge threshold is factory set. Refer to **Section 1.0 “Electrical Characteristics”** for recharge threshold options.

## 4.8 Thermal Regulation

The MCP73833/4 limits the charge current based on the die temperature. The thermal regulation optimizes the charge cycle time while maintaining device reliability. [Figure 4-2](#) depicts the thermal regulation for the MCP73833/4.



**FIGURE 4-2:** Thermal Regulation.

## 4.9 Thermal Shutdown

The MCP73833/4 suspends charge if the die temperature exceeds +150°C. Charging will resume when the die temperature has cooled by approximately +10°C. The thermal shutdown is a secondary safety feature in the event that there is a failure within the thermal regulation circuitry.

# **MCP73833/4**

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**NOTES:**

## 5.0 DETAILED DESCRIPTION

### 5.1 Analog Circuitry

#### 5.1.1 BATTERY MANAGEMENT INPUT SUPPLY ( $V_{DD}$ )

The  $V_{DD}$  input is the input supply to the MCP73833/4. The MCP73833/4 automatically enters a Power-down mode if the voltage on the  $V_{DD}$  input falls below the UVLO voltage ( $V_{STOP}$ ). This feature prevents draining the battery pack when the  $V_{DD}$  supply is not present.

#### 5.1.2 CURRENT REGULATION SET (PROG)

Fast charge current regulation can be scaled by placing a programming resistor ( $R_{PROG}$ ) from the PROG input to  $V_{SS}$ . The program resistor and the charge current are calculated using the [Equation 5-1](#):

#### EQUATION 5-1:

$$I_{REG} = \frac{1000V}{R_{PROG}}$$

Where:

$R_{PROG}$  = kilo-ohms

$I_{REG}$  = milliamperes

The preconditioning trickle-charge current and the charge termination current are ratiometric to the fast charge current based on the selected device options.

#### 5.1.3 BATTERY CHARGE CONTROL OUTPUT ( $V_{BAT}$ )

The battery charge control output is the drain terminal of an internal P-channel MOSFET. The MCP73833/4 provides constant current and voltage regulation to the battery pack by controlling this MOSFET in the linear region. The battery charge control output should be connected to the positive terminal of the battery pack.

#### 5.1.4 TEMPERATURE QUALIFICATION (THERM)

The MCP73833/4 continuously monitors battery temperature during a charge cycle by measuring the voltage between the THERM and  $V_{SS}$  pins. An internal 50  $\mu A$  current source provides the bias for most common 10 k $\Omega$  negative-temperature coefficient (NTC) or positive-temperature coefficient (PTC) thermistors. The current source is controlled, avoiding measurement sensitivity to fluctuations in the supply voltage ( $V_{DD}$ ). The MCP73833/4 compares the voltage at the THERM pin to factory set thresholds of 1.20V and 0.25V, typically. Once a voltage outside the thresholds is detected during a charge cycle, the MCP73833/4 immediately suspends the charge cycle. The MCP73833/4 suspends charge by turning off the

pass transistor and holding the timer value. The charge cycle resumes when the voltage at the THERM pin returns to the normal range.

If temperature monitoring is not required, place a standard 10 k $\Omega$  resistor from THERM to  $V_{SS}$ .

#### 5.1.4.1 System Test (LDO) Mode

The MCP73833/4 can be placed in a system test mode. In this mode, the MCP73833/4 operates as a low dropout linear regulator (LDO). The output voltage is regulated to the factory set voltage regulation option. The available output current is limited to the programmed fast charge current. For stability, the  $V_{BAT}$  output must be bypassed to  $V_{SS}$  with a minimum capacitance of 1  $\mu F$  for output currents up to 250 mA. A minimum capacitance of 4.7  $\mu F$  is required for output currents above 250 mA.

The system test mode is entered by driving the THERM input greater than ( $V_{DD}-100\text{ mV}$ ) with no battery connected to the output. In this mode, the MCP73833/4 can be used to power the system without a battery present.

**Note 1:**  $I_{THERM}$  is disabled during shutdown, stand-by, and system test modes.

- 2:** A pull-down current source on the THERM input is active only in stand-by and system test modes.
- 3:** During system test mode, the PROG input sets the available output current limit.
- 4:** System test mode shall be exited by releasing the THERM input or cycling input power.

## 5.2 Digital Circuitry

### 5.2.1 STATUS INDICATORS AND POWER GOOD (PG - OPTION)

The charge status outputs have two different states: Low (L), and High Impedance (Hi-Z). The charge status outputs can be used to illuminate LEDs. Optionally, the charge status outputs can be used as an interface to a host microcontroller. [Table 5-1](#) summarizes the state of the status outputs during a charge cycle.

**TABLE 5-1: STATUS OUTPUTS**

Charge Cycle State	STAT1	STAT2	PG
Shutdown	Hi-Z	Hi-Z	Hi-Z
Standby	Hi-Z	Hi-Z	L
Charge in Progress	L	Hi-Z	L
Charge Complete (EOC)	Hi-Z	L	L
Temperature Fault	Hi-Z	Hi-Z	L
Timer Fault	Hi-Z	Hi-Z	L
System Test Mode	L	L	L

# MCP73833/4

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## 5.2.2 POWER GOOD ( $\overline{PG}$ ) OPTION

The power good ( $\overline{PG}$ ) option is a pseudo open-drain output. The PG output can sink current, but not source current. However, there is a diode path back to the input, and as such, the  $\overline{PG}$  output should only be pulled up to the input. The PG output is low whenever the input to the MCP73833 is above the UVLO threshold and greater than the battery voltage. If the supply voltage is above the UVLO, but below  $V_{REG(Typical)}+0.3V$ , the MCP73833 will pulse the PG output as the device determines if a battery is present.

## 5.2.3 TIMER ENABLE ( $\overline{TE}$ ) OPTION

The timer enable ( $\overline{TE}$ ) input option is used to enable or disable the internal timer. A low signal on this pin enables the internal timer and a high signal disables the internal timer. The  $\overline{TE}$  input can be used to disable the timer when the charger is supplying current to charge the battery and power the system load. The  $\overline{TE}$  input is compatible with 1.8V logic.

## 5.2.4 DEVICE DISABLE (PROG)

The current regulation set input pin (PROG) can be used to terminate a charge at any time during the charge cycle, as well as to initiate a charge cycle or initiate a recharge cycle.

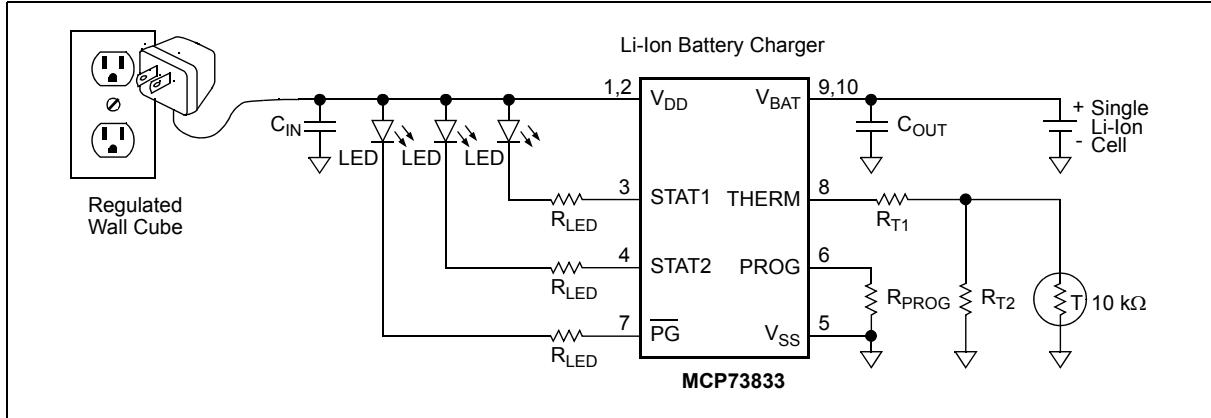
Placing a programming resistor from the PROG input to  $V_{SS}$  enables the device. Allowing the PROG input to float or by applying a logic-high input signal, disables the device and terminates a charge cycle. When disabled, the device's supply current is reduced to 100  $\mu A$ , typically.

# MCP73833/4

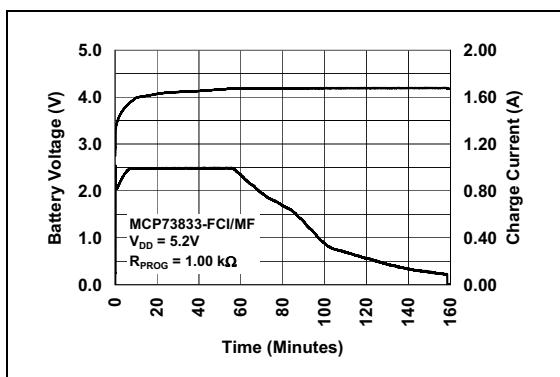
## 6.0 APPLICATIONS

The MCP73833/4 is designed to operate in conjunction with a host microcontroller or in stand-alone applications. The MCP73833/4 provides the preferred charge algorithm for Lithium-Ion and Lithium-Polymer

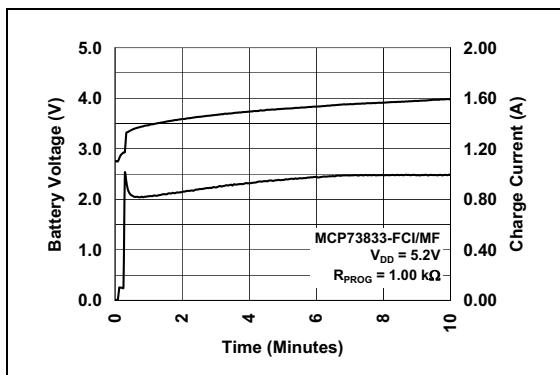
cells Constant-current followed by Constant-voltage. [Figure 6-1](#) depicts a typical stand-alone application circuit, while Figures [6-2](#) and [6-3](#) depict the accompanying charge profile.



**FIGURE 6-1:** Typical Application Circuit.



**FIGURE 6-2:** Typical Charge Profile with Thermal Regulation (1700 mAh Li-Ion Battery).



**FIGURE 6-3:** Typical Charge Cycle Start with Thermal Regulation (1700 mAh Li-Ion Battery).

## 6.1 Application Circuit Design

Due to the low efficiency of linear charging, the most important factors are thermal design and cost, which are a direct function of the input voltage, output current and thermal impedance between the battery charger and the ambient cooling air. The worst-case scenario is when the device has transitioned from the Preconditioning mode to the Constant-current mode. In this situation, the battery charger has to dissipate the maximum power. A trade-off must be made between the charge current, cost and thermal requirements of the charger.

### 6.1.1 COMPONENT SELECTION

Selection of the external components in [Figure 6-1](#) is crucial to the integrity and reliability of the charging system. The following discussion is intended as a guide for the component selection process.

#### 6.1.1.1 Current Programming Resistor (R<sub>PROG</sub>)

The preferred fast charge current for Lithium-Ion cells is at the 1C rate, with an absolute maximum current at the 2C rate. For example, a 500 mAh battery pack has a preferred fast charge current of 500 mA. Charging at this rate provides the shortest charge cycle times without degradation to the battery pack performance or life.

# MCP73833/4

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## 6.1.1.2 Thermal Considerations

The worst-case power dissipation in the battery charger occurs when the input voltage is at the maximum and the device has transitioned from the Preconditioning mode to the Constant-current mode. In this case, the power dissipation is:

$$\text{PowerDissipation} = (V_{DDMAX} - V_{PTHMIN}) \times I_{REGMAX}$$

Where:

- $V_{DDMAX}$  = the maximum input voltage
- $I_{REGMAX}$  = the maximum fast charge current
- $V_{PTHMIN}$  = the minimum transition threshold voltage

Power dissipation with a 5V,  $\pm 10\%$  input voltage source is:

$$\text{PowerDissipation} = (5.5V - 2.7V) \times 550mA = 1.54W$$

This power dissipation with the battery charger in the MSOP-10 package will cause thermal regulation to be entered as depicted in [Figure 6-3](#). Alternatively, the DFN-10 (3 mm x 3 mm) package could be utilized to reduce charge cycle times.

## 6.1.1.3 External Capacitors

The MCP73833/4 is stable with or without a battery load. In order to maintain good AC stability in the Constant-voltage mode, a minimum capacitance of 4.7  $\mu F$  is recommended to bypass the  $V_{BAT}$  pin to  $V_{SS}$ . This capacitance provides compensation when there is no battery load. In addition, the battery and interconnections appear inductive at high frequencies. These elements are in the control feedback loop during Constant-voltage mode. Therefore, the bypass capacitance may be necessary to compensate for the inductive nature of the battery pack.

Virtually any good quality output filter capacitor can be used, independent of the capacitor's minimum Effective Series Resistance (ESR) value. The actual value of the capacitor (and its associated ESR) depends on the output load current. A 4.7  $\mu F$  ceramic, tantalum or aluminum electrolytic capacitor at the output is usually sufficient to ensure stability for output currents up to a 500 mA.

## 6.1.1.4 Reverse-Blocking Protection

The MCP73833/4 provides protection from a faulted or shorted input. Without the protection, a faulted or shorted input would discharge the battery pack through the body diode of the internal pass transistor.

## 6.1.1.5 Charge Inhibit

The current regulation set input pin (PROG) can be used to terminate a charge at any time during the charge cycle, as well as to initiate a charge cycle or initiate a recharge cycle.

Placing a programming resistor from the PROG input to  $V_{SS}$  enables the device. Allowing the PROG input to float or by applying a logic-high input signal, disables the device and terminates a charge cycle. When disabled, the device's supply current is reduced to 100  $\mu A$ , typically.

## 6.1.1.6 Temperature Monitoring

The charge temperature window can be set by placing fixed value resistors in series-parallel with a thermistor. The resistance values of  $R_{T1}$  and  $R_{T2}$  can be calculated with the following equations in order to set the temperature window of interest.

For NTC thermistors:

$$24k\Omega = R_{T1} + \frac{R_{T2} \times R_{COLD}}{R_{T2} + R_{COLD}}$$
$$5k\Omega = R_{T1} + \frac{R_{T2} \times R_{HOT}}{R_{T2} + R_{HOT}}$$

Where:

- $R_{T1}$  = the fixed series resistance
- $R_{T2}$  = the fixed parallel resistance
- $R_{COLD}$  = the thermistor resistance at the lower temperature of interest
- $R_{HOT}$  = the thermistor resistance at the upper temperature of interest

For example, by utilizing a 10 k $\Omega$  at 25C NTC thermistor with a sensitivity index,  $\beta$ , of 3892, the charge temperature range can be set to 0C - 50C by placing a 1.54 k $\Omega$  resistor in series ( $R_{T1}$ ), and a 69.8 k $\Omega$  resistor in parallel ( $R_{T2}$ ) with the thermistor as depicted in [Figure 6-1](#).

## 6.1.1.7 Charge Status Interface

A status output provides information on the state of charge. The output can be used to illuminate external LEDs or interface to a host microcontroller. Refer to [Table 5-1](#) for a summary of the state of the status output during a charge cycle.

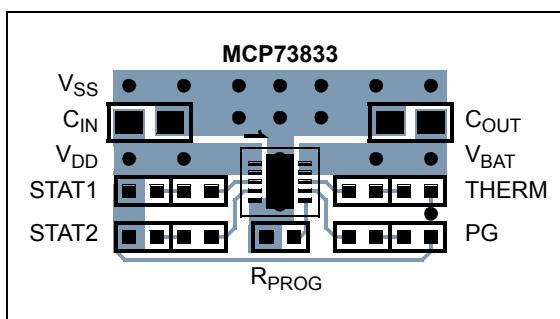
# MCP73833/4

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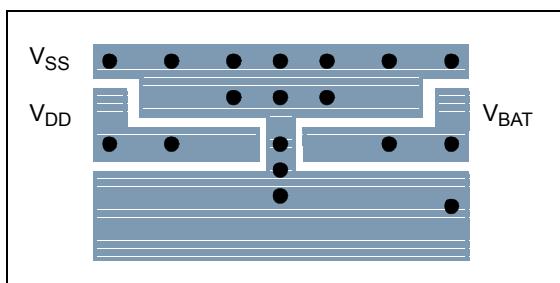
## 6.2 PCB Layout Issues

For optimum voltage regulation, place the battery pack as close as possible to the device's  $V_{BAT}$  and  $V_{SS}$  pins, recommended to minimize voltage drops along the high current-carrying PCB traces.

If the PCB layout is used as a heatsink, adding many vias in the heatsink pad can help conduct more heat to the backplane of the PCB, thus reducing the maximum junction temperature. Figures 6-4 and 6-5 depict a typical layout with PCB heatsinking.



**FIGURE 6-4:** Typical Layout (Top).



**FIGURE 6-5:** Typical Layout (Bottom).

# **MCP73833/4**

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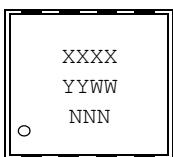
**NOTES:**

# MCP73833/4

## 7.0 PACKAGING INFORMATION

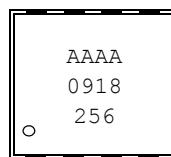
### 7.1 Package Marking Information

10-Lead DFN (3x3)



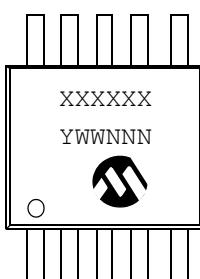
Part Number *	Marking Code	Part Number *	Marking Code
MCP73833-AMI/MF	AAAA		
MCP73833-BZI/MF	AAAB		
MCP73833-FCI/MF	AAAC	MCP73834-FCI/MF	BAAC
MCP73833-GPI/MF	AAAD	MCP73834-GPI/MF	BAAD
MCP73833-NVI/MF	AAAF	MCP73834-NVI/MF	BAAF
MCP73833-6SI/MF	AAAH	MCP73834-6SI/MF	BAAH
MCP73833-CNI/MF	AAAK	MCP73834-CNI/MF	BAAK

Example:



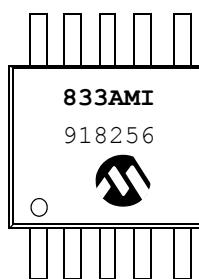
\* Consult Factory for Alternative Device Options.

10-Lead MSOP



Part Number *	Marking Code	Part Number *	Marking Code
MCP73833-AMI/UN	833AMI		
MCP73833-BZI/UN	833BZI		
MCP73833-FCI/UN	833FCI	MCP73834-FCI/UN	834FCI
MCP73833-GPI/UN	833GPI	MCP73834-GPI/UN	834GPI
MCP73833-NVI/UN	833NVI	MCP73834-NVI/UN	834NVI
MCP73833-CNI/UN	833CNI	MCP73834-CNI/UN	834CNI

Example:



\* Consult Factory for Alternative Device Options.

<b>Legend:</b>	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 <b>(e3)</b> Pb-free JEDEC designator for Matte Tin (Sn) <b>*</b> This package is Pb-free. The Pb-free JEDEC designator <b>(e3)</b> can be found on the outer packaging for this package.
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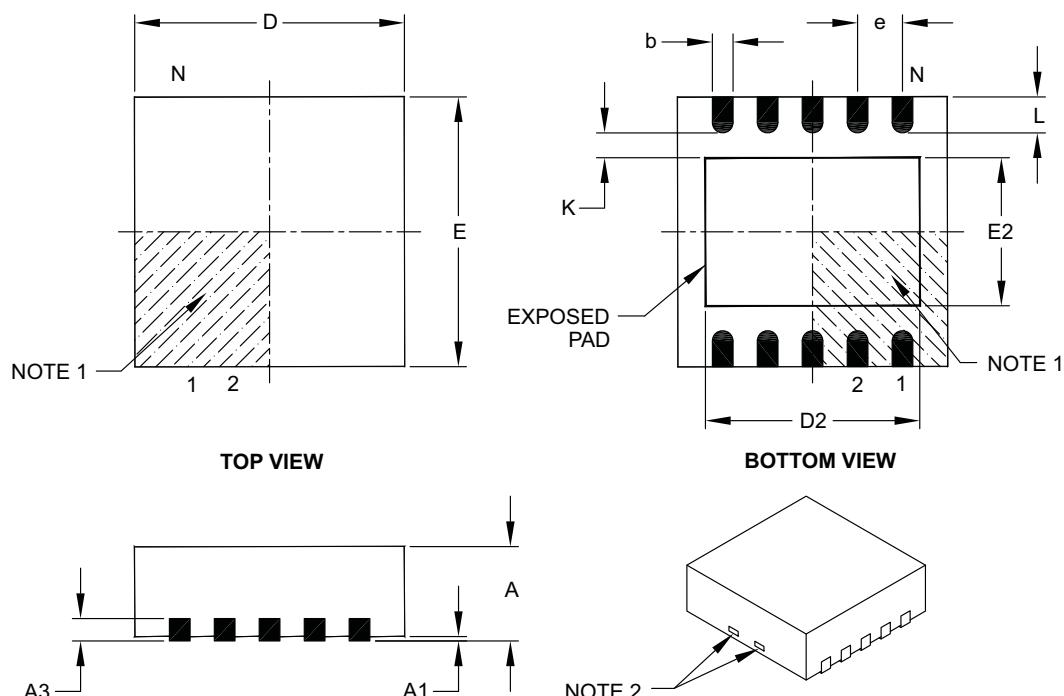
<b>Note:</b>	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.
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# MCP73833/4

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## 10-Lead Plastic Dual Flat, No Lead Package (MF) – 3x3x0.9 mm Body [DFN]

**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		10		
Pitch	e		0.50	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 Length	D	3.00 BSC			
Exposed Pad Length	D2	2.20	2.35	2.48	
Overall Width	E	3.00 BSC			
Exposed Pad Width	E2	1.40	1.58	1.75	
Contact Width	b	0.18	0.25	0.30	
Contact Length	L	0.30	0.40	0.50	
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 may have one or more exposed tie bars at ends.
3. Package is saw singulated.
4. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

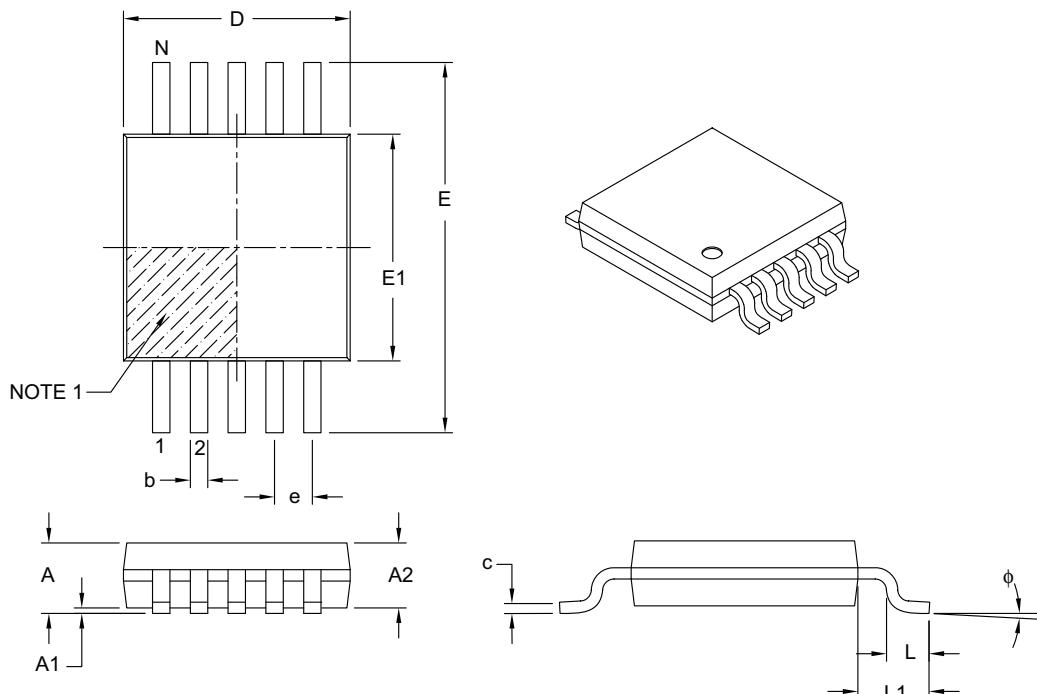
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-063B

# MCP73833/4

## 10-Lead Plastic Micro Small Outline Package (UN) [MSOP]

**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		10		
Pitch		0.50 BSC		
Overall Height		A	—	1.10
Molded Package Thickness		A2	0.75	0.85
Standoff		A1	0.00	—
Overall Width		E	4.90 BSC	
Molded Package Width		E1	3.00 BSC	
Overall Length		D	3.00 BSC	
Foot Length		L	0.40	0.60
Footprint		L1	0.95 REF	
Foot Angle		φ	0°	—
Lead Thickness		c	0.08	—
Lead Width		b	0.15	0.33

### 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 0.15 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.

# **MCP73833/4**

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**NOTES:**

# **MCP73833/4**

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## **APPENDIX A: REVISION HISTORY**

### **Revision B (May 2009)**

The following is the list of modifications:

1. Added the MCP73833-6SI/MF and MCP73834-6SI/MF10-lead DFN packages.
2. Updated DFN pinout.
3. Updated Package Outline Drawings.
4. Updated Appendix A Revision History.

### **Revision A (September 2006)**

- Original Release of this Document.

# **MCP73833/4**

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**NOTES:**

# MCP73833/4

## 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.	XX	X/	XX	Examples: * *		
Device	Output Options*	Temp.	Package	a) MCP73833-AMI/UN: 10-lead MSOP pkg.	b) MCP73833-BZI/UN: 10-lead MSOP pkg.	c) MCP73833-CNI/MF: 10-lead DFN pkg.
Device:	MCP73833: 1A Fully Integrated Charger, PG function on pin 7 MCP73833T: 1A Fully Integrated Charger, PG function on pin 7 (Tape and Reel) MCP73834: 1A Fully Integrated Charger, TE function on pin 7 MCP73834T: 1A Fully Integrated Charger, TE function on pin 7 (Tape and Reel)			d) MCP73833-FCI/UN: 10-lead MSOP pkg.	e) MCP73833-GPI/UN: 10-lead MSOP pkg.	f) MCP73833-NVI/MF: 10-lead DFN pkg.
Output Options **	* Refer to table below for different operational options.  ** Consult Factory for Alternative Device Options.			g) MCP73833-6SI/MF: 10-lead DFN pkg.		
Temperature:	I = -40°C to +85°C			a) MCP73834-CNI/MF: 10-lead DFN pkg.	b) MCP73834-FCI/UN: 10-lead MSOP pkg.	c) MCP73834-GPI/UN: 10-lead MSOP pkg.
Package Type:	MF = Plastic Dual Flat No Lead (DFN) (3x3x0.9 mm Body), 10-lead UN = Plastic Micro Small Outline Package (MSOP), 10-lead			d) MCP73834-NVI/MF: 10-lead DFN pkg.	e) MCP73834-6SI/MF: 10-lead DFN pkg.	
** Consult Factory for Alternative Device Options						
Part Number	V <sub>REG</sub>	I <sub>PREG</sub> /I <sub>REG</sub>	V <sub>PTH</sub> /V <sub>REG</sub>	I <sub>TERM</sub> /I <sub>REG</sub>	V <sub>RTH</sub> /V <sub>REG</sub>	Timer Period
MCP73833-AMI/MF	4.20V	10%	71.5%	7.5%	96.5%	0 hours
MCP73833-BZI/MF	4.20V	100%	N/A	7.5%	96.5%	0 hours
MCP73833-CNI/MF	4.20V	10%	71.5%	20%	94%	4 hours
MCP73833-FCI/MF	4.20V	10%	71.5%	7.5%	96.5%	6 hours
MCP73833-GPI/MF	4.20V	100%	N/A	7.5%	96.5%	6 hours
MCP73833-NVI/MF	4.35V	10%	71.5%	7.5%	96.5%	6 hours
MCP73833-6SI/MF	4.50V	10%	71.5%	7.5%	96.5%	6 hours
MCP73833-AMI/UN	4.20V	10%	71.5%	7.5%	96.5%	0 hours
MCP73833-FCI/UN	4.20V	10%	71.5%	7.5%	96.5%	6 hours
MCP73834-BZI/MF	4.20V	100%	N/A	7.5%	96.5%	0 hours
MCP73834-CNI/MF	4.20V	10%	71.5%	20%	94%	4 hours
MCP73834-FCI/MF	4.20V	10%	71.5%	7.5%	96.5%	6 hours
MCP73834-NVI/MF	4.35V	10%	71.5%	7.5%	96.5%	6 hours
MCP73834-6SI/MF	4.50V	10%	71.5%	7.5%	96.5%	6 hours
MCP73834-FCI/UN	4.20V	10%	71.5%	7.5%	96.5%	6 hours

# **MCP73833/4**

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**NOTES:**

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**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

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## Anexo XIV. Hoja de características de la referencia de tensión NCP700BSN33T1G

## ISL21080

300nA NanoPower Voltage References

FN6934  
Rev.5.00  
Jun 23, 2014

The ISL21080 analog voltage references feature low supply voltage operation at ultra-low 310nA typ, 1.5 $\mu$ A max operating current. Additionally, the ISL21080 family features guaranteed initial accuracy as low as  $\pm 0.2\%$  and 50ppm/ $^{\circ}$ C temperature coefficient.

These references are ideal for general purpose portable applications to extend battery life at lower cost. The ISL21080 is provided in the industry standard 3 Ld SOT-23 pinout.

The ISL21080 output voltages can be used as precision voltage sources for voltage monitors, control loops, standby voltages for low power states for DSP, FPGA, Datapath Controllers, microcontrollers and other core voltages: 0.9V, 1.024V, 1.25V, 1.5V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V and 5.0V.

**Special Note:** Post-assembly x-ray inspection may lead to permanent changes in device output voltage and should be minimized or avoided. For further information, please see "Applications Information" on page 14 and [AN1533](#), "X-Ray Effects on Intersil FGA References".

## Applications

- Energy harvesting applications
- Wireless sensor network applications
- Low power voltage sources for controllers, FPGA, ASICs or logic devices
- Battery management/monitoring
- Low power standby voltages
- Portable Instrumentation
- Consumer/medical electronics
- Wearable electronics
- Lower cost industrial and instrumentation
- Power regulation circuits
- Control loops and compensation networks
- LED/diode supply

## Features

- Reference output voltage ..... 0.900V, 1.024V, 1.250V, 1.500V, 2.048V, 2.500V, 3.000V, 3.300V, 4.096V, 5.000V
- Initial accuracy:
  - ISL21080-09 and -10 .....  $\pm 0.7\%$
  - ISL21080-12 .....  $\pm 0.6\%$
  - ISL21080-15 .....  $\pm 0.5\%$
  - ISL21080-20 and -25 .....  $\pm 0.3\%$
  - ISL21080-30, -33, -41, and -50 .....  $\pm 0.2\%$
- Input voltage range:
  - ISL21080-09 ..... 2.0V to 5.5V
  - ISL21080-10, -12, -15, -20 and -25 ..... 2.7V to 5.5V
  - ISL21080-30 ..... 3.2V to 5.5V
  - ISL21080-33 ..... 3.5V to 5.5V
  - ISL21080-41 ..... 4.5V to 8.0V
  - ISL21080-50 ..... 5.5V to 8.0V
- Output voltage noise ..... 30 $\mu$ V<sub>P-P</sub> (0.1Hz to 10Hz)
- Supply current ..... 1.5 $\mu$ A (max)
- Tempco ..... 50ppm/ $^{\circ}$ C
- Output current capability .....  $\pm 7\text{mA}$
- Operating temperature range ..... -40 $^{\circ}$ C to +85 $^{\circ}$ C
- Package ..... 3 Ld SOT-23
- Pb-Free (RoHS compliant)

## Related Literature

- See [AN1494](#), "Reflow and PC Board Assembly Effects on Intersil FGA References"
- See [AN1533](#), "X-Ray Effects on Intersil FGA References"
- See [AN1761](#), "ISL21080XXEV1Z User's Guide"

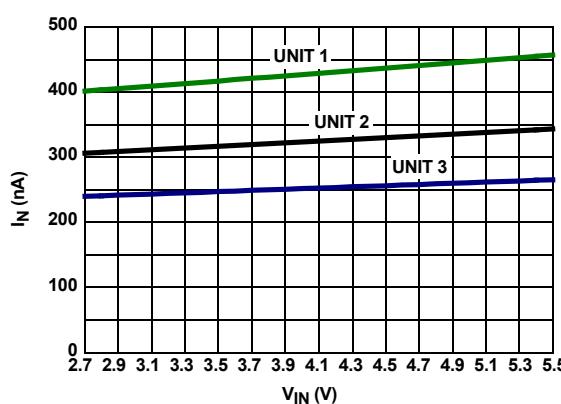
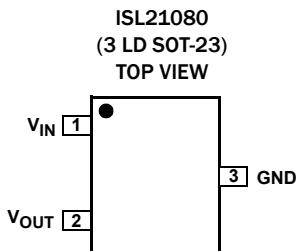


FIGURE 1. I<sub>N</sub> vs V<sub>IN</sub>, 3 UNITS

## Pin Configuration



## Pin Descriptions

PIN NUMBER	PIN NAME	DESCRIPTION
1	V <sub>IN</sub>	Input Voltage Connection.
2	V <sub>OUT</sub>	Voltage Reference Output
3	GND	Ground Connection

## Ordering Information

PART NUMBER (Notes 1, 2, 3)	PART MARKING (Note 4)	V <sub>OUT</sub> OPTION (V)	GRADE (%)	TEMP. RANGE (°C)	PACKAGE Tape & Reel (Pb-Free)	PKG. DWG. #
ISL21080DIH309Z-TK	BCLA	0.9	±0.7	-40 to +85	3 Ld SOT-23	P3.064
ISL21080DIH310Z-TK	BCMA	1.024	±0.7	-40 to +85	3 Ld SOT-23	P3.064
ISL21080DIH312Z-TK	BCNA	1.25	±0.6	-40 to +85	3 Ld SOT-23	P3.064
ISL21080CIH315Z-TK	BCDA	1.5	±0.5	-40 to +85	3 Ld SOT-23	P3.064
ISL21080CIH320Z-TK	BCPA	2.048	±0.3	-40 to +85	3 Ld SOT-23	P3.064
ISL21080CIH325Z-TK	BCRA	2.5	±0.3	-40 to +85	3 Ld SOT-23	P3.064
ISL21080CIH330Z-TK	BCSA	3.0	±0.2	-40 to +85	3 Ld SOT-23	P3.064
ISL21080CIH333Z-TK	BCTA	3.3	±0.2	-40 to +85	3 Ld SOT-23	P3.064
ISL21080CIH341Z-TK	BCVA	4.096	±0.2	-40 to +85	3 Ld SOT-23	P3.064
ISL21080CIH350Z-TK	BCWA	5.0	±0.2	-40 to +85	3 Ld SOT-23	P3.064

## NOTES:

1. Please refer to [TB347](#) for details on reel specifications.
2. These Intersil Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is RoHS compliant and compatible with both SnPb and Pb-free soldering operations). Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.
3. For Moisture Sensitivity Level (MSL), please see device information page for [ISL21080](#). For more information on MSL please see techbrief [TB363](#).
4. The part marking is located on the bottom of the part.

## Absolute Maximum Ratings

Max Voltage	
V <sub>IN</sub> to GND .....	-0.5V to +6.5V
V <sub>IN</sub> to GND (ISL21080-41 and 50 only) .....	-0.5V to +10V
V <sub>OUT</sub> to GND (10s) .....	-0.5V to V <sub>OUT</sub> +1V
V <sub>OUT</sub> to GND (10s)	
ISL21080-41 and 50 only .....	-0.5V to +5.1V
ESD Ratings	
Human Body Model (Tested to JESD22-A114) .....	5kV
Machine Model (Tested to JESD22-A115) .....	500V
Charged Device Model (Tested to JESD22-C101) .....	2kV
Latch Up (Tested per JESD-78B; Class 2, Level A) .....	100mA

## Thermal Information

Thermal Resistance (Typical)	$\theta_{JA}$ (°C/W)	$\theta_{JC}$ (°C/W)
3 Lead SOT-23 (Notes 6, 7) .....	275	110
Maximum Junction Temperature .....		+107°C
Continuous Power Dissipation ( $T_A = +85^\circ\text{C}$ ) .....		99mW
Storage Temperature Range .....		-65°C to +150°C
Pb-Free Reflow Profile .....		see <a href="#">TB493</a>

## Recommended Operating Conditions

Temperature .....	-40°C to +85°C
Supply Voltage .....	2.7V to 5.5V

## Environmental Operating Conditions

X-Ray Exposure (Note 5) .....	10mRem
-------------------------------	--------

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

### NOTES:

5. Measured with no filtering, distance of 10" from source, intensity set to 55kV and 70mA current, 30s duration. Other exposure levels should be analyzed for Output Voltage drift effects. See "Applications Information" on page 14.
6.  $\theta_{JA}$  is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief [TB379](#) for details.
7. For  $\theta_{JC}$ , the "case temp" location is taken at the package top center.
8. Post-reflow drift for the ISL21080 devices will range from 100µV to 1.0mV based on experimental results with devices on FR4 double sided boards. The design engineer must take this into account when considering the reference voltage after assembly.
9. Post-assembly x-ray inspection may also lead to permanent changes in device output voltage and should be minimized or avoided. Initial accuracy can change 10mV or more under extreme radiation. Most inspection equipment will not affect the FGA reference voltage, but if x-ray inspection is required, it is advisable to monitor the reference output voltage to verify excessive shift has not occurred.

## Electrical Specifications (ISL21080-09, V<sub>OUT</sub> = 0.9V) V<sub>IN</sub> = 3.0V, T<sub>A</sub> = -40°C to +85°C, I<sub>OUT</sub> = 0, unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +85°C.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
V <sub>OUT</sub>	Output Voltage			0.9		V
V <sub>OA</sub>	V <sub>OUT</sub> Accuracy @ T <sub>A</sub> = +25°C (Notes 8, 9)		-0.7		+0.7	%
TC V <sub>OUT</sub>	Output Voltage Temperature Coefficient (Note 10)				50	ppm/°C
V <sub>IN</sub>	Input Voltage Range		<b>2.0</b>		<b>5.5</b>	V
I <sub>IN</sub>	Supply Current			0.35	<b>1.5</b>	µA
ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>	Line Regulation	2V ≤ V <sub>IN</sub> ≤ 5.5V		30	<b>350</b>	µV/V
ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub>	Load Regulation	Sourcing: 0mA ≤ I <sub>OUT</sub> ≤ 10mA		6	<b>100</b>	µV/mA
		Sinking: -10mA ≤ I <sub>OUT</sub> ≤ 0mA		23	<b>350</b>	µV/mA
I <sub>SC</sub>	Short Circuit Current	T <sub>A</sub> = +25°C, V <sub>OUT</sub> tied to GND		30		mA
t <sub>R</sub>	Turn-on Settling Time	V <sub>OUT</sub> = ±0.1% with no load		1		ms
	Ripple Rejection	f = 120Hz		-40		dB
e <sub>N</sub>	Output Voltage Noise	0.1Hz ≤ f ≤ 10Hz		40		µV <sub>P-P</sub>
V <sub>N</sub>	Broadband Voltage Noise	10Hz ≤ f ≤ 1kHz		10		µV <sub>RMS</sub>
	Noise Density	f = 1kHz		1.1		µV/√Hz
ΔV <sub>OUT</sub> /ΔT <sub>A</sub>	Thermal Hysteresis (Note 11)	ΔT <sub>A</sub> = +125°C		100		ppm
ΔV <sub>OUT</sub> /Δt	Long Term Stability (Note 12)	T <sub>A</sub> = +25°C		60		ppm

**Electrical Specifications (ISL21080-10,  $V_{OUT} = 1.024V$ )**  $V_{IN} = 3.0V$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ ,  $I_{OUT} = 0$ , unless otherwise specified. Boldface limits apply over the operating temperature range,  $-40^\circ C$  to  $+85^\circ C$ .

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
$V_{OUT}$	Output Voltage			1.024		V
$V_{OA}$	$V_{OUT}$ Accuracy @ $T_A = +25^\circ C$ (Notes 8, 9)		-0.7		+0.7	%
TC $V_{OUT}$	Output Voltage Temperature Coefficient (Note 10)				50	ppm/ $^\circ C$
$V_{IN}$	Input Voltage Range		<b>2.7</b>		<b>5.5</b>	V
$I_{IN}$	Supply Current			0.31	<b>1.5</b>	$\mu A$
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$2.7V \leq V_{IN} \leq 5.5V$		80	<b>350</b>	$\mu V/V$
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	Sourcing: $0mA \leq I_{OUT} \leq 7mA$		25	<b>100</b>	$\mu V/mA$
		Sinking: $-7mA \leq I_{OUT} \leq 0mA$		50	<b>350</b>	$\mu V/mA$
$I_{SC}$	Short Circuit Current	$T_A = +25^\circ C$ , $V_{OUT}$ tied to GND		50		mA
$t_R$	Turn-on Settling Time	$V_{OUT} = \pm 0.1\%$ with no load		4		ms
	Ripple Rejection	$f = 120Hz$		-40		dB
$e_N$	Output Voltage Noise	$0.1Hz \leq f \leq 10Hz$		30		$\mu V_{P-P}$
$V_N$	Broadband Voltage Noise	$10Hz \leq f \leq 1kHz$		52		$\mu V_{RMS}$
	Noise Density	$f = 1kHz$		2.2		$\mu V/\sqrt{Hz}$
$\Delta V_{OUT}/\Delta T_A$	Thermal Hysteresis (Note 11)	$\Delta T_A = +165^\circ C$		100		ppm
$\Delta V_{OUT}/\Delta t$	Long Term Stability (Note 12)	$T_A = +25^\circ C$		50		ppm

**Electrical Specifications (ISL21080-12,  $V_{OUT} = 1.25V$ )**  $V_{IN} = 3.0V$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ ,  $I_{OUT} = 0$ , unless otherwise specified. Boldface limits apply over the operating temperature range,  $-40^\circ C$  to  $+85^\circ C$ .

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
$V_{OUT}$	Output Voltage			1.25		V
$V_{OA}$	$V_{OUT}$ Accuracy @ $T_A = +25^\circ C$ (Notes 8, 9)		-0.6		+0.6	%
TC $V_{OUT}$	Output Voltage Temperature Coefficient (Note 10)				50	ppm/ $^\circ C$
$V_{IN}$	Input Voltage Range		<b>2.7</b>		<b>5.5</b>	V
$I_{IN}$	Supply Current			0.31	<b>1.5</b>	$\mu A$
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$2.7V \leq V_{IN} \leq 5.5V$		80	<b>350</b>	$\mu V/V$
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	Sourcing: $0mA \leq I_{OUT} \leq 7mA$		25	<b>100</b>	$\mu V/mA$
		Sinking: $-7mA \leq I_{OUT} \leq 0mA$		50	<b>350</b>	$\mu V/mA$
$I_{SC}$	Short Circuit Current	$T_A = +25^\circ C$ , $V_{OUT}$ tied to GND		50		mA
$t_R$	Turn-on Settling Time	$V_{OUT} = \pm 0.1\%$ with no load		4		ms
	Ripple Rejection	$f = 120Hz$		-40		dB
$e_N$	Output Voltage Noise	$0.1Hz \leq f \leq 10Hz$		30		$\mu V_{P-P}$
$V_N$	Broadband Voltage Noise	$10Hz \leq f \leq 1kHz$		52		$\mu V_{RMS}$
	Noise Density	$f = 1kHz$		1.1		$\mu V/\sqrt{Hz}$
$\Delta V_{OUT}/\Delta T_A$	Thermal Hysteresis (Note 11)	$\Delta T_A = +165^\circ C$		100		ppm
$\Delta V_{OUT}/\Delta t$	Long Term Stability (Note 12)	$T_A = +25^\circ C$		50		ppm

**Electrical Specifications (ISL21080-15, V<sub>OUT</sub> = 1.5V)** V<sub>IN</sub> = 3.0V, T<sub>A</sub> = -40°C to +85°C, I<sub>OUT</sub> = 0, unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +85°C.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
V <sub>OUT</sub>	Output Voltage			1.5		V
V <sub>OA</sub>	V <sub>OUT</sub> Accuracy @ T <sub>A</sub> = +25°C (Notes 8, 9)		-0.5		+0.5	%
TC V <sub>OUT</sub>	Output Voltage Temperature Coefficient (Note 10)				<b>50</b>	ppm/°C
V <sub>IN</sub>	Input Voltage Range		<b>2.7</b>		<b>5.5</b>	V
I <sub>IN</sub>	Supply Current			0.31	<b>1.5</b>	µA
ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>	Line Regulation	2.7V ≤ V <sub>IN</sub> ≤ 5.5V		80	<b>350</b>	µV/V
ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub>	Load Regulation	Sourcing: 0mA ≤ I <sub>OUT</sub> ≤ 7mA		10	<b>100</b>	µV/mA
		Sinking: -7mA ≤ I <sub>OUT</sub> ≤ 0mA		50	<b>350</b>	µV/mA
I <sub>SC</sub>	Short Circuit Current	T <sub>A</sub> = +25°C, V <sub>OUT</sub> tied to GND		50		mA
t <sub>R</sub>	Turn-on Settling Time	V <sub>OUT</sub> = ±0.1% with no load		4		ms
	Ripple Rejection	f = 120Hz		-40		dB
e <sub>N</sub>	Output Voltage Noise	0.1Hz ≤ f ≤ 10Hz		30		µV <sub>P-P</sub>
V <sub>N</sub>	Broadband Voltage Noise	10Hz ≤ f ≤ 1kHz		52		µV <sub>RMS</sub>
	Noise Density	f = 1kHz		1.1		µV/√Hz
ΔV <sub>OUT</sub> /ΔT <sub>A</sub>	Thermal Hysteresis (Note 11)	ΔT <sub>A</sub> = +165°C		100		ppm
ΔV <sub>OUT</sub> /Δt	Long Term Stability (Note 12)	T <sub>A</sub> = +25°C		50		ppm

**Electrical Specifications (ISL21080-20, V<sub>OUT</sub> = 2.048V)** V<sub>IN</sub> = 3.0V, T<sub>A</sub> = -40°C to +85°C, I<sub>OUT</sub> = 0, unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +85°C.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
V <sub>OUT</sub>	Output Voltage			2.048		V
V <sub>OA</sub>	V <sub>OUT</sub> Accuracy @ T <sub>A</sub> = +25°C (Notes 8, 9)		-0.3		+0.3	%
TC V <sub>OUT</sub>	Output Voltage Temperature Coefficient (Note 10)				<b>50</b>	ppm/°C
V <sub>IN</sub>	Input Voltage Range		<b>2.7</b>		<b>5.5</b>	V
I <sub>IN</sub>	Supply Current			0.31	<b>1.5</b>	µA
ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>	Line Regulation	2.7V ≤ V <sub>IN</sub> ≤ 5.5V		80	<b>350</b>	µV/V
ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub>	Load Regulation	Sourcing: 0mA ≤ I <sub>OUT</sub> ≤ 7mA		25	<b>100</b>	µV/mA
		Sinking: -7mA ≤ I <sub>OUT</sub> ≤ 0mA		50	<b>350</b>	µV/mA
I <sub>SC</sub>	Short Circuit Current	T <sub>A</sub> = +25°C, V <sub>OUT</sub> tied to GND		50		mA
t <sub>R</sub>	Turn-on Settling Time	V <sub>OUT</sub> = ±0.1% with no load		4		ms
	Ripple Rejection	f = 120Hz		-40		dB
e <sub>N</sub>	Output Voltage Noise	0.1Hz ≤ f ≤ 10Hz		30		µV <sub>P-P</sub>
V <sub>N</sub>	Broadband Voltage Noise	10Hz ≤ f ≤ 1kHz		52		µV <sub>RMS</sub>
	Noise Density	f = 1kHz		1.1		µV/√Hz
ΔV <sub>OUT</sub> /ΔT <sub>A</sub>	Thermal Hysteresis (Note 11)	ΔT <sub>A</sub> = +165°C		100		ppm
ΔV <sub>OUT</sub> /Δt	Long Term Stability (Note 12)	T <sub>A</sub> = +25°C		50		ppm

**Electrical Specifications (ISL21080-25,  $V_{OUT} = 2.5V$ )**  $V_{IN} = 3.0V$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ ,  $I_{OUT} = 0$ , unless otherwise specified. Boldface limits apply over the operating temperature range,  $-40^\circ C$  to  $+85^\circ C$ .

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
$V_{OUT}$	Output Voltage			2.5		V
$V_{OA}$	$V_{OUT}$ Accuracy @ $T_A = +25^\circ C$ (Notes 8, 9)		-0.3		+0.3	%
TC $V_{OUT}$	Output Voltage Temperature Coefficient (Note 10)				50	ppm/ $^\circ C$
$V_{IN}$	Input Voltage Range		<b>2.7</b>		<b>5.5</b>	V
$I_{IN}$	Supply Current			0.31	<b>1.5</b>	$\mu A$
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$2.7V \leq V_{IN} \leq 5.5V$		80	<b>350</b>	$\mu V/V$
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	Sourcing: $0mA \leq I_{OUT} \leq 7mA$		25	<b>100</b>	$\mu V/mA$
		Sinking: $-7mA \leq I_{OUT} \leq 0mA$		50	<b>350</b>	$\mu V/mA$
$I_{SC}$	Short Circuit Current	$T_A = +25^\circ C$ , $V_{OUT}$ tied to GND		50		mA
$t_R$	Turn-on Settling Time	$V_{OUT} = \pm 0.1\%$ with no load		4		ms
	Ripple Rejection	$f = 120Hz$		-40		dB
$e_N$	Output Voltage Noise	$0.1Hz \leq f \leq 10Hz$		30		$\mu V_{P-P}$
$V_N$	Broadband Voltage Noise	$10Hz \leq f \leq 1kHz$		52		$\mu V_{RMS}$
	Noise Density	$f = 1kHz$		1.1		$\mu V/\sqrt{Hz}$
$\Delta V_{OUT}/\Delta T_A$	Thermal Hysteresis (Note 11)	$\Delta T_A = +165^\circ C$		100		ppm
$\Delta V_{OUT}/\Delta t$	Long Term Stability (Note 12)	$T_A = +25^\circ C$		50		ppm

**Electrical Specifications (ISL21080-30,  $V_{OUT} = 3.0V$ )**  $V_{IN} = 5.0V$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ ,  $I_{OUT} = 0$ , unless otherwise specified. Boldface limits apply over the operating temperature range,  $-40^\circ C$  to  $+85^\circ C$ .

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
$V_{OUT}$	Output Voltage			3.0		V
$V_{OA}$	$V_{OUT}$ Accuracy @ $T_A = +25^\circ C$ (Notes 8, 9)		-0.2		+0.2	%
TC $V_{OUT}$	Output Voltage Temperature Coefficient (Note 10)				<b>50</b>	ppm/ $^\circ C$
$V_{IN}$	Input Voltage Range		<b>3.2</b>		<b>5.5</b>	V
$I_{IN}$	Supply Current			0.31	<b>1.5</b>	$\mu A$
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$3.2V \leq V_{IN} \leq 5.5V$		80	<b>350</b>	$\mu V/V$
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	Sourcing: $0mA \leq I_{OUT} \leq 7mA$		25	<b>100</b>	$\mu V/mA$
		Sinking: $-7mA \leq I_{OUT} \leq 0mA$		50	<b>350</b>	$\mu V/mA$
$I_{SC}$	Short Circuit Current	$T_A = +25^\circ C$ , $V_{OUT}$ tied to GND		50		mA
$t_R$	Turn-on Settling Time	$V_{OUT} = \pm 0.1\%$ with no load		4		ms
	Ripple Rejection	$f = 120Hz$		-40		dB
$e_N$	Output Voltage Noise	$0.1Hz \leq f \leq 10Hz$		30		$\mu V_{P-P}$
$V_N$	Broadband Voltage Noise	$10Hz \leq f \leq 1kHz$		52		$\mu V_{RMS}$
	Noise Density	$f = 1kHz$		1.1		$\mu V/\sqrt{Hz}$
$\Delta V_{OUT}/\Delta T_A$	Thermal Hysteresis (Note 11)	$\Delta T_A = +165^\circ C$		100		ppm
$\Delta V_{OUT}/\Delta t$	Long Term Stability (Note 12)	$T_A = +25^\circ C$		50		ppm

**Electrical Specifications (ISL21080-33, V<sub>OUT</sub> = 3.3V)** V<sub>IN</sub> = 5.0V, T<sub>A</sub> = -40°C to +85°C, I<sub>OUT</sub> = 0, unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +85°C.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
V <sub>OUT</sub>	Output Voltage			3.3		V
V <sub>OA</sub>	V <sub>OUT</sub> Accuracy @ T <sub>A</sub> = +25°C (Notes 8, 9)		-0.2		+0.2	%
TC V <sub>OUT</sub>	Output Voltage Temperature Coefficient (Note 10)			50		ppm/°C
V <sub>IN</sub>	Input Voltage Range		<b>3.5</b>		<b>5.5</b>	V
I <sub>IN</sub>	Supply Current			0.31	<b>1.5</b>	µA
ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>	Line Regulation	3.5 V ≤ V <sub>IN</sub> ≤ 5.5V		80	<b>350</b>	µV/V
ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub>	Load Regulation	Sourcing: 0mA ≤ I <sub>OUT</sub> ≤ 10mA		25	<b>100</b>	µV/mA
		Sinking: -10mA ≤ I <sub>OUT</sub> ≤ 0mA		50	<b>350</b>	µV/mA
I <sub>SC</sub>	Short Circuit Current	T <sub>A</sub> = +25°C, V <sub>OUT</sub> tied to GND		50		mA
t <sub>R</sub>	Turn-on Settling Time	V <sub>OUT</sub> = ±0.1% with no load		4		ms
	Ripple Rejection	f = 120Hz		-40		dB
e <sub>N</sub>	Output Voltage Noise	0.1Hz ≤ f ≤ 10Hz		30		µV <sub>P-P</sub>
V <sub>N</sub>	Broadband Voltage Noise	10Hz ≤ f ≤ 1kHz		52		µV <sub>RMS</sub>
	Noise Density	f = 1kHz		1.1		µV/√Hz
ΔV <sub>OUT</sub> /ΔT <sub>A</sub>	Thermal Hysteresis (Note 11)	ΔT <sub>A</sub> = +165°C		100		ppm
ΔV <sub>OUT</sub> /Δt	Long Term Stability (Note 12)	T <sub>A</sub> = +25°C		50		ppm

**Electrical Specifications (ISL21080-41 V<sub>OUT</sub> = 4.096V)** V<sub>IN</sub> = 5.0V, T<sub>A</sub> = -40°C to +85°C, I<sub>OUT</sub> = 0, unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +85°C.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
V <sub>OUT</sub>	Output Voltage			4.096		V
V <sub>OA</sub>	V <sub>OUT</sub> Accuracy @ T <sub>A</sub> = +25°C (Notes 8, 9)		-0.2		+0.2	%
TC V <sub>OUT</sub>	Output Voltage Temperature Coefficient (Note 10)				<b>50</b>	ppm/°C
V <sub>IN</sub>	Input Voltage Range		<b>4.5</b>		<b>8.0</b>	V
I <sub>IN</sub>	Supply Current			0.5	<b>1.5</b>	µA
ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>	Line Regulation	4.5 V ≤ V <sub>IN</sub> ≤ 8.0V		80	<b>350</b>	µV/V
ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub>	Load Regulation	Sourcing: 0mA ≤ I <sub>OUT</sub> ≤ 10mA		10	<b>100</b>	µV/mA
		Sinking: -10mA ≤ I <sub>OUT</sub> ≤ 0mA		20	<b>350</b>	µV/mA
I <sub>SC</sub>	Short Circuit Current	T <sub>A</sub> = +25°C, V <sub>OUT</sub> tied to GND		80		mA
t <sub>R</sub>	Turn-on Settling Time	V <sub>OUT</sub> = ±0.1% with no load		4		ms
	Ripple Rejection	f = 120Hz		-40		dB
e <sub>N</sub>	Output Voltage Noise	0.1Hz ≤ f ≤ 10Hz		30		µV <sub>P-P</sub>
V <sub>N</sub>	Broadband Voltage Noise	10Hz ≤ f ≤ 1kHz		52		µV <sub>RMS</sub>
	Noise Density	f = 1kHz		1.1		µV/√Hz
ΔV <sub>OUT</sub> /ΔT <sub>A</sub>	Thermal Hysteresis (Note 11)	ΔT <sub>A</sub> = +165°C		100		ppm
ΔV <sub>OUT</sub> /Δt	Long Term Stability (Note 12)	T <sub>A</sub> = +25°C		50		ppm

**Electrical Specifications (ISL21080-50 V<sub>OUT</sub> = 5.0V)** V<sub>IN</sub> = 6.5V, T<sub>A</sub> = -40°C to +85°C, I<sub>OUT</sub> = 0, unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +85°C.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 13)	TYP	MAX (Note 13)	UNIT
V <sub>OUT</sub>	Output Voltage			5.0		V
V <sub>OA</sub>	V <sub>OUT</sub> Accuracy @ T <sub>A</sub> = +25°C (Notes 8, 9)		-0.2		+0.2	%
TC V <sub>OUT</sub>	Output Voltage Temperature Coefficient (Note 10)				<b>50</b>	ppm/°C
V <sub>IN</sub>	Input Voltage Range		<b>5.5</b>		<b>8.0</b>	V
I <sub>IN</sub>	Supply Current			0.5	<b>1.5</b>	µA
ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>	Line Regulation	5.5 V ≤ V <sub>IN</sub> ≤ 8.0V		80	<b>350</b>	µV/V
ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub>	Load Regulation	Sourcing: 0mA ≤ I <sub>OUT</sub> ≤ 10mA		10	<b>100</b>	µV/mA
		Sinking: -10mA ≤ I <sub>OUT</sub> ≤ 0mA		20	<b>350</b>	µV/mA
I <sub>SC</sub>	Short Circuit Current	T <sub>A</sub> = +25°C, V <sub>OUT</sub> tied to GND		80		mA
t <sub>R</sub>	Turn-on Settling Time	V <sub>OUT</sub> = ±0.1% with no load		4		ms
	Ripple Rejection	f = 120Hz		-40		dB
e <sub>N</sub>	Output Voltage Noise	0.1Hz ≤ f ≤ 10Hz		30		µV <sub>P-P</sub>
V <sub>N</sub>	Broadband Voltage Noise	10Hz ≤ f ≤ 1kHz		52		µV <sub>RMS</sub>
	Noise Density	f = 1kHz		1.1		µV/√Hz
ΔV <sub>OUT</sub> /ΔT <sub>A</sub>	Thermal Hysteresis (Note 11)	ΔT <sub>A</sub> = +165°C		100		ppm
ΔV <sub>OUT</sub> /Δt	Long Term Stability (Note 12)	T <sub>A</sub> = +25°C		50		ppm

## NOTES:

- Over the specified temperature range. Temperature coefficient is measured by the box method whereby the change in V<sub>OUT</sub> is divided by the temperature range; in this case, -40°C to +85°C = +125°C.
- Thermal Hysteresis is the change of V<sub>OUT</sub> measured @ T<sub>A</sub> = +25°C after temperature cycling over a specified range, ΔT<sub>A</sub>. V<sub>OUT</sub> is read initially at T<sub>A</sub> = +25°C for the device under test. The device is temperature cycled and a second V<sub>OUT</sub> measurement is taken at +25°C. The difference between the initial V<sub>OUT</sub> reading and the second V<sub>OUT</sub> reading is then expressed in ppm. For ΔT<sub>A</sub> = +125°C, the device under test is cycled from +25°C to +85°C to -40°C to +25°C.
- Long term drift is logarithmic in nature and diminishes over time. Drift after the first 1000 hours will be approximately 10ppm/√1khrs.
- Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.

## Typical Performance Characteristics Curves

V<sub>OUT</sub> = 0.9V, V<sub>IN</sub> = 3.0V, I<sub>OUT</sub> = 0mA, T<sub>A</sub> = +25°C

unless otherwise specified.

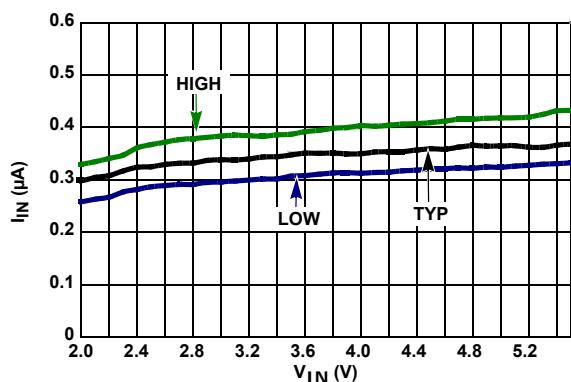


FIGURE 2. I<sub>IN</sub> vs V<sub>IN</sub>, 3 UNITS

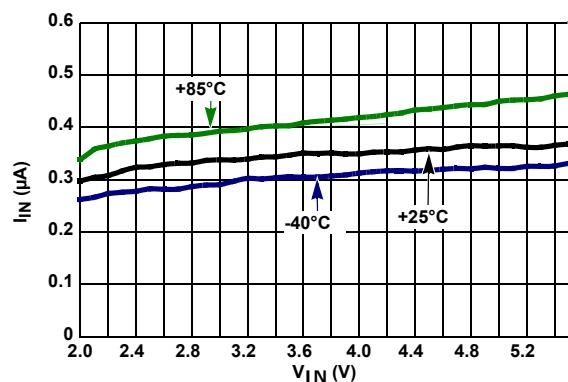


FIGURE 3. I<sub>IN</sub> vs V<sub>IN</sub> OVER-TEMPERATURE

## Typical Performance Characteristics Curves

$V_{OUT} = 0.9V$ ,  $V_{IN} = 3.0V$ ,  $I_{OUT} = 0mA$ ,  $T_A = +25^\circ C$

unless otherwise specified. (Continued)

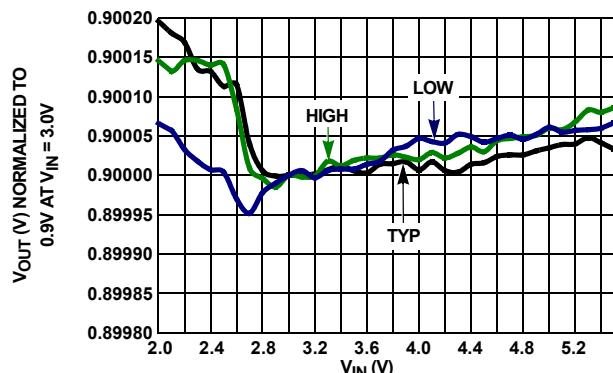


FIGURE 4. LINE REGULATION, 3 UNITS

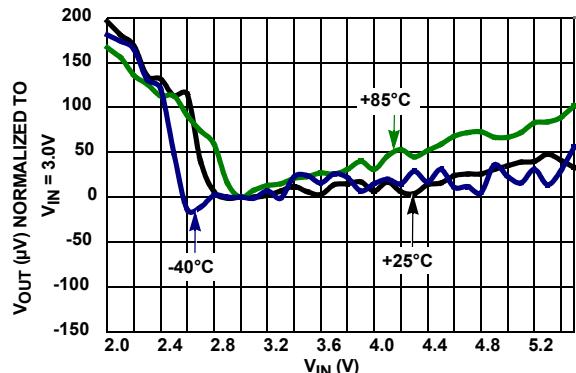


FIGURE 5. LINE REGULATION OVER-TEMPERATURE

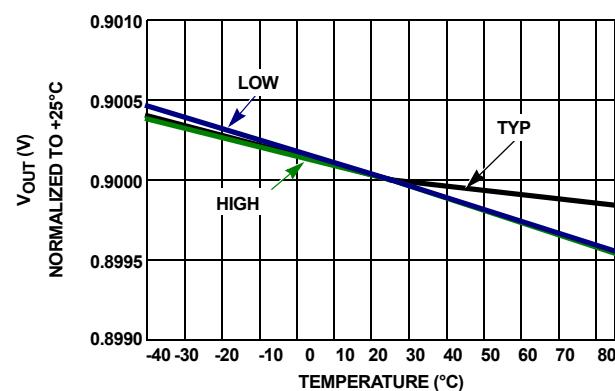


FIGURE 6.  $V_{OUT}$  VS TEMPERATURE NORMALIZED to  $+25^\circ C$

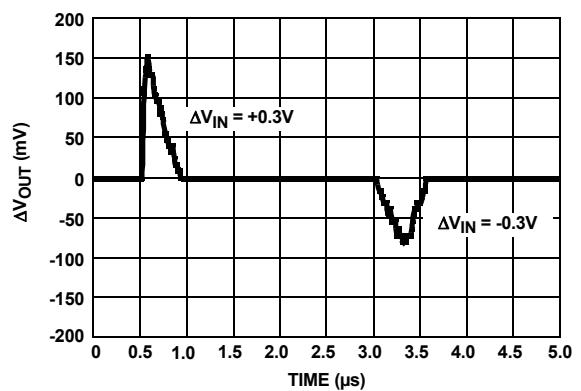


FIGURE 7. LINE TRANSIENT RESPONSE, WITH CAPACITIVE LOAD

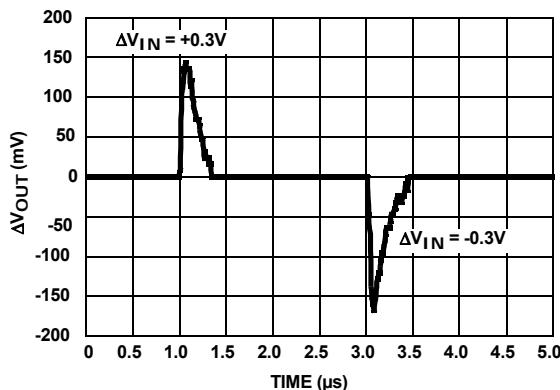


FIGURE 8. LINE TRANSIENT RESPONSE

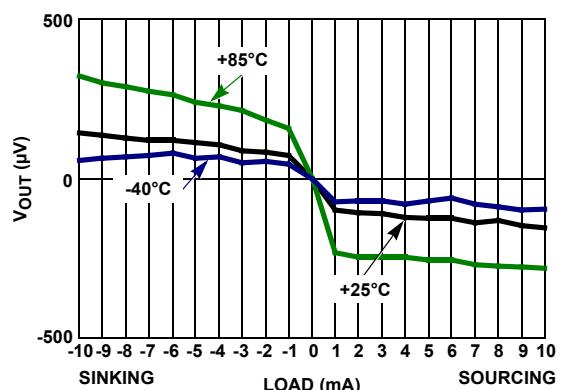


FIGURE 9. LOAD REGULATION OVER-TEMPERATURE

## Typical Performance Characteristics Curves

$V_{OUT} = 0.9V$ ,  $V_{IN} = 3.0V$ ,  $I_{OUT} = 0mA$ ,  $T_A = +25^\circ C$

unless otherwise specified. (Continued)

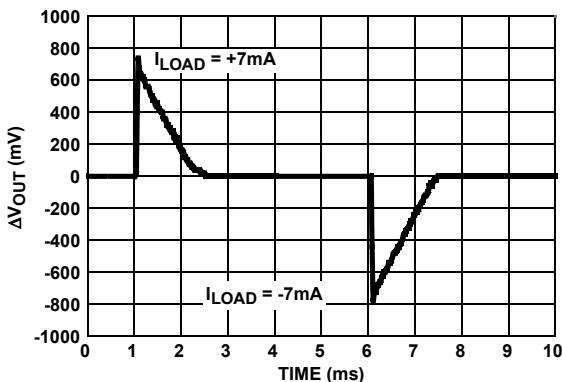


FIGURE 10. LOAD TRANSIENT RESPONSE

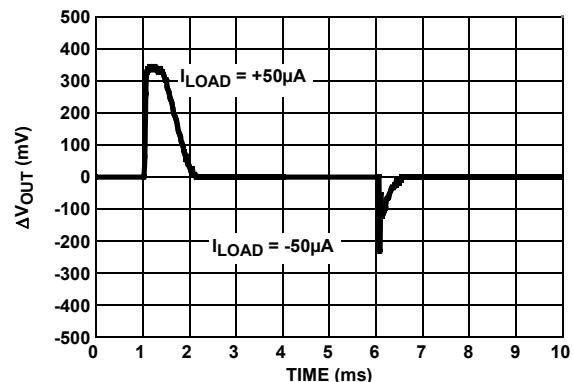


FIGURE 11. LOAD TRANSIENT RESPONSE

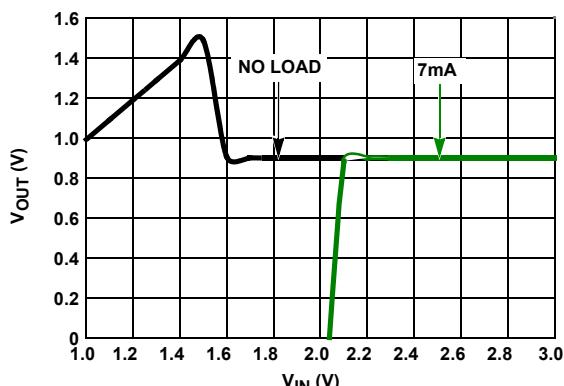


FIGURE 12. DROPOUT

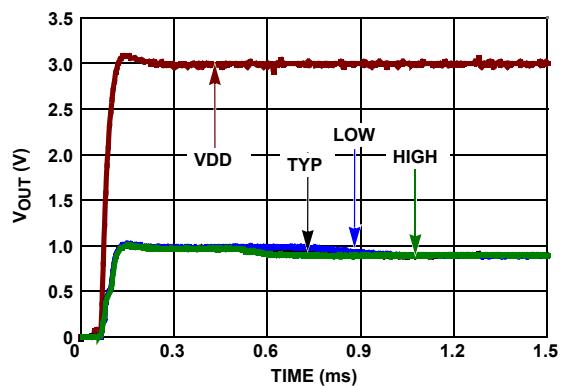


FIGURE 13. TURN-ON TIME

## Typical Performance Characteristics Curves

$V_{OUT} = 1.5V$ ,  $V_{IN} = 3.0V$ ,  $I_{OUT} = 0mA$ ,  $T_A = +25^\circ C$

unless otherwise specified.

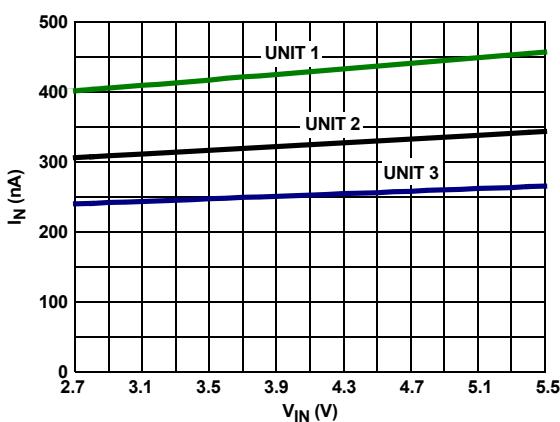


FIGURE 14. I<sub>IN</sub> vs V<sub>IN</sub>, 3 UNITS

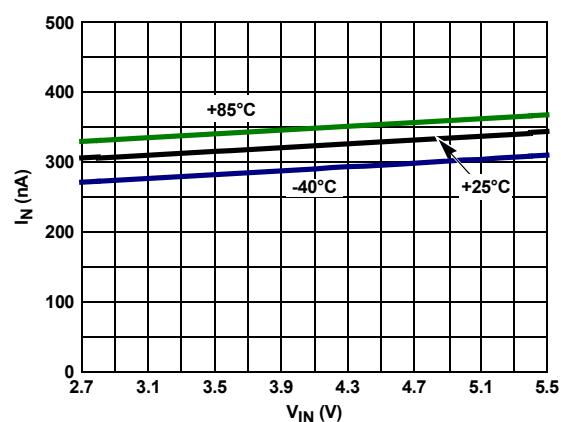


FIGURE 15. I<sub>IN</sub> vs V<sub>IN</sub> OVER-TEMPERATURE

## Typical Performance Characteristics Curves

$V_{OUT} = 1.5V, V_{IN} = 3.0V, I_{OUT} = 0mA, T_A = +25^\circ C$

unless otherwise specified. (Continued)

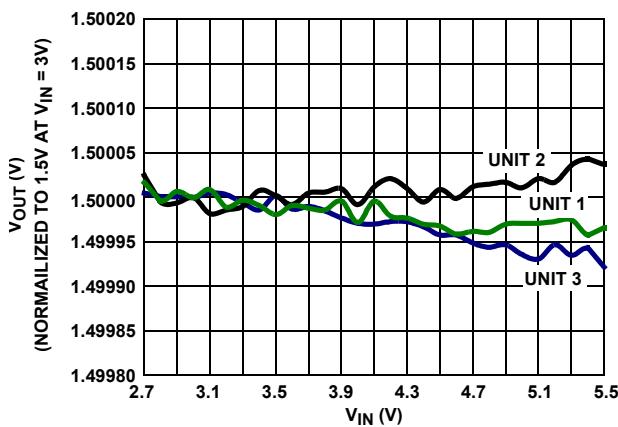


FIGURE 16. LINE REGULATION, 3 UNITS

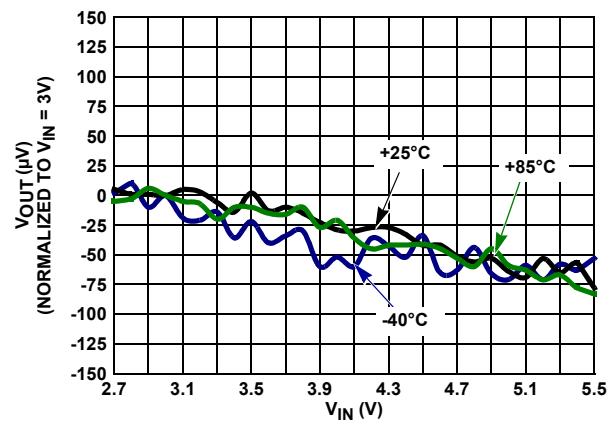


FIGURE 17. LINE REGULATION OVER-TEMPERATURE

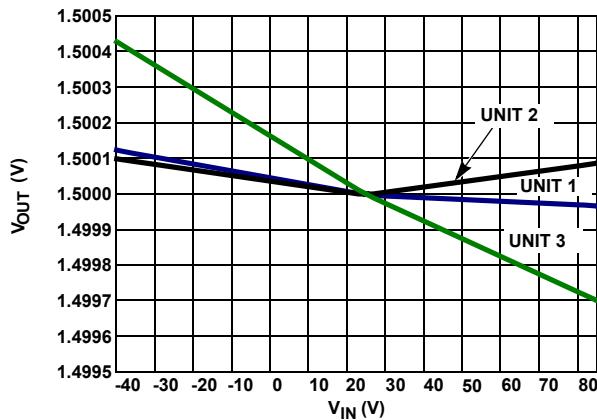


FIGURE 18.  $V_{OUT}$  VS TEMPERATURE NORMALIZED to  $+25^\circ C$

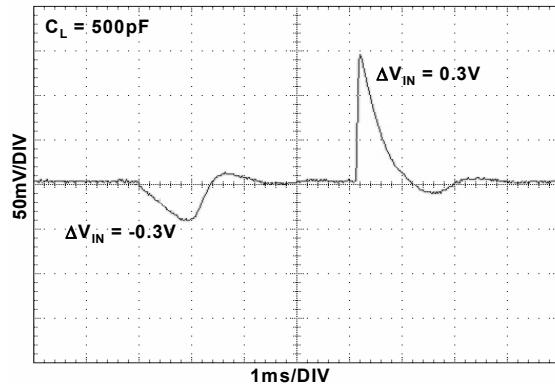


FIGURE 19. LINE TRANSIENT RESPONSE, WITH CAPACITIVE LOAD

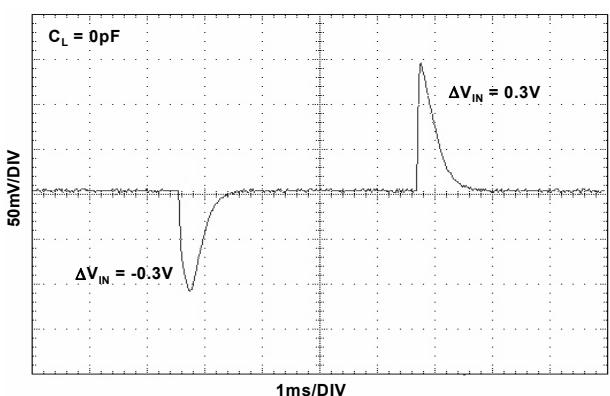


FIGURE 20. LINE TRANSIENT RESPONSE

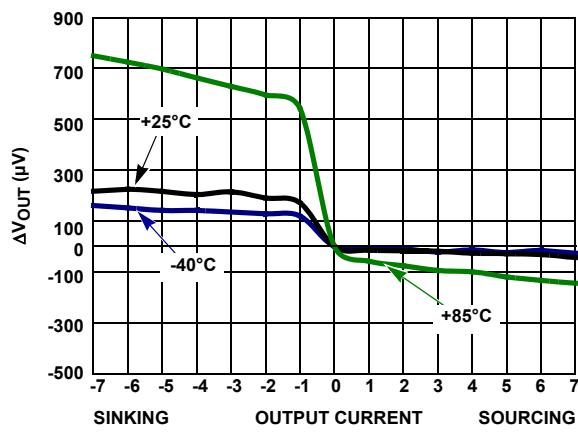


FIGURE 21. LOAD REGULATION OVER-TEMPERATURE

## Typical Performance Characteristics Curves

$V_{OUT} = 1.5V, V_{IN} = 3.0V, I_{OUT} = 0mA, T_A = +25^{\circ}C$

unless otherwise specified. (Continued)

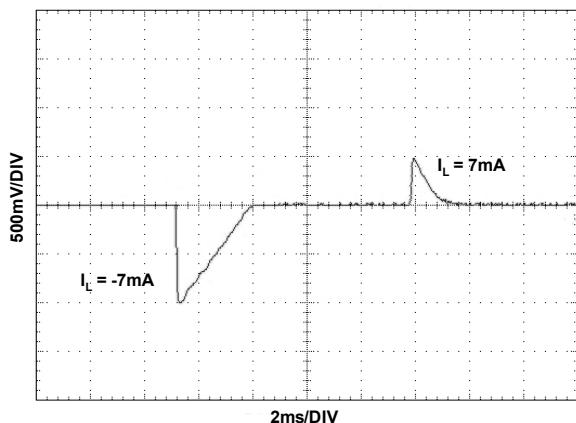


FIGURE 22. LOAD TRANSIENT RESPONSE

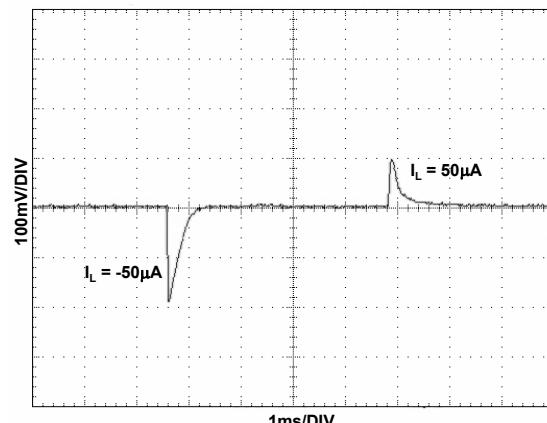


FIGURE 23. LOAD TRANSIENT RESPONSE

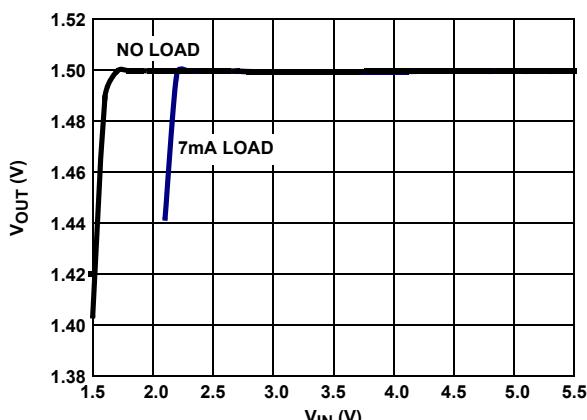


FIGURE 24. DROPOUT

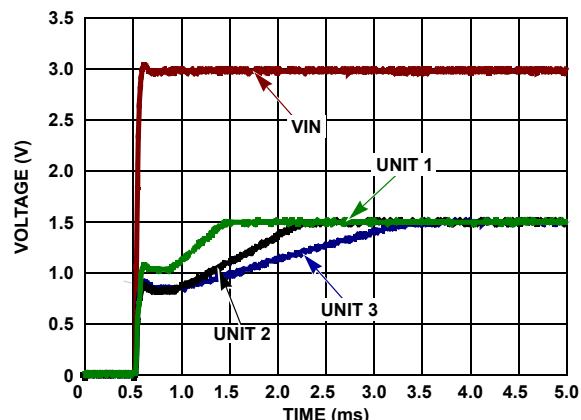


FIGURE 25. TURN-ON TIME

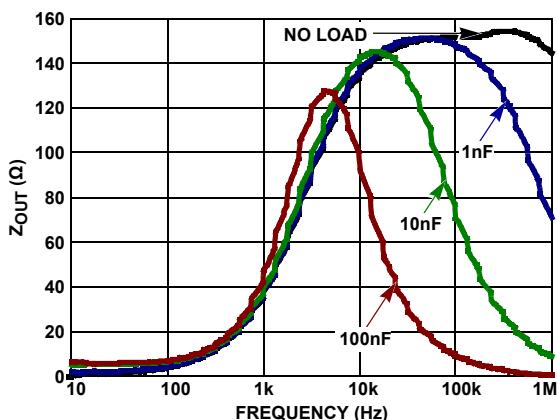


FIGURE 26.  $Z_{OUT}$  VS FREQUENCY

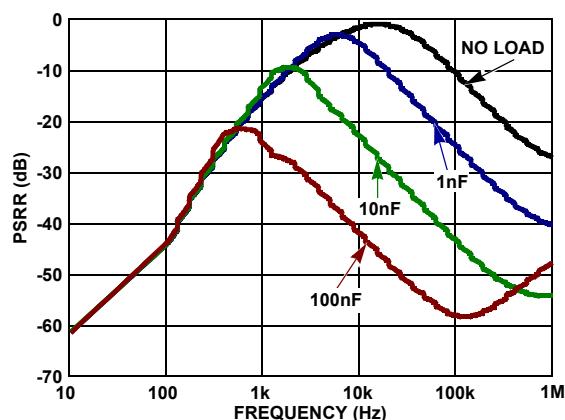


FIGURE 27. PSRR VS FREQUENCY

## Typical Performance Characteristics Curves

$T_A = +25^\circ\text{C}$  unless otherwise specified.

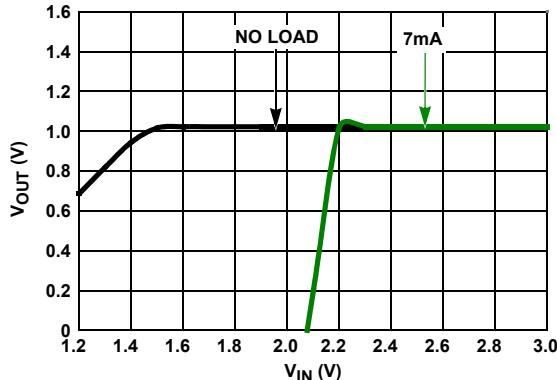


FIGURE 28. DROPOUT, ISL21080-10

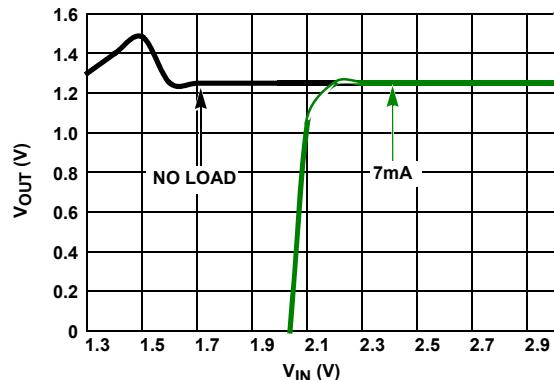


FIGURE 29. DROPOUT, ISL21080-12

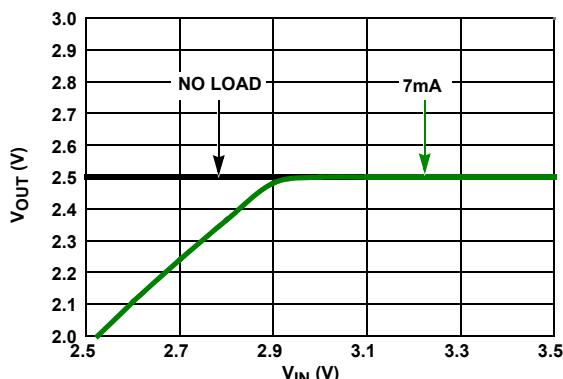


FIGURE 30. DROPOUT, ISL21080-25

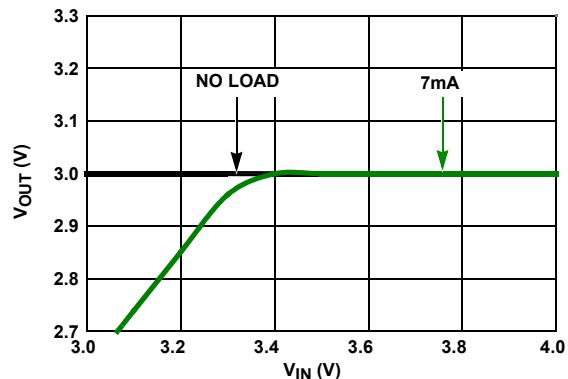


FIGURE 31. DROPOUT, ISL21080-30

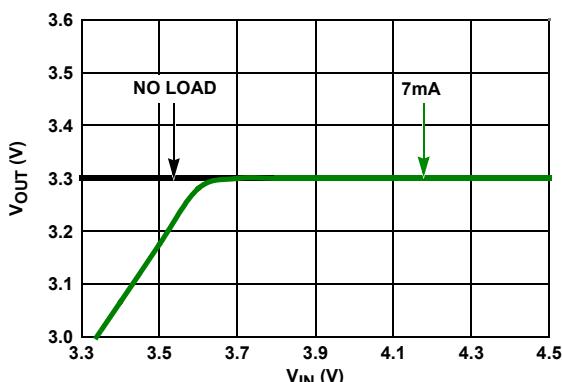


FIGURE 32. DROPOUT, ISL21080-33

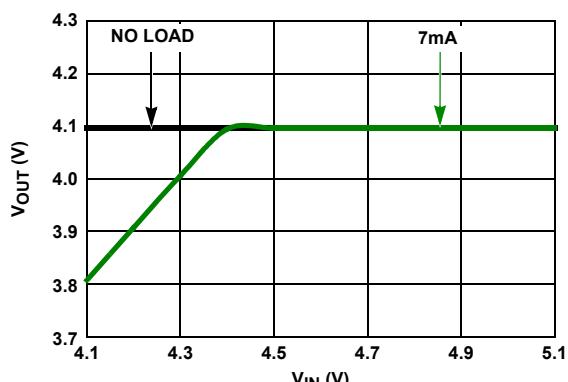


FIGURE 33. DROPOUT, ISL21080-41

## Typical Performance Characteristics Curves $T_A = +25^\circ\text{C}$ unless otherwise specified. (Continued)

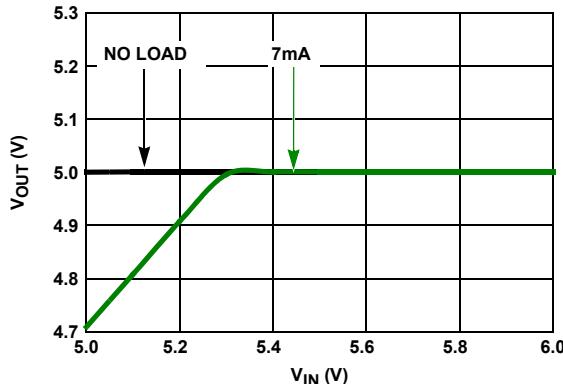
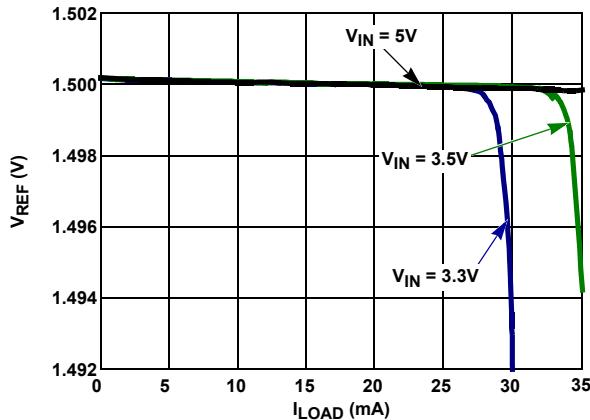
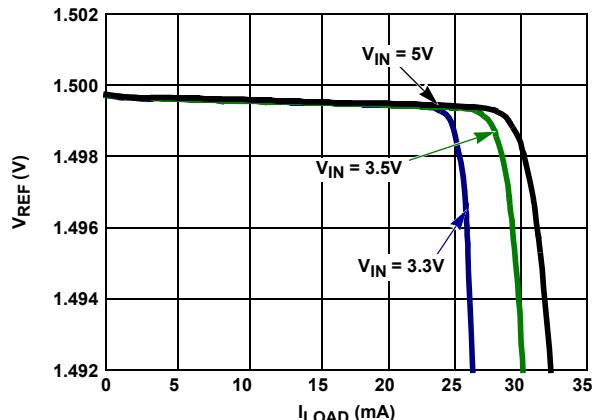


FIGURE 34. DROPOUT, ISL21080-50

## High Current Application

FIGURE 35. DIFFERENT  $V_{IN}$  AT ROOM TEMPERATUREFIGURE 36. DIFFERENT  $V_{IN}$  AT HIGH TEMPERATURE ( $+85^\circ\text{C}$ )

## Applications Information

### FGA Technology

The ISL21080 series of voltage references use the floating gate technology to create references with very low drift and supply current. Essentially, the charge stored on a floating gate cell is set precisely in manufacturing. The reference voltage output itself is a buffered version of the floating gate voltage. The resulting reference device has excellent characteristics which are unique in the industry: very low temperature drift, high initial accuracy, and almost zero supply current. Also, the reference voltage itself is not limited by voltage bandgaps or zener settings, so a wide range of reference voltages can be programmed (standard voltage settings are provided, but customer-specific voltages are available).

The process used for these reference devices is a floating gate CMOS process, and the amplifier circuitry uses CMOS transistors for amplifier and output transistor circuitry. While providing excellent accuracy, there are limitations in output noise level and load regulation due to the MOS device characteristics. These limitations are addressed with circuit techniques discussed in other sections.

### Board Assembly Considerations

FGA references provide high accuracy and low temperature drift but some PC board assembly precautions are necessary. Normal Output voltage shifts of  $100\mu\text{V}$  to  $1\text{mV}$  can be expected with Pb-free reflow profiles or wave solder on multi-layer FR4 PC boards. Precautions should be taken to avoid excessive heat or extended exposure to high reflow or wave solder temperatures, this may reduce device initial accuracy.

Post-assembly x-ray inspection may also lead to permanent changes in device output voltage and should be minimized or avoided. If x-ray inspection is required, it is advisable to monitor the reference output voltage to verify excessive shift has not occurred. If large amounts of shift are observed, it is best to add an X-ray shield consisting of thin zinc ( $300\mu\text{m}$ ) sheeting to allow clear imaging, yet block x-ray energy that affects the FGA reference.

### Special Applications Considerations

In addition to post-assembly examination, there are also other X-ray sources that may affect the FGA reference long term accuracy. Airport screening machines contain X-rays and will have a cumulative effect on the voltage reference output accuracy. Carry-on luggage screening uses low level X-rays and is

## ISL21080

not a major source of output voltage shift, however, if a product is expected to pass through that type of screening over 100 times, it may need to consider shielding with copper or aluminum. Checked luggage X-rays are higher intensity and can cause output voltage shift in much fewer passes, thus devices expected to go through those machines should definitely consider shielding. Note that just two layers of 1/2 ounce copper planes will reduce the received dose by over 90%. The leadframe for the device which is on the bottom also provides similar shielding.

If a device is expected to pass through luggage X-ray machines numerous times, it is advised to mount a 2-layer (minimum) PC board on the top, and along with a ground plane underneath will effectively shield it from 50 to 100 passes through the machine. Since these machines vary in X-ray dose delivered, it is difficult to produce an accurate maximum pass recommendation.

### Nanopower Operation

Reference devices achieve their highest accuracy when powered up continuously, and after initial stabilization has taken place. This drift can be eliminated by leaving the power on continuously.

The ISL21080 is the first high precision voltage reference with ultra low power consumption that makes it possible to leave power on continuously in battery operated circuits. The ISL21080 consumes extremely low supply current due to the proprietary FGA technology. Supply current at room temperature is typically 350nA, which is 1 to 2 orders of magnitude lower than competitive devices. Application circuits using battery power will benefit greatly from having an accurate, stable reference, which essentially presents no load to the battery.

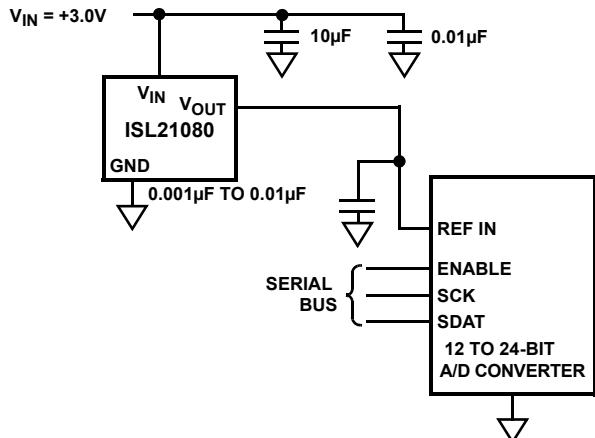
In particular, battery powered data converter circuits that would normally require the entire circuit to be disabled when not in use can remain powered up between conversions as shown in Figure 37. Data acquisition circuits providing 12 bits to 24 bits of accuracy can operate with the reference device continuously biased with no power penalty, providing the highest accuracy and lowest possible long term drift.

Other reference devices consuming higher supply currents will need to be disabled in between conversions to conserve battery capacity. Absolute accuracy will suffer as the device is biased and requires time to settle to its final value, or, may not actually settle to a final value as power on time may be short. Table 1 shows an example of battery life in years for ISL21080 in various power on condition with 1.5 $\mu$ A maximum current consumption.

**TABLE 1. EXAMPLE OF BATTERY LIFE IN YEARS FOR ISL21080 IN VARIOUS POWER ON CONDITIONS WITH 1.5 $\mu$ A MAX CURRENT**

BATTERY RATING (mAh)	CONTINUOUS	50% DUTY CYCLE	10% DUTY CYCLE
40	3	6	30*
225	16.3*	32.6*	163*

NOTE: \*Typical Li-Ion battery has a shelf life of up to 10 years.



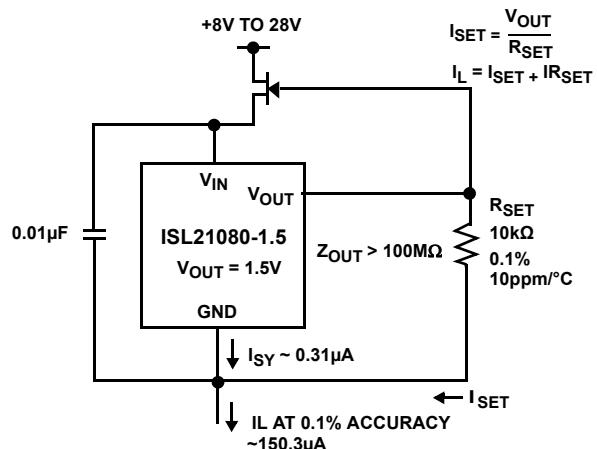
**FIGURE 37. REFERENCE INPUT FOR ADC CONVERTER**

### ISL21080 Used as a Low Cost Precision Current Source

Using an N-JET and a Nanopower voltage reference, ISL21080, a precision, low cost, high impedance current source can be created. The precision of the current source is largely dependent on the tempco and accuracy of the reference. The current setting resistor contributes less than 20% of the error.

### Board Mounting Considerations

For applications requiring the highest accuracy, board mounting location should be reviewed. Placing the device in areas subject to slight twisting can cause degradation of the accuracy of the reference voltage due to die stresses. It is normally best to place the device near the edge of a board, or the shortest side, as the axis of bending is most limited at that location. Obviously, mounting the device on flexprint or extremely thin PC material will likewise cause loss of reference accuracy.



**FIGURE 38. ISL21080 USED AS A LOW COST PRECISION CURRENT SOURCE**

## Noise Performance and Reduction

The output noise voltage in a 0.1Hz to 10Hz bandwidth is typically  $30\mu\text{V}_{\text{P-P}}$ . This is shown in the plot in the "Typical Performance Characteristics Curves" which begin on page 10. The noise measurement is made with a bandpass filter made of a 1-pole high-pass filter with a corner frequency at 0.1Hz and a 2-pole low-pass filter with a corner frequency at 12.6Hz to create a filter with a 9.9Hz bandwidth. Noise in the 10kHz to 1MHz bandwidth is approximately  $400\mu\text{V}_{\text{P-P}}$  with no capacitance on the output, as shown in Figure 39. These noise measurements are made with a 2 decade bandpass filter made of a 1-pole high-pass filter with a corner frequency at  $1/10$  of the center frequency and 1-pole low-pass filter with a corner frequency at 10 times the center frequency. Figure 39 also shows the noise in the 10kHz to 1MHz band can be reduced to about  $50\mu\text{V}_{\text{P-P}}$  using a  $0.001\mu\text{F}$  capacitor on the output. Noise in the 1kHz to 100kHz band can be further reduced using a  $0.1\mu\text{F}$  capacitor on the output, but noise in the 1Hz to 100Hz band increases due to instability of the very low power amplifier with a  $0.1\mu\text{F}$  capacitance load. For load capacitances above  $0.001\mu\text{F}$ , the noise reduction network shown in Figure 40 is recommended. This network reduces noise significantly over the full bandwidth. As shown in Figure 39, noise is reduced to less than  $40\mu\text{V}_{\text{P-P}}$  from 1Hz to 1MHz using this network with a  $0.01\mu\text{F}$  capacitor and a  $2\text{k}\Omega$  resistor in series with a  $10\mu\text{F}$  capacitor.

## Turn-On Time

The ISL21080 devices have ultra-low supply current and thus, the time to bias-up internal circuitry to final values will be longer than with higher power references. Normal turn-on time is typically 7ms. This is shown in Figure 38. Since devices can vary in supply current down to  $>300\text{nA}$ , turn-on time can last up to about 12ms. Care should be taken in system design to include this delay before measurements or conversions are started.

## Temperature Coefficient

The limits stated for temperature coefficient (tempco) are governed by the method of measurement. The overwhelming standard for specifying the temperature drift of a reference, is to measure the reference voltage at two temperatures, take the total variation, ( $V_{\text{HIGH}} - V_{\text{LOW}}$ ), and divide by the temperature extremes of measurement ( $T_{\text{HIGH}} - T_{\text{LOW}}$ ). The result is divided by the nominal reference voltage (at  $T = +25^{\circ}\text{C}$ ) and multiplied by  $10^6$  to yield ppm/ $^{\circ}\text{C}$ . This is the "Box" method for specifying temperature coefficient.

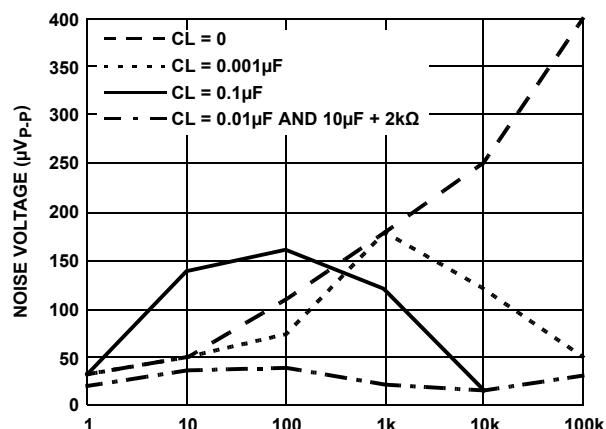


FIGURE 39. NOISE REDUCTION

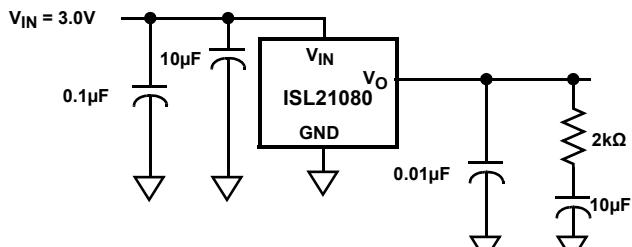


FIGURE 40. NOISE REDUCTION NETWORK

## Typical Application Circuits

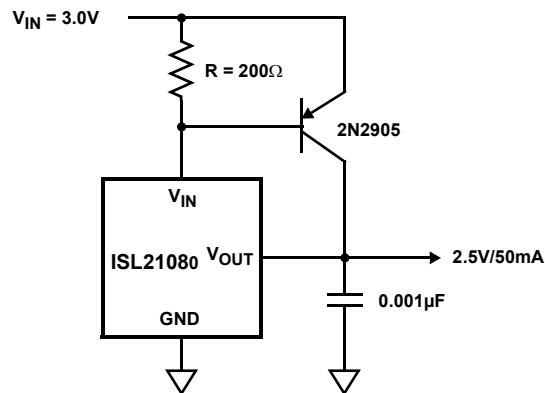


FIGURE 41. PRECISION 2.5V 50mA REFERENCE

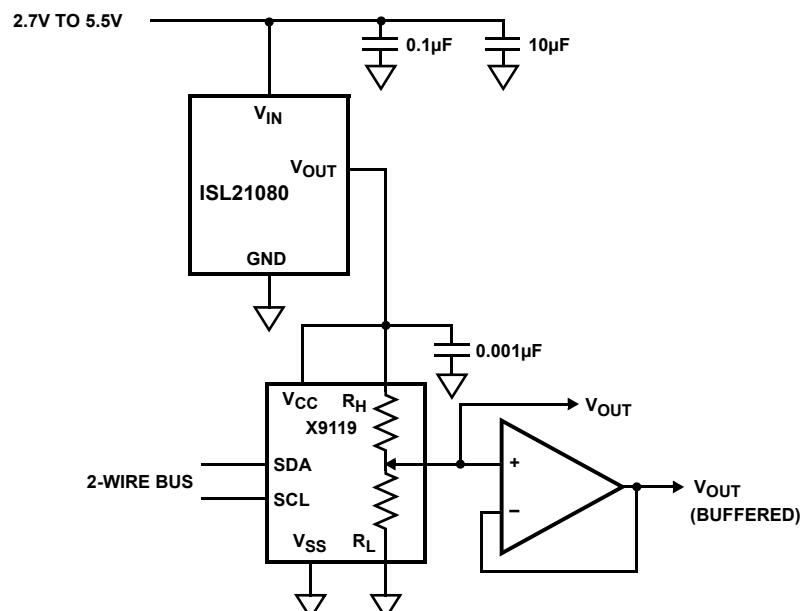


FIGURE 42. 2.5V FULL SCALE LOW-DRIFT 10-BIT ADJUSTABLE VOLTAGE SOURCE

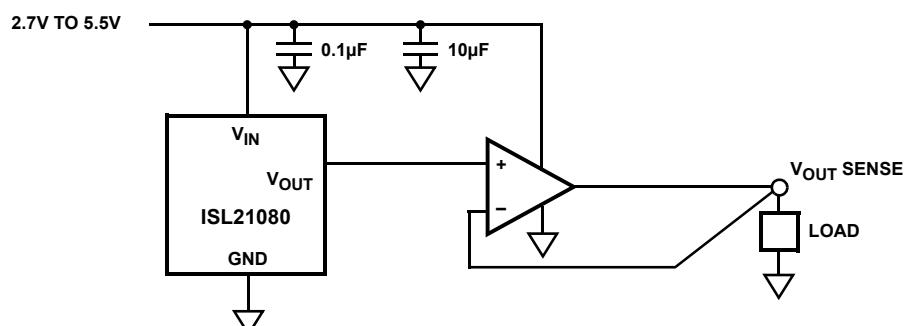


FIGURE 43. KELVIN SENSED LOAD

## Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest Rev.

DATE	REVISION	CHANGE
June 23, 2014	FN6934.5	<p>Converted to New Template            Updated POD with following changes:            In Detail A, changed lead width dimension from 0.13+/-0.05 to 0.085-0.19            Changed dimension of foot of lead from 0.31+/-0.10 to 0.38+/-0.10            In Land Pattern, added 0.4 Rad Typ dimension            In Side View, changed height of package from 0.91+/-0.03 to 0.95+/-0.07</p>
May, 12, 2010	FN6934.4	Changed Theta JA in the "Thermal Information" on page 3 from 170 to 275. Added Theta JC and applicable note.
April 29, 2010	FN6934.3	Incorrect Thermal information, needs to be re-evaluated and added at a later date when the final data is available. Removed Theta JC and applicable note from "Thermal Information" on page 3.
April 14, 2010		Corrected y axis label on Figure 9 from "V <sub>OUT</sub> (V)" to "V <sub>OUT</sub> (µV)"
April 6, 2010		<p>Source/sink for 0.9V option changed from 7mA to 10mA            Line regulation condition for 0.9V changed from 2.7V to 2V            Line regulation typical for 0.9V option changed from 10 to 30µV/V  <math>\Delta T_A</math> in Thermal Hysterisis conditions of 0.9V option changed from 165°C to 125°C            Moved "Board Assembly Considerations" and "Special Applications Considerations" to page 14. Deleted "Handling and Board Mounting" section since "Board Assembly Considerations" on page 14 contains same discussion.            Added "Special Note: Post-assembly x-ray inspection may lead to permanent changes in device output voltage and should be minimized or avoided." to "ISL21080" on page 1            Figures 2 and 3 revised to show line regulation and lin down to 2V.            Figures 4 and 5 revised to show Vin down to 2V.            Added "Initial accuracy can change 10mV or more under extreme radiation." to Note 9 on page 3.</p>
April 1, 2010		<p>1. page 3: Change Vin Min from 2.7 to 2.0            2. page 3: Change lin Typ from 0.31 to 0.35            3. page 3: Change Line Reg Typ from 80 to 10            4. page 3: Change Load Reg Condition from 7mA to 10mA and -7mA to -10mA            5. page 3: Change Load Reg Typ for Source from 25 to 6 and Sink from 50 to 23.            6. page 3: Change Isc Typ from 50 to 30            7. page 3: Change tR from 4 to 1            8. Change Ripple Rejection typ for all options from -30 to -40            9. page 3: Change eN typ from 30 to 40V            10. page 3: Change VN typ from 50 to 10V            11. page 3: Change Noise Density typ from 1.1 to 2.2            12. page 3: Change Long Term Stability from 50 to 60            13. Added Figure 2 to 13 on page 8 to page 10 for 0.9V curves.            14. Added Figure 28 to 34 on page 13 to page 14 for other options Dropout curve.            15. page 1: Change Input Voltage Range for 0.9V option from TBD to 2V to 5.5V            16. Added latch up to "Absolute Maximum Ratings" on page 3            17. Added Junction Temperature to "Thermal Information" on page 3            18. Added JEDEC standards used at the time of testing for "ESD Ratings" on page 3            19. HBM in "Absolute Maximum Ratings" on page 3 changed from 5.5kV to 5kV            20. Added Theta JC and applicable note.</p>
March 25, 2010		<p>Throughout- Converted to new format. Changes made as follows:            Moved "Pin Configuration" and "Pin Descriptions" to page 2            Added "Related Literature" to page 1            Added key selling feature graphic Figure 1 to page 1            Added "Boldface limits apply..." note to common conditions of Electrical Specifications tables on page 3 through page 8. Bolded applicable specs. Added Note 13 to MIN MAX columns of all Electrical Specifications tables.            Added "Environmental Operating Conditions" to page 3 and added Note 5            Added "The process used for these reference devices is a floating gate CMOS process, and the amplifier circuitry uses CMOS transistors for amplifier and output transistor circuitry. While providing excellent accuracy, there are limitations in output noise level and load regulation due to the MOS device characteristics. These limitations are addressed with circuit techniques discussed in other sections." on page 14</p>

## Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest Rev.

DATE	REVISION	CHANGE
Oct 14,2009	FN6934.2	<p>1. Removed "Coming Soon" on page 1 and 2 for -10, -20, -41, and -50 options.      2. Page 1. Moved "ISL21080-505.5V to 8.0V" from bullet to sub-bullet.      3. Update package outline drawing P3.064 to most recent revision. Updates to package were to add land pattern and move dimensions from table onto drawing (no change to package dimensions)</p>
Sep 04, 2009	FN6934.1	<p><b>Converted to new Intersil template.</b> Added Revision History and Products Information. Updated Ordering Information to match Intrepid, numbered all notes and added Moisture Sensitivity Note with links. Moved Pin Descriptions to page 1 to follow pinout</p> <p><b>Changed in Features Section</b></p> <p><b>From:</b> Reference Output Voltage 1.25V, 1.5V, 2.500V, 3.300V  <b>To:</b> Reference Output Voltage 0.900V, 1.024V, 1.250V, 1.500V, 2.048V, 2.500V, 3.000V, 3.300V, 4.096V, 5.000V  <b>From:</b> Initial Accuracy: 1.5V±0.5%  <b>To:</b> Initial Accuracy:      ISL21080-09 and -10±0.7%      ISL21080-12 ±0.6%      ISL21080-15±0.5%      ISL21080-20 and -25±0.3%      ISL21080-30, -33, -41, and -50±0.2%  <b>FROM:</b> Input Voltage Range      ISL21080-12 (Coming Soon) 2.7V to 5.5V      ISL21080-152.7V to 5.5V      ISL21080-25 (Coming Soon) 2.7V to 5.5V      ISL21080-33 (Coming Soon) 3.5V to 5.5V  <b>TO:</b> Input Voltage Range:      ISL21080-09, -10, -12, -15, -20, and -252.7V to 5.5V      ISL21080-09, -10, and 20 (Coming Soon)      ISL21080-303.2V to 5.5V      ISL21080-333.5V to 5.5V      ISL21080-41 (Coming Soon) 4.5V to 8.0V  <b>Added:</b> ISL21080-50 (Coming Soon) 5.5V to 8.0V Output Voltage Noise 30µVP-P (0.1Hz to 10Hz)  <b>Updated</b> Electrical Spec Tables by Tables with Voltage References 9, 10, 12, 20, 25, 30, 33 and 41.  <b>Added</b> to Abs Max Ratings:      VIN to GND (ISL21080-41 and 50 only-0.5V to +10V      VOUT to GND (10s)      (ISL21080-41 and 50 only-0.5V to +5.1V  <b>Changed</b> Tja in Thermal information from "202.70" to "170" to match ASYD in Intrepid  <b>Added Note:</b>      Post-assembly x-ray inspection may also lead to permanent changes in device output voltage and should be minimized or avoided. Most inspection equipment will not affect the FGA reference voltage, but if x-ray inspection is required, it is advisable to monitor the reference output voltage to verify excessive shift has not occurred.  <b>Added Special Applications Considerations Section on page 12.</b></p>
July 28,2009	FN6934.0	Initial Release.

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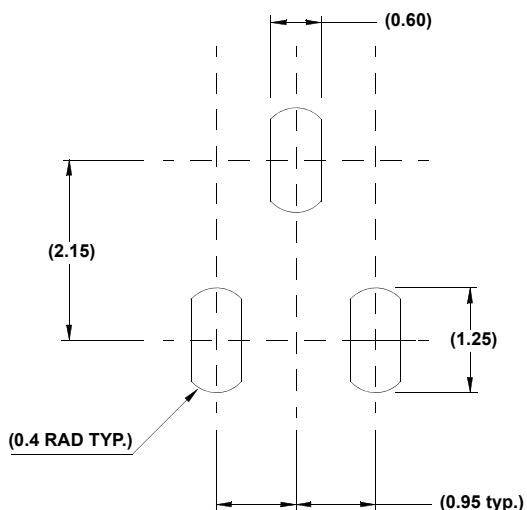
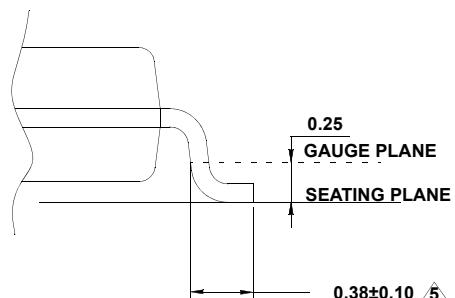
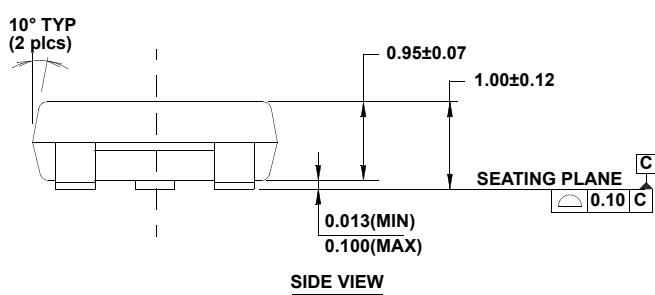
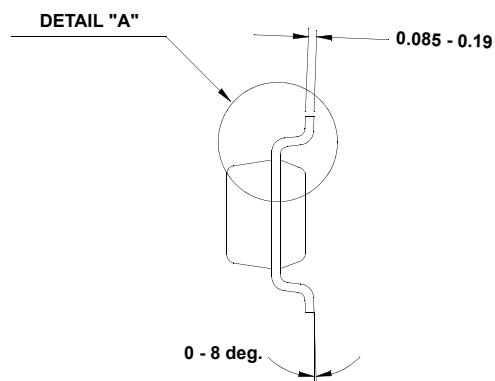
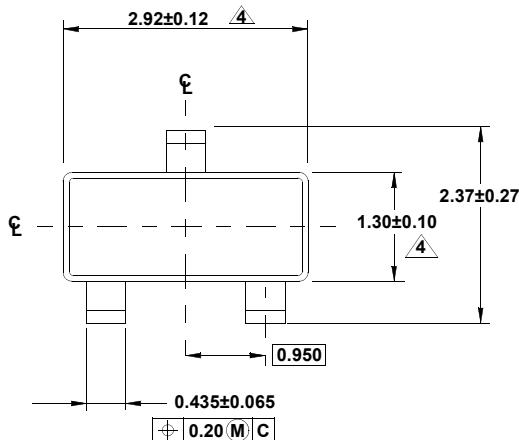
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**Package Outline Drawing****P3.064**

3 LEAD SMALL OUTLINE TRANSISTOR PLASTIC PACKAGE (SOT23-3)

Rev 3, 3/12

**NOTES:**

1. Dimensions are in millimeters.  
Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to AMSEY14.5m-1994.
3. Reference JEDEC TO-236.
4. Dimension does not include interlead flash or protrusions.  
Interlead flash or protrusions shall not exceed 0.25mm per side.
5. Footlength is measured at reference to gauge plane.

## Anexo XV. Hoja de características del regulador de tensión ISL21080CIH315Z-TK

# NCP700B

## 200 mA, Ultra Low Noise, High PSRR, BiCMOS RF LDO Regulator

Noise sensitive RF applications such as Power Amplifiers in cell phones and precision instrumentation require very clean power supplies. The NCP700B is 200 mA LDO that provides the engineer with a very stable, accurate voltage with ultra low noise and very high Power Supply Rejection Ratio (PSRR) suitable for RF applications. In order to optimize performance for battery operated portable applications, the NCP700B employs an advanced BiCMOS process to combine the benefits of low noise and superior dynamic performance of bipolar elements with very low ground current consumption at full loads offered by CMOS.

Furthermore, in order to provide a small footprint for space constrained applications, the NCP700B is stable with small, low value capacitors and is available in a very small WDFN6 1.5 mm x 1.5 mm and TSOP-5 package.

### Features

- Output Voltage Options:
  - ◆ 1.8 V, 2.5 V, 2.8 V, 3.0 V, 3.3 V
  - ◆ Contact Factory for Other Voltage Options
- Excellent Line and Load Regulation
- Ultra Low Noise (typ. 10  $\mu$ Vrms)
- Very High PSRR (typ 82 dB @ 1 kHz)
- Stable with Ceramic Output Capacitors as low as 1  $\mu$ F
- Very Low Ground Current (typ. 70  $\mu$ A @ no load)
- Low Disable Mode Current (max. 1  $\mu$ A)
- Active Discharge Circuit
- Current Limit Protection
- Thermal Shutdown Protection
- These are Pb-Free Devices

### Applications

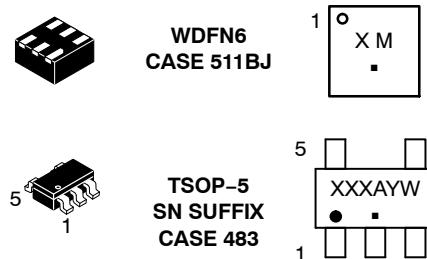
- Smartphones / PDAs / Palmtops / GPS
- Cellular Telephones (Power Amplifier)
- Noise Sensitive Applications (RF, Video, Audio)
- Analog Power Supplies
- Battery Supplied Devices



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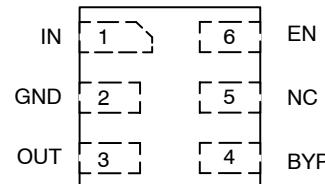
<http://onsemi.com>

### MARKING DIAGRAM

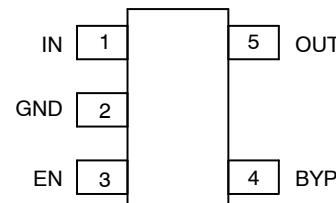


X, XXX = Specific Device Code  
M = Date Code  
A = Assembly Location  
Y = Year  
W = Work Week  
■ = Pb-Free Package

### PIN CONNECTIONS



(Top View)



(Top View)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 19 of this data sheet.

# NCP700B

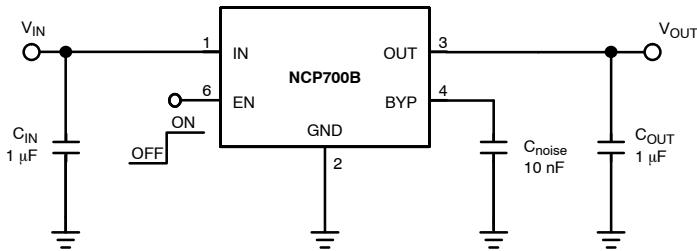


Figure 1. NCP700B Typical Application (WDFN6)

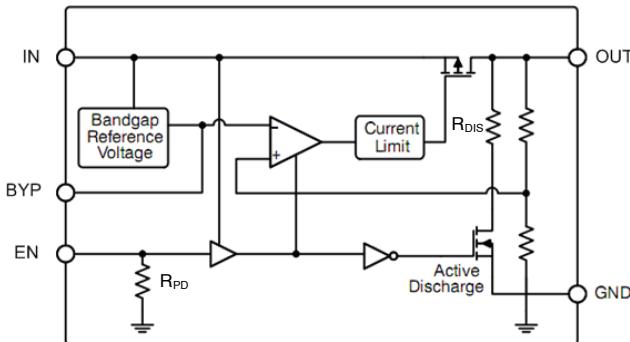


Figure 2. Simplified Block Diagram

## PIN FUNCTION DESCRIPTION

WDFN Pin No.	TSSOP-5 Pin No.	Pin Name	Description
1	1	IN	Input Voltage
2	2	GND	Power Supply Ground
3	5	OUT	Regulated Output Voltage
4	4	BYP	Noise reduction pin. (Connect 10 nF or 100 nF capacitor to GND)
6	3	EN	Enable pin: This pin allows on/off control of the regulator. To disable the device, connect to GND. If this function is not in use, connect to Vin. Internal 5 MΩ Pull Down resistor is connected between EN and GND.
5	-	N/C	Not connected

# NCP700B

## MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage	IN	-0.3 V to 6 V	V
Chip Enable Voltage	EN	-0.3 V to $V_{IN}$ +0.3 V	
Noise Reduction Voltage	BYP	-0.3 V to $V_{IN}$ +0.3 V	V
Output Voltage	OUT	-0.3 V to $V_{IN}$ +0.3 V	V
Output short-circuit duration		Infinity	
Maximum Junction Temperature	$T_J(max)$	150	°C
Storage Temperature Range	$T_{STG}$	-55 to 150	°C
Electrostatic Discharge (Note 1)	Human Body Model	ESD	V
	Machine Model		
		2000	
		200	

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. This device series contains ESD protection and exceeds the following tests:  
Human Body Model 2000 V tested per MIL-STD-883, Method 3015  
Machine Model Method 200 V

## THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Package Thermal Resistance, WDFN6: (Note 2) Junction-to-Ambient (Note 3)	$\theta_{JA}$	185	°C/W
Package Thermal Characterization Parameter, WDFN6: Junction-to-Lead (Pin 2) (Note 3) Junction-to-Board (Note 3)	$\Psi_{JL2}$ $\Psi_{JB}$	123 111	
Package Thermal Resistance, TSOP-5: (Note 2 and 3) Junction-to-Case (Pin 2) Junction-to-Ambient	$\Psi_{JL2}$ $R_{\theta JA}$	92 204	°C/W

2. Refer to APPLICATION INFORMATION for Safe Operating Area
3. Single component mounted on 1 oz, FR4 PCB with 645mm<sup>2</sup> Cu area.

# NCP700B

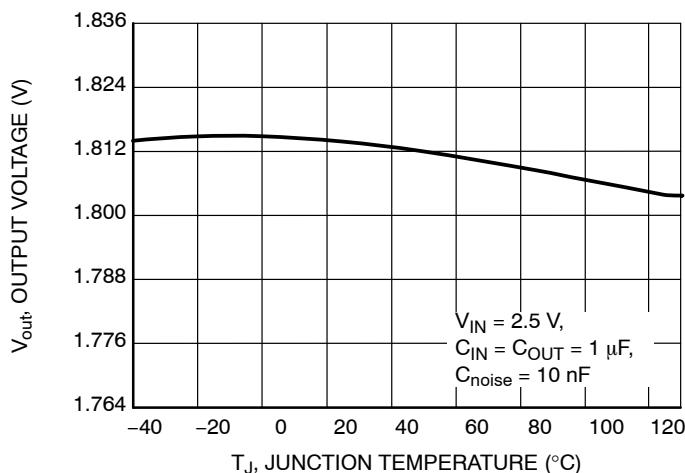
**ELECTRICAL CHARACTERISTICS**  $V_{IN} = V_{OUT} + 0.5 \text{ V}$  or  $2.5 \text{ V}$  (whichever is greater),  $V_{EN} = 1.2 \text{ V}$ ,  $C_{IN} = C_{OUT} = 1 \mu\text{F}$ ,  $C_{noise} = 10 \text{ nF}$ ,  $I_{OUT} = 1 \text{ mA}$ ,  $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ , unless otherwise specified (Note 4)

Parameter	Test Conditions		Symbol	Min	Typ	Max	Unit
<b>REGULATOR OUTPUT</b>							
Input Voltage Range			$V_{IN}$	2.5	–	5.5	V
Output Voltage Accuracy	$T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ , $V_{IN} = (V_{OUT} + 0.5 \text{ V})$ to $5.5 \text{ V}$ $I_{OUT} = 1 \text{ mA}$ to $200 \text{ mA}$	$V_{OUT}$	–2.5%	–	+2.5%	–	V
Line Regulation	$V_{IN} = (V_{OUT} + 0.5 \text{ V})$ to $5.5 \text{ V}$ , $I_{OUT} = 1 \text{ mA}$	$\Delta V_{OUT} / \Delta V_{IN}$	–	0.6	4	–	mV
Load Regulation	$I_{OUT} = 0 \text{ mA}$ to $200 \text{ mA}$	$\Delta V_{OUT} / \Delta I_{OUT}$	–	0.2	5	–	mV
Dropout Voltage (Note 5)	$I_{OUT} = 200 \text{ mA}$	$V_{OUT(NOM)} = 2.5 \text{ V}$ $V_{OUT(NOM)} = 2.8 \text{ V}$ $V_{OUT(NOM)} = 3.0 \text{ V}$ $V_{OUT(NOM)} = 3.3 \text{ V}$	$V_{DO}$	– – – –	140 120 115 110	230 205 190 185	mV
Output Current Limit	$V_{OUT} = V_{OUT(NOM)} - 0.1 \text{ V}$	$I_{LIM}$	200	310	470	–	mA
Output Short Circuit Current	$V_{OUT} = 0 \text{ V}$	$I_{SC}$	205	320	490	–	mA
Ground Current	$I_{OUT} = 0 \text{ mA}$ $I_{OUT} = 200 \text{ mA}$	$I_{GND}$	– –	70 75	110 130	–	$\mu\text{A}$
Disable Current	$V_{EN} = 0 \text{ V}$	$I_{DIS}$	–	0.1	1	–	$\mu\text{A}$
Power Supply Rejection Ratio	$V_{IN} = V_{OUT} + 1.0 \text{ V}$ , $V_{OUT} = 1.8 \text{ V}$ , $I_{OUT} = 150 \text{ mA}$ , $f = 1 \text{ kHz}$	$PSRR$	–	82	–	–	dB
Output Noise Voltage	$f = 10 \text{ Hz}$ to $100 \text{ kHz}$ , $I_{OUT} = 150 \text{ mA}$ , $V_{OUT} = 1.8 \text{ V}$	$C_{noise} = 10 \text{ nF}$ $C_{noise} = 100 \text{ nF}$	$V_N$	– –	15 10	– –	$\mu\text{VRMS}$
Turn-On Time (Note 6)	$I_{OUT} = 150 \text{ mA}$ , $C_{noise} = 10 \text{ nF}$	$t_{ON}$	–	400	–	–	$\mu\text{s}$
Enable Threshold	Low High		$V_{th(EN)}$	– 1.2	– –	0.4 –	V
Enable Internal Pull-Down Resistance (Note 7)			$R_{PD}$	2.5	5	10	$M\Omega$
Active Discharge Resistance	$V_{EN} = 0 \text{ V}$		$R_{DIS}$	–	1	–	$k\Omega$
Thermal Shutdown	Shutdown, Temperature increasing		$T_{SDU}$	–	150	–	$^\circ\text{C}$
	Reset, Temperature decreasing		$T_{SDD}$	–	135	–	$^\circ\text{C}$
Operating Junction Temperature			$T_J$	–40	–	125	$^\circ\text{C}$

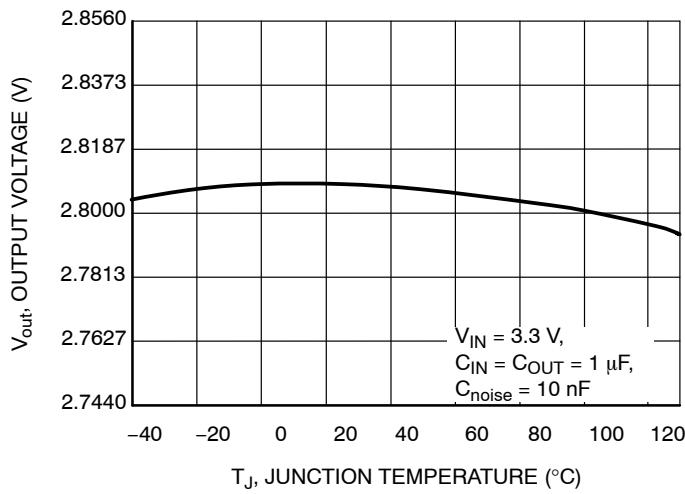
- Performance guaranteed over the indicated operating temperature range by design and/or characterization tested at  $T_J = T_A = 25^\circ\text{C}$ . Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
- Measured when the output voltage falls 100 mV below the nominal output voltage (nominal output voltage is the voltage at the output measured under the condition  $V_{IN} = V_{OUT} + 0.5 \text{ V}$ ). In the case of devices having the nominal output voltage  $V_{OUT} = 1.8 \text{ V}$  the minimum input to output voltage differential is given by the  $V_{IN(MIN)} = 2.5 \text{ V}$ .
- The turn-on time is the time from asserting the EN to the point where output voltage reaches 98% nominal voltage level.
- Expected to disable the device when EN pin is floating.

# NCP700B

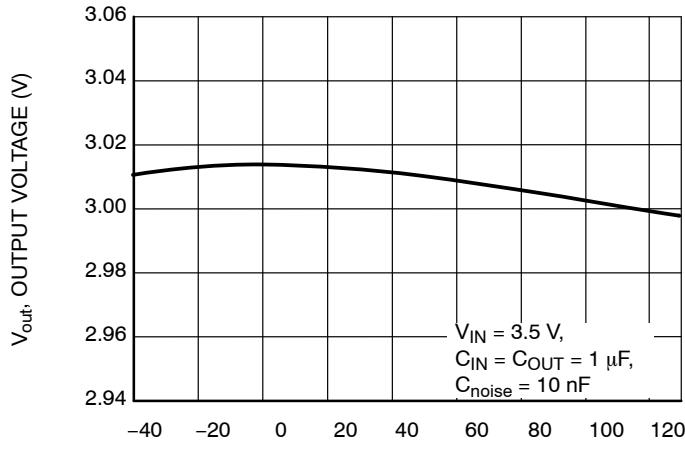
## TYPICAL CHARACTERISTICS



**Figure 3. Output Voltage vs. Junction Temperature,  $V_{OUT} = 1.8$  V**



**Figure 4. Output Voltage vs. Junction Temperature,  $V_{OUT} = 2.8$  V**



**Figure 5. Output Voltage vs. Junction Temperature,  $V_{OUT} = 3.0$  V**

## TYPICAL CHARACTERISTICS

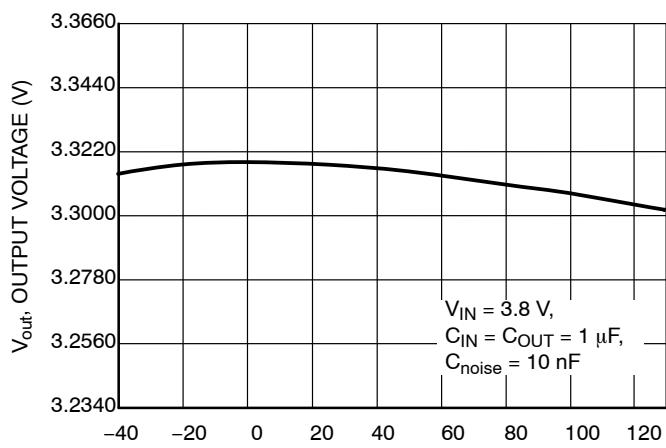


Figure 6. Output Voltage vs. Junction Temperature,  $V_{OUT} = 3.3 \text{ V}$

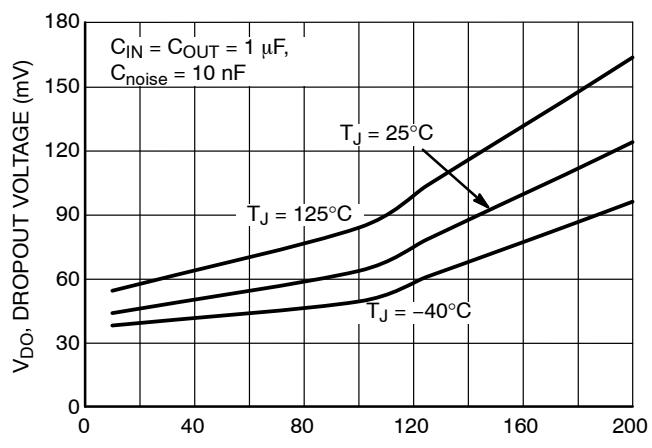


Figure 7. Dropout Voltage vs. Output Current,  $V_{OUT} = 2.8 \text{ V}$

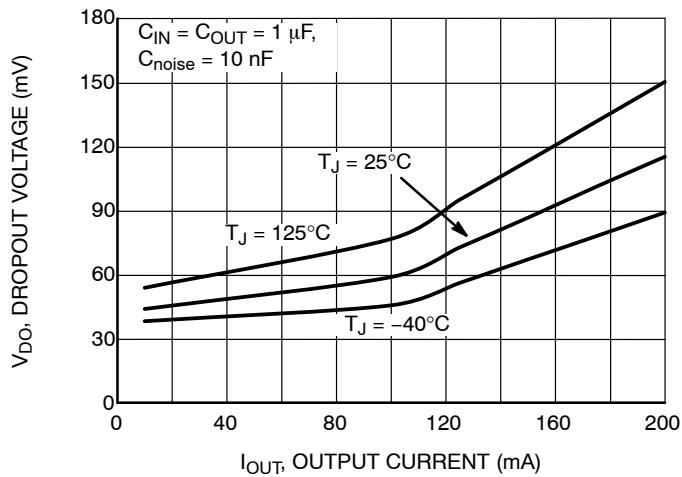


Figure 8. Dropout Voltage vs. Output Current,  $V_{OUT} = 3.0 \text{ V}$

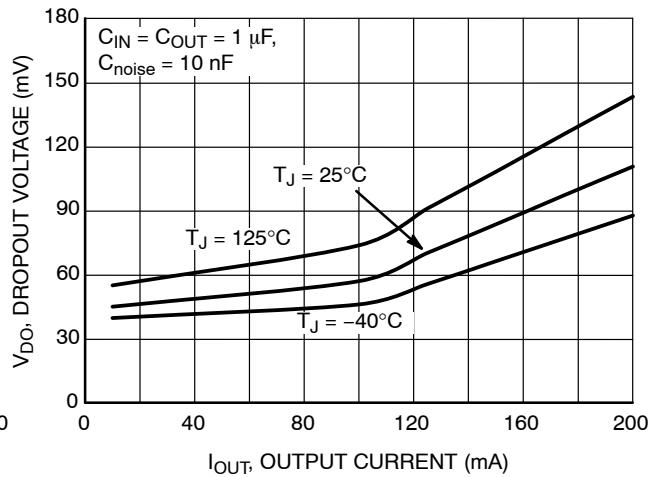
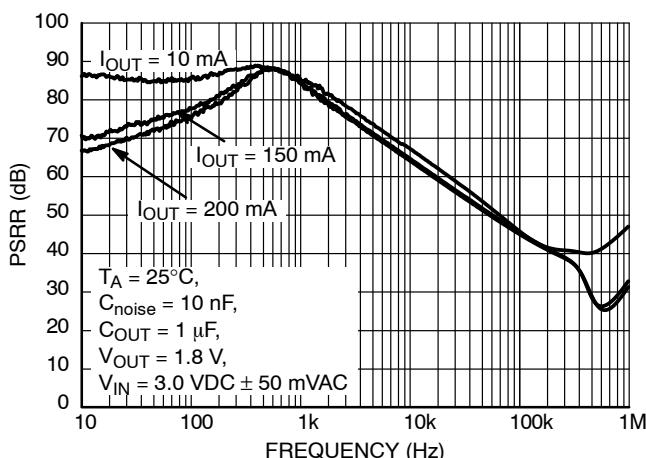
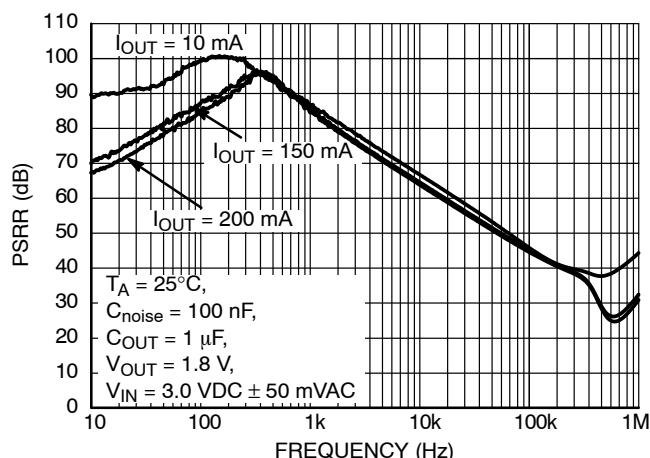


Figure 9. Dropout Voltage vs. Output Current,  $V_{OUT} = 3.3 \text{ V}$

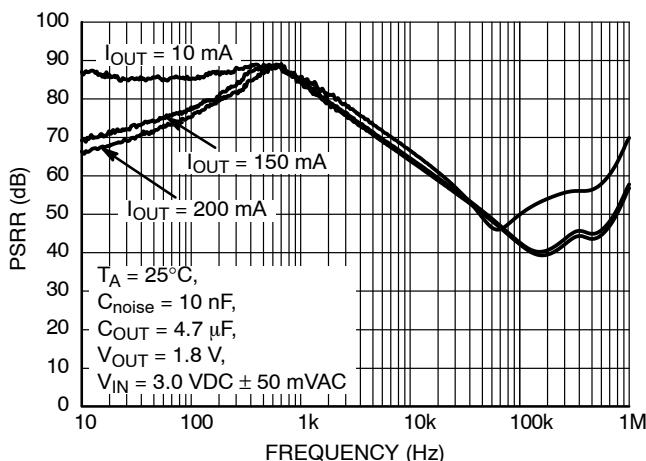
## TYPICAL CHARACTERISTICS



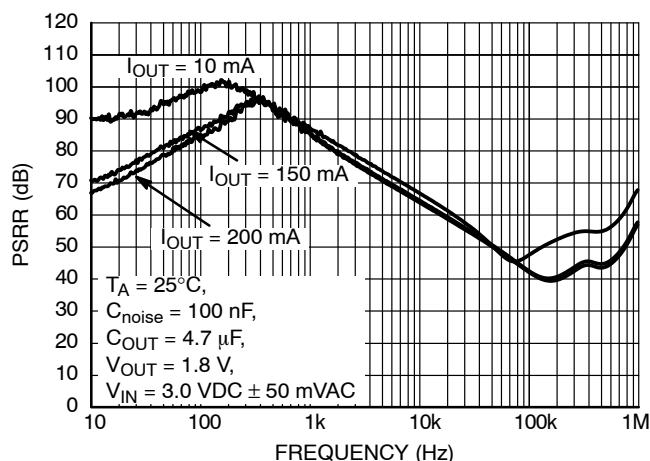
**Figure 10. PSRR vs. Frequency, 1.8 V Output Voltage Option,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 10 \text{ nF}$**



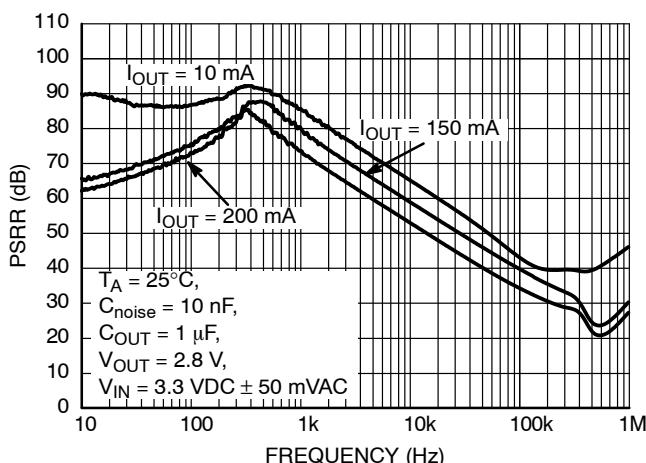
**Figure 11. PSRR vs. Frequency, 1.8 V Output Voltage Option,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 100 \text{ nF}$**



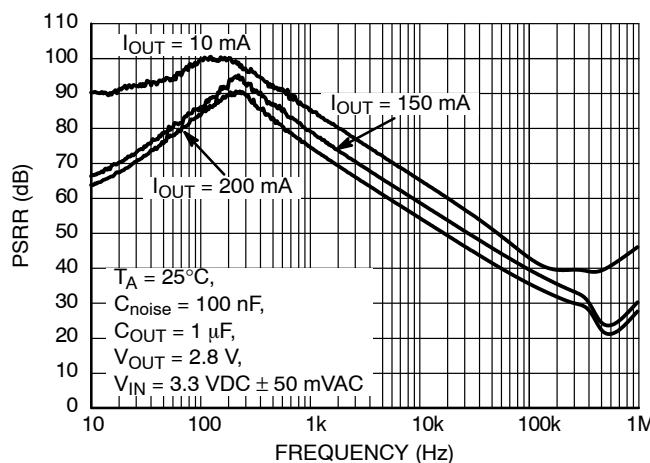
**Figure 12. PSRR vs. Frequency, 1.8 V Output Voltage Option,  $C_{\text{OUT}} = 4.7 \mu\text{F}$ ,  $C_{\text{noise}} = 10 \text{ nF}$**



**Figure 13. PSRR vs. Frequency, 1.8V Output Voltage Option,  $C_{\text{OUT}} = 4.7 \mu\text{F}$ ,  $C_{\text{noise}} = 100 \text{ nF}$**



**Figure 14. PSRR vs. Frequency, 2.8 V Output Voltage Option,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 10 \text{ nF}$**



**Figure 15. PSRR vs. Frequency, 2.8 V Output Voltage Option,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 100 \text{ nF}$**

## TYPICAL CHARACTERISTICS

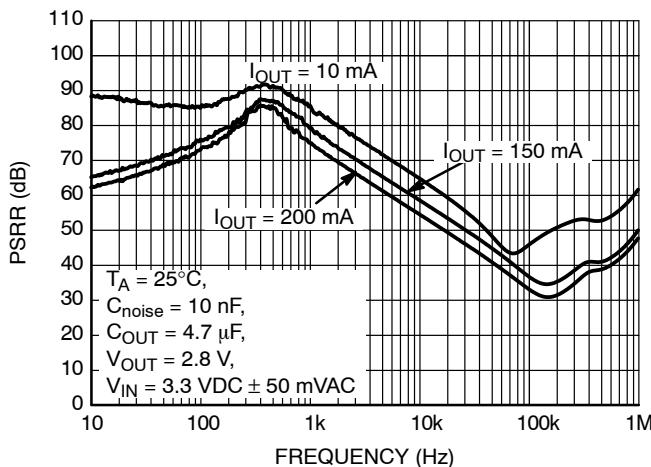


Figure 16. PSRR vs. Frequency, 2.8 V Output Voltage Option,  $C_{\text{OUT}} = 4.7 \mu\text{F}$ ,  $C_{\text{noise}} = 10 \text{ nF}$

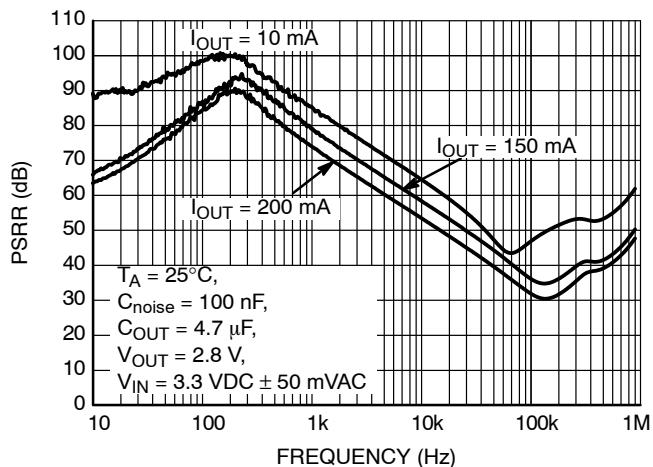


Figure 17. PSRR vs. Frequency, 2.8 V Output Voltage Option,  $C_{\text{OUT}} = 4.7 \mu\text{F}$ ,  $C_{\text{noise}} = 100 \text{ nF}$

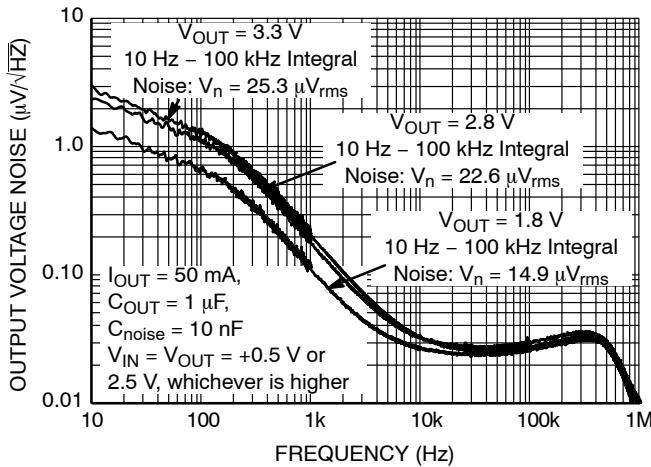


Figure 18. Output Noise vs. Frequency,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 10 \text{ nF}$ ,  $I_{\text{OUT}} = 50 \text{ mA}$

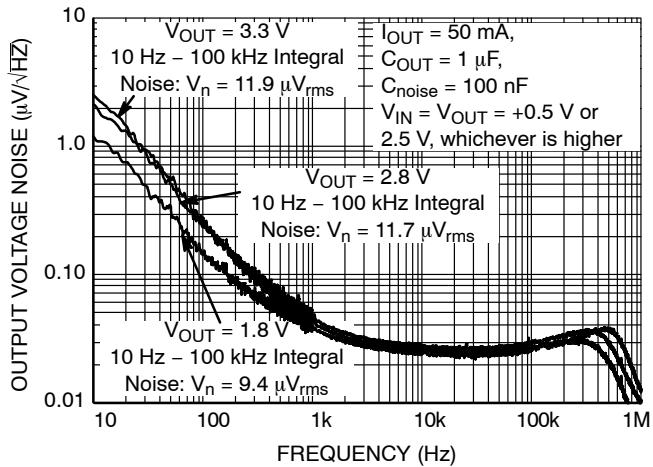


Figure 19. Output Noise vs. Frequency,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 100 \text{ nF}$ ,  $I_{\text{OUT}} = 50 \text{ mA}$

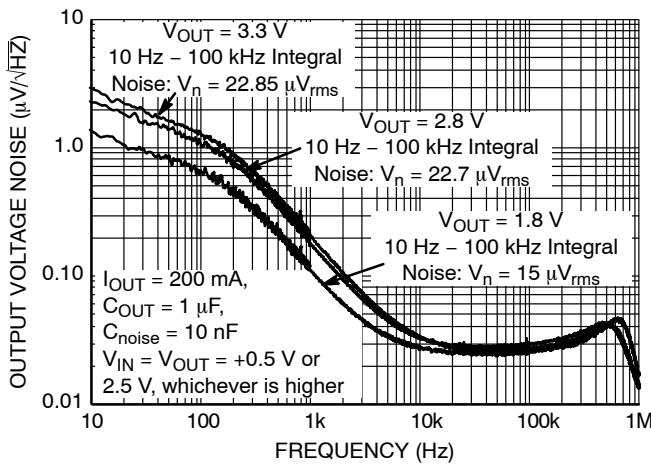


Figure 20. Output Noise vs. Frequency,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 10 \text{ nF}$ ,  $I_{\text{OUT}} = 200 \text{ mA}$

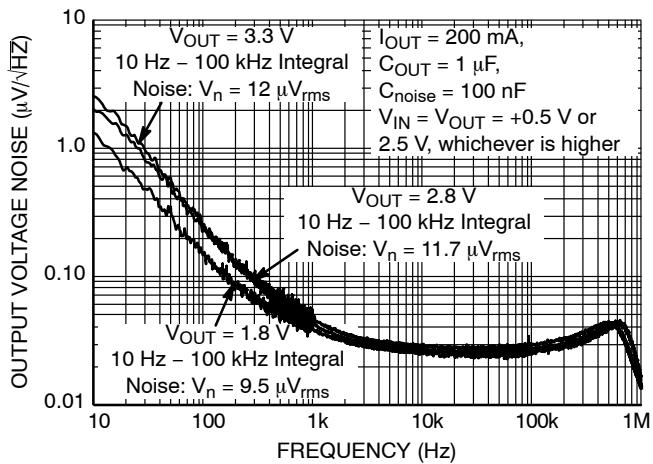
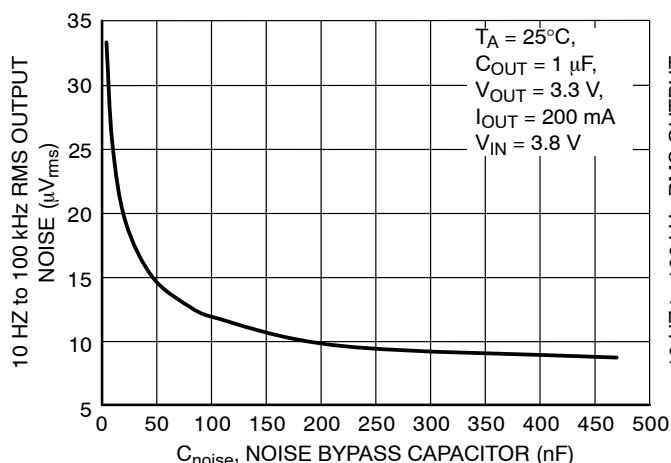


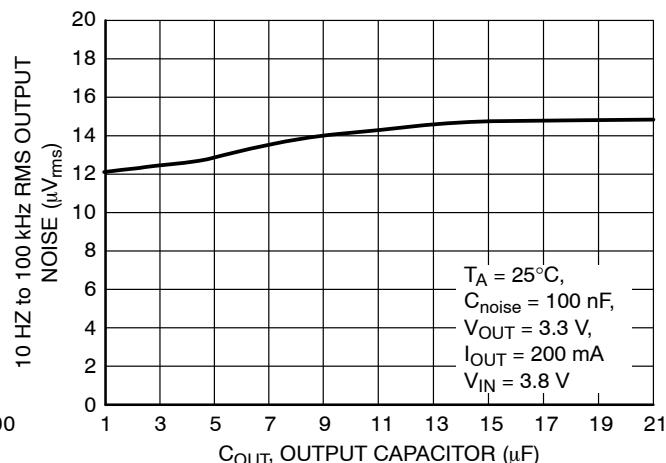
Figure 21. Output Noise vs. Frequency,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $C_{\text{noise}} = 100 \text{ nF}$ ,  $I_{\text{OUT}} = 200 \text{ mA}$

# NCP700B

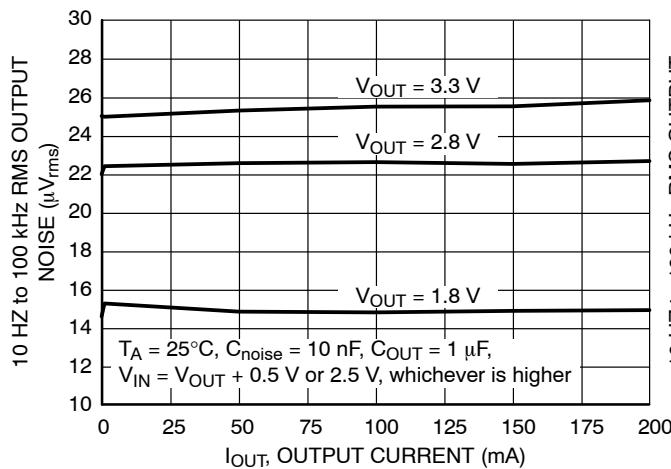
## TYPICAL CHARACTERISTICS



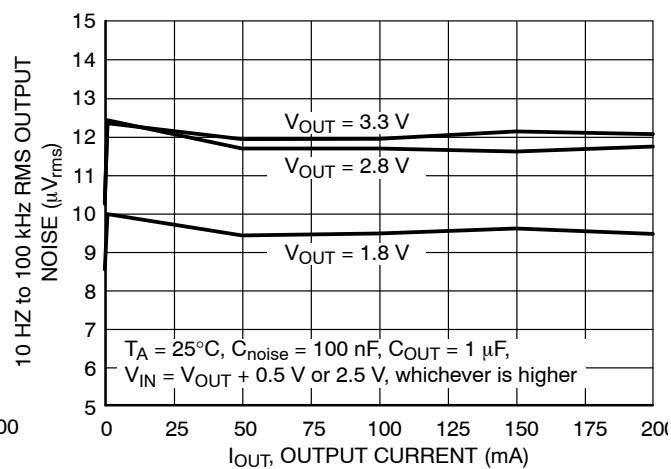
**Figure 22. Output Noise vs. Noise Bypass Capacitance,  $C_{\text{OUT}} = 1 \mu\text{F}$ ,  $V_{\text{OUT}} = 3.3 \text{ V}$ ,  $I_{\text{OUT}} = 200 \text{ mA}$**



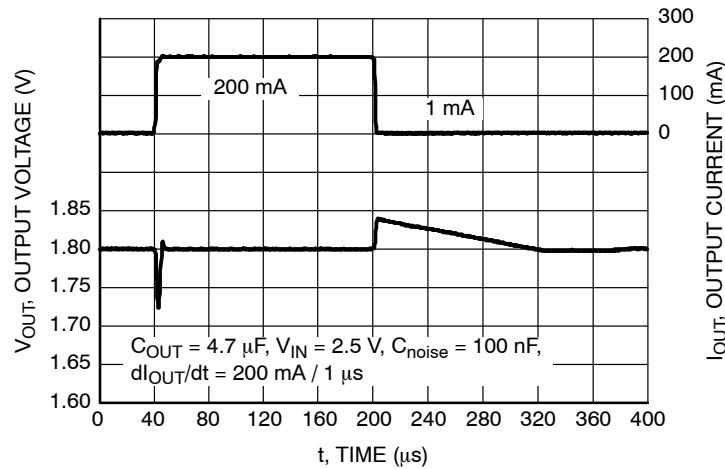
**Figure 23. Output Noise vs. Output Capacitance,  $C_{\text{noise}} = 100 \text{ nF}$ ,  $V_{\text{OUT}} = 3.3 \text{ V}$ ,  $I_{\text{OUT}} = 200 \text{ mA}$**



**Figure 24. Output Noise vs. Load Current,  $C_{\text{noise}} = 10 \text{ nF}$ ,  $C_{\text{OUT}} = 1 \mu\text{F}$**



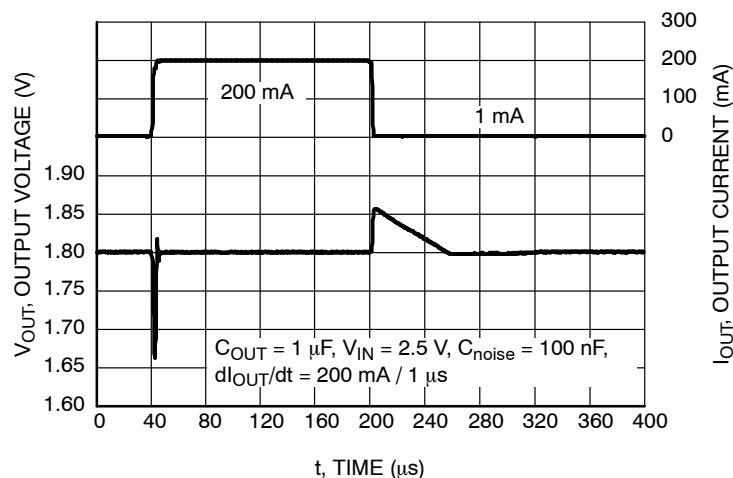
**Figure 25. Output Noise vs. Load Current,  $C_{\text{noise}} = 100 \text{ nF}$ ,  $C_{\text{OUT}} = 1 \mu\text{F}$**



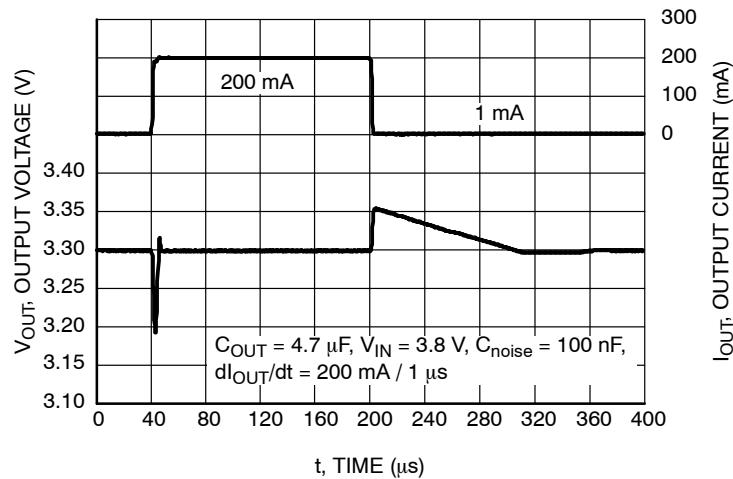
**Figure 26. Load Transient Response,  $V_{\text{OUT}} = 1.8 \text{ V}$ ,  $C_{\text{OUT}} = 4.7 \mu\text{F}$ ,  $C_{\text{noise}} = 100 \text{ nF}$**

# NCP700B

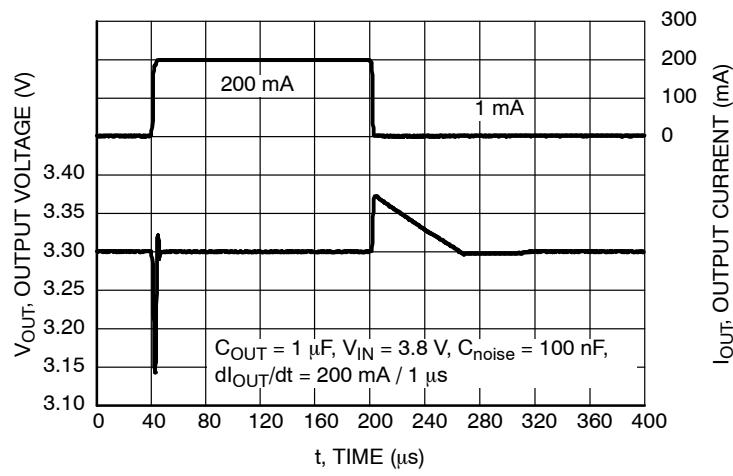
## TYPICAL CHARACTERISTICS



**Figure 27. Load Transient Response,  $V_{OUT} = 1.8 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$ ,  $C_{noise} = 100 \text{ nF}$**



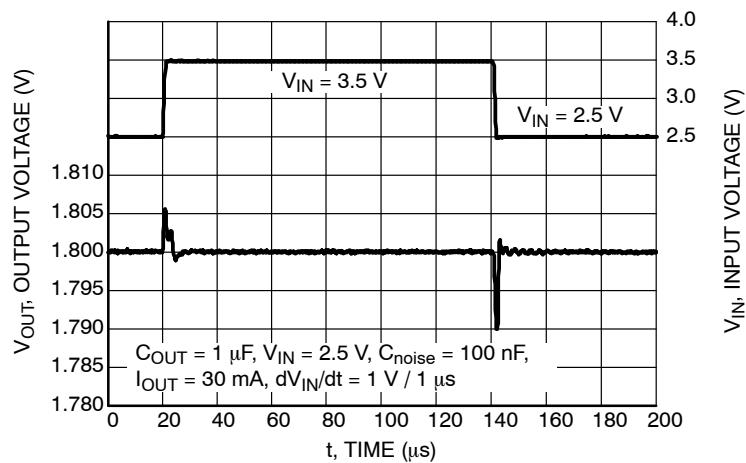
**Figure 28. Load Transient Response,  $V_{OUT} = 3.3 \text{ V}$ ,  $C_{OUT} = 4.7 \mu\text{F}$ ,  $C_{noise} = 100 \text{ nF}$**



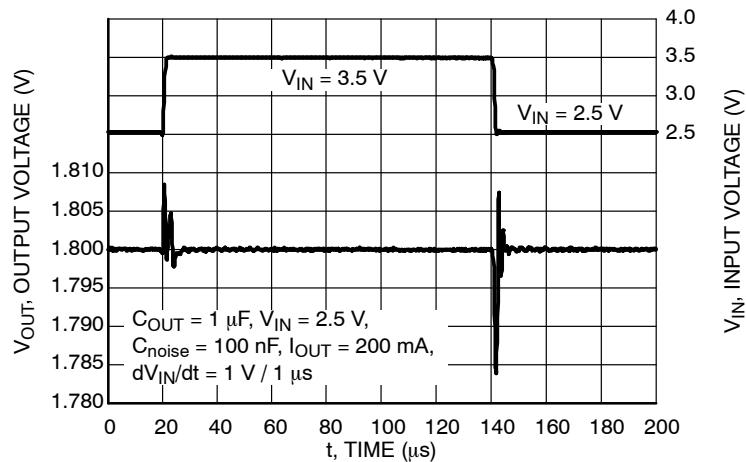
**Figure 29. Load Transient Response,  $V_{OUT} = 3.3 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$ ,  $C_{noise} = 100 \text{ nF}$**

# NCP700B

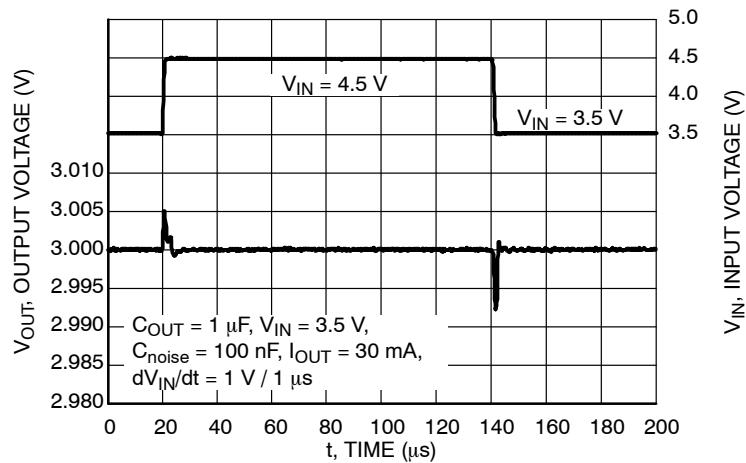
## TYPICAL CHARACTERISTICS



**Figure 30. Line Transient Response,  
 $V_{OUT} = 1.8 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$ ,  $I_{OUT} = 30 \text{ mA}$**

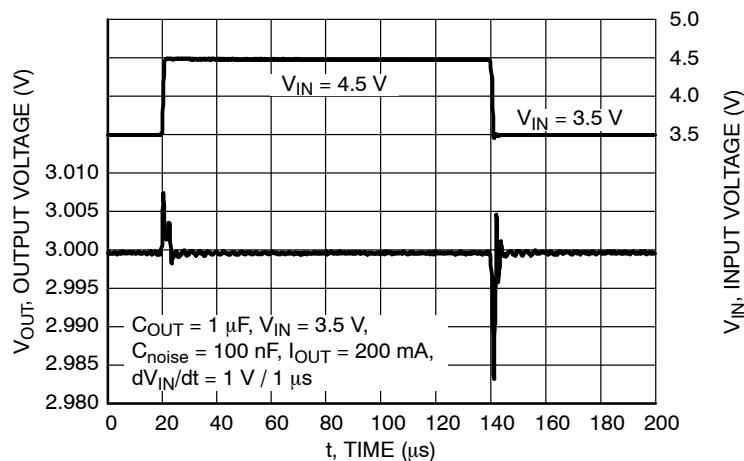


**Figure 31. Line Transient Response,  
 $V_{OUT} = 1.8 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$ ,  $I_{OUT} = 200 \text{ mA}$**

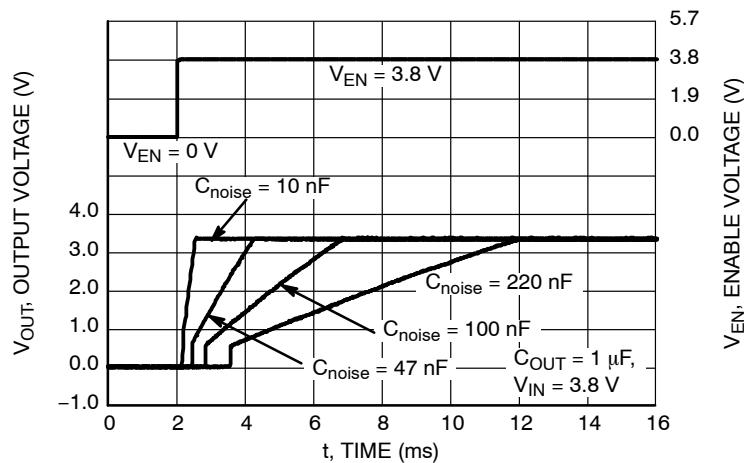


**Figure 32. Line Transient Response,  
 $V_{OUT} = 3.0 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$ ,  $I_{OUT} = 30 \text{ mA}$**

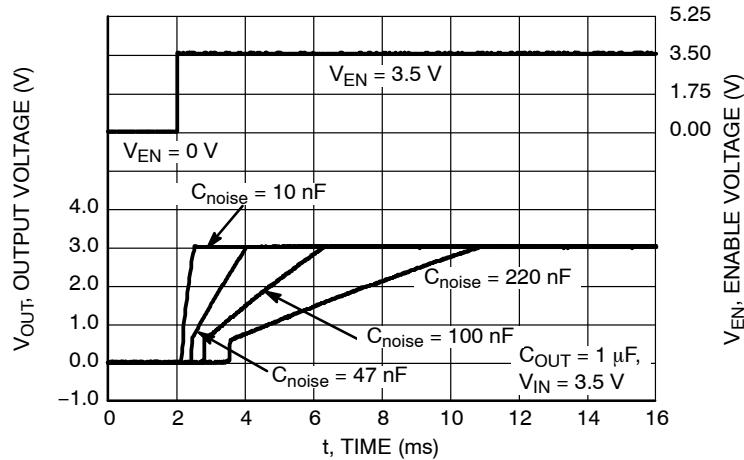
## TYPICAL CHARACTERISTICS



**Figure 33. Line Transient Response,**  
 $V_{OUT} = 3.0\text{ V}$ ,  $C_{OUT} = 1\text{ }\mu\text{F}$ ,  $I_{OUT} = 200\text{ mA}$

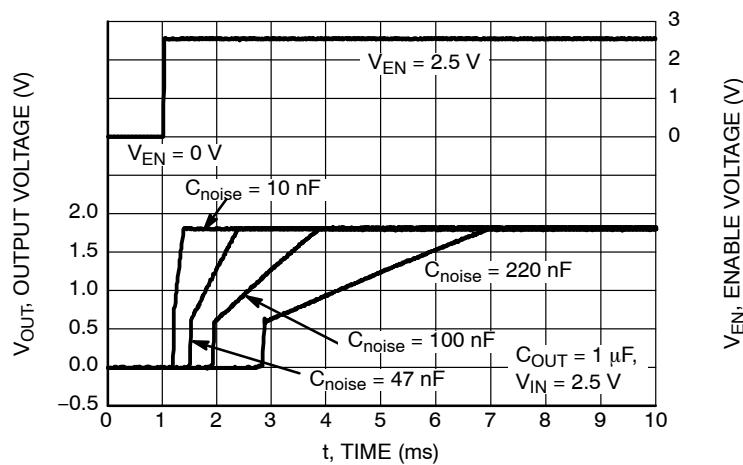


**Figure 34. Turn-On Response**  
 $V_{OUT} = 3.3\text{ V}$ ,  $C_{OUT} = 1\text{ }\mu\text{F}$ ,  $I_{OUT} = 30\text{ mA}$

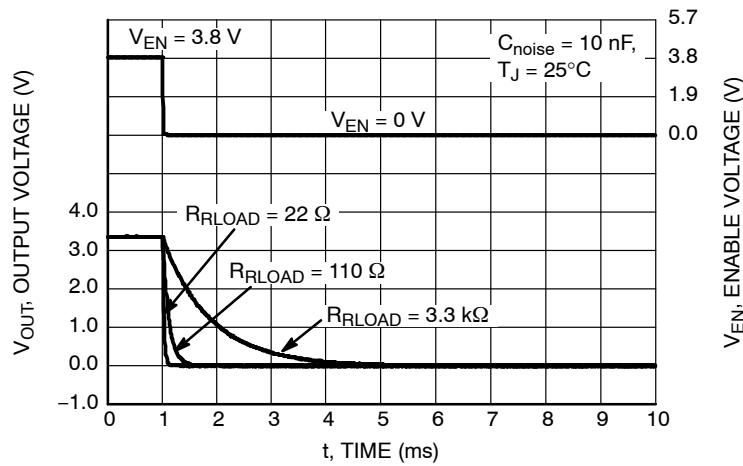


**Figure 35. Turn-On Response**  
 $V_{OUT} = 3\text{ V}$ ,  $C_{OUT} = 1\text{ }\mu\text{F}$ ,  $I_{OUT} = 30\text{ mA}$

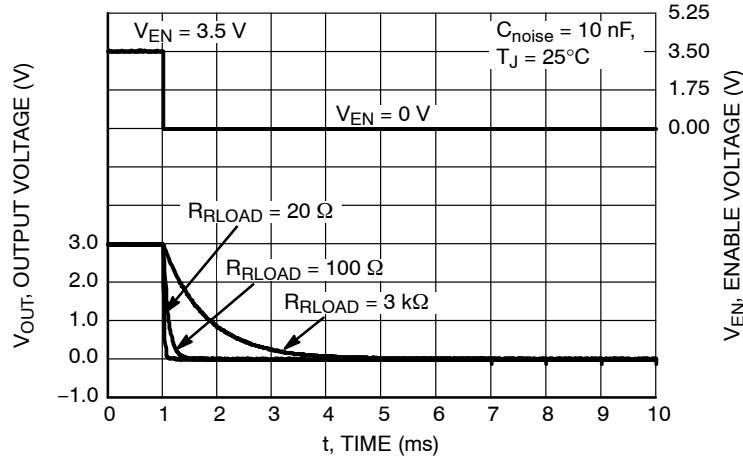
## TYPICAL CHARACTERISTICS



**Figure 36. Turn-On Response**  
 $V_{OUT} = 1.8$  V,  $C_{OUT} = 1 \mu\text{F}$ ,  $I_{OUT} = 30$  mA

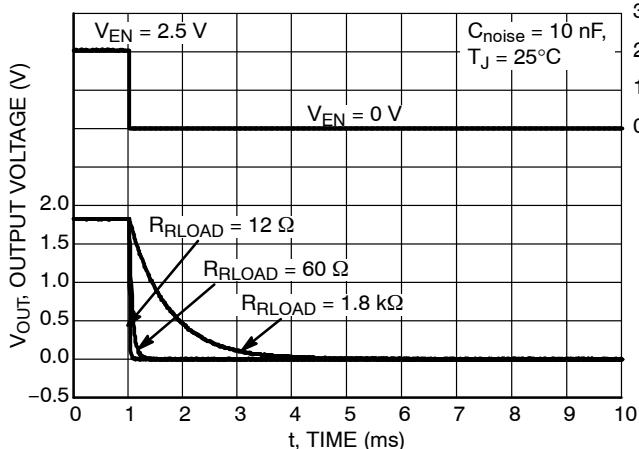


**Figure 37. Turn-Off Response**  
 $V_{OUT} = 3.3$  V,  $C_{OUT} = 1 \mu\text{F}$

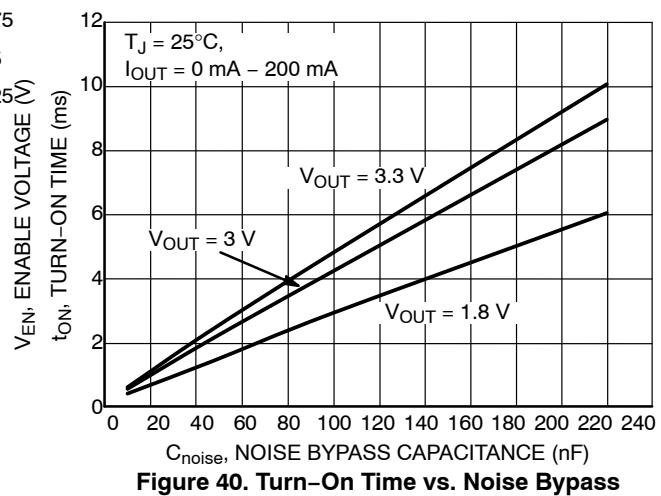


**Figure 38. Turn-Off Response**  
 $V_{OUT} = 3$  V,  $C_{OUT} = 1 \mu\text{F}$

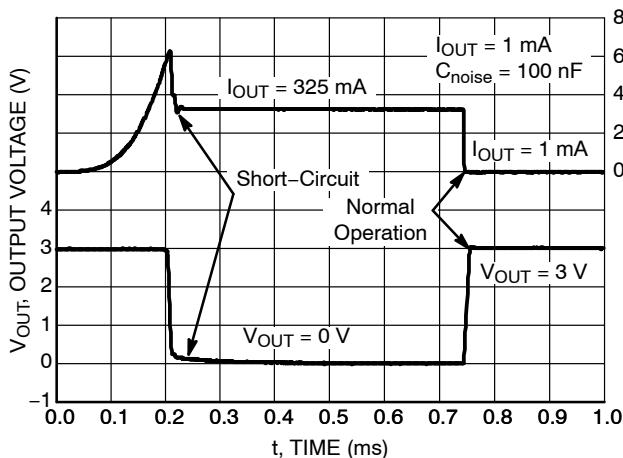
## TYPICAL CHARACTERISTICS



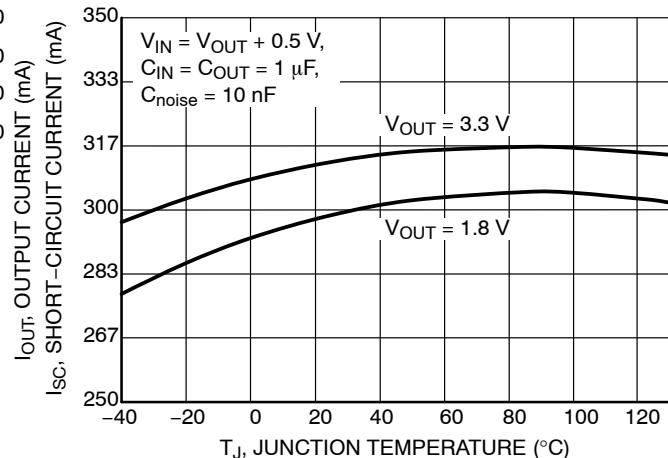
$V_{OUT} = 1.8 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$



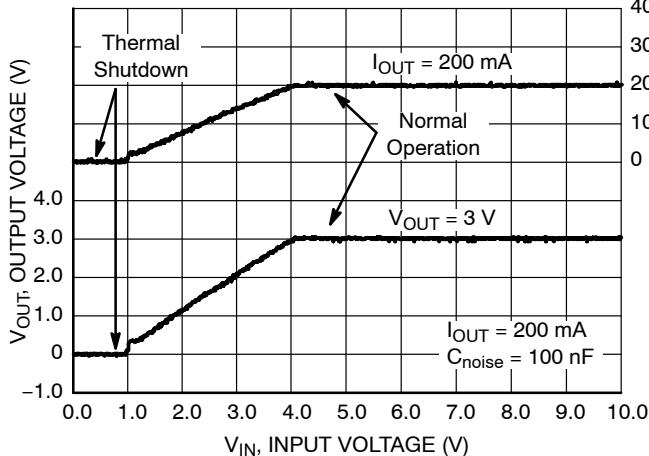
$C_{OUT} = 1 \mu\text{F}$ ,  $I_{OUT} = 0 \text{ mA} - 200 \text{ mA}$



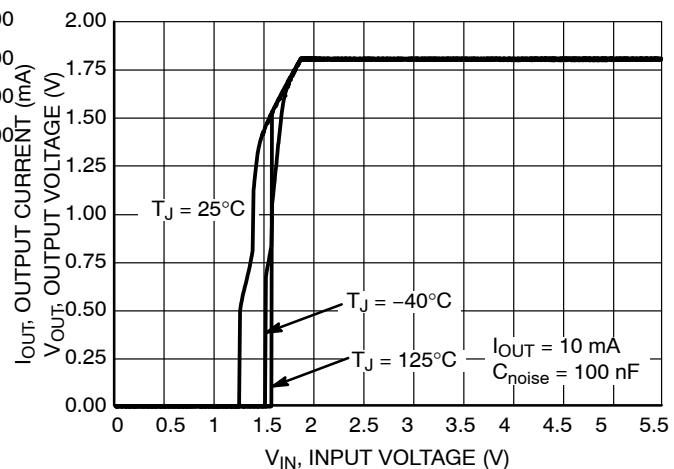
**Figure 41. Short-Circuit Protection,**  
 $V_{OUT} = 3 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$ ,  $C_{noise} = 100 \text{ nF}$



$V_{OUT} = 1.8 \text{ V}$ ,  $3.3 \text{ V}$

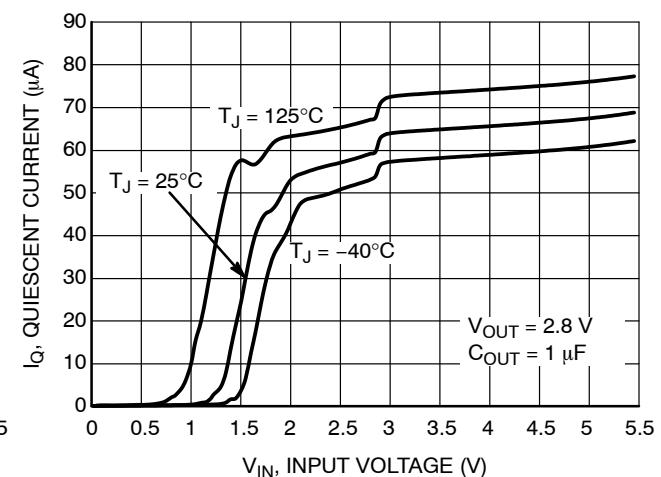
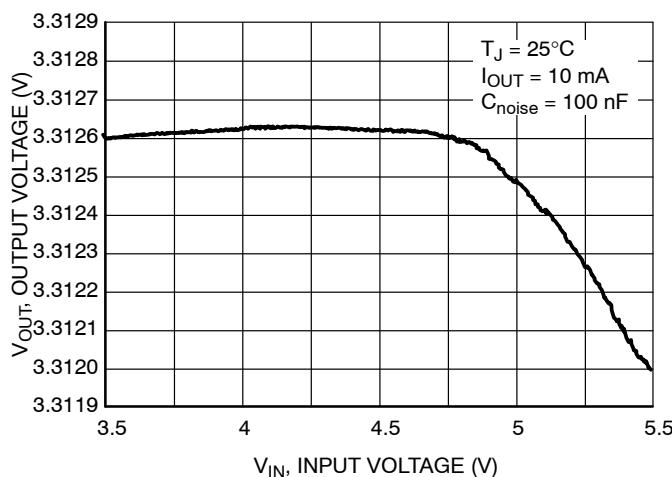
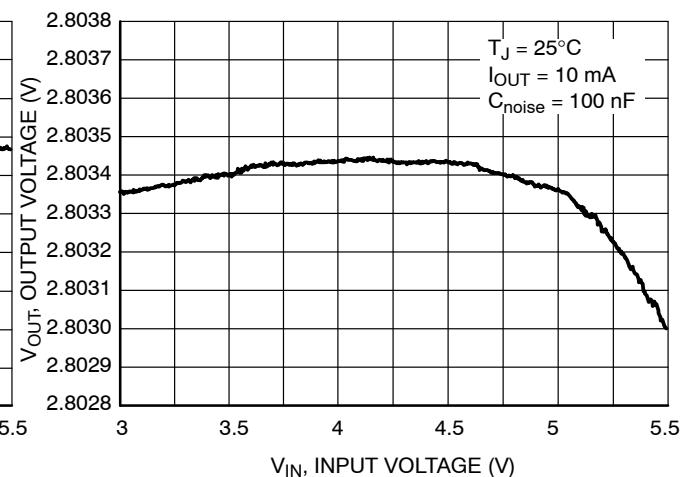
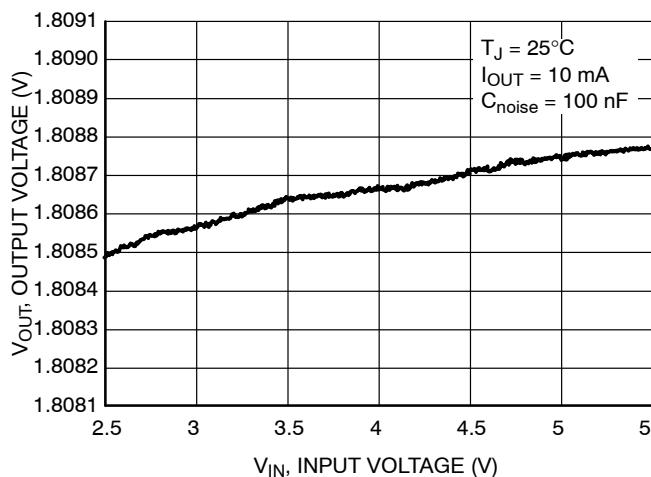
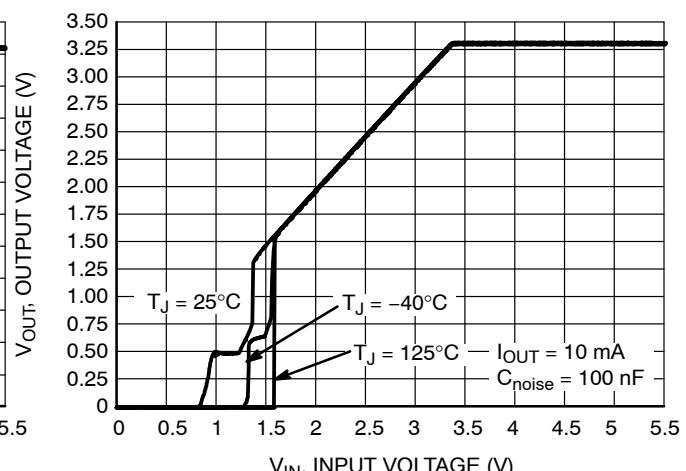
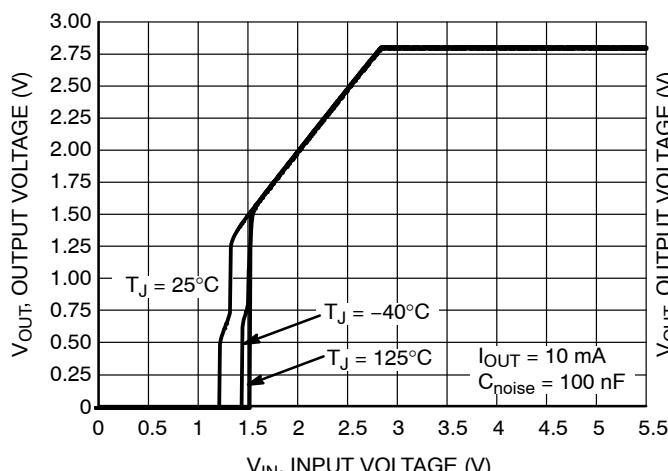


**Figure 43. Thermal Shutdown Protection**  
 $V_{OUT} = 3 \text{ V}$ ,  $C_{noise} = 100 \text{ nF}$ ,  $C_{OUT} = 1 \mu\text{F}$

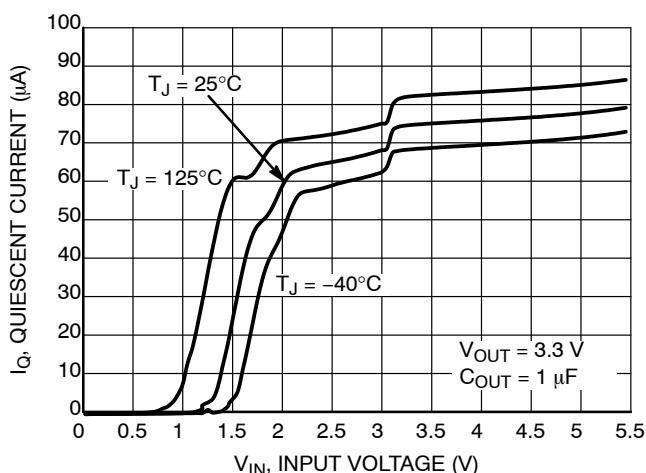


$V_{OUT} = 1.8 \text{ V}$ ,  $C_{OUT} = 1 \mu\text{F}$

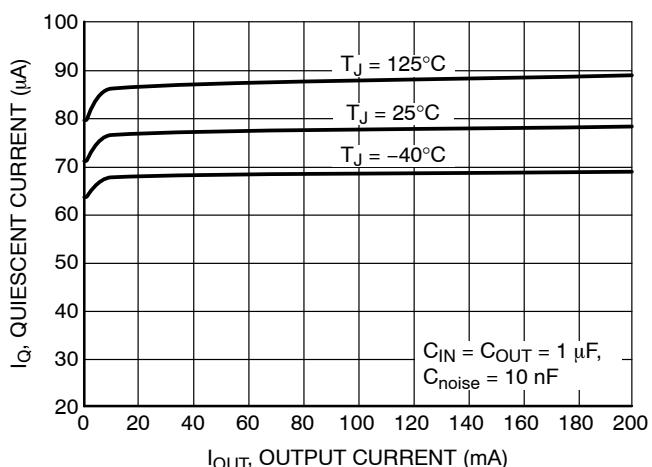
## TYPICAL CHARACTERISTICS



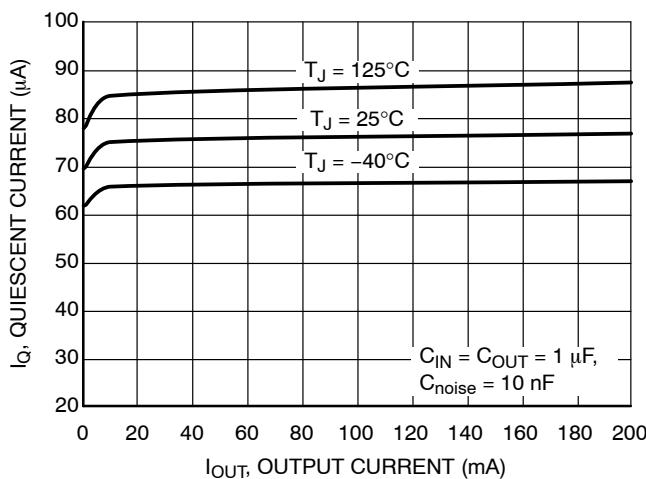
## TYPICAL CHARACTERISTICS



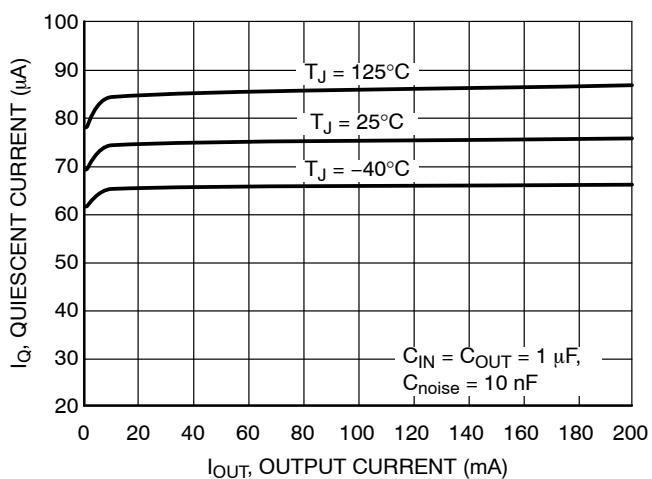
**Figure 51. Quiescent Current vs. Input Voltage,  $V_{OUT} = 3.3\text{ V}$ ,  $C_{OUT} = 1\text{ }\mu\text{F}$**



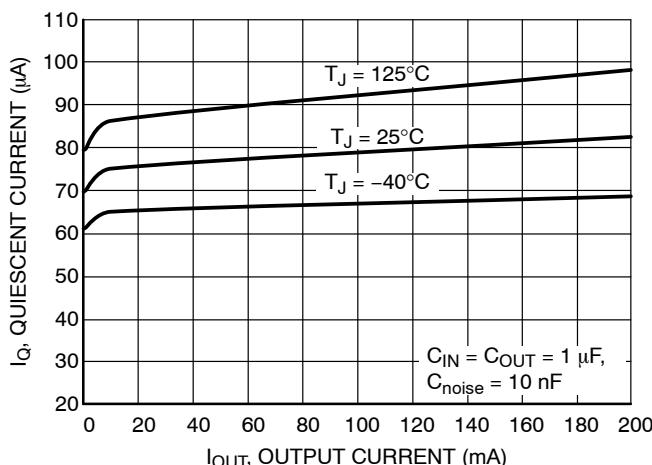
**Figure 52. Quiescent Current vs. Output Current,  $V_{OUT} = 3.3\text{ V}$**



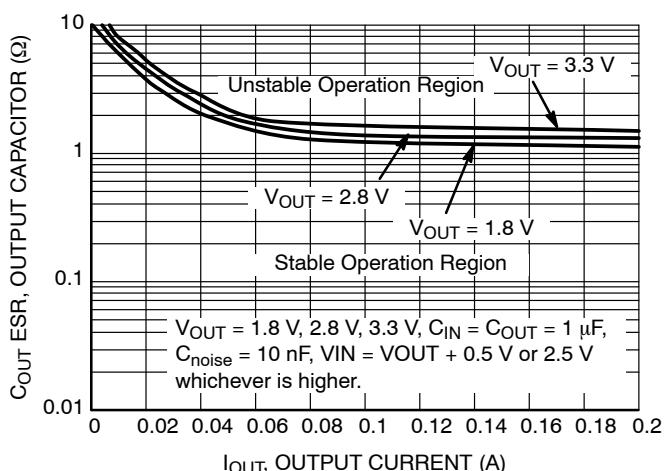
**Figure 53. Quiescent Current vs. Output Current,  $V_{OUT} = 3.0\text{ V}$**



**Figure 54. Quiescent Current vs. Output Current,  $V_{OUT} = 2.8\text{ V}$**



**Figure 55. Quiescent Current vs. Output Current,  $V_{OUT} = 1.8\text{ V}$**



**Figure 56. Output Capacitor ESR vs. Output Current**

## APPLICATIONS INFORMATION

**General**

The NCP700B is a high performance 200 mA low dropout linear regulator. This device delivers excellent noise and dynamic performance consuming only 75  $\mu$ A (typ) quiescent current at full load, with the PSRR of (typ) 82 dB at 1 kHz. Excellent load transient performance and small package size makes the device ideal for portable applications.

Logic EN input provides ON/OFF control of the output voltage. When the EN is low the device consumes as low as typically 0.1  $\mu$ A.

Access to the major contributor of noise within the integrated circuit – Bandgap Reference is provided through the BYP pin. This allows bypassing the source of noise by the noise reduction capacitor and reaching noise levels below 10  $\mu$ V<sub>RMS</sub>.

The device is fully protected in case of output short circuit condition and overheating assuring a very robust design.

**Input Capacitor Requirements ( $C_{IN}$ )**

It is recommended to connect a 1  $\mu$ F ceramic capacitor between IN pin and GND pin of the device. This capacitor will provide a low impedance path for unwanted AC signals or noise present on the input voltage. The input capacitor will also limit the influence of input trace inductances and Power Supply resistance during sudden load current changes. Higher capacitances will improve the line transient response.

**Output Capacitor Requirements ( $C_{OUT}$ )**

The NCP700B has been designed to work with low ESR ceramic capacitors on the output. The device will also work with other types of capacitors until the minimum value of capacitance is assured and the capacitor ESR is within the specified range. Generally it is recommended to use 1  $\mu$ F or larger X5R or X7R ceramic capacitor on the output pin.

**Noise Bypass Capacitor Requirements ( $C_{noise}$ )**

The  $C_{noise}$  capacitor is connected directly to the high impedance node. Any loading on this pin like the connection of oscilloscope probe, or the  $C_{noise}$  capacitor leakage will cause a voltage drop in regulated output voltage. The minimum value of noise bypass capacitor is 10 nF. Values below 10 nF should be avoided due to possible Turn-On overshoot. Particular value should be chosen based on the output noise requirements (Figure 22). Larger values of  $C_{noise}$  will improve the output noise and PSRR but will increase the regulator Turn-On time.

**Enable Operation**

The enable function is controlled by the logic pin EN. The voltage threshold of this pin is set between 0.4 V and 1.2 V. Voltage lower than 0.4 V guarantees the device is off. Voltage higher than 1.2 V guarantees the device is on. The NCP700B enters a sleep mode when in the off state drawing less than typically 0.1  $\mu$ A of quiescent current. The internal

5 M $\Omega$  pull-down resistor (RPD) assures that the device is turned off when EN pin is not connected.

The device can be used as a simple regulator without use of the chip enable feature by tying the EN to the IN pin.

**Active Discharge**

Active discharge circuitry has been implemented to insure a fast V<sub>OUT</sub> turn off time. When EN goes low, the active discharge transistor turns on creating a path to discharge the output capacitor C<sub>OUT</sub> through 1 k $\Omega$  (R<sub>DIS</sub>) resistor.

**Turn-On Time**

The Turn-On time of the regulator is defined as the time needed to reach the output voltage which is 98% V<sub>OUT</sub> after assertion of the EN pin. This time is determined by the noise bypass capacitance C<sub>noise</sub> and nominal output voltage level V<sub>OUT</sub> according the following formula:

$$t_{ON} [s] = C_{noise} [F] \cdot \frac{V_{OUT} [V]}{68 \cdot 10^{-6} [A]} \quad (\text{eq. 1})$$

Example:

Using C<sub>noise</sub> = 100 nF, V<sub>OUT</sub> = 3 V, C<sub>OUT</sub> = 1  $\mu$ F,

$$t_{ON} = 100 \cdot 10^{-9} \cdot \frac{3}{68 \cdot 10^{-6}} = 4.41 \text{ ms}$$

The Turn-On time is independent of the load current and output capacitor C<sub>OUT</sub>. To avoid output voltage overshoot during Turn-On please select C<sub>noise</sub>  $\geq$  10 nF.

**Current Limit**

Output Current is internally limited within the IC to a typical 310 mA. The NCP700B will source this amount of current measured with a voltage 100 mV lower than the typical operating output voltage. If the Output Voltage is directly shorted to ground (V<sub>OUT</sub> = 0 V), the short circuit protection will limit the output current to 320 mA (typ). The current limit and short circuit protection will work properly up to V<sub>IN</sub> = 5.5 V at T<sub>A</sub> = 25°C. There is no limitation for the short circuit duration.

**Thermal Shutdown**

When the die temperature exceeds the Thermal Shutdown threshold (T<sub>SDU</sub> – 150°C typical), Thermal Shutdown event is detected and the output (V<sub>OUT</sub>) is turned off.

The IC will remain in this state until the die temperature decreases below the Thermal Shutdown Reset threshold (T<sub>SDU</sub> – 135°C typical). Once the IC temperature falls below the 135°C the LDO is turned-on again.

The thermal shutdown feature provides the protection from a catastrophic device failure due to accidental overheating. This protection is not intended to be used as a substitute for proper heat sinking.

**Reverse Current**

The PMOS pass transistor has an inherent body diode which will conduct the current in case that the V<sub>OUT</sub> > V<sub>IN</sub>.

Such condition could exist in the case of pulling the  $V_{IN}$  voltage to ground. Then the output capacitor voltage will be partially discharged through the PMOS body diode. It has been verified that the device will not be damaged if the output capacitance is less than 22  $\mu\text{F}$ . If however larger output capacitors are used or extended reverse current condition is anticipated the device may require additional external protection against the excessive reverse current.

### Output Noise

If we neglect the noise coming from the (IN) input pin of the LDO, the main contributor of noise present on the output pin (OUT) is the internal bandgap reference. This is because any noise which is generated at this node will be subsequently amplified through the error amplifier and the PMOS pass device. Access to the bandgap reference node is supplied through the BYP pin. For the 1.8 V output voltage option Noise can be reduced from a typical value of

15  $\mu\text{VRms}$  by using 10 nF to less than 10  $\mu\text{VRms}$  by using a 100 nF from the BYP pin to ground. For more information please refer to Figures 22 through 24.

### Minimum Load Current

NCP700B does not require any minimum load current for stability. The minimum load current is assured by the internal circuitry.

### Power Dissipation

For given ambient temperature  $T_A$  and thermal resistance  $R_{\theta JA}$  the maximum device power dissipation can be calculated by:

$$P_{D(MAX)} = \frac{125 - T_A}{\theta_{JA}} \quad (\text{eq. 2})$$

For reliable operation junction temperature should be limited to +125°C.

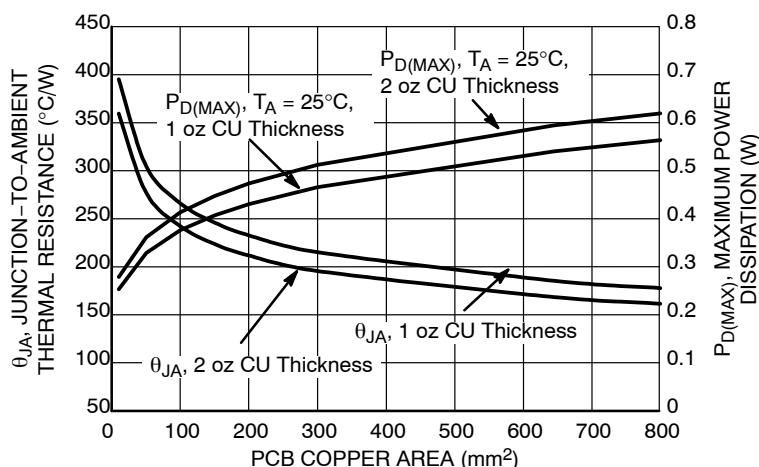


Figure 57. Thermal Resistance and Maximum Power Dissipation vs. Copper Area (WDFN6)

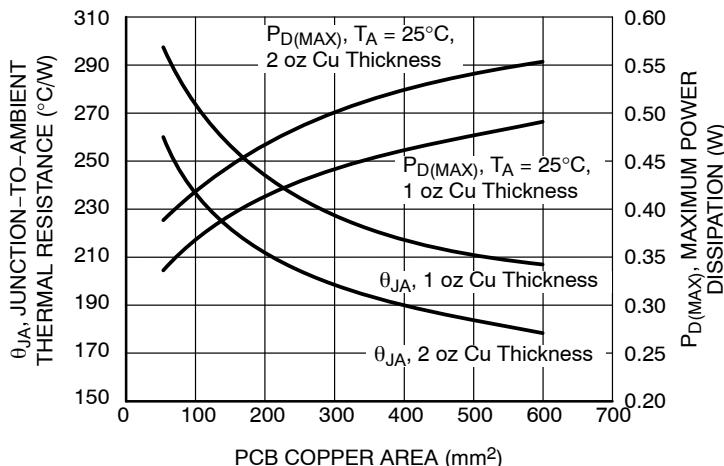


Figure 58. Thermal Resistance and Maximum Power Dissipation vs. Copper Area (TSOP-5)

## Load Regulation

The NCP700B features very good load regulation of 5 mV Max. in 0 mA to 200 mA range. In order to achieve this very good load regulation a special attention to PCB design is necessary. The trace resistance from the OUT pin to the point of load can easily approach 100 mΩ which will cause 20 mV voltage drop at full load current, deteriorating the excellent load regulation.

## Power Supply Rejection Ratio

The NCP700B features excellent Power Supply Rejection ratio. The PSRR can be tuned by selecting proper  $C_{noise}$  and  $C_{OUT}$  capacitors.

In the frequency range from 10 Hz up to about 10 kHz the larger noise bypass capacitor  $C_{noise}$  will help to improve the PSRR. At the frequencies above 10 kHz the addition of higher  $C_{OUT}$  output capacitor will result in improved PSRR.

## PCB Layout Recommendations

Connect the input ( $C_{IN}$ ), output ( $C_{OUT}$ ) and noise bypass capacitors ( $C_{noise}$ ) as close as possible to the device pins.

The  $C_{noise}$  capacitor is connected to high impedance BYP pin and thus the length of the trace between the capacitor and

the pin should be as small as possible to avoid noise pickup. In order to minimize the solution size use 0402 or 0603 capacitors. To obtain small transient variations and good regulation characteristics place  $C_{IN}$  and  $C_{OUT}$  capacitors close to the device pins and make the PCB traces wide. Larger copper area connected to the pins will also improve the device thermal resistance.

The actual power dissipation can be calculated by the formula:

$$P_D = (V_{IN} - V_{OUT})I_{OUT} + V_{IN}I_{GND} \quad (\text{eq. 3})$$

## Line Regulation

The NCP700B features very good line regulation of 0.6mV/V (typ). Furthermore the detailed Output Voltage vs. Input Voltage characteristics (Figures 47 through 49) show that up to  $V_{IN} = 5$  V the Output Voltage deviation is typically less than 250 µV for 1.8 V output voltage option and less than 150 µV for higher output voltage options. Above the  $V_{IN} = 5$  V the output voltage falls rapidly which leads to the typical 0.6 mV/V.

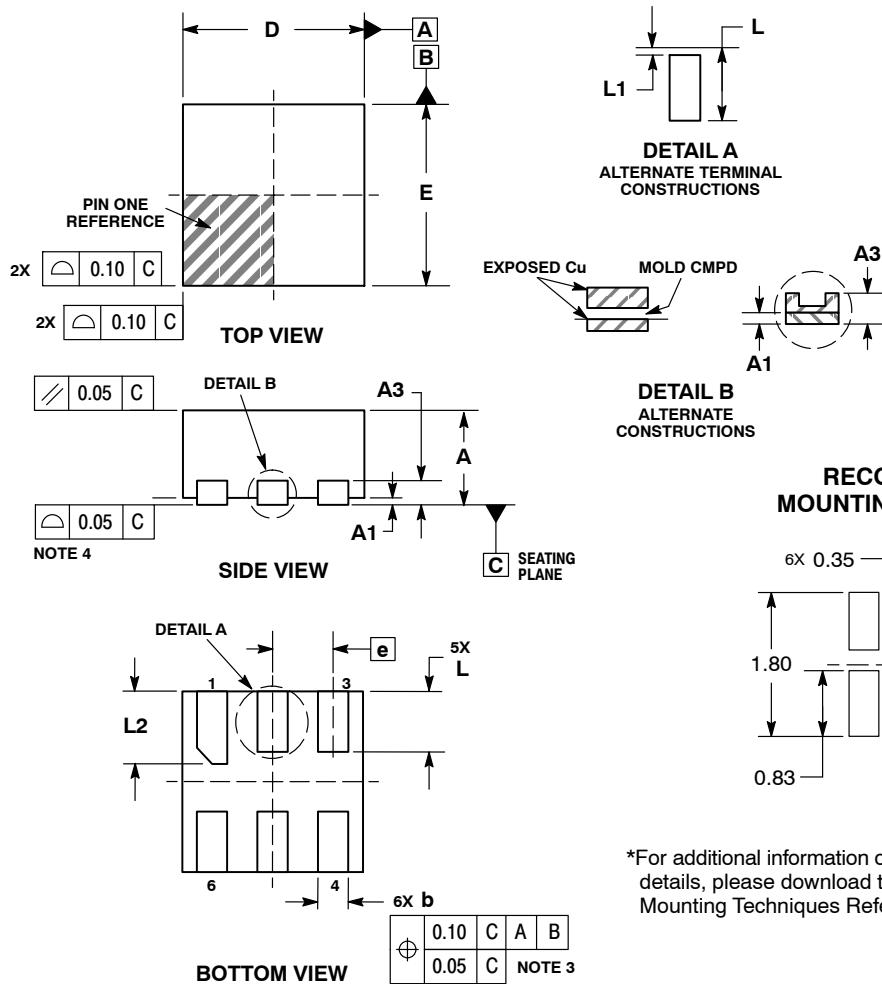
## ORDERING INFORMATION

Device	Nominal Output Voltage	Marking	Package	Shipping <sup>†</sup>
NCP700BMT18TBG	1.8 V	J	WDFN6 1.5 x 1.5 (Pb-Free)	3000 / Tape & Reel
NCP700BMT25TBG	2.5 V	Q		
NCP700BMT28TBG	2.8 V	K		
NCP700BMT30TBG	3.0 V	L		
NCP700BMT33TBG	3.3 V	P		
NCP700BSN18T1G	1.8 V	ADQ	TSOP-5 (Pb-Free)	3000 / Tape & Reel
NCP700BSN25T1G	2.5 V	AD3		
NCP700BSN28T1G	2.8 V	ADR		
NCP700BSN30T1G	3.0 V	ADT		
NCP700BSN33T1G	3.3 V	ADU		

<sup>†</sup>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.

## PACKAGE DIMENSIONS

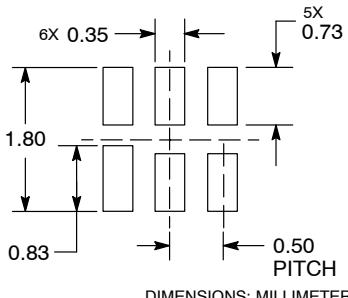
**WDFN6 1.5x1.5, 0.5P**  
CASE 511BJ  
ISSUE B



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: MILLIMETERS.
  3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM TERMINAL TIP.
  4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

DIM	MILLIMETERS	
	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
A3	0.20 REF	
b	0.20	0.30
D	1.50 BSC	
E	1.50 BSC	
e	0.50 BSC	
L	0.40	0.60
L1	---	0.15
L2	0.50	0.70

**RECOMMENDED MOUNTING FOOTPRINT\***

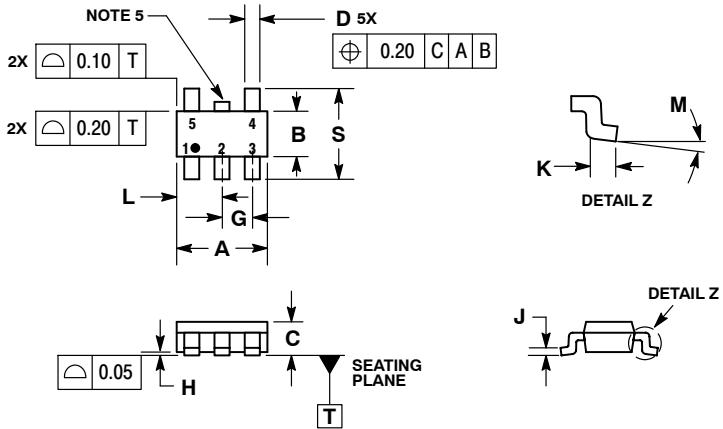


\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

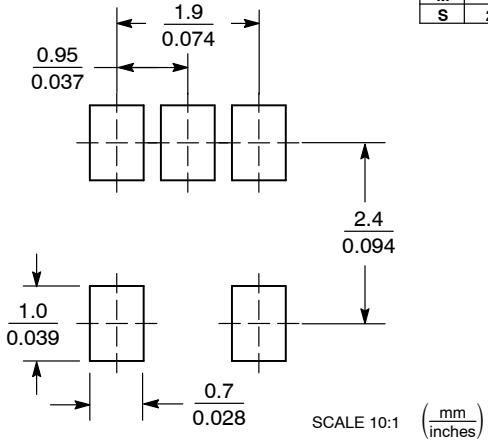
# NCP700B

## PACKAGE DIMENSIONS

**TSOP-5**  
CASE 483-02  
ISSUE H



**SOLDERING FOOTPRINT\***



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: MILLIMETERS.
  3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
  4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.
  5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

MILLIMETERS		
DIM	MIN	MAX
A	3.00	BSC
B	1.50	BSC
C	0.90	1.10
D	0.25	0.50
G	0.95	BSC
H	0.01	0.10
J	0.10	0.26
K	0.20	0.60
L	1.25	1.55
M	0 °	10 °
S	2.50	3.00

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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