ESCUELA UNIVERSITARIA POLITÉCNICA

DE LA ALMUNIA DE DOÑA GODINA (ZARAGOZA)

ANEXOS

Diseño de un Robot Bombero en Edificios

424.13.136

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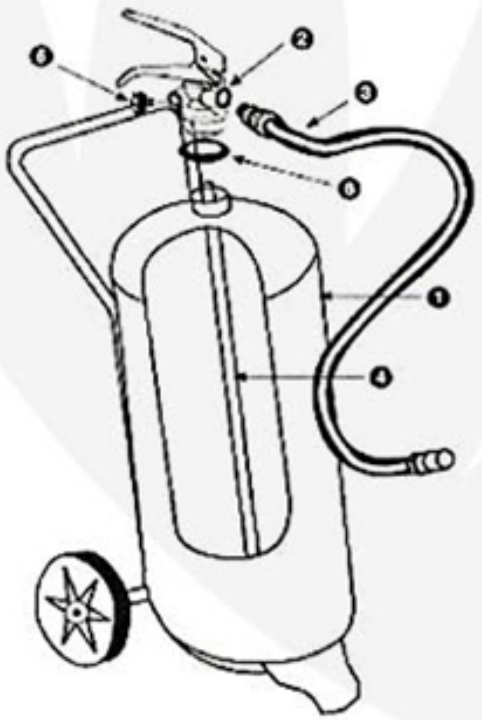
Fecha: Julio 2015

ÍNDICE ANEXOS

Ficha Técnica

MODELO	PG-25 Extintor Movil 25 Kg.	PG-50 Extintor Movil 50Kg.
PRESIÓN SERVICIO	17 BAR	17 BAR
PRESIÓN DISEÑO	15 BAR a 20ºC	15 BAR a 20ºC
PRESIÓN PRUEBA	25 BAR	25 BAR
EFICACIA	43A-233B C	89A-610B C
AGENTE EXTINTOR	Polvo QuimicoABC	Polvo QuimicoABC
CONTENIDO AGENTE EXTINTOR	25.000 grs. ±2%	50.000 grs. ±2%
AGENTE EXPULSOR	N^2	N^2
VOLUMEN RECIPIENTE	29,65±0,05 dm^3	51,90±0,05 dm^3
TEMPERATURA UYILIZACIÓN	-20ºC a +60ºC	-20ºC a +60ºC
MATERIAL RECIPIENTE	ACERO DD12-UNE 10111	ACERO DD12-UNE 10111
DIMENSIONES		
Altura Extintor	920 mm	1.020 mm
Altura Recipiente	648 mm	830 mm
Diametro	250 mm	300 mm
CERTIFICADO CE AENOR	A21/000016	A21/000016



1. **CUERPO**/BODY
2. **VÁLVULA DE CARGA** /DISCHARGE VALVE
3. **MANGUERA** / HOSE
4. **TUBO SONDA** /SYPHON TUBE
5. **MANÓMETRO** /PRESSURE GAUGE
6. **ARANDELA DE CIERRE** /CLOSING JOINT

Registro de Materiales
Información de producto, equipo o sistema

RM-CTE ITeC

Identificación

Empresa	**AIR TUB SL**
Producto comercial	**TUBO LISO**
Material	**Conductos circulares de acero, para ventilación**
Normativa obligatoria	**CTE/DB-SI**

Característica	Valores del producto		Q	Valores de referencia			
	Valor	UM		Método de ensayo	Requisito	Nivel	Condicionante
CTE							
Resistencia fuego *(Conforme con las especificaciones del SI 1-2 i SI 3-8 del CTE)*	E600/120	min	X	UNE-EN 13501-4:2007	90 *(1)*	E600/90	Conductos que transcurran por un único sector de incendio.
					30	EI30	Conductos que discurran per el interior del edificio, por fachadas a menos de 1,5 m de distancia de zonas de la misma o de balcones, terrazas o huecos practicables.
					90	EI90	Conductos que atraviesen elementos separadores de sectores de incendio.
					(1) T= 600ºC		
Características de identificación							
Diámetro nominal exterior	100 a 600	mm		UNE-EN 1506:2007			
Espesor	Acero inoxidable: 0,5 / 0,6	mm					
Resistencia a flexión	-	MPa					
Coeficiente de fricción							
Conductividad térmica		W/m.K		UNE-EN 1859:2000			
Estanquidad al aire *(Propiedad del sistema del que el producto forma parte)*				UNE-EN 1507:2007			
Presión estática máxima *(Propiedad del sistema del que el producto forma parte)*		Pa		UNE-EN 1507:2007			
Tipo de acero *(Acero galvanizado (G); acero inoxidable (I))*	• G • I			UNE-EN 10142:2001			
Tipo de unión de la chapa *(Grapada, soldada, ribeteada, soldada por puntos)*	autoconectable*(Las piezas acaban en un macho y una hembra para hacer la conexión entre ellas, introduciéndose uno dentro del otro)*			UNE-EN 1507:2007			
Temperatura máxima de trabajo	-	°C					
Densidad superficial media de la galvanización	275	g/m2					
Aislamiento: - Material							
- Espesor	-	mm					
Tolerancia de diámetro		mm		UNE-EN 1506:2007			
Tolerancia de espesor	-	mm					
Longitud de suministro	1	m					
Masa por metro lineal	-	kg					
Durabilidad *(Expectativa de vida útil en condiciones normales)*	-	años					
Particulares:	Las piezas acaban en un macho y una hembra para hacer la conexión entre ellas, introduciéndose uno dentro del otro.						

Notas:
Valor del producto: Cuando el valor es dado por más de un documento justificativo (obligado o voluntario) se muestra el más restrictivo.
Valor NPD: Prestación no determinada. Se puede utilizar cuando y donde la característica, para un uso previsto, no esté sometida a requisitos reglamentarios o condicionantes normativos.
Q: propiedad certificada por una entidad certificadora.

Control de recepción en obra de productos, equipos y sistemas

Control de recepción mediante ensayos

Ensayo inicial de tipo (AIT) **(acceso al documento)**

Núm. de certificación:	7993
Característica ensayada:	Resistencia fuego
Organismo notificado:	Laboratorio de Investigación y Control del Fuego
Fecha de ensayo:	23-10-2009
Fecha caducidad:	No caduca

Ensayo inicial de tipo (AIT) **(acceso al documento)**

Núm. de certificación:	8031
Característica ensayada:	Resistencia fuego
Organismo notificado:	Laboratorio de Investigación y Control del Fuego
Fecha de ensayo:	23-10-2009
Fecha caducidad:	No caduca

Ensayo inicial de tipo (AIT) **(acceso al documento)**

Núm. de certificación:	EST-055
Característica ensayada:	Resistencia fuego
Organismo notificado:	Laboratorio de Investigación y Control del Fuego
Fecha de ensayo:	03-10-2008
Fecha caducidad:	No caduca

FLIR A5sc, A15sc, A35sc Cameras

Real-Time Thermal Imaging and Analysis for Machine Vision and Test & Measurement

The A5sc, A15sc, and A35sc are affordable Infrared Camera Kits designed specifically for thermal bench top testing applications. The compact packaging makes the AX5sc a perfect fit for the bench top and allows for deployment in locations where size constraints are critical. They are available in a variety of pixel resolutions and can meet the spatial resolution requirements of most applications.

Eliminate the Guesswork – *See heat patterns with the thermal imagery and extract temperature values from live or recorded imagery*

Uncooled Microbolometer Detector – *Maintenance-free and provides excellent longwave imaging performance.*

Pixel Resolution and Optics – *Available in 80 x 64, 160 x 128, 320 x 256 pixel formats to achieve numerous fields of view.*

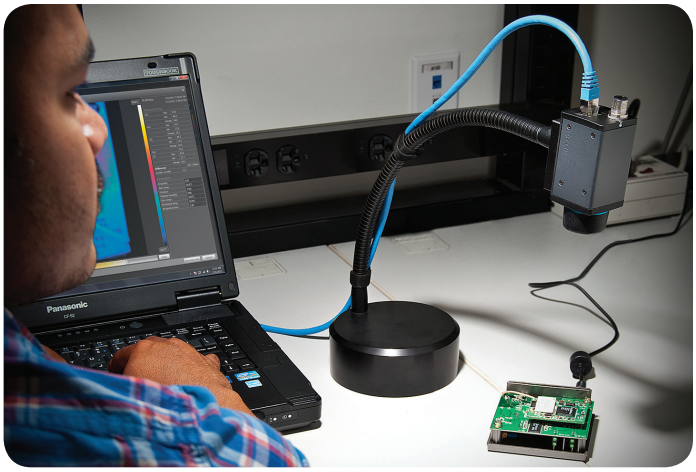
Versatility – *Compact, rugged, and lightweight with straightforward mounting that permits quick installation and easy movement for new application requirements.*

Plug-and-Play Compatibility – *The ideal system integration solution with universal plug and play through GigE Vision and GEN<i>CAM protocols, these cameras can be fully configured from a PC, allowing camera control and image capture in real time*

Fast Data Transfer – *Its RJ-45 gigabit Ethernet connection supplies 14-bit images at frame rates as high as 60 Hz.*

Image and Data Acquisition – *Record thermal snapshots and movies with FLIR Tools + recording and analysis software.*

Kit Components – *includes everything needed for quick "out of box" deployment.*



Imaging Specifications

Detector	A5sc	A15sc	A35sc
Detector Type	Uncooled VOx microbolometer		
Spectral Range	7.5 µm to 13.0 µm		
Resolution	80 x 64	160 x 128	320 x 256
Detector Pitch	50 µm	25 µm	25 µm
NETD	<50 mK		
Imaging			
Time Constant	Typical 12 ms		
Frame Rate (Full Window)	60 Hz		
Dynamic Range	14-bit		
Digital Data Streaming	Gigabit Ethernet		
Command and Control	Gigabit Ethernet		
Measurement			
Standard Temperature Range	-40 to +160°C (-40 to 320°F) -40 to +550°C (-40 to +1022°F).		
Accuracy	±5°C (±9°F) or ±5% of reading		
Optics			
Available Lenses	5 mm	9 mm	9 mm
Focus	Fixed		
Image Presentation			
Digital Data	Via PC Using FLIR R&D Software or GigE Vision Protocols		
General			
Operating Temperature Range	-15°C to 50°C (5°F to 122°F)		
Storage Temperature Range	-40°C to 70°C (-40°F to 158°F)		
Encapsulation	IP 40 (IEC 60527)		
Bump / Vibration	5 g (IEC 60068-2-27) / 2 g (IEC 60068-2-6)		
Power	12/24 VDC, TBA W absolute max		
Weight	0.2 kg (0.44 lb)		
Size (L x W x H) w/o Lens	106 x 40 x 43 mm (4.2 x 1.6 x 1.7 in.)		
Tripod Mounting	UNC 1/4'-20 via Base Support Accessory		
Base Mounting	4 x M3 thread mounting holes (on bottom)		

A5sc, A15sc, A35sc Kits include:
Hard transport case, Infrared camera with lens, focus adjustment tool, base support, gooseneck table stand, PoE Injector (power over Ethernet), Ethernet CAT-6 cables, 2m/6.6 ft (2 ea.), FLIR Tools+Analysis and Recording Software, getting started guide, service & training brochure

GiGE VISION™
GENICAM

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www.flir.com
NASDAQ: FLIR

Ultrasonic Ranging Module HC - SR04

Product features:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:
(1) Using IO trigger for at least 10us high level signal,
(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.
Test distance = (high level time×velocity of sound (340M/S) / 2,

Wire connecting direct as following:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

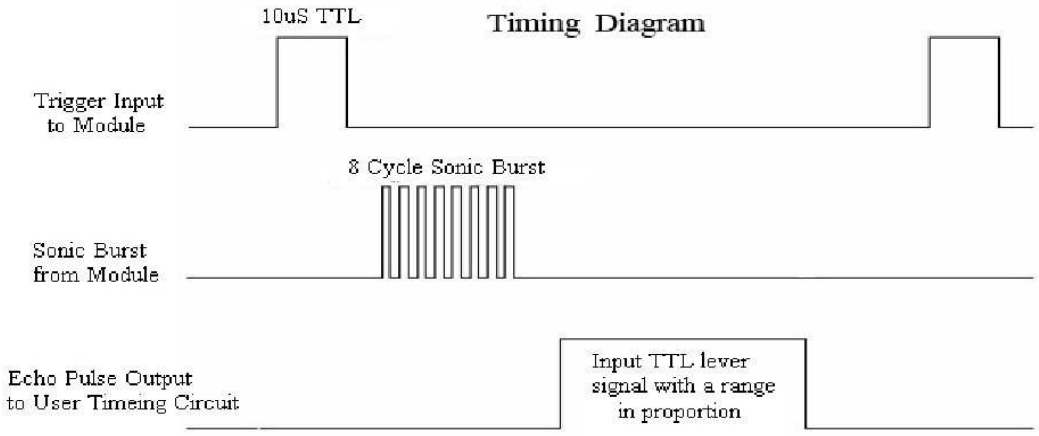
Electric Parameter

Working Voltage	**DC 5 V**
Working Current	**15mA**
Working Frequency	**40Hz**
Max Range	**4m**
Min Range	**2cm**
MeasuringAngle	**15 degree**
Trigger Input Signal	**10uS TTL pulse**
Echo Output Signal	**Input TTL lever signal and the range in proportion**
Dimension	**45*20*15mm**

Vcc Trig Echo GND

Timing diagram

The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



1. XBee®/XBee-PRO® RF Modules

The XBee and XBee-PRO RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices.

The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

Key Features

Long Range Data Integrity

XBee

- Indoor/Urban: up to 100’ (30 m)
- Outdoor line-of-sight: up to 300’ (90 m)
- Transmit Power: 1 mW (0 dBm)
- Receiver Sensitivity: -92 dBm

XBee-PRO

- Indoor/Urban: up to 300’ (90 m), 200' (60 m) for International variant
- Outdoor line-of-sight: up to 1 mile (1600 m), 2500' (750 m) for International variant
- Transmit Power: 63mW (18dBm), 10mW (10dBm) for International variant
- Receiver Sensitivity: -100 dBm

RF Data Rate: 250,000 bps

Advanced Networking & Security

Retries and Acknowledgements

DSSS (Direct Sequence Spread Spectrum)

Each direct sequence channels has over 65,000 unique network addresses available

Source/Destination Addressing

Unicast & Broadcast Communications

Point-to-point, point-to-multipoint and peer-to-peer topologies supported

Low Power

XBee

- TX Peak Current: 45 mA (@3.3 V)
- RX Current: 50 mA (@3.3 V)
- Power-down Current: < 10 µA

XBee-PRO

- TX Peak Current: 250mA (150mA for international variant)
- TX Peak Current (RPSMA module only): 340mA (180mA for international variant
- RX Current: 55 mA (@3.3 V)
- Power-down Current: < 10 µA

ADC and I/O line support

Analog-to-digital conversion, Digital I/O

I/O Line Passing

Easy-to-Use

No configuration necessary for out-of box RF communications

Free X-CTU Software (Testing and configuration software)

AT and API Command Modes for configuring module parameters

Extensive command set

Small form factor

Worldwide Acceptance

FCC Approval (USA) Refer to Appendix A [p64] for FCC Requirements. Systems that contain XBee®/XBee-PRO® RF Modules inherit Digi Certifications.

ISM (Industrial, Scientific & Medical) **2.4 GHz frequency band**

Manufactured under **ISO 9001:2000** registered standards

XBee®/XBee-PRO® RF Modules are optimized for use in the United States, Canada, Australia, Japan, and Europe. Contact Digi for complete list of government agency approvals.

Specifications

Table 1-01. Specifications of the XBee®/XBee-PRO® RF Modules

Specification	XBee	XBee-PRO
Performance		
Indoor/Urban Range	Up to 100 ft (30 m)	Up to 300 ft. (90 m), up to 200 ft (60 m) International variant
Outdoor RF line-of-sight Range	Up to 300 ft (90 m)	Up to 1 mile (1600 m), up to 2500 ft (750 m) international variant
Transmit Power Output (software selectable)	1mW (0 dBm)	63mW (18dBm)* 10mW (10 dBm) for International variant
RF Data Rate	250,000 bps	250,000 bps
Serial Interface Data Rate (software selectable)	1200 bps - 250 kbps (non-standard baud rates also supported)	1200 bps - 250 kbps (non-standard baud rates also supported)
Receiver Sensitivity	-92 dBm (1% packet error rate)	-100 dBm (1% packet error rate)
Power Requirements		
Supply Voltage	2.8 – 3.4 V	2.8 – 3.4 V
Transmit Current (typical)	45mA (@ 3.3 V)	250mA (@3.3 V) (150mA for international variant) RPSMA module only: 340mA (@3.3 V) (180mA for international variant)
Idle / Receive Current (typical)	50mA (@ 3.3 V)	55mA (@ 3.3 V)
Power-down Current	< 10 µA	< 10 µA
General		
Operating Frequency	ISM 2.4 GHz	ISM 2.4 GHz
Dimensions	0.960” x 1.087” (2.438cm x 2.761cm)	0.960” x 1.297” (2.438cm x 3.294cm)
Operating Temperature	-40 to 85º C (industrial)	-40 to 85º C (industrial)
Antenna Options	Integrated Whip, Chip or U.FL Connector, RPSMA Connector	Integrated Whip, Chip or U.FL Connector, RPSMA Connector
Networking & Security		
Supported Network Topologies	Point-to-point, Point-to-multipoint & Peer-to-peer	
Number of Channels (software selectable)	16 Direct Sequence Channels	12 Direct Sequence Channels
Addressing Options	PAN ID, Channel and Addresses	PAN ID, Channel and Addresses
Agency Approvals		
United States (FCC Part 15.247)	OUR-XBEE	OUR-XBEEPRO
Industry Canada (IC)	4214A XBEE	4214A XBEEPRO
Europe (CE)	ETSI	ETSI (Max. 10 dBm transmit power output)*
Japan	R201WW07215214	R201WW08215111 (Max. 10 dBm transmit power output)*
Austraila	C-Tick	C-Tick

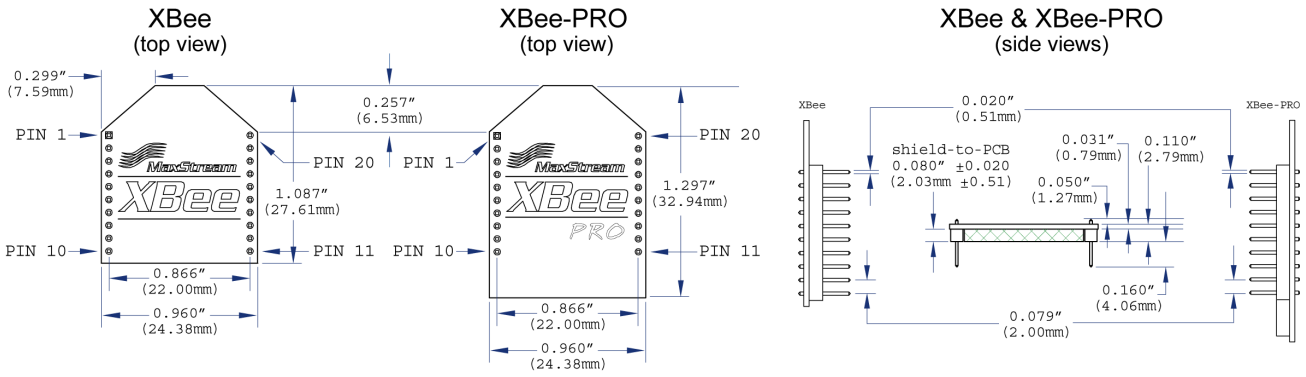
* See Appendix A for region-specific certification requirements.

Antenna Options: The ranges specified are typical when using the integrated Whip (1.5 dBi) and Dipole (2.1 dBi) antennas. The Chip antenna option provides advantages in its form factor; however, it typically yields shorter range than the Whip and Dipole antenna options when transmitting outdoors.For more information, refer to the "XBee Antennas" Knowledgebase Article located on Digi's Support Web site

Mechanical Drawings

Figure 1-01. Mechanical drawings of the XBee®/XBee-PRO® RF Modules (antenna options not shown)

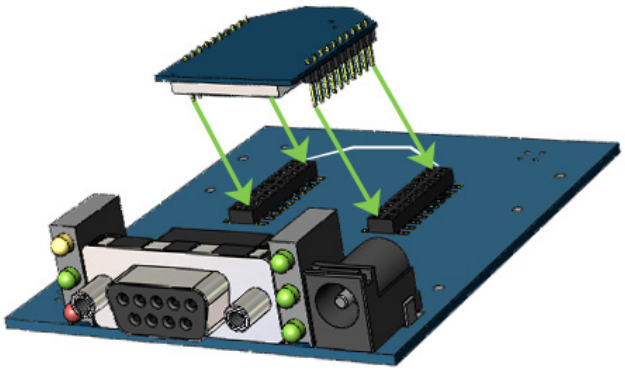
The XBee and XBee-PRO RF Modules are pin-for-pin compatible.



Mounting Considerations

The XBee®/XBee-PRO® RF Module was designed to mount into a receptacle (socket) and therefore does not require any soldering when mounting it to a board. The XBee Development Kits contain RS-232 and USB interface boards which use two 20-pin receptacles to receive modules.

Figure 1-02. XBee Module Mounting to an RS-232 Interface Board.



The receptacles used on Digi development boards are manufactured by Century Interconnect. Several other manufacturers provide comparable mounting solutions; however, Digi currently uses the following receptacles:

- Through-hole single-row receptacles -
  Samtec P/N: MMS-110-01-L-SV (or equivalent)
- Surface-mount double-row receptacles -
  Century Interconnect P/N: CPRMSL20-D-0-1 (or equivalent)
- Surface-mount single-row receptacles -
  Samtec P/N: SMM-110-02-SM-S

Digi also recommends printing an outline of the module on the board to indicate the orientation the module should be mounted.

Pin Signals

Figure 1-03. XBee®/XBee-PRO® RF Module Pin Numbers

(top sides shown - shields on bottom)

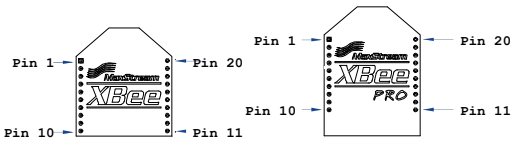


Table 1-02. Pin Assignments for the XBee and XBee-PRO Modules
(Low-asserted signals are distinguished with a horizontal line above signal name.)

Pin #	Name	Direction	Description
1	VCC	-	Power supply
2	DOUT	Output	UART Data Out
3	DIN / **CONFIG**	Input	UART Data In
4	DO8*	Output	Digital Output 8
5	**RESET**	Input	Module Reset (reset pulse must be at least 200 ns)
6	PWM0 / RSSI	Output	PWM Output 0 / RX Signal Strength Indicator
7	PWM1	Output	PWM Output 1
8	[reserved]	-	Do not connect
9	DTR / SLEEP_RQ / DI8	Input	Pin Sleep Control Line or Digital Input 8
10	GND	-	Ground
11	AD4 / DIO4	Either	Analog Input 4 or Digital I/O 4
12	**CTS** / DIO7	Either	Clear-to-Send Flow Control or Digital I/O 7
13	ON / **SLEEP**	Output	Module Status Indicator
14	VREF	Input	Voltage Reference for A/D Inputs
15	Associate / AD5 / DIO5	Either	Associated Indicator, Analog Input 5 or Digital I/O 5
16	**RTS** / AD6 / DIO6	Either	Request-to-Send Flow Control, Analog Input 6 or Digital I/O 6
17	AD3 / DIO3	Either	Analog Input 3 or Digital I/O 3
18	AD2 / DIO2	Either	Analog Input 2 or Digital I/O 2
19	AD1 / DIO1	Either	Analog Input 1 or Digital I/O 1
20	AD0 / DIO0	Either	Analog Input 0 or Digital I/O 0

* Function is not supported at the time of this release

Design Notes:

- Minimum connections: VCC, GND, DOUT & DIN
- Minimum connections for updating firmware: VCC, GND, DIN, DOUT, RTS & DTR
- Signal Direction is specified with respect to the module
- Module includes a 50k Ω pull-up resistor attached to **RESET**
- Several of the input pull-ups can be configured using the PR command
- Unused pins should be left disconnected

Electrical Characteristics

Table 1-03. DC Characteristics (VCC = 2.8 - 3.4 VDC)

Symbol	Characteristic	Condition	Min	Typical		Max	Unit
V_{IL}	Input Low Voltage	All Digital Inputs	-	-		0.35 * VCC	V
V_{IH}	Input High Voltage	All Digital Inputs	0.7 * VCC	-		-	V
V_{OL}	Output Low Voltage	I_{OL} = 2 mA, VCC >= 2.7 V	-	-		0.5	V
V_{OH}	Output High Voltage	I_{OH} = -2 mA, VCC >= 2.7 V	VCC - 0.5	-		-	V
II_{IN}	Input Leakage Current	V_{IN} = VCC or GND, all inputs, per pin	-	0.025		1	µA
II_{OZ}	High Impedance Leakage Current	V_{IN} = VCC or GND, all I/O High-Z, per pin	-	0.025		1	µA
TX	Transmit Current	VCC = 3.3 V	-	45 (XBee)	215, 140 (PRO, Int)	-	mA
RX	Receive Current	VCC = 3.3 V	-	50 (XBee)	55 (PRO)	-	mA
PWR-DWN	Power-down Current	SM parameter = 1	-	< 10		-	µA

Table 1-04. ADC Characteristics (Operating)

Symbol	Characteristic	Condition	Min	Typical	Max	Unit
V_{REFH}	VREF - Analog-to-Digital converter reference range		2.08	-	V_{DDAD*}	V
I_{REF}	VREF - Reference Supply Current	Enabled	-	200	-	µA
		Disabled or Sleep Mode	-	< 0.01	0.02	µA
V_{INDC}	Analog Input Voltage[1]		V_{SSAD} - 0.3	-	V_{DDAD} + 0.3	V

1. Maximum electrical operating range, not valid conversion range.

* V_{DDAD} is connected to VCC.

Table 1-05. ADC Timing/Performance Characteristics[1]

Symbol	Characteristic	Condition	Min	Typical	Max	Unit
R_{AS}	Source Impedance at Input[2]		-	-	10	kΩ
V_{AIN}	Analog Input Voltage[3]		V_{REFL}		V_{REFH}	V
RES	Ideal Resolution (1 LSB)[4]	2.08V ≤ V_{DDAD} ≤ 3.6V	2.031	-	3.516	mV
DNL	Differential Non-linearity[5]		-	±0.5	±1.0	LSB
INL	Integral Non-linearity[6]		-	±0.5	±1.0	LSB
E_{ZS}	Zero-scale Error[7]		-	±0.4	±1.0	LSB
F_{FS}	Full-scale Error[8]		-	±0.4	±1.0	LSB
E_{IL}	Input Leakage Error[9]		-	±0.05	±5.0	LSB
E_{TU}	Total Unadjusted Error[10]		-	±1.1	±2.5	LSB

1. All ACCURACY numbers are based on processor and system being in WAIT state (very little activity and no IO switching) and that adequate low-pass filtering is present on analog input pins (filter with 0.01 µF to 0.1 µF capacitor between analog input and VREFL). Failure to observe these guidelines may result in system or microcontroller noise causing accuracy errors which will vary based on board layout and the type and magnitude of the activity.
Data transmission and reception during data conversion may cause some degradation of these specifications, depending on the number and timing of packets. It is advisable to test the ADCs in your installation if best accuracy is required.
2. R_{AS} is the real portion of the impedance of the network driving the analog input pin. Values greater than this amount may not fully charge the input circuitry of the ATD resulting in accuracy error.
3. Analog input must be between V_{REFL} and V_{REFH} for valid conversion. Values greater than V_{REFH} will convert to $3FF.
4. The resolution is the ideal step size or 1LSB = $(V_{REFH}–V_{REFL})/1024$
5. Differential non-linearity is the difference between the current code width and the ideal code width (1LSB). The current code width is the difference in the transition voltages to and from the current code.
6. Integral non-linearity is the difference between the transition voltage to the current code and the adjusted ideal transition voltage for the current code. The adjusted ideal transition voltage is $(Current\ Code–1/2)*(1/((V_{REFH}+E_{FS})–(V_{REFL}+E_{ZS})))$.
7. Zero-scale error is the difference between the transition to the first valid code and the ideal transition to that code. The Ideal transition voltage to a given code is $(Code–1/2)*(1/(V_{REFH}–V_{REFL}))$.
8. Full-scale error is the difference between the transition to the last valid code and the ideal transition to that code. The ideal transition voltage to a given code is $(Code–1/2)*(1/(V_{REFH}–V_{REFL}))$.
9. Input leakage error is error due to input leakage across the real portion of the impedance of the network driving the analog pin. Reducing the impedance of the network reduces this error.

10. Total unadjusted error is the difference between the transition voltage to the current code and the ideal straight-line transfer function. This measure of error includes inherent quantization error (1/2LSB) and circuit error (differential, integral, zero-scale, and full-scale) error. The specified value of E_{TU} assumes zero E_{IL} (no leakage or zero real source impedance).

2. RF Module Operation

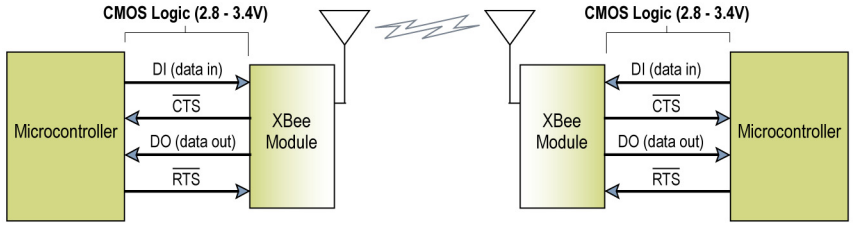
Serial Communications

The XBee®/XBee-PRO® RF Modules interface to a host device through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device (For example: Through a Digi proprietary RS-232 or USB interface board).

UART Data Flow

Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure below.

Figure 2-01. System Data Flow Diagram in a UART-interfaced environment
(Low-asserted signals distinguished with horizontal line over signal name.)

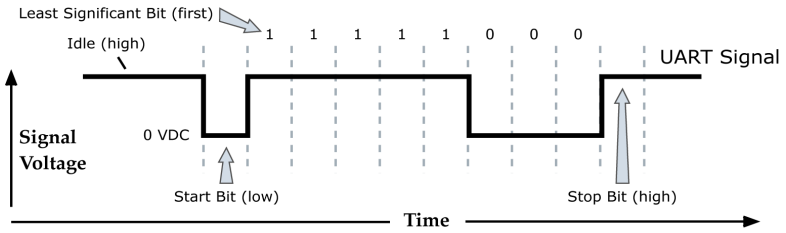


Serial Data

Data enters the module UART through the DI pin (pin 3) as an asynchronous serial signal. The signal should idle high when no data is being transmitted.

Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.

Figure 2-02. UART data packet 0x1F (decimal number "31") as transmitted through the RF module
Example Data Format is 8-N-1 (bits - parity - # of stop bits)



Serial communications depend on the two UARTs (the microcontroller's and the RF module's) to be configured with compatible settings (baud rate, parity, start bits, stop bits, data bits).

The UART baud rate and parity settings on the XBee module can be configured with the BD and SB commands, respectively. See the command table in Chapter 3 for details.

Su sistema motor maxon

maxon motor
driven by precision

Compuesto de:

Reductor planetario GP 32 B Ø32 mm, 1.0 - 6.0 Nm, versión en cerámica
Número de artículo 166939

EC-max 22 Ø22 mm, Conmutación electrónica (Brushless), 25 Vatios, con sensores Hall
Número de artículo 283860

Encoder MR Tipo M, 512 ppv, 3 canales, con line driver
Número de artículo 201940

Freno AB 20, 24 VCC, 0.14 Nm
Número de artículo 301212

Su persona de contacto

maxon motor en todo el mundo
http://www.maxonmotor.es:80/maxon/view/content/contact_page
E-Mail: info@maxonmotor.com
Internet: http://www.maxonmotor.es:80

Precio de venta recomendado:

1-4 Unidad(es)	**€847,09**
5-19 Unidad(es)	**€683,37**
20-49 Unidad(es)	**€568,45**
de 50 Unidad(es)	**Solicitado (en proceso)**

condiciones generales de contrato

Reductor planetario GP 32 B Ø32 mm, 1.0 - 6.0 Nm, versión en cerámica

Número de artículo 166939

Datos generales	
Tipo de reductor	GP
Diámetro exterior	32 mm
Versión	C

Datos del reductor	
Relación de reducción	51 : 1
Relación de reducción absoluta	17576/343
Máx. diámetro del eje del motor	6 mm
Número de etapas	3
Máx. par en continuo	6 Nm
Par de fuerza admisible brevemente	7.5 Nm
Sentido de giro, de motor a eje de salida	=
Máx. rendimiento	70 %
Holgura media del reductor sin carga	1 °
Momento de inercia	0.7 gcm²
Longitud del reductor (L1)	43.1 mm
Máx. potencia transmisible en continuo	99 W
Máx. potencia transmisible brevemente	120 W

Datos técnicos	
Juego radial	máx. 0.14 mm, 5 mm desde la brida
Juego axial	máx. 0.4 mm
Máx. carga radial	140 N, 10 mm desde la brida
Máx. carga axial (dinámica)	120 N
Máx. fuerza axial de montaje a presión	120 N
Máx. velocidad de entrada en continuo	8000 rpm
Máx. velocidad de entrada brevemente	8000 rpm
Rango de temperatura recomendado	-40...+100 °C
Número de ciclos de esterilización	0

Producto	
Peso	190 g

EC-max 22 Ø22 mm, Conmutación electrónica (Brushless), 25 Vatios, con sensores Hall

Número de artículo 283860

Valores a tensión nominal

Tensión nominal	48 V
Velocidad en vacío	12900 rpm
Corriente en vacío	60.4 mA
Velocidad nominal	10500 rpm
Par nominal (máx. par en continuo)	23.2 mNm
Corriente nominal (máx. corriente en continuo)	0.716 A
Par de arranque	127 mNm
Corriente de arranque	3.66 A
Máx. rendimiento	77 %

Datos característicos

Resistencia entre terminales	13.1 Ω
Inductancia en terminales	0.729 mH
Constante de par	34.8 mNm/A
Constante de velocidad	274 rpm/V
Relación velocidad/par	103 rpm/mNm
Constante mecánica de tiempo de arranque	4.82 ms
Momento de inercia del rotor	4.45 gcm²

Datos térmicos

Resistencia térmica carcasa-ambiente	10.2 K/W
Resistencia térmica bobinado-carcasa	1.02 K/W
Constante de tiempo térmica del bobinado	2.08 s
Constante de tiempo térmica del motor	628 s
Temperatura ambiente	-40...+100 °C
Máx. temperatura de bobinado	+155 °C

Datos mecánicos

Tipo de rodamiento/cojinete	Rodamiento de bolas
Velocidad límite	18000 rpm
Juego axial	0 - 0.14 mm
Máx. carga axial (dinámica)	3.5 N
Máx. fuerza axial de montaje a presión (estática)	60 N
(estático, eje apoyado)	1000 N
Máx. carga radial	16 N, 5 mm desde la brida

Más especificaciones

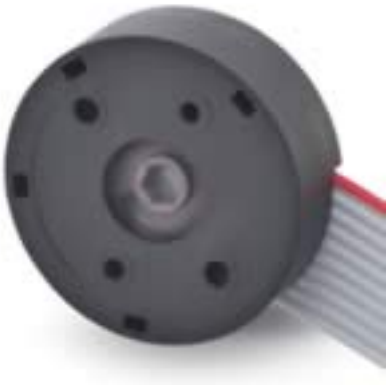
Número de pares de polos	1
Número de fases	3
Número de ciclos de esterilización	0

Producto

Peso	110 g

Encoder MR Tipo M, 512 ppv, 3 canales, con line driver

Número de artículo 201940



Tipo	
Número de pulsos por vuelta	512
Número de canales	3
Line Driver	Yes
Máx. velocidad	37500 rpm

Datos técnicos	
Tensión de alimentación Vcc	4.7...5.2 V
Lógica de driver de salida	TTL
Corriente por canal	0...5 mA
Desfase	90 °e
Imprecisión por desfase	45 °e
Canal índex sincronizado con AB	Yes
Máx. momento de inercia del disco del encoder	0.09 gcm²
Temperatura de funcionamiento	-25...+85 °C

Su sistema motor maxon

maxon motor
driven by precision

Compuesto de:

Reductor planetario GP 81 A Ø81 mm, 20 - 120 Nm
Número de artículo 110409

EC 60 Ø60 mm, Conmutación electrónica (Brushless), 400 Vatios, con sensores Hall
Número de artículo 167131

Encoder HEDL 9140, 500 ppv, 3 canales, con line driver RS 422
Número de artículo 137959

Freno AB 41, 24 VCC, 2.0 Nm
Número de artículo 228998

Su persona de contacto

maxon motor en todo el mundo
http://www.maxonmotor.es:80/maxon/view/content/contact_page
E-Mail: info@maxonmotor.com
Internet: http://www.maxonmotor.es:80

Precio de venta recomendado:

1-4 Unidad(es)	**€1.848,19**
5-19 Unidad(es)	**€1.637,19**
20-49 Unidad(es)	**€1.422,45**
de 50 Unidad(es)	**Solicitado (en proceso)**

condiciones generales de contrato

Reductor planetario GP 81 A Ø81 mm, 20 - 120 Nm

Número de artículo 110409

Datos generales	
Tipo de reductor	GP
Diámetro exterior	81 mm
Versión	A

Datos del reductor	
Relación de reducción	14 : 1
Relación de reducción absoluta	3969/289
Máx. diámetro del eje del motor	14 mm
Número de etapas	2
Máx. par en continuo	60 Nm
Par de fuerza admisible brevemente	90 Nm
Sentido de giro, de motor a eje de salida	=
Máx. rendimiento	75 %
Holgura media del reductor sin carga	0.6 °
Momento de inercia	155 gcm²
Longitud del reductor (L1)	113.7 mm
Máx. potencia transmisible en continuo	1300 W
Máx. potencia transmisible brevemente	2000 W

Datos técnicos	
Juego radial	máx. 0.1 mm, 8 mm desde la brida
Juego axial	máx. 1 mm
Máx. carga radial	600 N, 24 mm desde la brida
Máx. carga axial (dinámica)	120 N
Máx. fuerza axial de montaje a presión	1500 N
Máx. velocidad de entrada en continuo	3000 rpm
Máx. velocidad de entrada brevemente	3000 rpm
Rango de temperatura recomendado	-30...+140 °C
Número de ciclos de esterilización	0

Producto	
Peso	3000 g

EC 60 Ø60 mm, Conmutación electrónica (Brushless), 400 Vatios, con sensores Hall

Número de artículo 167131

Valores a tensión nominal

Tensión nominal	48 V
Velocidad en vacío	3100 rpm
Corriente en vacío	304 mA
Velocidad nominal	2680 rpm
Par nominal (máx. par en continuo)	830 mNm
Corriente nominal (máx. corriente en continuo)	5.85 A
Par de arranque	6820 mNm
Corriente de arranque	46.4 A
Máx. rendimiento	85 %

Datos característicos

Resistencia entre terminales	1.03 Ω
Inductancia en terminales	0.82 mH
Constante de par	147 mNm/A
Constante de velocidad	65 rpm/V
Relación velocidad/par	0.457 rpm/mNm
Constante mecánica de tiempo de arranque	3.98 ms
Momento de inercia del rotor	831 gcm²

Datos térmicos

Resistencia térmica carcasa-ambiente	1.3 K/W
Resistencia térmica bobinado-carcasa	0.5 K/W
Constante de tiempo térmica del bobinado	33.9 s
Constante de tiempo térmica del motor	1200 s
Temperatura ambiente	-20...+100 °C
Máx. temperatura de bobinado	+125 °C

Datos mecánicos

Tipo de rodamiento/cojinete	Rodamiento de bolas
Velocidad límite	7000 rpm
Juego axial	0 - 0.14 mm
Máx. carga axial (dinámica)	24 N
Máx. fuerza axial de montaje a presión (estática)	390 N
(estático, eje apoyado)	6000 N
Máx. carga radial	240 N, 5 mm desde la brida

Más especificaciones

Número de pares de polos	1
Número de fases	3
Número de ciclos de esterilización	0
Certificación	
Grado de protección	IP54

Producto

Peso	2400 g

Encoder HEDL 9140, 500 ppv, 3 canales, con line driver RS 422

Número de artículo 137959

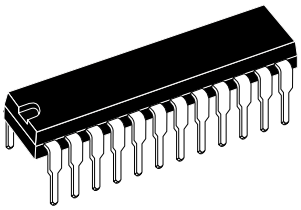
Tipo	
Número de pulsos por vuelta	500
Número de canales	3
Line Driver	DS26LS31
Máx. velocidad	12000 rpm
Diámetro del eje	-1 mm

Datos técnicos	
Tensión de alimentación Vcc	5.0V ± 10.0%
Lógica de driver de salida	EIA RS 422
Máx. aceleración angular	250000 rad / s²
Corriente por canal	-20...20 mA
Tiempo del flanco de subida	180 ns
Condición de medición del tiempo del flanco de subida	CL=25pF, RL=11kOhm,
Tiempo del flanco de bajada	40 ns
Condición de medición del tiempo del flanco de bajada	CL=25pF, RL=11kOhm,
Desfase	90 °e
Imprecisión por desfase	45 °e
Canal índex sincronizado con AB	Yes
Máx. momento de inercia del disco del encoder	0.6 gcm²
Temperatura de funcionamiento	-40...+85 °C
Posición de la salida del cable del encoder respecto al montaje del motor	-1 °

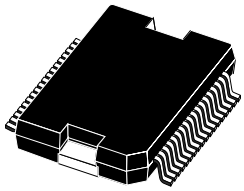
L6235

DMOS driver for 3-phase brushless DC motor

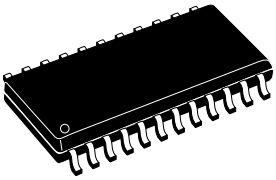
Datasheet - production data



PowerDIP24
(20 + 2 + 2)



PowerSO36



SO24
(20 + 2 + 2)

Ordering numbers:
L6235N (PowerDIP24)
L6235PD (PowerSO36)
L6235D (SO24)

Features

- Operating supply voltage from 8 to 52 V
- 5.6 A output peak current (2.8 A DC)
- $R_{DS(ON)}$ 0.3 Ω typ. value at T_j = 25 °C
- Operating frequency up to 100 KHz
- Non-dissipative overcurrent detection and protection
- Diagnostic output
- Constant t_{OFF} PWM current controller
- Slow decay synchr. rectification
- 60° and 120° hall effect decoding logic
- Brake function
- Tachometer output for speed loop
- Cross conduction protection
- Thermal shutdown
- Undervoltage lockout
- Integrated fast freewheeling diodes

Description

The L6235 device is a DMOS fully integrated 3-phase motor driver with overcurrent protection.

Realized in BCD technology, the device combines isolated DMOS power transistors with CMOS and bipolar circuits on the same chip.

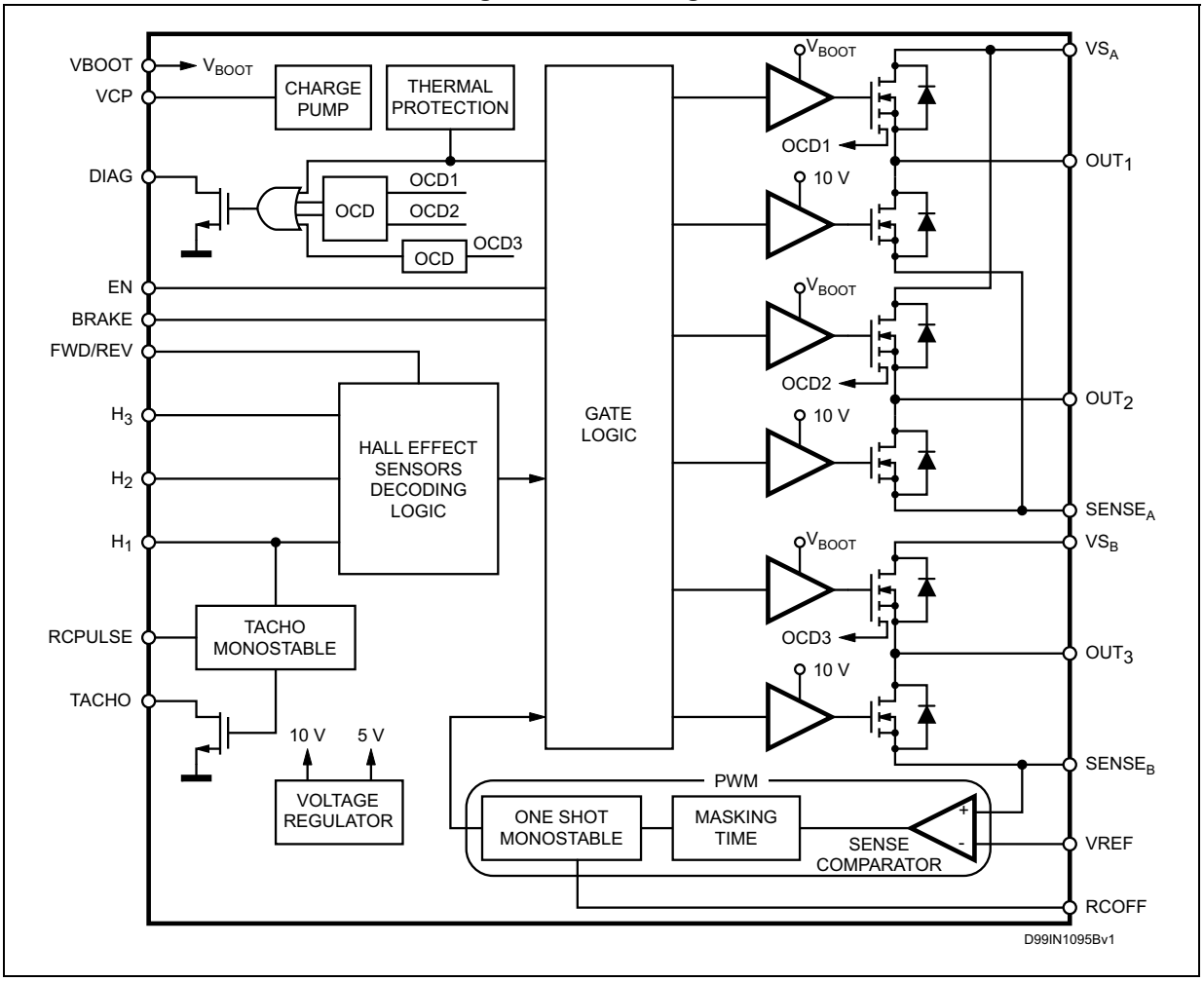
The device includes all the circuitry needed to drive a 3-phase BLDC motor including: a 3-phase DMOS bridge, a constant off time PWM current controller and the decoding logic for single ended hall sensors that generates the required sequence for the power stage.

Available in PowerDIP24 (20 + 2 + 2), PowerSO36 and SO24 (20 + 2 + 2) packages, the L6235 device features a non-dissipative overcurrent protection on the high-side power MOSFETs and thermal shutdown.

Contents

1 Block diagram

Figure 1. Block diagram



2 Maximum ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Test conditions	Value	Unit
V_S	Supply voltage	$V_{SA} = V_{SB} = V_S$	60	V
V_{OD}	Differential voltage between: VS_A, OUT_1, OUT_2, $SENSE_A$ and VS_B, OUT_3, $SENSE_B$	$V_{SA} = V_{SB} = V_S$ = 60 V; $V_{SENSEA} = V_{SENSEB}$ = GND	60	V
V_{BOOT}	Bootstrap peak voltage	$V_{SA} = V_{SB} = V_S$	V_S + 10	V
V_{IN}, V_{EN}	Logic inputs voltage range		-0.3 to 7	V
V_{REF}	Voltage range at pin VREF		-0.3 to 7	V
V_{RCOFF}	Voltage range at pin RCOFF		-0.3 to 7	V
$V_{RCPULSE}$	Voltage range at pin RCPULSE		-0.3 to 7	V
V_{SENSE}	Voltage range at pins $SENSE_A$ and $SENSE_B$		-1 to 4	V
$I_{S(peak)}$	Pulsed supply current (for each VS_A and VS_B pin)	$V_{SA} = V_{SB} = V_S$; T_{PULSE} < 1 ms	7.1	A
I_S	DC supply current (for each VS_A and VS_B pin)	$V_{SA} = V_{SB} = V_S$	2.8	A
T_{stg}, T_{OP}	Storage and operating temperature range		-40 to 150	°C

Table 2. Recommended operating condition

Symbol	Parameter	Test conditions	Min.	Max.	Unit
V_S	Supply voltage	$V_{SA} = V_{SB} = V_S$	12	52	V
V_{OD}	Differential voltage between: VS_A, OUT_1, OUT_2, $SENSE_A$ and VS_B, OUT_3, $SENSE_B$	$V_{SA} = V_{SB} = V_S$; $V_{SENSEA} = V_{SENSEB}$		52	V
V_{REF}	Voltage range at pin VREF		-0.1	5	V
V_{SENSE}	Voltage range at pins $SENSE_A$ and $SENSE_B$	(pulsed $t_W < t_{rr}$) (DC)	-6 -1	6 1	V V
I_{OUT}	DC output current	$V_{SA} = V_{SB} = V_S$		2.8	A
T_J	Operating junction temperature		-25	125	°C
f_{SW}	Switching frequency			100	KHz

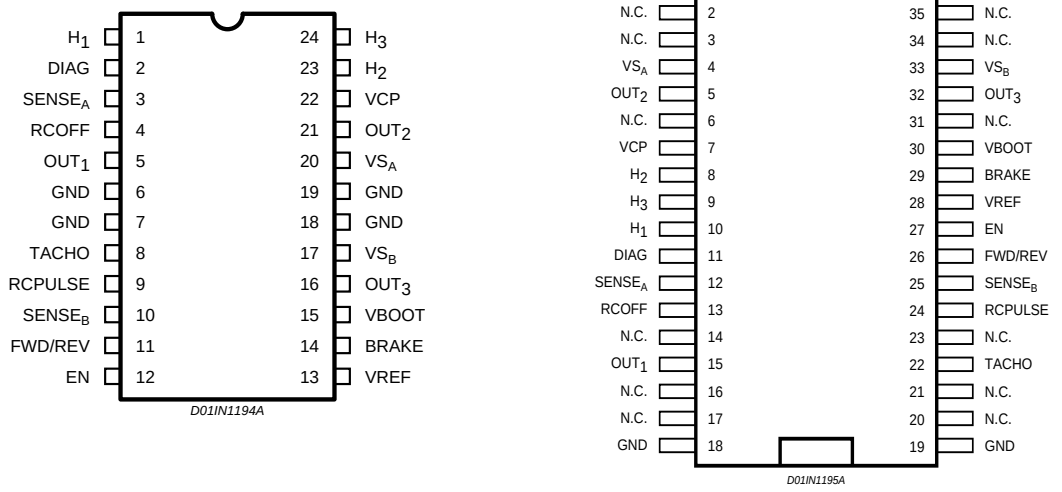
Table 3. Thermal data

Symbol	Description	PDIP24	SO24	PowerSO36	Unit
$R_{th(j\text{-}pins)}$	Maximum thermal resistance junction pins	18	14		°C/W
$R_{th(j\text{-}case)}$	Maximum thermal resistance junction case			1	°C/W
$R_{th(j\text{-}amb)1}$	Maximum thermal resistance junction ambient(1)	43	51	-	°C/W
$R_{th(j\text{-}amb)1}$	Maximum thermal resistance junction ambient(2)	-	-	35	°C/W
$R_{th(j\text{-}amb)1}$	Maximum thermal resistance junction ambient(3)	-	-	15	°C/W
$R_{th(j\text{-}amb)2}$	Maximum thermal resistance junction ambient(4)	58	77	62	°C/W

1. Mounted on a multilayer FR4 PCB with a dissipating copper surface on the bottom side of 6 cm^2 (with a thickness of 35 µm).
2. Mounted on a multilayer FR4 PCB with a dissipating copper surface on the top side of 6 cm^2 (with a thickness of 35 µm).
3. Mounted on a multilayer FR4 PCB with a dissipating copper surface on the top side of 6 cm^2 (with a thickness of 35 µm), 16 via holes and a ground layer.
4. Mounted on a multilayer FR4 PCB without any heatsinking surface on the board.

3 Pin connections

Figure 2. Pin connections (top view)



PowerDIP24/SO24 **PowerSO6(1)**

1. The slug is internally connected to pins 1, 18, 19 and 36 (GND pins).

Table 4. Pin description

Package		Name	Type	Function
SO24/ PowerDIP24	PowerSO36			
Pin no.	Pin no.			
1	10	H_1	Sensor input	Single ended hall effect sensor input 1.
2	11	DIAG	Open drain output	Overcurrent detection and thermal protection pin. An internal open drain transistor pulls to GND when an overcurrent on one of the high-side MOSFETs is detected or during thermal protection.
3	12	$SENSE_A$	Power supply	Half-bridge 1 and half-bridge 2 source pin. This pin must be connected together with pin $SENSE_B$ to power ground through a sensing power resistor.
4	13	RCOFF	RC pin	RC network pin. A parallel RC network connected between this pin and ground sets the current controller OFF-time.
5	15	OUT_1	Power output	Output 1

Table 4. Pin description (continued)

Package		Name	Type	Function
SO24/ PowerDIP24	PowerSO36			
Pin no.	Pin no.			
6, 7, 18, 19	1, 18, 19, 36	GND	GND	Ground terminals. On PowerDIP24 and SO24 packages, these pins are also used for heat dissipation toward the PCB. On PowerSO36 package the slug is connected on these pins.
8	22	TACHO	Open drain output	Frequency-to-voltage open drain output. Every pulse from pin H_1 is shaped as a fixed and adjustable length pulse.
9	24	RCPULSE	RC pin	RC network pin. A parallel RC network connected between this pin and ground sets the duration of the monostable pulse used for the frequency-to-voltage converter.
10	25	$SENSE_B$	Power supply	Half-bridge 3 source pin. This pin must be connected together with pin $SENSE_A$ to power ground through a sensing power resistor. At this pin also the inverting input of the sense comparator is connected.
11	26	FWD/REV	Logic input	Selects the direction of the rotation. HIGH logic level sets forward operation, whereas LOW logic level sets reverse operation. If not used, it has to be connected to GND or +5 V.
12	27	EN	Logic input	Chip enable. LOW logic level switches OFF all power MOSFETs. If not used, it has to be connected to +5 V.
13	28	VREF	Logic input	Current controller reference voltage. Do not leave this pin open or connect to GND.
14	29	BRAKE	Logic input	Brake input pin. LOW logic level switches ON all high-side Power MOSFETs, implementing the brake function. If not used, it has to be connected to +5 V.
15	30	VBOOT	Supply voltage	Bootstrap voltage needed for driving the upper Power MOSFETs.
16	32	OUT_3	Power output	Output 3.
17	33	VS_B	Power supply	Half-bridge 3 power supply voltage. It must be connected to the supply voltage together with pin VS_A.
20	4	VS_A	Power supply	Half-bridge 1 and half-bridge 2 power supply voltage. It must be connected to the supply voltage together with pin VS_B.
21	5	OUT_2	Power output	Output 2.
22	7	VCP	Output	Charge pump oscillator output.
23	8	H_2	Sensor input	Single ended hall effect sensor input 2.
24	9	H_3	Sensor input	Single ended hall effect sensor input 3.

4 Electrical characteristics

Table 5. Electrical characteristics
(V_S = 48 V, T_{amb} = 25 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{Sth(ON)}$	Turn ON threshold		6.6	7.4		V
$V_{Sth(OFF)}$	Turn OFF threshold		5.6	6	6.4	V
I_S	Quiescent supply current	All bridges OFF; T_j = -25 to 125 °C(1)		5	10	mA
$T_{J(OFF)}$	Thermal shutdown temperature			165		°C
Output DMOS transistors						
$R_{DS(ON)}$	High-side switch ON resistance	T_j = 25 °C		0.34	0.4	Ω
		T_j =125 °C(1)		0.53	0.59	Ω
	Low-side switch ON resistance	T_j = 25 °C		0.28	0.34	Ω
		T_j = 125 °C(1)		0.47	0.53	Ω
I_{DSS}	Leakage current	EN = low; OUT = V_{CC}			2	mA
		EN = low; OUT = GND	-0.15			mA
Source drain diodes						
V_{SD}	Forward ON voltage	I_{SD} = 2.8 A, EN = LOW		1.15	1.3	V
t_{rr}	Reverse recovery time	I_f = 2.8 A		300		ns
t_{fr}	Forward recovery time			200		ns
Logic input (H1, H2, H3, EN, FWD/REV, BRAKE)						
V_{IL}	Low level logic input voltage		-0.3		0.8	V
V_{IH}	High level logic input voltage		2		7	V
I_{IL}	Low level logic input current	GND logic input voltage	-10			µA
I_{IH}	High level logic input current	7 V logic input voltage			10	µA
$V_{th(ON)}$	Turn-ON input threshold			1.8	2.0	V
$V_{th(OFF)}$	Turn-OFF input threshold		0.8	1.3		V
V_{thHYS}	Input thresholds hysteresis		0.25	0.5		V
Switching characteristics						
$t_{D(on)EN}$	Enable to out turn-ON delay time(2)	I_{LOAD} = 2.8 A, resistive load	110	250	400	ns
$t_{D(off)EN}$	Enable to out turn-OFF delay time(2)	I_{LOAD} = 2.8 A, resistive load	300	550	800	ns
$t_{D(on)IN}$	Other logic inputs to output turn-ON delay time	I_{LOAD} = 2.8 A, resistive load			2	µs
$t_{D(off)IN}$	Other logic inputs to out turn-OFF delay time	I_{LOAD} = 2.8 A, resistive load			2	µs
t_{RISE}	Output rise time(2)	I_{LOAD} = 2.8 A, resistive load	40		250	ns
t_{FALL}	Output fall time(2)	I_{LOAD} = 2.8 A, resistive load	40		250	ns
t_{DT}	Deadtime		0.5	1		µs
f_{CP}	Charge pump frequency	T_j = -25 to 125 °C(1)		0.6	1	MHz

Table 5. Electrical characteristics (continued)
(V_S = 48 V, T_{amb} = 25 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
PWM comparator and monostable						
I_{RCOFF}	Source current at pin RC_{OFF}	V_{RCOFF} = 2.5 V	3.5	5.5		mA
V_{OFFSET}	Offset voltage on sense comparator	V_{ref} = 0.5 V		±5		mV
t_{prop}	Turn OFF propagation delay(3)	V_{ref} = 0.5 V		500		ns
t_{blank}	Internal blanking time on sense comparator			1		µs
$t_{ON(min)}$	Minimum on time			1.5	2	µs
t_{OFF}	PWM recirculation time	R_{OFF} = 20 kΩ; C_{OFF} =1 nF		13		µs
		R_{OFF}= 100 kΩ; C_{OFF} =1 nF		61		µs
I_{BIAS}	Input bias current at pin VREF				10	µA
TACHO monostable						
$I_{RCPULSE}$	Source current at pin RCPULSE	$V_{RCPULSE}$ = 2.5 V	3.5	5.5		mA
t_{PULSE}	Monostable of time	R_{PUL} = 20 kΩ; C_{PUL} =1 nF		12		µs
		R_{PUL} = 100 kΩ; C_{PUL} =1 nF		60		µs
R_{TACHO}	Open drain ON resistance			40	60	Ω
Overcurrent detection and protection						
I_{SOVER}	Supply overcurrent protection threshold	T_J = -25 to 125 °C(1)	4.0	5.6	7.1	A
R_{OPDR}	Open drain ON resistance	I_{DIAG} = 4 mA		40	60	Ω
I_{OH}	OCD high level leakage current	V_{DIAG} = 5 V		1		µA
$t_{OCD(ON)}$	OCD turn-ON delay time(4)	I_{DIAG} = 4 mA; C_{DIAG} < 100 pF		200		ns
$t_{OCD(OFF)}$	OCD turn-OFF delay time(4)	I_{DIAG} = 4 mA; C_{DIAG} < 100 pF		100		ns

1. Tested at 25 °C in a restricted range and guaranteed by characterization.
2. See*Figure 3: Switching characteristic definition*.
3. Measured applying a voltage of 1 V to pin SENSE and a voltage drop from 2 V to 0 V to pin VREF.
4. See *Figure 4: Overcurrent detection timing definition*.

Figure 3. Switching characteristic definition

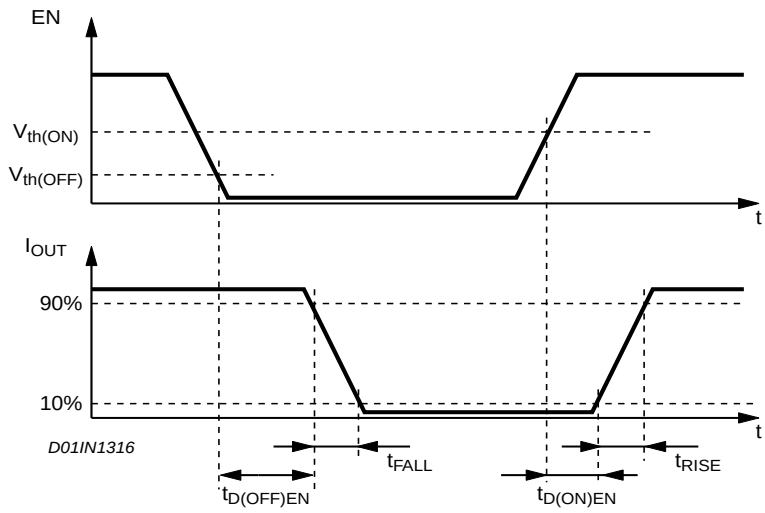
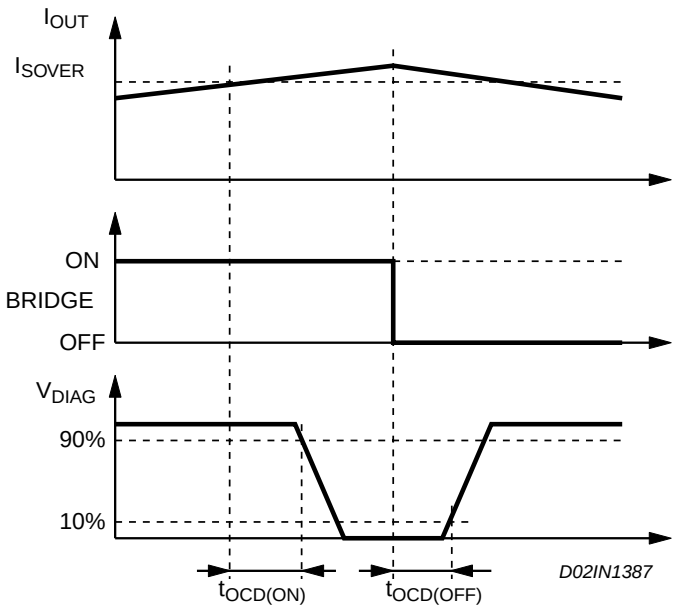


Figure 4. Overcurrent detection timing definition



8 Decoding logic

The decoding logic section is a combinatory logic that provides the appropriate driving of the 3-phase bridge outputs according to the signals coming from the three hall sensors that detect rotor position in a 3-phase BLDC motor. This novel combinatory logic discriminates between the actual sensor positions for sensors spaced at 60, 120, 240 and 300 electrical degrees. This decoding method allows the implementation of a universal IC without dedicating pins to select the sensor configuration.

There are eight possible input combinations for three sensor inputs. Six combinations are valid for rotor positions with 120 electrical degrees sensor phasing (see *Figure 14*, positions 1, 2, 3a, 4, 5 and 6a) and six combinations are valid for rotor positions with 60 electrical degrees phasing (see *Figure 15*, positions 1, 2, 3b, 4, 5 and 6b). Four of them are in common (1, 2, 4 and 5) whereas there are two combinations used only in 120 electrical degrees sensor phasing (3a and 6a) and two combinations used only in 60 electrical degrees sensor phasing (3b and 6b).

The decoder can drive motors with different sensor configuration simply by following *Table 7*. For any input configuration (H_1, H_2 and H_3) there is one output configuration (OUT_1, OUT_2 and OUT_3). The output configuration 3a is the same as 3b and analogously output configuration 6a is the same as 6b.

The sequence of the hall codes for 300 electrical degrees phasing is the reverse of 60 and the sequence of the hall codes for 240 phasing is the reverse of 120. So, by decoding the 60 and the 120 codes it is possible to drive the motor with all the four conventions by changing the direction set.

Table 7. 60 and 120 electrical degree decoding logic in forward direction

Hall 120°	**1**	**2**	**3a**	**-**	**4**	**5**	**6a**	**-**
Hall 60°	**1**	**2**	**-**	**3b**	**4**	**5**	**-**	**6b**
H_1	H	H	L	H	L	L	H	L
H_2	L	H	H	H	H	L	L	L
H_3	L	L	L	H	H	H	H	L
OUT_1	Vs	High Z	GND	GND	GND	High Z	Vs	Vs
OUT_2	High Z	Vs	Vs	Vs	High Z	GND	GND	GND
OUT_3	GND	GND	High Z	High Z	Vs	Vs	High Z	High Z
Phasing	1 -> 3	2 -> 3	2 -> 1	2 -> 1	3 -> 1	3 -> 2	1 -> 2	1 -> 2

Figure 14. 120° hall sensor sequence

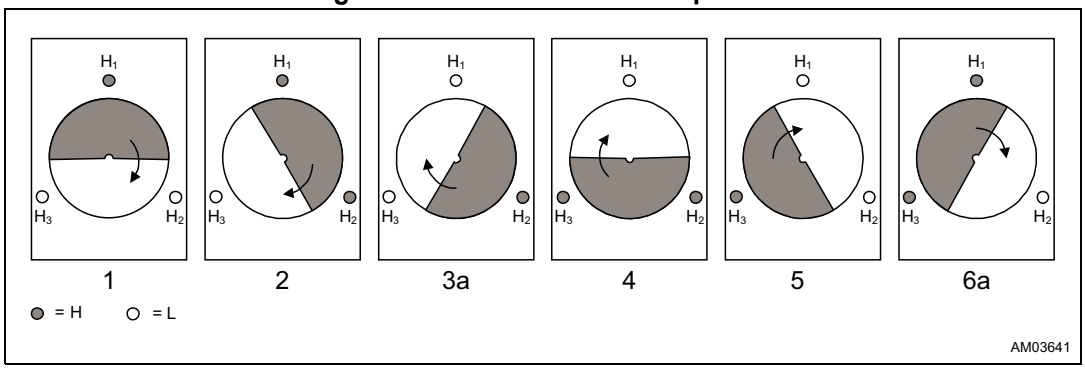


Figure 15. 60° hall sensor sequence

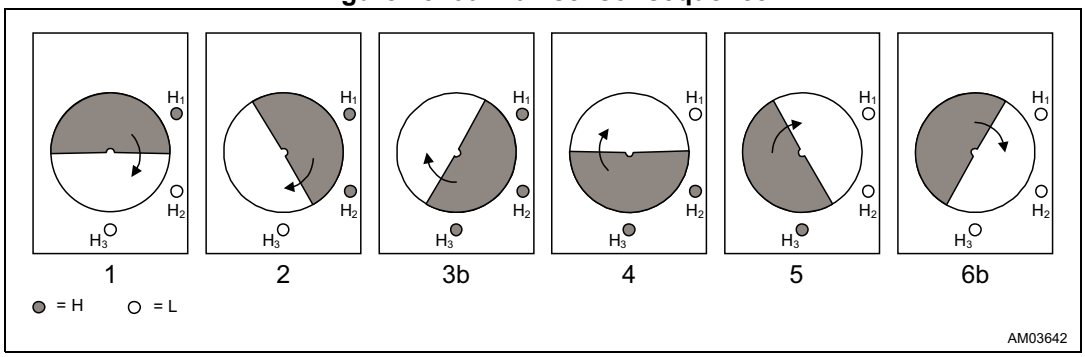


Figure 37. SO24 package outline

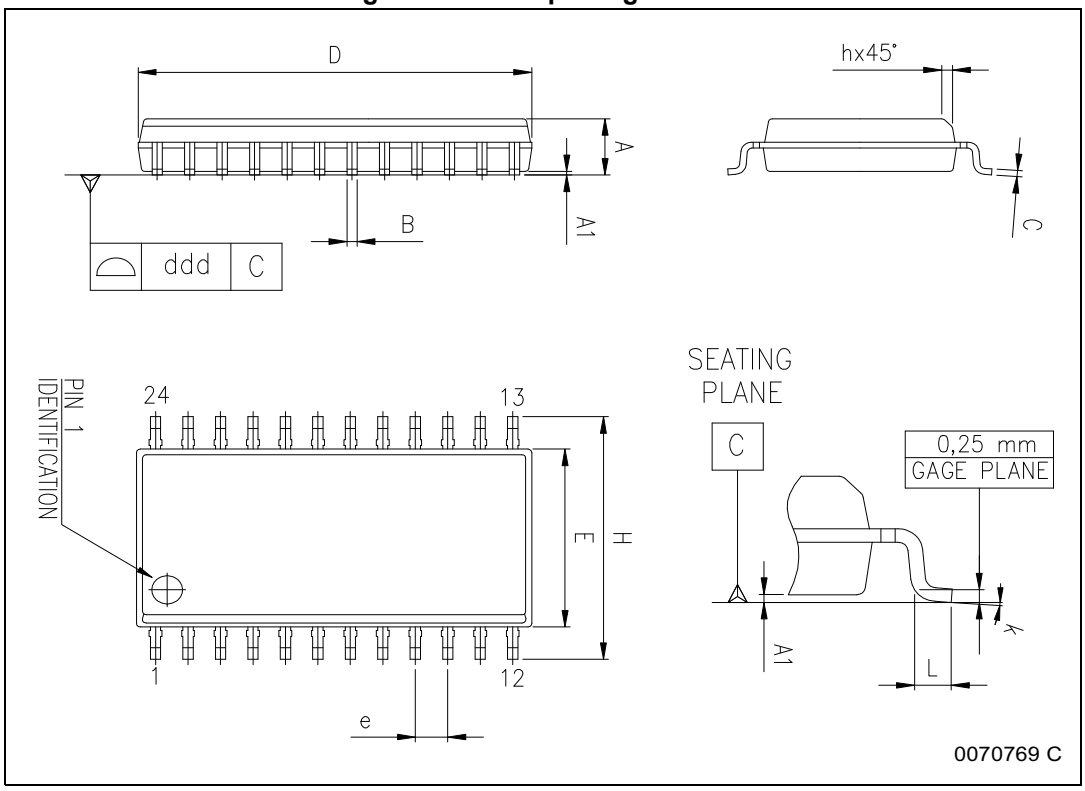
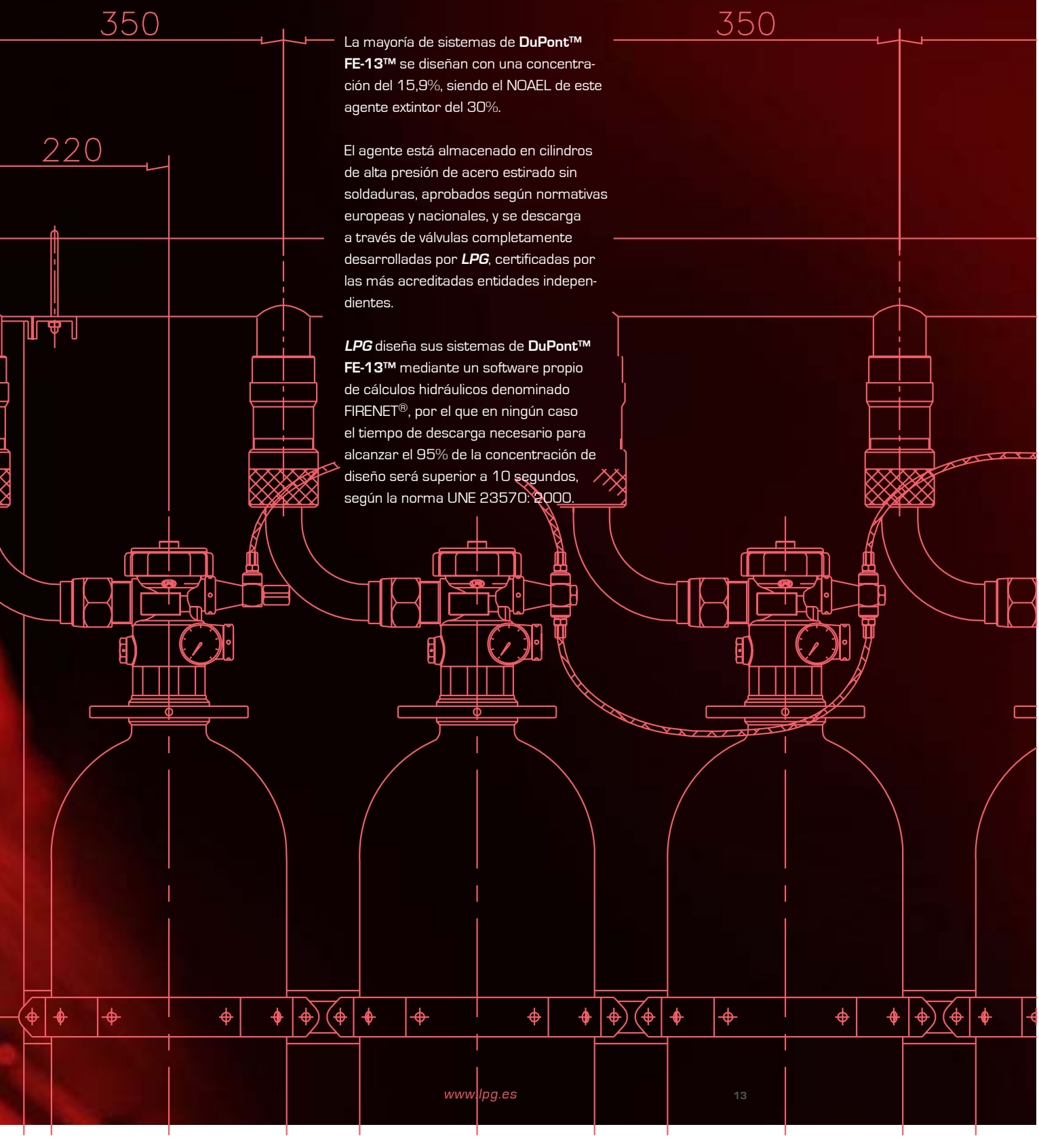


Table 11. SO24 package mechanical data

Symbol	Dimensions					
	mm			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	2.35		2.65	0.093		0.104
A1	0.10		0.30	0.004		0.012
B	0.33		0.51	0.013		0.020
C	0.23		0.32	0.009		0.013
D(1)	15.20		15.60	0.598		0.614
E	7.40		7.60	0.291		0.299
e		1.27			0.050	
H	10.0		10.65	0.394		0.419
h	0.25		0.75	0.010		0.030
L	0.40		1.27	0.016		0.050
k	0° (min.), 8° (max.)					
ddd			0.10			0.004

1. “D” dimension does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per side.

Sistemas *LPG* con **FE-13™**



La mayoría de sistemas de **DuPont™ FE-13™** se diseñan con una concentración del 15,9%, siendo el NOAEL de este agente extintor del 30%.

El agente está almacenado en cilindros de alta presión de acero estirado sin soldaduras, aprobados según normativas europeas y nacionales, y se descarga a través de válvulas completamente desarrolladas por ***LPG***, certificadas por las más acreditadas entidades independientes.

LPG diseña sus sistemas de **DuPont™ FE-13™** mediante un software propio de cálculos hidráulicos denominado FIRENET®, por el que en ningún caso el tiempo de descarga necesario para alcanzar el 95% de la concentración de diseño será superior a 10 segundos, según la norma UNE 23570: 2000.

Propiedades

DuPont™ FE-13™ es un agente extintor limpio de alta presión certificado por la UL (Underwriters Laboratories) y fabricado por DuPont. Es totalmente seguro para aplicaciones en áreas ocupadas y no deja residuos tras su aplicación, ya sea por una descarga fortuita por falsa alarma o por la existencia de un fuego.

La mayoría de sistemas de **DuPont™ FE-13™** se diseñan con una concentración del 15,9%. Como todos los agentes fluorados que sustituyen al halón 1301, el **DuPont™ FE-13™** extingue los incendios principalmente por absorción de calor.

VENTAJAS PRINCIPALES:

- *Adecuado para techos altos (hasta 7,5 m.)*
- *Adecuado para bajas temperaturas (-40º C)*
- *Descarga en 10 segundos*
- *Amplio margen de seguridad en zonas ocupadas (NOAEL 30%)*
- *No conductivo*
- *No deja residuos*

NORMATIVAS:

- *UNE-EN 15004-1*
- *NFPA 2001*
- *ISO 14520-10*
- *ISO 14520-1*

Características

Nombre químico	Trifluorometano
Fórmula química	CHF_3
Designación según ISO 14520, UNE-EN 15004-1 y NFPA 2001	HFC 23
Peso molecular	70,01
Punto de ebullición a 1,013 bar	-82,1ºC
Densidad del líquido a 20ºC	807 kg/m^3
Temperatura crítica	25,9º C
Presión crítica	48,36 bar
Presión de vapor a 20º C	41,83 bar
Resistencia eléctrica relativa a 1 atm. 25º C (N_2=1.0)	1,04
Densidad de llenado máxima	0,85 kg/l
NOAEL	30%
LOAEL	>50%
Concentración máxima. Para 5' de exposición	30%
Poder destructor del ozono	0
Potencial de efecto invernadero	11.700
Aprobaciones y reconocimientos	EPA-NFPA, UL-FM
Factor de incremento	s/cálculos hidráulicos ~ 20% +

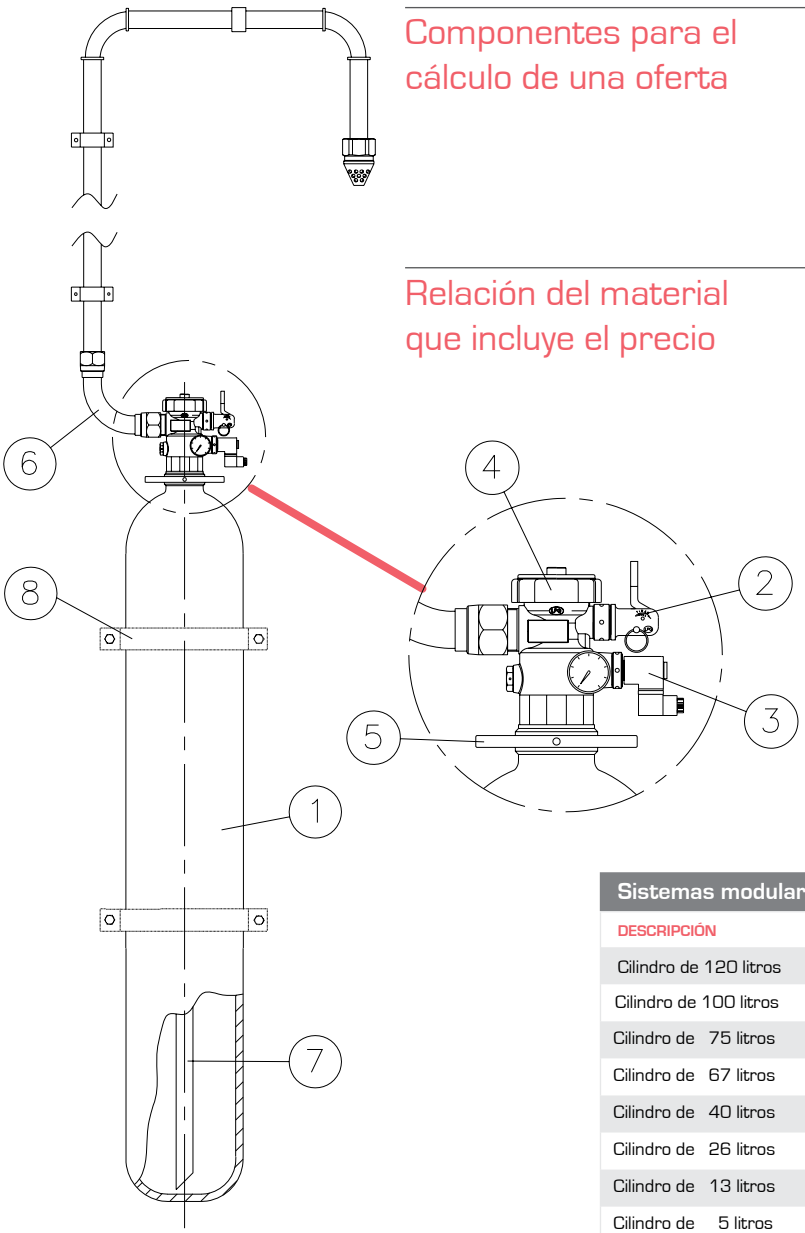
Certificados

Los sistemas y componentes de ***LPG*** para **DuPont™ FE-13™** están certificados por LPCB (Loss Prevention Certification Board) del Reino Unido **Nº: 446b/01 (sistema), 446a (componentes)**, por CNPP (Centre National de Prevention et Protection) de Francia Nº PV/MM 01 07 390, por VNIIPO de Rusia según **NPB-51-96 (gas)** y **NPB-54-96 (hardware)** y por APCI de Cuba **Nº SE 416424**. IMO protocolo MSC/ Circ. 848.

Notas a considerar

La presión máxima de trabajo en tubería es de 137 bar. (UNE-EN 15004). Se aconseja utilizar tubería según norma ASTM / ANSI B.36.10-XS o equivalente. Hasta 3/4" Sch.40, para diámetros mayores Sch.80. Hasta 2" se aconseja roscar tubería con accesorios forjados de 3000 lb. ANSI B.16.11, y a partir de 2 1/2" se aconseja soldar tubería con accesorios ANSI B.16.9 y B.16.28.

Sistemas modulares



Componentes para el cálculo de una oferta

- Cilindro
- Gas
- Complementos (ver páginas 121-125)
- Difusores (ver página 116)
- Diafragma y placa embellecedora (ver página 116)

Relación del material que incluye el precio

1	Cilindro
2	Disparo manual palanca
3	Válvula solenoide
4	Válvula LPG
5	Brida
6	Latiguillo descarga
7	Tubo sonda
8	Herraje

También incluye tapón protector y juego de etiquetas.

Sistemas modulares

DESCRIPCIÓN	CARGA MAX. kg	CÓDIGO
Cilindro de 120 litros	102	CC720FE930
Cilindro de 100 litros	85	CC795FE930
Cilindro de 75 litros	63	CC775FE930
Cilindro de 67 litros	56	CC767FE130
Cilindro de 40 litros	34	CC740FE130
Cilindro de 26 litros	22	CC726FE130
Cilindro de 13 litros	11	CC713FE130
Cilindro de 5 litros	4	CC705FE130

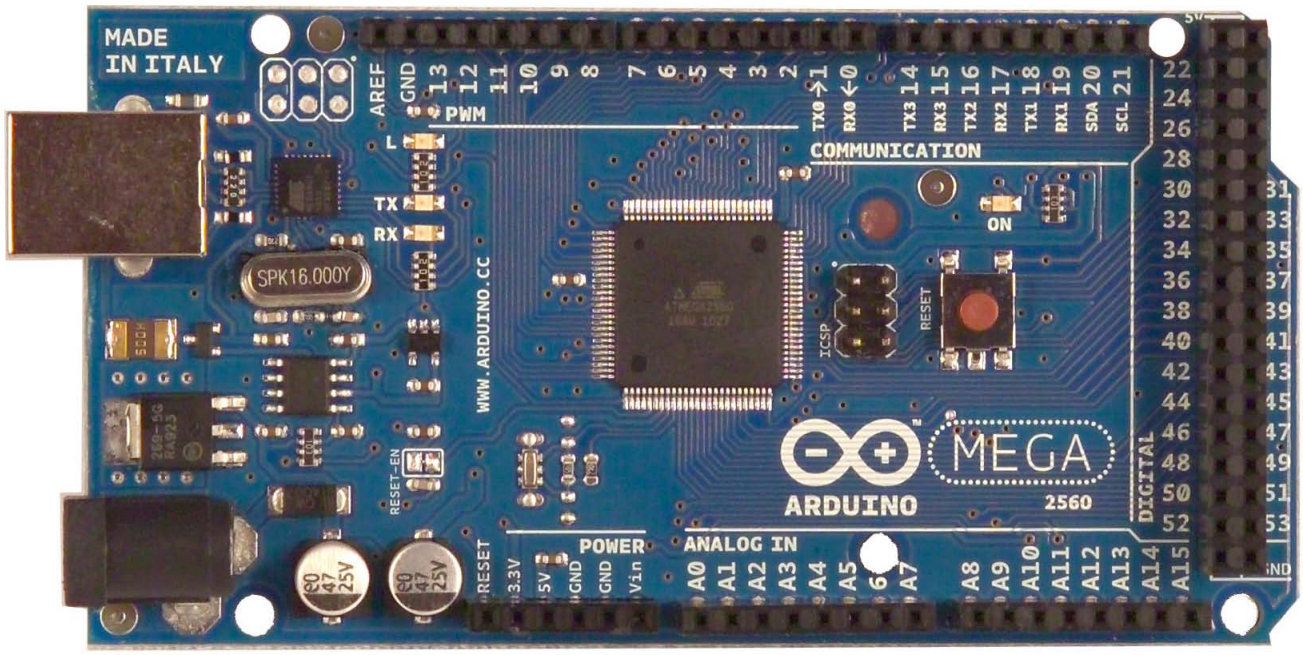
Gas

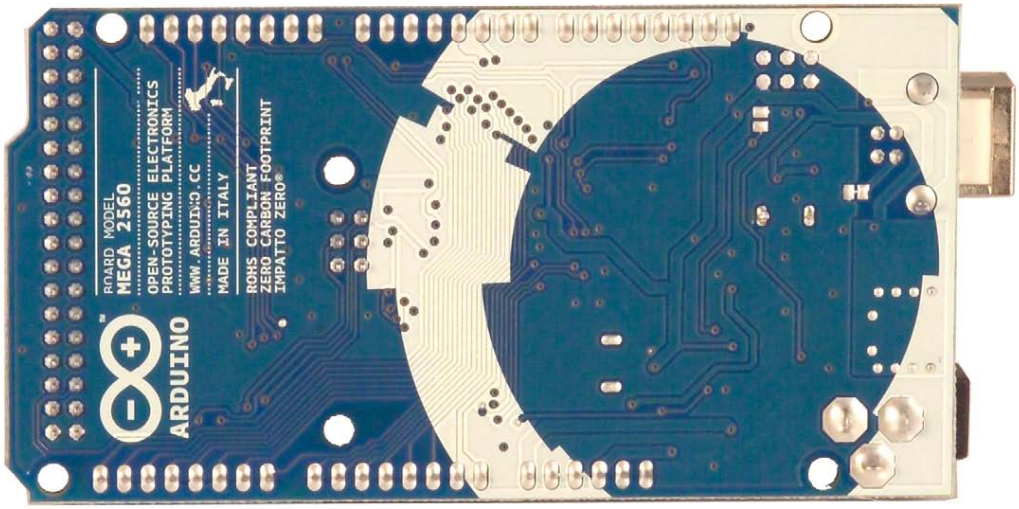
NOMBRE	CÓDIGO
Kilo de Dupont™ FE-13™	400FE130

Complementos opcionales a sistemas modulares

PARA MÁS INFORMACIÓN VER PÁGINAS 121-125
Llave de gancho articulada para montaje disparo manual

Arduino Mega 2560





Overview

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

Schematic & Reference Design

EAGLE files: arduino-mega2560-reference-design.zip

Schematic: arduino-mega2560-schematic.pdf

Summary

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

Power

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

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

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

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

- **GND.** Ground pins.

Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

- **External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2).** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

- **PWM: 0 to 13.** Provide 8-bit PWM output with the analogWrite() function.

- **SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS).** These pins support SPI communication using the SPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Uno, Duemilanove and Diecimila.

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

- **I^2C: 20 (SDA) and 21 (SCL).** Support I^2C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I^2C pins on the Duemilanove or Diecimila.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

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

Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Mega2560's digital pins.

The ATmega2560 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation on the Wiring website for details. For SPI communication, use the SPI library.

Programming

The Arduino Mega can be programmed with the Arduino software (download). For details, see the reference and tutorials.

The ATmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

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

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

Automatic (Software) Reset

Rather then requiring a physical press of the reset button before an upload, the Arduino Mega2560 is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega2560 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can

have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Mega2560 is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Mega2560. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Mega2560 contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

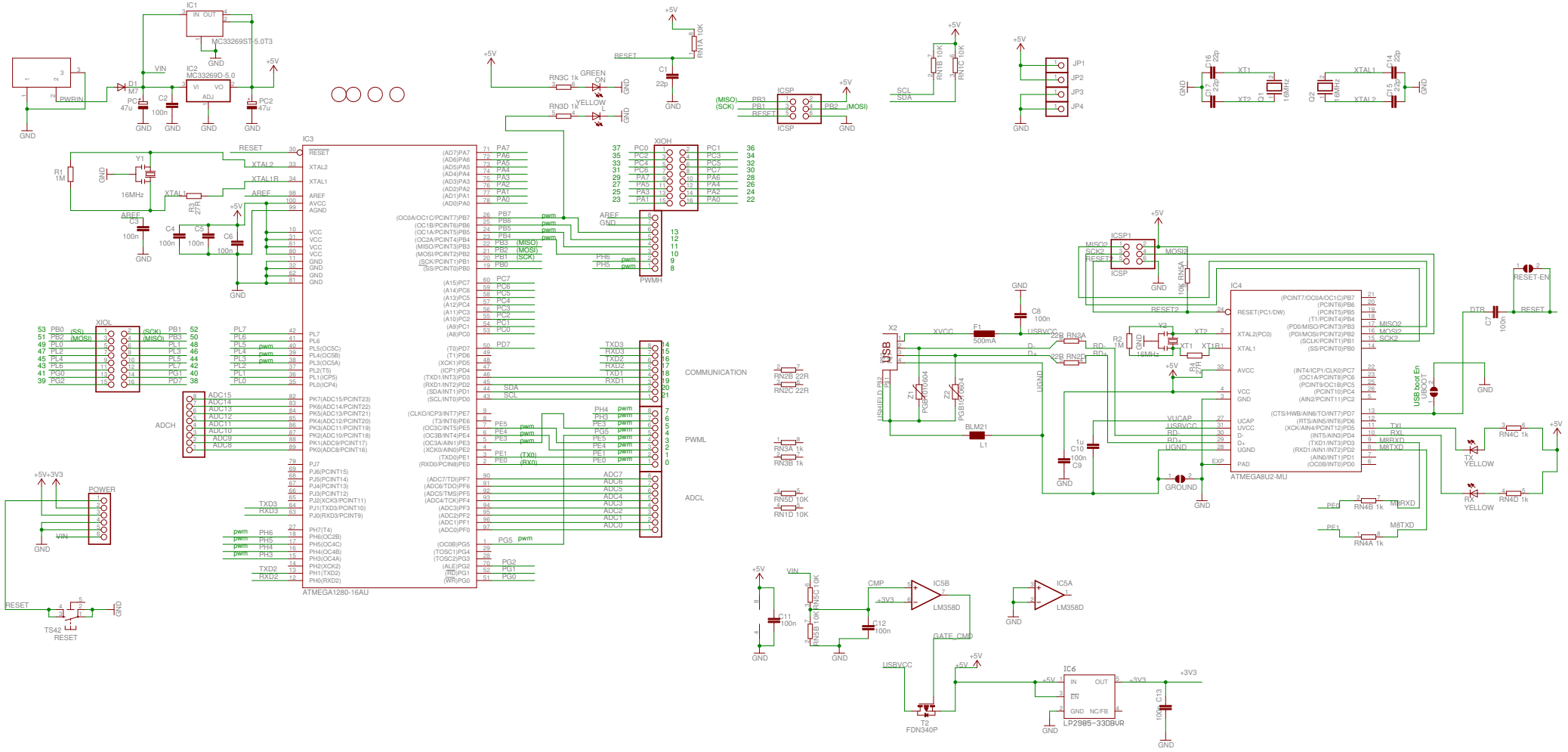
The Arduino Mega2560 has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics and Shield Compatibility

The maximum length and width of the Mega2560 PCB are 4 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

The Mega2560 is designed to be compatible with most shields designed for the Uno, Diecimila or Duemilanove. Digital pins 0 to 13 (and the adjacent AREF and GND pins), analog inputs 0 to 5, the power header, and ICSP header are all in equivalent locations. Further the main UART (serial port) is located on the same pins (0 and 1), as are external interrupts 0 and 1 (pins 2 and 3 respectively). SPI is available through the ICSP header on both the Mega2560 and Duemilanove / Diecimila. *Please note that I^2C is not located on the same pins on the Mega (20 and 21) as the Duemilanove / Diecimila (analog inputs 4 and 5).*

Arduino™ Mega 2560 Reference Design



High Voltage High Current Controller for Battery Charging and Power Management

FEATURES

- **Complete High Performance Battery Charger When Paired with a DC/DC Converter**
- **Wide Input and Output Voltage Range: 3V to 60V**
- **Input Ideal Diode for Low Loss Reverse Blocking and Load Sharing**
- **Output Ideal Diode for Low Loss PowerPath™ and Load Sharing with the Battery**
- **Instant-On Operation with Heavily Discharged Battery**
- **Programmable Input and Charge Current: ±1% Accuracy**
- **±0.25% Accurate Programmable Float Voltage**
- Programmable C/X or Timer Based Charge Termination
- NTC Input for Temperature Qualified Charging
- 28-Lead 4mm × 5mm QFN or SSOP Packages

APPLICATIONS

- High Power Battery Charger Systems
- High Performance Portable Instruments
- Industrial Battery Equipped Devices
- Notebook/Subnotebook Computers

DESCRIPTION

The LTC®4000 is a high voltage, high performance controller that converts many externally compensated DC/DC power supplies into full-featured battery chargers.

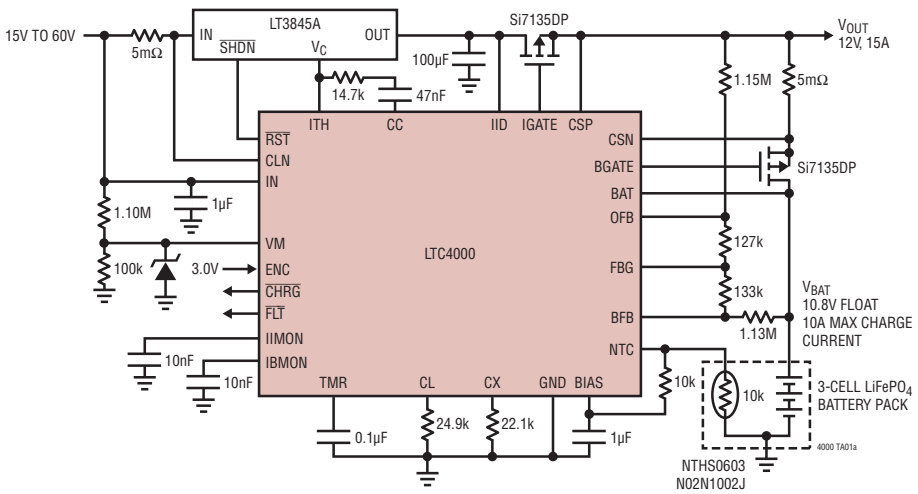
Features of the LTC4000's battery charger include: accurate (±0.25%) programmable float voltage, selectable timer or current termination, temperature qualified charging using an NTC thermistor, automatic recharge, C/10 trickle charge for deeply discharged cells, bad battery detection and status indicator outputs. The battery charger also includes precision current sensing that allows lower sense voltages for high current applications.

The LTC4000 supports intelligent PowerPath control. An external PFET provides low loss reverse current protection. Another external PFET provides low loss charging or discharging of the battery. This second PFET also facilitates an instant-on feature that provides immediate downstream system power even when connected to a heavily discharged or short faulted battery.

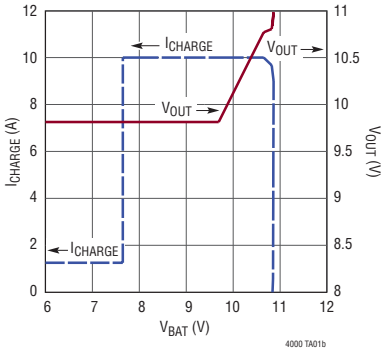
The LTC4000 is available in a low profile 28-lead 4mm × 5mm QFN and SSOP packages.

TYPICAL APPLICATION

48V to 10.8V at 10A Buck Converter Charger for Three $LiFePO_4$ Cells



Charge Current and V_{OUT} Profile vs V_{BAT} During a Charge Cycle

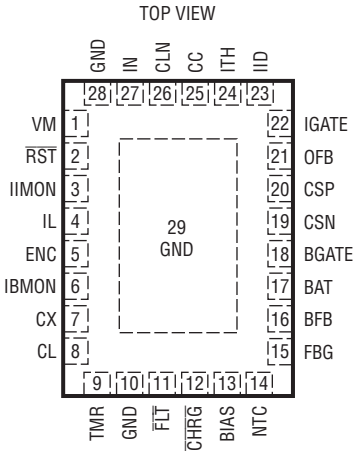


ABSOLUTE MAXIMUM RATINGS

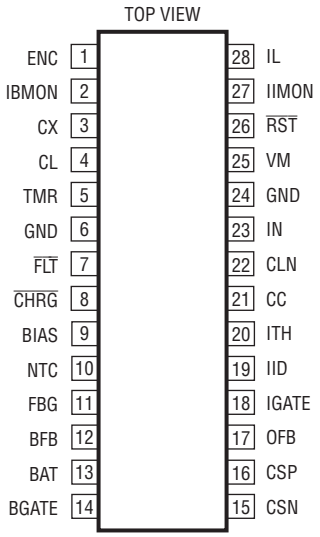
(Note 1)

IN, CLN, IID, CSP, CSN, BAT ..... –0.3V to 62V
IN-CLN, CSP-CSN ..... –1V to 1V
OFB, BFB, FBG ..... –0.3V to 62V
FBG ..... –1mA to 2mA
IGATE ..... Max (V_{IID}, V_{CSP}) – 10V to Max (V_{IID}, V_{CSP})
BGATE ..... Max (V_{BAT}, V_{CSN}) – 10V to Max (V_{BAT}, V_{CSN})
ENC, CX, NTC, VM ..... –0.3V to V_{BIAS}
IL, CL, TMR, IIMON, CC ..... –0.3V to V_{BIAS}
BIAS ..... –0.3V to Min (6V, V_{IN})
IBMON ..... –0.3V to Min (V_{BIAS}, V_{CSP})
ITH ..... –0.3V to 6V
$\overline{CHRG}$, $\overline{FLT}$, $\overline{RST}$ ..... –0.3V to 62V
$\overline{CHRG}$, $\overline{FLT}$, $\overline{RST}$ ..... –1mA to 2mA
Operating Junction Temperature Range
(Note 2) ..... 125°C
Storage Temperature Range ..... –65°C to 150°C

PIN CONFIGURATION



UFD PACKAGE
28-LEAD (4mm × 5mm) PLASTIC QFN
T_{JMAX} = 125°C, θ_{JA} = 43°C/W, θ_{JC} = 4°C/W
EXPOSED PAD (PIN 29) IS GND, MUST BE SOLDERED TO PCB



GN PACKAGE
28-LEAD PLASTIC SSOP
T_{JMAX} = 125°C, θ_{JA} = 80°C/W, θ_{JC} = 25°C/W

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LTC4000EUFD#PBF	LTC4000EUFD#TRPBF	4000	28-Lead (4mm × 5mm) Plastic QFN	–40°C to 125°C
LTC4000IUFD#PBF	LTC4000IUFD#TRPBF	4000	28-Lead (4mm × 5mm) Plastic QFN	–40°C to 125°C
LTC4000EGN#PBF	LTC4000EGN#TRPBF	LTC4000GN	28-Lead Plastic SSOP	–40°C to 125°C
LTC4000IGN#PBF	LTC4000IGN#TRPBF	LTC4000GN	28-Lead Plastic SSOP	–40°C to 125°C

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating junction temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = V_{CLN} = 3V to 60V unless otherwise noted (Notes 2, 3).

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{IN}	Input Supply Operating Range		●	3		60	V
I_{IN}	Input Quiescent Operating Current				0.4		mA
I_{BAT}	Battery Pin Operating Current	$V_{IN} \geq 3V$, $V_{CSN} = V_{CSP} \geq V_{BAT}$	●		50	100	µA
	Battery Only Quiescent Current	$V_{IN} = 0V$, $V_{CSN} = V_{CSP} \leq V_{BAT}$	●		10	20	µA
Shutdown							
	ENC Input Voltage Low		●			0.4	V
	ENC Input Voltage High		●	1.5			V
	ENC Pull-Up Current	$V_{ENC} = 0V$		–4	–2	–0.5	µA
	ENC Open Circuit Voltage	V_{ENC} = Open	●	1.5	2.5		V
Voltage Regulation							
V_{BFB_REG}	Battery Feedback Voltage		 ●	1.133 1.120	1.136 1.136	1.139 1.147	V V
	BFB Input Current	V_{BFB} = 1.2V			± 0.1		µA
V_{OFB_REG}	Output Feedback Voltage		●	1.176	1.193	1.204	V
	OFB Input Current	V_{OFB} = 1.2V			± 0.1		µA
R_{FBG}	Ground Return Feedback Resistance		●		100	400	Ω
$V_{RECHRG(RISE)}$	Rising Recharge Battery Threshold Voltage	% of V_{BFB_REG}	●	96.9	97.6	98.3	%
$V_{RECHRG(HYS)}$	Recharge Battery Threshold Voltage Hysteresis	% of V_{BFB_REG}			0.5		%
$V_{OUT(INST\_ON)}$	Instant-On Battery Voltage Threshold	% of V_{BFB_REG}	●	82	86	90	%
V_{LOBAT}	Falling Low Battery Threshold Voltage	% of V_{BFB_REG}	●	65	68	71	%
$V_{LOBAT(HYS)}$	Low Battery Threshold Voltage Hysteresis	% of V_{BFB_REG}			3		%
Current Regulation							
	Ratio of Monitored-Current Voltage to Sense Voltage	$V_{IN,CLN} \leq 50mV$, $V_{IIMON}/V_{IN,CLN}$ $V_{CSP,CSN} \leq 50mV$, $V_{IBMON}/V_{CSP,CSN}$	●	18.5	20	21	V/V
V_{OS}	Sense Voltage Offset	$V_{CSP,CSN} \leq 50mV$, V_{CSP} = 60V or $V_{IN,CLN} \leq 50mV$, V_{IN} = 60V (Note 4)		–300		300	µV
	CLN, CSP, CSN Common Mode Range	(Note 4)	●	3		60	V
	CLN Pin Current				±1		µA
	CSP Pin Current	V_{IGATE} = Open, $V_{IID} = 0V$			90		µA
	CSN Pin Current	V_{BGATE} = Open, $V_{BAT} = 0V$			45		µA
I_{IL}	Pull-Up Current for the Input Current Limit Programming Pin		●	–55	–50	–45	µA
I_{CL}	Pull-Up Current for the Charge Current Limit Programming Pin		●	–55	–50	–45	µA
I_{CL_TRKL}	Pull-Up Current for the Charge Current Limit Programming Pin in Trickle Charge Mode	$V_{BFB} < V_{LOBAT}$	●	–5.5	–5.0	–4.5	µA
	Input Current Monitor Resistance to GND			40	90	140	kΩ
	Charge Current Monitor Resistance to GND			40	90	140	kΩ
	A4, A5 Error Amp Offset for the Current Loops (See Figure 1)	V_{CL} = 0.8V, V_{IL} = 0.8V	●	–10	0	10	mV
	Maximum Programmable Current Limit Voltage Range		●	0.985	1.0	1.015	V

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating junction temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = V_{CLN} = 3V to 60V unless otherwise noted (Notes 2, 3).

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Charge Termination							
	CX Pin Pull-Up Current	V_{CX} = 0.1V	●	–5.5	–5.0	–4.5	µA
$V_{CX,IBMON(OS)}$	CX Comparator Offset Voltage, IBMON Falling	V_{CX} = 0.1V	●	0.5	10	25	mV
$V_{CX,IBMON(HYS)}$	CX Comparator Hysteresis Voltage				5		mV
	TMR Pull-Up Current	V_{TMR} = 0V			–5.0		µA
	TMR Pull-Down Current	V_{TMR} = 2V			5.0		µA
	TMR Pin Frequency	C_{TMR} = 0.01µF		400	500	600	Hz
	TMR Threshold for CX Termination		●		2.1	2.5	V
t_T	Charge Termination Time	C_{TMR} = 0.1µF	●	2.3	2.9	3.5	h
t_T/t_{BB}	Ratio of Charge Terminate Time to Bad Battery Indicator Time	C_{TMR} = 0.1µF	●	3.95	4	4.05	h/h
$V_{NTC(COLD)}$	NTC Cold Threshold	V_{NTC} Rising, % of V_{BIAS}	●	73	75	77	%
$V_{NTC(HOT)}$	NTC Hot Threshold	V_{NTC} Falling, % of V_{BIAS}	●	33	35	37	%
$V_{NTC(HYS)}$	NTC Thresholds Hysteresis	% of V_{BIAS}			5		%
$V_{NTC(OPEN)}$	NTC Open Circuit Voltage	% of V_{BIAS}	●	45	50	55	%
$R_{NTC(OPEN)}$	NTC Open Circuit Input Resistance				300		kΩ
Voltage Monitoring and Open Drain Status Pins							
$V_{VM(TH)}$	VM Input Falling Threshold		●	1.176	1.193	1.204	V
$V_{VM(HYS)}$	VM Input Hysteresis				40		mV
	VM Input Current	V_{VM} = 1.2V			±0.1		µA
$I_{\overline{RST},\overline{CHRG},\overline{FLT}(LKG)}$	Open Drain Status Pins Leakage Current	V_{PIN} = 60V			±1		µA
$V_{\overline{RST},\overline{CHRG},\overline{FLT}(VOL)}$	Open Drain Status Pins Voltage Output Low	I_{PIN} = 1mA	●			0.4	V
Input PowerPath Control							
	Input PowerPath Forward Regulation Voltage	$V_{IID,CSP}$, 3V ≤ V_{CSP} ≤ 60V	●	0.1	8	20	mV
	Input PowerPath Fast Reverse Turn-Off Threshold Voltage	$V_{IID,CSP}$, 3V ≤ V_{CSP} ≤ 60V, V_{IGATE} = V_{CSP} – 2.5V, $\Delta I_{IGATE}/\Delta V_{IID,CSP}$ ≥ 100µA/mV	●	–90	–50	–20	mV
	Input PowerPath Fast Forward Turn-On Threshold Voltage	$V_{IID,CSP}$, 3V ≤ V_{CSP} ≤ 60V, V_{IGATE} = V_{IID} – 1.5V, $\Delta I_{IGATE}/\Delta V_{IID,CSP}$ ≥ 100µA/mV	●	40	80	130	mV
	Input Gate Turn-Off Current	V_{IID} = V_{CSP}, V_{IGATE} = V_{CSP} – 1.5V			–0.3		µA
	Input Gate Turn-On Current	V_{CSP} = V_{IID} – 20mV, V_{IGATE} = V_{IID} – 1.5V			0.3		µA
$I_{IGATE(FASTOFF)}$	Input Gate Fast Turn-Off Current	V_{CSP} = V_{IID} + 0.1V, V_{IGATE} = V_{CSP} – 3V			–0.5		mA
$I_{IGATE(FASTON)}$	Input Gate Fast Turn-On Current	V_{CSP} = V_{IID} – 0.2V, V_{IGATE} = V_{IID} – 1.5V			0.7		mA
$V_{IGATE(ON)}$	Input Gate Clamp Voltage	I_{IGATE} = 2µA, V_{IID} = 12V to 60V, V_{CSP} = V_{IID} – 0.5V, Measure V_{IID} – V_{IGATE}	●		13	15	V
	Input Gate Off Voltage	I_{IGATE} = – 2µA, V_{IID} = 3V to 59.9V, V_{CSP} = V_{IID} + 0.5V, Measure V_{CSP} – V_{IGATE}	●		0.45	0.7	V

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating junction temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = V_{CLN} = 3V to 60V unless otherwise noted (Notes 2, 3).

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Battery PowerPath Control							
	Battery Discharge PowerPath Forward Regulation Voltage	$V_{BAT,CSN}$, 2.8V ≤ V_{BAT} ≤ 60V	●	0.1	8	20	mV
	Battery PowerPath Fast Reverse Turn-Off Threshold Voltage	$V_{BAT,CSN}$, 2.8V ≤ V_{BAT} ≤ 60V, Not Charging, V_{BGATE} = V_{CSN} – 2.5V, $\Delta I_{BGATE}/\Delta V_{BAT,CSN}$ ≥ 100µA/mV	●	–90	–50	–20	mV
	Battery PowerPath Fast Forward Turn-On Threshold Voltage	$V_{BAT,CSN}$, 2.8V ≤ V_{CSN} ≤ 60V, V_{BGATE} = V_{BAT} – 1.5V, $\Delta I_{BGATE}/\Delta V_{BAT,CSN}$ ≥ 100µA/mV	●	40	80	130	mV
	Battery Gate Turn-Off Current	V_{BGATE} = V_{CSN} – 1.5V, V_{CSN} ≥ V_{BAT}, V_{OFB} < $V_{OUT(INST\_ON)}$ and Charging in Progress, or V_{CSN} = V_{BAT} and Not Charging			–0.3		µA
	Battery Gate Turn-On Current	V_{BGATE} = V_{BAT} – 1.5V, V_{CSN} ≥ V_{BAT}, V_{OFB} > $V_{OUT(INST\_ON)}$ and Charging in Progress, or V_{CSN} = V_{BAT} – 20mV			0.3		µA
$I_{BGATE(FASTOFF)}$	Battery Gate Fast Turn-Off Current	V_{CSN} = V_{BAT} + 0.1V and Not Charging, V_{BGATE} = V_{CSN} – 3V			–0.5		mA
$I_{BGATE(FASTON)}$	Battery Gate Fast Turn-On Current	V_{CSN} = V_{BAT} – 0.2V, V_{BGATE} = V_{BAT} – 1.5V			0.7		mA
$V_{BGATE(ON)}$	Battery Gate Clamp Voltage	I_{BGATE} = 2µA, V_{BAT} = 12V to 60V, V_{CSN} = V_{BAT} – 0.5V, Measure V_{BAT} – V_{BGATE}	●		13	15	V
	Battery Gate Off Voltage	I_{BGATE} = – 2µA, V_{BAT} = 2.8V to 60V, V_{CSN} = V_{BAT} + 0.5V and not Charging, Measure V_{CSN} – V_{BGATE}	●		0.45	0.7	V
BIAS Regulator Output and Control Pins							
V_{BIAS}	BIAS Output Voltage	No Load	●	2.4	2.9	3.5	V
ΔV_{BIAS}	BIAS Output Voltage Load Regulation	I_{BIAS} = – 0.5mA			–0.5	–10	%
	BIAS Output Short-Circuit Current	V_{BIAS} = 0V			–12		mA
	Transconductance of Error Amp	CC = 1V			0.5		mA/V
	Open Loop DC Voltage Gain of Error Amp	CC = Open			80		dB
$I_{ITH(PULL\_UP)}$	Pull-Up Current on the ITH Pin	V_{ITH} = 0V, CC = 0V		–6	–5	–4	µA
$I_{ITH(PULL\_DOWN)}$	Pull-Down Current on the ITH Pin	V_{ITH} = 0.4V, CC = Open	●	0.5	1		mA
	Open Loop DC Voltage Gain of ITH Driver	ITH = Open			60		dB

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The LTC4000 is tested under conditions such that $T_J \approx T_A$. The LTC4000E is guaranteed to meet specifications from 0°C to 85°C junction temperature. Specifications over the –40°C to 125°C operating junction temperature range are assured by design, characterization and correlation with statistical process controls. The LTC4000I is guaranteed over the full –40°C to 125°C operating junction temperature range. Note that the maximum ambient temperature consistent with these specifications is determined by specific operating conditions in conjunction with board layout, the rated package thermal impedance and other environmental factors. The junction temperature (T_J, in °C) is calculated from the ambient temperature (T_A, in °C) and power dissipation (P_D, in Watts) according to the following formula:

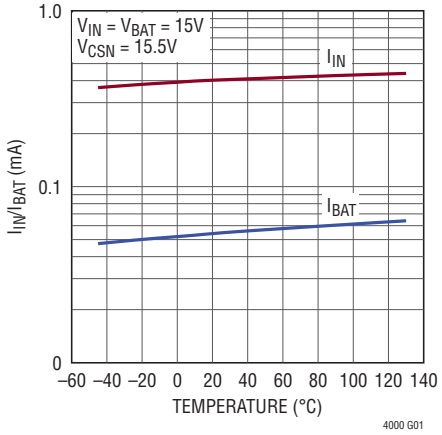
$T_J = T_A + (P_D \bullet \theta_{JA})$, where θ_{JA} (in °C/W) is the package thermal impedance.

Note 3: All currents into pins are positive; all voltages are referenced to GND unless otherwise noted.

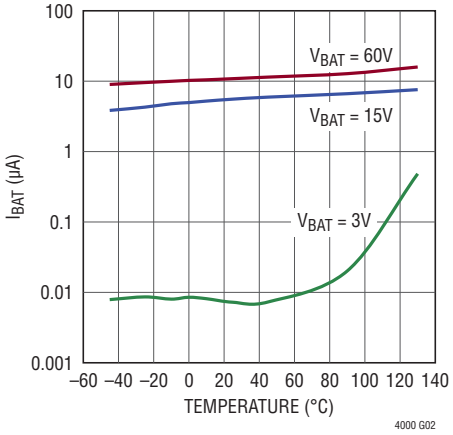
Note 4: These parameters are guaranteed by design and are not 100% tested.

TYPICAL PERFORMANCE CHARACTERISTICS

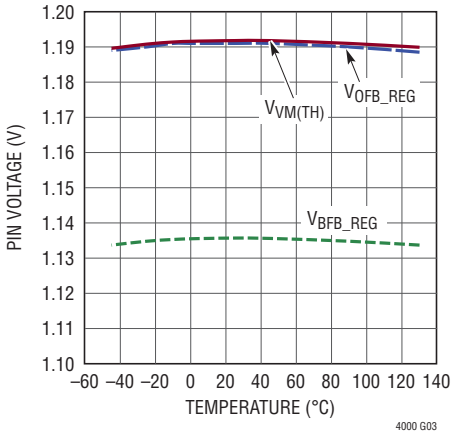
Input Quiescent Current and Battery Quiescent Current Over Temperature



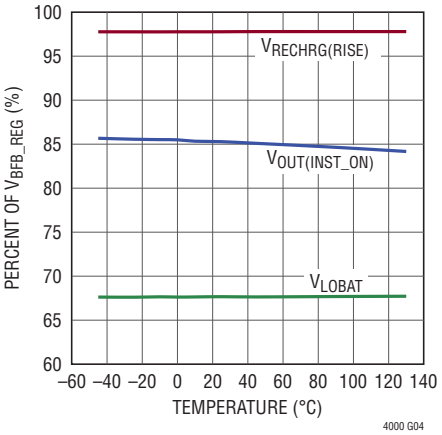
Battery Only Quiescent Current Over Temperature



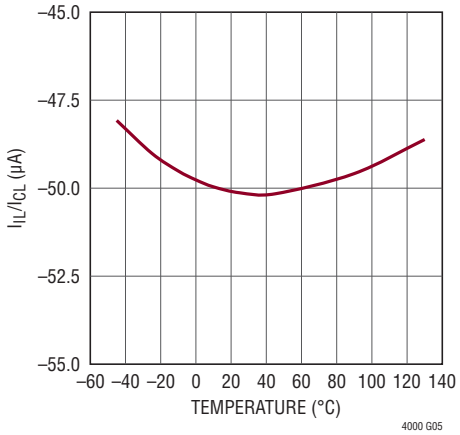
Battery Float Voltage Feedback, Output Voltage Regulation Feedback and VM Falling Threshold Over Temperature



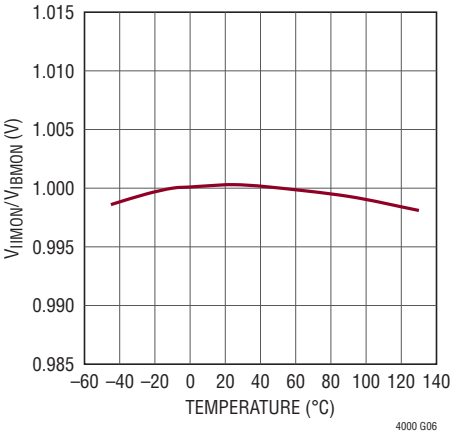
Battery Thresholds: Rising Recharge, Instant-On Regulation and Falling Low Battery As a Percentage of Battery Float Feedback Over Temperature



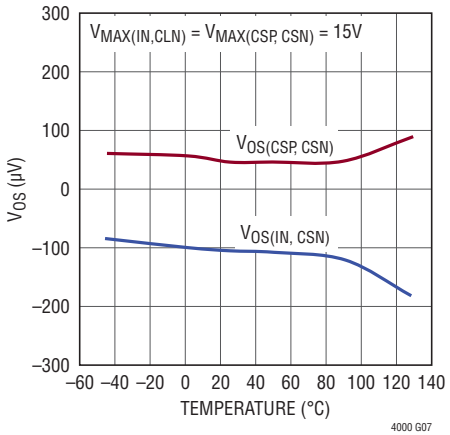
IL and CL Pull-Up Current Over Temperature



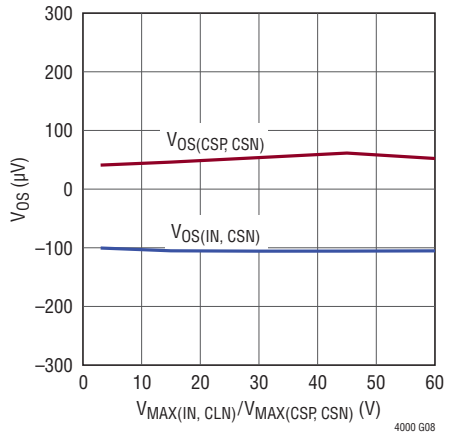
Maximum Programmable Current Limit Voltage Over Temperature



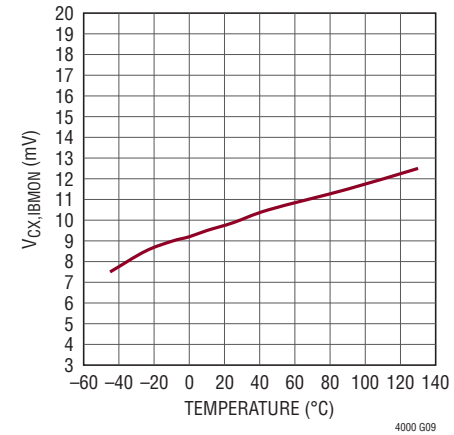
Current Sense Offset Voltage Over Temperature



Current Sense Offset Voltage Over Common Mode Voltage Range

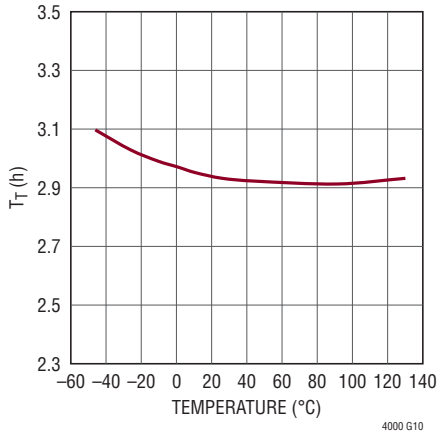


CX Comparator Offset Voltage with V_{IBMON} Falling Over Temperature

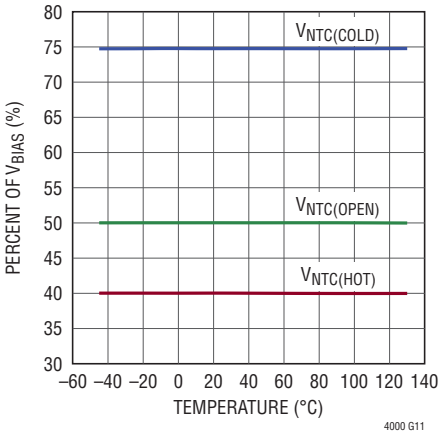


TYPICAL PERFORMANCE CHARACTERISTICS

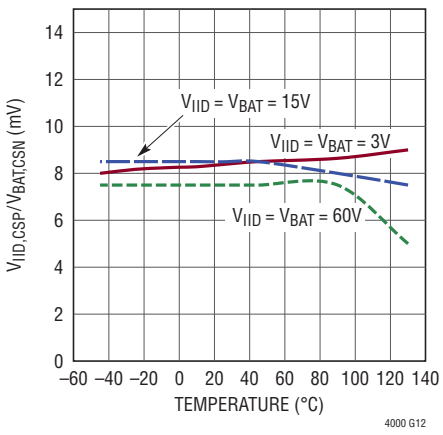
Charge Termination Time with 0.1µF Timer Capacitor Over Temperature



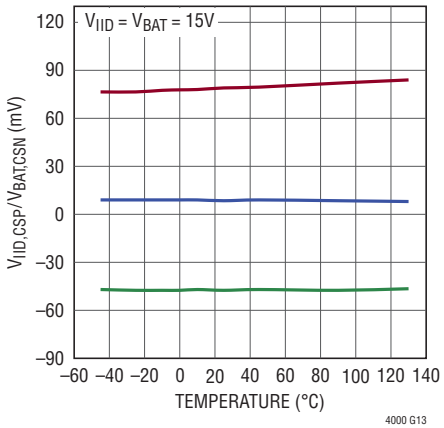
NTC Thresholds Over Temperature



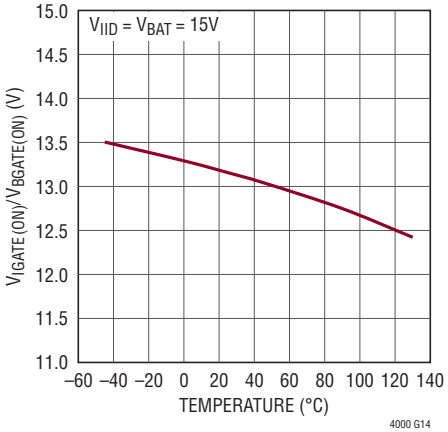
PowerPath Forward Voltage Regulation Over Temperature



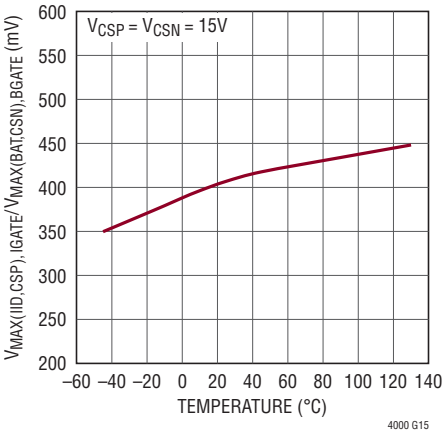
PowerPath Fast Off, Fast On and Forward Regulation Over Temperature



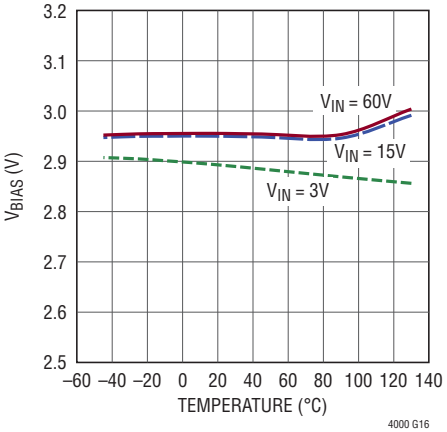
PowerPath Turn-On Gate Clamp Voltage Over Temperature



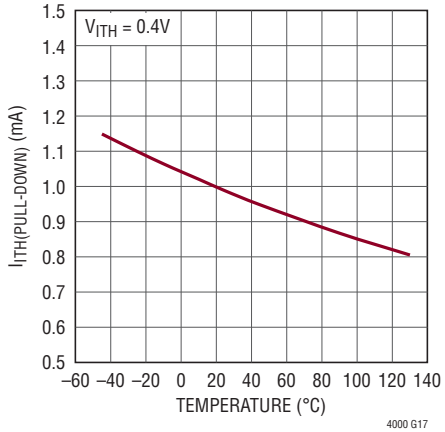
PowerPath Turn-Off Gate Voltage Over Temperature



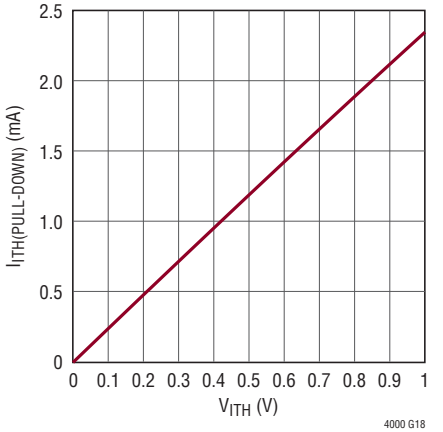
BIAS Voltage at 0.5mA Load Over Temperature



I_{TH} Pull-Down Current Over Temperature



I_{TH} Pull-Down Current vs V_{ITH}



PIN FUNCTIONS (QFN/SSOP)

VM (Pin 1/Pin 25): Voltage Monitor Input. High impedance input to an accurate comparator with a 1.193V threshold (typical). This pin controls the state of the $\overline{RST}$ output pin. Connect a resistor divider (R_{VM1}, R_{VM2}) between the monitored voltage and GND, with the center tap point connected to this pin. The falling threshold of the monitored voltage is calculated as follows:

$$V_{VM\_RST} = \frac{R_{VM1} + R_{VM2}}{R_{VM2}} \bullet 1.193V$$

where R_{VM2} is the bottom resistor between the VM pin and GND. Tie to the BIAS pin if voltage monitoring function is not used.

$\overline{RST}$ (Pin 2/Pin 26): High Voltage Open Drain Reset Output. When the voltage at the VM pin is below 1.193V, this status pin is pulled low. When driven low, this pin can disable a DC/DC converter when connected to the converter's enable pin. This pin can also drive an LED to provide a visual status indicator of a monitored voltage. Short this pin to GND when not used.

IIMON (Pin 3/Pin 27): Input Current Monitor. The voltage on this pin is 20 times (typical) the sense voltage ($V_{IN,CLN}$) across the input current sense resistor(R_{IS}), therefore providing a voltage proportional to the input current. Connect an appropriate capacitor to this pin to obtain a voltage representation of the time-average input current. Short this pin to GND to disable input current limit feature.

IL (Pin 4/Pin 28): Input Current Limit Programming. Connect the input current programming resistor (R_{IL}) to this pin. This pin sources 50µA of current. The regulation loop compares the voltage on this pin with the input current monitor voltage (V_{IIMON}), and drives the ITH pin accordingly to ensure that the programmed input current limit is not exceeded. The input current limit is determined using the following formula:

$$I_{ILIM} = 2.5\mu A \bullet \left(\frac{R_{IL}}{R_{IS}}\right)$$

where R_{IS} is the sense resistor connected to the IN and the CLN pins. Leave the pin open for the maximum input current limit of $50mV/R_{IS}$.

ENC (Pin 5/Pin 1): Enable Charging Pin. High impedance digital input pin. Pull this pin above 1.5V to enable charging and below 0.5V to disable charging. Leaving this pin open causes the internal 2µA pull-up current to pull the pin to 2.5V (typical).

IBMON (Pin 6/Pin 2): Battery Charge Current Monitor. The voltage on this pin is 20 times (typical) the sense voltage ($V_{CSP,CSN}$) across the battery current sense resistor (R_{CS}), therefore providing a voltage proportional to the battery charge current. Connect an appropriate capacitor to this pin to obtain a voltage representation of the time-average battery charge current. Short this pin to GND to disable charge current limit feature.

CX (Pin 7/Pin 3): Charge Current Termination Programming. Connect the charge current termination programming resistor (R_{CX}) to this pin. This pin is a high impedance input to a comparator and sources 5µA of current. When the voltage on this pin is greater than the charge current monitor voltage (V_{IBMON}), the $\overline{CHRG}$ pin turns high impedance indicating that the CX threshold is reached. When this occurs, the charge current is immediately terminated if the TMR pin is shorted to the BIAS pin, otherwise charging continues until the charge termination timer expires. The charge current termination value is determined using the following formula:

$$I_{C/X} = \frac{\left(0.25\mu A \bullet R_{CX}\right) - 0.5mV}{R_{CS}}$$

Where R_{CS} is the sense resistor connected to the CSP and the CSN pins. Note that if $R_{CX} = R_{CL} \leq 19.1k\Omega$, where R_{CL} is the charge current programming resistor, then the charge current termination value is one tenth the full charge current, more familiarly known as C/10. Short this pin to GND to disable CX termination.

CL (Pin 8/Pin 4): Charge Current Limit Programming. Connect the charge current programming resistor (R_{CL}) to this pin. This pin sources 50µA of current. The regulation loop compares the voltage on this pin with the charge current monitor voltage (V_{IBMON}), and drives the ITH pin accordingly to ensure that the programmed charge current limit

PIN FUNCTIONS (QFN/SSOP)

is not exceeded. The charge current limit is determined using the following formula:

$$I_{CLIM} = 2.5\mu A \bullet \left(\frac{R_{CL}}{R_{CS}}\right)$$

Where R_{CS} is the sense resistor connected to the CSP and the CSN pins. Leave the pin open for the maximum charge current limit of $50mV/R_{CS}$.

TMR (Pin 9/Pin 5): Charge Timer. Attach 1nF of external capacitance (C_{TMR}) to GND for each 104 seconds of charge termination time and 26 seconds of bad battery indicator time. Short to GND to prevent bad battery indicator time and charge termination time from expiring – allowing a continuous trickle charge and top off float voltage regulation charge. Short to BIAS to disable bad battery detect and enable C/X charging termination.

GND (Pins 10, 28, 29/Pins 6, 24): Device Ground Pins. Connect the ground pins to a suitable PCB copper ground plane for proper electrical operation. The QFN package exposed pad must be soldered to PCB ground for rated thermal performance.

$\overline{FLT}$, $\overline{CHRG}$ (Pin 11, Pin 12/Pin 7, Pin 8): Charge Status Indicator Pins. These pins are high voltage open drain pull down pins. The $\overline{FLT}$ pin pulls down when there is an under or over temperature condition during charging or when the voltage on the BFB pin stays below the low battery threshold during charging for a period longer than the bad battery indicator time. The $\overline{CHRG}$ pin pulls down during a charging cycle. Please refer to the application information section for details on specific modes indicated by the combination of the states of these two pins. Pull up each of these pins with an LED in series with a resistor to a voltage source to provide a visual status indicator. Short these pins to GND when not used.

BIAS (Pin 13/Pin 9): 2.9V Regulator Output. Connect a capacitor of at least 470nF to bypass this 2.9V regulated voltage output. Use this pin to bias the resistor divider to set up the voltage at the NTC pin.

NTC (Pin 14/Pin 10): Thermistor Input. Connect a thermistor from NTC to GND, and a corresponding resistor from BIAS to NTC. The voltage level on this pin determines if the battery temperature is safe for charging. The charge current and charge timer are suspended if the thermistor indicates a temperature that is unsafe for charging. Once the temperature returns to the safe region, charging resumes. Leave the pin open or connected to a capacitor to disable the temperature qualified charging function.

FBG (Pin 15/Pin 11): Feedback Ground Pin. This is the ground return pin for the resistor dividers connected to the BFB and OFB pins. As soon as the voltage at IN is valid (>3V typical), this pin has a 100Ω resistance to GND. When the voltage at IN is not valid, this pin is disconnected from GND to ensure that the resistor dividers connected to the BFB and OFB pins do not continue to drain the battery when the battery is the only available power source.

BFB (Pin 16/Pin 12): Battery Feedback Voltage Pin. This pin is a high impedance input pin used to sense the battery voltage level. In regulation, the battery float voltage loop sets the voltage on this pin to 1.136V (typical). Connect this pin to the center node of a resistor divider between the BAT pin and the FBG pin to set the battery float voltage. The battery float voltage can then be obtained as follows:

$$V_{FLOAT} = \frac{R_{BFB2} + R_{BFB1}}{R_{BFB2}} \bullet 1.136V$$

BAT (Pin 17/Pin 13): Battery Pack Connection. Connect the battery to this pin. This pin is the anode of the battery ideal diode driver (the cathode is the CSN pin).

BGATE (Pin 18/Pin 14): External Battery PMOS Gate Drive Output. When not charging, the BGATE pin drives the external PMOS to behave as an ideal diode from the BAT pin (anode) to the CSN pin (cathode). This allows efficient delivery of any required additional power from the battery to the downstream system connected to the CSN pin.

When charging a heavily discharged battery, the BGATE pin is regulated to set the output feedback voltage (OFB pin) to 86% of the battery float voltage (0.974V typical). This allows the instant-on feature, providing an immediate valid voltage level at the output when the LTC4000 is charging a heavily discharged battery. Once the voltage on the OFB pin is above the 0.974V typical value, then the BGATE pin is driven low to ensure an efficient charging path from the CSN pin to the BAT pin.

PIN FUNCTIONS (QFN/SSOP)

CSN (Pin 19/Pin 15): Charge Current Sense Negative Input and Battery Ideal Diode Cathode. Connect a sense resistor between this pin and the CSP pin. The LTC4000 senses the voltage across this sense resistor and regulates it to a voltage equal to 1/20th (typical) of the voltage set at the CL pin. The maximum regulated sense voltage is 50mV. The CSN pin is also the cathode input of the battery ideal diode driver (the anode input is the BAT pin). Tie this pin to the CSP pin if no charge current limit is desired. Refer to the Applications Information section for complete details.

CSP (Pin 20/Pin 16): Charge Current Sense Positive Input and Input Ideal Diode Cathode. Connect a sense resistor between this pin and the CSN pin for charge current sensing and regulation. This input should be tied to CSN to disable the charge current regulation function. This pin is also the cathode of the input ideal diode driver (the anode is the IID pin).

OFB (Pin 21/Pin 17): Output Feedback Voltage Pin. This pin is a high impedance input pin used to sense the output voltage level. In regulation, the output voltage loop sets the voltage on this feedback pin to 1.193V. Connect this pin to the center node of a resistor divider between the CSP pin and the FBG pin to set the output voltage when battery charging is terminated and all the output load current is provided from the input. The output voltage can then be obtained as follows:

$$V_{OUT} = \frac{R_{OFB2} + R_{OFB1}}{R_{OFB2}} \bullet 1.193V$$

When charging a heavily discharged battery (such that $V_{OFB} < V_{OUT(INST\_ON)}$), the battery PowerPath PMOS connected to BGATE is regulated to set the voltage on this feedback pin to 0.974V (approximately 86% of the battery float voltage). The instant-on output voltage is then as follows:

$$V_{OUT(INST\_ON)} = \frac{R_{OFB2} + R_{OFB1}}{R_{OFB2}} \bullet 0.974V$$

IGATE (Pin 22/Pin 18): Input PMOS Gate Drive Output. The IGATE pin drives the external PMOS to behave as an ideal diode from the IID pin (anode) to the CSP pin (cathode) when the voltage at the IN pin is within its operating range (3V to 60V). To ensure that the input PMOS is turned off when the IN pin voltage is not within its operating range, connect a 10M resistor from this pin to the CSP pin.

IID (Pin 23/Pin 19): Input Ideal Diode Anode. This pin is the anode of the input ideal diode driver (the cathode is the CSP pin).

ITH (Pin 24/Pin 20): High Impedance Control Voltage Pin. When any of the regulation loops (input current, charge current, battery float voltage or the output voltage) indicate that its limit is reached, the ITH pin will sink current (up to 1mA) to regulate that particular loop at the limit. In many applications, this ITH pin is connected to the control/compensation node of a DC/DC converter. Without any external pull-up, the operating voltage range on this pin is GND to 2.5V. With an external pull-up, the voltage on this pin can be pulled up to 6V. Note that the impedance connected to this pin affects the overall loop gain. For details, refer to the Applications Information section.

CC (Pin 25/Pin 21): Converter Compensation Pin. Connect an R-C network from this pin to the ITH pin to provide a suitable loop compensation for the converter used. Refer to the Applications Information section for discussion and procedure on choosing an appropriate R-C network for a particular DC/DC converter.

CLN (Pin 26/Pin 22): Input Current Sense Negative Input. Connect a sense resistor between this pin and the IN pin. The LTC4000 senses the voltage across this sense resistor and regulates it to a voltage equal to 1/20th (typical) of the voltage set at the IL pin. Tie this pin to the IN pin if no input current limit is desired. Refer to the Applications Information section for complete details.

IN (Pin 27/Pin 23): Input Supply Voltage: 3V to 60V. Supplies power to the internal circuitry and the BIAS pin. Connect the power source to the downstream system and the battery charger to this pin. This pin is also the positive sense pin for the input current limit. Connect a sense resistor between this pin and the CLN pin. Tie this pin to CLN if no input current limit is desired. A local 0.1µF bypass capacitor to ground is recommended on this pin.

BLOCK DIAGRAM

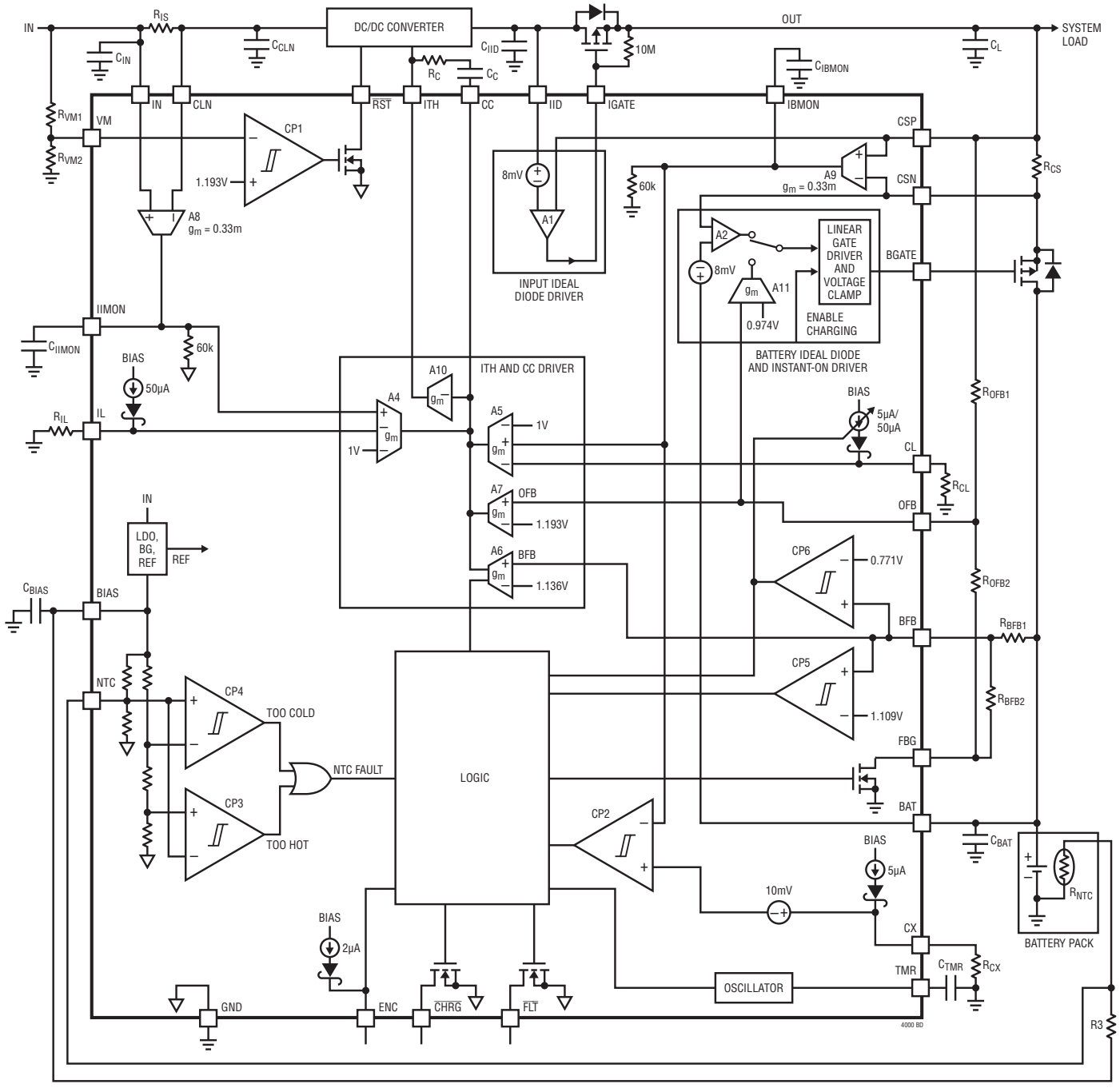


Figure 1. LTC4000 Functional Block Diagram

OPERATION

Overview

The LTC4000 is designed to simplify the conversion of any externally compensated DC/DC converter into a high performance battery charger with PowerPath control. It only requires the DC/DC converter to have a control or external-compensation pin (usually named VC or ITH) whose voltage level varies in a positive monotonic way with its output. The output variable can be either output voltage or output current. For the following discussion, refer to the Block Diagram in Figure 1.

The LTC4000 includes four different regulation loops: input current, charge current, battery float voltage and output voltage (A4-A7). Whichever loop requires the lowest voltage on the ITH pin for its regulation controls the external DC/DC converter.

The input current regulation loop ensures that the programmed input current limit (using a resistor at IL) is not exceeded at steady state. The charge current regulation loop ensures that the programmed battery charge current limit (using a resistor at CL) is not exceeded. The float voltage regulation loop ensures that the programmed battery stack voltage (using a resistor divider from BAT to FBG via BFB) is not exceeded. The output voltage regulation loop ensures that the programmed system output voltage (using a resistor divider from CSP to FBG via OFB) is not exceeded. The LTC4000 also provides monitoring pins for the input current and charge current at the IIMON and IBMON pins respectively.

The LTC4000 features an ideal diode controller at the input from the IID pin to the CSP pin and a PowerPath controller at the output from the BAT pin to the CSN pin. The output PowerPath controller behaves as an ideal diode controller when not charging. When charging, the output PowerPath controller has two modes of operation. If V_{OFB} is greater than $V_{OUT(INST\_ON)}$, BGATE is driven low. When V_{OFB} is less than $V_{OUT(INST\_ON)}$, a linear regulator implements the instant-on feature. This feature provides regulation of the BGATE pin so that a valid voltage level is immediately available at the output when the LTC4000 is charging an over-discharged, dead or short faulted battery.

The state of the ENC pin determines whether charging is enabled. When ENC is grounded, charging is disabled and the battery float voltage loop is disabled. Charging is enabled when the ENC pin is left floating or pulled high (≥1.5V)

The LTC4000 offers several user configurable battery charge termination schemes. The TMR pin can be configured for either C/X termination, charge timer termination or no termination. After a particular charge cycle terminates, the LTC4000 features an automatic recharge cycle if the battery voltage drops below 97.6% of the programmed float voltage.

Trickle charge mode drops the charge current to one tenth of the normal charge current (programmed using a resistor from the CL pin to GND) when charging into an over discharged or dead battery. When trickle charging, a capacitor on the TMR pin can be used to program a time out period. When this bad battery timer expires and the battery voltage fails to charge above the low battery threshold (V_{LOBAT}), the LTC4000 will terminate charging and indicate a bad battery condition through the status pins ($\overline{FLT}$ and $\overline{CHRG}$).

The LTC4000 also includes an NTC pin, which provides temperature qualified charging when connected to an NTC thermistor thermally coupled to the battery pack. To enable this feature, connect the thermistor between the NTC and the GND pins, and a corresponding resistor from the BIAS pin to the NTC pin. The LTC4000 also provides a charging status indicator through the $\overline{FLT}$ and the $\overline{CHRG}$ pins.

Aside from biasing the thermistor-resistor network, the BIAS pin can also be used for a convenient pull up voltage. This pin is the output of a low dropout voltage regulator that is capable of providing up to 0.5mA of current. The regulated voltage on the BIAS pin is available as soon as the IN pin is within its operating range (≥3V).

Input Ideal Diode

The input ideal diode feature provides low loss conduction and reverse blocking from the IID pin to the CSP pin. This reverse blocking prevents reverse current from the output (CSP pin) to the input (IID pin) which causes unnecessary drain on the battery and in some cases may result in unexpected DC/DC converter behavior.

The ideal diode behavior is achieved by controlling an external PMOS connected to the IID pin (drain) and the

OPERATION

CSP pin (source). The controller (A1) regulates the external PMOS by driving the gate of the PMOS device such that the voltage drop across IID and CSP is 8mV (typical). When the external PMOS ability to deliver a particular current with an 8mV drop across its source and drain is exceeded, the voltage at the gate clamps at $V_{IGATE(ON)}$ and the PMOS behaves like a fixed value resistor ($R_{DS(ON)}$).

Note that this input ideal diode function is only enabled when the voltage at the IN pin is within its operating range (3V to 60V). To ensure that the external PMOS is turned off when the voltage at the IN pin is not within its operating range, a 10M pull-up resistor between the IGATE and the CSP pin is recommended.

Input Current Regulation and Monitoring

One of the loops driving the ITH and CC pins is the input current regulation loop (Figure 2). This loop prevents the input current sensed through the input current sense resistor (R_{IS}) from exceeding the programmed input current limit.

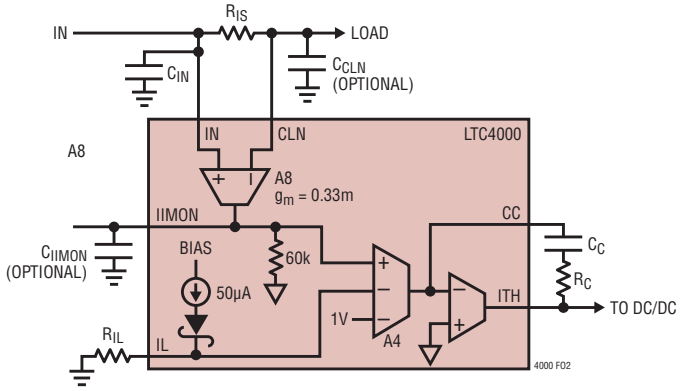


Figure 2. Input Current Regulation Loop

Battery Charger Overview

In addition to the input current regulation loop, the LTC4000 regulates charge current, battery voltage and output voltage.

When a battery charge cycle begins, the battery charger first determines if the battery is over-discharged. If the battery feedback voltage is below V_{LOBAT}, an automatic trickle charge feature uses the charge current regulation loop to set the battery charge current to 10% of the programmed full scale value. If the TMR pin is connected to a capacitor or open, the bad battery detection timer is enabled. When this bad battery detection timer expires and the battery voltage is still below V_{LOBAT}, the battery charger automatically terminates and indicates, via the $\overline{FLT}$ and $\overline{CHRG}$ pins, that the battery was unresponsive to charge current.

Once the battery voltage is above V_{LOBAT}, the charge current regulation loop begins charging in full power constant-current mode. In this case, the programmed full charge current is set with a resistor on the CL pin.

Depending on available input power and external load conditions, the battery charger may not be able to charge at the full programmed rate. The external load is always prioritized over the battery charge current. The input current limit programming is always observed, and only additional power is available to charge the battery. When system loads are light, battery charge current is maximized.

Once the float voltage is achieved, the battery float voltage regulation loop takes over from the charge current regulation loop and initiates constant voltage charging. In constant voltage charging, charge current slowly declines.

Charge termination can be configured with the TMR pin in several ways. If the TMR pin is tied to the BIAS pin, C/X termination is selected. In this case, charging is terminated when constant voltage charging reduces the charge current to the C/X level programmed at the CX pin. Connecting a capacitor to the TMR pin selects the charge timer termination and a charge termination timer is started at the beginning of constant voltage charging. Charging terminates when the termination timer expires. When continuous charging at the float voltage is desired, tie the TMR pin to GND to disable termination.

Upon charge termination, the PMOS connected to BGATE behaves as an ideal diode from BAT to CSN. The diode function prevents charge current but provides current to the system load as needed. If the system load can be completely supplied from the input, the battery PMOS turns off. While terminated, if the input current limit is not in regulation, the output voltage regulation loop takes over to ensure that the output voltage at CSP remains in control. The output voltage regulation loop regulates the voltage at the CSP pin such that the output feedback voltage at the OFB pin is 1.193V.

OPERATION

If the system load requires more power than is available from the input, the battery ideal diode controller provides supplemental power from the battery. When the battery voltage discharges below 97.1% of the float voltage ($V_{BFB} < V_{RECHRG(FALL)}$), the automatic recharge feature initiates a new charge cycle.

Charge Current Regulation

The first loop involved in a normal charging cycle is the charge current regulation loop (Figure 3). As with the input current regulation loop, this loop also drives the ITH and CC pins. This loop ensures that the charge current sensed through the charge current sense resistor (R_{CS}) does not exceed the programmed full charge current.

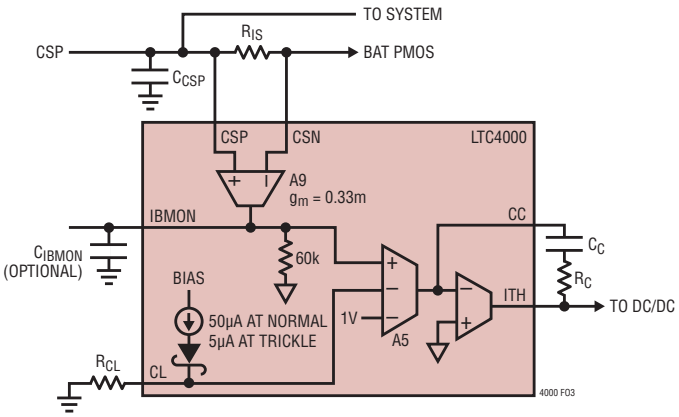


Figure 3. Charge Current Regulation Loop

Battery Voltage Regulation

Once the float voltage is reached, the battery voltage regulation loop takes over from the charge current regulation loop (Figure 4).

The float voltage level is programmed using the feedback resistor divider between the BAT pin and the FBG pin with the center node connected to the BFB pin. Note that the ground return of the resistor divider is connected to the FBG pin. The FBG pin disconnects the resistor divider load when $V_{IN} < 3V$ to ensure that the float voltage resistor divider does not consume battery current when the battery is the only available power source. For $V_{IN} \geq 3V$, the typical resistance from the FBG pin to GND is 100Ω.

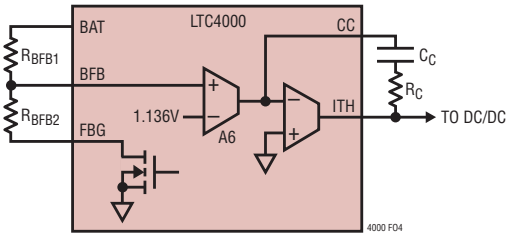


Figure 4. Battery Float Voltage Regulation Loop with FBG

Output Voltage Regulation

When charging terminates and the system load is completely supplied from the input, the PMOS connected to BGATE is turned off. In this scenario, the output voltage regulation loop takes over from the battery float voltage regulation loop (Figure 5). The output voltage regulation loop regulates the voltage at the CSP pin such that the output feedback voltage at the OFB pin is 1.193V.

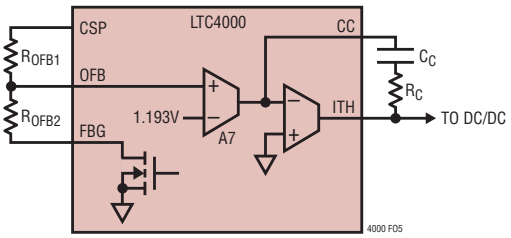


Figure 5. Output Voltage Regulation Loop with FBG

Battery Instant-On and Ideal Diode

The LTC4000 controls the external PMOS connected to the BGATE pin with a controller similar to the input ideal diode controller driving the IGATE pin. When not charging, the PMOS behaves as an ideal diode between the BAT (anode) and the CSN (cathode) pins. The controller (A2) regulates the external PMOS to achieve low loss conduction by driving the gate of the PMOS device such that the voltage drop from the BAT pin to the CSN pin is 8mV. When the ability to deliver a particular current with an 8mV drop across the PMOS source and drain is exceeded, the voltage at the gate clamps at $V_{BGATE(ON)}$ and the PMOS behaves like a fixed value resistor ($R_{DS(ON)}$).

The ideal diode behavior allows the battery to provide current to the load when the input supply is in current limit or the DC/DC converter is slow to react to an immediate load increase at the output. In addition to the ideal diode

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behavior, BGATE also allows current to flow from the CSN pin to the BAT pin during charging.

There are two regions of operation when current is flowing from the CSN pin to the BAT pin. The first is when charging into a battery whose voltage is below the instant-on threshold ($V_{OFB} < V_{OUT(INST\_ON)}$). In this region of operation, the controller regulates the voltage at the CSP pin to be approximately 86% of the final float voltage level ($V_{OUT(INST\_ON)}$). This feature provides a CSP voltage significantly higher than the battery voltage when charging into a heavily discharged battery. This instant-on feature allows the LTC4000 to provide sufficient voltage at the output (CSP pin), independent of the battery voltage.

The second region of operation is when the battery feedback voltage is greater than or equal to the instant-on threshold ($V_{OUT(INST\_ON)}$). In this region, the BGATE pin is driven low and clamped at $V_{BGATE(ON)}$ to allow the PMOS to turn completely on, reducing any power dissipation due to the charge current.

Battery Temperature Qualified Charging

The battery temperature is measured by placing a negative temperature coefficient (NTC) thermistor close to the battery pack. The comparators CP3 and CP4 implement the temperature detection as shown in the Block Diagram in Figure 1. The rising threshold of CP4 is set at 75% of V_{BIAS} (cold threshold) and the falling threshold of CP3 is set at 35% of V_{BIAS} (hot threshold). When the voltage at the NTC pin is above 75% of V_{BIAS} or below 35% of V_{BIAS} then the LTC4000 pauses any charge cycle in progress. When the voltage at the NTC pin returns to the range of 40% to 70% of V_{BIAS}, charging resumes.

When charging is paused, the external charging PMOS turns off and charge current drops to zero. If the LTC4000 is charging in the constant voltage mode and the charge termination timer is enabled, the timer pauses until the thermistor indicates a return to a valid temperature. If the battery charger is in the trickle charge mode and the bad battery detection timer is enabled, the bad battery timer pauses until the thermistor indicates a return to a valid temperature.

Input UVLO and Voltage Monitoring

The regulated voltage on the BIAS pin is available as soon as $V_{IN} \geq 3V$. When $V_{IN} \geq 3V$, the FBG pin is pulled low to GND with a typical resistance of 100Ω and the rest of the chip functionality is enabled.

When the IN pin is high impedance and a battery is connected to the BAT pin, the BGATE pin is pulled down with a 2µA (typical) current source to hold the battery PMOS gate voltage at $V_{BGATE(ON)}$ below V_{BAT}. This allows the battery to power the output. The total quiescent current consumed by LTC4000 from the battery when IN is not valid is typically ≤ 10µA.

When the IN pin is high impedance, the input ideal diode function for the external FET connected to the IGATE pin is disabled. To ensure that this FET is completely turned off when the voltage at the IN pin is not within its operating range, connect a 10M pull-up resistor between the IGATE pin and the CSP pin.

Besides the internal input UVLO, the LTC4000 also provides voltage monitoring through the VM pin. The $\overline{RST}$ pin is pulled low when the voltage on the VM pin falls below 1.193V (typical). On the other hand, when the voltage on the VM pin rises above 1.233V (typical), the $\overline{RST}$ pin is high impedance.

One common use of this voltage monitoring feature is to ensure that the converter is turned off when the voltage at the input is below a certain level. In this case, connect the $\overline{RST}$ pin to the DC/DC converter chip select or enable pin (see Figure 6).

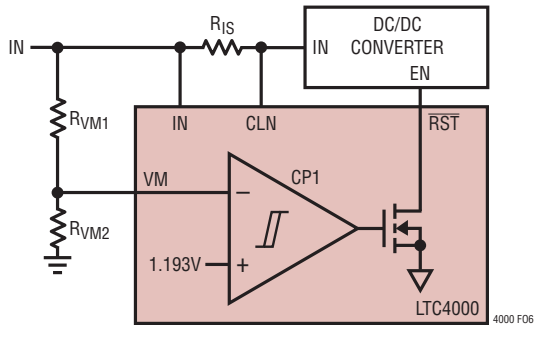


Figure 6. Input Voltage Monitoring with $\overline{RST}$ Connected to the EN Pin of the DC/DC Converter

High Voltage Synchronous Current Mode Step-Down Controller with Adjustable Operating Frequency

FEATURES

- **High Voltage Operation: Up to 60V**
- **Synchronizable Up to 600kHz**
- **Adjustable Constant Frequency: 100kHz to 500kHz**
- **Output Voltages Up to 36V**
- **Stable Operation in Current Limit**
- Adaptive Nonoverlap Circuitry Prevents Switch Shoot-Through
- Reverse Inductor Current Inhibit for Discontinuous Operation Improves Efficiency with Light Loads
- Programmable Soft-Start
- 120µA No Load Quiescent Current
- 10µA Shutdown Supply Current
- 1% Regulation Accuracy
- Standard Gate N-Channel Power MOSFETs
- Reverse Overcurrent Protection
- 16-Lead Thermally Enhanced TSSOP Package

APPLICATIONS

- 12V and 42V Automotive and Heavy Equipment
- 48V Telecom Power Supplies
- Avionics and Industrial Control Systems
- Distributed Power Converters

DESCRIPTION

The LT®3845A is a high voltage, synchronous, current mode controller used for medium to high power, high efficiency supplies. It offers a wide 4V to 60V input range (7.5V minimum start-up voltage). An onboard regulator simplifies the biasing requirements by providing IC power directly from V_{IN}.

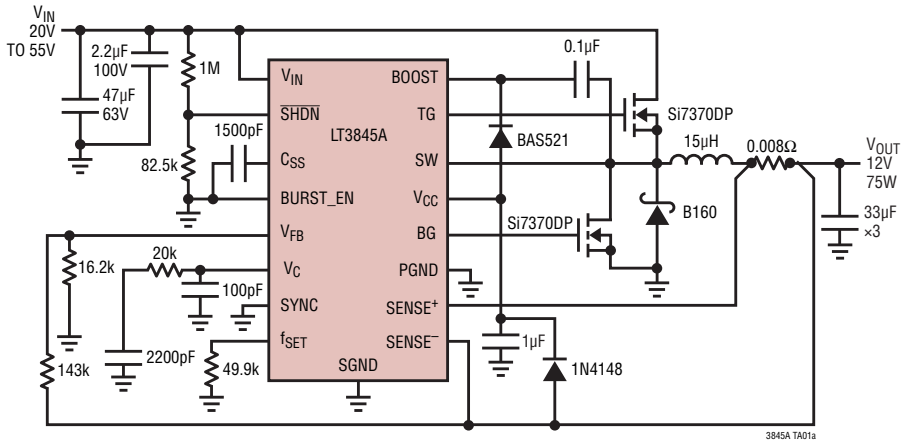
Burst Mode® operation maintains high efficiency at light loads by reducing IC quiescent current to 120µA. Light load efficiency is also improved with the reverse inductor current inhibit function which supports discontinuous operation.

Additional features include adjustable fixed operating frequency that can be synchronized to an external clock for noise sensitive applications, gate drivers capable of driving large N-channel MOSFETs, a precision undervoltage lockout, 10µA shutdown current, short-circuit protection and a programmable soft-start.

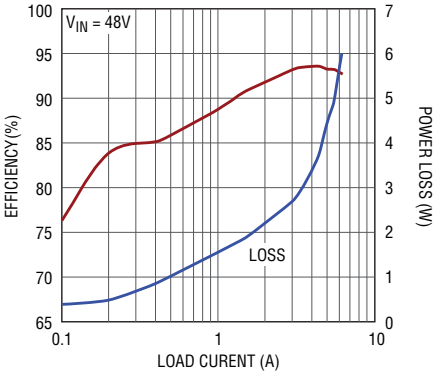
The LT3845A is available in a 16-lead thermally enhanced TSSOP package.

TYPICAL APPLICATION

High Voltage Step-Down Regulator 48V to 12V at 75W



Efficiency and Power Loss vs Load Current

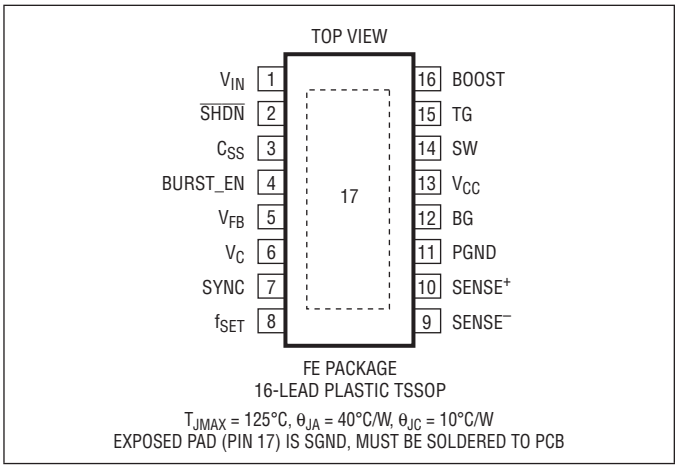


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Input Supply Voltage (V_{IN}) 65V
Boosted Supply Voltage (BOOST) 80V
Switch Voltage (SW) (Note 8) ..... 65V to –2V
Differential Boost Voltage
(BOOST to SW) 24V
Bias Supply Voltage (V_{CC}) 24V
$SENSE^+$ and $SENSE^-$ Voltages 40V
Differential Sense Voltage
($SENSE^+$ to $SENSE^-$) ..... 1V to –1V
BURST_EN Voltage 24V
SYNC, V_C, V_{FB}, C_{SS}, and $\overline{SHDN}$ Voltages 5V
$\overline{SHDN}$ Pin Currents 1mA
Operating Junction Temperature Range (Note 2)
LT3845AE (Note 3) ..... –40°C to 125°C
LT3845AI ..... –40°C to 125°C
LT3845AMP ..... –55°C to 125°C
Storage Temperature ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PIN CONFIGURATION



FE PACKAGE
16-LEAD PLASTIC TSSOP

T_{JMAX} = 125°C, θ_{JA} = 40°C/W, θ_{JC} = 10°C/W
EXPOSED PAD (PIN 17) IS SGND, MUST BE SOLDERED TO PCB

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LT3845AEFE#PBF	LT3845AEFE#TRPBF	3845AFE	16-Lead Plastic TSSOP	–40°C to 125°C
LT3845AIFE#PBF	LT3845AIFE#TRPBF	3845AFE	16-Lead Plastic TSSOP	–40°C to 125°C
LT3845AMPFE#PBF	LT3845AMPFE#TRPBF	3845AFE	16-Lead Plastic TSSOP	–55°C to 125°C

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 20V, V_{CC} = BOOST = BURST_EN = 10V, $\overline{SHDN}$ = 2V, R_{SET} = 49.9kΩ, $SENSE^-$ = $SENSE^+$ = 10V, SGND = PGND = SW = SYNC = 0V, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{IN} Operating Voltage Range (Note 4)		●	4		60	V
V_{IN} Minimum Start Voltage		●			7.5	V
V_{IN} UVLO Threshold (Falling)		●	3.6	3.8	4	V
V_{IN} UVLO Threshold Hysteresis				670		mV
V_{IN} Supply Current	V_{CC} > 9V			20		µA
V_{IN} Burst Mode Current	V_{BURST_EN} = 0V, V_{FB} = 1.35V			20		µA
V_{IN} Shutdown Current	$V_{\overline{SHDN}}$ = 0V	●		9	15	µA
BOOST Operating Voltage Range		●			75	V
BOOST Operating Voltage Range (Note 5)	$V_{BOOST} - V_{SW}$	●			20	V
BOOST UVLO Threshold (Rising)	$V_{BOOST} - V_{SW}$			5		V
BOOST UVLO Threshold Hysteresis	$V_{BOOST} - V_{SW}$			400		mV
BOOST Supply Current (Note 6)				1.4		mA
BOOST Burst Mode Current	V_{BURST_EN} = 0V			0.1		µA
BOOST Shutdown Current	$V_{\overline{SHDN}}$ = 0V			0.1		µA
V_{CC} Operating Voltage Range (Note 5)		●			20	V
V_{CC} Output Voltage	Over Full Line and Load Range	●		8	8.3	V
V_{CC} UVLO Threshold (Rising)				6.25		V
V_{CC} UVLO Threshold Hysteresis				500		mV
V_{CC} Supply Current (Note 6)		●		3	3.7	mA
V_{CC} Burst Mode Current	V_{BURST_EN} = 0V			100		µA
V_{CC} Shutdown Current	$V_{\overline{SHDN}}$ = 0V			20		µA
V_{CC} Current Limit		●	–40	–150		mA
Error Amp Reference Voltage	Measured at V_{FB} Pin		1.224	1.231	1.238	V
		●	1.215		1.245	V
V_{FB} Pin Input Current	V_{FB} = 1.231V			25		nA
$\overline{SHDN}$ Enable Threshold (Rising)		●	1.3	1.35	1.4	V
$\overline{SHDN}$ Threshold Hysteresis				120		mV
Sense Pins Common Mode Range		●	0		36	V
Current Limit Sense Voltage	$V_{SENSE}^+ - V_{SENSE}^-$	●	90	100	115	mV
Reverse Protect Sense Voltage	$V_{SENSE}^+ - V_{SENSE}^-$, V_{BURST_EN} = V_{CC}			–100		mV
Reverse Current Inhibit Offset	V_{BURST_EN} = 0V or V_{BURST_EN} = V_{FB}			10		mV
Input Current ($I_{SENSE}^+ + I_{SENSE}^-$)	$V_{SENSE(CM)}$ = 0V			800		µA
	$V_{SENSE(CM)}$ = 2V			–20		µA
	$V_{SENSE(CM)}$ > 4V			–300		µA
Operating Frequency		●	270	300	330	kHz
Minimum Programmable Frequency		●			100	kHz
Maximum Programmable Frequency		●	500			kHz
External Sync Frequency Range		●	100		600	kHz
SYNC Input Resistance				40		kΩ
SYNC Voltage Threshold		●		1.4	2	V
Soft-Start Capacitor Control Current				2		µA
Error Amp Transconductance		●	270	340	410	µS
Error Amp DC Voltage Gain				62		dB
Error Amp Sink/Source Current				±30		µA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 20V, V_{CC} = BOOST = BURST_EN = 10V, $\overline{SHDN}$ = 2V, R_{SET} = 49.9kΩ, $SENSE^-$ = $SENSE^+$ = 10V, SGND = PGND = SW = SYNC = 0V, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
TG, BG Drive On Voltage (Note 7) TG, BG Drive Off Voltage	C_{LOAD} = 3300pF C_{LOAD} = 3300pF			9.8 0.1		V V
TG, BG Drive Rise/Fall Time	10% to 90% or 90% to 10%, C_{LOAD} = 3300pF			50		ns
Minimum TG Off Time		●		350	650	ns
Minimum TG On Time		●		250	400	ns
Gate Drive Nonoverlap Time	TG Fall to BG Rise BG Fall to TG Rise			200 150		ns ns

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The LT3845A includes overtemperature protection that is intended to protect the device during momentary overload conditions. Junction temperature will exceed 125°C when overtemperature protection is active. Continuous operation above the specified maximum operating junction temperature may impair device reliability.

Note 3: The LT3845AE is guaranteed to meet performance specifications from 0°C to 125°C junction temperature. Specifications over the –40°C to 125°C operating junction temperature range are assured by design, characterization and correlation with statistical process controls. The LT3845AI is guaranteed over the full –40°C to 125°C operating junction temperature range. The LT3845AMP is 100% tested and guaranteed over the –55°C to 125°C temperature range.

Note 4: V_{IN} voltages below the start-up threshold (7.5V) are only supported when the V_{CC} is externally driven above 6.5V.

Note 5: Operating range is dictated by MOSFET absolute maximum V_{GS}.

Note 6: Supply current specification does not include switch drive currents. Actual supply currents will be higher.

Note 7: DC measurement of gate drive output "ON" voltage is typically 8.6V. Internal dynamic bootstrap operation yields typical gate "ON" voltages of 9.8V during standard switching operation. Standard operation gate "ON" voltage is not tested but guaranteed by design.

Note 8: The –2V absolute maximum on the SW pin is a transient condition. It is guaranteed by design and not subject to test.

PIN FUNCTIONS

BG: The BG pin is the gate drive for the bottom N-channel MOSFET. Since very fast high currents are driven from this pin, connect it to the gate of the power MOSFET with a short and wide, typically 0.02" width, PCB trace to minimize inductance.

BOOST: The BOOST pin is the supply for the bootstrapped gate drive and is externally connected to a low ESR ceramic boost capacitor referenced to SW pin. The recommended value of the BOOST capacitor, C_{BOOST}, is at least 50 times greater than the total gate capacitance of the topside MOSFET. In most applications 0.1µF is adequate. The maximum voltage that this pin sees is $V_{IN} + V_{CC}$, ground referred.

BURST_EN: Burst Mode Operation Enable Pin. This pin also controls reverse-current inhibit mode of operation. When the pin voltage is below 0.5V, Burst Mode operation and reverse-current inhibit functions are enabled. When the pin voltage is above 0.5V, Burst Mode operation is disabled, but reverse-current inhibit operation is maintained. In this mode of operation (BURST_EN = V_{FB}) there is a 1mA minimum load requirement. Reverse-current inhibit is disabled when the pin voltage is above 2.5V. This pin is typically shorted to ground to enable Burst Mode operation and reverse-current inhibit, shorted to V_{FB} to disable Burst Mode operation while enabling reverse-current inhibit, and connected to V_{CC} pin to disable both functions. See Applications Information section.

C_{SS}: The soft-start pin is used to program the supply soft-start function. Use the following formula to calculate C_{SS} for a given output voltage slew rate:

$$C_{SS} = 2\mu A(t_{SS}/1.231V)$$

The pin should be left unconnected when not using the soft-start function.

f_{SET}: The f_{SET} pin programs the oscillator frequency with an external resistor, R_{SET}. The resistor is required even when supplying external sync clock signal. See the Applications Information section for resistor value selection details.

PGND: The PGND pin is the high-current ground reference for internal low side switch driver and the V_{CC} regulator circuit. Connect the pin directly to the negative terminal of the V_{CC} decoupling capacitor. See the Application Information section for helpful hints on PCB layout of grounds.

SENSE⁻: The SENSE⁻ pin is the negative input for the current sense amplifier and is connected to the V_{OUT} side of the sense resistor for step-down applications.

SENSE⁺: The SENSE⁺ pin is the positive input for the current sense amplifier and is connected to the inductor side of the sense resistor for step-down applications.

SGND: The SGND pin is the low noise ground reference. It should be connected to the $-V_{OUT}$ side of the output capacitors. Careful layout of the PCB is necessary to keep high currents away from this SGND connection. See the Application Information section for helpful hints on PCB layout of grounds.

$\overline{SHDN}$: The $\overline{SHDN}$ pin has a precision IC enable threshold of 1.35V (rising) with 120mV of hysteresis. It is used to implement an undervoltage lockout (UVLO) circuit. See Application Information section for implementing a UVLO function. When the $\overline{SHDN}$ pin is pulled below a transistor V_{BE} (0.7V), a low current shutdown mode is entered, all internal circuitry is disabled and the V_{IN} supply current is reduced to approximately 9µA. Typical pin input bias current is <10nA and the pin is internally clamped to 6V. If the function is not used, this pin may be tied to V_{IN} through a high value resistor.

SW: Reference for V_{BOOST} Supply and High Current Return for Bootstrapped Switch.

SYNC: The Sync pin provides an external clock input for synchronization of the internal oscillator. R_{SET} is set such that the internal oscillator frequency is 10% to 25% below the external clock frequency. If unused the Sync pin is connected to SGND. For more information see "Oscillator Sync" in the Application Information section of this data sheet. Sync pin not available in PDIP package.

PIN FUNCTIONS

TG: The TG pin is the bootstrapped gate drive for the top N-Channel MOSFET. Since very fast high currents are driven from this pin, connect it to the gate of the power MOSFET with a short and wide, typically 0.02" width, PCB trace to minimize inductance.

V_C: The V_C pin is the output of the error amplifier whose voltage corresponds to the maximum (peak) switch current per oscillator cycle. The error amplifier is typically configured as an integrator by connecting an RC network from the V_C pin to SGND. This circuit creates the dominant pole for the converter regulation control loop. Specific integrator characteristics can be configured to optimize transient response. When Burst Mode operation is enabled (see Pin 4 description), an internal low impedance clamp on the V_C pin is set at 100mV below the burst threshold, which limits the negative excursion of the pin voltage. Therefore, this pin cannot be pulled low with a low impedance source. If the V_C pin must be externally manipulated, do so through a 1kΩ series resistance.

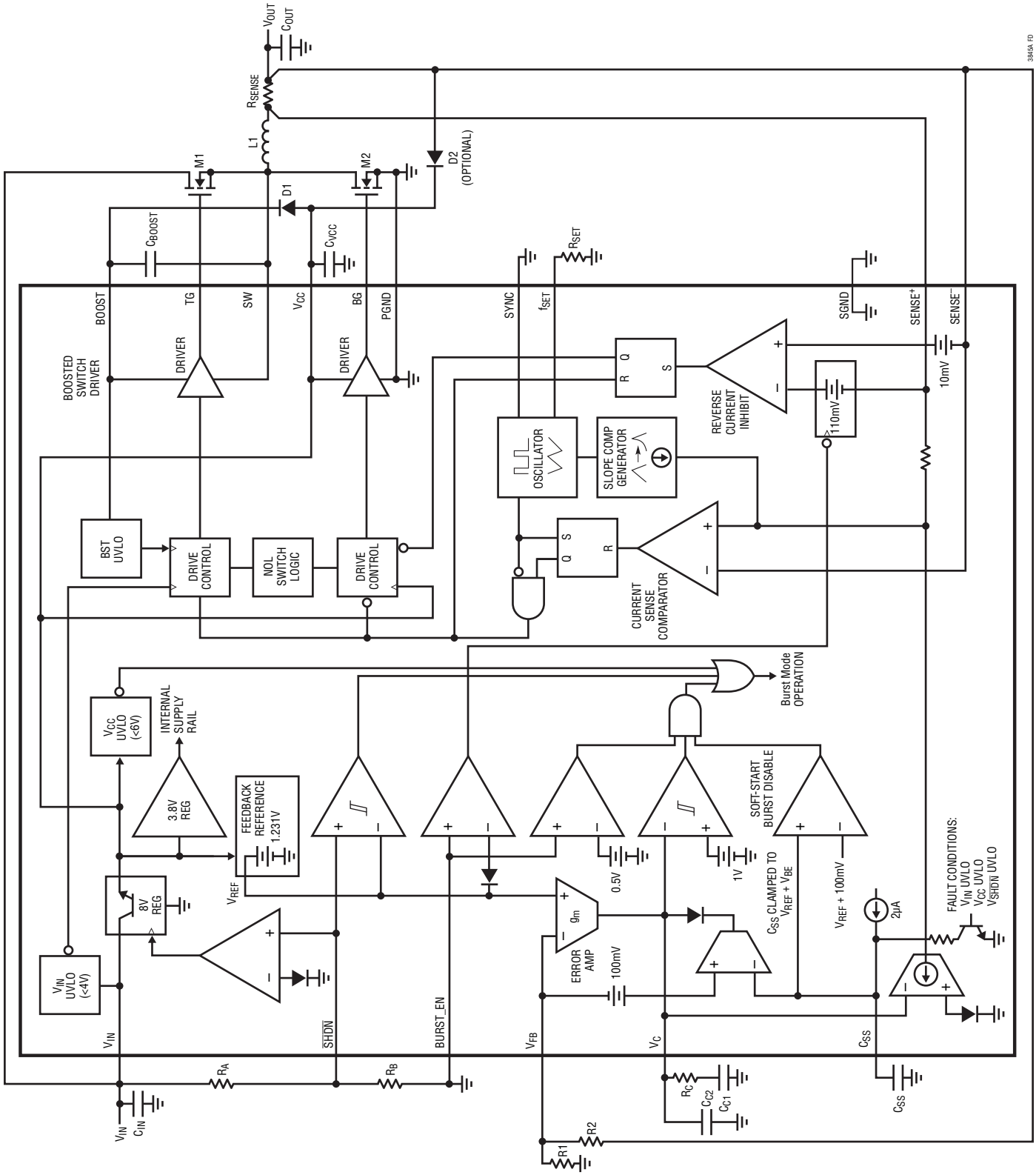
V_{CC}: The V_{CC} pin is the internal bias supply decoupling node. Use a low ESR, 1µF or greater ceramic capacitor to decouple this node to PGND. Most internal IC functions are powered from this bias supply. An external diode connected from V_{CC} to the BOOST pin charges the bootstrapped capacitor during the off-time of the main power switch. Back driving the V_{CC} pin from an external DC voltage source, such as the V_{OUT} output of the regulator supply, increases overall efficiency and reduces power dissipation in the IC. In shutdown mode this pin sinks 20µA until the pin voltage is discharged to 0V.

V_{FB}: The output voltage feedback pin, V_{FB}, is externally connected to the supply output voltage via a resistive divider. The V_{FB} pin is internally connected to the inverting input of the error amplifier. In regulation, V_{FB} is 1.231V.

V_{IN}: The V_{IN} pin is the main supply pin and should be decoupled to SGND with a low ESR capacitor (at least 0.1µF) located close to the pin.

Exposed Pad (SGND) (TSSOP Only): The exposed leadframe is internally connected to the SGND pin. Solder the exposed pad to the PCB ground for electrical contact and optimal thermal performance.

BLOCK DIAGRAM



LM3481 / -Q1 High-Efficiency Controller for Boost, SEPIC and Flyback DC-DC Converters

1 Features

- LM3481QMM are Automotive-Grade Products That are AEC-Q100 Grade 1 Qualified (–40°C to +125°C Operating Junction Temperature)
- 10-Lead VSSOP Package
- Internal Push-Pull Driver With 1-A Peak Current Capability
- Current Limit and Thermal Shutdown
- Frequency Compensation Optimized With a Capacitor and a Resistor
- Internal Softstart
- Current Mode Operation
- Adjustable Undervoltage Lockout With Hysteresis
- Pulse Skipping at Light Loads
- Key Specifications
  - Wide Supply Voltage Range of 2.97 V to 48 V
  - 100-kHz to 1-MHz Adjustable and Synchronizable Clock Frequency
  - ±1.5% (Over Temperature) Internal Reference
  - 10-µA Shutdown Current (Over Temperature)

2 Applications

- Automotive Start-Stop Applications
- Automotive ADAS Driver Information
- One Cell/Two Cell Li-ion Battery Powered Portable Bluetooth Audio Systems
- Notebooks, PDAs, Digital Cameras, and Other Portable Applications
- Offline Power Supplies
- Set-Top Boxes
- Boost for Audio Amplifiers

3 Description

The LM3481 device is a versatile Low-Side N-FET high-performance controller for switching regulators. The device is designed for use in Boost, SEPIC and Flyback converters and topologies requiring a low-side FET as the primary switch. The LM3481 device can be operated at very high switching frequencies to reduce the overall solution size. The switching frequency of the LM3481 device can be adjusted to any value between 100kHz and 1MHz by using a single external resistor or by synchronizing it to an external clock. Current mode control provides superior bandwidth and transient response in addition to cycle-by-cycle current limiting. Current limit can be programmed with a single external resistor.

The LM3481 device has built-in protection features such as thermal shutdown, short-circuit protection and overvoltage protection. Power-saving shutdown mode reduces the total supply current to 5 µA and allows power supply sequencing. Internal soft-start limits the inrush current at start-up. Integrated current slope compensation simplifies the design and, if needed for specific applications, can be increased using a single resistor.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM3481	VSSOP (10)	3.00 mm × 3.00 mm
LM3481-Q1		

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

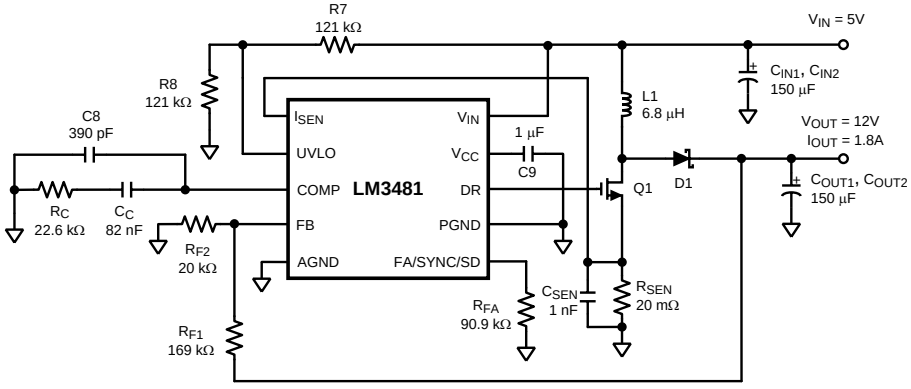


Figure 1. LM3481 Typical 5Vin to 12Vout Boost Converter Application

Table of Contents

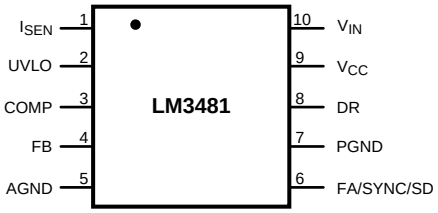
4 Revision History

Changes from Revision E (April 2012) to Revision F **Page**

- Added *Pin Configuration and Functions* section, *Handling Rating* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1

5 Pin Configuration and Functions

10-Pin
VSSOP Package
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	I_{SEN}	A	Current sense input pin. Voltage generated across an external sense resistor is fed into this pin.
2	UVLO	A	Under voltage lockout pin. A resistor divider from V_{IN} to ground is connected to the UVLO pin. The ratio of these resistances determine the input voltage which allows switching and the hysteresis to disable switching.
3	COMP	A	Compensation pin. A resistor and capacitor combination connected to this pin provides compensation for the control loop.
4	FB	A	Feedback pin. Inverting input of the error amplifier.
5	AGND	G	Analog ground pin. Internal bias circuitry reference. Should be connected to PGND at a single point.
6	FA/SYNC/SD	I/A	Frequency adjust, synchronization, and shutdown pin. A resistor connected from this pin to ground sets the oscillator frequency. An external clock signal at this pin will synchronize the controller to the frequency of the clock. A high level on this pin for ≥ 30 µs will turn the device off and the device will then draw 5 µA from the supply typically.
7	PGND	G	Power ground pin. External power circuitry reference. Should be connected to AGND at a single point.
8	DR	O	Drive pin of the IC. The gate of the external MOSFET should be connected to this pin.
9	V_{CC}	O	Driver supply voltage pin. A bypass capacitor must be connected from this pin to PGND. See *Driver Supply Capacitor Selection* section. Do not bias externally.
10	V_{IN}	P	Power supply input pin.

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{IN}	Pin Voltage	–0.4	50	V
FB	Pin Voltage	–0.4	6	V
FA/SYNC/SD	Pin Voltage	–0.4	6	V
COMP	Pin Voltage	–0.4	6	V
UVLO	Pin Voltage	–0.4	6	V
V_{CC}	Pin Voltage	–0.4	6.5	V
DR	Pin Voltage	–0.4	6	V
I_{SEN}	Pin Voltage	–400	600	mV
	Peak Driver Output Current		1	A
	Power Dissipation	Internally Limited		
	Junction Temperature		150	°C
Lead Temperature (only applies to operating conditions)	DGS Package		220	°C
Peak Body Temperature (2)			260	°C

(1) Absolute Maximum Ratings are limits beyond which damage to the device may occur. *Recommended Operating Ratings* indicates conditions for which the device is intended to be functional, but does not ensure specific performance limits. For ensured specifications and test conditions, see the *Electrical Characteristics*. The ensured specifications apply only for the test conditions.
(2) Part is MSL1-260C qualified

6.2 Handling Ratings: LM3481

			MIN	MAX	UNIT
T_{stg}	Storage temperature range		–65	150	°C
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	–2000	+2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins(2)	–750	+750	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Handling Ratings: LM3481-Q1

				MIN	MAX	UNIT
T_{stg}	Storage temperature range			–65	150	°C
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002(1)		–2000	+2000	V
		Charged device model (CDM), per AEC Q100-011	Corner pins (1, 5, 6, and 10)	–750	+750	
			Other pins	–750	+750	

(1) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.4 Recommended Operating Ratings

	MIN	MAX	UNIT
Supply Voltage	2.97	48	V
Junction Temperature Range	–40	125	°C
Switching Frequency Range	100	1	kHz/MHz

6.5 Thermal Information

THERMAL METRIC[1]		LM3481 VSSOP 10 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	157.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	51.1	
$R_{\theta JB}$	Junction-to-board thermal resistance	76.9	
ψ_{JT}	Junction-to-top characterization parameter	5.0	
ψ_{JB}	Junction-to-board characterization parameter	75.6	
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	-	

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

6.6 Electrical Characteristics

V_{IN}= 12 V, R_{FA}= 40 kΩ, T_J = 25°C, unless otherwise indicated.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{FB}	Feedback Voltage	V_{COMP} = 1.4 V, 2.97 ≤ V_{IN} ≤ 48 V		1.275		V
		V_{COMP} = 1.4 V, 2.97 ≤ V_{IN} ≤ 48 V, –40°C ≤ T_J ≤ 125°C	1.256		1.294	
ΔV_{LINE}	Feedback Voltage Line Regulation	2.97 ≤ V_{IN} ≤ 48 V		0.003		%/V
ΔV_{LOAD}	Output Voltage Load Regulation	I_{EAO} Source/Sink		±0.5		%/A
$V_{UVLOSEN}$	Undervoltage Lockout Reference Voltage	V_{UVLO} Ramping Down		1.430		V
		V_{UVLO} Ramping Down, –40°C ≤ T_J ≤ 125°C	1.345		1.517	
I_{UVLO}	UVLO Source Current	Enabled		5		µA
		Enabled, –40°C ≤ T_J ≤ 125°C	3		6	
V_{UVLOSD}	UVLO Shutdown Voltage		0.55	0.7	0.82	V
I_{COMP}	COMP pin Current Sink	V_{FB} = 0V		640		µA
V_{COMP}		V_{FB} = 1.275V		1		V
f_{nom}	Nominal Switching Frequency	R_{FA} = 40 kΩ		475		kHz
		R_{FA} = 40 kΩ, –40°C ≤ T_J ≤ 125°C	406		550	
$V_{sync-HI}$	Threshold for Synchronization on FA/SYNC/SD pin	Synchronization Voltage Rising		1.4		V
$V_{sync-LOW}$	Threshold for Synchronization on FA/SYNC/SD pin	Synchronization Voltage Falling		0.7		V
$R_{DS1\ (ON)}$	Driver Switch On Resistance (top)	I_{DR} = 0.2A, V_{IN}= 5 V		4		Ω
$R_{DS2\ (ON)}$	Driver Switch On Resistance (bottom)	I_{DR} = 0.2A		2		Ω
$V_{DR\ (max)}$	Maximum Drive Voltage Swing[1]	V_{IN} < 6V		V_{IN}		V
		V_{IN} ≥ 6V		6		
D_{max}	Maximum Duty Cycle	R_{FA}=40 kΩ	81%	85%		
t_{min} (on)	Minimum On Time			250	363	ns
		worst case over temperature			571	ns
I_{SUPPLY}	Supply Current (switching)	See[2]		3.7		mA
		See[2], –40°C ≤ T_J ≤ 125°C			5.0	

(1) The drive pin voltage, V_{DR}, is equal to the input voltage when input voltage is less than 6 V. V_{DR} is equal to 6 V when the input voltage is greater than or equal to 6 V.
(2) For this test, the FA/SYNC/SD Pin is pulled to ground using a 40-kΩ resistor.

Electrical Characteristics (continued)

V_{IN}= 12 V, R_{FA}= 40 kΩ, T_J = 25°C, unless otherwise indicated.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_Q	Quiescent Current in Shutdown Mode	$V_{FA/SYNC/SD}$ = 3 V(3), V_{IN} = 12 V		9		µA
		$V_{FA/SYNC/SD}$ = 3 V(3), V_{IN} = 12 V, –40°C ≤ T_J ≤ 125°C			15	
		$V_{FA/SYNC/SD}$ = 3 V(3), V_{IN} = 5 V		5		
		$V_{FA/SYNC/SD}$ = 3 V(3), V_{IN} = 5 V, –40°C ≤ T_J ≤ 125°C			10	
V_{SENSE}	Current Sense Threshold Voltage			160		mV
		–40°C ≤ T_J ≤ 125°C	100		190	
V_{SC}	Over Load Current Limit Sense Voltage			220		mV
		–40°C ≤ T_J ≤ 125°C	157		275	
V_{SL}	Internal Compensation Ramp Voltage			90		mV
V_{OVP}	Output Over-voltage Protection (with respect to feedback voltage)(4)	V_{COMP} = 1.4 V		85		mV
		V_{COMP} = 1.4 V, –40°C ≤ T_J ≤ 125°C	26		135	
$V_{OVP(HYS)}$	Output Over-Voltage Protection Hysteresis	V_{COMP} = 1.4 V		70		mV
		V_{COMP} = 1.4 V, –40°C ≤ T_J ≤ 125°C	28		106	
Gm	Error Amplifier Transconductance	V_{COMP} = 1.4 V		450		µmho
		V_{COMP} = 1.4 V, –40°C ≤ T_J ≤ 125°C	216		690	
A_{VOL}	Error Amplifier Voltage Gain	V_{COMP} = 1.4 V, I_{EAO} = 100 µA (Source/Sink)		60		V/V
		V_{COMP} = 1.4 V, I_{EAO} = 100 µA (Source/Sink), –40°C ≤ T_J ≤ 125°C	35		66	
I_{EAO}	Error Amplifier Output Current (Source/ Sink)	Source, V_{COMP} = 1.4 V, V_{FB} = 1.1 V		640		µA
		Source, V_{COMP} = 1.4 V, V_{FB} = 1.1 V, –40°C ≤ T_J ≤ 125°C	475		837	
		Sink, V_{COMP} = 1.4 V, V_{FB} = 1.4 V		65		µA
		Sink, V_{COMP} = 1.4 V, V_{FB} = 1.4 V, –40°C ≤ T_J ≤ 125°C	31		100	
V_{EAO}	Error Amplifier Output Voltage Swing	Upper Limit: V_{FB} = 0 V, COMP Pin Floating		2.70		V
		Upper Limit: V_{FB} = 0 V, COMP Pin Floating, –40°C ≤ T_J ≤ 125°C	2.45		2.93	
		Lower Limit: V_{FB} = 1.4 V		0.60		V
		Lower Limit: V_{FB} = 1.4 V, –40°C ≤ T_J ≤ 125°C	0.32		0.90	
t_{SS}	Internal Soft-Start Delay	V_{FB} = 1.2 V, COMP Pin Floating	8.7	15	21.3	ms
t_r	Drive Pin Rise Time	Cgs = 3000 pf, V_{DR} = 0 V to 3 V		25		ns
t_f	Drive Pin Fall Time	Cgs = 3000 pf, V_{DR} = 3 V to 0 V		25		ns
V_{SD}	Shutdown signal threshold(5)FA/SYNC/SD pin	Output = High (Shutdown)		1.31		V
		Output = High (Shutdown), –40°C ≤ T_J ≤ 125°C			1.40	
		Output = Low (Enable)		0.68		V
		Output = Low (Enable), –40°C ≤ T_J ≤ 125°C	0.40			

(3) For this test, the FA/SYNC/SD Pin is pulled to 3 V using a 40-kΩ resistor.
(4) The overvoltage protection is specified with respect to the feedback voltage. This is because the overvoltage protection tracks the feedback voltage. The overvoltage threshold can be calculated by adding the feedback voltage (V_{FB}) to the overvoltage protection specification.
(5) The FA/SYNC/SD pin should be pulled to V_{IN} through a resistor to turn the regulator off. The voltage on the FA/SYNC/SD pin must be above the max limit for the Output = High longer than 30 µs to keep the regulator off and must be below the minimum limit for Output = Low to keep the regulator on.

Electrical Characteristics (continued)

V_{IN}= 12 V, R_{FA}= 40 kΩ, T_J = 25°C, unless otherwise indicated.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{SD}	Shutdown Pin Current FA/SYNC/SD pin	V_{SD} = 5 V		−1		µA
		V_{SD} = 0 V		20		
T_{SD}	Thermal Shutdown			165		°C
T_{sh}	Thermal Shutdown Hysteresis			10		°C

6.7 Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_J = 25°C.

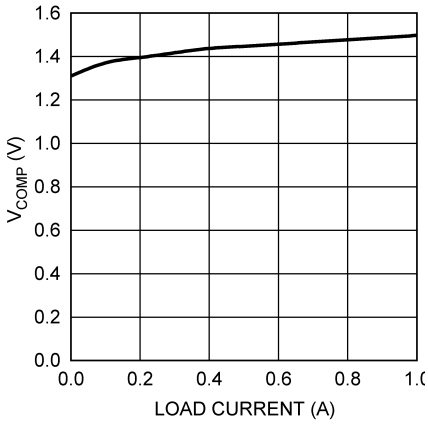


Figure 3. Comp Pin Voltage vs. Load Current

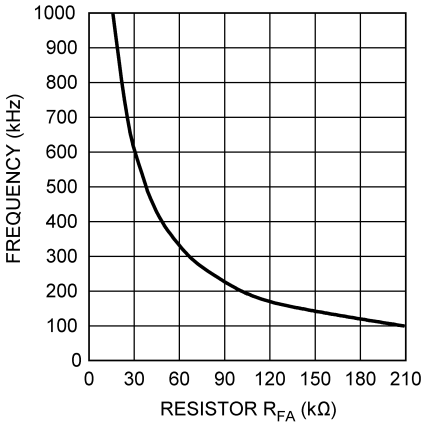


Figure 4. Switching Frequency vs. R_{FA}

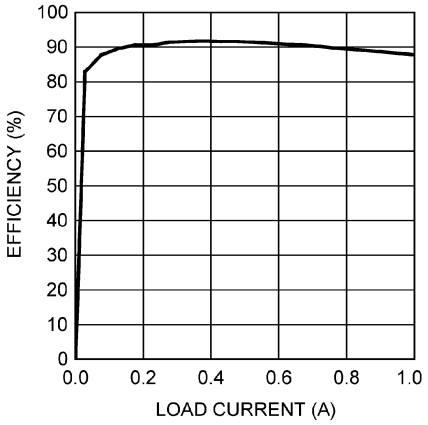


Figure 5. Efficiency vs. Load Current (3.3 V_{IN} and 12 V_{OUT})

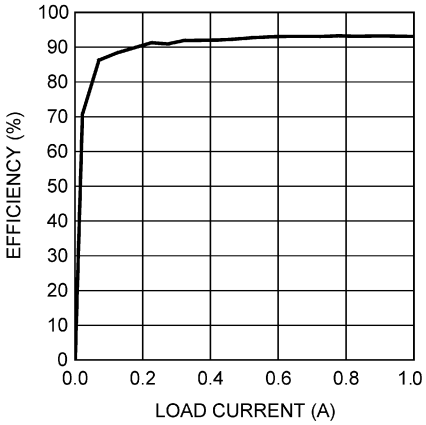


Figure 6. Efficiency vs. Load Current (5 V_{IN} and 12 V_{OUT})

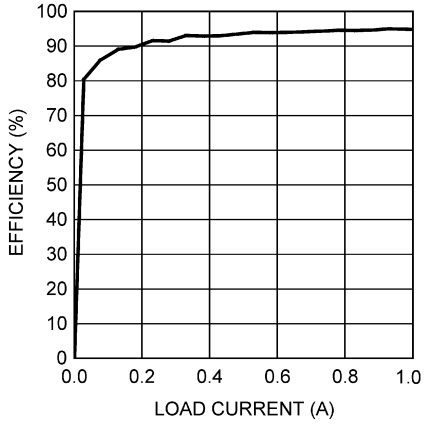


Figure 7. Efficiency vs. Load Current (9 V_{IN} and 12 V_{OUT})

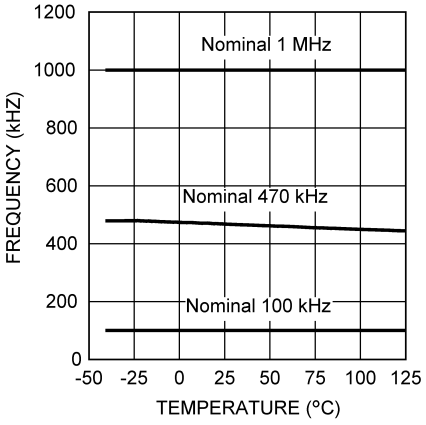


Figure 8. Frequency vs. Temperature

Typical Characteristics (continued)

Unless otherwise specified, V_{IN} = 12 V, T_J = 25°C.

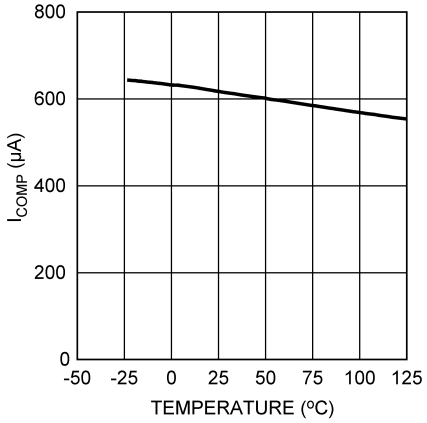


Figure 9. COMP Pin Source Current vs. Temperature

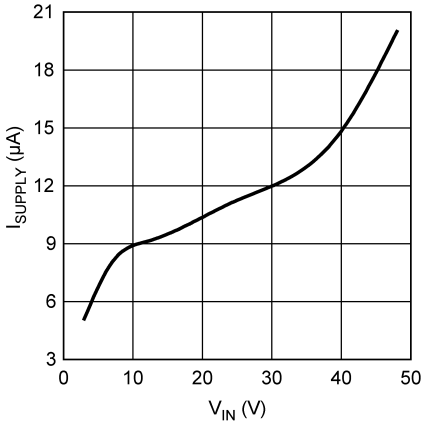


Figure 10. I_{Supply} vs. Input Voltage (Nonswitching)

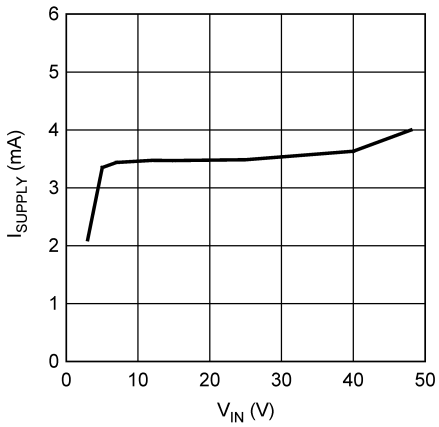


Figure 11. I_{Supply} vs. Input Voltage (Switching)

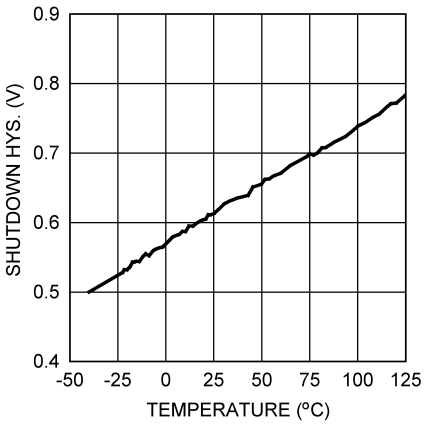


Figure 12. Shutdown Threshold Hysteresis vs. Temperature

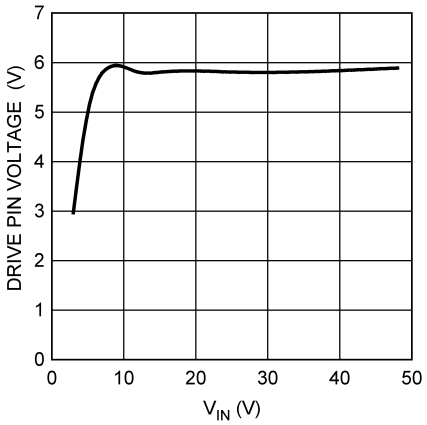


Figure 13. Drive Voltage vs. Input Voltage

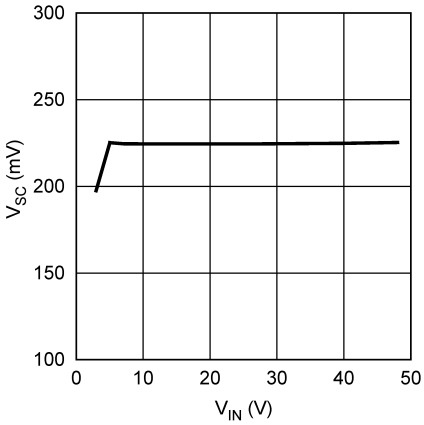


Figure 14. Short Circuit Protection vs. V_{IN}

Typical Characteristics (continued)

Unless otherwise specified, V_{IN} = 12 V, T_J = 25°C.

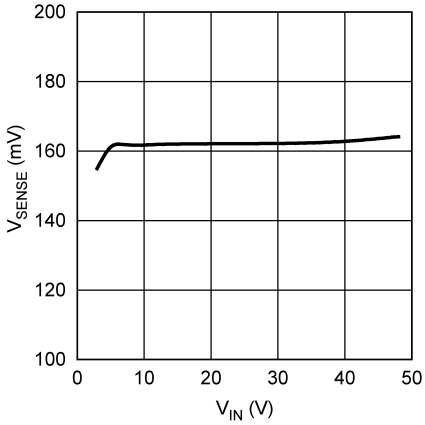


Figure 15. Current Sense Threshold vs. Input Voltage

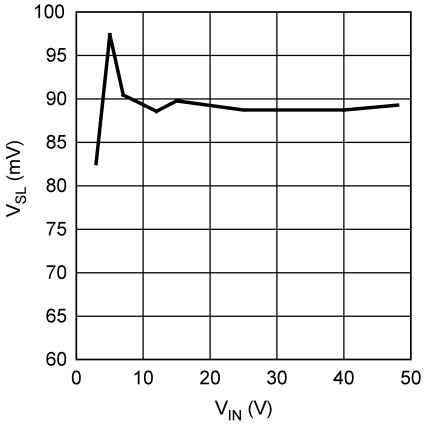


Figure 16. Compensation Ramp Amplitude vs. Input Voltage

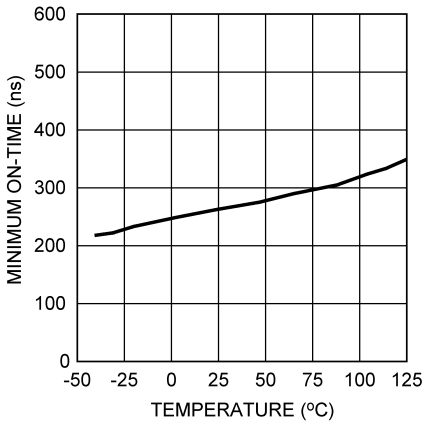


Figure 17. Minimum On-Time vs. Temperature

7 Detailed Description

7.1 Overview

The LM3481 device uses a fixed frequency, Pulse Width Modulated (PWM), current mode control architecture. In a typical application circuit, the peak current through the external MOSFET is sensed through an external sense resistor. The voltage across this resistor is fed into the I_{SEN} pin. This voltage is then level shifted and fed into the positive input of the PWM comparator. The output voltage is also sensed through an external feedback resistor divider network and fed into the error amplifier (EA) negative input (feedback pin, FB). The output of the error amplifier (COMP pin) is added to the slope compensation ramp and fed into the negative input of the PWM comparator.

At the start of any switching cycle, the oscillator sets the RS latch using the SET/Blank-out and switch logic blocks. This forces a high signal on the DR pin (gate of the external MOSFET) and the external MOSFET turns on. When the voltage on the positive input of the PWM comparator exceeds the negative input, the RS latch is reset and the external MOSFET turns off.

The voltage sensed across the sense resistor generally contains spurious noise spikes, as shown in Figure 18. These spikes can force the PWM comparator to reset the RS latch prematurely. To prevent these spikes from resetting the latch, a blank-out circuit inside the IC prevents the PWM comparator from resetting the latch for a short duration after the latch is set. This duration, called the blank-out time, is typically 250 ns and is specified as t_{min} (on) in the *Electrical Characteristics* section.

Under extremely light load or no-load conditions, the energy delivered to the output capacitor when the external MOSFET is on during the blank-out time is more than what is delivered to the load. An overvoltage comparator inside the LM3481 prevents the output voltage from rising under these conditions by sensing the feedback (FB pin) voltage and resetting the RS latch. The latch remains in a reset state until the output decays to the nominal value. Thus the operating frequency decreases at light loads, resulting in excellent efficiency.

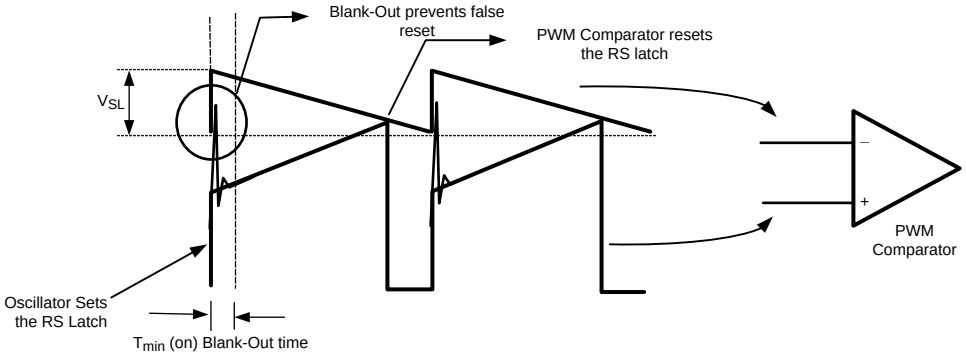


Figure 18. Basic Operation of the PWM Comparator

7.2 Functional Block Diagram

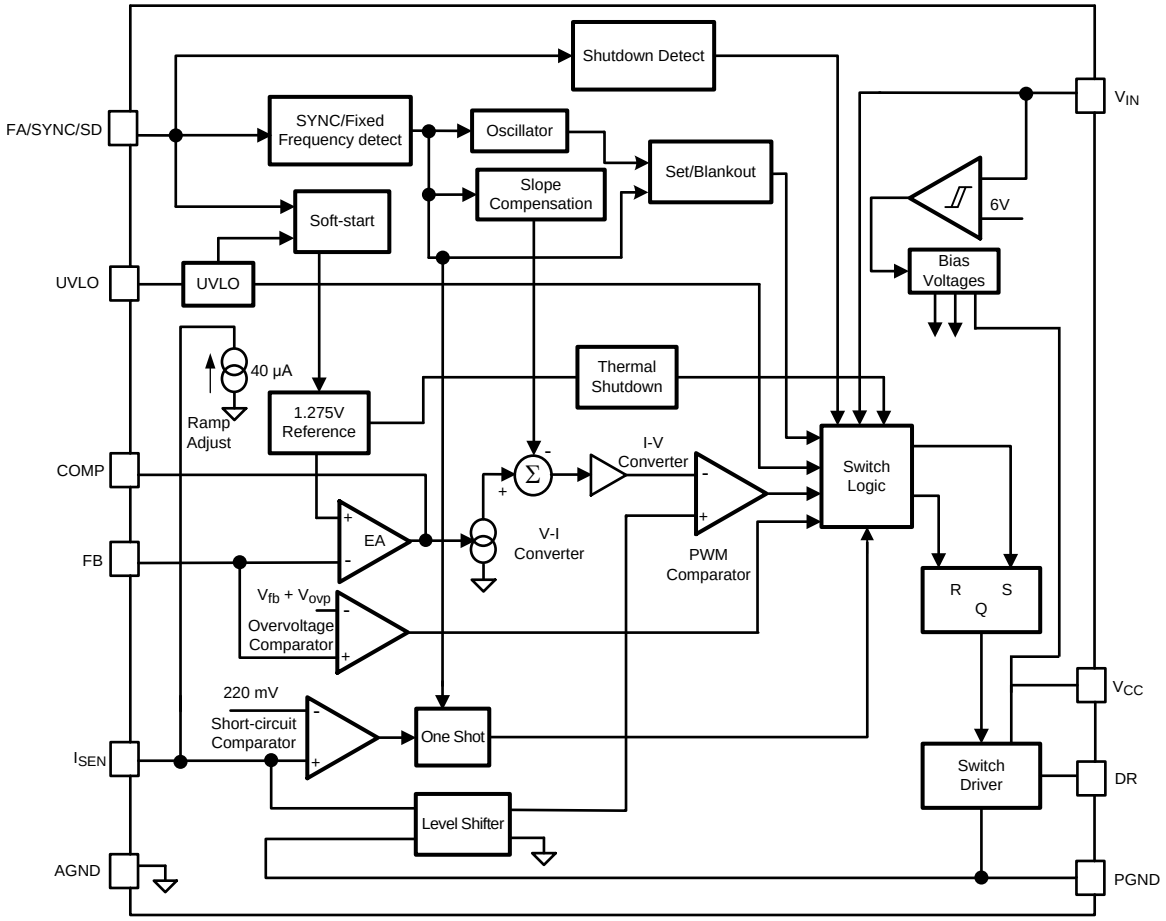


Figure 19. LM3481 Simplified Functional Block Diagram

7.3 Feature Description

7.3.1 Overvoltage Protection

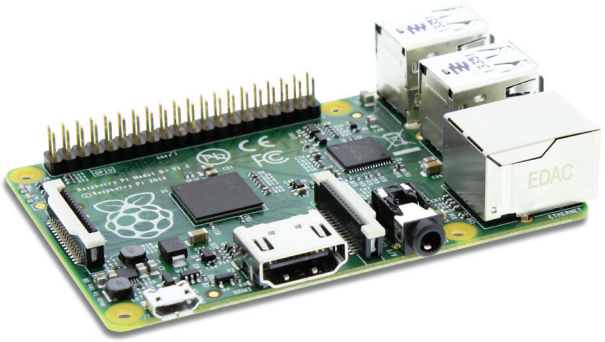
The LM3481 has overvoltage protection (OVP) for the output voltage. OVP is sensed at the feedback pin (FB). If at anytime the voltage at the feedback pin rises to V_{FB} + V_{OVP}, OVP is triggered. See the *Electrical Characteristics* section for limits on V_{FB} and V_{OVP}.

OVP will cause the drive pin (DR) to go low, forcing the power MOSFET off. With the MOSFET off, the output voltage will drop. The LM3481 will begin switching again when the feedback voltage reaches V_{FB} + (V_{OVP} - $V_{OVP(HYS)}$). See the *Electrical Characteristics* section for limits on $V_{OVP(HYS)}$. The Error Amplifier is operationnal during OVP events.

7.3.2 Bias Voltage

The internal bias of the LM3481 comes from either the internal bias voltage generator as shown in the block diagram or directly from the voltage at the VIN pin. At input voltages lower than 6 V the internal IC bias is the input voltage and at voltages above 6 V the internal bias voltage generator of the LM3481 provides the bias. The voltage for the gate driver is output on the VCC pin for compensation by an external capacitor (0.47µF to 4.7µF depending on the FET requirements). Biasing the VCC pin by an external voltage source should not be attempted.

Raspberry Pi



MODEL B+

Product Name	**Raspberry Pi Model B+**
Product Description	The Raspberry Pi Model B+ incorporates a number of enhancements and new features. Improved power consumption, increased connectivity and greater IO are among the improvements to this powerful, small and lightweight ARM based computer.

Specifications

Chip	Broadcom BCM2835 SoC
Core architecture	ARM11
CPU	700 MHz Low Power ARM1176JZFS Applications Processor
GPU	Dual Core VideoCore IV® Multimedia Co-Processor
	Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode
	Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure
Memory	512MB SDRAM
Operating System	Boots from Micro SD card, running a version of the Linux operating system
Dimensions	85 x 56 x 17mm
Power	Micro USB socket 5V, 2A

Connectors:

Ethernet	10/100 BaseT Ethernet socket
Video Output	HDMI (rev 1.3 & 1.4)
	Composite RCA (PAL and NTSC)
Audio Output	3.5mm jack, HDMI
USB	4 x USB 2.0 Connector
GPIO Connector	40-pin 2.54 mm (100 mil) expansion header: 2x20 strip
	Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines
Camera Connector	15-pin MIPI Camera Serial Interface (CSI-2)
JTAG	Not populated
Display Connector	Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane
Memory Card Slot	SDIO

ESCUELA UNIVERSITARIA POLITÉCNICA

DE LA ALMUNIA DE DOÑA GODINA (ZARAGOZA)

PLANOS

Diseño de un Robot Bombero en Edificios

424.13.136

Autor: Juan Hernández Vicén

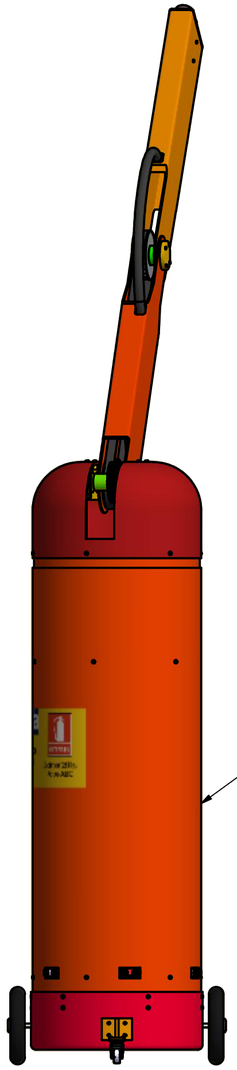
Director: Javier Esteban Escaño

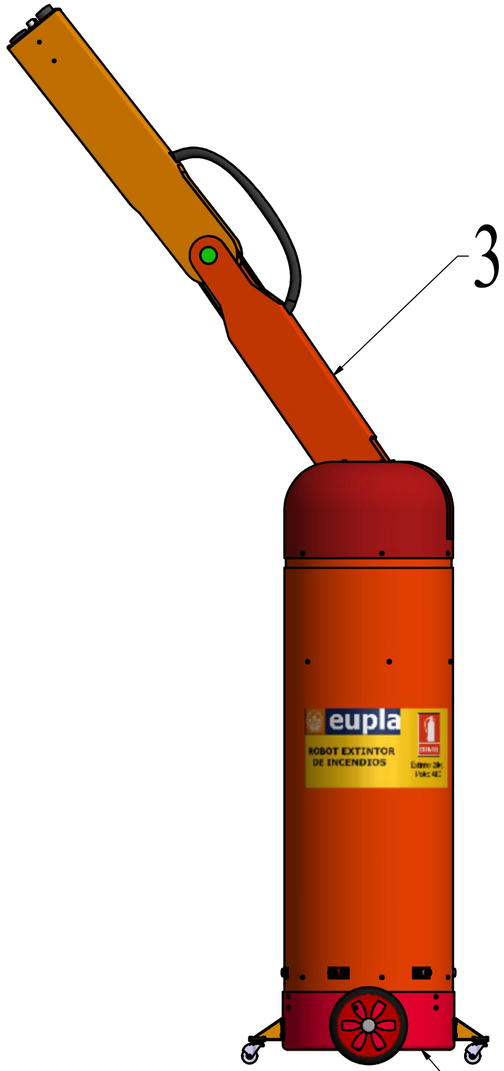
Fecha: Julio 2015

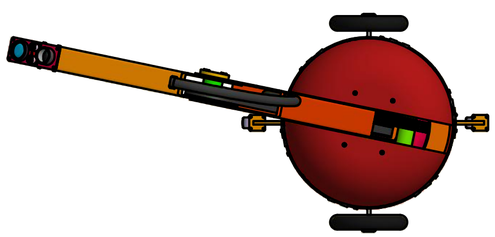
ÍNDICE PLANOS

PLANOS ELÉCTRICOS: 424.13.136.02.XXX

Esquema electrónica	424.13.136.02.001
PCB electrónica	424.13.136.02.002
Esquema alimentación	424.13.136.02.003
PCB alimentación	424.13.136.02.004







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200	1	TRONCO	424.13.136.01.200	424.13.136.01.200
100	1	BASE	424.13.136.01.100	424.13.136.01.100
MARCA	CTDAD	DENOMINACIÓN Y CARACTERÍSTICAS	Nº PLANO/ ABRE.NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales	Observaciones de plano
Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS **Palabras clave:** **Empresa:** EUPLA **Estado del proyecto:** En curso **Versión:** V2	**Plano nº:** 1 **de:** 1 **Formato:** A2 **Coment:**

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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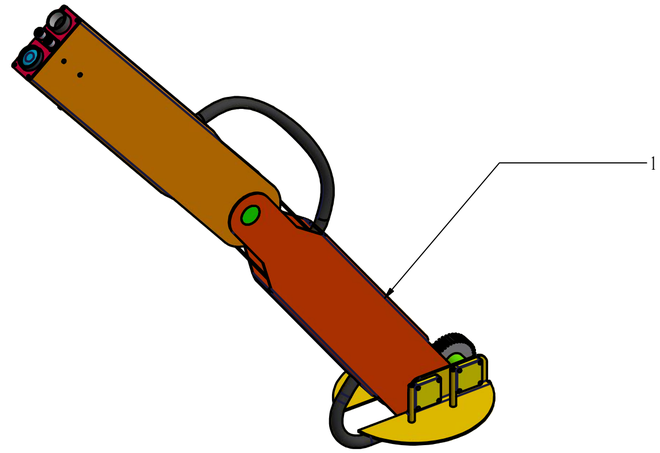
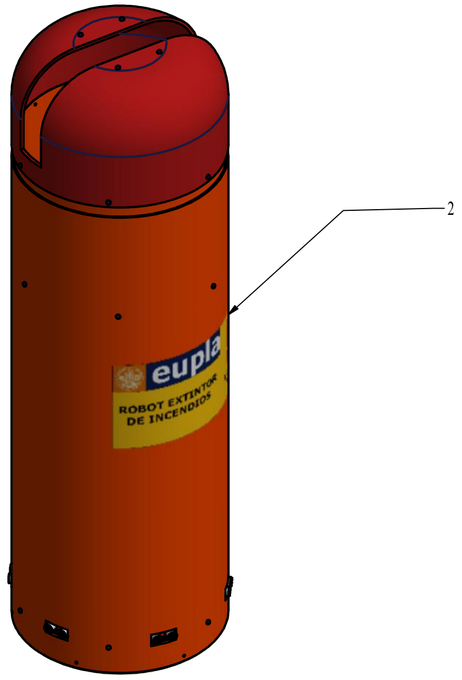
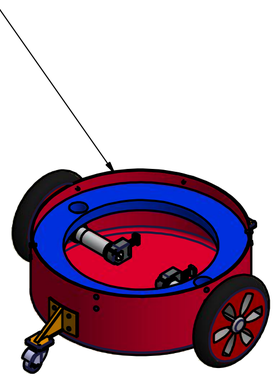
La Almunia de Dª Godina -ZARAGOZA-

ESCALA 1:9	**ROBOT BOMBERO** Plano General	**Nº P.:** 424.13.136.01.001 **Nº O.:** 424.13.136 **Nom.Ar.:** Plano general.idw







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2	1	GRUPO TRONCO	424.13.136.200	Acero F-314
3	1	GRUPO BRAZO	424.13.136.300	Acero F-314

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V1

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A2
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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La Almunia de Dª Godina -ZARAGOZA-

ESCALA

ROBOT BOMBERO

PLANO GENERAL
EXPLOSIONADO

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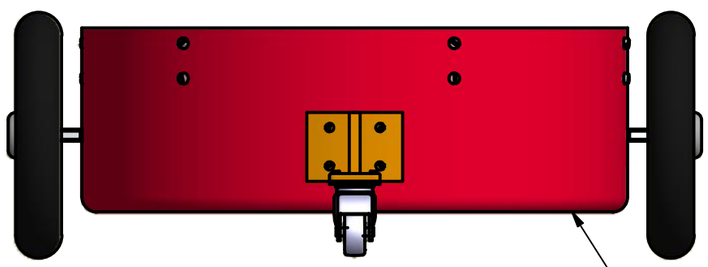
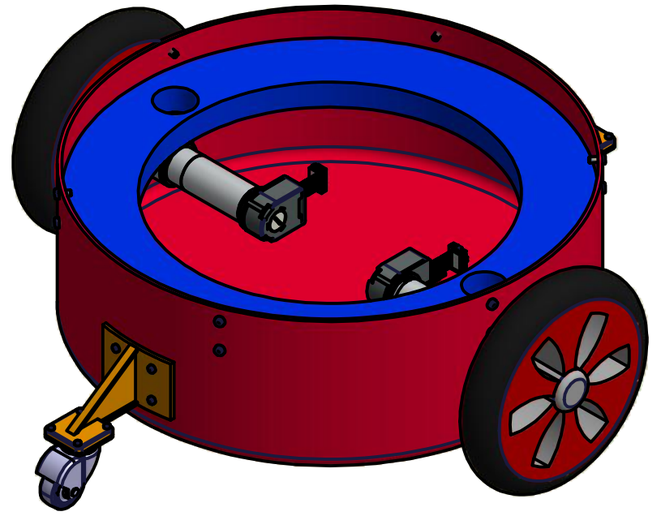
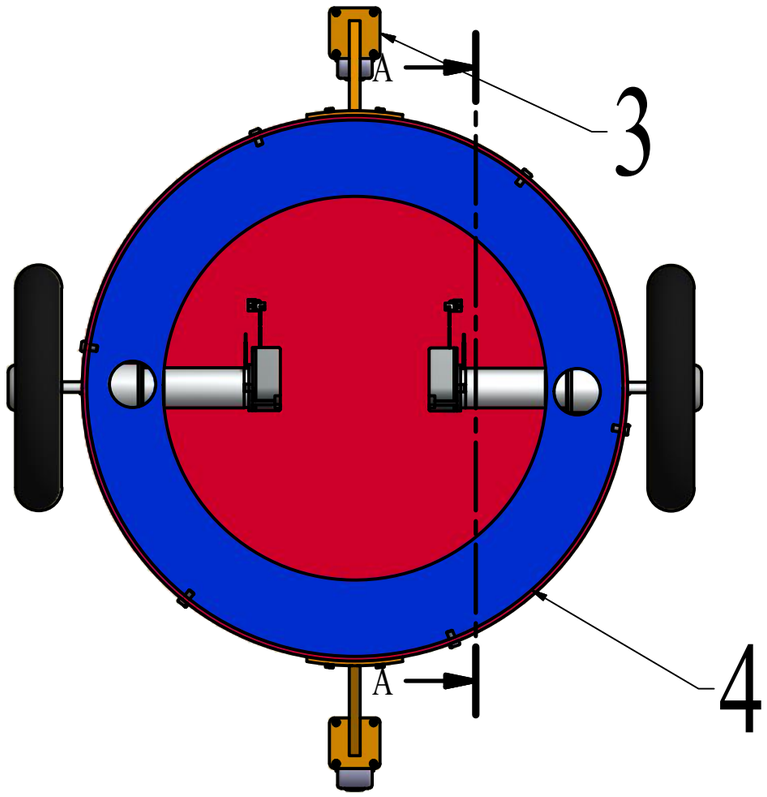
Nº O.: 424.13.136
Nom.Ar.: Explosionado general Robot.idw







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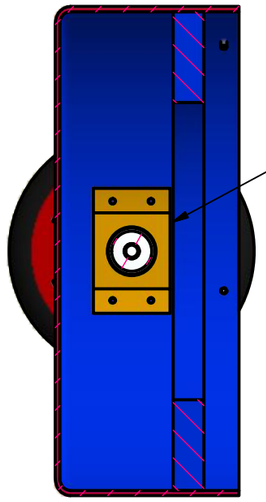

IDENTIFICACIÓN DE GRUPO EN PLANO 424.13.136.01.001

MARCA	CTDAD	DENOMINACIÓN Y CARACTERÍSTICAS	Nº PLANO/ ABRE.NORMA	MATERIAL/OBSERVACIONES
4	1	Soporte tronco	424.13.136.01.104	Acero F-314
3	2	Soporte rueda loca	424.13.136.01.103	Acero F-314
2	2	Soporte motor	424.13.136.01.102	Acero F-314
1	1	Base robot	424.13.136.01.101	Acero F-314

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V1

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:4

ROBOT BOMBERO
BASE (GRUPO 100)
GRUPO BASE

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La Almunia de Dª Godina -ZARAGOZA-

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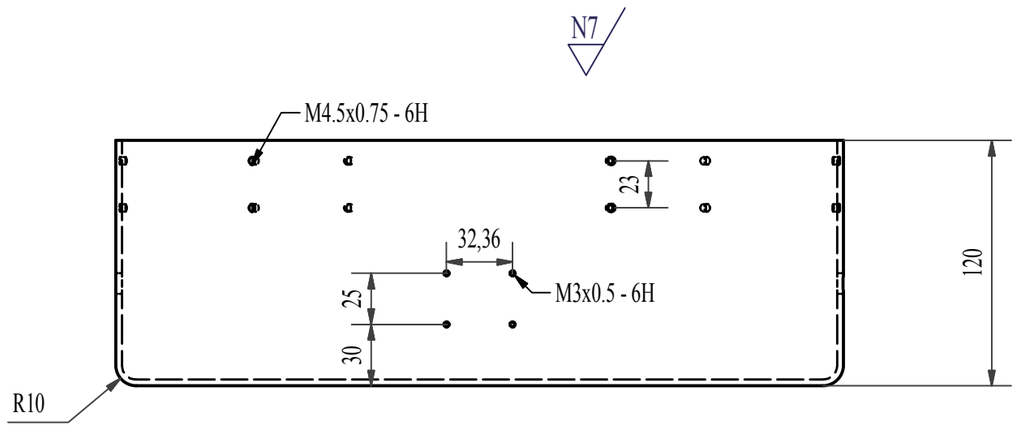
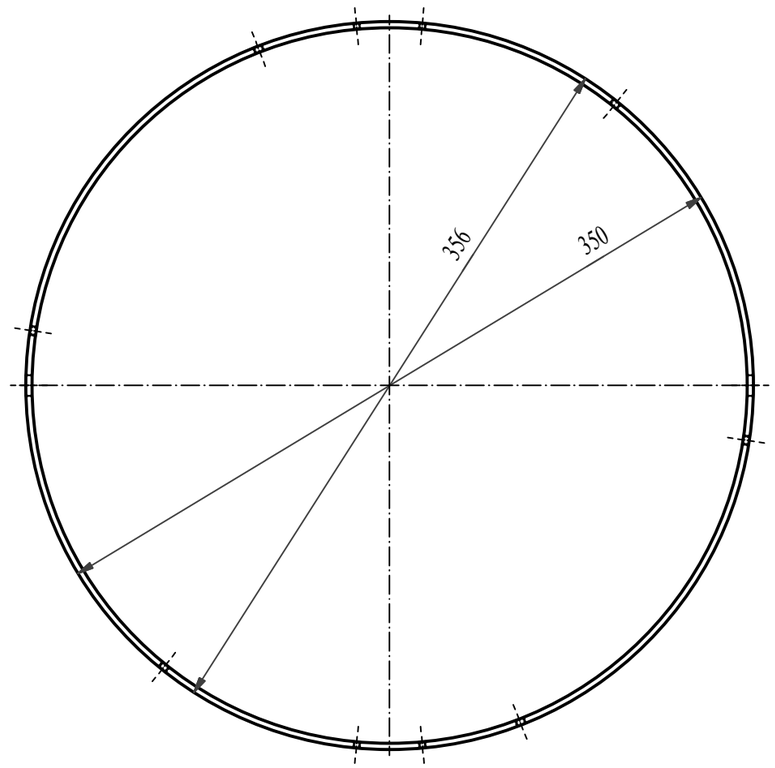
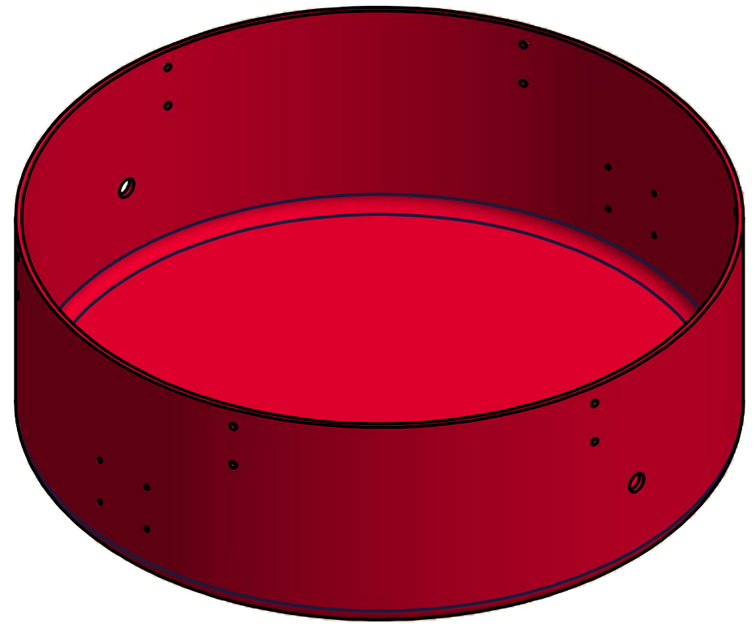
Nº O.: 424.13.136
Nom.Ar.: BLOQUE BASE.idw







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MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V6

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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La Almunia de Dª Godina -ZARAGOZA-

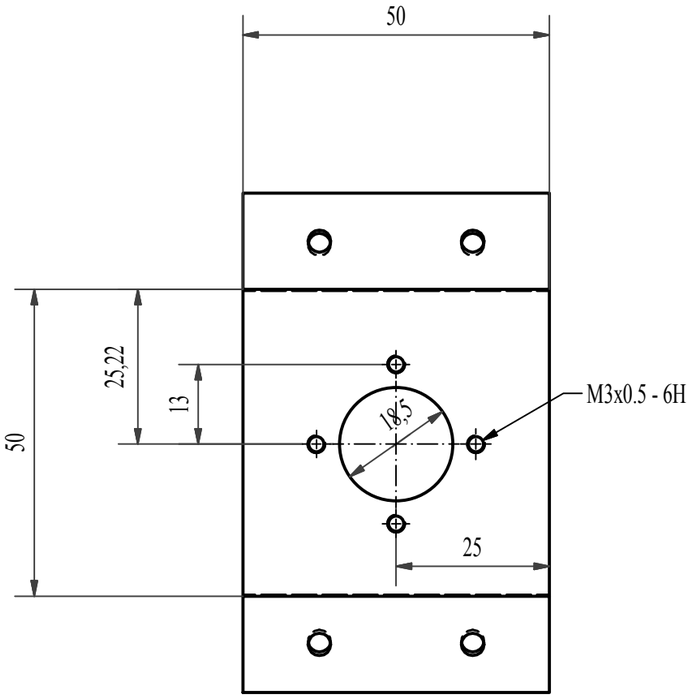
ESCALA 1:3

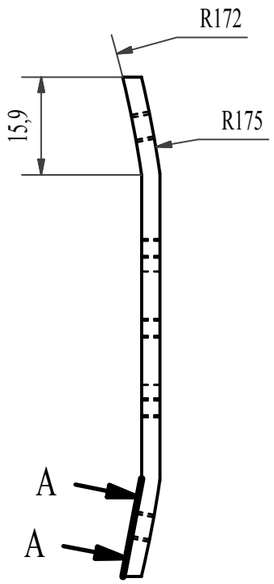
ROBOT BOMBERO

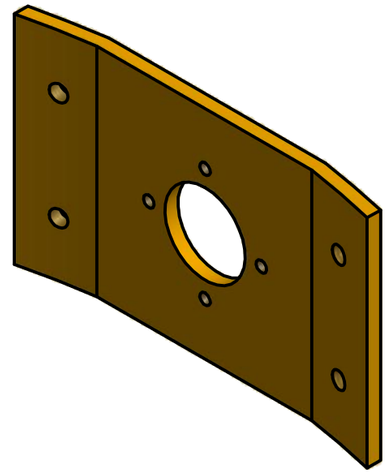
BASE (GRUPO 100)
Base robot

Nº P.: 424.13.136.01.101
Nº O.: 424.13.136
Nom.Ar.: Base Robot.idw

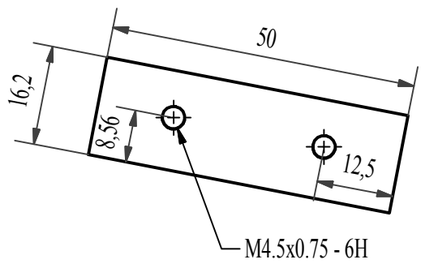
N7







A-A (1 : 1)



102	2	Soporte motor	424.13.136.01.102	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V5

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:1

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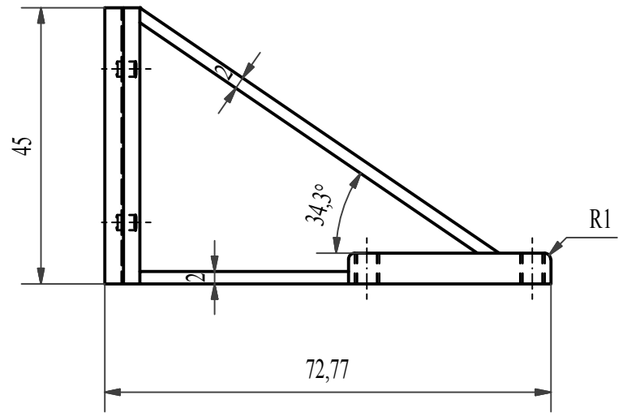
La Almunia de Dª Godina -ZARAGOZA-

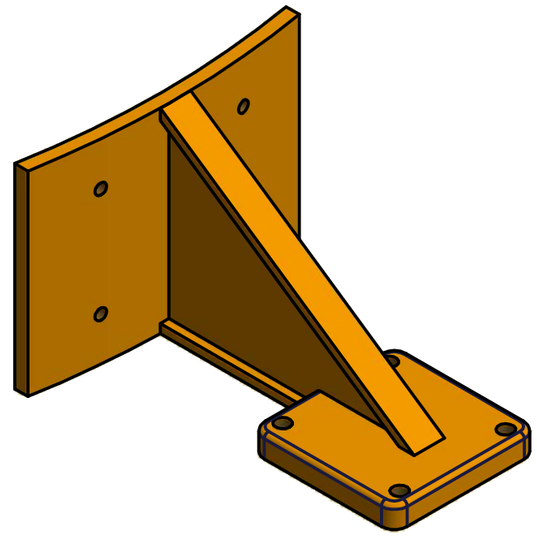
ROBOT BOMBERO

BASE (GRUPO 100)
Soporte motor

Nº P.: 424.13.136.01.102
Nº O.: 424.13.136
Nom.Ar.: Soporte motor.idw

N7





103	2	Soporte rueda loca	424.13.136.01.103	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:1

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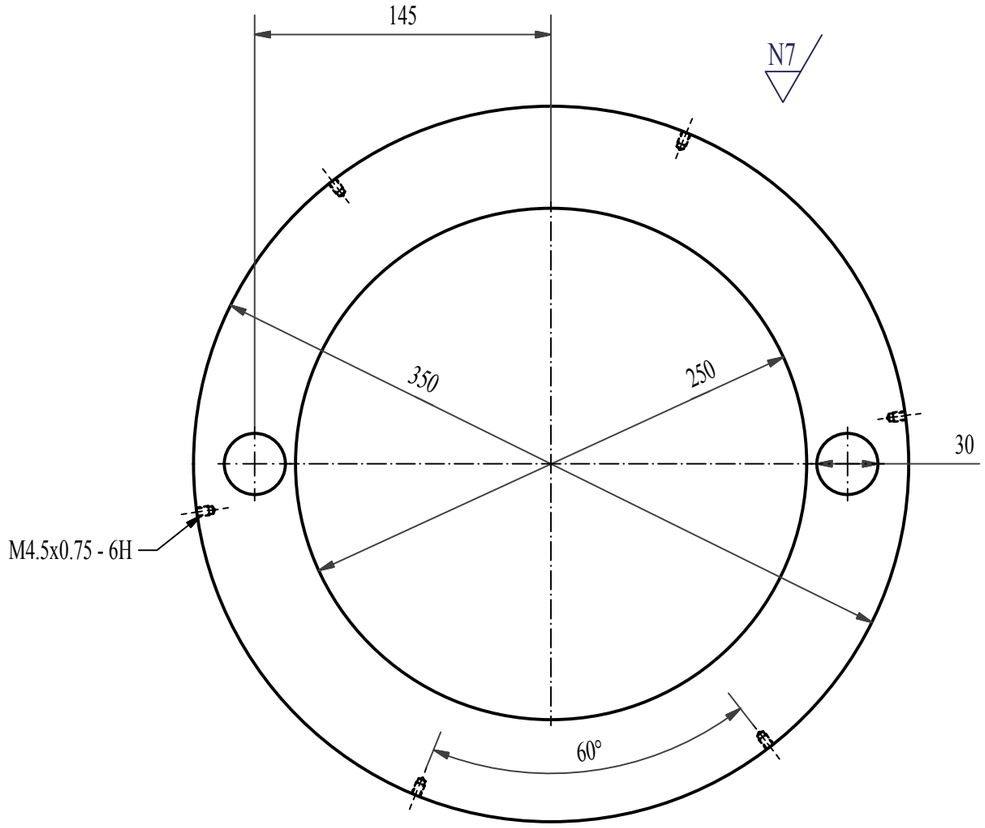
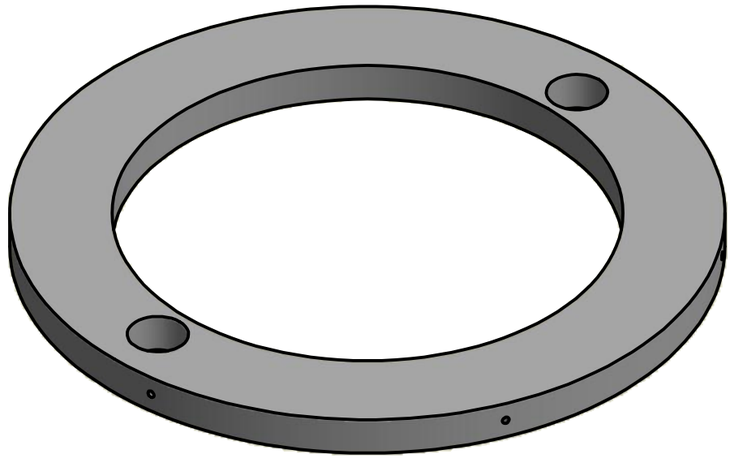
La Almunia de Dª Godina -ZARAGOZA-

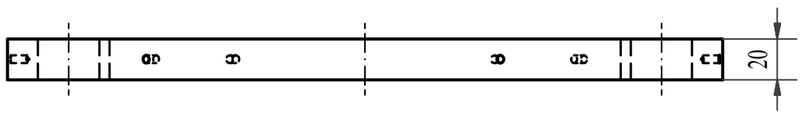
ROBOT BOMBERO

BASE (GRUPO 100)
Soporte rueda loca

Nº P.: 424.13.136.01.103
Nº O.: 424.13.136
Nom.Ar.: Soporte Rueda Loca.idw







104	1	Soporte tronco	424.13.136.01.104	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:3

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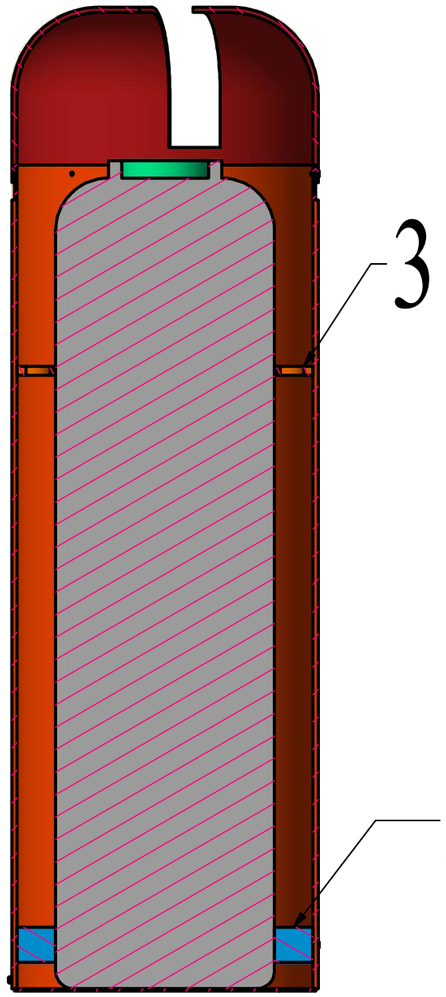
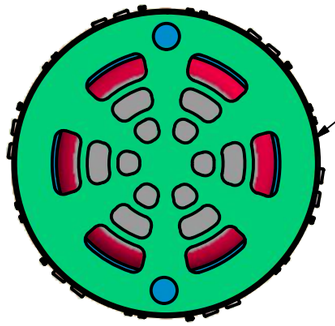
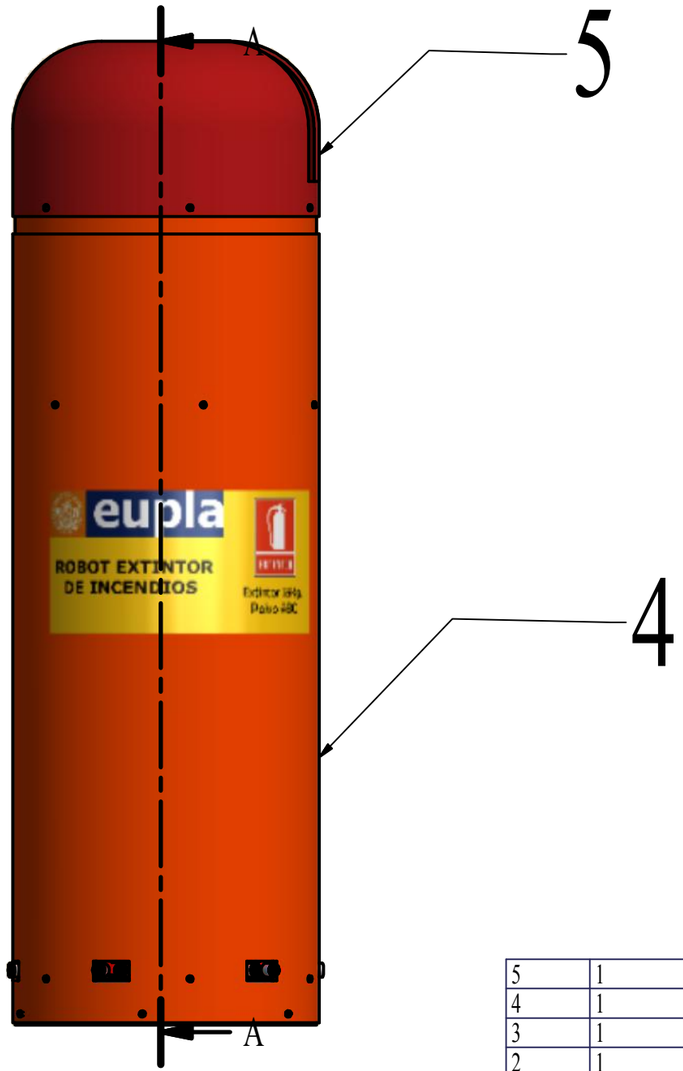
ROBOT BOMBERO

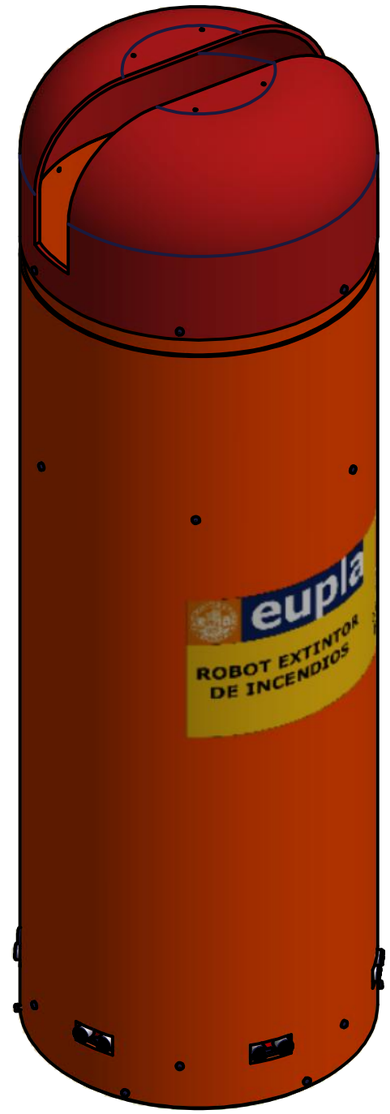
BASE (GRUPO 100)
Soporte tronco

Nº P.: 424.13.136.01.104
Nº O.: 424.13.136
Nom.Ar.: Soporte tronco.idw









IDENTIFICACIÓN DE GRUPO EN PLANO 424.13.136.01.001

5	1	Casco robot	424.13.136.01.205	Acero F-314
4	1	Tronco robot	424.13.136.01.204	Acero F-314
3	1	Soporte extintor	424.13.136.01.203	Acero F-314
2	1	Batería ultrasonidos	424.13.136.01.202	Acero F-314
1	1	Plato extintor	424.13.136.01.201	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERÍSTICAS	Nº PLANO/ ABRE.NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V1

Observaciones de plano

Plano nº: 1 **de:** 3
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:7

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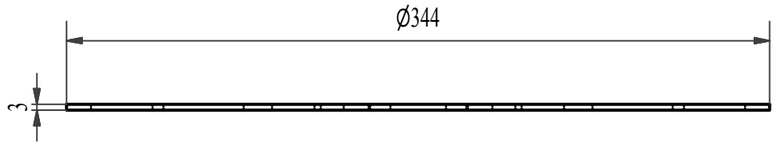
La Almunia de Dª Godina -ZARAGOZA-

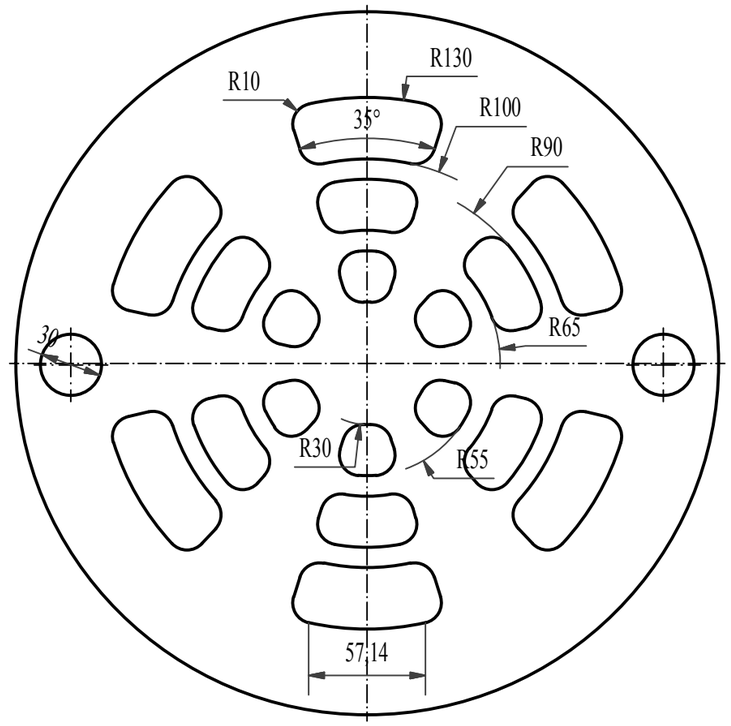
ROBOT BOMBERO

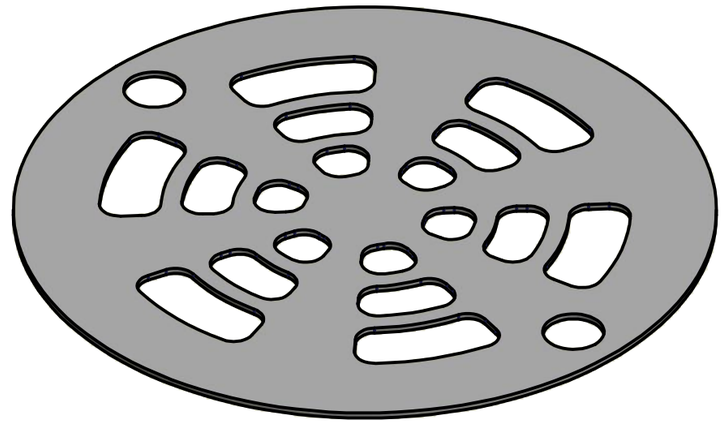
TRONCO (GRUPO 200)
GRUPO TRONCO

Nº P.: 424.13.136.01.200
Nº O.: 424.13.136
Nom.Ar.: BLOQUE TRONCO.idw

N7







201	1	Plato extintor	424.13.136.01.201	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:3

ROBOT BOMBERO
TRONCO (GRUPO 200)
Plato extintor

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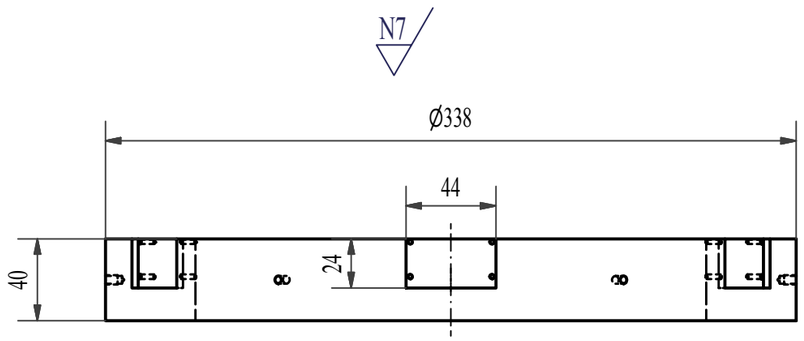
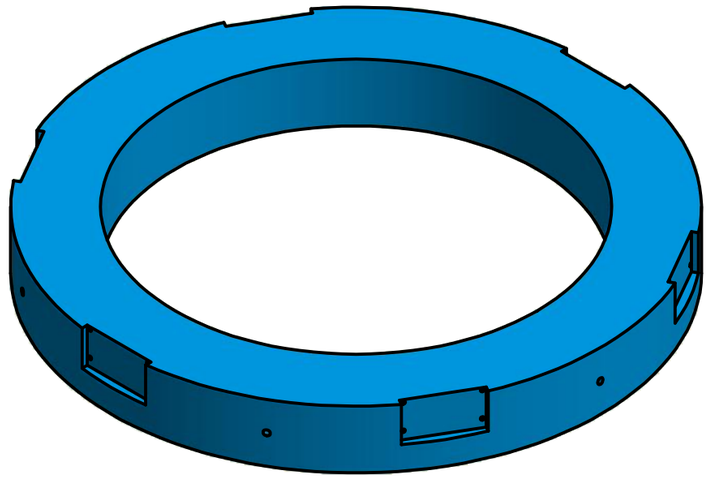
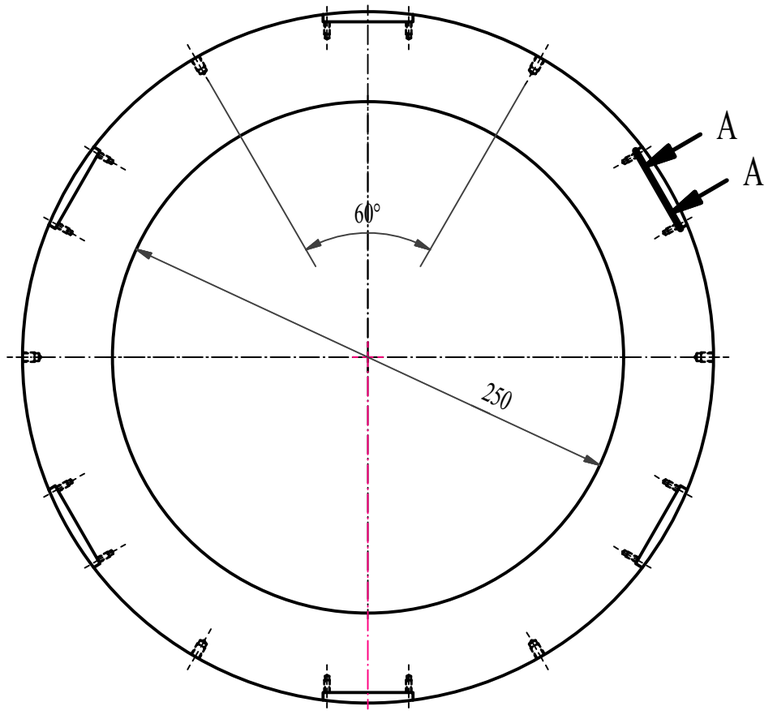
La Almunia de Dª Godina -ZARAGOZA-

Nº P.: 424.13.136.01.201
Nº O.: 424.13.136
Nom.Ar.: Plato extintor.idw







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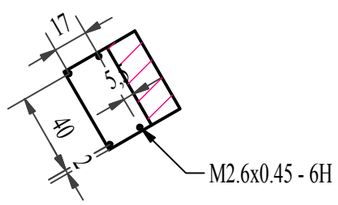

202	1	Batería ultrasonidos	424.13.136.01.202	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales	Observaciones de plano
Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS **Palabras clave:** **Empresa:** EUPLA **Estado del proyecto:** En curso **Versión:** V4	**Plano nº:** 1 **de:** 1 **Formato:** A3 **Coment:**

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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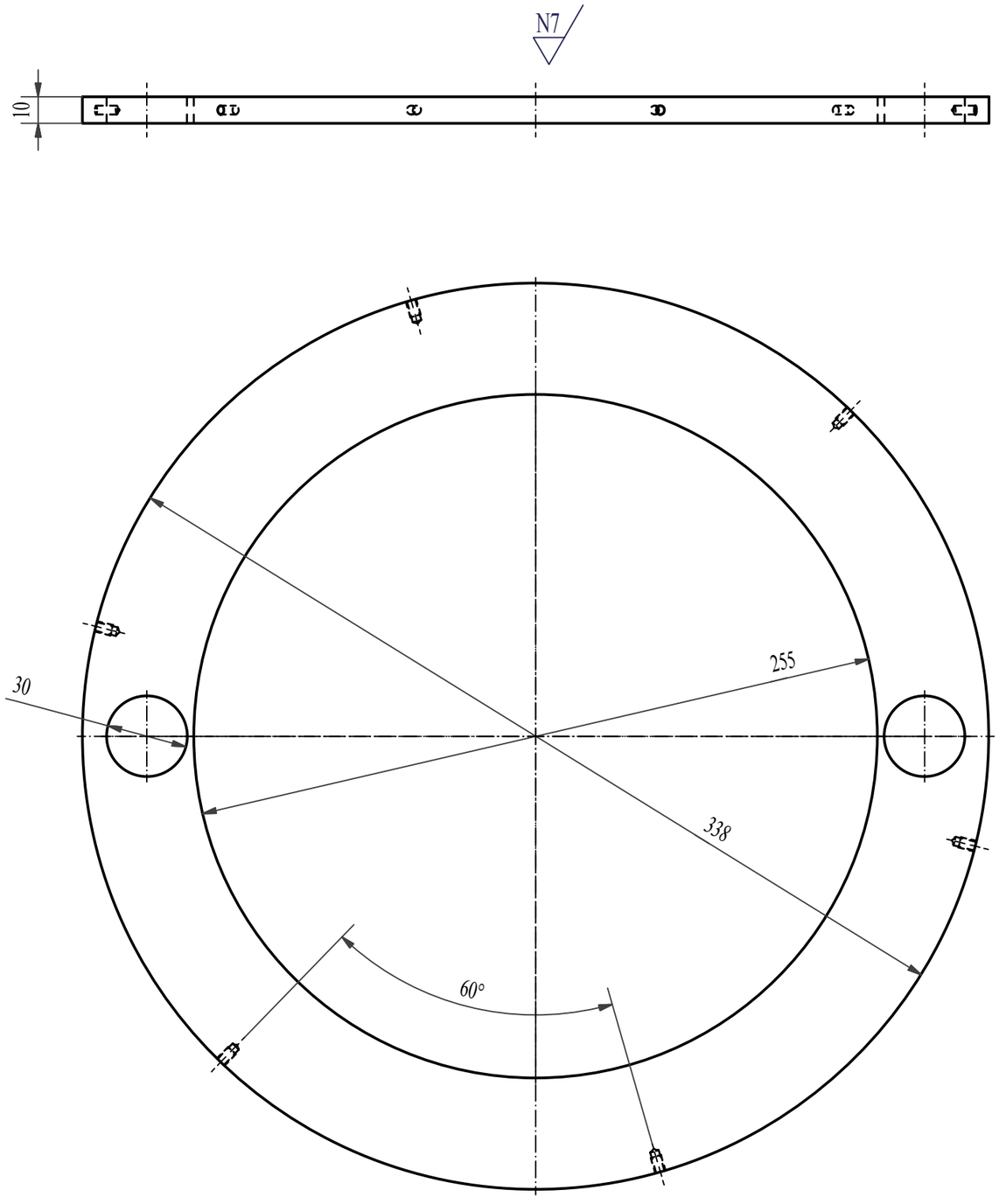
La Almunia de Dª Godina -ZARAGOZA-

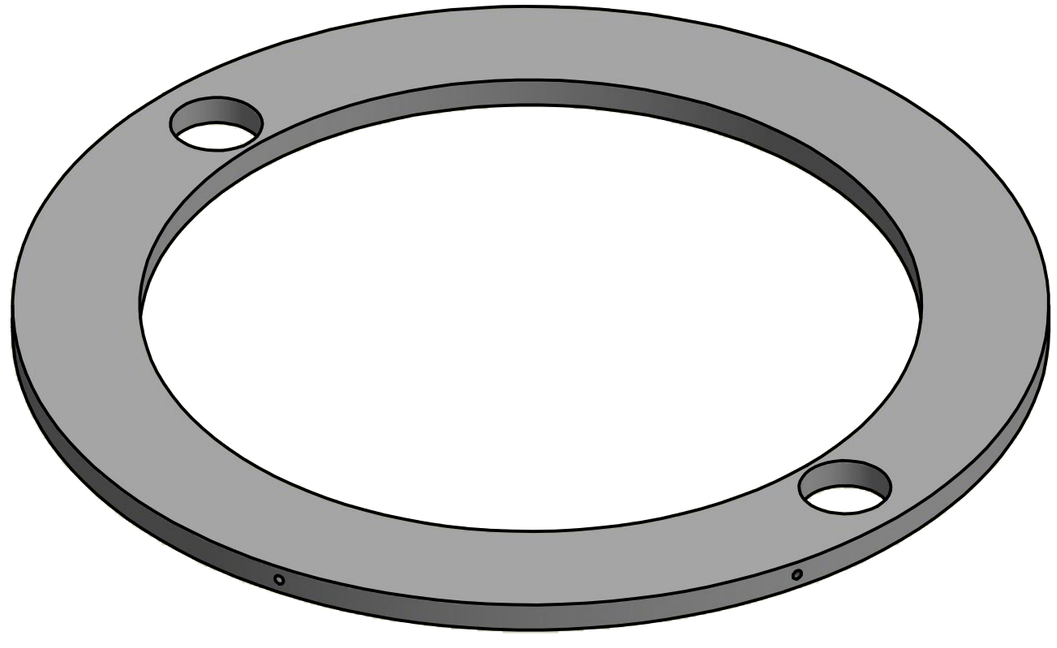
ESCALA 1:3

ROBOT BOMBERO

TRONCO (GRUPO 200)
Batería ultrasonidos

Nº P.: 424.13.136.01.202
Nº O.: 424.13.136.01
Nom.Ar.: Bateria ultrasonidos.idw





203	1	Soporte extintor	424.13.136.01.203	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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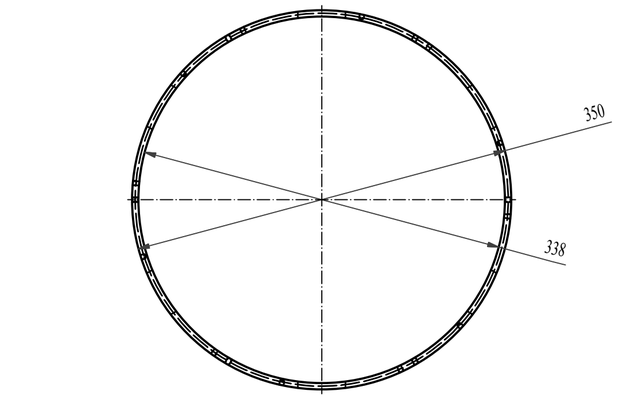
La Almunia de Dª Godina -ZARAGOZA-

ESCALA 1:2

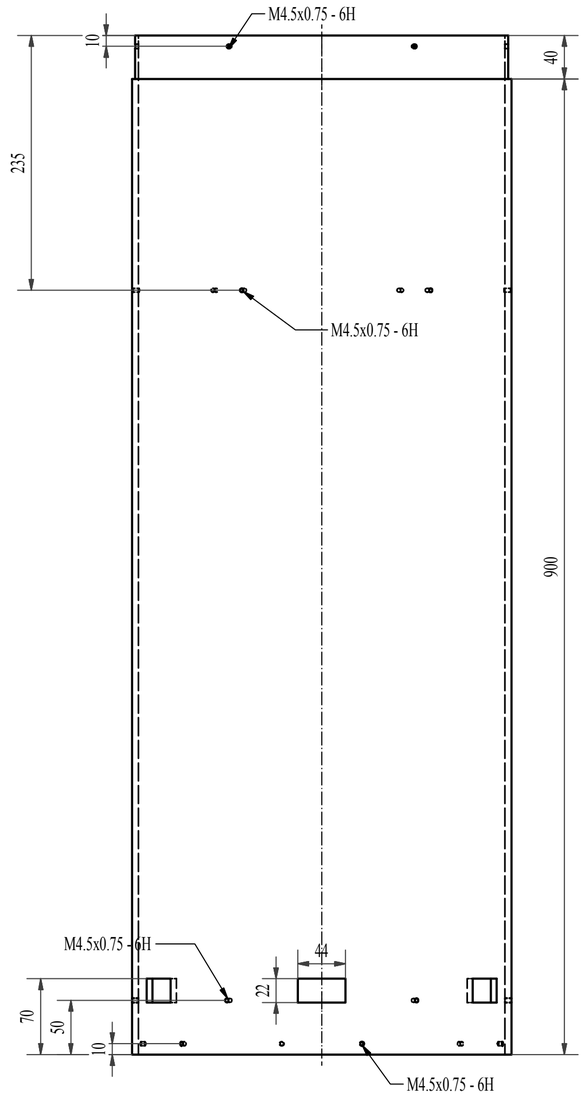
ROBOT BOMBERO

TRONCO (GRUPO 200)
Soporte extintor

Nº P.: 424.13.136.01.203
Nº O.: 424.13.136
Nom.Ar.: Soporte Extintor.idw



N7



1	1	Tronco robot	424.13.136.01.204	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales	Observaciones de plano
Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS **Palabras clave:** **Empresa:** EUPLA **Estado del proyecto:** En curso **Versión:** V3	**Plano nº:** 1 **de:** 1 **Formato:** A2 **Coment:**

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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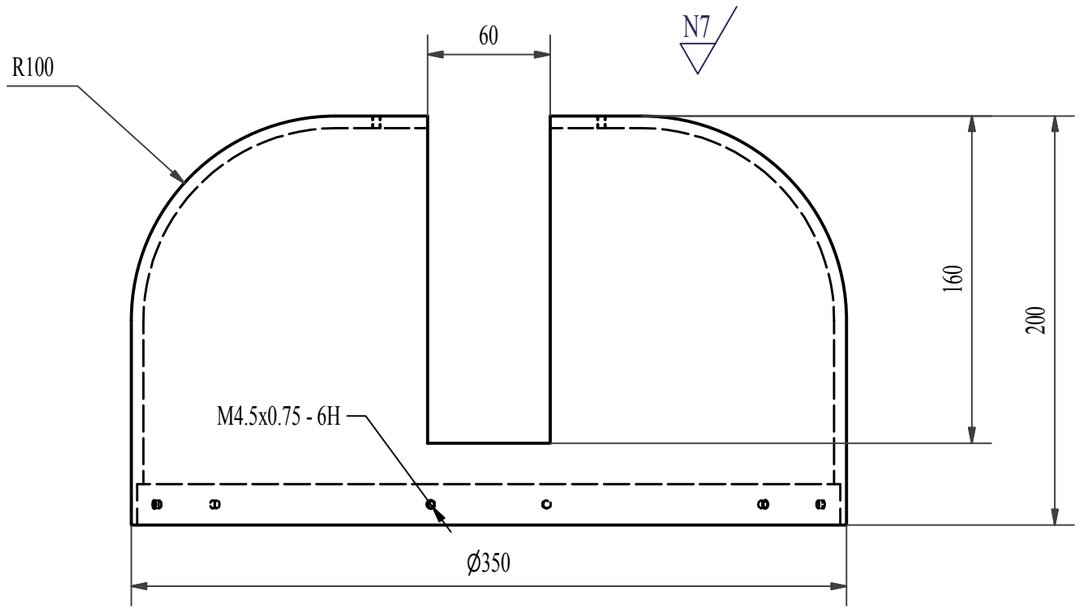
La Almunia de Dª Godina -ZARAGOZA-

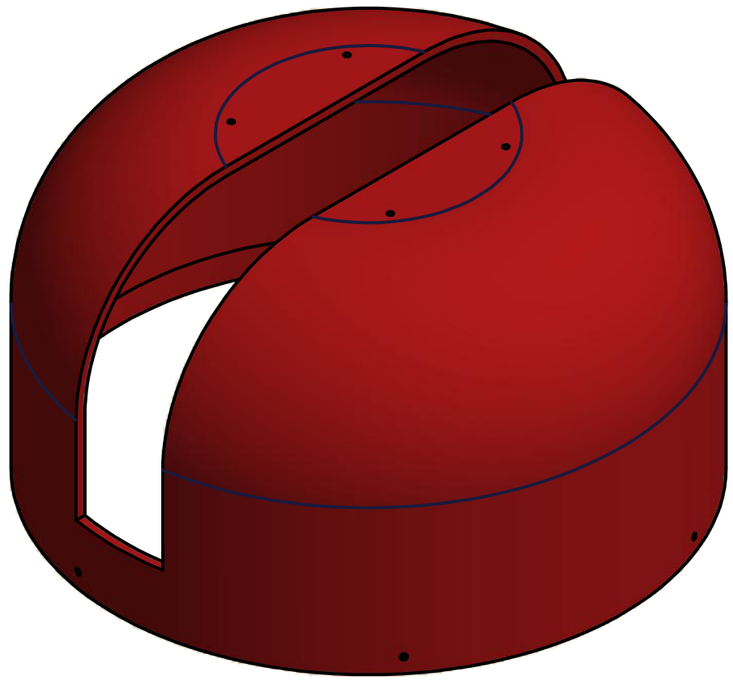
ESCALA 1:4

ROBOT BOMBERO

TRONCO (GRUPO 200)
Tronco robot

Nº P.: 424.13.136.01.204
Nº O.: 424.13.136
Nom.Ar.: Tronco Robot.idw





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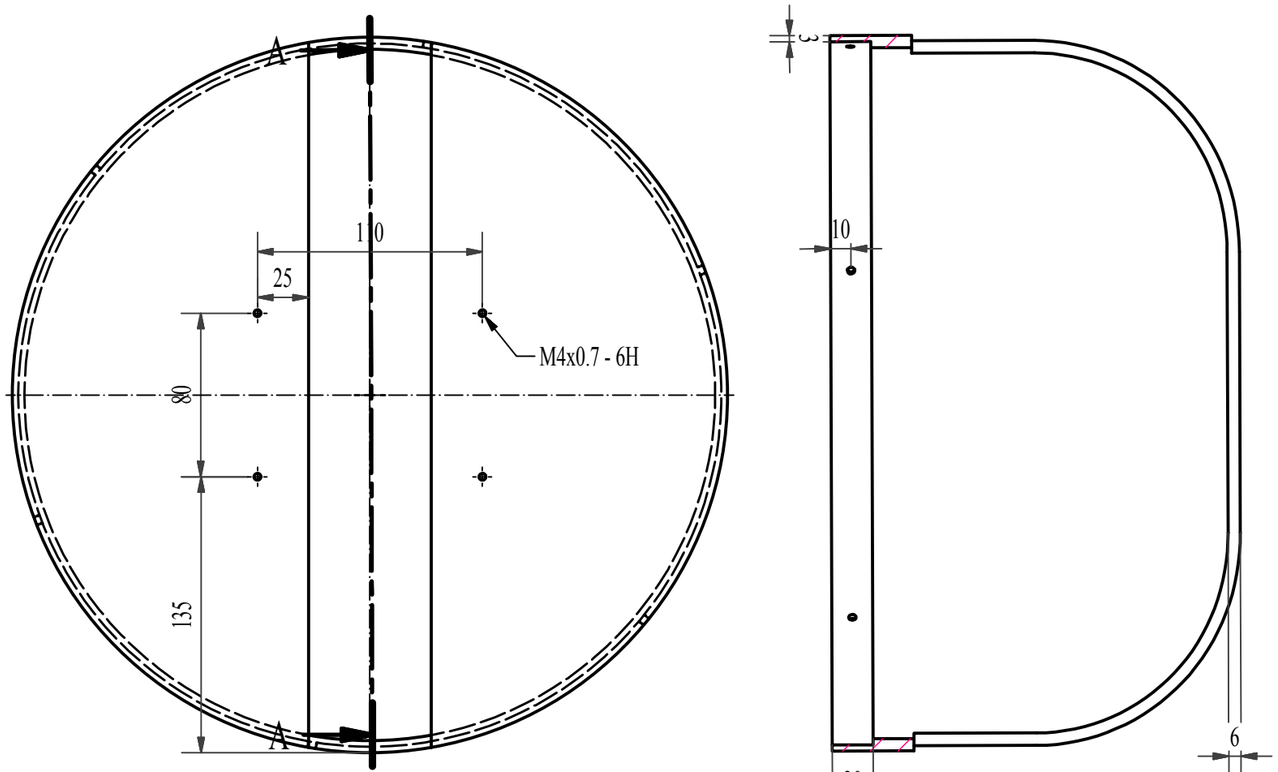

205	1	Casco robot	424.13.136.01.205	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA

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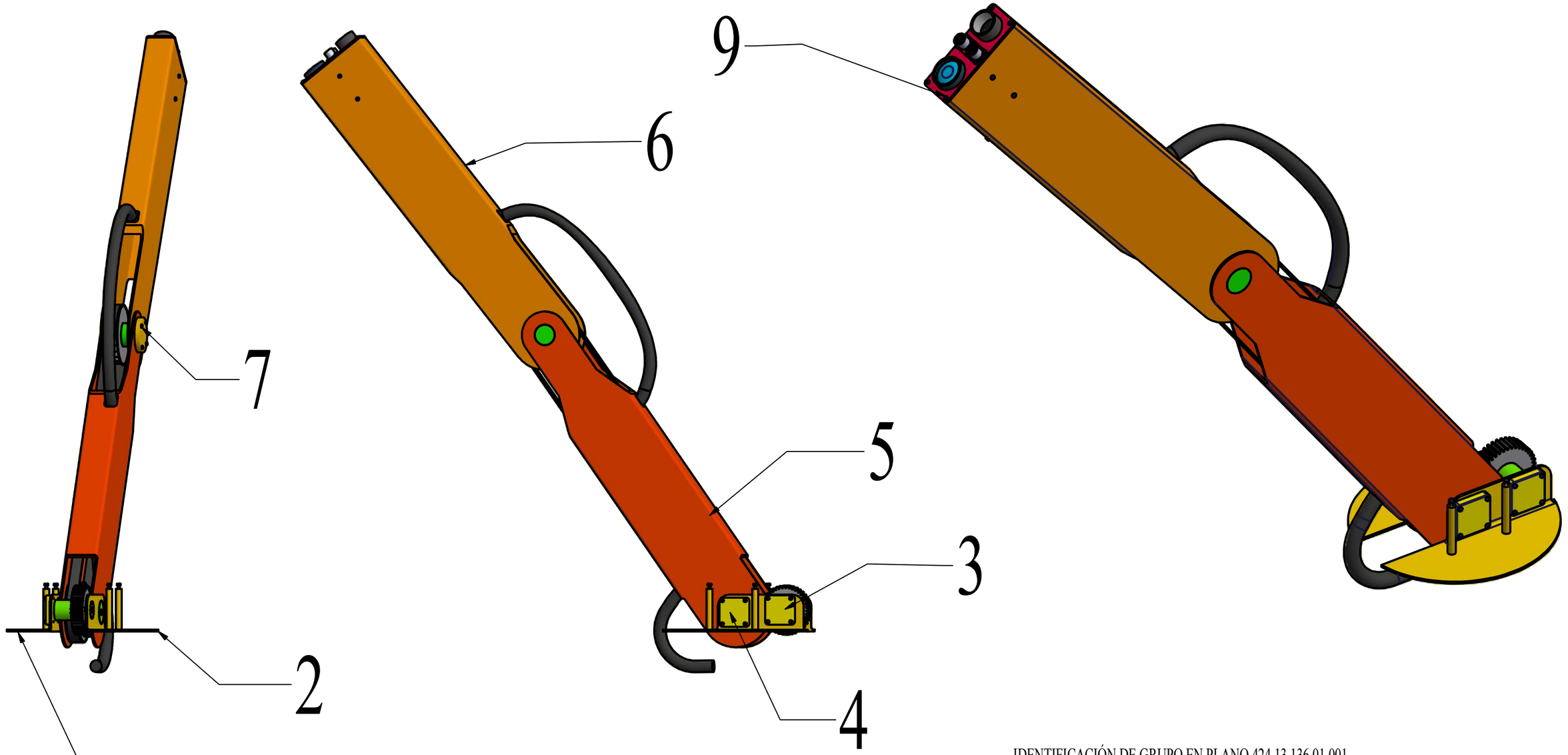
La Almunia de Dª Godina -ZARAGOZA-

ROBOT BOMBERO

TRONCO (GRUPO 200)
Casco robot

Nº P.: 424.13.136.01.205
Nº O.: 424.13.136
Nom.Ar.: Casco Robot.idw



IDENTIFICACIÓN DE GRUPO EN PLANO 424.13.136.01.001

MARCA	CTDAD	DENOMINACIÓN Y CARACTERÍSTICAS	Nº PLANO/ ABRE.NORMA	MATERIAL/OBSERVACIONES
9	1	Tapa brazo	424.13.136.01.309	Acero F-314
8	1	Soporte cámara	424.13.136.01.308	Acero F-314
7	1	Límite eje brazo	424.13.136.01.307	Acero F-314
6	1	Brazo robot	424.13.136.01.306	Acero F-314
5	1	Antebrazo robot	424.13.136.01.305	Acero F-314
4	1	Límite eje antebrazo	424.13.136.01.304	Acero F-314
3	1	Límite eje antebrazo 2	424.13.136.01.303	Acero F-314
2	1	Base motor casco izq	424.13.136.01.302	Acero F-314
1	1	Base motor casco	424.13.136.01.301	Acero F-314

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V1

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA

ROBOT BOMBERO

BRAZO (GRUPO 300)
GRUPO BRAZO

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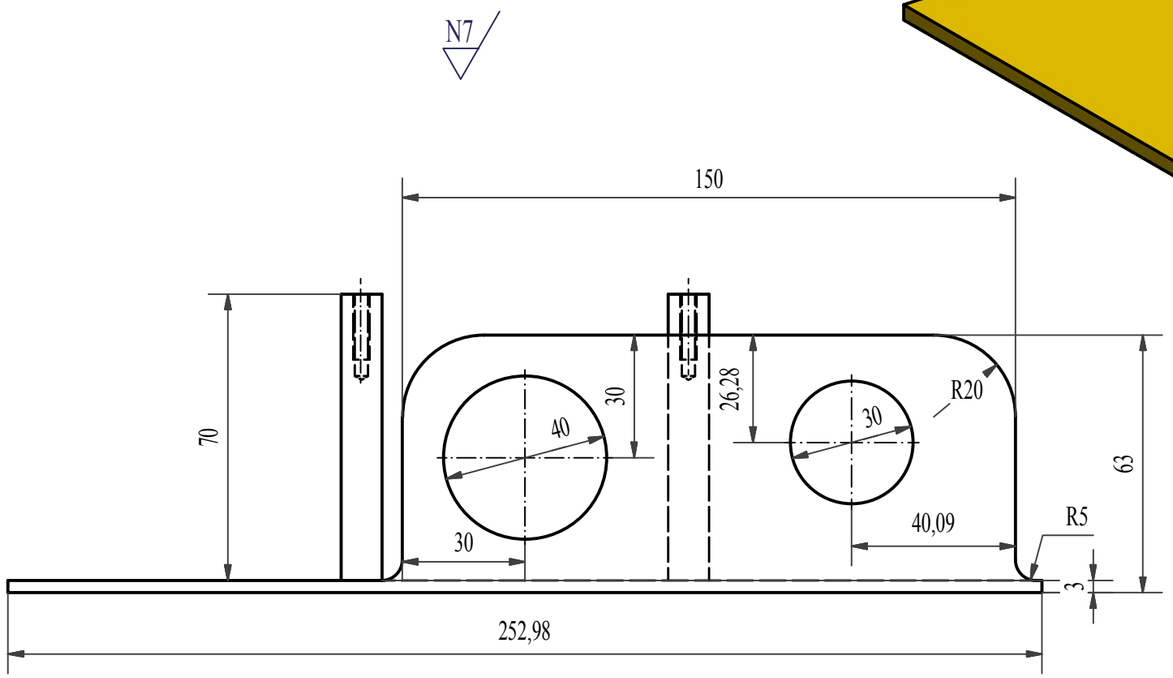
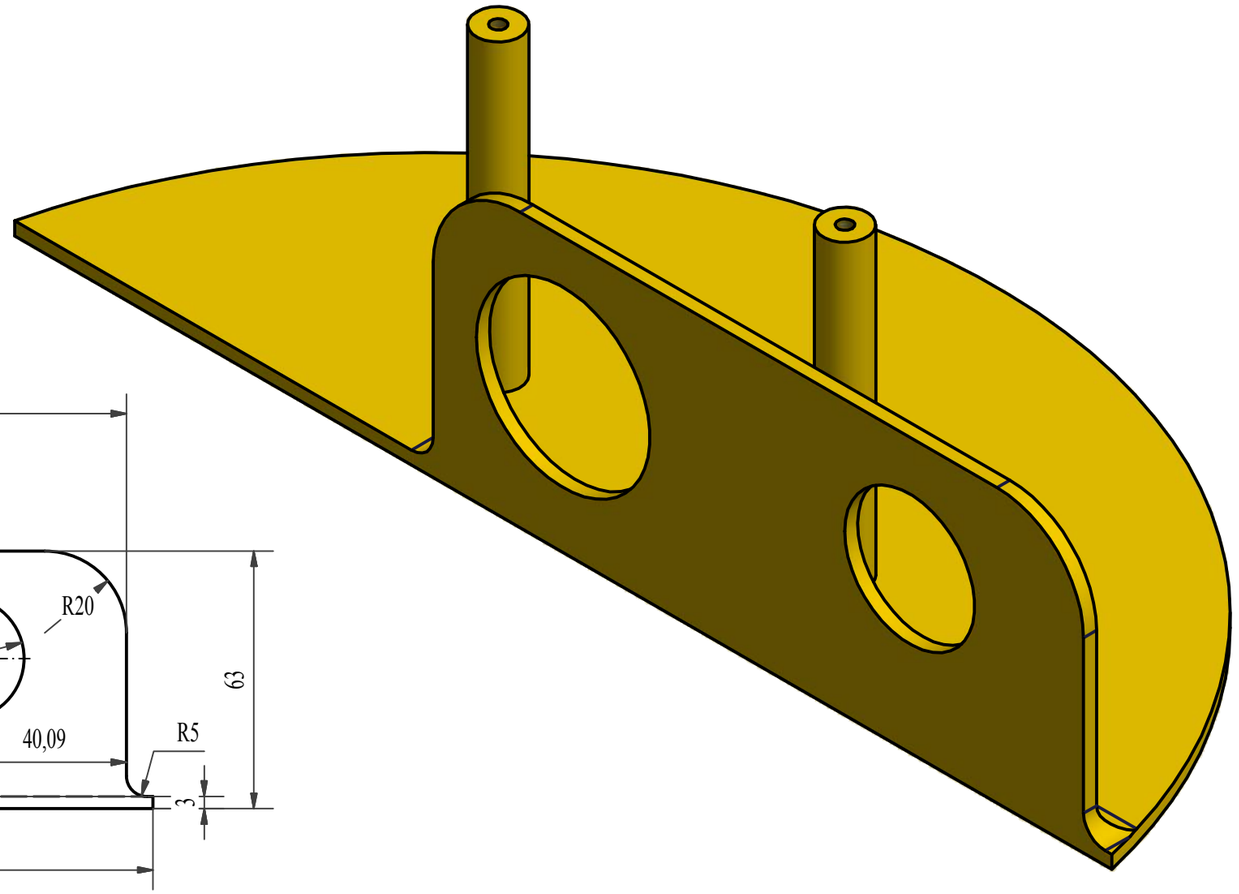
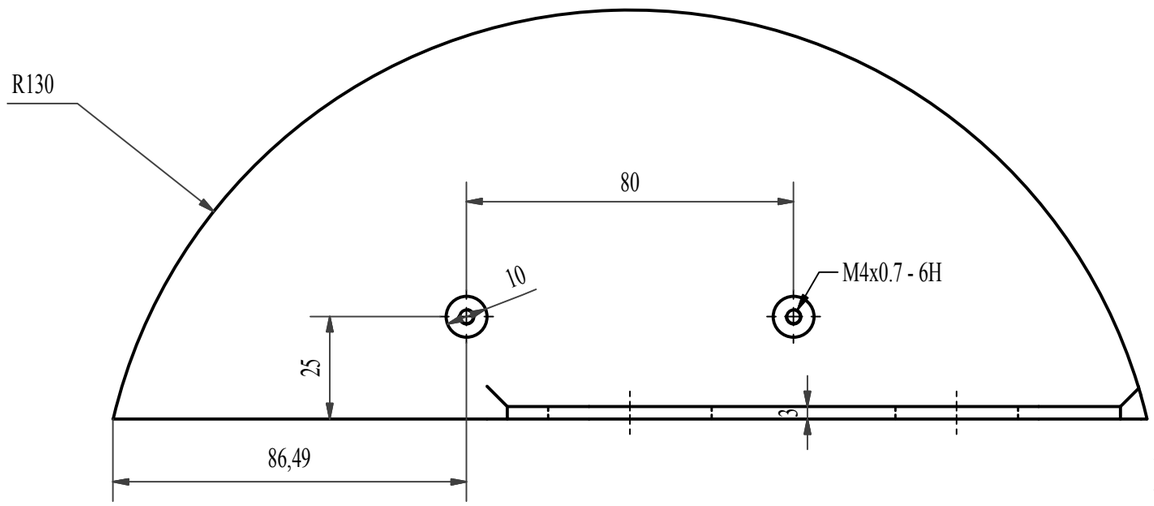
La Almunia de Dª Godina -ZARAGOZA-

Nº P.: 424.13.136.01.300
Nº O.: 424.13.136
Nom.Ar.: BLOQUE BRAZO.idw







301	1	Base motor casco dcho	424.13.136.01.301	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V7

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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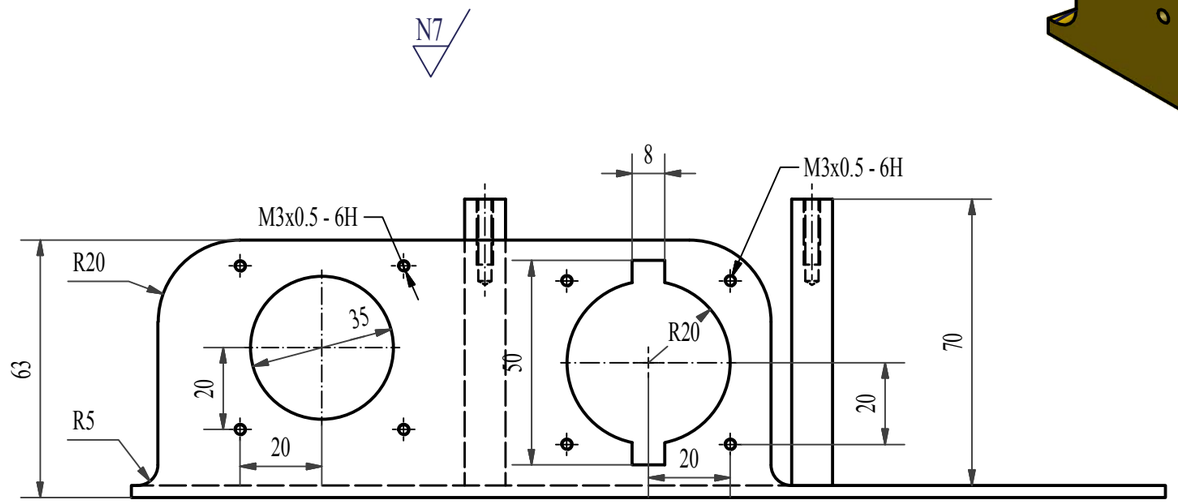
La Almunia de Dª Godina -ZARAGOZA-

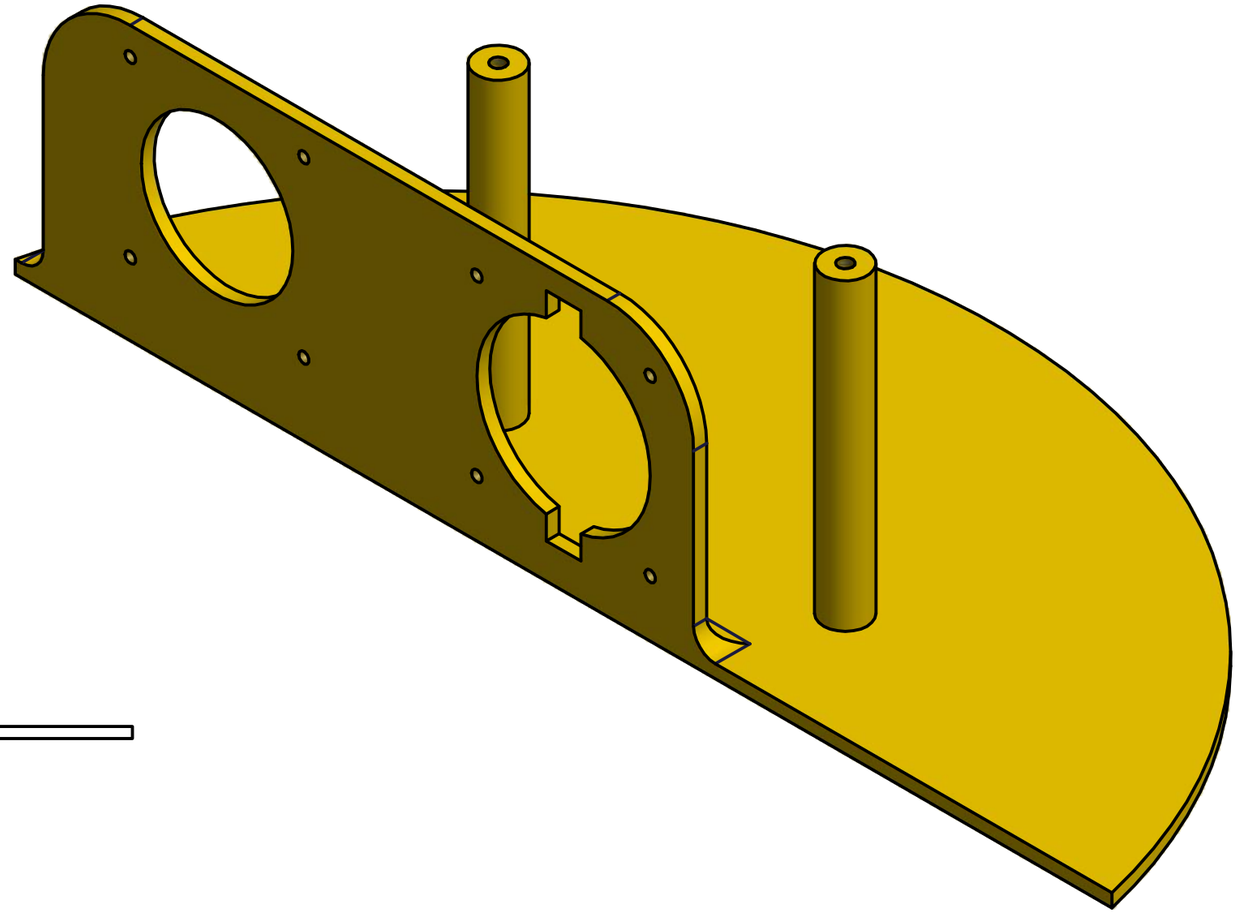
ESCALA 1:1.5

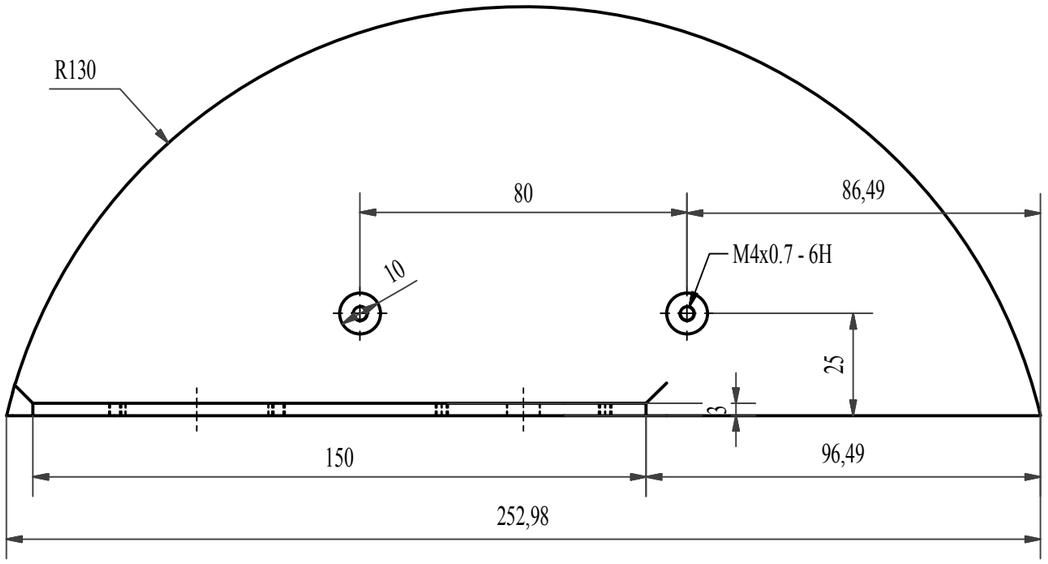
ROBOT BOMBERO

BRAZO (GRUPO 300)
Base motor casco dcho

Nº P.: 424.13.136.01.301
Nº O.: 424.13.136
Nom.Ar.: Base motor casco.idw







302	1	Base motor casco izq	424.13.136.01.302	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V6

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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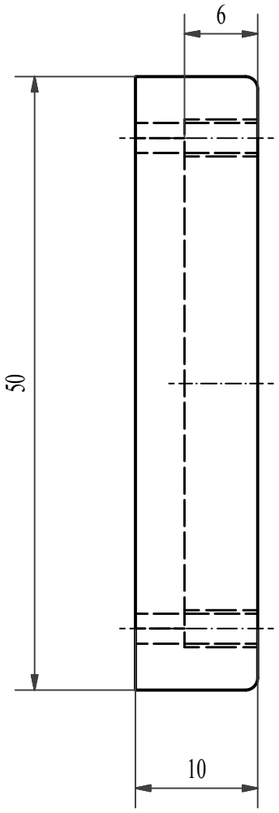
La Almunia de Dª Godina -ZARAGOZA-

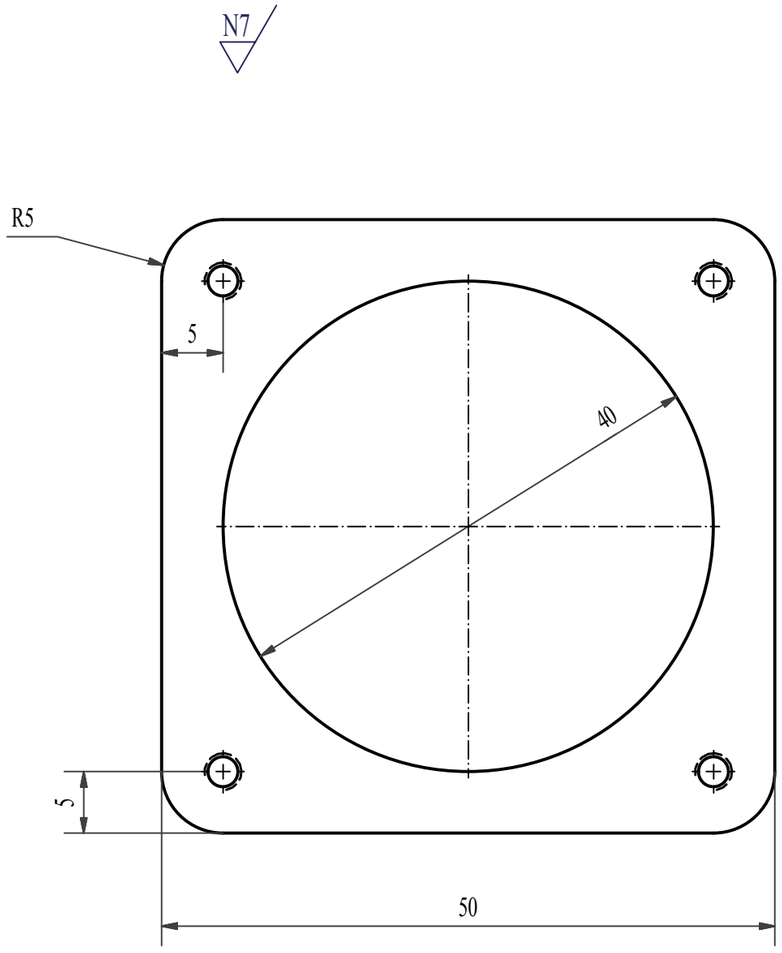
ESCALA 1:1.5

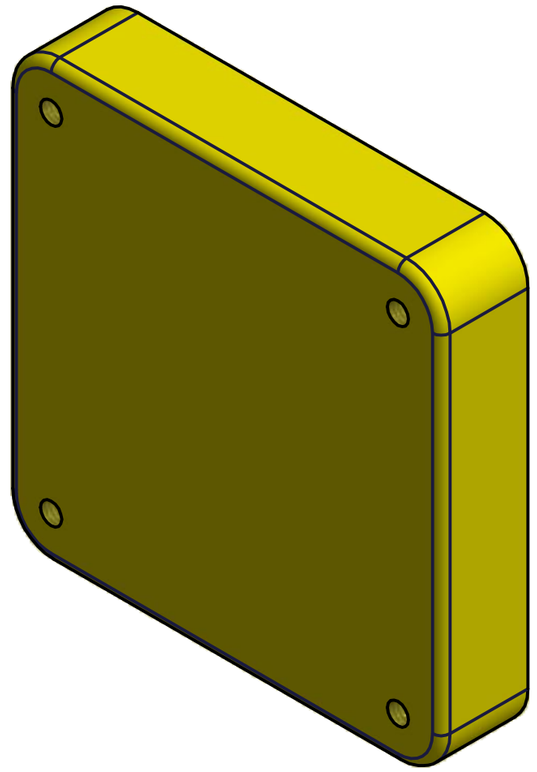
ROBOT BOMBERO

BRAZO (GRUPO 300)
Base motor casco izq

Nº P.: 424.13.136.01.302
Nº O.: 424.13.136
Nom.Ar.: Base motor casco izq.idw







303	1	Límite eje antebrazo 2	424.13.136.01.303	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 2:1

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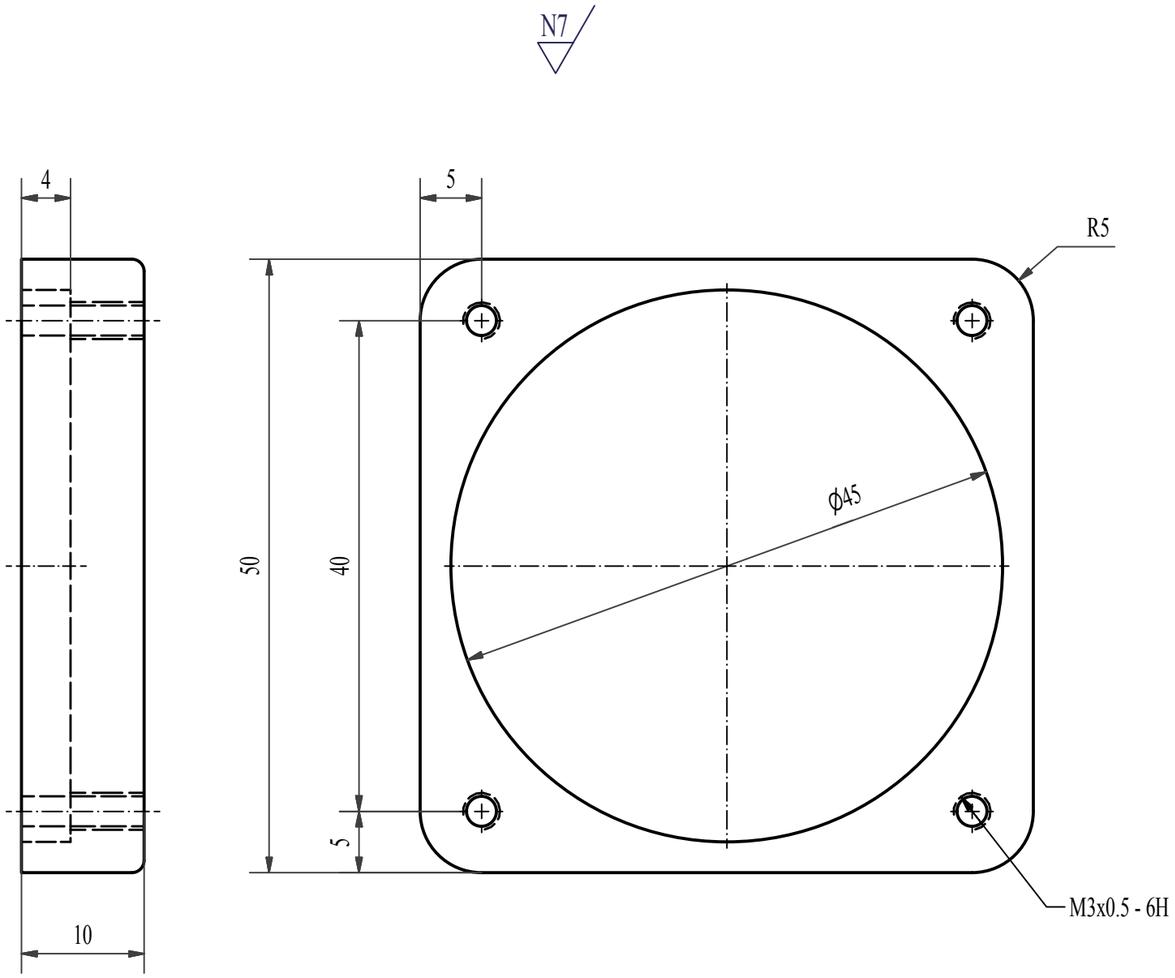
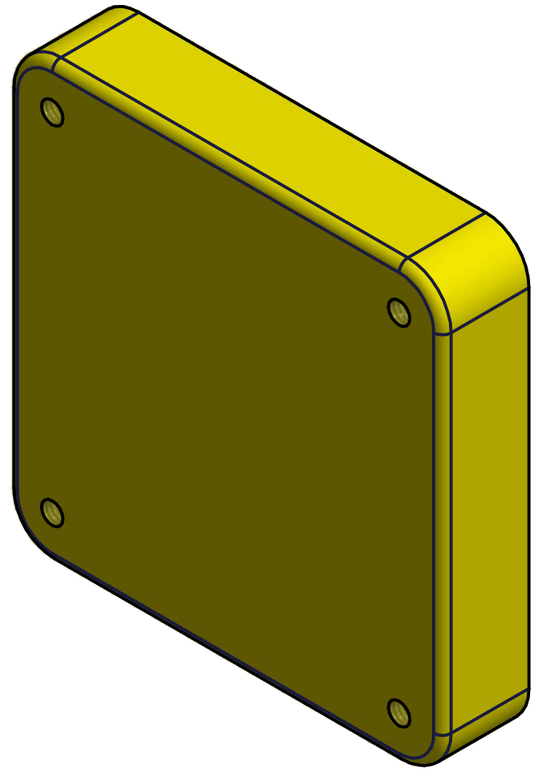
ROBOT BOMBERO

BRAZO (GRUPO 300)
Limite eje antebrazo 2

Nº P.: 424.13.136.01.303
Nº O.: 424.13.136
Nom.Ar.: limite eje antebrazo 2.idw





304	1	Límite eje antebrazo	424.13.136.01.304	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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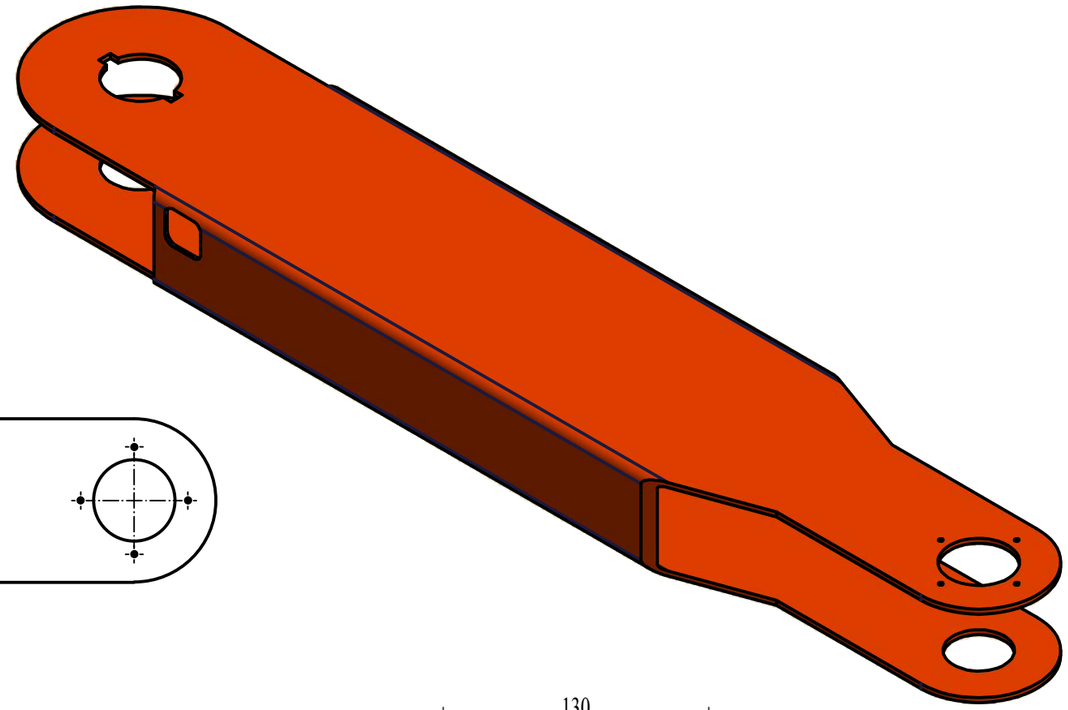
ESCALA 2:1

ROBOT BOMBERO

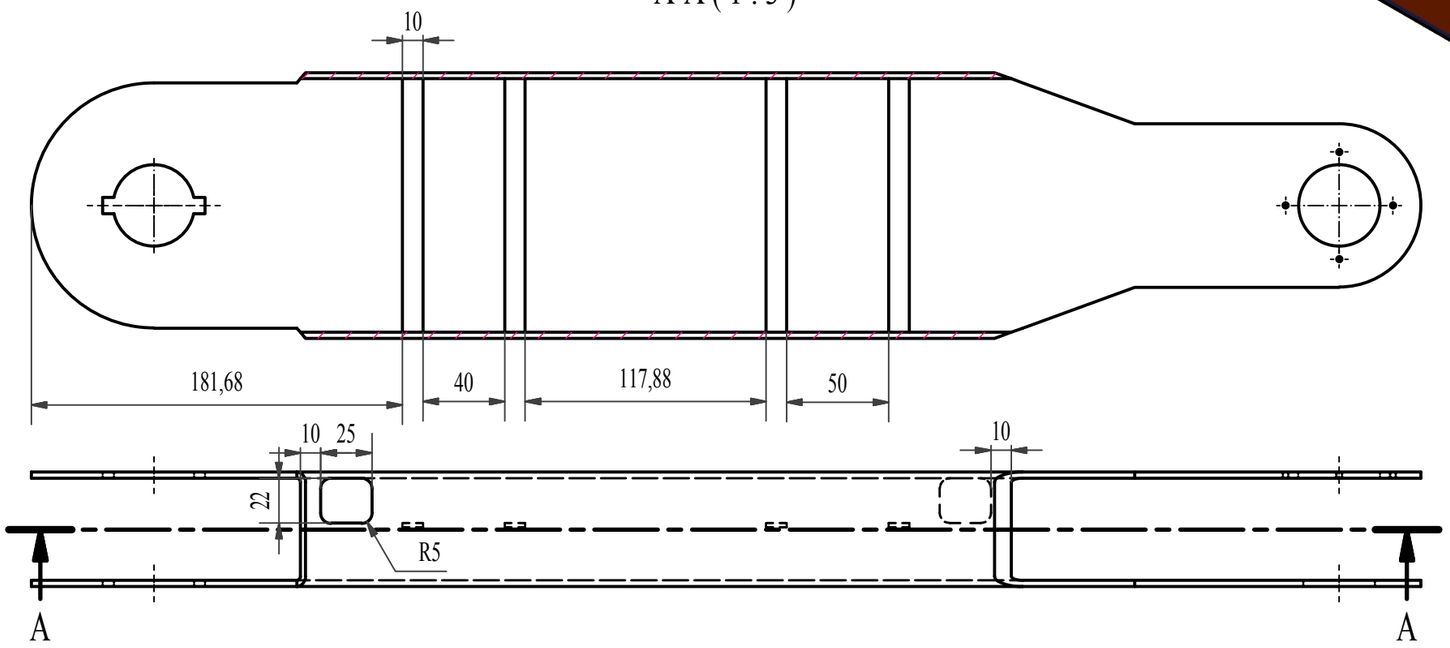
BRAZO (GRUPO 300)
Límite eje antebrazo

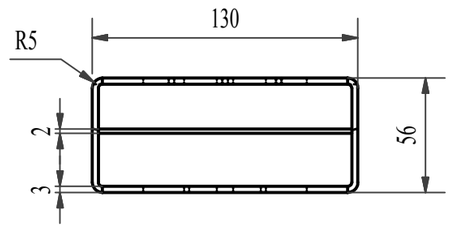
Nº P.: 424.13.136.01.304
Nº O.: 424.13.136
Nom.Ar.: limite eje antebrazo.idw

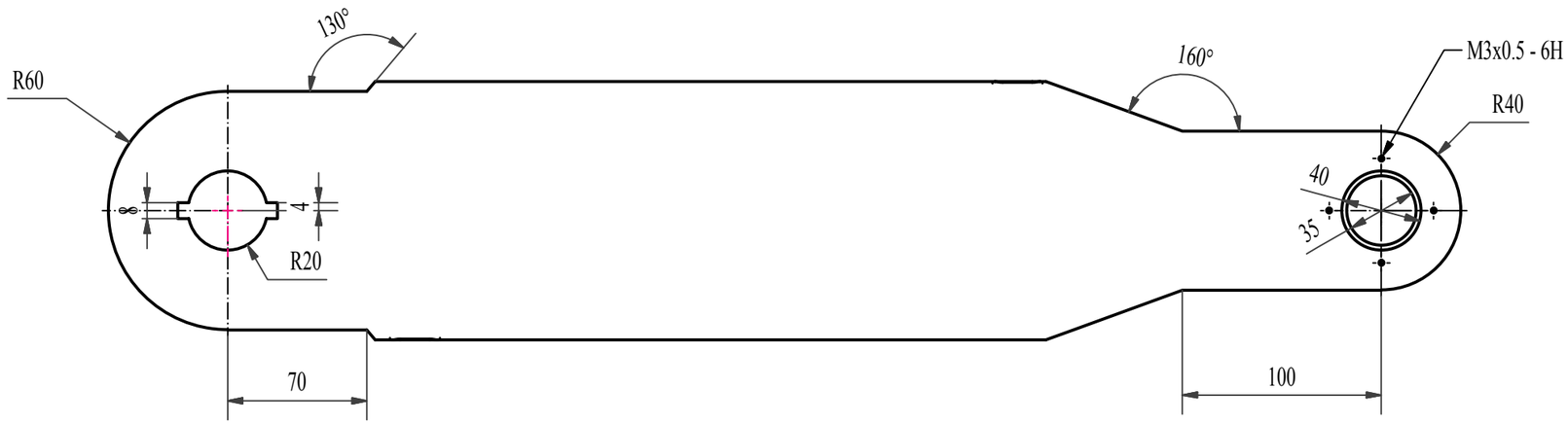


N7

A-A (1 : 3)







305	1	Antebrazo Robot	424.13.136.01.305	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V7

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:3

ROBOT BOMBERO
BRAZO (GRUPO 300)
Antebrazo Robot

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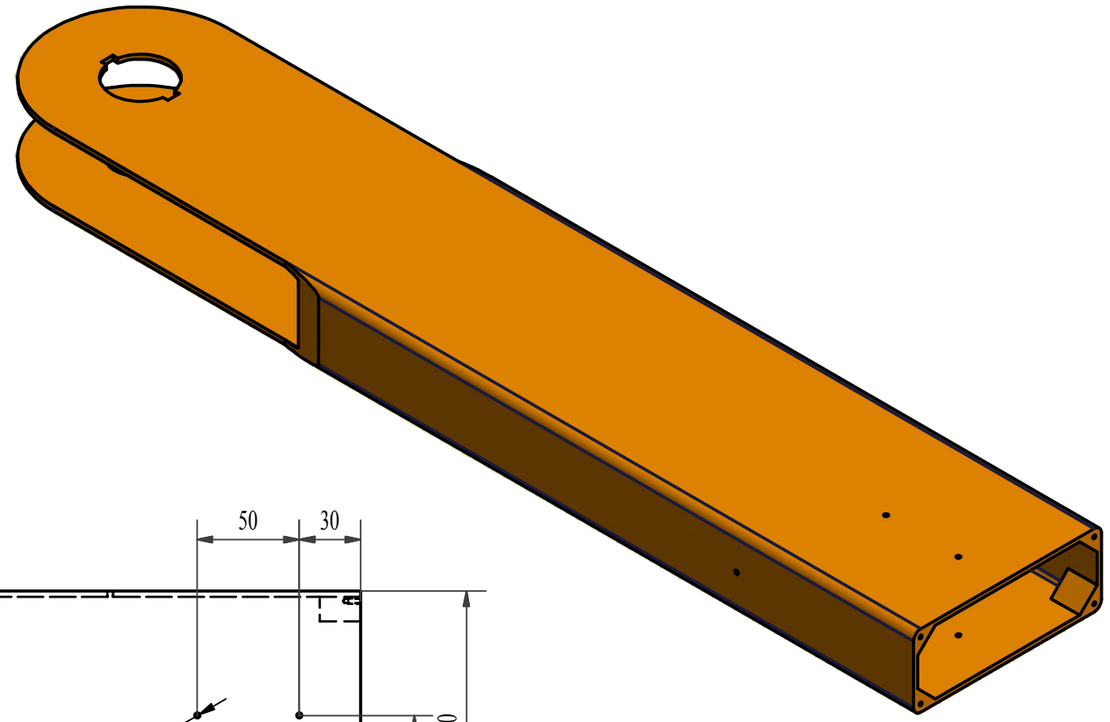
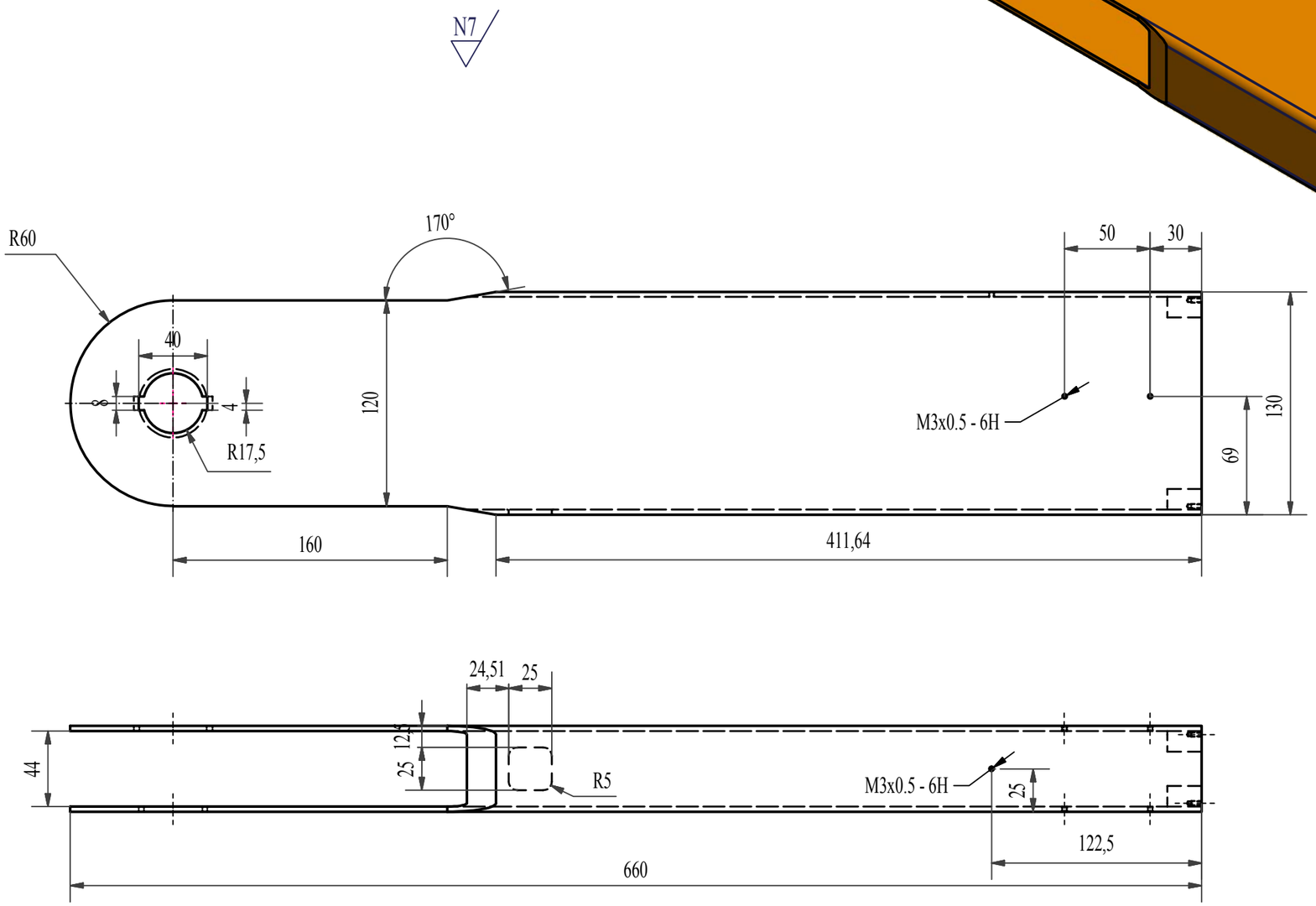
La Almunia de Dª Godina -ZARAGOZA-

Nº P.: 424.13.136.01.305
Nº O.: 424.13.136
Nom.Ar.: Antebrazo Robot.idw





306	1	Brazo robot	424.13.136.01.306	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:3

ROBOT BOMBERO

BRAZO (GRUPO 300)
Brazo robot

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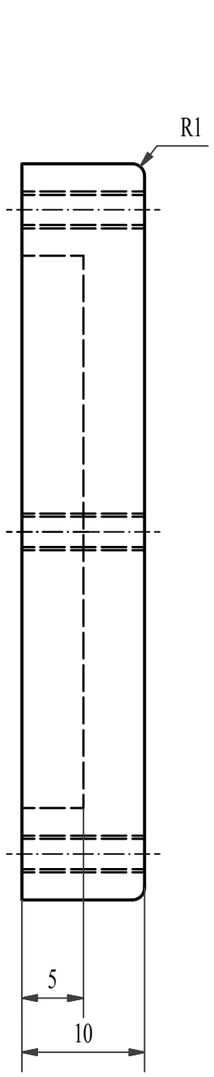
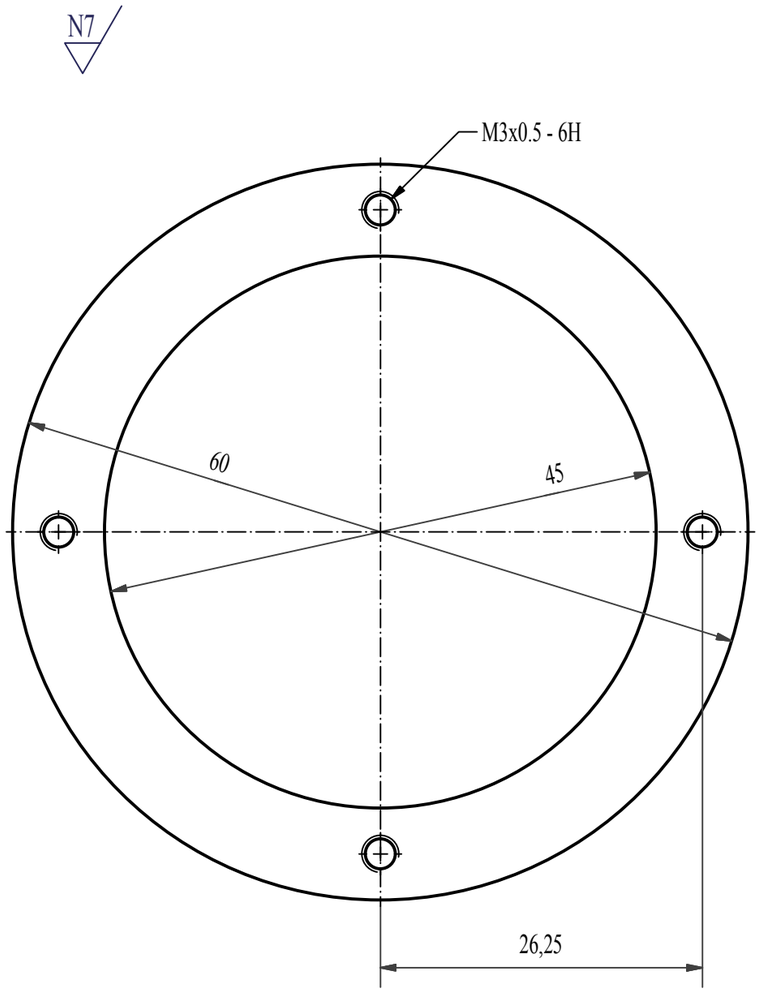
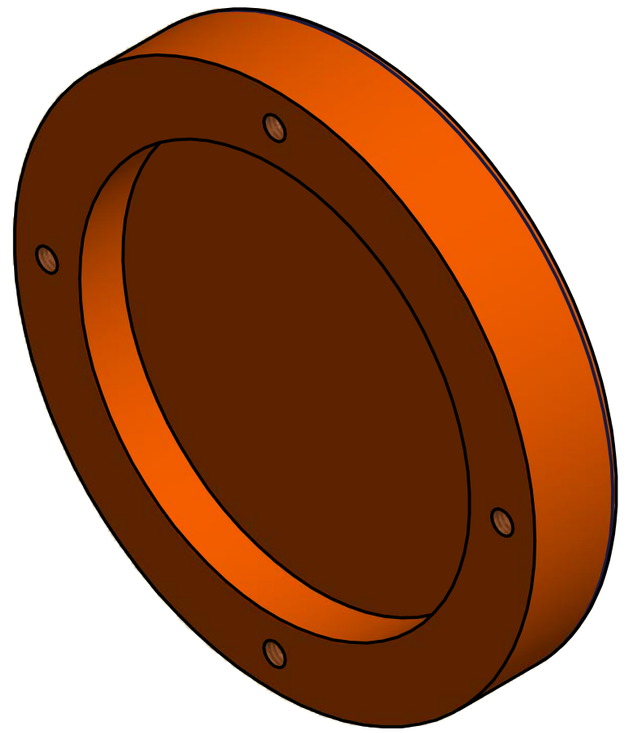
La Almunia de Dª Godina -ZARAGOZA-

Nº P.: 424.13.136.01.306
Nº O.: 424.13.136
Nom.Ar.: Brazo Robot.idw







307	1	Límite eje brazo	424.13.136.01.307	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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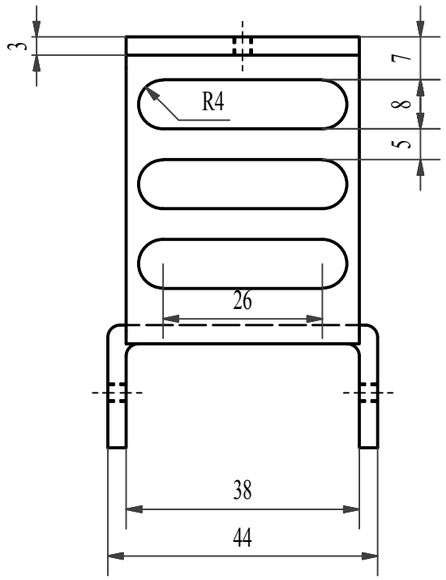
La Almunia de Dª Godina -ZARAGOZA-

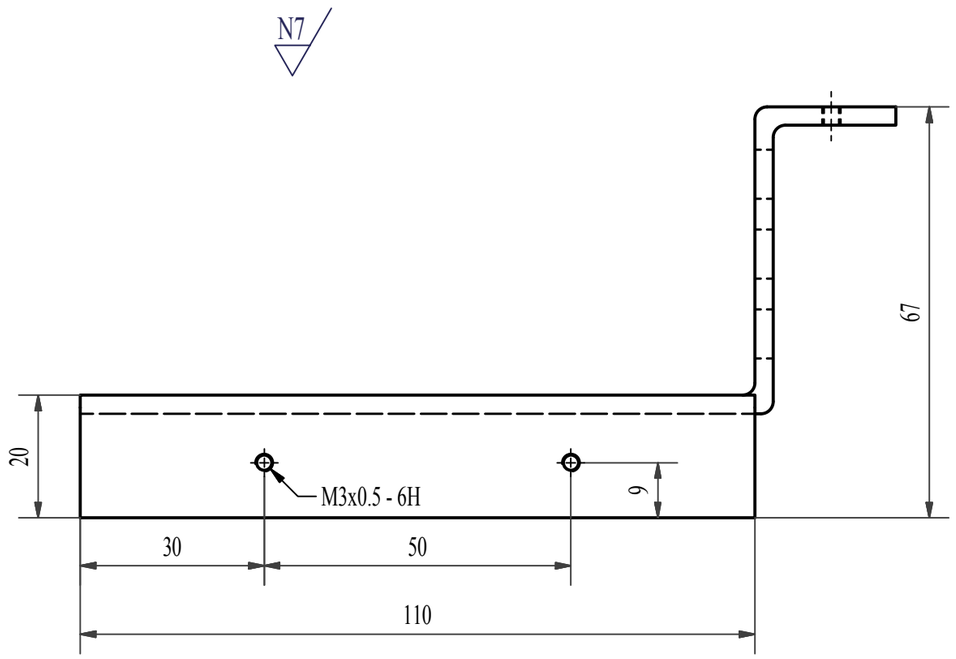
ESCALA 2:1

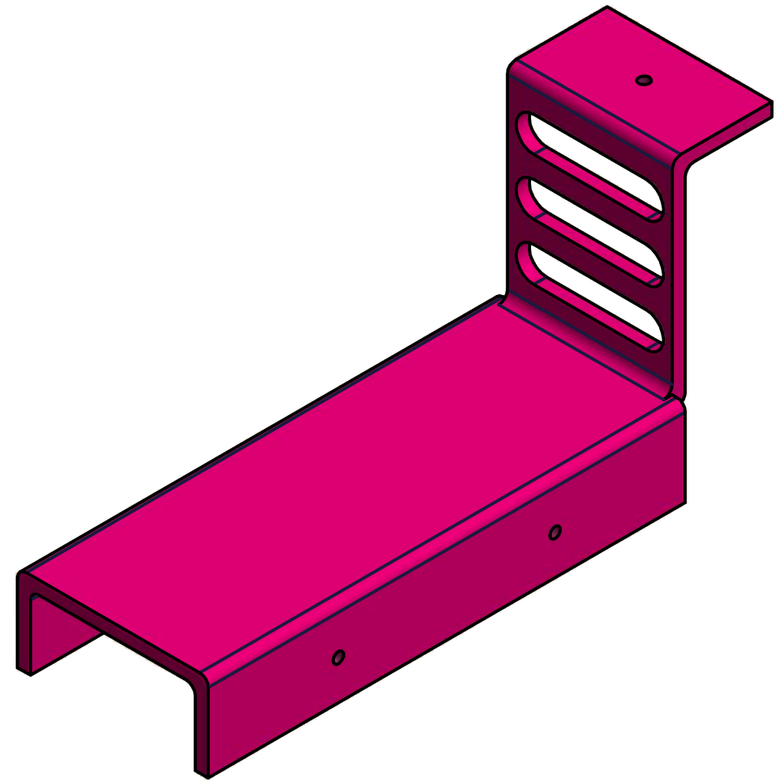
ROBOT BOMBERO

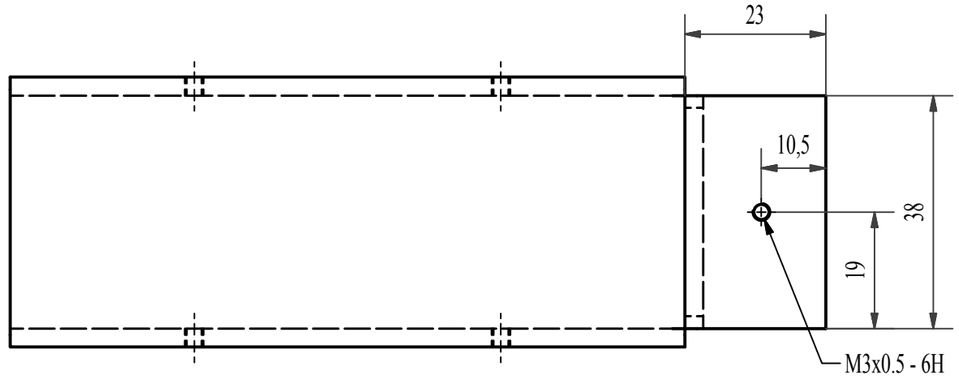
BRAZO (GRUPO 300)
Límite eje brazo

Nº P.: 424.13.136.01.307
Nº O.: 424.13.136
Nom.Ar.: Limite eje brazo.idw









308	1	Soporte cámara	424.13.136.01.308	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V4

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

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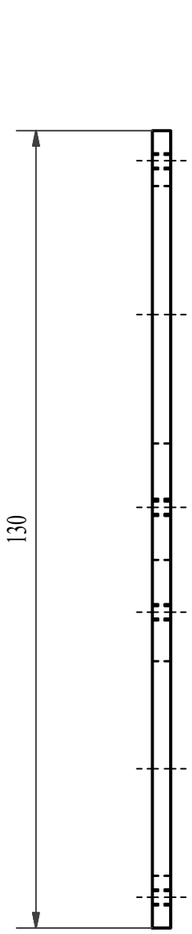
ESCUELA UNIVERSITARIA POLITECNICA
La Almunia de Dª Godina -ZARAGOZA-

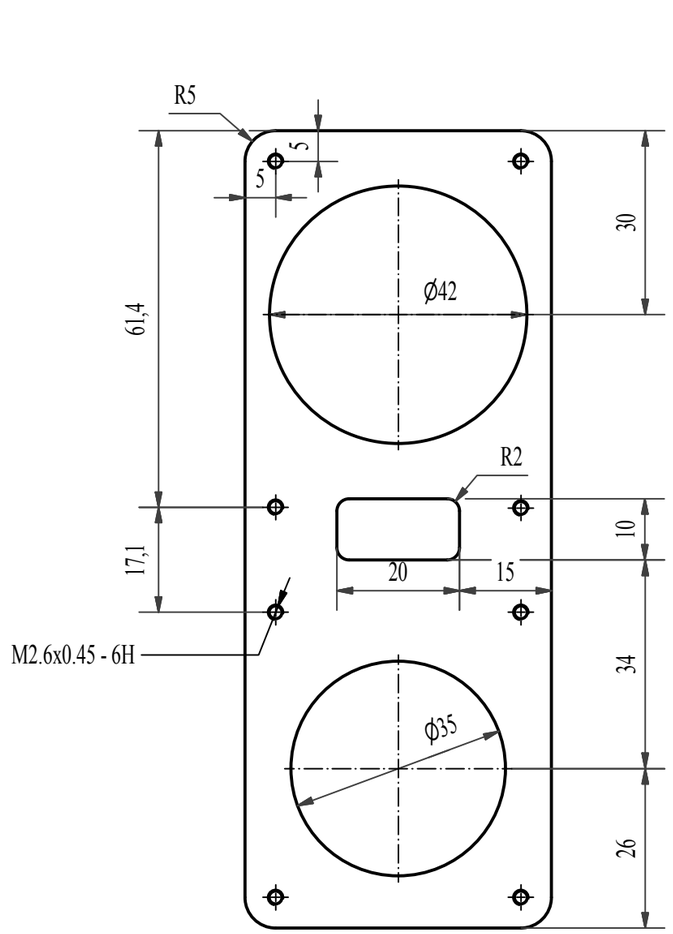
ESCALA 1:1

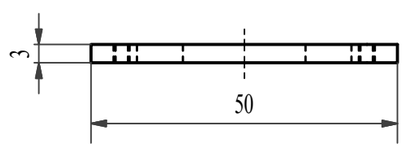
ROBOT BOMBERO

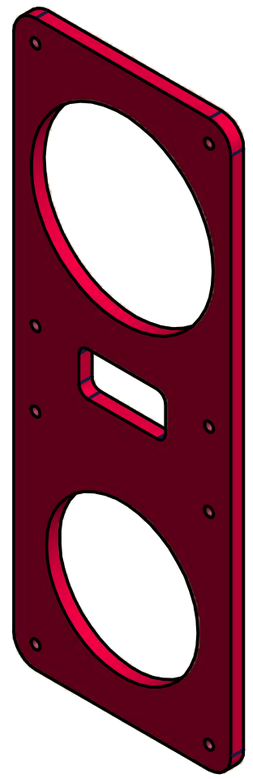
BRAZO (GRUPO 300)
Soporte cámara

Nº P.: 424.13.136.01.308
Nº O.: 424.13.136
Nom.Ar.: Soporte camara.idw









309	1	Tapa brazo	424.13.136.01.309	Acero F-314
MARCA	CTDAD	DENOMINACIÓN Y CARACTERISTICAS	Nº PLANO / ABRE. NORMA	MATERIAL/OBSERVACIONES

Observaciones Generales

Proyecto: DISEÑO DE UN ROBOT BOMBERO EN EDIFICIOS
Palabras clave:
Empresa: EUPLA
Estado del proyecto: En curso
Versión: V5

Observaciones de plano

Plano nº: 1 **de:** 1
Formato: A3
Coment:

	Fecha	Nombre
Dibujado	19/06/2015	Juan H.V.
Comprobado		
Idem.s.normas		

ESCALA 1:1

ROBOT BOMBERO
BRAZO (GRUPO 300)
Tapa brazo

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La Almunia de Dª Godina -ZARAGOZA-

Nº P.: 424.13.136.01.309
Nº O.: 424.13.136
Nom.Ar.: Tapa Brazo.idw

ALIMENTACION 12V1
ALIMENTACION 24V1
ALIMENTACION 48V1
Vs 48V

CONTROLADOR_BRUSHLESS
BR1
BR1 HALL1
BR1 HALL2
BR1 HALL3
BR1 OUT1
BR1 OUT2
BR1 OUT3
BR1 F/R
BR1 EN
BR1 BRAKE
RsenseM1 14 Ohm
Roff1 33KOhm
Coff1 1nF
Rpul1 47KOhm
Cpul1 10nF
Ren1 100KOhm
Cen1 5,6nF
Rh1 10 KOhm
Rh2 10 KOhm
Rh3 10 KOhm
Cp1 10nF
Rp1 100 Ohm
DIODO D2
DIODO D3
200nF Cboot1
R2 5.6 KOhm
RDD1 1KOhm
Cref1 33nF
R4 1.8 KOhm
C1 220nF
R4 1 MOhm
R3 4.7 KOhm
LM324 U8A
Vref1

CONTROLADOR_BRUSHLESS
BR3
BR2 HALL1
BR2 HALL2
BR2 HALL3
BR2 OUT1
BR2 OUT2
BR2 OUT3
BR2 F/R
BR2 EN
BR2 BRAKE
RsenseM2 14 Ohm
Roff3 33KOhm
Coff3 1nF
Rpul3 47KOhm
Cpul3 10nF
Ren3 100KOhm
Cen3 5,6nF
Rh6 10 KOhm
Rh8 10 KOhm
Rh9 10 KOhm
Cp3 10nF
Rp3 100 Ohm
DIODO D5
DIODO D7
200nF Cboot3
R8 5.6 KOhm
RDD3 1KOhm
Cref3 33nF
R6 1.8 KOhm
C3 220nF
R12 1 MOhm
R10 4.7 KOhm
U9A LM324AN
Vref2

Vs 48V
C4 1000uF
C5 1000uF
C6 1000uF
C7 1000uF
C9 220KpF
C10 220KpF
C11 220KpF
C12 220KpF

SOLENOID S1
DIODO D1
PN2222A T092 Q1
SOLE

CONTROLADOR_BRUSHLESS
BR4
BR4 HALL1
BR4 HALL2
BR4 HALL3
BR4 OUT1
BR4 OUT2
BR4 OUT3
BR4 F/R
BR4 EN
BR4 BRAKE
RsenseB1 2 Ohm
Roff2 33KOhm
Coff2 1nF
Rpul2 47KOhm
Cpul2 10nF
Ren2 100KOhm
Cen2 5,6nF
Rh4 10 KOhm
Rh5 10 KOhm
Rh7 10 KOhm
Cp2 10nF
Rp2 100 Ohm
DIODO D4
DIODO D6
200nF Cboot2
R7 5.6 KOhm
RDD2 1KOhm
Cref2 33nF
R5 1.8 KOhm
C2 220nF
R11 1 MOhm
R9 4.7 KOhm
U11A TL074
Vref4

CONTROLADOR_BRUSHLESS
BR3
BR3 HALL1
BR3 HALL2
BR3 HALL3
BR3 OUT1
BR3 OUT2
BR3 OUT3
BR3 F/R
BR3 EN
BR3 BRAKE
RsenseB2 2 Ohm
Roff4 33KOhm
Coff4 1nF
Rpul4 47KOhm
Cpul4 10nF
Ren4 100KOhm
Cen4 5,6nF
Rh10 10 KOhm
Rh11 10 KOhm
Rh12 10 KOhm
Cp4 10nF
Rp4 100 Ohm
DIODO D8
DIODO D9
200nF Cboot4
R18 5.6 KOhm
RDD4 1KOhm
Cref4 33nF
R17 1.8 KOhm
C8 220nF
R20 1 MOhm
R19 4.7 KOhm
U10A LM324N
Vref3

U1 PWM2 ULTRA
U2 PWM3 ULTRA
U3 PWM4 ULTRA
U4 PWM5 ULTRA
U5 PWM6 ULTRA
U6 PWM7 ULTRA
U7 PWM8 ULTRA
ULTRASONIDS ULTRASONIDS ULTRASONIDS

ARDUINO_MEGA
AM1
RESET 3V3 5V GND GND VIN A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
AREF GND PWM13 PWM12 PWM11 PWM10 PWM9 PWM8 PWM7 PWM6 PWM5 PWM4 PWM3 PWM2 TX0_1 RX0_0 TX3_14 RX3_15 TX2_16 RX2_17 TX1_18 RX1_19 SDA20 SCL21
GND GND D53 D52 D51 D50 D49 D48 D47 D46 D45 D44 D43 D42 D41 D40 D39 D38 D37 D36 D35 D34 D33 D32 D31 D30 D29 D28 D27 D26 D25 D24 D23 D22 5V 5V
D53 F1
D52 F2
SOLE
D50 EN R1
D49 EN R1
D48 EN R2
D47 EN R2
D46 EN B1
D45 EN B1
D44 EN B2
D43 EN B2
BR1 BRAKE
BR2 BRAKE
BR3 BRAKE
BR4 BRAKE
BR1 F/R
BR2 F/R
BR3 F/R
BR4 F/R
BR1 EN
BR2 EN
BR3 EN
BR4 EN

XBEE
X1
VDD DATA_OUT DATA_IN CD RESET PWM NC NC SLEEP/Dtr GND
i/o i/o i/o RTS i/o Vref STATUS CTS CTS TX_led
TX1 XBEE
RX1 XBEE

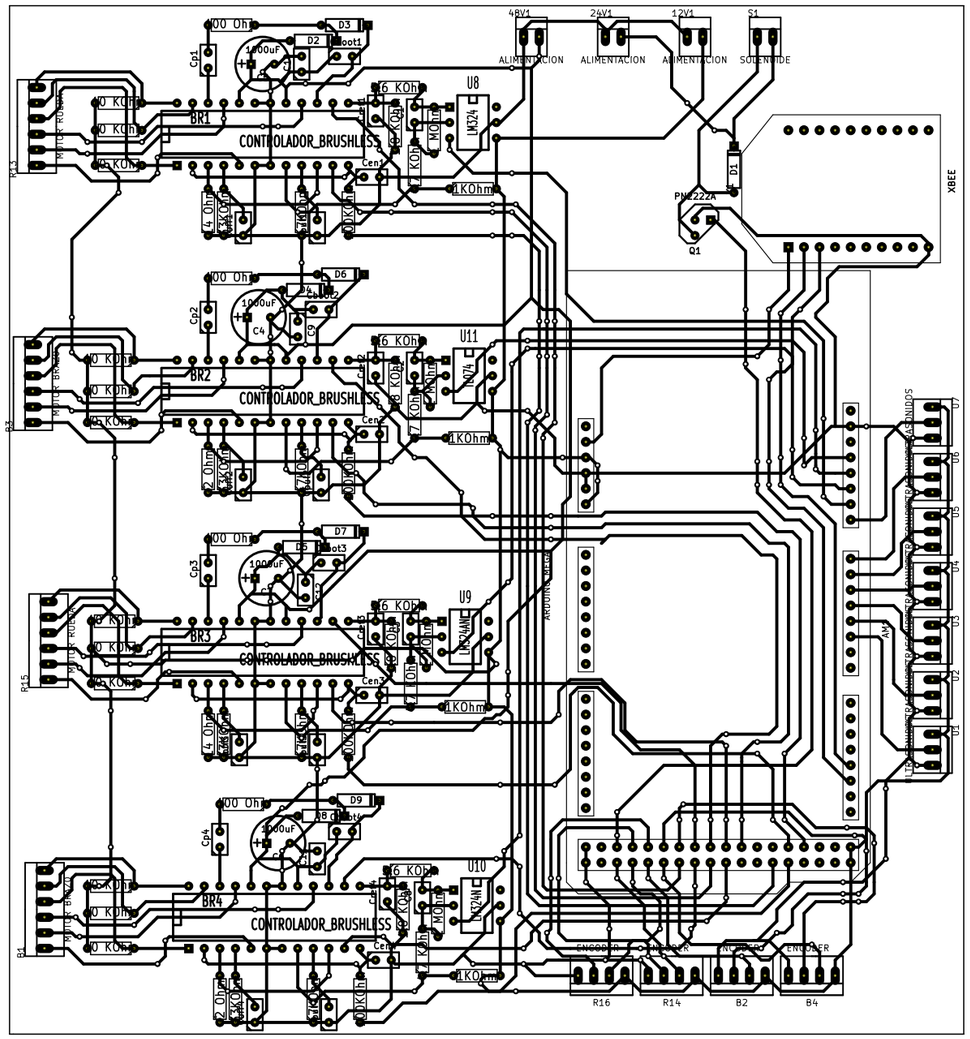
BR1 OUT1 BR1 OUT2 BR1 OUT3 BR1 HALL1 BR1 HALL2 BR1 HALL3
R13 MOTOR RUEDA
D50 EN R1
D49 EN R1
R14 ENCODER

BR3 OUT1 BR3 OUT2 BR3 OUT3 BR3 HALL1 BR3 HALL2 BR3 HALL3
B1 MOTOR BRAZO
D46 EN B1
D45 EN B1
B2 ENCODER

BR2 OUT1 BR2 OUT2 BR2 OUT3 BR2 HALL1 BR2 HALL2 BR2 HALL3
R15 MOTOR RUEDA
D48 EN R2
D47 EN R2
R16 ENCODER

BR4 OUT1 BR4 OUT2 BR4 OUT3 BR4 HALL1 BR4 HALL2 BR4 HALL3
B3 MOTOR BRAZO
D44 EN B2
D43 EN B2
B4 ENCODER

File: Esquema TFG Robot.sch	
Sheet: /	
Title: 424.13.136.02.001	
Size: A3	Date: 30 jun 2015
KiCad E.D.A.	eeschema (2013-07-07 BZR 4022)-stable
Rev:	
Id: 1/1	



File: PCB Robot Bombero TFG.kicad_pcb	
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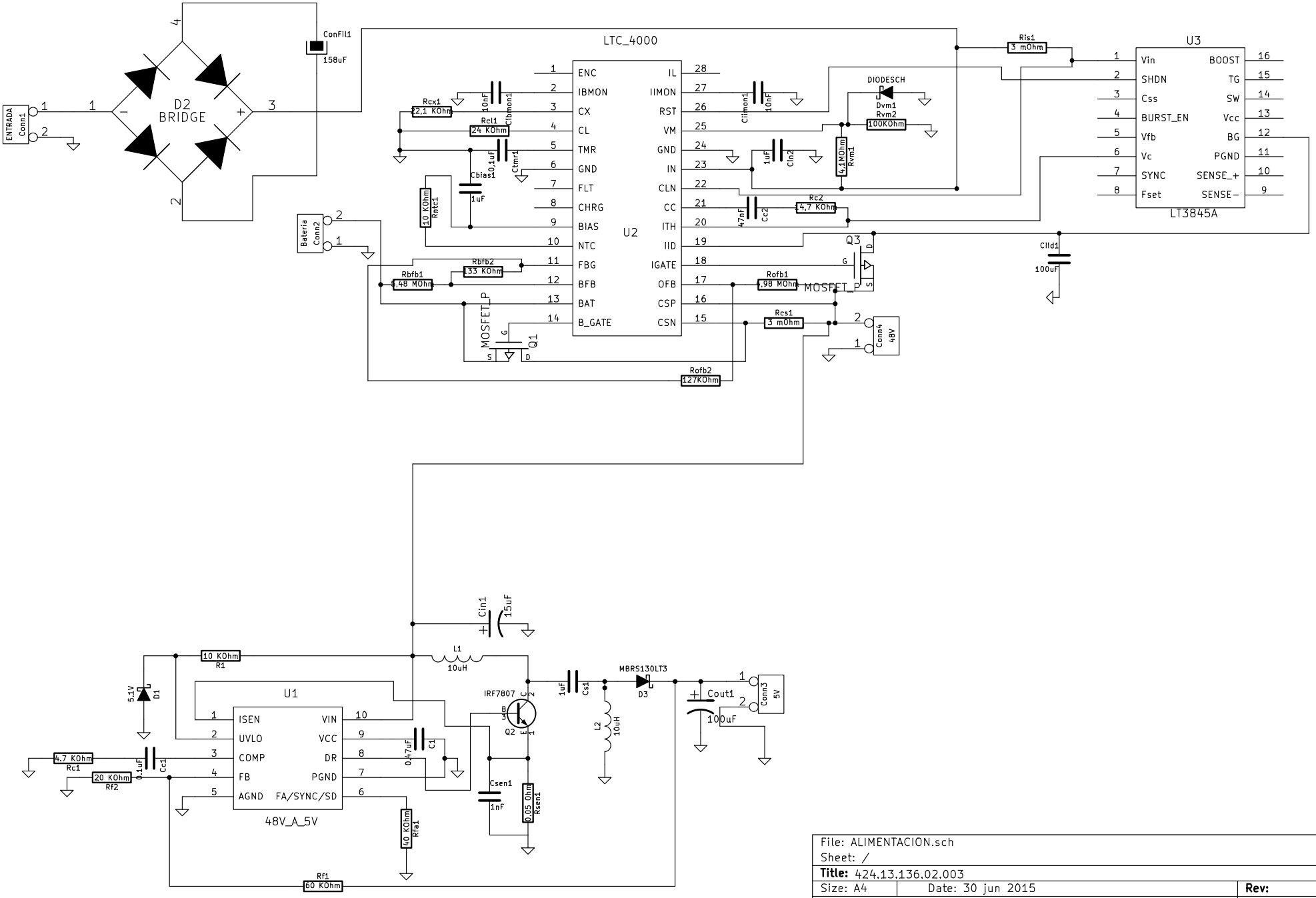

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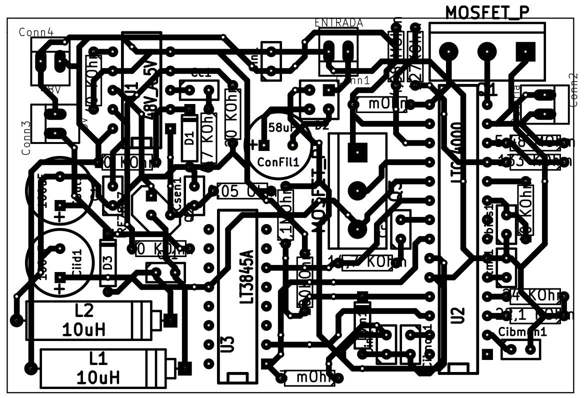

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