Universidad del País Vasco Euskal Herriko Unibertsitatea
BILBOKO INGENIARITZA ESKOLA
ESCUELA DE INGENIERÍA DE BILBAO

GRADO EN INGENIERÍA ELECTRÓNICA INDUSTRIAL Y AUTOMÁTICA

TRABAJO FIN DE GRADO

RED INALÁMBRICA DE SENSORES POR RADIOFRECUENCIA

DOCUMENTO 6 - DOCUMENTACIÓN

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Director/Directora: Oleagordia Aguirre Iñigo Javier

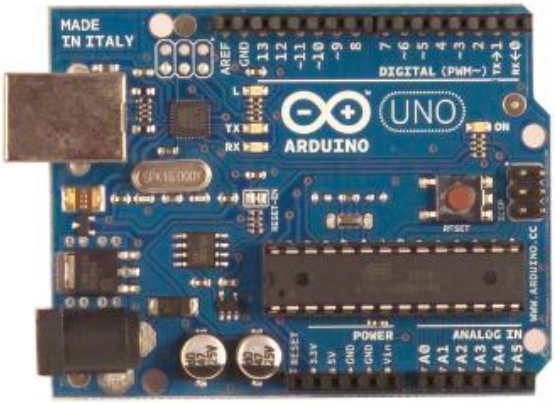
Curso: 2018-2019

Fecha: 15/ 07/ 2019

ÍNDICE

1. ARDUINO UNO

Arduino UNO



Product Overview

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

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

Index

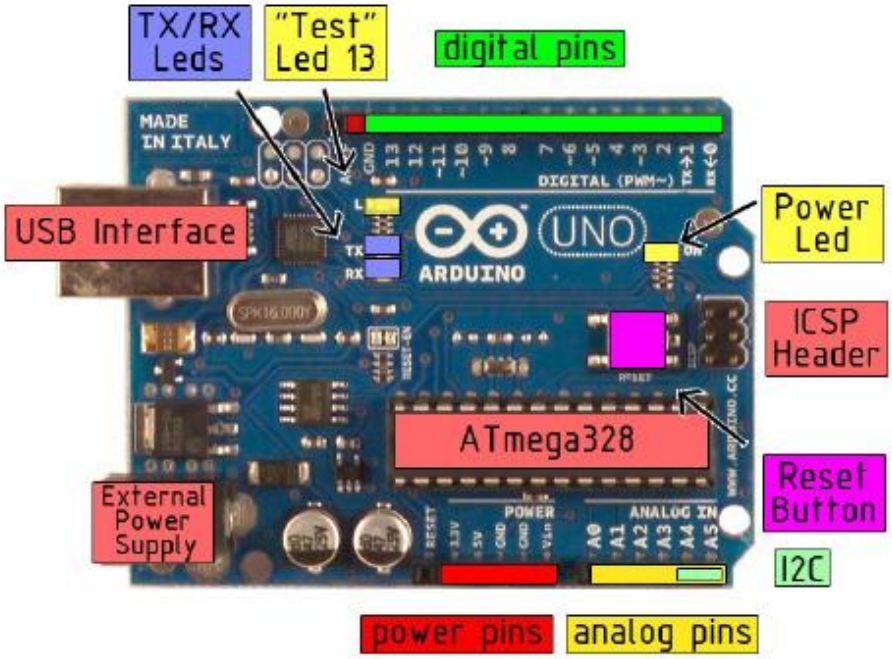
Technical Specification

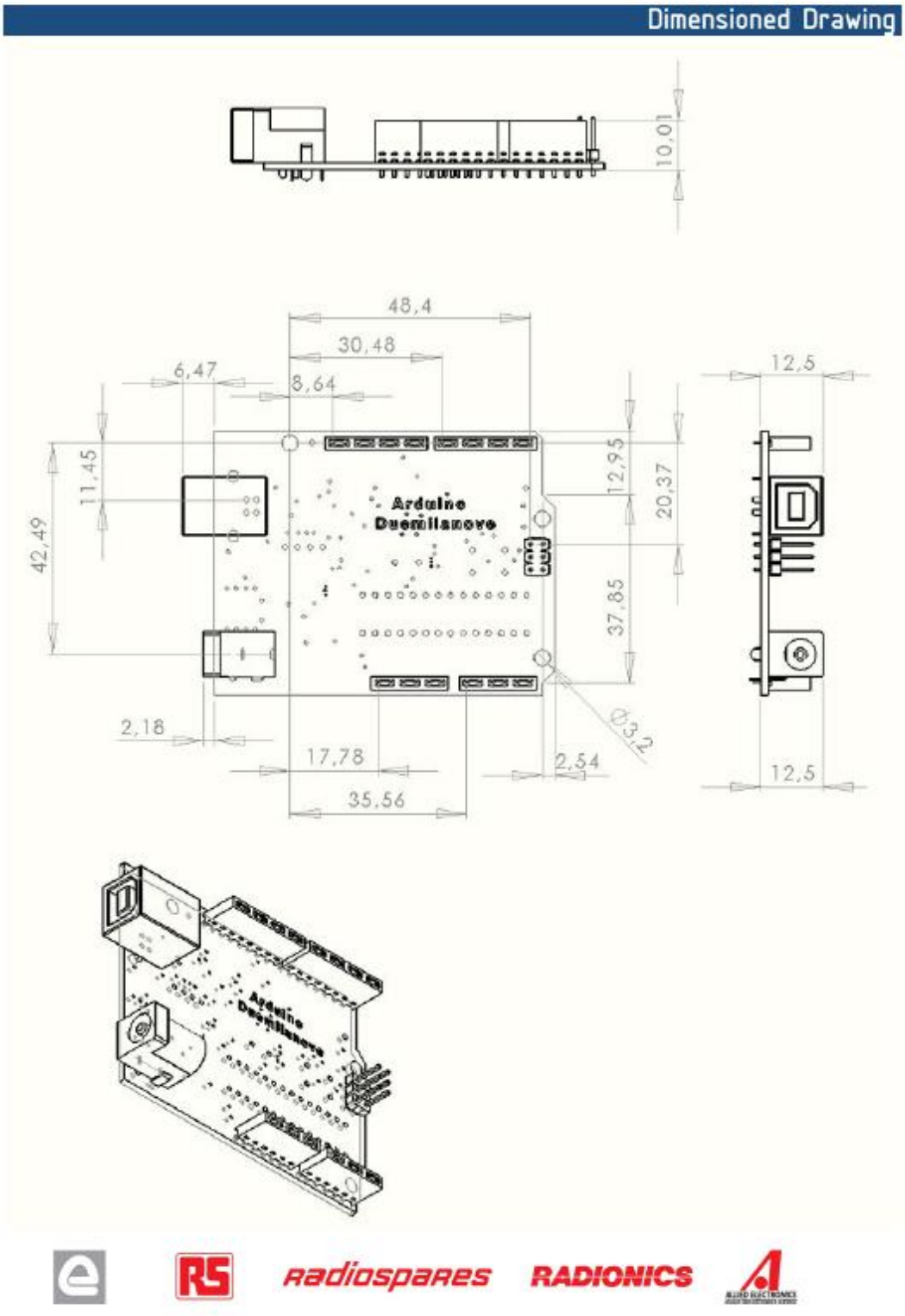
EAGLE files: arduino-duemilanove-uno-design.zip Schematic: arduino-uno-schematic.pdf

Summary

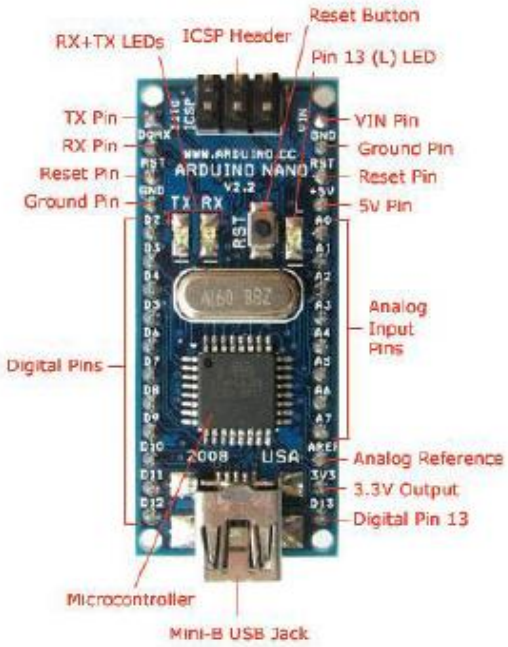
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2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

the board




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

2. ARDUINO NANO



Schematic and Design

Arduino Nano 3.0 (ATmega328): schematic, Eagle files.
Arduino Nano 2.3 (ATmega168): manual (pdf), Eagle files. *Note:* since the free version of Eagle does not handle more than 2 layers, and this version of the Nano is 4 layers, it is published here unrouted, so users can open and use it in the free version of Eagle.

Specifications:

Microcontroller	Atmel ATmega168 or ATmega328
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limits)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader
SRAM	1 KB (ATmega168) or 2 KB (ATmega328)
EEPROM	512 bytes (ATmega168) or 1 KB (ATmega328)
Clock Speed	16 MHz
Dimensions	0.73" x 1.70"

Power:

The Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.

The FTDI FT232RL chip on the Nano is only powered if the board is being powered over USB. As a result, when running on external (non-USB) power, the 3.3V output (which is supplied by the FTDI chip) is not available and the RX and TX LEDs will flicker if digital pins 0 or 1 are high.

Memory

The ATmega168 has 16 KB of flash memory for storing code (of which 2 KB is used for the bootloader); the ATmega328 has 32 KB, (also with 2 KB used for the bootloader). The ATmega168 has 1 KB of SRAM and 512 bytes of EEPROM (which can be read and written with the EEPROM library); the ATmega328 has 2 KB of SRAM and 1 KB of EEPROM.

Input and Output

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

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

The Nano has 8 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 analogReference() function. Additionally, some pins have specialized functionality:

I²C: 4 (SDA) and 5 (SCL). Support I²C (TWI) communication using the Wire library (documentation on the Wiring website).

There are a couple of other pins on the board:

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

See also the mapping between Arduino pins and ATmega168 ports.

Communication

The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega168 and ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI 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 Nano's digital pins.
The ATmega168 and ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega168 or ATmega328 datasheet.

Programming

The Arduino Nano can be programmed with the Arduino software (download). Select "Arduino Diecimila, Duemilanove, or Nano w/ ATmega168" or "Arduino Duemilanove or Nano w/ ATmega328" from the **Tools**

> **Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega168 or ATmega328 on the Arduino Nano 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.

Automatic (Software) Reset

Rather then requiring a physical press of the reset button before an upload, the Arduino Nano 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 FT232RL is connected to the reset line of the ATmega168 or ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.
This setup has other implications. When the Nano 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 Nano. 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.

3. MÓDULO CONVERTIDO DC-DC

TEXAS INSTRUMENTS

TPS61080, TPS61081

SLVS644E – FEBRUARY 2006 – REVISED DECEMBER 2014

TPS6108x High-Voltage DC-DC Boost Converter With 0.5-A,1.3-A Integrated Switch

1 Features

- 2.5-V to 6-V Input Voltage Range
- Up to 27-V Output Voltage
- 0.5-A Integrated Switch (TPS61080)
  1.3-A Integrated Switch (TPS61081)
- 12-V/400-mA and 24-V/170-mA From 5-V Input (Typical)
- Integrated Power Diode
- 1.2-MHz/600-kHz Selectable Fixed Switching Frequency
- Input-to-Output Isolation
- Short-Circuit Protection
- Programmable Soft Start
- Overvoltage Protection
- Up to 87% Efficiency
- 10-Pin 3-mm × 3-mm QFN Package

2 Applications

- 3.3-V to 12-V, 5-V to 12-V, and 24-V Boost Converter
- White LED Backlight for Media Form Factor Display
- OLED Power Supply
- xDSL Applications
- TFT-LCD Bias Supply
- White LED Flash Light

3 Description

The TPS6108x is a 1.2 MHz/600 kHz fixed-frequency boost regulator designed for high integration, which integrates a power switch, an I/O isolation switch, and a power diode. When a short-circuit condition is detected, the isolation switch opens up to disconnect the output from the input. As a result, the IC protects itself and the input source from any pin, except VIN, from being shorted to ground. The isolation switch also disconnects the output from input during shutdown to prevent any leakage current. Other provisions for protection include 0.5 A/1.3 A peak-to-peak overcurrent protection, programmable soft start (SS), over voltage protection (OVP), thermal shutdown, and under voltage lockout (UVLO).

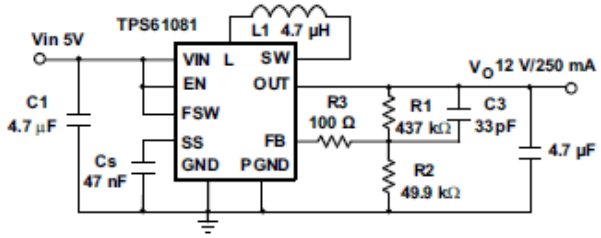
The IC operates from input supplies including single Li-ion battery, triple NiMH, and regulated 5 V, such as USB output. The output can be boosted up to 27 V. TPS6108x can provide the supply voltages of OLED, TFT-LCD bias, 12-V and 24-V power rails. The output of TPS6108x can also be configured as a current source to power up to seven WLEDs in flash light applications.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS61080	VSON (10)	3.00 mm × 3.00 mm
TPS61081		

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

4 5-V To 12-V, 250-mA Step-Up DC-DC Converter



L1: TDK VLCF5020T-4R7N1R7-1
C1: Murata GRM188R60J105K
C2: Murata GRM219R61C475K

C3: Feed forward capacitor for stability
R3: Noise decoupling resistor
Cs: Soft start programming capacitor

8 Specifications

8.1 Absolute Maximum Ratings

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

	MIN	MAX	UNIT
Supply Voltages on pin VIN(2)	–0.3	7	V
Voltages on pins EN, FB, SS, L and FSW(2)	–0.3	7	V
Voltage on pin OUT(2)		30V	V
Voltage on pin SW(2)		30V	V
Continuous Power Dissipation	See *Thermal Information*		
Operating Junction Temperature Range	–40	150	°C
Storage temperature range	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to network ground terminal.

8.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±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.

8.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{IN}	Input voltage range	2.5		6.0	V
V_{OUT}	Output voltage range	VIN		27	V
L	Inductor(1)	4.7		10	µH
C_{IN}	Input capacitor(1)	1			µF
C_{OUT}	Output capacitor(1)	4.7		30	µF
T_A	Operating ambient temperature	–40		85	°C
T_J	Operating junction temperature	–40		125	°C

(1) Refer to Application and Implementation for further information

8.4 Thermal Information

THERMAL METRIC(1)		TPS6108x DRC 10 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	45.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	52.2	
$R_{\theta JB}$	Junction-to-board thermal resistance	20.9	
Ψ_{JT}	Junction-to-top characterization parameter	0.9	
Ψ_{JB}	Junction-to-board characterization parameter	20.7	
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	5.3	

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

8.5 Electrical Characteristics

VIN = 3.6 V, EN = VIN, T_A = –40°C to 85°C, typical values are at T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY CURRENT						
V_{IN}	Input voltage range		2.5		6.0	V
I_Q	Operating quiescent current into VIN	Device switching no load			6	mA
I_{SD}	Shutdown current	EN = GND			1	µA
V_{UVLO}	Undervoltage lockout threshold	V_{IN} falling		1.65	1.8	V
V_{hys}	Undervoltage lockout hysterisis			50		mV
ENABLE						
V_{EN}	Enable level voltage	V_{IN} = 2.5 V to 6 V	1.2			V
	Disable level voltage	V_{IN} = 2.5 V to 6 V			0.4	
R_{en}	Enable pulldown resistor		400	800	1600	kΩ
t_{off}	EN pulse width to disable	EN high to low	74			ms
SOFT START						
I_{ss}	Soft start bias current	T_A = 25°C	4.75	5	5.25	µA
			4.6	5	5.4	
V_{clp}	SS pin to FB pin accuracy	V_{SS} = 500 mV	487	500	513	mV
FEEDBACK FB						
I_{FB}	Feedback input bias current	V_{FB} = 1.229 V	–100		100	nA
V_{FB}	Feedback regulation voltage		1.204	1.229	1.254	V
POWER SWITCH AND DIODE						
$R_{DS(ON)}$	Isolation MOSFET on-resistance			0.06	0.1	Ω
	N-channel MOSFET on-resistance	V_{IN} = VGS = 3.6 V		0.17	0.22	Ω
		V_{IN} = VGS = 2.5 V		0.2	0.32	
I_{LN_NFET}	N-channel leakage current	V_{DS} = 28 V		1	2	µA
V_F	Power diode forward voltage	Id = 1 A		0.85	1	V
I_{LN_ISO}	Isolation FET leakage current	L pin to ground			1	µA
OC AND SC						
I_{LIM}	N-Channel MOSFET current limit(1)	TPS61080, FSW = High or FSW = Low	0.5	0.7	1.0	A
		TPS61081, FSW = High or FSW = Low	1.3	1.6	2.0	
I_{SC}	Short circuit current limit	TPS61080	1.0		2.2	A
		TPS61081	2.0		3.5	
t_{scd}	Short circuit delay time			13		µs
t_{scr}	Short circuit release time			57		ms
V_{SC}	OUT short detection threshold (2)	$V_{IN} – V_{OUT}$		1.4		V
OSCILLATOR						
f_S	Oscillator frequency	FSW pin high	1.0	1.2	1.5	MHz
		FSW pin low	0.5	0.6	0.7	
D_{max}	Maximum duty cycle	FB = 1.0 V	90%	94%		
D_{min}	Minimum duty cycle			5%		
R_{fsw}	FSW pin pulldown resistance		400	800	1600	kΩ
V_{FSW}	FSW high logic		1.6			V
	FSW low logic				0.8	

(1) V_{IN} = 3.6 V, V_{OUT} = 15 V, Duty cycle = 76%. See Figure 5 to Figure 8 for other operation conditions.
(2) OUT short circuit condition is detected if OUT stays lower than VIN – V_{SC} for 1.7 ms after IC enables. See the *Start Up* section for details.

9 Detailed Description

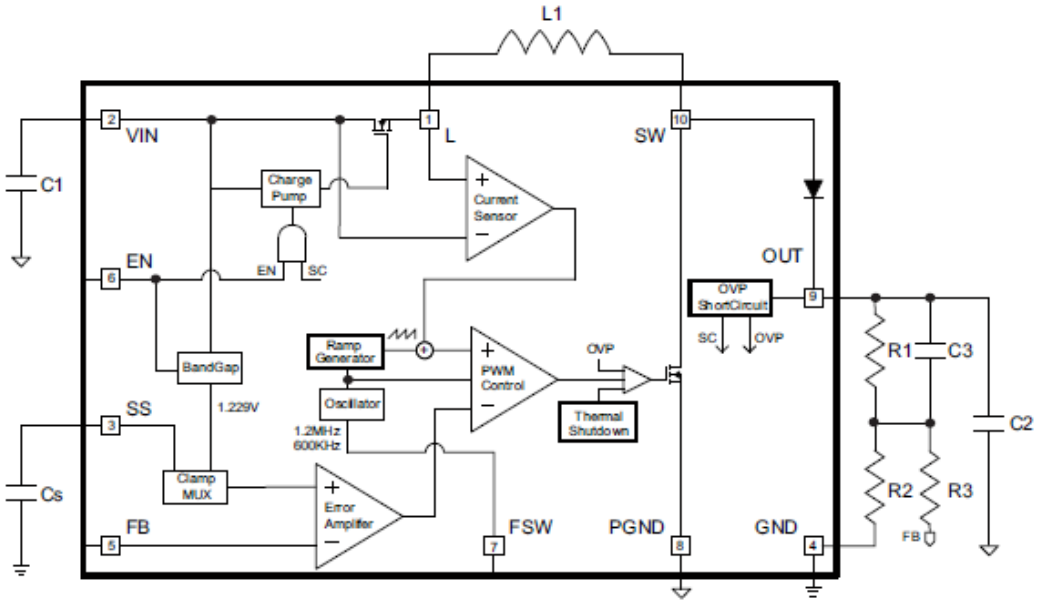
9.1 Overview

TPS6108x is a highly integrated boost regulator for up to 27-V output. In addition to the on-chip 0.5-A/1.2-A PWM switch and power diode, this IC also builds in an input side isolation switch as shown in the block diagram. One common issue with conventional boost regulator is the conduction path from input to output even when PWM switch is turned off. It creates three problems, inrush current during start up, output leakage voltage under shutdown, and unlimited short circuit current. To address these issues, TPS6108x turns off the isolation switch under shutdown mode and short circuit condition to eliminate any possible current path.

TPS6108x adopts current mode control with constant PWM (pulse width modulation) frequency. The switching frequency can be configured to either 600 kHz or 1.2 MHz through the FSW pin. 600 kHz improves light load efficiency, while 1.2 MHz allows using smaller external component. The PWM operation turns on the PWM switch at the beginning of each switching cycle. The input voltage is applied across the inductor and stores the energy as inductor current ramps up. The load current is provided by the output capacitor. When the inductor current across the threshold set by error amplifier output, the PWM switch is turned off, and the power diode is forward biased. The inductor transfers its stored energy to replenish the output capacitor. This operation repeats in the next switching cycle.

The error amplifier compares the FB pin voltage with an internal reference, and its output determines the duty cycle of the PWM switching. This close loop system requires loop compensation for stable operation. TPS6108x has internal compensation circuitry which accommodates a wide range of input and output voltages. The TPS6108x integrates slope compensation to the current ramp to avoid the sub-harmonic oscillation that is intrinsic to current mode control schemes.

9.2 Functional Block Diagram

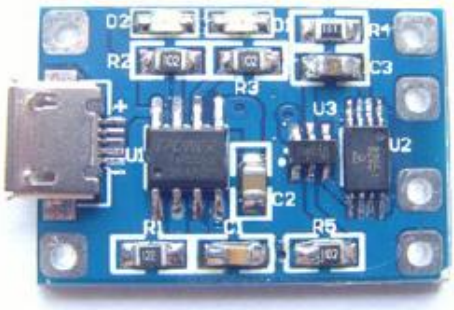


4. CARGADOR DE BATERÍAS

Shenzhen LC Technology Co.,Ltd.

Shenzhen LC Technology Co., Ltd.
Address: Room 509,Building 213,Tairan Industry and Trade Park,
Futian District, Shenzhen, China Postcode: 518040
Tel/Fax: 86-755-82720811

Function Description



LC TP4056 Lithium battery charge and discharge protection module equipped with TP4056 chip,a maximum charge current up to 1.2A,and this module is equipped with a charge-discharge protection device for the voltage of 3.6V,3.7V, such as 18650,polymer etc., single or multiple parallel can also be used.

Product Features

1. onboard TP4056 lithium battery charging management chip;
2. on-board micro USB,can connect with most smartphone charger directly as an input to the lithium battery;
3. reserved IN + and IN- input port, convenient to user's DIY;
4. on-board charging status indicator;
5. support the charge and discharge current protection;
6. the chip with constant current, full automatic stop;
7. supports simultaneous charging and discharging;

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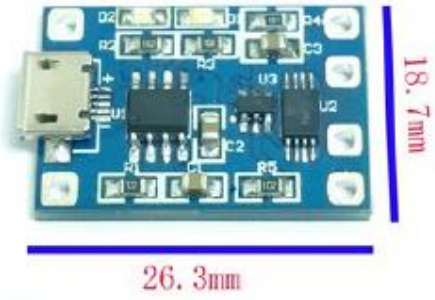
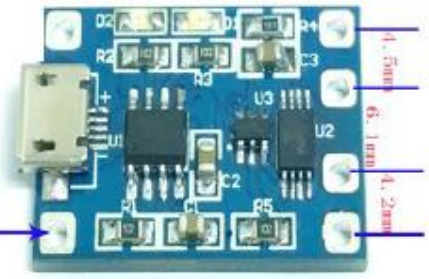
Performance Parameters

Input Voltage	DC 5V
Charging cut-off voltage	DC 4.2V±1%
maximum output current	1.2A
Charging method	Linear Charge
Working temperature	-20℃-85℃

The hardware size





Note: 6 pads are the same size, the hole diameter is 1.54 mm Φ1.54mm

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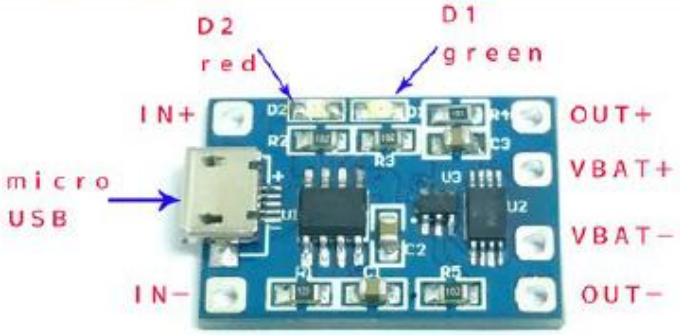
Basic Features



•Inputs can via USB or IN +, IN- to input;IN + connected positive input voltage,IN- connected to the negative;

D1 is full indication Green LED, that only take input,output without any connection or the lithium battery is fully charged,then D1 light;

• OUT +, OUT- connected load, the output interface does not support the charge and discharge over-current protection, the remaining functions and VBAT +, VBAT- consistent interface functions;

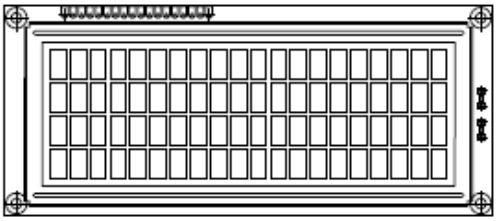
•VBAT +, VBAT- take lithium positive and negative charge, VBAT + connected lithium battery positive, VBAT- then negative, charging red LED D1 light, green LED D2 lights off, the lithium battery positive and negative poles can not be reversed!

5. PANTALLA LCD

VISHAY.
www.vishay.com

LCD-020N004L
Vishay

20 x 4 Character LCD



FEATURES

- Type: Character
- Display format: 20 x 4 characters
- Built-in controller: ST 7066 (or equivalent)
- Duty cycle: 1/16
- 5 x 8 dots includes cursor
- + 5 V power supply (also available for + 3 V)
- LED can be driven by pin 1, pin 2, pin 15, pin 16 or A and K
- N.V. optional for + 3 V power supply
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free
RoHS COMPLIANT

MECHANICAL DATA

ITEM	STANDARD VALUE	UNIT
Module Dimension	146.0 x 62.5	mm
Viewing Area	123.5 x 43.0	
Dot Size	0.92 x 1.10	
Dot Pitch	0.98 x 1.16	
Mounting Hole	139.0 x 55.5	
Character Size	4.84 x 9.22	

ABSOLUTE MAXIMUM RATINGS

ITEM	SYMBOL	STANDARD VALUE			UNIT
		MIN.	TYP.	MAX.	
Power Supply	V_{DD} to V_{SS}	- 0.3	-	7.0	V
Input Voltage	V_I	- 0.3	-	V_{DD}	

Note

- V_{SS} = 0 V, V_{DD} = 5.0 V

ELECTRICAL CHARACTERISTICS

ITEM	SYMBOL	CONDITION	STANDARD VALUE			UNIT
			MIN.	TYP.	MAX.	
Input Voltage	V_{DD}	V_{DD} = + 5 V	4.7	5.0	5.3	V
		V_{DD} = + 3 V	2.7	3.0	5.3	
Supply Current	I_{DD}	V_{DD} = + 5 V	-	8.0	10.0	mA
Recommended LC Driving Voltage for Normal Temperature Version Module	V_{DD} to V_0	- 20 °C	5.0	5.1	5.7	V
		0 °C	4.6	4.8	5.2	
		25 °C	4.1	4.5	4.7	
		50 °C	3.9	4.2	4.5	
		70 °C	3.7	3.9	4.3	
LED Forward Voltage	V_F	25 °C	-	4.2	4.6	V
LED Forward Current	I_F	25 °C	-	540	1080	mA
EL Power Supply Current	I_{EL}	V_{EL} = 110 V_{AC}, 400 Hz	-	-	5.0	mA

OPTIONS

PROCESS COLOR						BACKLIGHT			
TN	STN Gray	STN Yellow	STN Blue	FSTN B&W	STN Color	None	LED	EL	CCFL
x	x	x	x	x		x	x	x	

For detailed information, please see the "Product Numbering System" document.

DISPLAY CHARACTER ADDRESS CODE

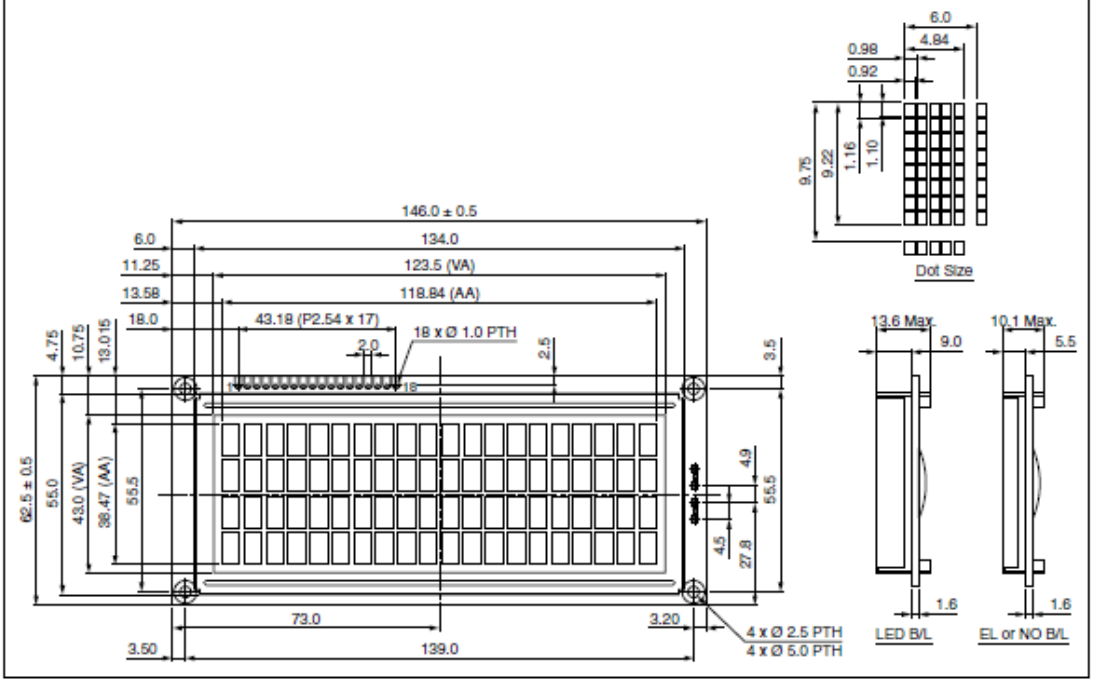
Display Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DD RAM Address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13
DD RAM Address	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53
DD RAM Address	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27
DD RAM Address	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67

VISHAY.
www.vishay.com

LCD-020N004L
Vishay

INTERFACE PIN FUNCTION		
PIN NO.	**SYMBOL**	**FUNCTION**
1	V_{SS}	Ground
2	V_{DD}	+ 3 V or + 5 V
3	V_0	Contrast adjustment
4	RS	H/L register select signal
5	R/$\overline{W}$	H/L read/write signal
6	E	H → L enable signal
7	DB0	H/L data bus line
8	DB1	H/L data bus line
9	DB2	H/L data bus line
10	DB3	H/L data bus line
11	DB4	H/L data bus line
12	DB5	H/L data bus line
13	DB6	H/L data bus line
14	DB7	H/L data bus line
15	A	Power supply for LED (4.2 V)
16	K	Power supply for B/L (0 V)
17	NC/V_{EE}	NC or negative voltage output
18	NC	NC connection

DIMENSIONS in millimeters

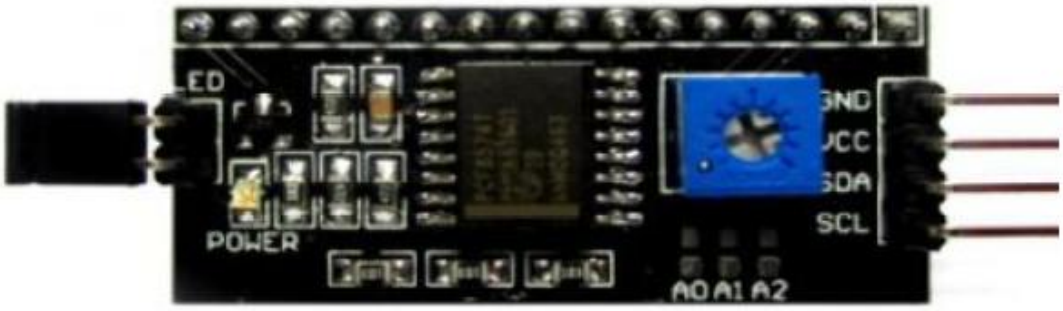


6. MÓDULO I2C

MANTECH ELECTRONICS
International Components Distributor
A MOBICON COMPANY

TEL JHB : (011) 493-9307
CAPE : (021) 535-3150
KZN : (031) 309-7686
FAX : (011) 493-9310
sales@mantech.co.za
www.mantech.co.za

I2C interface for LCD



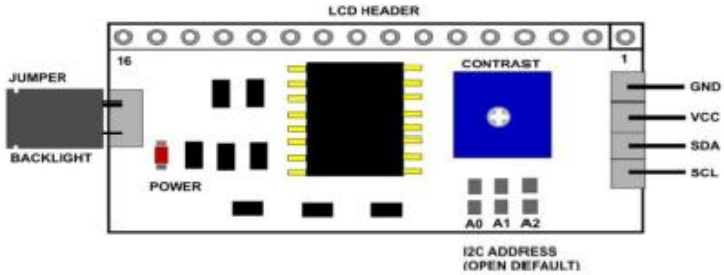
Discription:

This LCD2004 is a great I2C interface for 2x16 and 4x20 LCD displays. With the limited pin resources, your project may be out of resources using normal LCD shield. With this I2C interface LCD module, you only need 2 lines (I2C) to display the information. If you already has I2C devices in your project, this LCD module actually cost no more resources at all. Fantastic for Arduino based projects.

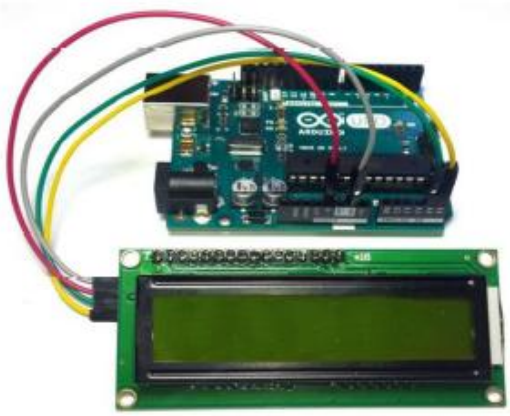
Specification:

Compatible with 16x2 and 20x4 LCD's
Default I2C Address = 0X27
Address selectable - Range 0x20 to 0x27

Board Layout:



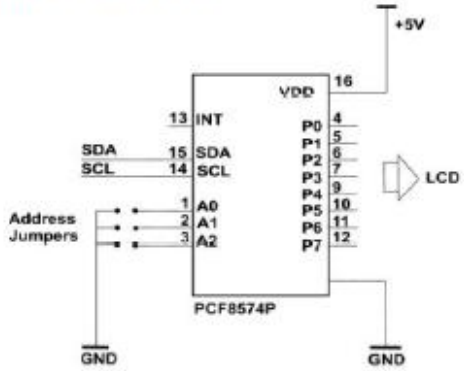
I2C Address Setup:

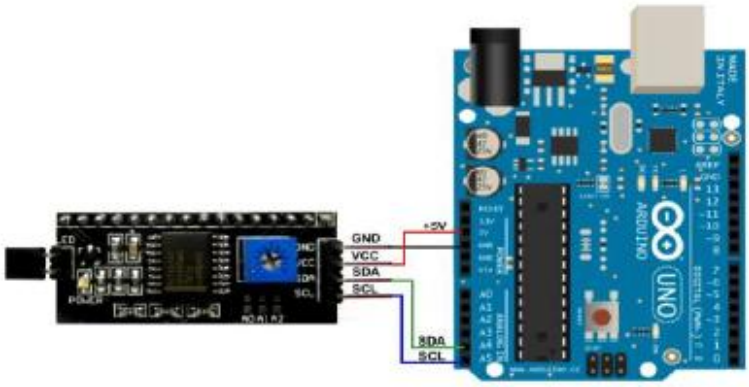


The LCD2004 board utilized the PCF8574 I/O expander. This nifty little chip provides eight bits of parallel I/O addressabl by a I2C bus address – 0x00 to 0x27. SainSmart tied all address leads to Vcc, so the LCD2004 board's I2C address is permanently fixed at hex 27. This is rather limiting since no additional LCD2004s can be added to the bus. Anyway, you simply address the board and write an eight bit value which is then presented on the output pins of the PCF8574, which, in this case, are connected to the HD44780 based LCD screen.

INPUTS			I2C SLAVE ADDRESS
A2	A1	A0	
L	L	L	0x20
L	L	H	0x21
L	H	L	0x22
L	H	H	0x23
H	L	L	0x24
H	L	H	0x25
H	H	L	0x26
H	H	H	0x27

H = Open Jumper L = Close Jumper






```
//Arduino Code
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,2,1,0,4,5,6,7,3, POSITIVE); // Initialize LCD Display at address 0x27
                                                       // unmodified backpack
void setup() {
 // activate LCD module
 lcd.begin (16,2); // for 16 x 2 LCD module
 lcd.setBacklightPin(3,POSITIVE);
 lcd.setBacklight(HIGH);
 }

void loop() {
 lcd.home (); // set cursor to 0,0
 lcd.print(" Hello, world!");
 lcd.setCursor (0,1);       // go to start of 2nd line
 lcd.print(millis());
 delay(1000);
 lcd.setBacklight(LOW);     // Backlight off
 delay(500);
 lcd.setBacklight(HIGH);    // Backlight on

 delay(1000);
}      // END
```

7. DIODO

1N4001 THRU 1N4007

PLASTIC SILICON RECTIFIER

VOLTAGE - 50 to 1000 Volts CURRENT - 1.0 Ampere

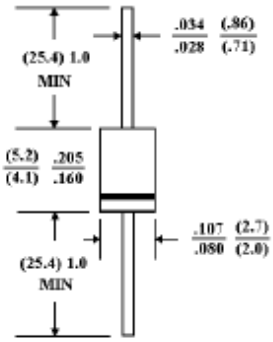
FEATURES

- Low forward voltage drop
- High current capability
- High reliability
- High surge current capability
- Exceeds environmental standards of MIL-S-19500/228

MECHANICAL DATA

Case: Molded plastic , DO-41
Epoxy: UL 94V-O rate flame retardant
Lead: Axial leads, solderable per MIL-STD-202,
method 208 guaranteed
Polarity: Color band denotes cathode end
Mounting Position: Any
Weight: 0.012 ounce, 0.3 gram

DO-41



Dimensions in inches and (millimeters)

MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS

Ratings at 25 •• ambient temperature unless otherwise specified.
Single phase, half wave, 60 Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	UNITS
Maximum Recurrent Peak Reverse Voltage	50	100	200	400	600	800	1000	V
Maximum RMS Voltage	35	75	140	280	420	560	700	V
Maximum DC Blocking Voltage	50	100	200	400	600	800	1000	V
Maximum Average Forward Rectified Current .375"(9.5mm) Lead Length at T_A=75 ••	1.0							A
Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load (JEDEC method)	30							A
Maximum Forward Voltage at 1.0A DC and 25 ••	1.1							V
Maximum Full Load Reverse Current Full Cycle Average at 75 •• Ambient	30							•• A
Maximum Reverse Current at T_A=25 ••	5.0							•• A
At Rated DC Blocking Voltage T_A=100 ••	500							•• A
Typical Junction capacitance (Note 1)	15							pF
Typical Thermal Resistance (Note 2) R •• JA	50							••/W
Typical Thermal resistance (NOTE 2) R •• JL	25							••/W
Operating and Storage Temperature Range T_J, T_{STG}	-55 to +150							••

NOTES:

1. Measured at 1 MHz and applied reverse voltage of 4.0 VDC.
2. Thermal Resistance Junction to Ambient and from junction to lead at 0.375"(9.5mm) lead length P.C.B mounted.

8. RASPBERRY PI

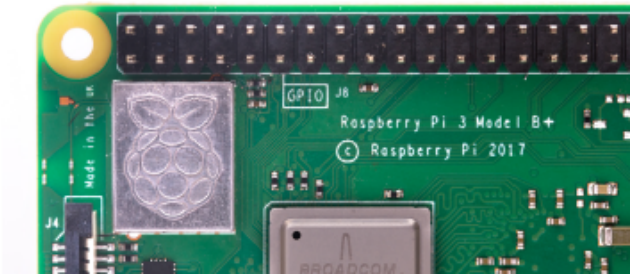
Raspberry Pi 3 Model B+

2

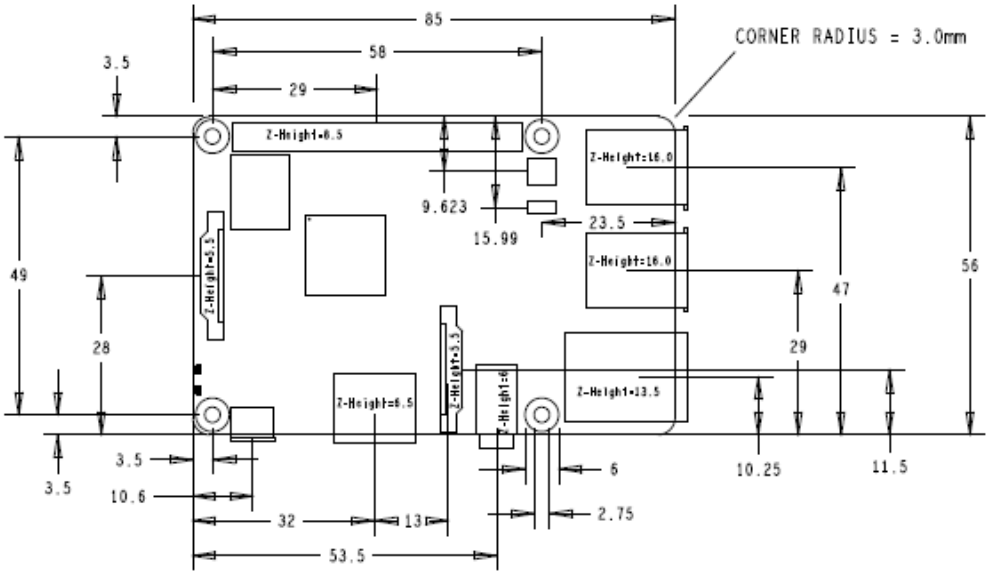
Specifications

Processor:	Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4GHz
Memory:	1GB LPDDR2 SDRAM
Connectivity:	■ 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE ■ Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps) ■ 4 × USB 2.0 ports
Access:	Extended 40-pin GPIO header
Video & sound:	■ 1 × full size HDMI ■ MIPI DSI display port ■ MIPI CSI camera port ■ 4 pole stereo output and composite video port
Multimedia:	H.264, MPEG-4 decode (1080p30); H.264 encode (1080p30); OpenGL ES 1.1, 2.0 graphics
SD card support:	Micro SD format for loading operating system and data storage
Input power:	■ 5V/2.5A DC via micro USB connector ■ 5V DC via GPIO header ■ Power over Ethernet (PoE)–enabled (requires separate PoE HAT)
Environment:	Operating temperature, 0–50°C
Compliance:	For a full list of local and regional product approvals, please visit www.raspberrypi.org/products/raspberry-pi-3-model-b+
Production lifetime:	The Raspberry Pi 3 Model B+ will remain in production until at least January 2023.

raspberrypi.org



Physical specifications



Warnings

- This product should only be connected to an external power supply rated at 5V/2.5A DC. Any external power supply used with the Raspberry Pi 3 Model B+ shall comply with relevant regulations and standards applicable in the country of intended use.
- This product should be operated in a well-ventilated environment and, if used inside a case, the case should not be covered.
- Whilst in use, this product should be placed on a stable, flat, non-conductive surface and should not be contacted by conductive items.
- The connection of incompatible devices to the GPIO connection may affect compliance, result in damage to the unit, and invalidate the warranty.
- All peripherals used with this product should comply with relevant standards for the country of use and be marked accordingly to ensure that safety and performance requirements are met. These articles include but are not limited to keyboards, monitors, and mice when used in conjunction with the Raspberry Pi.
- The cables and connectors of all peripherals used with this product must have adequate insulation so that relevant safety requirements are met.

Safety instructions

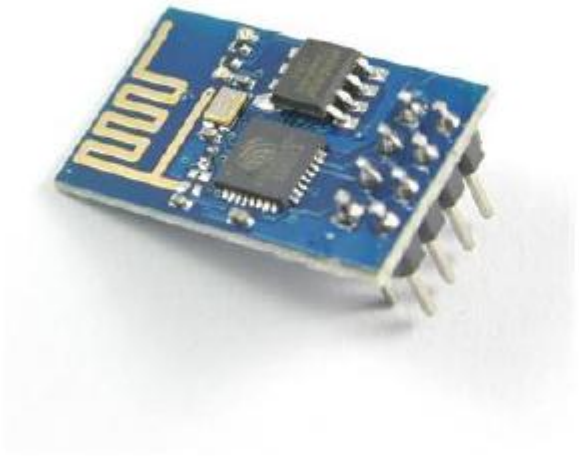
To avoid malfunction of or damage to this product, please observe the following:

- Do not expose to water or moisture, or place on a conductive surface whilst in operation.
- Do not expose to heat from any source; the Raspberry Pi 3 Model B+ is designed for reliable operation at normal ambient temperatures.
- Take care whilst handling to avoid mechanical or electrical damage to the printed circuit board and connectors.
- Whilst it is powered, avoid handling the printed circuit board, or only handle it by the edges to minimise the risk of electrostatic discharge damage.

raspberrypi.org

9. MÓDULO WIFI ESP 8266

ESP8266 Serial Esp-01 WIFI Wireless



Building the gcc toolchain
have a look at the github wiki https://github.com/esp8266/esp8266-wiki/wiki
Code examples
have a look at the github wiki https://github.com/esp8266/esp8266-wiki/wiki
Running the module
The modules pins only allow 3.3v (use a multi meter to check your serial lines if you are not sure)
Connect CH_PD to VCC to make it boot

Uploading code
The modules pins only allow 3.3v (use a multi meter to check your serial lines if you are not sure)
see https://github.com/esp8266/esp8266-wiki/wiki/Uploading
links
Internal space links
https://git.nurdspace.lan/esp8266/led_example/source/
External
SDK documentation (all chinees) DOCS
VM file [1] Password: i90l
Forum about the module http://www.esp8266.com/
seeedstudio.com/depot/WiFi-Serial-Transceiver-Module-w-ESP8266-p-1994.html
ESP8266 ROM Bootloader utility https://github.com/themadinventor/esptool
Datasheet
English Datasheet
http://www.seeedstudio.com/document/pdf/ESP8266%20Specifications(Chinese).pdf (Chinese)

Power

The following data are based on a 3.3V power supply, ambient temperature 25C and use the internal regulator measured. [1] All measurements are made in the absence of the SAW filter, the antenna interface is completed. [2] all transmit data based on 90% duty cycle, continuous transmission mode in the measured.

Mode	Min	Typical	Max	Units
802.11b, CCK 1Mbps, POUT=+19.5dBm		215		mA
802.11b, CCK 11Mbps, POUT=+18.5dBm		197		mA
802.11g, OFDM 54Mbps, POUT=+16dBm		145		mA
802.11n, MCS7, POUT =+14dBm		135		mA
802.11b, packet size of 1024 bytes, -80dBm		60		mA
802.11b, packet size of 1024 bytes, -70dBm		60		mA
802.11b, packet size of 1024 bytes, -65dBm		62		mA
Standby		0.9		uA
Deep sleep		10		mA
Saving mode DTIM 1		1.2		mA
Saving mode DTIM 3		0.86		mA
Shutdown		0.5		uA

RF specifications

The following data is at room temperature, the voltage of 3.3V and 1.1V, respectively, when measured

Description	Min	Typical	Max	Units
Input Frequency	2412		2484	MHz
Input resistance		50		Ω
Input reflection			-10	dB
At 72.2Mbps, PA output power	14	15	16	dBm
11b mode, PA output power	17.5	18.5	19.5	dBm
Sensitivity				
CCK, 1Mbps		-98		dBm
CCK, 11Mbps		-91		dBm
6Mbps (1/2 BPSK)		-93		dBm
54Mbps (3/4 64-QAM)		-75		dBm
HT20, MCS7 (65Mbps, 72.2Mbps)		-71		dBm
Adjacent suppression				
OFDM, 6Mbps		37		dB

OFDM, 54Mbps		21		dB
HT20, MCS0		37		dB
HT20, MCS7		20		dB

CPU and memory

CPU Interface

The chip embedded in an ultra-low-power 32-bit micro-CPU, with 16 compact mode. Can be connected to the CPU via the following interfaces:

connecting storage controllers can also be used to access external code memory RAM / ROM interface (iBus)

Also attached storage controller data RAM interface (dBus)

Access Register of AHB interface

JTAG debug interface

Storage Controller

Storage controller contains ROM and SRAM. CPU can iBus, dBus and AHB interface to access the storage controller. Any one of these interfaces can apply for access to ROM or RAM cells, memory arbiter to determine the running order in the order of arrival.

AHB and AHB module

AHB module acts as arbiter, through the MAC, and SDIO host CPU control AHB interface. Since sending Address different, AHB data requests may arrive the following two slaves in one: APB module, or flash memory controller (usually in the case of off-line applications) to the received request is a high speed memory controllers often request, APB module receives register access is often Request. APB module acts as a decoder, but only you can access the ESP8266 main module programmable registers. Since the sending address different, APB request may reach the radio receiver, SI / SPI, hosts SDIO, GPIO, UART, real-time clock (RTC), MAC or digital baseband.

Interface

ESP 8266 contains multiple analog and digital interfaces, as follows:

Main SI / SPI control (optional)

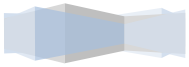
Main Serial Interface (SI) can run at two, three, four-wire bus configuration, is used to control the EEPROM or other I2C / SPI devices. Multiple devices share the two-wire I2C bus. Multiple SPI devices to share the clock and data signals, and according to the chip select, each controlled by software alone GPIO pins. SPI can be used to control external devices, such as serial flash, audio CODEC or other slave devices, installation, effectively giving it three different pins, making it the standard master SPI device.

SPI_EN0

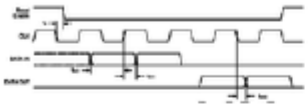
SPI_EN1

SPI_EN2

SPI slave is used as the primary interface, giving SPI master and slave SPI support. In the built-in applications, SPI_EN0 is used as an enable signal, the role of external serial flash, download firmware and / or MIB data to baseband. In host-based applications, the firmware and you can choose one MIB data downloaded via the host interface both. This pin is active low when not should be left unconnected. SPI_EN1 often used for user applications, such as controlling the built-in applications or external audio codec sensor ADC. This pin is active low when not should be left unconnected. SPI_EN2 often used to control the EEPROM, storing individual data



(individual data), such as MIB information, MAC address, and calibration data, or for general purposes. This pin is active low when not should be left unconnected.



General Purpose IO

A total of up to 16 GPIO pins. The firmware can assign them different functions. Each GPIO can be configured internal pullup / pulldown resistors available software registers sampled input, triggering edge or level CPU interrupt input, trigger level wake-up interrupt input, open-drain or complementary push-pull output drivers, software register output source or sigma-delta PWM DAC. These pins are multiplexed with other functions, such as the main interface, UART, SI, Bluetooth co-existence and so on.

Digital IO pins

Digital IO pad is two-way, three states. It includes a three-state control input and output buffers. In addition, for low-power operation, IO can be set to hold state. For example, when we reduce the chip's power consumption, all the output enable signal can be set to maintain a low-power state. Hold function can be selectively implanted IO in need. When the IO help internal and external circuit driving, hold function can be used to hold last state. Hold function to pin introduce some positive feedback. Therefore, the external drive pin must be stronger than the positive feedback. However, the required driving force size is still small, in the 5uA of.

Variables	Symbol	Min	Max	Units
Input Low Voltage	Vil	-0.3	0.25xV10	V
Input High Voltage	Vih	0.75xV10	3.6	V
Input leakage current	IIL	-	50	nA
Output Low Voltage	VOL	-	0.1xV10	V
Output High Voltage	VOH	0.8xV10	-	V
Input pin capacitance	Cpad	-	2	pF
VDDIO	V10	1.7	3.6	V
Current	Imax	-	12	mA
Temperature	Tamb	-20	100	C

All digital IO pins must add an overvoltage protection circuit (snap back circuit) between the pin and ground. Usually bounce (snap back) voltage is about 6V, while maintaining the voltage is 5.8V. This prevents excessive voltage and generating ESD. Diodes also avoid reverse voltage output devices.

Firmware and software tools development kit

The firmware running on the ROM and SRAM chip, when the device is awake, firmware via SDIO sector Download the instructions from the host side. Firmware is fully compliant with 802.11 b / g / n / e / i WLAN MAC protocol and Wi-Fi Direct specification only supports basic services unit distributed control function (DCF) under (BSS) operation, but also follow the latest Wi-Fi P2P

Dynamic capacitance	Cm	2	5	pF
Serial resistance	Rs	0	65	Ω
Frequency tolerance	Fxo	-15	15	ppm
Frequency vs Temperature (-25C ~ 75C)	Fxo,Temp	-15	15	ppm

External Reference Requirements

At 26MHz external clock frequency between 52MHz. In order to make a well-functioning radio receiver, the clock will Must have the following characteristics:

Variables	Symbol	Min	Max	Units
Clock amplitude	Vxo	0.2	1	Vpp
External clock accuracy	Fxo,EXT	-15	15	ppm
Phase Noise @ 1kHz offset, 40MHz clock			-120	dBc/Hz
Phase Noise @ 10kHz offset, 40MHz clock			-130	dBc/Hz
Phase Noise @ 100kHz offset, 40MHz clock			-138	dBc/Hz

Radio receivers

ESP8266 radio receiver mainly includes the following modules:

2.4GHz receiver

2.4GHz transmitter

High-speed clock generator and crystal oscillator

Real-time clock

bias and regulators

Power Management

Channel Frequency

According IEEE802.11bgn standard, RF transceiver supports the following channels:

Channel	Freq.	Channel	Freq.
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442	14	2484

2.4GHz receiver

2.4GHz RF signal receiver down into quadrature baseband signal, with two high-resolution, high-speed ADC and the latter into a digital signal. In order to accommodate different signal channels, a radio receiver integrated RF filters, automatic gain control (AGC), DC offset compensation circuit and a baseband filter.

2.4GHz transmitter

2.4 GHz transmitter orthogonal frequency baseband signals up to 2.4GHz, using high-power

CMOS power amplifier to drive the antenna. Further use of the digital calibration improves the linearity of the power amplifier to achieve the average power of + 19dBm in 802.11b transmission, the transmission reaches + 16dBm 802.11n average power, features super. To offset defects in the radio receiver is also calibrated by other measures such as:
carrier leakage
I / Q phase matching, and
baseband nonlinear
This will reduce the time and equipment required for testing.
Clock generator
The clock generator generates the receiver and transmitter 2.4GHz clock signal all of its components are integrated on the chip, Include:
inductor
varactor
closed-loop filter
Clock generator contains a built-in calibration circuit and self-test circuitry. Clock phase and quadrature phase noise through the optimal calibration algorithm processing patent on the chip, in order to ensure that the receiver and transmitter to achieve the best performance.
AT Commands
Tnx to http://www.electrodragon.com/w/Wi07c
Format
Baud rate at 57600
x is the commands

Set	Inquiry	Test	Execute
AT+<x>=<...>	AT+<x>?	AT+<x>=?	AT+<x>
AT+CWMODE=<mode>	AT+CWMODE?	AT+CWMODE=?	-
Set the network mode	Check current mode	Return which modes supported	-

Commands
carefully there are must be no any spaces between the " and IP address or port

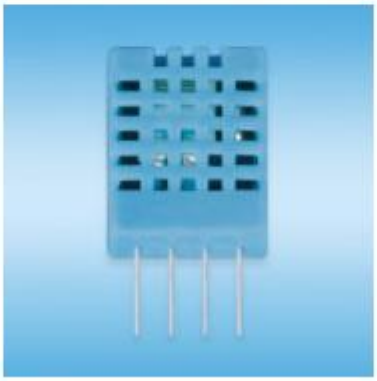
Commands	Description	Type	Set/Execute	Inquiry	test	Parameters	Examples
AT+RST	restart the module	basic	-	-	-	-	
AT+CWMODE	wifi mode	wifi	AT+CWMODE=<mode>	AT+CWMODE?	AT+CWMODE=?	1= Sta, 2= AP, 3=both	
AT+CWJAP	join the AP	wifi	AT+ CWJAP =<ssid>,<pwd >	AT+ CWJAP?	-	ssid = ssid, pwd = wifi	

10. SENSOR DHT11

AOSONG Temp、Humidity & Dew point measurement experts

1、Product Overview

DHT11 digital temperature and humidity sensor is a composite Sensor contains a calibrated digital signal output of the temperature and humidity. Application of a dedicated digital modules collection technology and the temperature and humidity sensing technology, to ensure that the product has high reliability and excellent long-term stability. The sensor includes a resistive sense of wet components and an NTC temperature measurement devices, and connected with a high-performance 8-bit microcontroller.



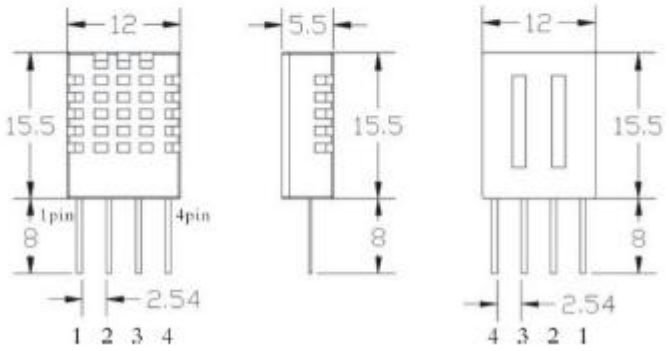
2、Applications

HVAC, dehumidifier, testing and inspection equipment, consumer goods, automotive, automatic control, data loggers, weather stations, home appliances, humidity regulator, medical and other humidity measurement and control.

3、Features

Low cost, long-term stability, relative humidity and temperature measurement, excellent quality, fast response, strong anti-interference ability, long distance signal transmission, digital signal output, and precise calibration.

4、Dimensions (unit: mm)



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5、Product parameters

Relative humidity
Resolution: 16Bit
Repeatability: ±1% RH
Accuracy: At 25℃ ±5% RH
Interchangeability: fully interchangeable
Response time: 1 / e (63%) of 25℃ 6s
1m / s air 6s
Hysteresis: <± 0.3% RH
Long-term stability: <± 0.5% RH / yr in

Temperature
Resolution: 16Bit
Repeatability: ±0.2℃
Range: At 25℃ ±2℃
Response time: 1 / e (63%) 10S

Electrical Characteristics
Power supply: DC 3.5 ~ 5.5V
Supply Current: measurement 0.3mA standby 60μ A
Sampling period: more than 2 seconds

Pin Description
1, the VDD power supply 3.5 ~ 5.5V DC
2 DATA serial data, a single bus
3, NC, empty pin
4, GND ground, the negative power

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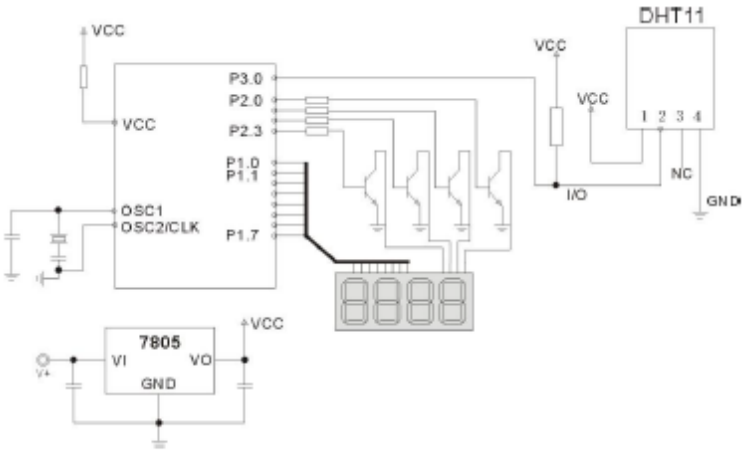
6、Typical circuit



Microprocessor and DHT11 of connection typical application circuit as shown above, DATA pull the microprocessor I / O ports are connected.

1. Typical application circuit recommended in the short cable length of 20 meters on the 5.1K pull-up resistor, the resistance of greater than 20 meters under the pull-up resistor on the lower of the actual situation.

2. When using a 3.5V voltage supply cable length shall not be greater than 20cm. Otherwise, the line voltage drop will cause the sensor power supply shortage, caused by measurement error.

3. Each read out the temperature and humidity values are the results of the last measurement For real-time data, sequential read twice, but is not recommended to repeatedly read the sensors, each read sensor interval is greater than 5 seconds can be obtainedaccurate data.

7、Serial communication instructions (single-wire bi-directional)

◎Single bus Description

DHT11 uses a simplified single-bus communication. Single bus that only one data line, the system of data exchange, control by a single bus to complete. Device (master or slave) through an open-drain or tri-state port connected to the data line to allow the device does not send data to release the bus, while other devices use the bus; single bus usually require an external one about 5.1kΩ pull-up resistor, so that when the bus is idle, its status is high. Because they are the master-slave structure, and only when the host calls the slave, the slave can answer, the host access devices must strictly follow the single-bus sequence, if the chaotic sequence, the device will not respond to the host.

◎Single bus to transfer data defined

DATA For communication and synchronization between the microprocessor and DHT11, single-bus data format, a transmission of 40 data, the high first-out.

11. BATERÍA DE LI-ION

EEMB™

LIR18650 Datasheet
Li-ion Battery
Edition: DEC. 2006

This Specification describes the requirements of the lithium ion rechargeable battery supplied by EEMB Co., Ltd.

1.0 BASIC CHARACTERISTICS

1.1	Battery Type	LIR18650
1.2	Nominal Capacity	2000mAh (0.2C discharge)
	Minimum Capacity	2000mAh (0.2C discharge)
1.3	Charging Voltage	4.2V
1.4	Nominal Voltage	3.7V
1.5	Standard Charge	Method: CC/CV (constant current / constant voltage) Current: 0.5C Voltage: 4.2V End Current:: 20mA
1.6	Maximum Charge Current	1500mA
1.7	Maximum Discharge Current	3000mA
1.8	End of Discharge Voltage	2.75V
1.9	Weight	Approx. 45g
1.10	Operating Temperature	Charge: 0 °C ~ 45°C Discharge: -20 °C ~ 60°C
1.11	Storage Temperature	-20°C ~ 45°C
1.12	Appearance	There shall be no such defect as scratch, flaw, crack, rust, leakage, which may adversely affect commercial value of the cell.

2.0 TECHNICAL REQUIREMENTS

2.1 Testing Conditions (unless otherwise specified)

Temperature: 20±5°C

Relative Humidity: 65±20%RH

Accuracy of voltmeters and ammeters used in the test is equal to or better than the grade 0.5

2.2 Electrical Characteristics

NO	ITEM	TESTING INSTRUCTION	REQUIREMENTS
2.2.1	Charge Condition	Charge the battery with constant current 0.5C to 4.2V, and then charge at constant voltage 4.2V until the current decays to 20mA during the constant voltage stage.	

Page:1/5

2.2.2	Nominal Capacity	Within one hour after the charge according to 2.2.1, discharge at 0.2C until 2.75V cut-off voltage.	Capacity ⩾ nominal capacity
2.2.3	1C discharge	With in 1 hours after the charge according to 2.2.1, discharge at constant current 1C until 2.75V cut-off voltage. If the discharge duration does not reach specified value, the test may be repeated up to three times in total.	
2.2.4	Internal Resistance	The initial internal resistance shall be measured at AC 1000Hz initially.	The initial internal resistance⩽80mohm
2.2.5	Cycle Life	After the charge according to 2.2.1, the battery stays for 1 hour. At 20±5°C, discharge the battery at constant current 0.5C until 2.75V cut-off voltage. Then the battery stays for 1 hour. A cycle defined as one charge and discharge. This charge and discharge circle shall be repeated 300 times.	The capacity at 300th cycle ⩾ 80% of the nominal capacity
2.2.6	Electricity Preservation	After the charge according to 2.2.1, the battery stays at 20±5°C for 28 days and then discharge at 0.2C to 2.75V cut-off.	The discharge capacity 90% of the nominal capacity
2.2.7	High Temperature Performance	After the charge according to 2.2.1, store the testing cells at 60±2°C for 4 hours. Then discharge at 1C until 2.75V cut-off voltage.	The discharge capacity 90% of the nominal capacity
	Low Temperature Performance	After the charge according to 2.2.1, store the testing cells at -20±2°C for 16-24 hours. Then discharge at 0.2C until 2.75V cut-off voltage	The discharge capacity 60% of the nominal capacity
2.2.8	Short-circuit	After the charge at 2.2.1, short circuit the cathode and anode. Stop testing when battery temperature decays to about 10°C from the maximum temperature.	No fire, no explosion
2.2.9	Overcharge	Put the testing batteries connecting with thermocouple in ventilated cabinet, connect the cathode and anode to a power supply with CC/CV (constant current / constant voltage) function. Adjust the current to 3C and voltage to 4.6V. Then charge the battery at 3C until the limit voltage reaches 4.6V. The charging continued for 8 hours.	No fire, no explosion

2.2.10	Hot box test	Put the testing batteries connecting with thermocouple in constant temperature box. Heat the batteries and box (speed of ascending temperature is 5±2°C at room temperature simultaneously. Monitor the temperature change of the box. Keep for 10 minutes after the box temperature reaches 150±2°C, then stop the test.	No fire, no explosion
2.2.11	Vibration test	After the charge at 2.2.2, put the testing battery on the vibration testing equipment. Vibrate it from X,Y two different directions for 30 minutes (Frequency of vibration: 10Hz-30Hz, displacement of single swing: 0.38mm; Frequency of vibration: 30Hz- 55Hz, displace of single swing: 0.19mm) in swept vibration from 10Hz to 50Hz. The swept rate is 1 oct/min.	No fire, no explosion
2.2.12	Drop test	After the charge at 2.2.2, free drop the testing battery from the height of 1.0 meter (the lowest point height) once from the each six positive and negative X,Y,Z directions to the hardwood board (the thickness of the board is about 50mm).	No fire, no explosion

3.0 BATTERY DIMENSION