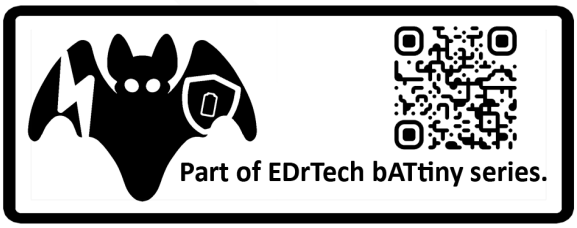
bATtiny Guard - PMG001
Power management module



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EDrTech d.o.o.
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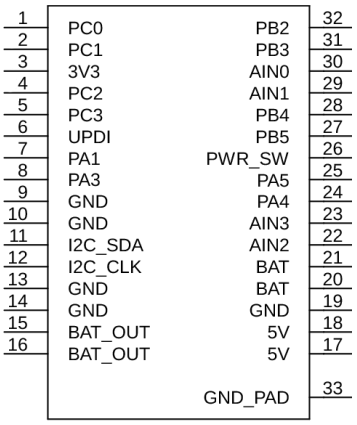
1 Features

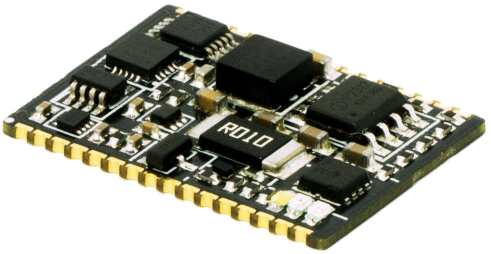
- 32 PIN 22.22mm *16.51mm package
- On/off behavior control
- 2A single cell charger
- Single li-po cell powered
- 4+16 ADC channels
- Bi-directional battery current measurement
- Brown-out detection/reset circuit
- Low RDSon battery output MOSFET
- On-module precision temperature measurement
- I2C Interface (access to integrated microcontroller or separate devices on the module)
- Arduino compatible

2 Applications

- Portable electronics
- Power supply monitoring
- Mobile devices with multiple power rails
- Single rechargeable cell powered devices



Symbol with pins



3 Description

bATtiny Guard - PMG001 provides flexible management and monitoring of power circuitry in systems utilizing a single-cell Li-Po battery. It can monitor up to 4 voltages using a dedicated ADS1015 ADC, with the option to monitor additional voltages through the ATTINY1616's built-in ADC. The module includes current sensing for the battery with INA219, hardware brown-out monitoring using the APX803 (keeping the microcontroller and circuitry in reset state if battery voltage drops below a set level), and precision temperature monitoring via the TMP102 sensor. The IP2312 allows charging currents up to 2A, and an integrated low on-resistance MOSFET for battery output is controlled by the main microcontroller.

Designed as a compact module with castellated holes on two sides, it features 16 pins per side, measuring 22.225 mm by 16.51 mm, allowing for simple drop-in integration into larger systems. The primary functions include managing on/off behavior using a switch or pushbutton, and monitoring various power-related aspects such as power rail voltages, battery current, and temperature, as well as controlling external peripherals using the GPIOs.
While ATTINY1616 enables standalone operation, individual components can also be accessed externally via the I2C interface if required.

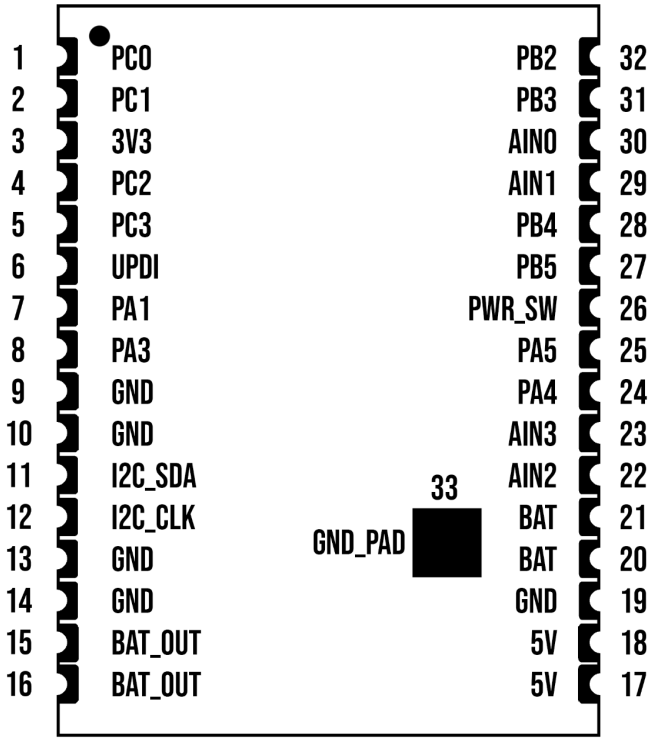
Table of Contents

4 Pin configuration and Functions

Table 4.1 Pin Functions

PIN		TYPE	DESCRIPTION
NO.	NAME		
1	PC0	I/O	Pin PC0 of ATTINY1616
2	PC1	I/O	Pin PC1 of ATTINY1616
3	3V3	O	3.3V regulator output
4	PC2	I/O	Pin PC2 of ATTINY1616
5	PC3	I/O	Pin PC3 of ATTINY1616
6	UPDI	I/O	UPDI pin of ATTINY1616
7	PA1	I/O	Pin PA1of ATTINY1616
8	PA3	I/O	Pin PA3 of ATTINY1616
9	GND	_	Ground
10	GND	_	Ground
11	I2C_SDA	I/O	I2C interface SDA line, connected to PB0 on ATTINY1616
12	I2C_CLK	I/O	I2C interface CLK line, connected to PB1 on ATTINY1616
13	GND	_	Ground
14	GND	_	Ground
15	BAT_OUT	O	Battery MOSFET drain
16	BAT_OUT	O	Battery MOSFET drain
17	5V	I	5V input
18	5V	I	5V input
19	GND	_	Ground
20	BAT	I	Battery input
21	BAT	I	Battery input
22	AIN2	I	ADC channel 2 of ADS1015
23	AIN3	I	ADC channel 3 of ADS1015
24	PA4	I/O	Pin PC0 of ATTINY1616
25	PA5	I/O	Pin PC0 of ATTINY1616
26	PWR_SW	I	Power switch/button input, connected to pin PA7 on ATTINY1616
27	PB5	I/O	Pin PC0 of ATTINY1616
28	PB4	I/O	Pin PC0 of ATTINY1616
29	AIN1	I	ADC channel 1 of ADS1015
30	AIN0	I	ADC channel 0 of ADS1015
31	PB3	I/O	Pin PB3 of ATTINY1616
32	PB2	I/O	Pin PB2 of ATTINY1616
33	GND_PAD	_	Thermal ground pad

32 Pin Package (Top View)



5 Module schematic and layout

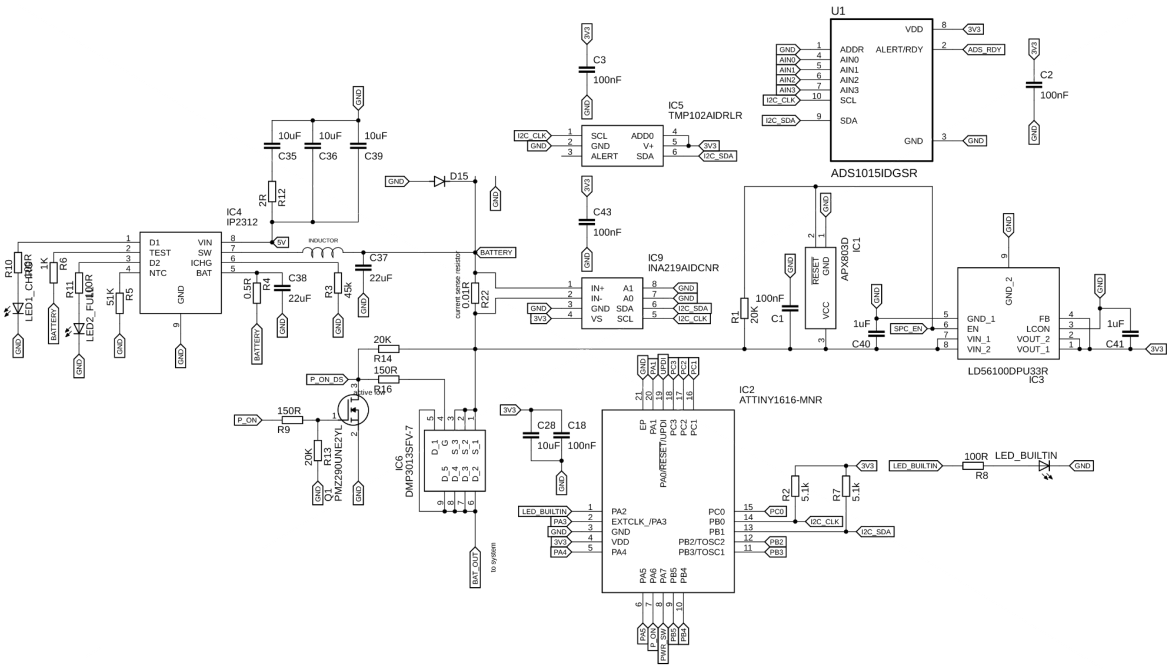


Figure 5.1 Module schematic

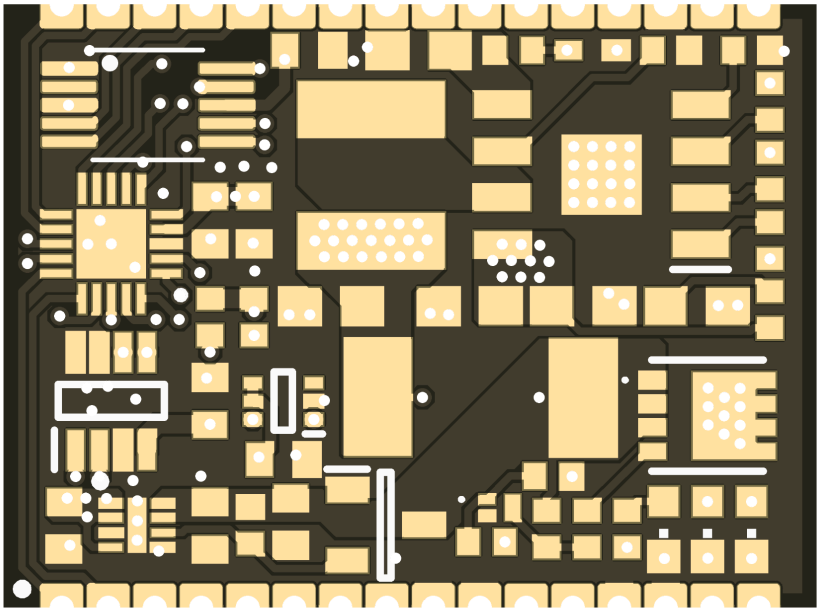


Figure 5.2 Module layout

6 Specifications

6.1 Absolute Maximum Ratings

	MIN	MAX	UNIT
Voltage at BAT pins		4.23	V
Voltage at 5V pins	-0.3	6.5	V
Voltage at ADC pins	-0.3	3.6	V
Voltage at ATTINY1616 pins	-0.5	3.8	V
Operating temperature	-30	85	℃
Storage temperature	-40	90	℃

6.2 Recommended Operating Conditions

Please refer to datasheets of respective individual components contained within the module

Component	Reference
Microcontroller	ATTINY1616-MNR
ADC	ADS1015IDGSR
Voltage monitor/reset circuit	APX803D-31SAG-7
Battery output MOSFET	DMP3013SFV-7
Current sensor	INA219AIDCNR
Battery charger	IP2312
3.3V regulator	LD56100DPU33R
Temperature sensor	TMP102AIDRLR

7 bATtiny Guard - PMG001 Module detailed description

7.1 bATtiny Guard - PMG001 Description

bATtiny Guard - PMG001 is a highly integrated module designed for efficient management of single-cell Li-Po battery systems. It incorporates various essential ICs to address all aspects of power management, including battery charging, switch/button power on/off behavior, undervoltage and overvoltage protection, flexible voltage measurement, battery current measurement, and temperature monitoring. Additionally, it features a microcontroller for programming custom behaviors, ensuring comprehensive management of single-cell rechargeable battery systems.

Furthermore, when paired with the demo kit base PCB, the module serves as a general development board for the ATTINY1616, with all[1] pins accessible for any application.

7.2 Module power

The module is powered by connecting the BAT pins to a single-cell battery, typically 3.7V. An integrated regulator supplies up to 1A of current at 3.3V for all components on the module, and can also power external circuitry. The 3.3V regulator operates independently of BAT_OUT and is disabled only under undervoltage conditions[2].

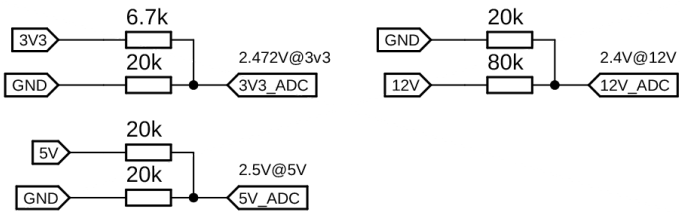
7.3 ADC

The module features a built-in Texas Instruments ADS1015 for precise voltage measurements up to 3.3V. Care must be taken to bring higher voltages to a suitable level for measurement to avoid exceeding maximum operation conditions. This is typically achieved using a voltage divider, as shown in the example in Figure 7.1.

In addition to the dedicated ADC pins, most of the ATTINY1616 GPIOs can be used as ADC inputs according to the datasheet[3].

ADS1015 I2C Address - 0x48

Figure 7.1 Resistor divider examples with resulting voltages



[1] Except the dedicated pins like PWR_SW, UPDI etc.
[2] The system enters undervoltage condition below 3.08V with 40mV hysteresis
[3] ATTINY1616 Datasheet

7.4 Current sensor

The PMG001 features a Texas Instruments INA219 current sensor, which monitors the battery voltage and current flowing to the externally connected system. This is achieved by measuring the voltage drop across a precision 10mΩ shunt resistor. Various power usage data can be derived from these measurements.

INA219 I2C Address - 0x40

7.5 Temperature sensor

The built-in temperature sensor provides accurate readings from the module, which are crucial for designing an overtemperature protection system. Monitoring temperature is essential for safe battery charging and precise current calculations, as temperature variations can significantly impact battery performance and overall system efficiency.

TMP102 I2C Address - 0x49

7.6 Battery charging

Battery charging is automatically managed by the IP2312 IC, which can provide up to 2A charging current to the battery. This current is not adjustable, so it is important to ensure the battery can safely handle this charging current. Alternatively, external circuitry must be implemented to limit the 5V line current to safe levels for the battery.

The charging circuitry is designed for a 5V input, such as that from a standard USB connection, but it can be powered from any equivalent source.

The PMG001 features LED indicators to show the current charging status: a red LED indicates charging is active, a green LED indicates the battery is fully charged, and both LEDs are off when no charging source is connected.

7.7 BAT_OUT Specifications

BAT_OUT Pins output battery power through DMP3013SFV MOSFET, the module has specific thermal properties so care should be taken to not exceed the following ratings:

Table 7.1 BAT_OUT Ratings

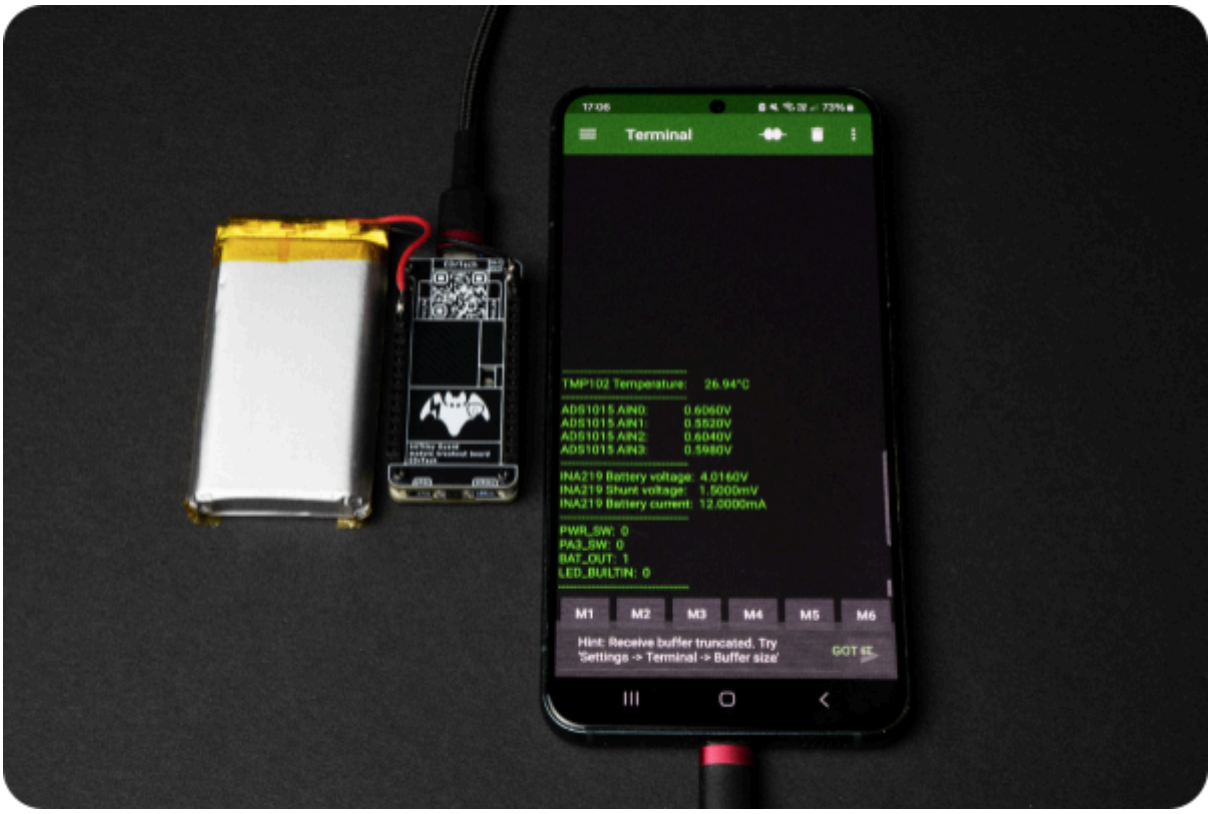
Parameter	Value	Unit
Continuous Drain Current (T_A=25°C, V_GS=-3.7V)	7.47	A
Power Dissipation (T_A=25°C)	0.94 - 1.94	W
Junction Temperature (T_J)	-55 to 150	°C
Gate Threshold Voltage (V_GS(TH))	-1.0 to -3.0	V
On-Resistance (R_DS(on))	25	mΩ

7.8 Module default behavior

The PMG001 comes preloaded with firmware that provides basic functionality right out of the box. The PWR_SW pin should be connected to an external push button, which serves as the user input for the ON/OFF behavior. When the push button is pressed for more than 500ms, the BAT_OUT will connect to BAT (via internal module circuitry), supplying power to the external system. Conversely, a long press and hold for more than 3 seconds will turn off the BAT_OUT output, cutting power to any connected external system. The built-in LED will illuminate to indicate the status of the BAT_OUT pins, providing a clear visual cue of the power state.

The default firmware is designed to output sensor data in a human-readable format over a dedicated serial connection, making monitoring straightforward.

7.2 Serial data default output example (Note)[4]

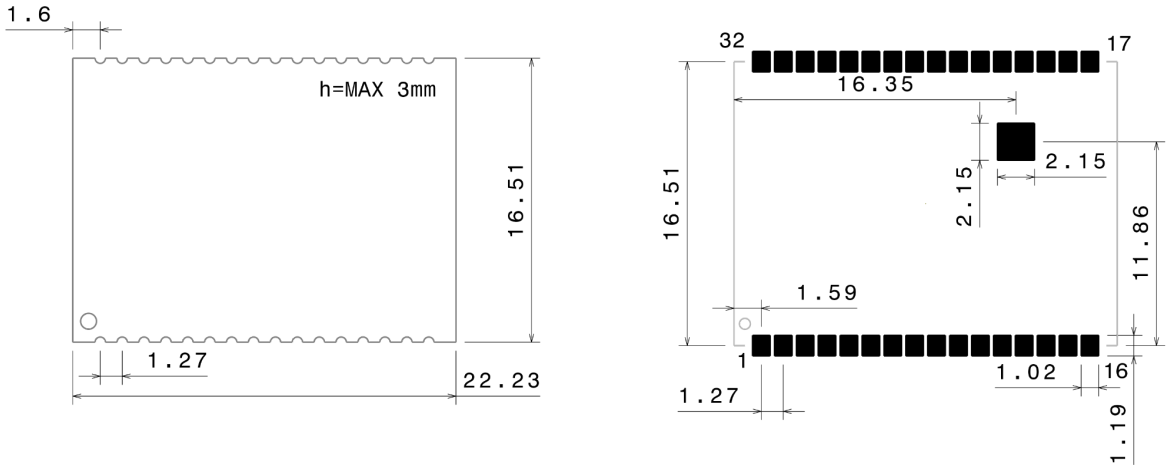


For orders of larger quantities, custom preloaded firmware can be provided to meet specific requirements. Please inquire at contact@rudectech.com for more information on custom firmware options.

[4] Example values are with ADC pins floating, with no external load connected. Battery voltage will be around the value shown in the example if the USB cable is connected to the demo kit as the battery will be charging.

8 Module dimensions and recommended SMT Footprint

Figure 8.1 Module dimensions and recommended footprint



9 Demo kit

9.1 Demo kit description

The bATtiny Guard - PMG001 Demo Kit showcases the module's basic features in a compact, breadboard-friendly design. All module pins are accessible via two 2.54mm pitch 16-pin headers.

The kit features two user programmable tactile switches, and an additional BAT_OUT status LED on the PCB (on when BAT_OUT is active).
One button provides USB interface switching capability - selection between UPDI interface and serial interface of the ATtiny1616. LEDs next to the button show the currently selected interface.
Battery can be connected using the pin headers (Positive terminal of the battery to BAT+, negative to BAT- or GND). Solder pads with battery input contacts are provided, and recommended for reliable performance.

The cover PCB additionally protects the USB connector and other components. It does not serve any electrical purpose, except the possible EMI shielding effect it provides since it’s a solid copper plane connected to the ground of the base board.

Figure 9.1 Base PCB

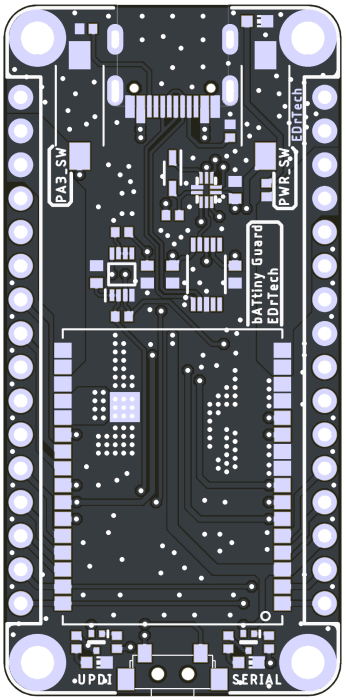


Figure 9.2 Base PCB Back

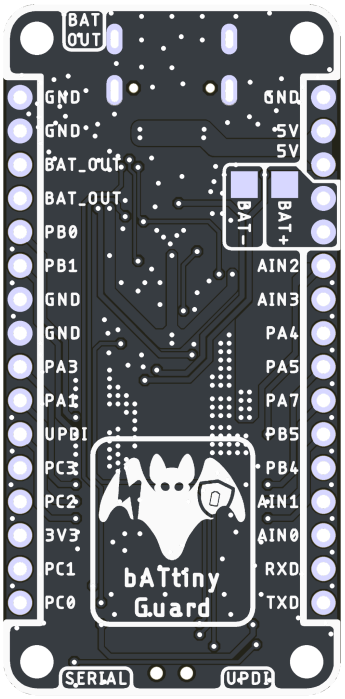
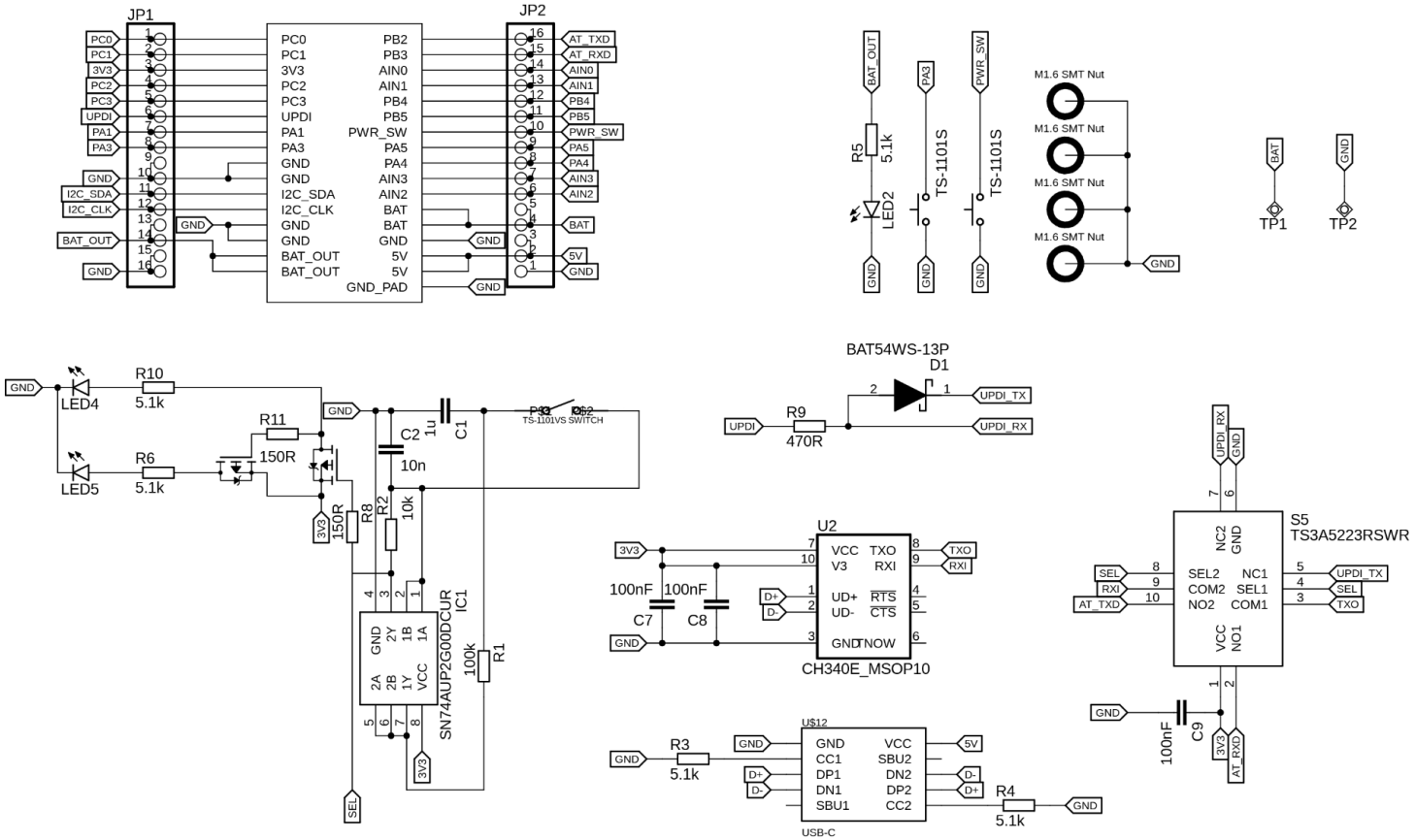


Figure 9.2 Cover PCB

Please visit [EDrTech bATtiny Guard Github Repository] for usage and programming resources.

9.2 Demo kit schematic

Figure 9.3 Demo kit schematic



10 Recommended reflow profile

The module is suitable for SMT reflow soldering. Being made of high quality FR-4 material of increased temperature resistance ensures the board integrity during the reflow soldering process.
The recommended reflow profile for lead-free soldering is provided in Figure 10.1 below:

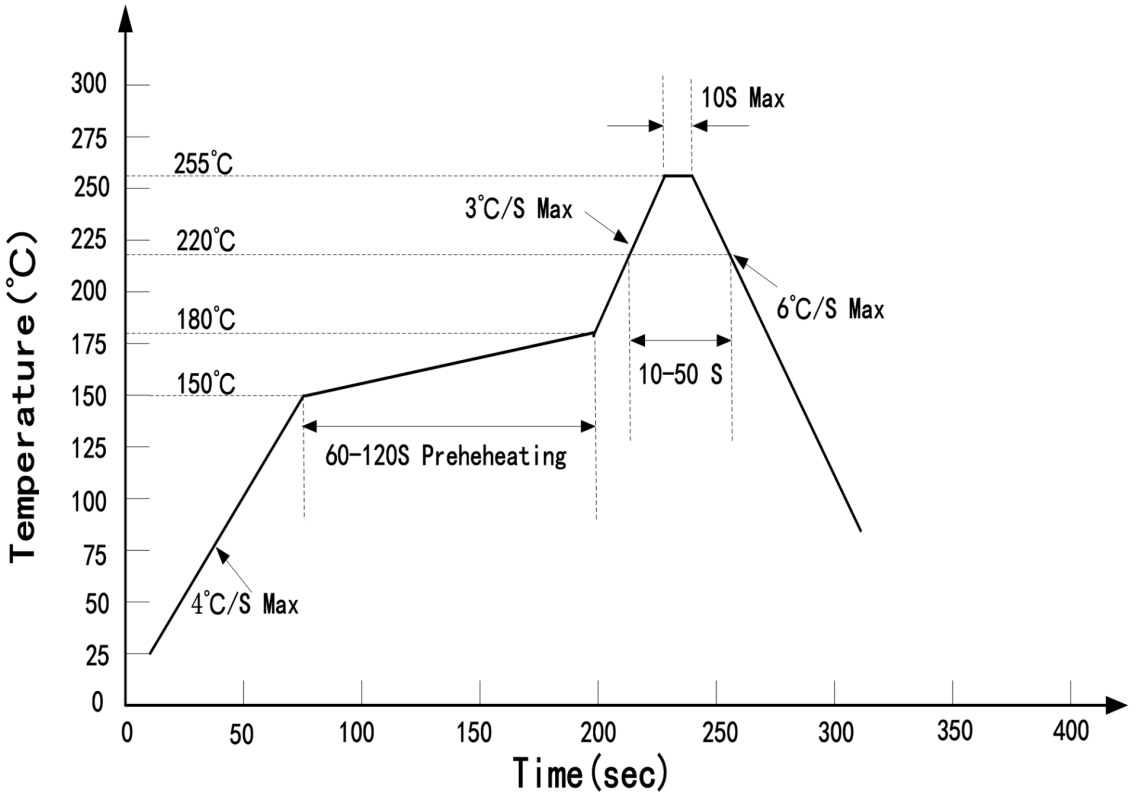


Figure 10.1