BC35-G&BC28&BC95 R2.0 Low Power Design Guide

NB-IoT Module Series

Rev. BC35-G&BC28&BC95 R2.0_Low_Power_Design_Guide_V1.2

Date: 2019-10-15

Status: Released

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About the Document

History

Revision	Date	Author	Description
1.0	2018-05-24	Ewent LU	Initial
1.1	2018-06-04	Ewent LU	Updated recommended types of lithium-thionyl chloride (Li-SOCl2) batteries in Table 1
1.2	2019-10-15	Glenn GE	1. Updated applicable module BC95 to BC95 R2.0; 2. Updated some of the reference designs; 3. Updated the content of Boost Converter Design (Chapter 2.3.1); 4. Updated the table Power Consumption of the Modules (Table 5).

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1 Introduction

In most NB-IoT applications, devices are battery powered, and low-power operation is therefore one of the key requirements of NB-IoT devices. This document mainly introduces solutions and reference designs for reducing power consumption of Quectel NB-IoT modules in low-power applications.

This document is applicable to Quectel BC35-G, BC28 and BC95 R2.0 modules.

2 Low Power Solutions

The low power solutions provided in this document are only applied for wireless terminals which feature following characteristics:

- A lithium-thionyl chloride (Li-SOCl2) battery, lithium manganese oxide (LiMn2O4) battery or dry cell is used as the main power supply of the system.
- The battery is a non-rechargeable one and its life cycle can reach up to one year or much longer.
- Low frequency of data transmission on wireless terminals.

2.1. Power Supply Solution

The power supply of the modules ranges from 3.1V~4.2V, and the power supply for MCU is 3.3V or lower. Since the battery is used as the power source of a terminal, the battery capacity should be large enough to ensure a long battery life.

2.1.1. Types of Batteries

The following three types of batteries can be used as the power supply for the modules in a lower power consumption application system, for they can not only provide the maximum energy ratio and voltage, but also have a preferable discharge characteristic and rather low self-discharge.

- Lithium-thionyl chloride (Li-SOCl2) batteries
- Lithium manganese oxide (LiMn2O4) batteries
- Dry cells

The following tables list some commonly used batteries and compare their key parameters for reference. Customers can choose a proper battery according to actual needs.

Table 1: Comparison of Lithium-thionyl Chloride (Li-SOCl2) Batteries

Parameter	Power Type (ER34615M)	Energy Battery Pack (ER34615+SPC1520)
Nominal Capacity	13Ah @5mA, 2V	19Ah @2mA, 2V

Nominal Voltage	3.6V	3.6V
Maximum Continuous Discharge Current	2000mA	/
Maximum Pulse Current	4000mA @0.1s	2000mA @1s
Temperature Range	-60°C ~ +85°C	-40°C ~ +85°C
Voltage Delay	Supported	Not supported
Parameter	**Power Type (ER26500M)**	**Energy Battery Pack (ER26500+SPC1520)**
Nominal Capacity	6Ah @10mA, 2V	8.5Ah @4mA, 2V
Nominal Voltage	3.6V	3.6V
Maximum Continuous Discharge Current	1000mA	/
Maximum Pulse Current	2000mA @0.1s	2000mA @1s
Temperature Range	-60°C ~ +85°C	-40°C ~ +85°C
Voltage Delay	Supported	Not supported
Parameter	**Power Type (Three ER18500 in Parallel)**	**Energy Battery Pack (Three ER18500 in Parallel+SPC1520)**
Nominal Capacity	12Ah @9mA, 2V	12Ah @9mA, 2V
Nominal Voltage	3.6V	3.6V
Maximum Continuous Discharge Current	360mA	/
Maximum Pulse Current	540mA @0.1s	2000mA @1s
Temperature Range	-60°C ~ +85°C	-40°C ~ +85°C
Voltage Delay	Supported	Not supported

Table 2: Description of Lithium Manganese Oxide ($LiMn_2O_4$) Battery CR17450

Parameter	**CR17450**
Nominal Capacity	2.4Ah @10mA, 2V
Nominal Voltage	3.0V

Maximum Continuous Discharge Current	1500mA
Maximum Pulse Current	3000mA @0.1s
Temperature Range	-40°C ~ +85°C
Voltage Delay	Not supported

Table 3: Description of Dry Cell LR6/AA

Parameter	LR6/AA
Nominal Capacity	2500mAh @43Ω, 0.8V
Nominal Voltage	1.5V
Maximum Continuous Discharge Current	1000mA
Maximum Pulse Current	1000mA @10s
Temperature Range	-20°C ~ +55°C
Voltage delay	Not supported

NOTE

For more information of these batteries, please visit http://en.evebattery.com.

2.2. Power Supply Reference Designs

The power circuit design plays an important role in reducing power consumption of the whole system. As the power supply range of the module is 3.1V~4.2V, please make sure that the input voltage will never drop below 3.1V even in a burst transmission. Reference circuit designs of some commonly used batteries are illustrated in the following figures.

2.2.1. Reference Design of a Single Power Battery Type

The following figure shows a reference design with a single power battery type ER34615M as the power supply.

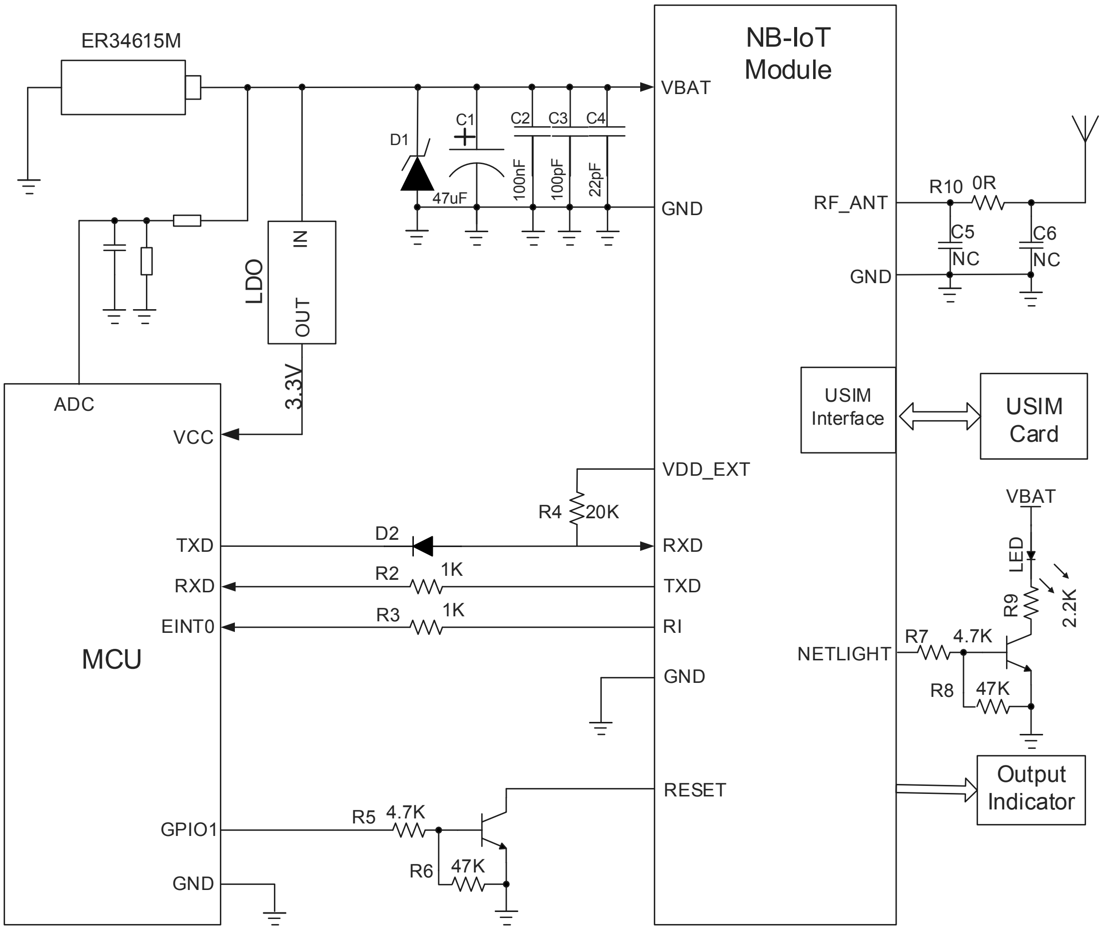

Figure 1: Reference Design of a Single Battery ER34615M

NOTE

D2 is used to avoid the current flowing into the module so as to reduce the power consumption of the MCU. For more details, please refer to the hardware design of corresponding modules.

2.2.2. Reference Design of an Energy Battery Pack

The following figure shows a reference design with an energy battery pack ER34615+SPC1520 as the power supply.

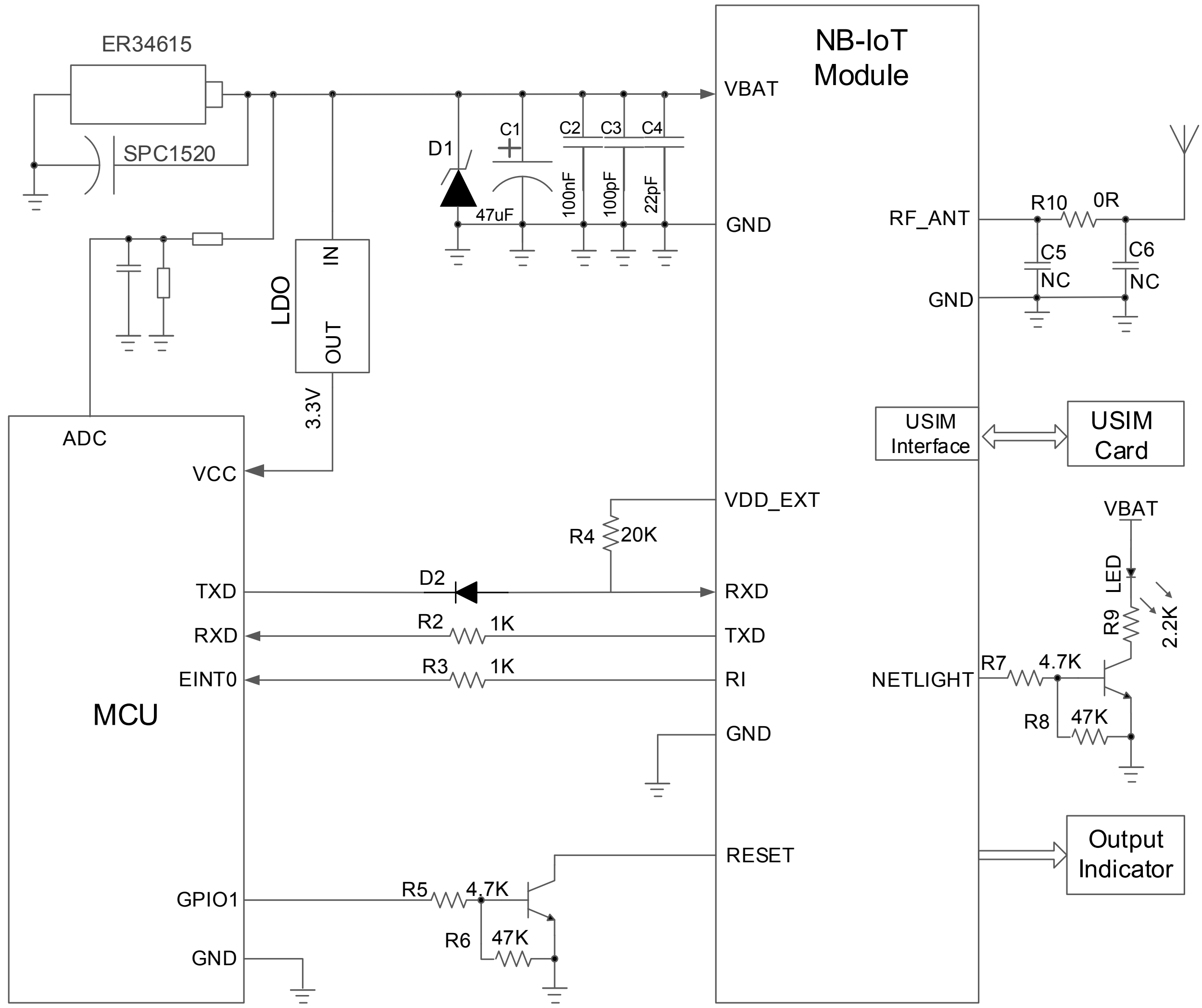

Figure 2: Reference Design of an Energy Battery Pack ER34615+SPC1520

NOTE

D2 is used to avoid the current flowing into the module so as to reduce the power consumption of the MCU. For more details, please refer to the hardware design of corresponding modules.

2.2.3. Reference Design of a Single Lithium Manganese Oxide (LiMn2O4) Battery

The following figure shows a reference design with a single lithium manganese oxide (LiMn2O4) battery CR17450 as the power supply.

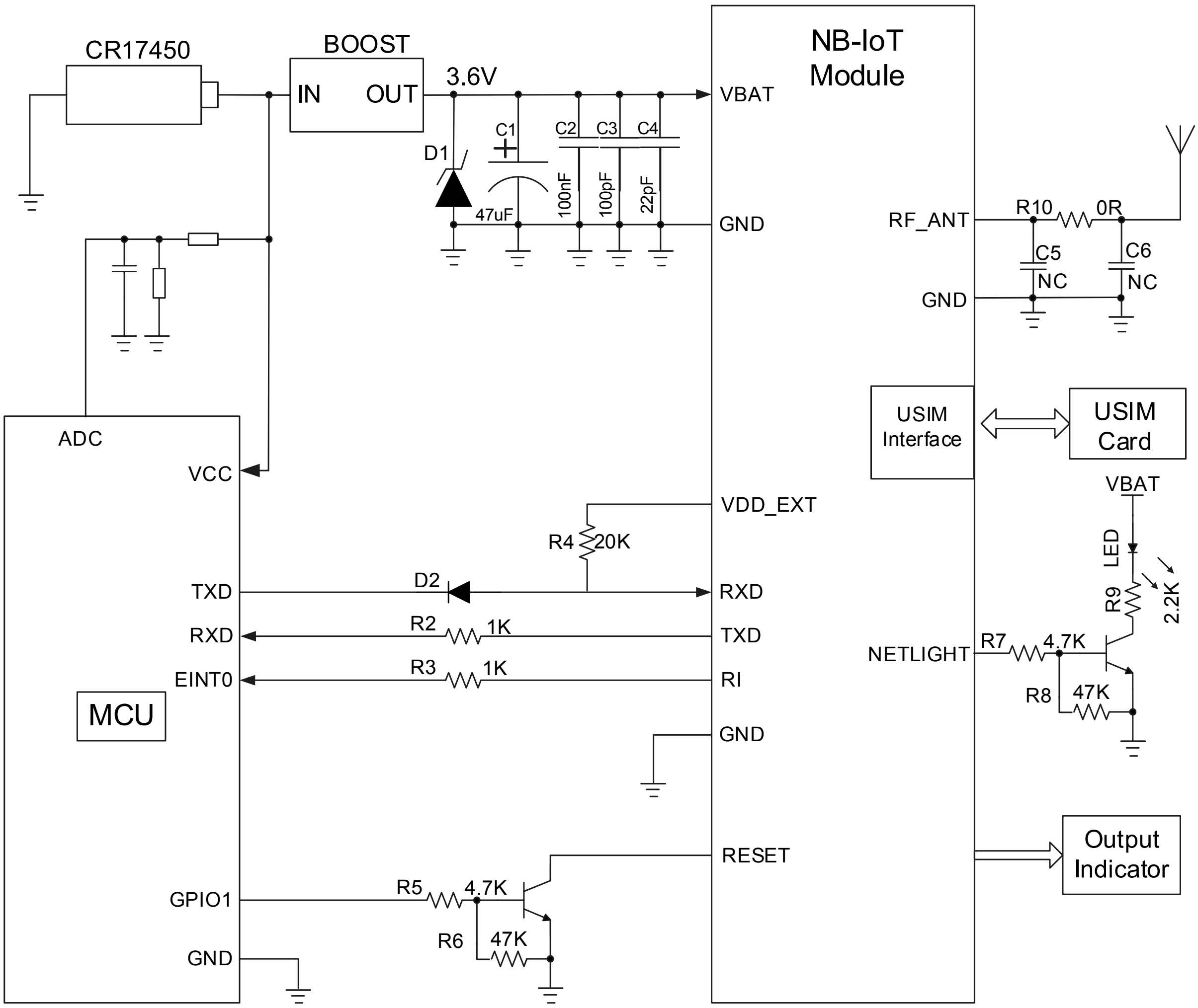

Figure 3: Reference Design of a Single Lithium Manganese Oxide (LiMn2O4) Battery CR17450

NOTE

D2 is used to avoid the current flowing into the module so as to reduce the power consumption of the MCU. For more details, please refer to the hardware design of corresponding modules.

2.2.4. Reference Design of a Dry Cell

The following figure shows a reference design with a single dry cell LR6/AA as the power supply.

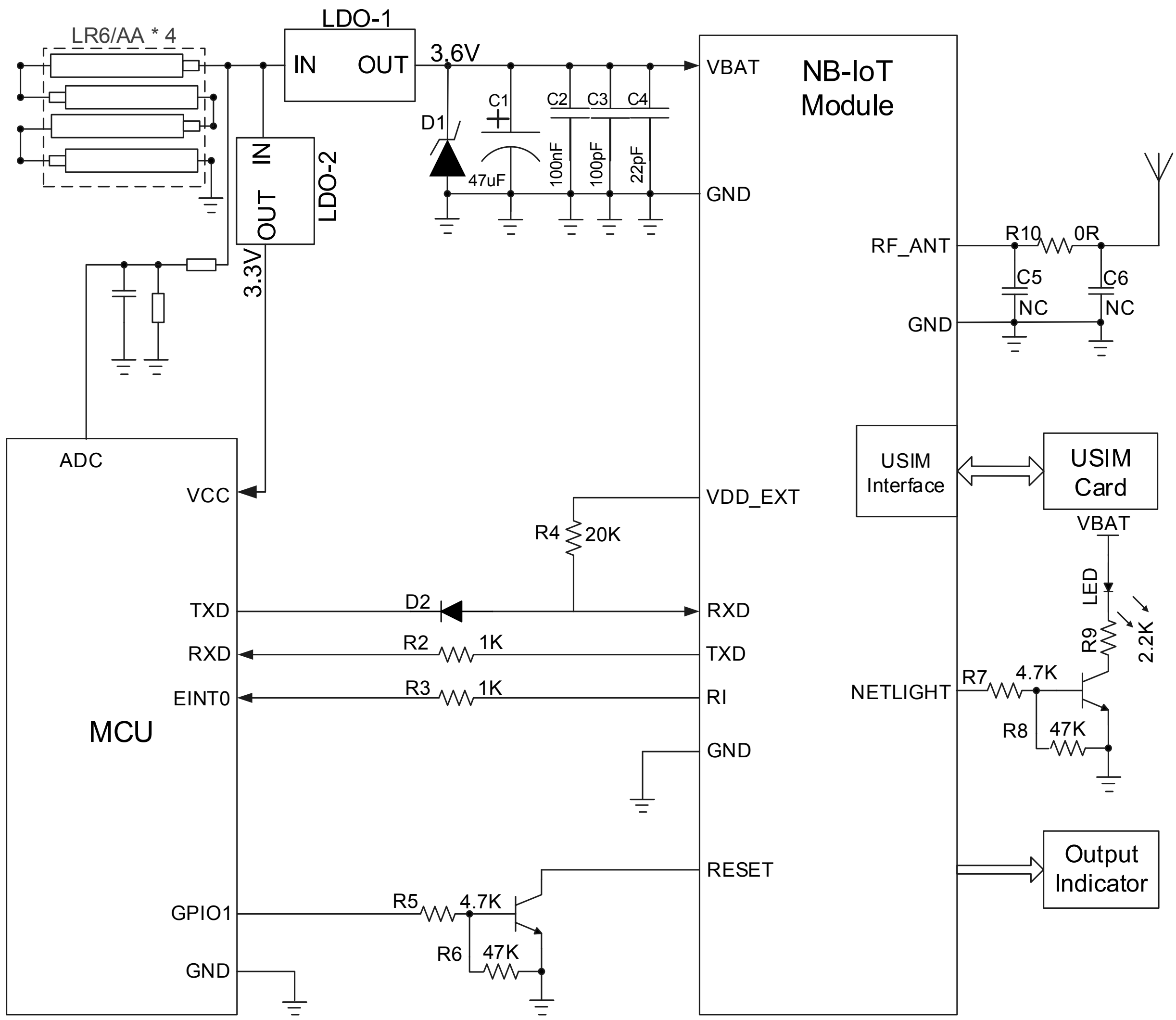

Figure 4: Reference Design of a Single Dry Cell LR6/AA

NOTE

D2 is used to avoid the current flowing into the module so as to reduce the power consumption of the MCU. For more details, please refer to the hardware design of corresponding modules.

2.3. Boost Converter Solution

2.3.1. Boost Converter Design

If a lithium manganese oxide ($LiMn_2O_4$) battery is used in customers applications, then a boost converter is needed. The boost converter should be selected based on the following principles.

- The input voltage range of the boost converter should be wider than the output voltage range of the battery.
- The maximum output current should be at least 0.8A, and can keep high efficiency at light loads.

TPS610995 from TI is recommended to be used as a boost converter. It is a synchronous boost converter with 1-μA ultra-low quiescent current, which can achieve a high efficiency under light load conditions to ensure a long battery life.

A reference circuit of TPS610995 for NB-IoT modules is as below.

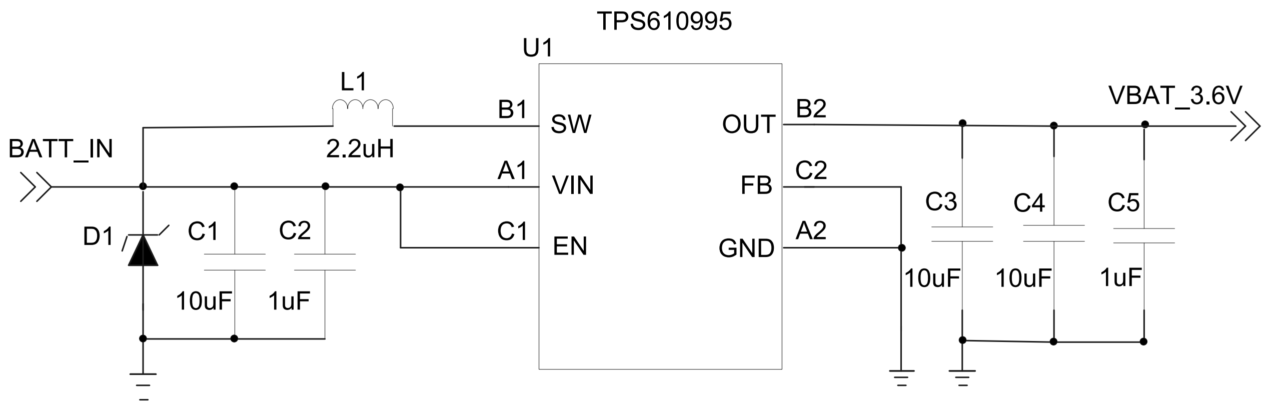

Figure 5: Reference Circuit of TPS610995

2.3.2. Layout Guidelines for Boost Converters

The layout of a switching power supply is very important, especially at high peak currents and high switching frequencies. Therefore, please use wide and short traces for the main current paths and the power ground paths. The input and output capacitors as well as the inductors should be placed to the IC as close as possible. Meanwhile, the bottom layer should be designed as the reference ground and ground vias should be added.

A reference layout design of a boost converter is shown below.

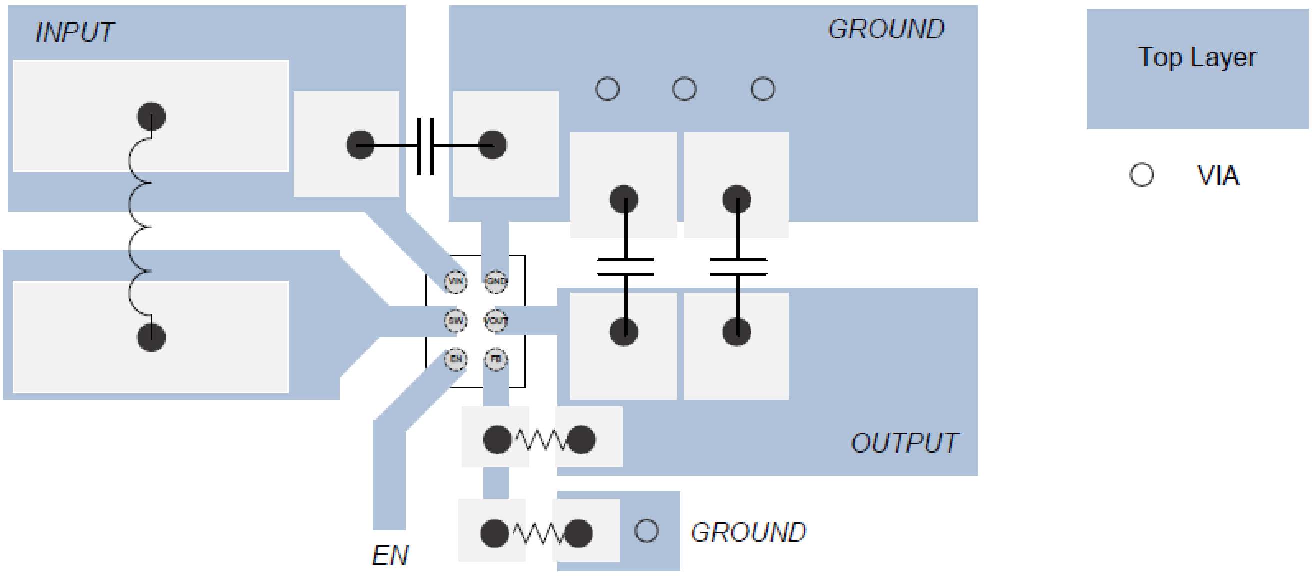

Figure 6: Reference Layout Design of a Boost Converter

2.4. Power Consumption of the Modules

In order to choose a battery with a proper capacity in lower power designs, it needs to evaluate the power consumption of the modules in normal working environment. The following figure shows the average current consumption of the modules during Tx/Rx modes and PSM in real NB-IoT network. The power consumption will vary with different ECLs and environments.

The working process of NB-IoT modules is as follows: Start the module → Search network → Connect to the network successfully → Transmit data in Cat NB1 mode → Succeed to transmit data → Enter into Idle (eDRX) mode → Enter into PSM.

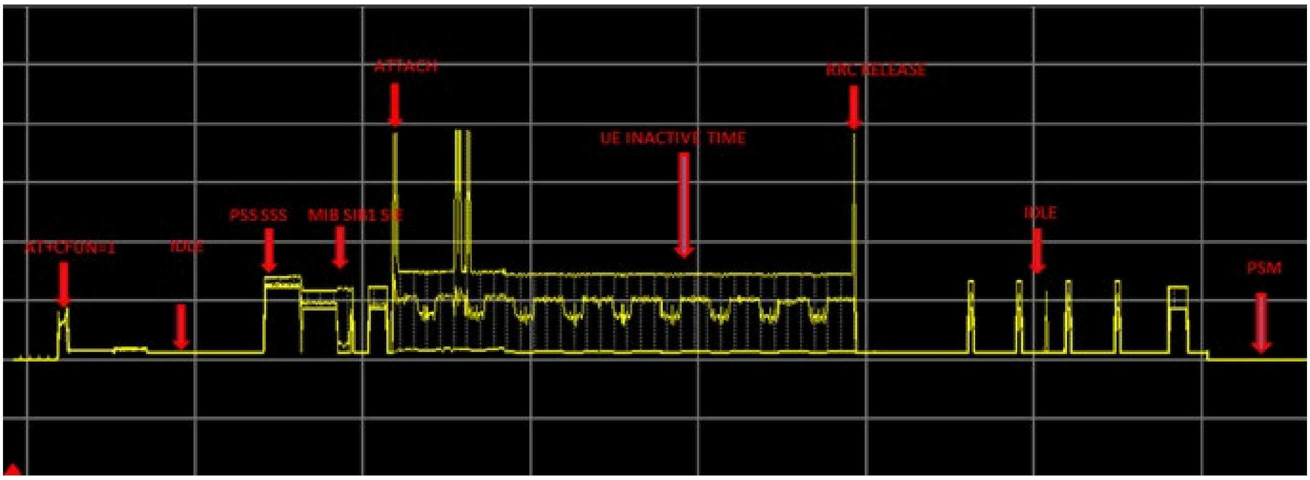

Figure 7: Current Consumption of the Modules

Table 4: Test Conditions

UE Inactive Time	eDRX Cycle	Power Supply
20s	40.96s	3.6V

Table 5: Power Consumption of the Modules

ECL	RSRP	Total Time	Data Size	Power Consumption
ECL0	-93.9dBm	144s	50 Bytes	343uAh
		144s	200 Bytes	344uAh
		144s	510 Bytes	346uAh
ECL1	-128dBm	147s	50 Bytes	506uAh
		151s	200 Bytes	619.2uAh
		152s	510 Bytes	628uAh
ECL2	-137dBm	158s	50 Bytes	1.01mAh
		162s	200 Bytes	1.2526mAh
		191s	510 Bytes	2.3mAh

2.5. Battery Capacity Assessment

The power consumption of a terminal can be calculated in two modes: sleep mode and working mode. No matter in which mode the device works, the power consumption of the terminal can be divided into four parts:

- MCU control system
- NB-IoT module system
- Self-discharge of the battery
- Other external controlled targets (e.g. valves)

The following shows an example of how to calculate the power consumption of the terminal, assuming that the life cycle of the terminal is 6 years.

Table 6: Average Power Consumption on Different ECL (One Day)

ECL	Power on → PSM	PSM → Send 200 Bytes Data → PSM	TAU Process	PSM
ECL0	398uAh	310uAh	91.8uAh	3.3uA
ECL1	770uAh	619.2uAh	484.8uAh	3.3uA
ECL2	1900uAh	1252.6uAh	860.1uAh	3.3uA

If the terminal is powered on once per year, sends data once per day and initiates TAU process once per day on ECL1, then the total power consumption in 10 years is calculated as follows:

First Day: 770uAh+619.2uAh+484.8uAh+3.3uA*24h=1953.2uAh;

364 Days: (619.2uAh+484.8uAh+3.3uA*24h)*364=1183.2uAH*364=430684.8uAh;

1 Year: 1953.2uAh+430684.8uAh=432638uAh=432.638mAh;

10 Years: 432.638mAh*10=4326.38mAh.

3 Appendix A References

Table 7: Related Documents

SN	Document Name	Remark
[1]	Quectel_BC35-G_Hardware_Design	BC35-G Hardware Design
[2]	Quectel_BC28_Hardware_Design	BC28 Hardware Design
[3]	Quectel_BC95_R2.0_Hardware_Design	BC95 R2.0 Hardware Design
[4]	Quectel_BC35-G&BC28&BC95 R2.0_AT_Commands_Manual_V1.5	AT command manual for BC35-G, BC28 and BC95 R2.0 modules.

Table 8: Terms and Abbreviations

Abbreviation	Description
ECL	Enhanced Coverage Level
IC	Integrated Circuit
MCU	Microprogrammed Control Unit
NB-IoT	Narrow Band Internet of Things
PSM	Power Saving Mode
TAU	Tracking Area Update