

BG770A-GL Low Power Design Guide

LPWA Module Series

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About the Document

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1 Introduction

In most LTE Cat NB2 and Cat M1 applications, it is battery that powers the devices. Therefore, low-power operation is one of the key requirements for devices that supports Cat NB2 and Cat M1. This document mainly introduces solutions and reference designs for reducing power consumption of the BG770A-GL module in low-power applications.

2 Low Power Solutions

The low power solution provided in this document only applies to wireless terminals featuring the following characteristics:

- Use primary batteries (lithium sub-battery/lithium manganese battery) as the main power source.
- Long service life.
- Low frequency of data transmission.

2.1. Power Supply Solutions

The power supply of the BG770A-GL ranges from 3.1 to 4.35 V (typ.3.3 V), and the power supply for MCU is 3.3 V normally. The module in low power solution needs a large battery capacity to ensure long service life. The lithium-thionyl chloride (Li-SOCl₂) battery is a proper choice for two reasons:

- It provides high energy ratio and voltage.
- It has a preferable discharge and rather low self-discharge.

The following table lists two common models of Li-SOCl₂ battery and their key parameters. You can choose a proper one according to actual needs.

Table 1: Parameters of Li-SOCl₂ Batteries

Parameter	ES-341520	ES-261550
Nominal Capacity	19 Ah @ 2 mA, 3 V	8.5 Ah @ 4 mA, 3 V
Nominal Voltage	3.6 V	3.6 V
Maximum Continuous Discharge Current	-	-
Maximum Pulse Current	1000 mA @ 1 s	3000 mA @ 1 s
Extended Temperature Range	-40 to +85 °C	-40 to +85 °C
Voltage Delay	-	-

2.2. Power Supply Reference Design

The power design is vital in reducing power consumption of the whole system. The power supply of the BG770A-GL ranges from 3.1 to 4.35 V, please ensure that the input voltage never drops below 3.1 V. The following figure shows a reference design with ES-341520 working as the power supply.

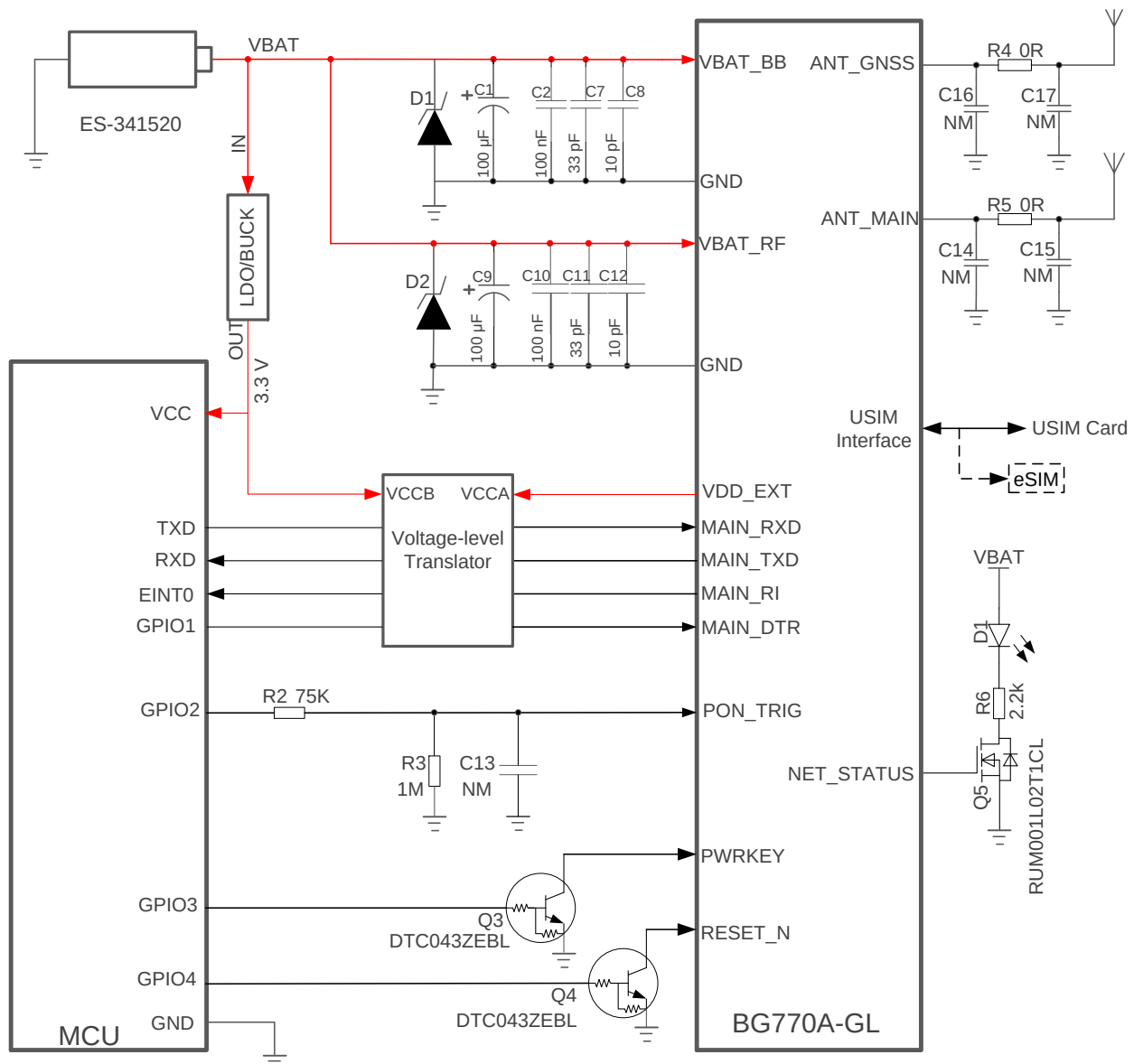


Figure 1: Power Supply Reference Design with ES-341520

NOTE

As NET_STATUS function increases the power consumption. If this function is unnecessary, it is recommended to turn it off.

2.3. Power Consumption in Low Power Design

To choose a battery with a proper capacity in lower power solutions, it is necessary to evaluate the power consumption of the module in normal operating environment. The power consumption varies with different ECLs and in diverse environments.

Here is one typical working process of the module: Power Off → Start up → Network Searching → RRC Connection → RRC Release → Idle → Sleep → Power down → Power Off.

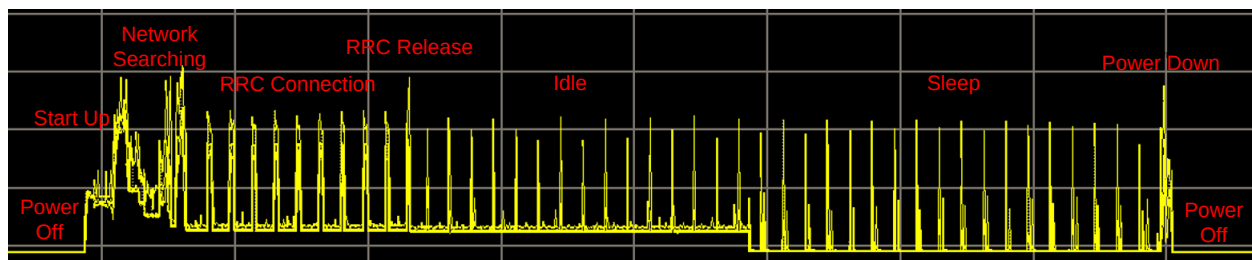


Figure 2: One Typical Working Process of the Module

Here is one typical working process of the module after it is wake up from PSM: PSM → Wake up (by T3412 Timer) → Network Searching → Send Data → RRC Connection → RRC Release → Sleep → PSM.

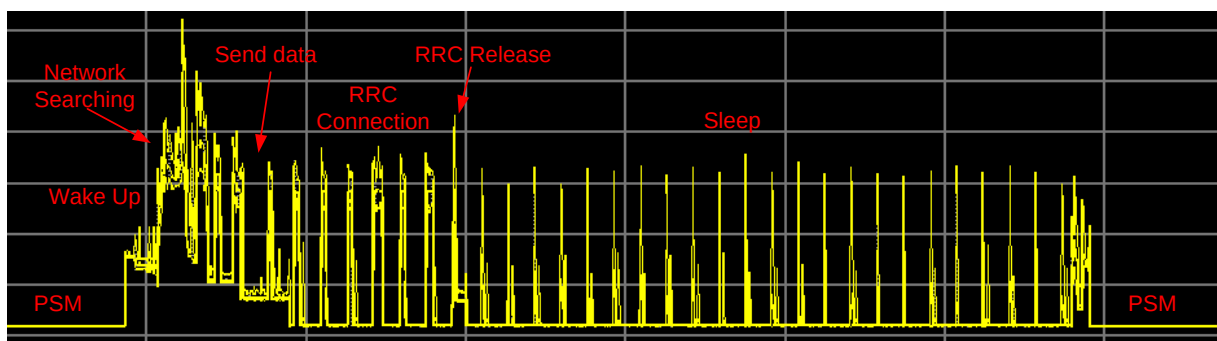


Figure 3: One Typical Working Process of the Module After it is Wake up from PSM

2.3.1. Power Consumption (Real Network)

The following tables show power consumption of the module in different conditions under different coverage level. The data is related to signal quality, so the following data are for your reference only.

Table 2: Power-off Power Consumption

RAT	Power-off	
	RSRP (dBm)	Avg. Current (μA)
LTE Cat M1	-80	1.48
	-112	1.34
	-122	1.39
LTE Cat NB1	-85	1.41
	-118	1.39
	-125	1.43

Table 3: Start Up Power Consumption

RAT	Start Up			
	RSRP (dBm)	Avg. Duration (s)	Avg. Current (mA)	Energy Consumption (mAh)
LTE Cat M1	-80	7.14	51.040	0.1012
	-112	7.31	50.740	0.1030
	-122	7.16	51.000	0.1015
LTE Cat NB1	-85	7.67	47.130	0.1004
	-118	7.64	46.650	0.0990
	-125	7.63	46.990	0.0996

The network searching power consumption is closely related to network coverage and signal quality. The data in tables below are the test results in real network.

Table 4: Network Searching Power Consumption

RAT	Network Searching			
	RSRP (dBm)	Avg. Duration (s)	Avg. Current (mA)	Energy Consumption (mAh)
LTE Cat M1	-80	1.35	107.870	0.0404

	-112	1.42	114.790	0.0453
	-122	2.87	100.900	0.0805
	-85	2.38	50.670	0.0335
LTE Cat NB1	-118	1.99	41.380	0.0229
	-125	2.85	34.140	0.0270

Table 5: RRC Power Consumption

RAT	RRC Connection and RRC Release			
	RSRP (dBm)	Avg. Duration (s)	Avg. Current (mA)	Electric Capacity (mAh)
	-80	2.48	99.599	0.0686
LTE Cat M1	-112	3.54	100.211	0.0985
	-122	3.12	101.290	0.0879
	-85	3.605	62.152	0.0622
LTE Cat NB1	-118	2.790	69.655	0.0540
	-125	3.32	73.388	0.0677

Table 6: Idle Power Consumption

RAT	Idle			
	Mode	RSR (dBm)	Avg. Current (mA)	Electric Capacity (mAh)
		-80	15.227	0.0054
	DRX = 1.28 s	-112	15.235	0.0054
		-122	15.323	0.0054
LTE Cat M1		-80	14.821	0.0105
	DRX = 2.56 s	-112	14.910	0.0106
		-122	14.886	0.0106
LTE Cat NB1	DRX = 1.28 s	-85	15.625	0.0055

	-118	16.307	0.0058
	-125	20.935	0.0074
	-85	15.213	0.0108
DRX = 2.56 s	-118	15.499	0.0110
	-125	17.836	0.0127

Table 7: Sleep Power Consumption

RAT	Sleep		
	Mode	RSRP (dBm)	Electric Capacity (mAh)
LTE Cat M1	DRX = 1.28 s	-80	0.0004
		-112	0.0005
		-122	0.0005
	DRX = 2.56 s	-80	0.0004
		-112	0.0006
		-122	0.0006
	e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	-80	0.0017
		-112	0.0032
		-122	0.0033
	e-I-DRX = 40.96 s @ PTW = 10.24 s, DRX = 2.56 s	-80	0.0029
		-112	0.0029
		-122	0.0044
LTE Cat NB1	DRX = 1.28 s	-85	0.0008
		-118	0.0013
		-125	0.0039
	DRX = 2.56 s	-85	0.0008
		-118	0.0010

	-125	2.460	0.0017
e-I-DRX = 81.92 s	-85	0.119	0.0027
@ PTW = 2.56 s, DRX = 1.28 s	-118	0.162	0.0037
	-125	0.406	0.0092
e-I-DRX = 40.96 s	-85	0.405	0.0046
@ PTW = 10.24 s, DRX = 2.56 s	-118	0.557	0.0063
	-125	0.703	0.0080

Table 8: Power Consumption of Waking Up from Sleep

RAT	Wake Up from Sleep			
	RSRP (dBm)	Avg. Duration (s)	Avg. Current (mA)	Electric Capacity (mAh)
LTE Cat M1	-80	0.039	15.307	0.00016
	-112	0.039	15.014	0.00016
	-122	0.040	15.046	0.00017
LTE Cat NB1	-85	0.042	13.373	0.00016
	-118	0.042	15.000	0.00017
	-125	0.037	16.581	0.00017

Table 9: Power Down Power Consumption

RAT	Power Down			
	RSRP (dBm)	Avg. Duration (s)	Avg. Current (mA)	Electric Capacity (mAh)
LTE Cat M1	-80	8.48	9.020	0.0212
	-112	8.34	9.110	0.0211
	-122	8.32	9.230	0.0213
LTE Cat NB1	-85	7.13	6.790	0.0134
	-118	7.28	8.970	0.0181

-125	8.37	13.720	0.0319
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Table 10: PSM Power Consumption

RAT	PSM	
	RSRP (dBm)	Avg. Current (μA)
LTE Cat M1	-80	1.48
	-112	1.34
	-122	1.39
LTE Cat NB1	-80	1.41
	-118	1.39
	-125	1.43

Table 11: Power Consumption of Waking Up from PSM

RAT	Wake up from PSM (by T3412 Timer)			
	RSRP (dBm)	Avg. Duration (s)	Avg. Current (mA)	Energy Consumption (mAh)
LTE Cat M1	-80	0.12	34.850	0.0012
	-112	0.12	34.340	0.0012
	-122	0.12	34.750	0.0012
LTE Cat NB1	-85	0.11	29.470	0.0009
	-118	0.11	28.760	0.0009
	-125	0.11	29.440	0.0010

Table 12: Power Consumption of Sending Data

RAT	Send Data					
	Data Size (B)	Socket	RSRP (dBm)	Avg. Duration (s)	Avg. Current (mA)	Electric Capacity (mAh)
LTE Cat M1	50	UDP	-80	0.43	98.690	0.0118
			-112	0.44	98.288	0.0120
			-125	0.44	99.898	0.0122
		TCP	-80	0.51	97.499	0.0138
			-112	0.51	100.166	0.0142
			-125	0.55	100.917	0.0154
	200	UDP	-85	0.44	98.818	0.0121
			-112	0.47	99.141	0.0129
			-125	0.48	103.207	0.0138
		TCP	-85	0.52	98.350	0.0142
			-112	0.54	101.396	0.0152
			-125	0.58	103.247	0.0167
	500	UDP	-80	0.45	99.846	0.0125
			-112	0.58	100.428	0.0162
			-125	0.53	98.164	0.0145
		TCP	-80	0.52	99.664	0.0144
			-112	0.57	101.326	0.0160
			-125	0.79	101.640	0.0223
	10K	UDP	-85	1.33	108.431	0.0401
			-112	1.34	109.696	0.0408
			-125	1.42	108.013	0.0426
		TCP	-85	1.42	104.503	0.0412

LTE Cat NB1	50	UDP	-112	1.45	108.696	0.0438
			-125	1.46	110.179	0.0447
			-80	0.32	70.496	0.0063
		TCP	-112	0.37	63.461	0.0065
			-125	0.49	71.129	0.0097
			-80	0.34	70.396	0.0066
	200	UDP	-112	0.38	66.596	0.0070
			-125	0.57	76.098	0.0120
			-80	0.33	80.176	0.0073
		TCP	-112	0.35	85.574	0.0083
			-125	0.44	83.597	0.0102
			-80	0.37	79.863	0.0082
	500	UDP	-112	0.38	80.817	0.0085
			-125	0.54	77.658	0.0116
			-80	0.49	82.921	0.0113
		TCP	-112	0.45	90.674	0.0113
			-122	0.57	89.700	0.0142
			-80	0.48	87.008	0.0116
	10K	UDP	-112	0.53	87.406	0.0129
			-125s	0.65	86.584	0.0156
			-80	4.77	104.433	0.1384
		TCP	-112	4.85	110.163	0.1484
			-125	4.88	113.809	0.1543
			-80	5.20	101.634	0.1468
	10K	TCP	-112	5.24	105.241	0.1532
			-125	5.33	110.745	0.1640

2.3.2. GNSS Power Consumption (Real Network)

The following shows the test conditions of the module in the real network.

Table 13: GNSS Power Consumption (Real Network)

Description	Conditions	Avg. Duration (s)	Avg. Current (mA)	Electric Capacity (mAh)
Acquisition (AT+CFUN=0)	Cold start @ Real network	39	49.276	0.5338
	Hot start @ Real network	0.8	51.287	0.0114
	Warm start @ Real network	38	49.442	0.5219
	Lost state @ Real network	-	-	-
Tracking (AT+CFUN=0)	Open Sky @ Real network, Passive Antenna	-	48.91	-
	Open Sky @ Real network, Active Antenna	-	48.775	-

For more information about the AT command mentioned above, see **document [1]**.

2.4. Cases Introduction

A terminal's power consumption can be calculated in two modes: full functionality mode and power saving mode. Whichever mode the terminal is in, its power consumption comes from the following four parts:

- MCU control system
- LPWA module system
- Battery self-discharge
- Other integrated circuits

The remaining battery capacity can be estimated by confirming the following things:

1. Confirm the ECL level and signal quality
2. Confirm the registered network
3. Confirm the turn-on process of the module, and the (e)DRX cycle and operating time in idle and sleep modes.

4. Confirm the time of T3324 and T3412 in PSM mode
5. Confirm the data transmission protocol, and the data size
6. Confirm the GNSS startup method

The following chapters show some examples of how to calculate the power consumption of a terminal with a 10-year service life:

2.4.1. LTE Cat M1 Cases

The following shows the test conditions of the module in the real network.

Table 14: Test Conditions (LTE Cat M1 Band 3)

Test case 1

Power Off → Start Up → Network Searching → RRC → Sleep (DRX = 1.28 s) → PSM

Test case 2

PSM → Wake Up → Send data (TCP 200B) → Sleep (DRX = 1.28 s) → PSM

Test case 3

Idle (DRX = 1.28 s) → Send data (TCP 200B) → Idle (DRX = 1.28 s)

Test case 4

Idle (DRX = 1.28 s) → Sleep (DRX = 1.28 s) → Wake up → Send data (TCP 200B) →
Idle (DRX = 1.28 s) → Sleep (DRX = 1.28 s)

Test case 5

Cat M1 + GNSS → Sleep (DRX = 1.28 s) → PSM → Wake up → GNSS positioning data →
Cat M1 + GNSS → Sleep (DRX = 1.28 s) → PSM

Table 15: Example 1 (LTE Cat M1 Band 3)

Status	Example 1 (LTE Cat M1 Band 3)		
	RSRP (dBm)	Avg. Duration (s)	Electric Quantity (mAh)
Start Up	-112	7.31	0.1030
Network Searching		1.42	0.0453
RRC		3.54	0.0985

Sleep	1.28	0.0005
PSM	approx. 24 h	0.0322
Wake Up from PSM	0.12	0.0012

The power consumption of the first day differs from the other days since the module wakes up from PSM rather than start up from turn-off.

1st Day: $0.1030 \text{ mAh} + 0.0453 \text{ mAh} + 0.0985 \text{ mAh} + 0.0005 \text{ mAh} + 0.00134 \text{ mA} \times 24 \text{ h} = 0.2795 \text{ mAh}$;

364 Days: $(0.0012 \text{ mAh} + 0.0453 \text{ mAh} + 0.0985 \text{ mAh} + 0.0005 \text{ mAh} + 0.00134 \text{ mA} \times 24 \text{ h}) \times 364 \text{ days} = 0.1777 \text{ mAh} \times 364 \text{ days} = 64.6828 \text{ mAh}$;

1st Year: $0.2795 \text{ mAh} + 64.6828 \text{ mAh} = 64.9623 \text{ mAh}$;

10 Years: $64.9623 \text{ mAh} + 0.1777 \text{ mAh} \times 365 \text{ days} \times 9 \text{ years} = 648.7068 \text{ mAh}$.

Table 16: Example 2 (LTE Cat M1 Band 3)

Status	Example 2 (LTE Cat M1 Band 3)			
	RSRP (dBm)	Avg. Duration (s)	Electric Quantity (mAh)	Comment
PSM	-112	approx. 24 h	0.0322	TCP 200B
Wake up from PSM		0.12	0.0012	
Send data		0.54	0.0152	
Sleep		1.28	0.0005	
PSM		approx.24 h	0.0322	

1 Day: $0.0012 \text{ mAh} + 0.0152 \text{ mAh} + 0.0005 \text{ mAh} + 0.00134 \text{ mA} \times 24 \text{ h} = 0.0491 \text{ mAh}$;

1 Year: $0.0491 \text{ mAh} \times 365 \text{ days} = 17.9215 \text{ mAh}$;

10 Years: $17.9215 \text{ mAh} \times 10 \text{ years} = 179.2150 \text{ mAh}$.

2.4.2. LTE Cat NB1 Cases

The following shows the test conditions of the module in the real network.

Table 17: Test Conditions (LTE Cat NB1 Band 8)

Test case 1

Power Off → Start Up → Network Searching → RRC → Sleep (DRX = 1.28 s) → PSM

Test case 2

PSM → Wake up → Send data (TCP 200B) → Sleep (DRX = 1.28 s) → PSM

Test case 3

Idle (DRX = 1.28 s) → Send data (TCP 200B) → Idle (DRX = 1.28 s)

Test case 4

Idle (DRX = 1.28 s) → Sleep (DRX = 1.28 s) → Wake up → Send data (TCP 200B) →
Idle (DRX = 1.28 s) → Sleep (DRX = 1.28 s)

Test case 5

LTE Cat NB1 + GNSS → Sleep (DRX = 1.28 s) → PSM → Wake up → GNSS positioning data → LTE
Cat NB1 + GNSS → Sleep (DRX = 1.28 s) → PSM

Table 18: Example 3 (LTE Cat NB1 Band 8)

Status	Example 3 (LTE Cat NB1 Band 8)		
	RSRP (dBm)	Avg Duration (s)	Electric Quantity (mAh)
Start up	-118	7.64	0.0990
Network Searching		1.99	0.0229
RRC		2.79	0.0540
Sleep		1.28	0.0008
PSM		approx. 24 h	0.0334
Wake Up from PSM		0.11	0.0009

The power consumption of the first day differs from the other days since the module wakes up from PSM rather than start up from turn-off.

First Day: $0.0990 \text{ mAh} + 0.0229 \text{ mAh} + 0.0540 \text{ mAh} + 0.0008 \text{ mAh} + 0.00139 \text{ mA} \times 24 \text{ h} = 0.2101 \text{ mAh}$;

364 Days: $(0.0009 \text{ mAh} + 0.0229 \text{ mAh} + 0.0540 \text{ mAh} + 0.0008 \text{ mAh} + 0.00139 \text{ mA} \times 24 \text{ h}) \times 364 \text{ days} = 0.1120 \text{ mAh} \times 364 \text{ days} = 40.7680 \text{ mAh}$;

First Year: $0.2101 \text{ mAh} + 40.7680 \text{ mAh} = 40.9781 \text{ mAh}$;

10 Years: $40.9781 \text{ mAh} + 0.1120 \text{ mAh} \times 365 \text{ days} \times 9 \text{ years} = 408.8981 \text{ mAh}$.

Table 19: Example 4 (LTE Cat NB1 Band 8)

Status	Example 4 (LTE Cat NB1 Band 8)			
	RSRP (dBm)	Avg Duration (s)	Electric Quantity (mAh)	Comment
PSM	-118	approx. 24 h	0.0334	TCP 200B
Wake up from PSM		0.11	0.0009	
Send data		0.38	0.0085	
Sleep		1.28	0.0008	
PSM		approx. 24 h	0.0334	

1 Day: $0.0009 \text{ mAh} + 0.0085 \text{ mAh} + 0.0008 \text{ mAh} + 0.00139 \text{ mA} \times 24 \text{ h} = 0.0436 \text{ mAh}$;

1 Year: $0.0436 \text{ mAh} \times 365 \text{ days} = 15.914 \text{ mAh}$;

10 Years: $62.2252 \text{ mAh} \times 10 \text{ years} = 159.14 \text{ mAh}$.

2.5. Power Consumption of BG770A-GL

2.5.1. Power Consumption (Instrument)

The table below lists the power consumption of BG770A-GL in all operating modes.

Table 20: BG770A-GL Power Consumption (3.3 V Power Supply, Room Temperature)

Description	Conditions	Avg.	Unit
Leakage	Turn-off @ USB/UART disconnected	1.4	μA

PSM	PSM @ USB/UART disconnected	1.4	μA
Rock Bottom	AT+CFUN=0 @ Sleep mode	45	μA
Sleep Mode (USB/UART disconnected)	LTE Cat M1 DRX = 1.28 s	1.1	mA
	LTE Cat NB1 DRX = 1.28 s	2.2	mA
	LTE Cat M1 e-I-DRX = 40.96 s @ PTW = 1.28 s, DRX = 1.28 s	0.06	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 1.28 s, DRX = 1.28 s	0.05	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	0.07	mA
	LTE Cat NB1 e-I-DRX = 40.96 s @ PTW = 2.56 s, DRX = 1.28 s	0.16	mA
	LTE Cat NB1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	0.12	mA
Idle State (USB/UART disconnected)	LTE Cat M1 DRX = 1.28 s	16.5	mA
	LTE Cat NB1 DRX = 1.28 s	17.0	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	16.0	mA
	LTE Cat NB1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	16.0	mA
LTE Cat M1 data transfer (GNSS OFF)	LTE HD-FDD B1 @ 23.53 dBm	178	mA
	LTE HD-FDD B2 @ 23.70 dBm	179	mA
	LTE HD-FDD B3 @ 23.65 dBm	187	mA
	LTE HD-FDD B4 @ 23.61 dBm	187	mA
	LTE HD-FDD B5 @ 23.24 dBm	201	mA
	LTE HD-FDD B8 @ 23.60 dBm	192	mA
	LTE HD-FDD B12 @ 23.42 dBm	205	mA

LTE Cat NB1 data transfer (GNSS OFF)	LTE HD-FDD B13 @ 23.62 dBm	203	mA
	LTE HD-FDD B18 @ 23.28 dBm	201	mA
	LTE HD-FDD B19 @ 23.37 dBm	203	mA
	LTE HD-FDD B20 @ 23.30 dBm	204	mA
	LTE HD-FDD B25 @ 23.51 dBm	186	mA
	LTE HD-FDD B26 @ 23.44 dBm	201	mA
	LTE HD-FDD B27 @ 23.33 dBm	200	mA
	LTE HD-FDD B28A @ 23.56 dBm	201	mA
	LTE HD-FDD B28B @ 23.69 dBm	201	mA
	LTE HD-FDD B66 @ 23.64 dBm	188	mA
	LTE HD-FDD B1 @ 23.49 dBm	173	mA
	LTE HD-FDD B2 @ 23.48 dBm	174	mA
	LTE HD-FDD B3 @ 23.75 dBm	174	mA
	LTE HD-FDD B4 @ 23.48 dBm	178	mA
	LTE HD-FDD B5 @ 23.34 dBm	192	mA
	LTE HD-FDD B8 @ 23.87 dBm	185	mA
	LTE HD-FDD B12 @ 23.42 dBm	198	mA
	LTE HD-FDD B13 @ 23.75 dBm	192	mA
	LTE HD-FDD B17 @ 23.55 dBm	198	mA
	LTE HD-FDD B18 @ 23.47 dBm	194	mA
	LTE HD-FDD B19 @ 23.41 dBm	194	mA
	LTE HD-FDD B20 @ 23.56 dBm	191	mA
	LTE HD-FDD B25 @ 23.50 dBm	174	mA
	LTE HD-FDD B28 @ 23.93 dBm	192	mA
	LTE HD-FDD B66 @ 23.97 dBm	175	mA

Table 21: GNSS Power Consumption of BG770A-GL (3.3 V Power Supply, Room Temperature)

Description	Conditions	Typ.	Unit
Acquisition (AT+CFUN=0)	Cold start @ Instrument	49.04	mA
	Hot start @ Instrument	50.17	mA
	Lost state @ Instrument	49.31	mA
Tracking (AT+CFUN=0)	Instrument environment @ Passive antenna	49.58	mA
	Half sky @ Real network, Passive antenna	48.37	mA

For more information about the AT commands mentioned above, see **document [1]**.

2.5.2. Power Consumption in DFOTA (Real Network)

The following shows the DFOTA power consumption of the module in the real network (Cat M1 Band 3).

Table 22: DFOTA Power Consumption Under Real Network Conditions (BG770A-GL 3.3 V)

ECL	Feature	Download Process	Upgrade Process
ECL0	Time (s)	37.66	248.44
	Avg Consumption (mA)	92.028	36.382
	Electric Capacity (mAh)	0.9627	2.5108

3 Appendix References

Table 23: Related Documents

Document Name
[1] Quectel_BG77xA-GL&BG95xA-GL_AT_Commands_Manual
[2] Quectel_BG770A-GL_Hardware_Design

Table 24: Terms and Abbreviations

Abbreviation	Description
Cat M	Category M
DFOTA	Delta Firmware Upgrade Over-The-Air
DRX	Discontinuous Reception
ECL	Enhanced Coverage Level
eDRX	extended Discontinuous Reception
e-I-DRX	Extended Idle Mode Discontinuous Reception
GNSS	Global Navigation Satellite System
LPWA	Low Power Wide Area
MCU	Microprogrammed Control Unit
PSM	Power Saving Mode
RAT	Radio Access Technology
RRC	Radio Resource Control
RSRP	Reference Signal Receiving Power

TAU	Tracking Area Update
TCP	Transmission Control Protocol
UART	Universal Asynchronous Receiver/Transmitter
UDP	User Data Protocol
USB	Universal Serial Bus
