

BG95&BG77&BG600L Series

RF FTM Application Note

LPWA Module Series

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About the Document

Revision History

Version	Date	Author	Description
1.0	2020-05-28	Hyman DING/ Miles MA	Initial
1.1	2020-11-29	Miles MA	<ol style="list-style-type: none"> Updated the uplink channel range for LTE B85 in AT+QRFTEST. Added the applicability restrictions on LTE B26, B27 and B71 in AT+QRFTEST and AT+QRXFTM.
1.2	2022-04-24	Lane HAO	<ol style="list-style-type: none"> Added a note for AT+QRFTESTMODE (Chapter 2.3.1). Added notes 3–5 for AT+QRFTEST (Chapter 2.3.2). Updated the value range of <ul_offset> in AT+QRFTEST (Chapter 2.3.2). Added the summary of error codes (Chapter 4).

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1 Introduction

The document describes the AT commands which are used to test the receiving and transmitting performance of Quectel BG95 series, BG77 and BG600L-M3 modules under FTM (Factory Test Mode) so as to facilitate RF calibration.

1.1. Applicable Modules

Table 1: Applicable Modules

Module Series	Model	Description
BG95	BG95-M1	Cat M1 only
	BG95-M2	Cat M1/Cat NB2
	BG95-M3	Cat M1/Cat NB2/EGPRS
	BG95-M4	Cat M1/Cat NB2, 450 MHz Supported
	BG95-M5	Cat M1/Cat NB2/EGPRS, Power Class 3
	BG95-M6	Cat M1/Cat NB2, Power Class 3
	BG95-MF	Cat M1/Cat NB2, Wi-Fi Positioning
BG77	BG77	Cat M1/Cat NB2
BG600L	BG600L-M3	Cat M1/Cat NB2/EGPRS

NOTE

See the firmware release notes of corresponding module models to check whether the function has been supported.

2 RF FTM AT Commands

2.1. AT Command Introduction

2.1.1. Definitions

- **<CR>** Carriage return character.
- **<LF>** Line feed character.
- **<...>** Parameter name. Angle brackets do not appear on the command line.
- **[...]** Optional parameter of a command or an optional part of TA information response. Square brackets do not appear on the command line. When an optional parameter is not given in a command, the new value equals its previous value or the default settings, unless otherwise specified.
- **Underline** Default setting of a parameter.

2.1.2. AT Command Syntax

All command lines must start with **AT** or **at** and end with **<CR>**. Information responses and result codes always start and end with a carriage return character and a line feed character: **<CR><LF><response><CR><LF>**. In tables presenting commands and responses throughout this document, only the commands and responses are presented, and **<CR>** and **<LF>** are deliberately omitted.

Table 2: Types of AT Commands

Command Type	Syntax	Description
Test Command	AT+<cmd>=?	Test the existence of the corresponding command and return information about the type, value, or range of its parameter.
Read Command	AT+<cmd>?	Check the current parameter value of the corresponding command.
Write Command	AT+<cmd>=<p1>[,<p2>[,<p3>[...]]]	Set user-definable parameter value.
Execution Command	AT+<cmd>	Return a specific information parameter or perform a specific action.

2.2. Declaration of AT Command Examples

The AT command examples in this document are provided to help you learn about the use of the AT commands introduced herein. The examples, however, should not be taken as Quectel’s recommendations or suggestions about how to design a program flow or what status to set the module into. Sometimes multiple examples may be provided for one AT command. However, this does not mean that there is a correlation among these examples, or that they should be executed in a given sequence.

2.3. Description of RF FTM AT Commands

2.3.1. AT+QRFTESTMODE Enter/Exit FTM

The Write Command makes the module enter/exit FTM.

AT+QRFTEST (see **Chapter 2.3.2**) and **AT+QRXFTM** (see **Chapter 2.3.3**) are available only when the module enters FTM with this command.

AT+QRFTESTMODE Enter/Exit FTM

Test Command AT+QRFTESTMODE=?	Response +QRFTESTMODE: (list of supported <mode>s) OK
Read Command AT+QRFTESTMODE?	Response +QRFTESTMODE: <mode> OK
Write Command AT+QRFTESTMODE=<mode>	Response OK If there is any error related to ME functionality: +CME ERROR: <err> If there is any other error: ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<mode>	Integer type. Enter/exit FTM. 0 Exit FTM 1 Enter FTM
<err>	Integer type. Error code. See Chapter 4 for details.

NOTE

It is recommended to reboot the module after entering FTM, otherwise the module may dump in some cases.

2.3.2. AT+QRFTEST Transmit in FTM

The Write Commands force the module to transmit in FTM.

AT+QRFTEST Transmit in FTM	
Test Command Currently only returns the parameters supported by the Write Command in GSM AT+QRFTEST=?	Response +QRFTEST: <band>,<channel>,<tx_enable>,<tx_burst>,<tx_gain> OK
Write Command In GSM: AT+QRFTEST=<band>,<channel>,<tx_enable>,<tx_burst>,<tx_gain>	Response ALL ON OK Or ALL OFF OK If there is any error related to ME functionality: +CME ERROR: <err> If there is any other error: ERROR
Write Command In LTE-M: AT+QRFTEST=<band>,<channel>,<tx_enable>,<rgi>,<waveform>	Response ALL ON OK Or ALL OFF

	<p>OK</p> <p>If there is any error related to ME functionality: +CME ERROR: <err></p> <p>If there is any other error: ERROR</p>
<p>Write Command In NB-IoT: AT+QRFTEST=<band>,<channel>,<tx_enable>,<rgi>,<waveform>,<ul_offset>,<mod_type>,<power>,<tone_bw>,<tone_idx></p>	<p>Response ALL ON</p> <p>OK Or ALL OFF</p> <p>OK If there is any error related to ME functionality: +CME ERROR: <err></p> <p>If there is any other error: ERROR</p>
<p>Maximum Response Time</p>	<p>300 ms</p>
<p>Characteristics</p>	<p>The command takes effect immediately. The configurations is not saved.</p>

Parameter

<band>	<p>String type. Supported bands in GSM/LTE. The possible values are:</p> <p>For GSM: "GSM850" "GSM900" "GSM1800" "GSM1900"</p> <p>For LTE: "LTE BAND1" "LTE BAND2" "LTE BAND3" "LTE BAND4" "LTE BAND5" "LTE BAND8" "LTE BAND12" "LTE BAND13"</p>
---------------------	--

"LTE BAND18"
 "LTE BAND19"
 "LTE BAND20"
 "LTE BAND25"
 "LTE BAND26" (Supported by LTE-M only)
 "LTE BAND27" (Supported by LTE-M only)
 "LTE BAND28"
 "LTE BAND31" (Supported by BG95-M4 only)
 "LTE BAND66"
 "LTE BAND71" (Supported by NB-IoT only)
 "LTE BAND72" (Supported by BG95-M4 only)
 "LTE BAND73" (Supported by BG95-M4 only)
 "LTE BAND85"

<channel> Integer type. Supported uplink channels in GSM/LTE. The corresponding channels for different bands in GSM/LTE are as follows:

Uplink Channels	GSM band
128–251	GSM850
1–124, 975–1023	GSM900
512–885	GSM1800
512–810	GSM1900

Uplink Channels	LTE band
18000–18599	LTE BAND1
18600–19199	LTE BAND2
19200–19949	LTE BAND3
19950–20399	LTE BAND4
20400–20649	LTE BAND5
21450–21799	LTE BAND8
23010–23179	LTE BAND12
23180–23279	LTE BAND13
23850–23999	LTE BAND18
24000–24149	LTE BAND19
24150–24449	LTE BAND20
26040–26689	LTE BAND25
26690–27039	LTE BAND26 (Supported by LTE-M only)
27040–27209	LTE BAND27 (Supported by LTE-M only)
27210–27659	LTE BAND28
27760–27809	LTE BAND31 (Supported by BG95-M4 only)
131972–132671	LTE BAND66
131122–133471	LTE BAND71 (Supported by NB-IoT only)
133472–133521	LTE BAND72 (Supported by BG95-M4 only)
133522–133571	LTE BAND73 (Supported by BG95-M4 only)
134002–134181	LTE BAND85

<tx_enable> String type. Enable/disable RF Tx.

	"ON" Enable
	"OFF" Disable
<tx_burst>	Integer type. 0 Continuous Tx mode
<tx_gain>	Integer type. GSM power level (GSM power in dBm × 100). Range: 0–3300. Recommended value: not exceeding 3100.
<rgi>	Integer type. LTE power level. Range: 0–100. Recommended value: not exceeding 75.
<waveform>	Integer type. 1 LTE modulated Tx mode
<ul_offset>	Integer type. Uplink carrier frequency offset. Range: -10 to 9.
<mod_type>	Integer type. Modulation type. 0 BPSK 1 QPSK
<power>	Integer type. Tx power in dBm. Range: -128 to 127.
<tone_bw>	Integer type. Uplink tone bandwidth. 0 Single-tone, 3.75 kHz 1 Single-tone, 15 kHz 2 Multi-tone, 3 × 15 kHz 3 Multi-tone, 6 × 15 kHz 4 Multi-tone, 12 × 15 kHz
<tone_idx>	Integer type. Tone start index. Range: 0–255.
<err>	Integer type. Error code. See Chapter 4 for details.

NOTE

1. Please refer to *3GPP TS 36.101 subclause 5.7.3F Carrier frequency and EARFCN for category NB1 and NB2*, to calculate the specific uplink carrier frequency offset, namely, the value of <ul_offset>.
2. In LTE-M, the bandwidth is 10 MHz by default, and cannot be configured currently.
3. When executing **AT+QRFTEST** Write Commands consecutively for forced Tx tests in different RATs, it is recommended to reboot the module before switching to another RAT.
4. For different module models, the value of <rgi> during mid-frequency band tests and low-frequency band tests is as follows:

Model	Mid-frequency Bands	Low-frequency Bands
BG95-M1/BG95-M2/BG95-M3/BG95-MF /BG77/BG600L-M3	≤ 65	≤ 74
BG95-M4 (excluding LTE B31, B72 and B73)	≤ 63	≤ 73
BG95-M4 (LTE B31, B72 and B73 only)	-	≤ 65
BG95-M5	≤ 68	≤ 66
BG95-M6	≤ 59	≤ 66

2.3.3. AT+QRXFTM Receive in FTM

The Write Command forces the module to receive in FTM.

AT+QRXFTM Receive in FTM	
Test Command AT+QRXFTM=?	Response +QRXFTM: <mode>,<band>,<channel>,<path>,<lna>,<bw> OK
Read Command AT+QRXFTM?	Response OK
Write Command AT+QRXFTM=<mode>,<band>,<channel>[,<path>[,<lna>[,<bw>]]]	Response +QRXFTM: <agc_val>,<agc_to_pwr> OK If there is any error related to ME functionality: +CME ERROR: <err> If there is any other error: ERROR
Maximum Response Time	3000 ms
Characteristics	The command takes effect immediately. The configurations is not saved.

Parameter

<mode>	Integer type. 1 LTE Rx test
<band>	String type. Supported bands in GSM/LTE. The possible values are: For GSM: "GSM850" "GSM900" "GSM1800" "GSM1900" For LTE: "LTE BAND1" "LTE BAND2" "LTE BAND3" "LTE BAND4" "LTE BAND5"

- "LTE BAND8"
- "LTE BAND12"
- "LTE BAND13"
- "LTE BAND18"
- "LTE BAND19"
- "LTE BAND20"
- "LTE BAND25"
- "LTE BAND26" (Supported by LTE-M only)
- "LTE BAND27" (Supported by LTE-M only)
- "LTE BAND28"
- "LTE BAND31" (Supported by BG95-M4 only)
- "LTE BAND66"
- "LTE BAND71" (Supported by NB-IoT only)
- "LTE BAND72" (Supported by BG95-M4 only)
- "LTE BAND73" (Supported by BG95-M4 only)
- "LTE BAND85"

<channel> Integer type. Supported downlink channels in GSM/LTE. The corresponding channels for different bands in GSM/LTE are as follows:

Downlink Channels	GSM band
128–251	GSM850
1–124, 975–1023	GSM900
512–885	GSM1800
512–810	GSM1900

Downlink Channels	LTE band
0–599	LTE BAND1
600–1199	LTE BAND2
1200–1949	LTE BAND3
1950–2399	LTE BAND4
2400–2649	LTE BAND5
3450–3799	LTE BAND8
5010–5179	LTE BAND12
5180–5279	LTE BAND13
5850–5999	LTE BAND18
6000–6149	LTE BAND19
6150–6449	LTE BAND20
8040–8689	LTE BAND25
8690–9039	LTE BAND26 (Supported by LTE-M only)
9040–9209	LTE BAND27 (Supported by LTE-M only)
9210–9659	LTE BAND28
9870–9919	LTE BAND31 (Supported by BG95-M4 only)
66436–67335	LTE BAND66
68586–68935	LTE BAND71 (Supported by NB-IoT only)
68936–68985	LTE BAND72 (Supported by BG95-M4 only)

	68986–69035	LTE BAND73 (Supported by BG95-M4 only)
	70366–70545	LTE BAND85
<path>	Integer type.	
	<u>0</u> Main antenna path.	
<lna>	Integer type. Gain stage. Range: <u>0</u> –5.	
<bw>	Integer type. Bandwidth. Range: <u>0</u> –5.	
	This parameter is only valid for LTE RAT (that is, not applicable for GSM RAT).	
	<u>0</u>	1.4 MHz
	1	3 MHz
	2	5 MHz
	3	10 MHz
	4	15 MHz
	5	20 MHz
<agc_val>	Integer type. The value of received power.	
<agc_to_pwr>	Integer type. Received power level in dBm converted from <agc_val>.	
<err>	Integer type. Error code. See Chapter 4 for details.	

NOTE

1. The Write Command responses are instantaneous values.
2. Currently, this command only supports LTE Rx test in FTM.
3. In LTE RAT, the value of <agc_to_pwr> equals to <agc_val> / 10.

3 Examples

3.1. Set the Module into FTM

```

AT+QRFTESTMODE=?           //Test command
+QRFTESTMODE: (0,1)

OK
AT+QRFTESTMODE=1          //Enter FTM
OK

//After the module reboots
AT+QRFTESTMODE?           //Query the current FTM state of the module
+QRFTESTMODE: 1

OK
AT+QRFTESTMODE=0          //Exit FTM
OK
AT+QRFTESTMODE?           //Query the current FTM state of the module
+QRFTESTMODE: 0

OK
    
```

3.2. Transmit in FTM

```

AT+QRFTESTMODE=1          //Enter FTM
OK

//After the module reboots

//In GSM RAT
AT+QRFTEST="GSM900",122,"ON",0,100 //Enable RF Tx on 122 channel of GSM900
ALL ON

OK
AT+QRFTEST="GSM900",122,"OFF",0,100 //Disable RF Tx on 122 channel of GSM900
    
```

```

ALL OFF

OK
//After the module reboots

//In LTE-M RAT
AT+QRFTEST="LTE BAND1",18300,"ON",50,1 //Enable RF Tx on 18300 channel of LTE B1
ALL ON

OK
AT+QRFTEST="LTE BAND1",18300,"OFF",50,1 //Disable RF Tx on 18300 channel of LTE B1
ALL OFF

OK
AT+QRFTEST="LTE BAND2",18900,"ON",50,1 //Enable RF Tx on 18900 channel of LTE B2
ALL ON

OK
AT+QRFTEST="LTE BAND2",18900,"OFF",50,1 //Disable RF Tx on 18900 channel of LTE B2
ALL OFF

OK
AT+QRFTEST="LTE BAND12",23095,"ON",50,1 //Enable RF Tx on 23095 channel of LTE B12
ALL ON

OK
AT+QRFTEST="LTE BAND12",23095,"OFF",50,1 //Disable RF Tx on 23095 channel of LTE B12
ALL OFF

OK
AT+QRFTEST="LTE BAND20",24300,"ON",50,1 //Enable RF Tx on 24300 channel of LTE B20
ALL ON

OK
AT+QRFTEST="LTE BAND20",24300,"OFF",50,1 //Disable RF Tx on 24300 channel of LTE B20
ALL OFF

OK
AT+QRFTEST="LTE BAND28",27435,"ON",50,1 //Enable RF Tx on 27435 channel of LTE B28
ALL ON

OK
AT+QRFTEST="LTE BAND28",27435,"OFF",50,1 //Disable RF Tx on 27435 channel of LTE B28
ALL OFF

```

OK

//After the module reboots

//In NB-IoT RAT

AT+QRFTEST="LTE BAND1",18300,"ON",50,1,100,0,50,4,0 //Enable RF Tx on 18300 channel of LTE B1

ALL ON

OK

AT+QRFTEST="LTE BAND1",18300,"OFF",50,1,100,0,50,4,0 //Disable RF Tx on 18300 channel of LTE B1

ALL OFF

OK

AT+QRFTEST="LTE BAND2",18900,"ON",50,1,100,0,50,4,0 //Enable RF Tx on 18900 channel of LTE B2

ALL ON

OK

AT+QRFTEST="LTE BAND2",18900,"OFF",50,1,100,0,50,4,0 //Disable RF Tx on 18900 channel of LTE B2

ALL OFF

OK

AT+QRFTEST="LTE BAND20",24300,"ON",50,1,100,0,50,4,0 //Enable RF Tx on 24300 channel of LTE B20

ALL ON

OK

AT+QRFTEST="LTE BAND20",24300,"OFF",50,1,100,0,50,4,0 //Disable RF Tx on 24300 channel of LTE B20

ALL OFF

OK

AT+QRFTEST="LTE BAND28",27435,"ON",50,1,100,0,50,4,0 //Enable RF Tx on 27435 channel of LTE B28

ALL ON

OK

AT+QRFTEST="LTE BAND28",27435,"OFF",50,1,100,0,50,4,0 //Disable RF Tx on 27435 channel of LTE B28

ALL OFF

```

OK
AT+QRFTESTMODE=0 //Exit FTM
OK
    
```

3.3. Receive in FTM

```

AT+QRFTESTMODE=1 //Enter FTM
OK
//After the module reboots
//In LTE RAT
AT+QRXFTM=1,"LTE BAND1",300,0,0,0 //Enable RF Rx on 300 channel of LTE B1
+QRXFTM: -1100,-110

OK
AT+QRXFTM=1,"LTE BAND2",900,0,0,0 //Enable RF Rx on 900 channel of LTE B2
+QRXFTM: -1100,-110

OK
AT+QRXFTM=1,"LTE BAND12",5095,0,0,0 //Enable RF Rx on 5095 channel of LTE B12
+QRXFTM: -1100,-110

OK
AT+QRXFTM=1,"LTE BAND20",6300,0,0,0 //Enable RF Rx on 6300 channel of LTE B20
+QRXFTM: -1100,-110

OK
AT+QRXFTM=1,"LTE BAND28",9435,0,0,0 //Enable RF Rx on 9435 channel of LTE B28
+QRXFTM: -1100,-110

OK
AT+QRFTESTMODE=0 //Exit FTM
OK
    
```

4 Summary of CME ERROR Codes

The **CME ERROR: <err>** indicates an error related to mobile equipment or network. The details about <err> are described in the following table.

Table 3: Summary of CME ERROR Codes

<err>	Meaning
3	Operation not allowed
323	Invalid input parameter

5 Appendix References

Table 4: Terms and Abbreviations

Abbreviation	Description
BPSK	Binary Phase Shift Keying
LTE-M	LTE-MTC (Machine Type Communication)
FTM	Factory Test Mode
GSM	Global System for Mobile Communications
LPWA	Low-Power Wide-Area
LTE	Long Term Evolution
NB-IoT	Narrowband Internet of Things
QPSK	Quadrature Phase Shift Keying
RAT	Radio Access Technology
RF	Radio Frequency
Rx	Receive
Tx	Transmit