BG95&BG77&BG600L Series Network Searching Scheme Introduction

LPWA Module Series

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About the Document

Revision History

Revision	Date	Author	Description
1.0	2020-01-13	Elvis SUN	Initial
2.0	2022-04-24	Forest WANG	1. Added the applicable module BG600L-M3. 2. Updated the frequency bands of BG95 series and BG77: deleted the eMTC band B14 and NB-IoT B26 (Chapters 2.1 and 2.2). 3. Updated the RAT/PLMN selection procedure figure (Figure 2). 4. Updated notes of network searching AT commands (Chapter 5). 5. Updated the default setting of <mode> in AT+QCFG="iotopmode" (Chapter 5.3). 6. Added some typical problems and corresponding cause analysis (Chapters 7.3, 7.4 and 7.5). 7. Added the FAQ chapter (Chapter 8).

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1 Introduction

This document outlines the supported RATs and frequency bands of Quectel BG95 series, BG77 and BG600L-M3 modules, and describes the network searching scheme by illustrating network searching/registration processes and related AT commands to help users understand the network searching mechanism of the modules.

Furthermore, the document describes some problems observed in the process of network searching, and provides the corresponding root cause analysis.

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

2 Supported RATs and Bands

2.1. Supported RATs and Bands of BG95 Series

Quectel BG95 series module supports three RATs: eMTC, NB-IoT and EGPRS.

- Default RATs: eMTC, NB-IoT and EGPRS
- Default searching sequence: eMTC → NB-IoT → EGPRS
- If the three RATs need to be supported synchronously or other searching sequences are needed, set the relevant configuration values via AT commands. The details of AT commands are provided in ***Chapter 5***.

The following table lists the supported frequency bands of BG95 series module.

Table 2: Frequency Bands of BG95 Series Module

RAT	Frequency Band
eMTC	B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/B25/B26/B27/B28/B31/B66/B72/B73/B85
NB-IoT	B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/B25/B28/B31/B66/B71/B72/B73/B85
EGPRS	GSM850, EGSM900, DCS1800, PCS1900

NOTE

Quectel BG95 series includes multiple models with different RATs and frequency bands. For detailed information, see ***document [1]***.

2.2. Supported RATs and Bands of BG77

Quectel BG77 module supports two RATs: eMTC and NB-IoT.

- Default RATs: eMTC and NB-IoT
- Default searching sequence: eMTC → NB-IoT
- If the two RATs need to be supported synchronously or other searching sequences are needed, set the relevant configuration values via AT commands. The details of AT commands are provided in ***Chapter 5***.

The following table lists the supported frequency bands of BG77.

Table 3: Frequency Bands of BG77 Module

RAT	Frequency Band
eMTC	B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/B25/B26/B27/B28/B66/B85*
NB-IoT	B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/B25/B28/B66/B71/B85*

2.3. Supported RATs and Bands of BG600L-M3

Quectel BG600L-M3 module supports three RATs: eMTC, NB-IoT and EGPRS.

- Default RATs: eMTC, NB-IoT and EGPRS
- Default searching sequence: eMTC → NB-IoT → EGPRS
- If the three RATs need to be supported synchronously or other searching sequences are needed, set the relevant configuration values via AT commands. The details of AT commands are provided in ***Chapter 5***.

The following table lists the supported frequency bands of BG600L-M3 module.

Table 4: Frequency Bands of BG600L-M3 Module

RAT	Frequency Band
eMTC	B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/B25/B26/B27/B28/B66/B85
NB-IoT	B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/B25/B28/B66/B71/B85
EGPRS	GSM850, EGSM900, DCS1800, PCS1900

3 Network Searching/Registration Processes

The network searching/registration processes of BG95 series, BG77 and BG600L-M3 modules are illustrated below:

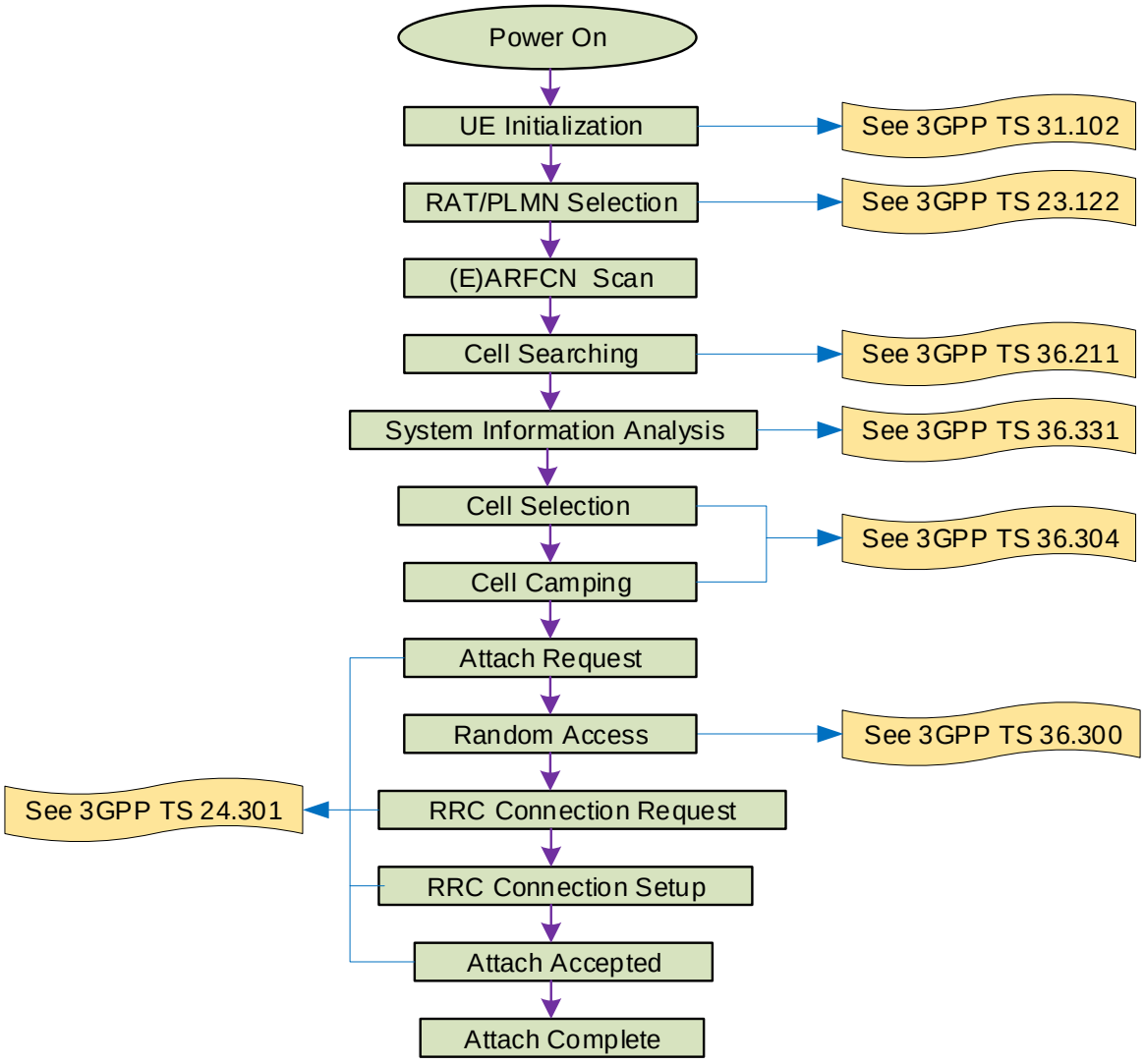


Figure 1: Network Searching and Registration Process

1. **UE Initialization**

   UE initialization includes (U)SIM card recognition and reading of NVM related to network searching.

2. **RAT/PLMM Selection**

   - Set the RAT searching sequence and the RAT(s) allowed to be searched according to network searching related NVM and related (U)SIM EF files.
   - PLMN selection can be performed in either automatic or manual modes.
   - For more information, see ***Chapter 4.1***.

3. **(E)ARFCN Scan**

   - LTE EARFCN scan includes system scan and band scan.
   - EGPRS ARFCN scan refers to power scan.
   - For more information, see ***Chapter 4.2***.

4. **Cell Searching**

   Cell searching refers to cell recognition and downlink synchronization.

5. **System Information Analysis**

   This step includes reading and analyzing MIB and SIB information. For detailed definition of system information, see *3GPP TS 36.331 [5.2]*.

   - MIB information: the number of antennas, downlink bandwidth, cell ID and registered (E)ARFCN.
   - SIB information: PLMN, cell ID, etc.

6. **Cell Selection**

   If the acquired band satisfies the signal strength requirement of UE, the UE will perform the next step (cell camping), otherwise it will continue (E)ARFCN scanning.

7. **Cell Camping**

   Cell camping is started after successful cell selection.

8. **Attach Request/Location Update Request**

   After the cell is camped, the UE will send the attach request/location update request.

9. **Random Access**

   UE performs uplink synchronization (random access) after sending attach request/location update request.

10. **RRC Connection Request**

11. **RRC Connection Setup**

12. Attach Accepted/Location Updating Accepted

4 Factors Influencing Network Registration Speed

Network registration speed is affected by RAT/PLMN selection and LTE EARFCN scan. The details about the two processes are provided below.

4.1. RAT/PLMN Selection

This chapter describes the steps involved in RAT/PLMN selection. The following figure illustrates the overall processes of RAT/PLMN selection in automatic mode. As shown below, the search order during RAT/PLMN selection is determined not only by the module settings but also by some files on the (U)SIM card. By default, the files on the (U)SIM card have a higher priority.

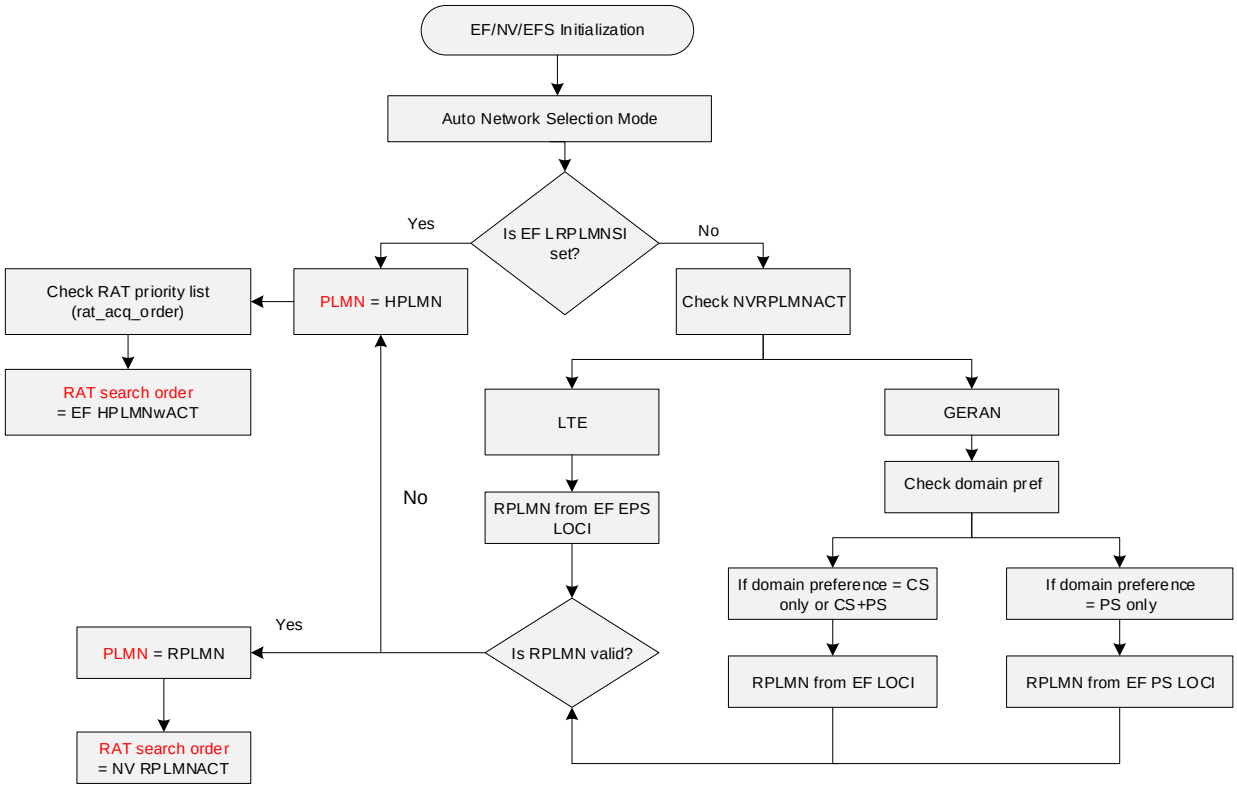


Figure 2: RAT/PLMN Selection

4.2. LTE EARFCN Scan

This chapter describes the effect of LTE EARFCN scan on the speed of network registration.

LTE EARFCN scan includes system scan and band scan. When the module shuts down, it will store the current network registration information (e.g., EARFCN, PCI and so on). When the module powers on next time for network registration, UE will try to acquire the stored network registration information. This procedure is called system scan. This procedure will speed up the network registration process. If the network information acquisition failed in system scan, UE will attempt to scan all supported bands, which process constitutes the band scan.

According to statistics, the scan for all bands under eMTC and EGPRS takes about tens of seconds. However, EARFCN scan will take longer under NB-IoT, due to the characteristics of NB-IoT network (especially the weak signal feature). The following table shows the test results of some of the NB-IoT bands, which displays the EARFCN scan time required in each band.

Table 5: Network Searching Time of NB-IoT Bands with Different SNR

Band	Band Width (MHz)	Searching Time with SNR 0 (Unit: s)	Searching Time with SNR 1 (Unit: s)	Searching Time with SNR 2 (Unit: s)
B1	60	25	139	313
B2	60	26	132	310
B3	75	32	164	386
B4	45	20	104	229
B5	25	11	69	132
B8	35	15	77	185
B12	17	7	38	90
B13	10	4	21	49
B18	15	7	36	78
B19	15	6	39	77
B20	40	13	67	157
B25	65	15	86	183
B28	45	20	104	238

As BG95 series, BG77 and BG600L-M3 modules support dozens of bands under NB-IoT, it is recommended to enable only the bands supported by the service operator.

Table 6: eMTC/NB-IoT Band Deployment over the World (For Reference Only)

Band	DL Freq. (MHz)	Applicability as per 3GPP TS36.1.0.1	U.S.	China	The Middle East	Japan	Korea	Europe	Australia
B1	2100	eMTC/NB-IoT		■		■			
B2	1900	eMTC/NB-IoT	■						
B3	1800	eMTC/NB-IoT		■	■		■	■	■
B4	1700	eMTC	■						
B5	850	eMTC/NB-IoT		■			■		
B8	900	eMTC/NB-IoT		■	■	■		■	
B12	700	eMTC/NB-IoT	■						
B13	700	eMTC/NB-IoT	■						
B18	800	eMTC/NB-IoT				■			
B19	800	eMTC/NB-IoT				■			
B20	800	eMTC/NB-IoT						■	
B26	850	eMTC/NB-IoT		■					
B28	700	eMTC/NB-IoT			■				■

5 Network Searching Related AT Commands

In order to optimize network searching/registration time, related AT commands can be used to set the RAT searching sequence, RAT(s) to be searched, network category to be searched under LTE RAT, and preferred bands to be searched.

5.1. AT+QCFG="nwscanseq" Configure RAT Searching Sequence

This Write Command configures the searching sequence of RATs or queries the current setting.

AT+QCFG="nwscanseq" Configure RAT Searching Sequence	
Write Command **AT+QCFG="nwscanseq"[,<scanseq>[,<effect>]]**	Response If the optional parameters are omitted, query the current setting. **+QCFG: "nwscanseq",<scanseq>** **OK** If any of the optional parameters is specified, configure the RAT searching sequence. **OK** If there is an error related to ME functionality: **+CME ERROR: <err>** If there is any other error: **ERROR**
Maximum Response Time	300 ms
Characteristics	**<effect>** determines when the command will take effect. The configurations will be saved automatically.

Parameter

<scanseq>	Integer type. RAT searching sequence. (e.g.: 020301 stands for eMTC → NB-IoT → GSM) 00 Automatic (eMTC → NB-IoT → GSM) 01 GSM 02 eMTC 03 NB-IoT
<effect>	Integer type. When to take effect. 0 Take effect after UE reboots 1 Take effect immediately
<err>	Integer type. Error code. See Chapter 9 for details.

NOTE

1. This command is invalid on BG95-M1 module.
2. GSM RAT (**<scanseq>**=01) is valid only on BG95-M3, BG95-M5 and BG600L-M3 modules.
3. NB-IoT is disabled by default.
4. Don't repeatedly select one RAT while specifying **<scanseq>** (for example "020202"), to prevent unexpected situations.

5.2. AT+QCFG="nwscanmode" Configure RAT(s) to be Searched for

This Write Command configures the RAT(s) to be searched for or queries the current setting

AT+QCFG="nwscanmode" Configure RAT(s) to be Searched for	
Write Command **AT+QCFG="nwscanmode"[,<scan_mode>[,<effect>]]**	Response If the optional parameters are omitted, query the current setting. **+QCFG: "nwscanmode",<scan_mode>** **OK** If any of the optional parameters is specified, configure the RAT(s) to be searched for: **OK** If there is an error related to ME functionality: **+CME ERROR: <err>** If there is any other error:

	ERROR
Maximum Response Time	300 ms
Characteristics	**<effect>** determines when the command will take effect. The configurations will be saved automatically.

Parameter

<scan_mode>	Integer type. RAT(s) to be searched for. 0 Automatic (GSM and LTE) 1 GSM only 3 LTE only
<effect>	Integer type. When to take effect. 0 Take effect after UE reboots 1 Take effect immediately
<err>	Integer type. Error code. See ***Chapter 9*** for details.

NOTE

This command is valid only on BG95-M3, BG95-M5 and BG600L-M3 modules.

5.3. AT+QCFG="iotopmode" Configure Network Category to be Searched for under LTE RAT

This Write Command configures the network category to be searched for under LTE RAT or queries the current setting.

AT+QCFG="iotopmode" Configure Network Category to be Searched for under LTE RAT	
Write Command **AT+QCFG="iotopmode"[,<mode>[,<effect>]]**	Response If the optional parameters are omitted, query the current setting. **+QCFG: "iotopmode",<mode>** **OK** If any of the optional parameters is specified, configure the network category to be searched for under LTE RAT: **OK**

	If there is an error related to ME functionality: **+CME ERROR: <err>** If there is any other error: **ERROR**
Maximum Response Time	300 ms
Characteristics	**<effect>** determines when the command will take effect. The configurations will be saved automatically.

Parameter

<mode>	Integer type. Network category to be searched for under LTE RAT. 0 eMTC 1 NB-IoT 2 eMTC and NB-IoT
<effect>	Integer type. When to take effect. 0 Take effect after UE reboots 1 Take effect immediately
<err>	Integer type. Error code. See ***Chapter 9*** for details.

NOTE

This command is invalid on BG95-M1 module.

5.4. AT+QCFG="band" Configure Frequency Band

This Write Command configures the frequency bands to be searched for or queries the current setting.

AT+QCFG="band" Configure Frequency Band	
Write Command **AT+QCFG="band"[,<GSM_bandval>,<eMTC_bandval>,<NB-IoT_bandval>[,<effect>]]**	Response If the optional parameters are omitted, query the current setting. **+QCFG: "band",<GSM_bandval>,<eMTC_bandval>,<NB-IoT_bandval>** **OK** If any of the optional parameters is specified, configure the

	frequency bands to be searched for. **OK** If there is an error related to ME functionality: **+CME ERROR: <err>** If there is any other error: **ERROR**
Maximum Response Time	300 ms
Characteristics	**<effect>** determines when the command will take effect. The configurations will be saved automatically.

Parameter

<GSM_bandval> A hexadecimal value that specifies the GSM frequency band (e.g.: 0xa = 0x2(DCS1800) + 0x8(PCS1900)). If it is set to 0, it means not to change GSM frequency band.

0	No change
0x1	EGSM900
0x2	DCS1800
0x4	GSM850
0x8	PCS1900
0xF	All of the supported bands above

<eMTC_bandval> A hexadecimal value that specifies the eMTC frequency band (e.g.: 0x15 = 0x1(LTE B1) + 0x4(LTE B3) + 0x10(LTE B5)). If it is set to 0, it means not to change the eMTC frequency band.

0	No change
0x1 (BAND_PREF_LTE_BAND1)	LTE B1
0x2 (BAND_PREF_LTE_BAND2)	LTE B2
0x4 (BAND_PREF_LTE_BAND3)	LTE B3
0x8 (BAND_PREF_LTE_BAND4)	LTE B4
0x10 (BAND_PREF_LTE_BAND5)	LTE B5
0x80 (BAND_PREF_LTE_BAND8)	LTE B8
0x800 (BAND_PREF_LTE_BAND12)	LTE B12
0x1000 (BAND_PREF_LTE_BAND13)	LTE B13
0x20000 (BAND_PREF_LTE_BAND18)	LTE B18
0x40000 (BAND_PREF_LTE_BAND19)	LTE B19
0x80000 (BAND_PREF_LTE_BAND20)	LTE B20
0x1000000 (BAND_PREF_LTE_BAND25)	LTE B25
0x2000000 (BAND_PREF_LTE_BAND26)	LTE B26
0x4000000 (BAND_PREF_LTE_BAND27)	LTE B27
0x8000000 (BAND_PREF_LTE_BAND28)	LTE B28
0x40000000 (BAND_PREF_LTE_BAND31)	LTE B31

	0x20000000000000000 (BAND_PREF_LTE_BAND66)	LTE B66
	0x800000000000000000 (BAND_PREF_LTE_BAND72	LTE B72
	0x1000000000000000000 (BAND_PREF_LTE_BAND73)	LTE B73
	0x100000000000000000000 (BAND_PREF_LTE_BAND85)	LTE B85
<NB-IoT_bandval>	A hexadecimal value that specifies the NB-IoT frequency band (e.g.: 0x15 = 0x1(LTE B1) + 0x4(LTE B3) + 0x10(LTE B5)). If it is set to 0, it means not to change the NB-IoT frequency band.	
	0	No change
	0x1 (BAND_PREF_LTE_BAND1)	LTE B1
	0x2 (BAND_PREF_LTE_BAND2)	LTE B2
	0x4 (BAND_PREF_LTE_BAND3)	LTE B3
	0x8 (BAND_PREF_LTE_BAND4)	LTE B4
	0x10 (BAND_PREF_LTE_BAND5)	LTE B5
	0x80 (BAND_PREF_LTE_BAND8)	LTE B8
	0x800 (BAND_PREF_LTE_BAND12)	LTE B12
	0x1000 (BAND_PREF_LTE_BAND13)	LTE B13
	0x20000 (BAND_PREF_LTE_BAND18)	LTE B18
	0x40000 (BAND_PREF_LTE_BAND19)	LTE B19
	0x80000 (BAND_PREF_LTE_BAND20)	LTE B20
	0x1000000 (BAND_PREF_LTE_BAND25)	LTE B25
	0x8000000 (BAND_PREF_LTE_BAND28)	LTE B28
	0x40000000 (BAND_PREF_LTE_BAND31)	LTE B31
	0x20000000000000000 (BAND_PREF_LTE_BAND66)	LTE B66
	0x400000000000000000 (BAND_PREF_LTE_BAND71)	LTE B71
	0x800000000000000000 (BAND_PREF_LTE_BAND72)	LTE B72
	0x1000000000000000000 (BAND_PREF_LTE_BAND73)	LTE B73
	0x100000000000000000000 (BAND_PREF_LTE_BAND85)	LTE B85
<effect>	Integer type. When to take effect.	
	0 Take effect after UE reboots	
	1 Take effect immediately	
<err>	Integer type. Error code. See ***Chapter 9*** for details.	

NOTE

1. For the specific bands supported by each model, see corresponding specifications of the modules.
   - **<GSM_bandval>** is valid only on BG95-M3, BG95-M5 and BG600L-M3 modules.
   - **<NB-IoT_bandval>** is invalid on BG95-M1 module.
   - LTE B31/B72/B73 is valid on BG95-M4 module only.
2. The value setting of **<eMTC_bandval>** when all eMTC bands are intended to be searched for:
   - 0x100182000000004F0E189F for BG95-M4
   - 0x100002000000000F0E189F for BG77, BG600L-M3 and other BG95 series modules
3. The value setting of **<NB-IoT_bandval>** when all NB-IoT bands are intended to be searched for:
   - 0x10018200000000490E189F for BG95-M4

- 0x10004200000000090E189F for BG77, BG600L-M3 and other BG95 series modules

6 Solutions to Speed up Network Searching

6.1. Overview of NB-IoT Network Searching Time

As per 3GPP specifications, NB-IoT is expected to be deployed in a much lower coverage area. Expected Maximum Coupling Loss for NB-IoT is 164 dB, whereas it is only around 155 dB for eMTC. This pushes the device to accommodate more SNR range to detect a possible NB-IoT cell deployment. In addition, eMTC has a 1.4 MHz bandwidth, whereas NB-IoT has a 200 KHz bandwidth. This means NB-IoT has much more candidates to scan and detect in a given LTE deployed area, which leads to much longer searching time for NB-IoT than eMTC.

BG95 series, BG77 and BG600L-M3 modules divide the search process into three levels according to NB-IoT signal characteristics:

- Frequency scan level 0 (SNR level 0): SNR value > 0 dB. This takes only few milliseconds for each raster.
- Frequency scan level 1 (SNR level 1): SNR value ranges from 0 to -9 dB. This takes about 100 msec for each raster.
- Frequency scan level 2 (SNR level 2): typical SNR value is about -12 dB. This takes about 400 to 500 msec for each raster.

According to the test results in ***Table 5***, NB-IoT network was searched for a long period of time. This, coupled with the dozens of bands supported by the modules, makes the total network searching time very long.

- Under SNR level 0, searching the network takes only tens of seconds.
- Under SNR level 1, the time for network searching is five to six times as long as the time for searching under SNR level 0.
- Under SNR level 2, the time for network searching is ten to fifteen times as long as the time for searching under SNR level 0.

To avoid the long network searching time, either of the following solutions should be used to optimize the network searching scheme of modules.

6.2. Solutions to Speed up Network Searching

6.2.1. Disable NB-IoT and Enable Required RAT(s)

Network searching can be sped up by disabling NB-IoT and enabling only the required RAT(s).

Table 7: Solutions to Speed up Network Searching (Disable NB-IoT)

Solutions		Related AT Commands
Disable NB-IoT		Default configuration
Enable Required RAT(s)	Enable EGPRS only	AT+QCFG="nwscanmode",1
	Enable eMTC only	AT+QCFG="iotopmode",0 AT+QCFG="nwscanmode",3
	Enable eMTC and EGPRS both	AT+QCFG="iotopmode",0 AT+QCFG="nwscanmode",0

6.2.2. Enable NB-IoT Bands Supported by Current Operator Only

When NB-IoT is necessary, it is recommended to enable only the bands supported by the current service operator.

Table 8: Solutions to Speed up Network Searching (Enable NB-IoT Bands Supported)

Regions	Solutions	Related AT Commands
U.S	Enable the three RATs synchronously. Set B2, B4, B12 and B13 as the bands to be searched.	AT+QCFG="band",F,180A,180A AT+QCFG="iotopmode",2 AT+QCFG="nwscanseq",020301 AT+QCFG="nwscanmode",0 AT+QCFG="nwscanmode",3 (set only when EGPRS is not needed)
Europe	Enable the three RATs synchronously. Set B3, B8 and B20 as the bands to be searched.	AT+QCFG="band",F,80084,80084 AT+QCFG="iotopmode",2 AT+QCFG="nwscanseq",020301 AT+QCFG="nwscanmode",0 AT+QCFG="nwscanmode",3 (set only when EGPRS is not needed)
Korea	Enable the three RATs synchronously. Set B3 and B5 as the bands to	AT+QCFG="band",F,14,14 AT+QCFG="iotopmode",2 AT+QCFG="nwscanseq",020301

	be searched.	AT+QCFG="nwscanmode",0 AT+QCFG="nwscanmode",3 (set only when EGPRS is not needed)
Australia	Enable the three RATs synchronously. Set B3 and B28 as the bands to be searched.	AT+QCFG="band",F,8000004,8000004 AT+QCFG="iotopmode",2 AT+QCFG="nwscanseq",020301 AT+QCFG="nwscanmode",0 AT+QCFG="nwscanmode",3 (set only when EGPRS is not needed)
The Middle East	Enable the three RATs synchronously. Set B3, B5 and B28 as the bands to be searched.	AT+QCFG="band",F,8000084,8000084 AT+QCFG="iotopmode",2 AT+QCFG="nwscanseq",020301 AT+QCFG="nwscanmode",0 AT+QCFG="nwscanmode",3 (set only when EGPRS is not needed)
Japan	Enable the three RATs synchronously. Set B1, B8, B18 and B19 as the bands to be searched.	AT+QCFG="band",F,60081,60081 AT+QCFG="iotopmode",2 AT+QCFG="nwscanseq",020301 AT+QCFG="nwscanmode",0 AT+QCFG="nwscanmode",3 (set only when EGPRS is not needed)
China	Enable the three RATs synchronously. Set B1, B3, B5, B8 and B26 as the bands to be searched.	AT+QCFG="band",F,2000095,2000095 AT+QCFG="iotopmode",2 AT+QCFG="nwscanseq",020301 AT+QCFG="nwscanmode",0 AT+QCFG="nwscanmode",3 (set only when EGPRS is not needed)

7 Typical Problems and Root Cause Analysis

This chapter describes some typical problems and corresponding root cause analysis.

7.1. Network Searching Sequence Determined by (U)SIM Card Files

Problem Description:

The RAT searching sequence does not comply with the setting of **AT+QCFG="nwscanseq"**.

Root Cause Analysis:

The sequence is determined by some files in (U)SIM card, as illustrated in the example below.

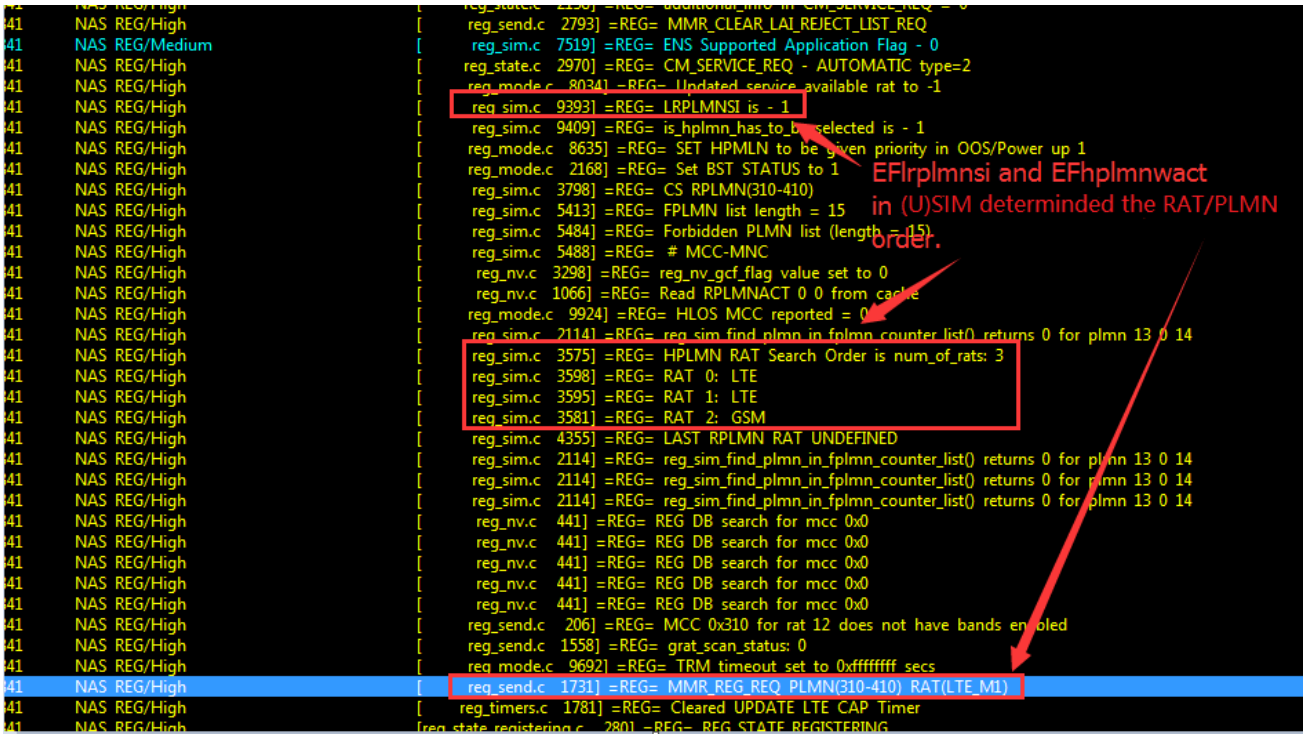


Figure 3: RAT Searching Sequence Determined by (U)SIM Card Files

7.2. Network Searching Sequence Determined by RPLMN/RPLMNACT Stored on Module Flash

Problem Description:

The RAT searching sequence does not comply with the setting of **AT+QCFG="nwscanseq"**.

Root Cause Analysis:

In the example shown below, $EF_{LRPLMNSI}$ (0x6FDC, this file is optional in 3GPP protocol) does not exist on the (U)SIM card. The module thus searches RPLMN/RPLMNACT stored inside.

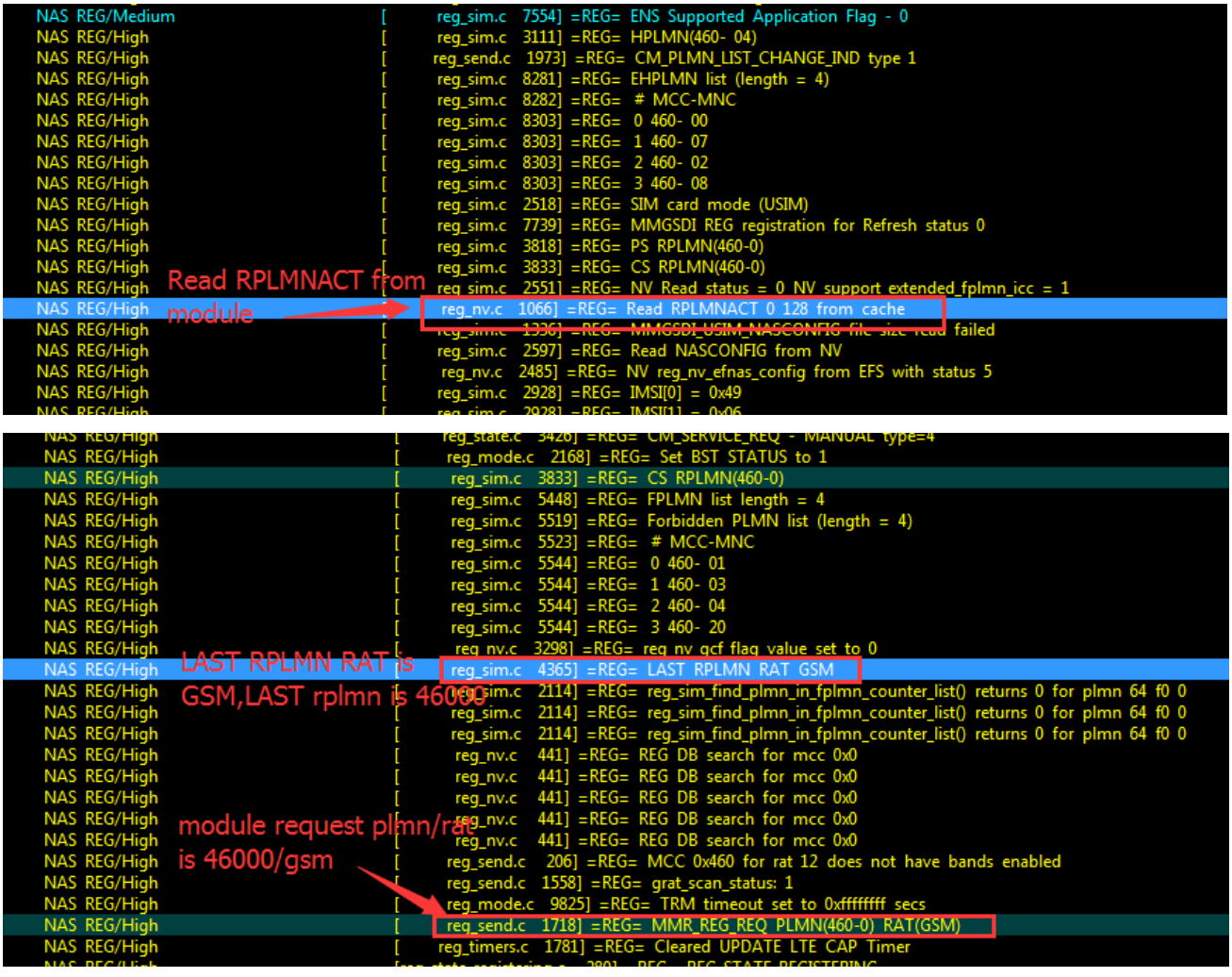


Figure 4: RAT Searching Sequence Determined by RPLMN/RPLMNACT Stored on Module Flash

7.3. Long Network Registration Time in Roaming State

Problem Description:

When the module is in roaming state, the network registration time becomes longer, especially when the module powers on for the first time in roaming state or when the module registers to NB-IoT network.

Roaming State Introduction:

When the PLMN of the module's registered network is not consistent with the HPLMN or EHPLMN of (U)SIM card, the module is in the roaming state. In this case, **<stat>** returned by executing **AT+CREG?/AT+CGREG?/AT+CEREG?** is **5**, which also indicates that the module is in the roaming state.

The behaviour of the module if the (U)SIM card is in roaming state is described in the figure below:

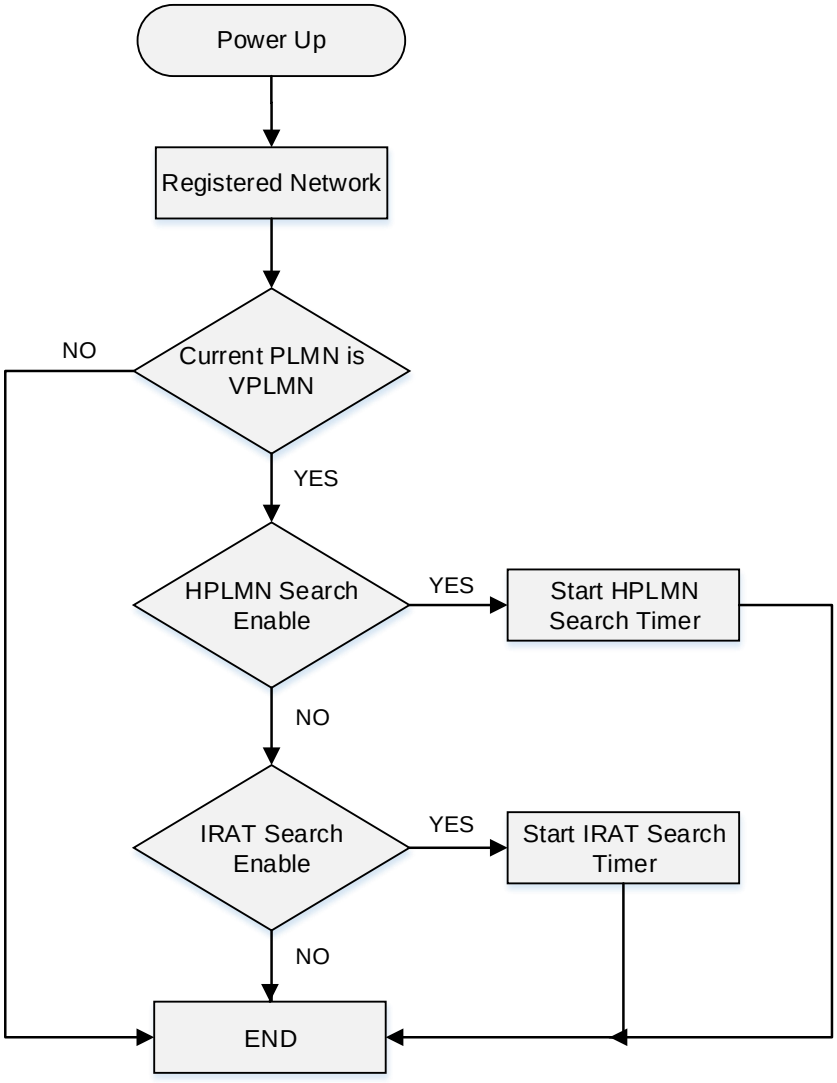


Figure 5: Behaviour of the Module if (U)SIM is Card in Roaming State

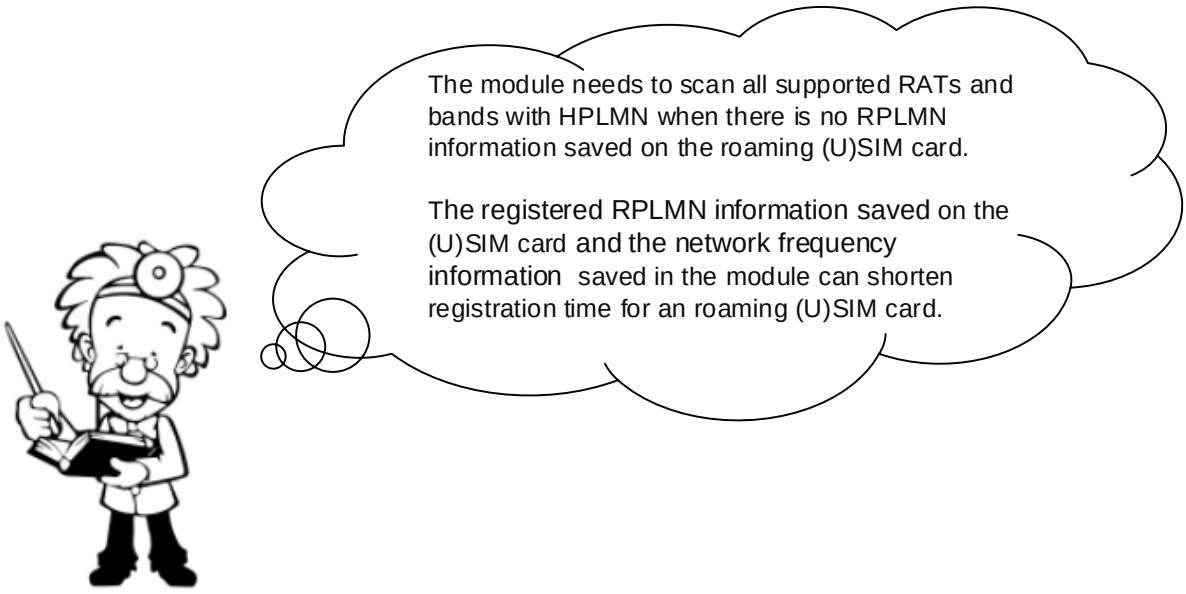
Root Cause Analysis:

When the module is powered on for the first time with a roaming (U)SIM card, there is no RPLMN information on the (U)SIM card, thus the module needs to scan for high priority PLMN (HPLMN, EHPLMN and so on). It means that the module needs to scan all supported RATs and bands to confirm whether there is any available HPLMN around the cells first. Therefore, the network registration time of the module is always longer when powering on for the first time with a roaming (U)SIM card.

Due to the NB-IoT network characteristics (200 kHz bandwidth), network scanning is much slower (For more details, see ***Chapter 6.1***).

For non-initial network registration, the last registered RPLMN information is saved on the (U)SIM card and the last registered network frequency information is saved in the module. It means that the module can find the target network as fast as possible. Therefore, the network registration time of the module is faster for non-initial network registration of a roaming (U)SIM card.

According to 3GPP specification (*3GPP TS 23.122 subclause 4.4.3.3*), the module should attempt to access the HPLMN, EHPLMN or another high priority PLMN (hereinafter referred to as "HPLMN search") with HPLMN search timer when the module is in the roaming state. For BG95 series, BG77 or BG600L-M3 module, when the module is locked to one RAT, HPLMN search process is imperceptible for users, and the ongoing operation will not be affected.



Recommendation:

- Lock as few as possible RATs and bands to shorten the network searching time.
- Use normal power-down methods (such as executing **AT+QPOWD=1**, see ***document [2]*** for details) to power off the module, to make sure the network registration information is saved on the (U)SIM card and the module flash. It is not recommended to disconnect the power supply of the module directly.

7.4. Network Registration Request Rejected by Network

Problem Description:

The module's network registration request was rejected.

Reject Cause Information Element Introduction:

The purpose of the reject cause information element is to indicate the reason why a GMM/EMM request from the UE was rejected by the network. The GMM cause information element is defined in *3GPP TS 24.008*, and the EMM cause information element is defined in *3GPP 24.301*. The reject cause is a type 3 information element with the length of 2 octets (see ***Figure 6*** for GMM cause value and ***Figure 7*** for EMM cause value).

When the module receives a reject cause code, it means that the module has searched the network, but the registration request was rejected by the network. The network searching sequence of the module complies with the 3GPP specification when the module receives a reject cause code, and the module will always try to search for available networks even if it receives a reject cause code from a certain network.

Table 10.5.147/3GPP TS 24.008: GMM cause information element

Cause value (octet 2) Bits 8	7	6	5	4	3	2	1	
0	0	0	0	0	0	1	0	IMSI unknown in HLR
0	0	0	0	0	0	1	1	Illegal MS
0	0	0	0	0	1	0	1	IMEI not accepted
0	0	0	0	0	1	1	0	Illegal ME
0	0	0	0	0	1	1	1	GPRS services not allowed
0	0	0	0	1	0	0	0	GPRS services and non-GPRS services not allowed
0	0	0	0	1	0	0	1	MS identity cannot be derived by the network
0	0	0	0	1	0	1	0	Implicitly detached
0	0	0	0	1	0	1	1	PLMN not allowed
0	0	0	0	1	1	0	0	Location Area not allowed
0	0	0	0	1	1	0	1	Roaming not allowed in this location area
0	0	0	0	1	1	1	0	GPRS services not allowed in this PLMN
0	0	0	0	1	1	1	1	No Suitable Cells In Location Area
0	0	0	1	0	0	0	0	MSC temporarily not reachable
0	0	0	1	0	0	0	1	Network failure
0	0	0	1	0	1	0	0	MAC failure
0	0	0	1	0	1	0	1	Synch failure
0	0	0	1	0	1	1	0	Congestion
0	0	0	1	0	1	1	1	GSM authentication unacceptable
0	0	0	1	1	0	0	1	Not authorized for this CSG
0	0	0	1	1	1	0	0	SMS provided via GPRS in this routing area
0	0	1	0	1	0	0	0	No PDP context activated
0	0	1	1	0	0	0	0	}
			to					} retry upon entry into a new cell
0	0	1	1	1	1	1	1	}
0	1	0	1	1	1	1	1	Semantically incorrect message
0	1	1	0	0	0	0	0	Invalid mandatory information
0	1	1	0	0	0	0	1	Message type non-existent or not implemented
0	1	1	0	0	0	1	0	Message type not compatible with the protocol state
0	1	1	0	0	0	1	1	Information element non-existent or not implemented
0	1	1	0	0	1	0	0	Conditional IE error
0	1	1	0	0	1	0	1	Message not compatible with the protocol state
0	1	1	0	1	1	1	1	Protocol error, unspecified

Any other value received by the mobile station shall be treated as 0110 1111, "Protocol error, unspecified". Any other value received by the network shall be treated as 0110 1111, "Protocol error, unspecified".

NOTE: The listed reject cause values are defined in annex G.

Figure 6: GMM Cause Information Element

Table 9.9.3.9.1: EMM cause information element

Cause value (octet 2)

Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	1	0	IMSI unknown in HSS
0	0	0	0	0	0	1	1	Illegal UE
0	0	0	0	0	1	0	1	IMEI not accepted
0	0	0	0	0	1	1	0	Illegal ME
0	0	0	0	0	1	1	1	EPS services not allowed
0	0	0	0	1	0	0	0	EPS services and non-EPS services not allowed
0	0	0	0	1	0	0	1	UE identity cannot be derived by the network
0	0	0	0	1	0	1	0	Implicitly detached
0	0	0	0	1	0	1	1	PLMN not allowed
0	0	0	0	1	1	0	0	Tracking Area not allowed
0	0	0	0	1	1	0	1	Roaming not allowed in this tracking area
0	0	0	0	1	1	1	0	EPS services not allowed in this PLMN
0	0	0	0	1	1	1	1	No Suitable Cells In tracking area
0	0	0	1	0	0	0	0	MSC temporarily not reachable
0	0	0	1	0	0	0	1	Network failure
0	0	0	1	0	0	1	0	CS domain not available
0	0	0	1	0	0	1	1	ESM failure
0	0	0	1	0	1	0	0	MAC failure
0	0	0	1	0	1	0	1	Synch failure
0	0	0	1	0	1	1	0	Congestion
0	0	0	1	0	1	1	1	UE security capabilities mismatch
0	0	0	1	1	0	0	0	Security mode rejected, unspecified
0	0	0	1	1	0	0	1	Not authorized for this CSG
0	0	0	1	1	0	1	0	Non-EPS authentication unacceptable
0	0	1	0	0	0	1	1	Requested service option not authorized in this PLMN
0	0	1	0	0	1	1	1	CS service temporarily not available
0	0	1	0	1	0	0	0	No EPS bearer context activated
0	0	1	0	1	0	1	0	Severe network failure
0	1	0	1	1	1	1	1	Semantically incorrect message
0	1	1	0	0	0	0	0	Invalid mandatory information
0	1	1	0	0	0	0	1	Message type non-existent or not implemented
0	1	1	0	0	0	1	0	Message type not compatible with the protocol state
0	1	1	0	0	0	1	1	Information element non-existent or not implemented
0	1	1	0	0	1	0	0	Conditional IE error
0	1	1	0	0	1	0	1	Message not compatible with the protocol state
0	1	1	0	1	1	1	1	Protocol error, unspecified

Any other value received by the mobile station shall be treated as 0110 1111, "protocol error, unspecified". Any other value received by the network shall be treated as 0110 1111, "protocol error, unspecified".

Figure 7: EMM Cause Information Element

Example Analysis:

When the module receives a reject cause code from the network, it means that the module has searched the network and initiated an attach request.

Then the module starts the T3247 timer, which is a random value ranging from 30 minutes to 60 minutes. After the timer expires, the module initiates network registration again on the PLMN, as illustrated in the figure below.

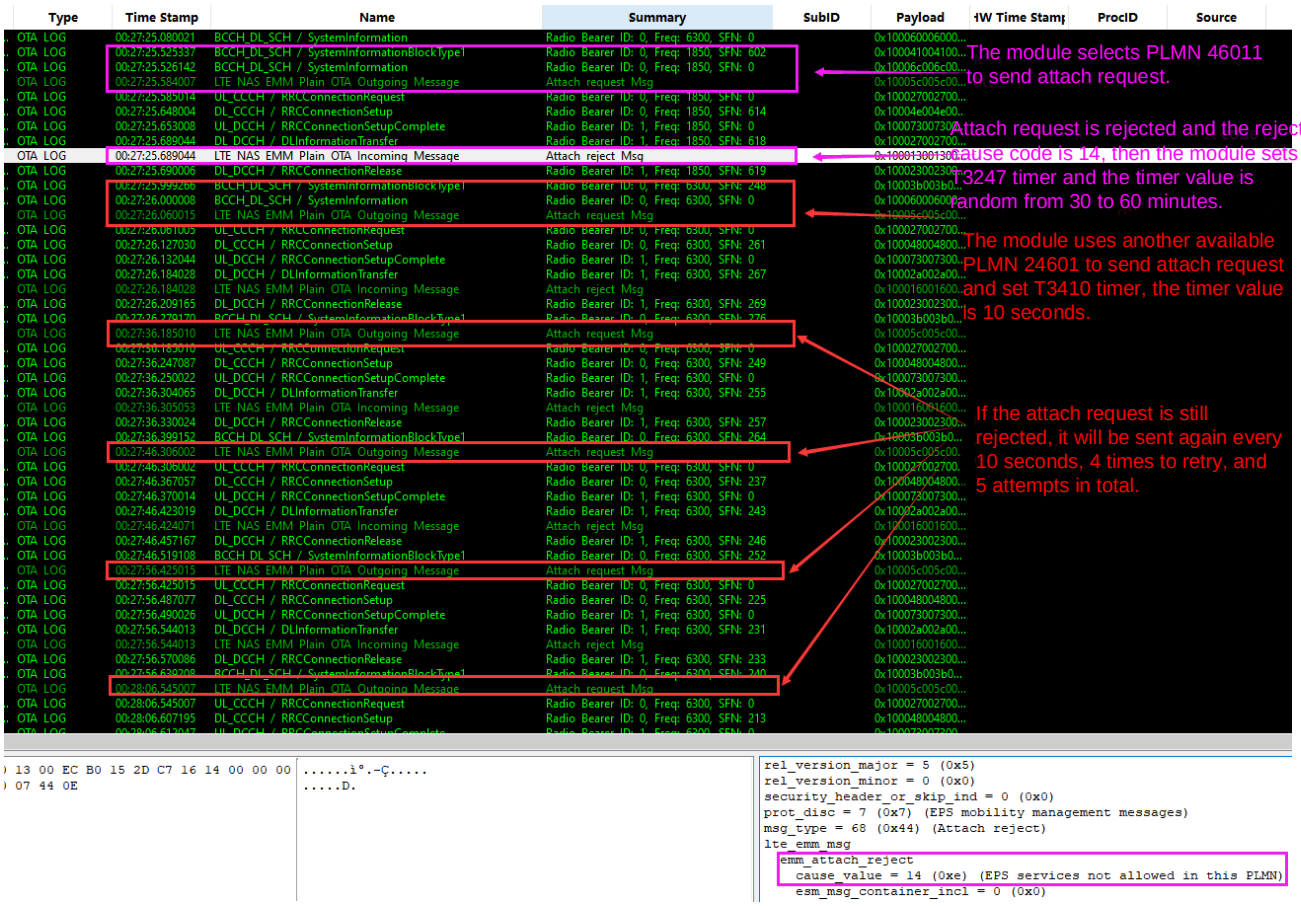


Figure 8: Module Received Reject Cause Code

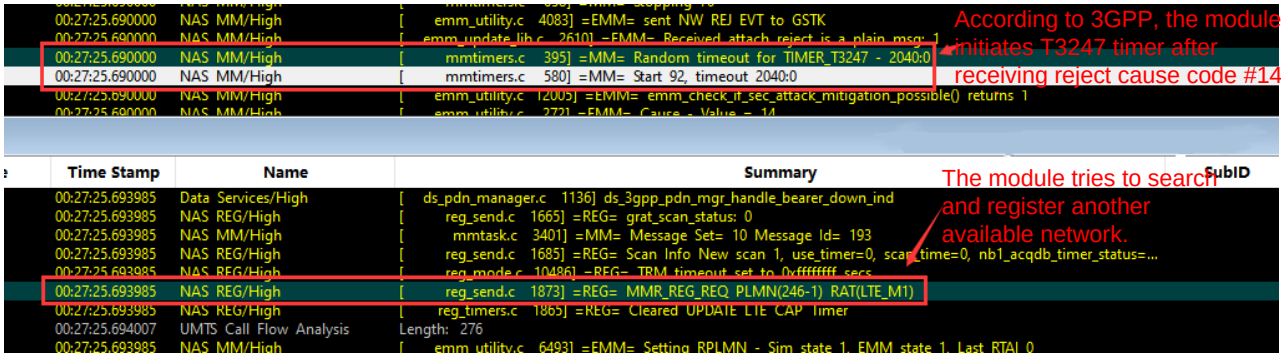


Figure 9: Module Initiated T3247 Timer and Tried to Register Another Available Network

7.5. Long Network Registration Time if AT Commands are Executed Frequently

Problem Description:

During the network searching progress, the network registration time becomes longer if some network-searching commands are executed frequently.

Root Cause Analysis:

Executing a network-searching command (see ***Chapter 5*** for more information) immediately triggers a one-time network search even if network searching is already in progress. Therefore, frequent executing of network-searching commands may cause longer network registration time.

Recommendation:

Before executing any network-searching command, it is recommended to check whether the current network configuration of the module is the desired one. If it is, there is no need to reset the network configuration.

Example

```
AT+QCFG="nwscanmode"                //Query the current RAT(s) allowed to be searched for.
+QCFG: "nwscanmode",3               //The module only searches for LTE bands.

OK
AT+QCFG="nwscanmode",1              //Change the network configuration if it is not the desired one.
OK
```

8 FAQ

1. **Q:** How does the module search for the network in OOS (Out of Service) state?
   A: When the module is in OOS (Out of Service) state, it will always periodically try to search for available networks, as shown in the figure below.

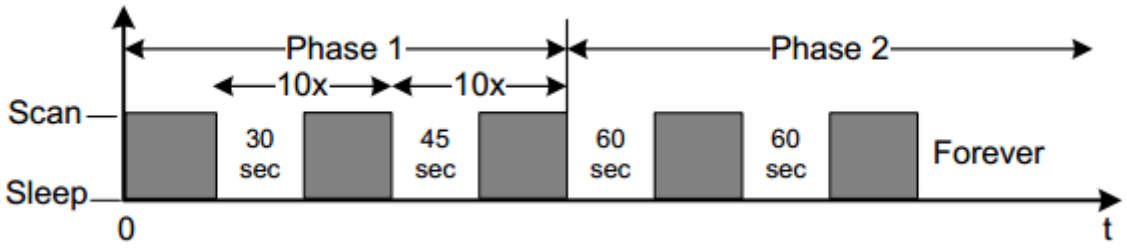


Figure 10: Restore the Network Information

Phase 1

a) Sleep for 30 seconds
   i. Attempt acquisition of full service and then limited service on the GSM and LTE acquisition list.
   ii. Go back to step a. and repeat 10 times.

b) Sleep for 45 seconds
   i. Attempt acquisition of full service and then limited service on the GSM and LTE acquisition list.
   ii. Go back to step b. and repeat 10 times.

Phase 2

c) Sleep for 60 seconds
   i. Attempt acquisition of full service and then limited service on the GSM and LTE acquisition list.
   ii. Go back to step c. and repeats continuously until a service is found.

2. **Q:** How to clear the registration information history of the module?
   A: a) If you want to clear the historical frequency information stored in the module, you can execute the following commands:
   - **AT+QNVFD="/nv/item_files/modem/geran/grr/acq_db"** under GSM.
   - **AT+QNVFD="/nv/reg_files/modem/lte/rrc/csp/acq_db"** under LTE (eMTC and NB-IoT).
   - **AT+QNVFD="/nv/reg_files/modem/nb1/rrc/csp/acq_db"** under NB-IoT.

   b) If you want to clear RPLMN information stored on (U)SIM card, you can execute the following commands:

- **AT+CRSM=214,28542,0,0,11,"FFFFFFFFFFFFFFFFFFFFFF"** to clear LOCI (including RPLMN).
- **AT+CRSM=214,28531,0,0,14,"FFFFFFFFFFFFFFFFFFFFFFFFFFFF"** to clear PSLOCI.
- **AT+CRSM=214,28643,0,0,18,"FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF"** to clear EPSLOCI.

9 Summary of CME ERROR Codes

Final result code **+CME ERROR: <err>** indicates an error related to mobile equipment or network. The operation is similar to **ERROR** result code.

<err> values are mostly used by common message commands. The following table lists most of general and GPRS related **ERROR** codes. For some GSM protocol failure causes described in GSM specifications, the corresponding **ERROR** codes are not included.

Table 1: Summary of CME ERROR Codes

<err>	Meaning
0	Phone failure
1	No connection to phone
2	Phone-adaptor link reserved
3	Operation not allowed
4	Operation not supported
5	PH-SIM PIN required
6	PH-FSIM PIN required
7	PH-FSIM PUK required
10	(U)SIM not inserted
11	(U)SIM PIN required
12	(U)SIM PUK required
13	(U)SIM failure
14	(U)SIM busy
15	(U)SIM wrong

16	Incorrect password
17	(U)SIM PIN2 required
18	(U)SIM PUK2 required
20	Memory full
21	Invalid index
22	Not found
23	Memory failure
24	Text string too long
25	Invalid characters in text string
26	Dial string too long
27	Invalid characters in dial string
30	No network service
31	Network timeout
32	Network not allowed - emergency calls only
40	Network personalization PIN required
41	Network personalization PUK required
42	Network subset personalization PIN required
43	Network subset personalization PUK required
44	Service provider personalization PIN required
45	Service provider personalization PUK required
46	Corporate personalization PIN required
47	Corporate personalization PUK required

10 Appendix References

Table 9: Related Documents

Document Name
[1] Quectel_BG95_LPWA_Specification
[2] Quectel_BG95&BG77&BG600L_Series_AT_Commands_Manual
[3] Quectel_BG95&BG77&BG600L_Series_QCFG_AT_Commands_Manual

Table 10: Terms and Abbreviations

Abbreviation	Description
(U)SIM	(Universal) Subscriber Identity Module
3GPP	3rd Generation Partnership Project
ARFCN	Absolute Radio Frequency Channel Number
CS	Circuit Switching Domain
CSG	Closed Subscriber Group
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
EF	Elementary File
EFS	Encrypt File System
EGPRS	Enhanced General Packet Radio Service
EHPLMN	Equivalent Home PLMN
EMM	EPS Mobility Management
eMTC	Enhanced Machine Type Communication
EPS	Evolved Packet System

EPSLOCI	EPS Location Information
ESM	EPS Session Management
GMM	GPRS Mobility Management
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HLR	Home Location Register
HPLMN	Home Public Land Mobile Network
HSS	Home Subscriber Server
IE	Information Element
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
IRAT	Inter-RAT
LOCI	Location Information
LTE	Long Term Evolution
MAC	Medium Access Control
ME	Mobile Equipment
MIB	Master Information Block
MS	Mobile Station
MSC	Mobile Switching Center
NB-IoT	Narrow Band Internet of Things
NV	Non-volatile Flash Memory
NVM	Non-Volatile Memory
PCI	Peripheral Component Interconnect
PDP	Packet Data Protocol
PLMN	Public Land Mobile Network
PS	Packet Switching Domain
PSLOCI	Packet Switch Location Information

RAT	Radio Access Technology
RPLMN	Registered Public Land Mobile Network
RRC	Radio Resource Control
SIB	System Information Block
SNR	Signal Noise Ratio
UE	User Equipment
VPLMN	Visiting Public Land Mobile Network