BC66 Network Searching Scheme Introduction

NB-IoT Module Series

Rev. BC66_Network_Searching_Scheme_Introduction_V1.0

Date: 2019-02-02

Status: Released

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About the Document

History

Revision	Date	Author	Description
1.0	2019-02-02	Jacobi RAO	Initial

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Table Index

1 Introduction

This document introduces the supported bands of BC66 module, and also describes its network searching scheme through illustrating related AT commands and network searching/registration procedure.

Also, the document describes some problems observed in the process of searching the network, and gives corresponding cause analysis.

1.1. Supported Bands

Quectel BC66 supports the following bands:

B1, B2, B3, B4, B5, B8, B12, B13, B17, B18, B19, B20, B25, B26*, B28, B66

NOTE

"*" means under development.

2 Network Searching/Registration Procedure

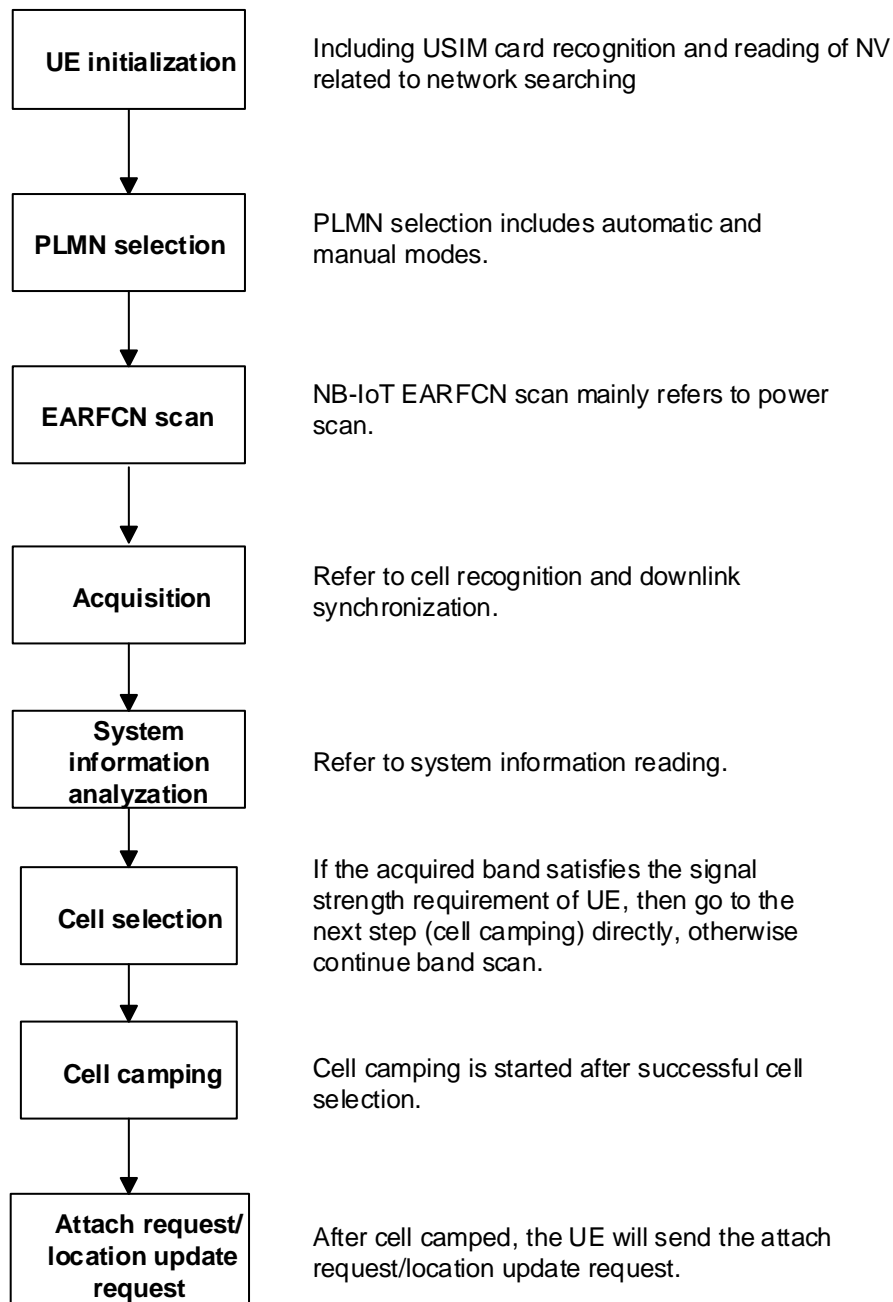|	
UE initialization	Including USIM card recognition and reading of NV related to network searching
PLMN selection	PLMN selection includes automatic and manual modes.
EARFCN scan	NB-IoT EARFCN scan mainly refers to power scan.
Acquisition	Refer to cell recognition and downlink synchronization.
System information analyzation	Refer to system information reading.
Cell selection	If the acquired band satisfies the signal strength requirement of UE, then go to the next step (cell camping) directly, otherwise continue band scan.
Cell camping	Cell camping is started after successful cell selection.
Attach request/ location update request	After cell camped, the UE will send the attach request/location update request.

Figure 1: Overall Network Searching Process

3 Processes Affect Registration Speed

PLMN selection and EARFCN scan are procedures that affect registration speed, and the following provides details on the two procedures.

3.1. PLMN Selection

This chapter describes the steps involved in PLMN selection procedure. The following figure illustrates the overall process of PLMN selection under automatic network operation mode. As shown below, the PLMN selection process is determined by not only the module setting but also some files in the USIM card. By default, the USIM card has a higher priority.
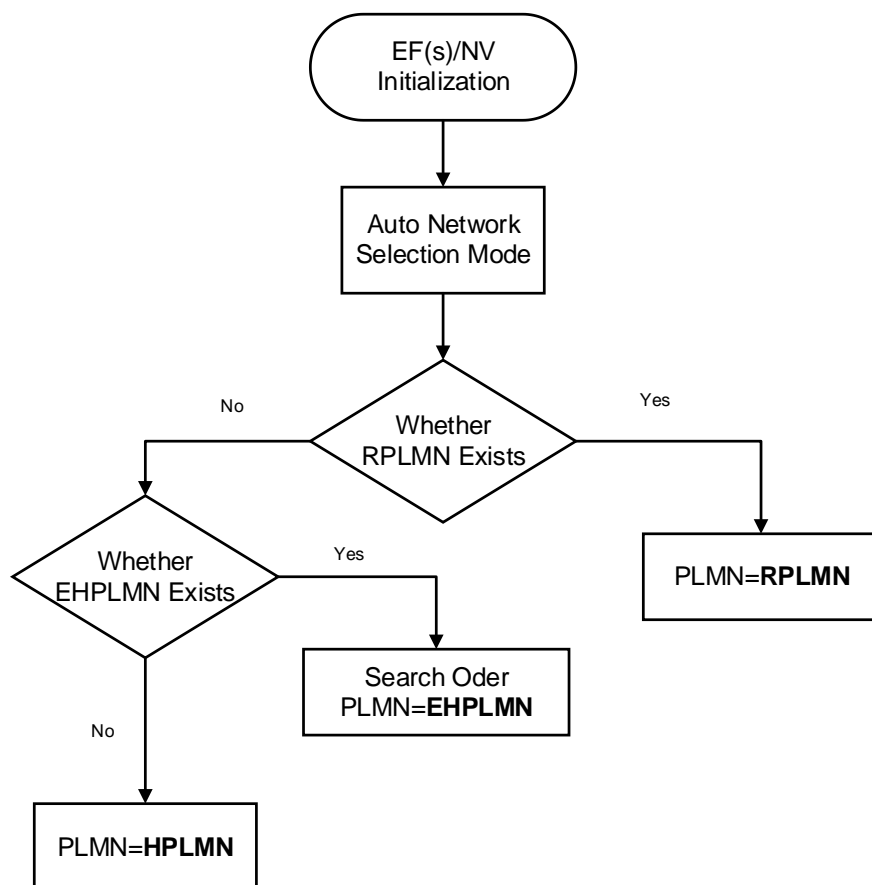
Figure 2: PLMN Selection Procedure

3.2. EARFCN Scan (Frequency Scan)

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

When the PLMN is selected, the module begins to scan all supported bands under NB-IoT network to find a suitable cell to camp on for communication with the network. UE will optimize this process according to the data recorded in the inserted USIM card and NVRAM to accelerate the speed of network access. The overall search process is as follows:
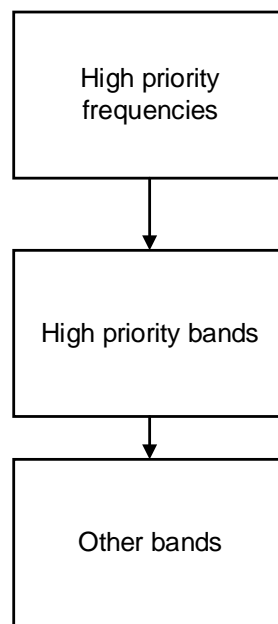

Figure 3: Frequency Scanning Process

The high-priority frequencies include the previously registered frequencies or prior frequencies according to the EHPLMN/HPLMN of the inserted USIM card and the frequencies which are recorded in the search process.

Please be noted that in the scanning process, if an appropriate frequency is scanned and the access criteria is met, UE will initiate an attach procedure and will not continue to search for other frequencies or bands.

BC66 supports multiple bands under LTE Cat NB1, so it may spend a few minutes on searching a suitable cell during full-band search. Due to the bandwidth of NB-CIoT is 200KHz, it may take a longer period of time for frequency scan, especially in weak signal conditions. The following table shows our test results, which displays the frequency scan time required for each band, and the unit of time is second.

Table 1: Network Searching Time under LTE Cat NB1 with Different CEL in Each Band

Band	F_{DL_low} (MHz)	$N_{Offs-DL}$	Range of N_{DL}	F_{UL_low} (MHz)	$N_{Offs-UL}$	Range of N_{UL}	Band Width	Time in CE 0	Time in CE 1	Time in CE 2
1	2110	0	0 - 599	1920	18000	18000 - 18599	60M	36	180	432
2	1930	600	600 - 1199	1850	18600	18600 - 19199	60M	36	180	432
3	1805	1200	1200 - 1949	1710	19200	19200 - 19949	75M	45	225	540
4	2110	1950	1950 - 2399	1710	19950	19950 - 20399	45M	27	135	324
5	869	2400	2400 - 2649	824	20400	20400 - 20649	25M	15	75	180
8	925	3450	3450 - 3799	880	21450	21450 - 21799	35M	21	105	252
12	729	5010	5010 - 5179	699	23010	23010 - 23179	17M	10.2	51	122.4
13	746	5180	5180 - 5279	777	23180	23180 - 23279	10M	6	30	72
17	734	5730	5730 - 5849	704	23730	23730 - 23849	12M	7.2	36	86.4
18	860	5850	5850 - 5999	815	23850	23850 - 23999	15M	9	45	108
19	875	6000	6000 - 6149	830	24000	24000 - 24149	15M	9	45	108
20	791	6150	6150 - 6449	832	24150	24150 - 24449	30M	18	90	216
25	1930	8040	8040 - 8689	1850	26040	26040 - 26689	65M	39	195	468
26	859	8690	8690 - 9039	814	26690	26690 - 27039	35M	21	105	252
28	758	9210	9210 - 9659	703	27210	27210 - 27659	45M	27	135	324
66	2110	66436	66436 - 67335	1710	131972	131972 - 132671	90M	54	270	648

NOTES

1. F_{DL_low}: The lowest frequency of the downlink operating band
2. F_{UL_low}: The lowest frequency of the uplink operating band
3. $N_{Offs-DL}$: Offset used for calculating downlink EARFCN
4. $N_{Offs-UL}$: Offset used for calculating uplink EARFCN

5. N_{DL}: Downlink EARFCN
6. N_{UL}: Uplink EARFCN

As BC66 supports sixteen LTE Cat NB1 bands, we recommend that customers only enable the bands used by the service operator.

Table 2: LTE Cat NB1 Band Deployment Conditions over the World

Band	U.S.	China	The Middle East	Japan	Korea	Europe	Australia
1		■		■			
2	■						
3		■	■		■	■	■
4	■						
5		■			■		
8		■	■	■		■	
12	■						
13	■						
17							
18				■			
19				■			
20		■				■	
25							
26							
28			■				■
66	■						

4 Network Searching Related AT Commands

In order to optimize network searching/registration time, related AT commands can be used to set the preferred bands or preferred frequency to be searched.

4.1. AT+QBAND　Get and Set Mobile Operation Band

The command is used to get the currently locked band or set the bands to be locked. Please refer to *Quectel_BC66_AT_Commands_Manual* for possible **<err>** values.

AT+QBAND　Get and Set Mobile Operation Band	
Test Command **AT+QBAND=?**	Response **+QBAND:** (range of **<band number>**s)[,(list of supported **<band>**s)] **OK**
Read Command **AT+QBAND?**	Response **+QBAND: <Setting Band>** **OK** If there is any error, response: **ERROR** or **+CME ERROR: <err>**
Write Command **AT+QBAND=<band number>[,<band>[,<band>[,…]]]**	Response **OK** If there is any error, response: **ERROR** or **+CME ERROR: <err>**
Maximum Response Time	300ms

Parameter

<band number>	Integer value indicating the number of bands that can be locked
	0 No band to be locked
	1-16 Number of bands to be locked
<band>	Integer value indicating NB-IoT band(s) that can be locked
	Valid values: 1, 2, 3, 4, 5, 8, 12, 13, 17, 18, 19, 20, 25, 26*, 28, 66
<Setting Band>	Integer value indicating the band(s) being locked
	Valid values: 1, 2, 3, 4, 5, 8, 12, 13, 17, 18, 19, 20, 25, 26*, 28, 66

NOTE

"*" means under development.

Example

AT+QBAND=?   //Query the list of bands that can be locked
+QBAND: (0-16),(1,2,3,4,5,8,12,13,17,18,19,20,25,26,28,66)

OK
AT+QBAND=1,5   //Set the band to be locked

OK
AT+QBAND?   //Query the band being locked
+QBAND: 5

OK

4.2. AT+QLOCKF Lock NB-IoT Frequency

This command is used to lock UE to specific frequency and optionally Cell ID. Please refer to *Quectel_BC66_AT_Commands_Manual* for possible **<err>** values.

AT+QLOCKF Lock NB-IoT Frequency	
Test Command **AT+QLOCKF=?**	Response **OK**
Read command **AT+QLOCKF?**	Response **OK**
Write Command **AT+QLOCKF=<mode>[,<earfcn>,<ear**	Response **OK**

fcn_offset>[,<pci>]]	
	If there is any error, response:
	ERROR
	or
	+CME ERROR: <err>
Maximum Response Time	300ms

Parameter

<mode>	Integer value indicating activate/remove lock
	0 Remove lock
	1 Activate lock
<earfcn>	Integer value indicating requested EARFCN on which to lock. Range: 0-262143.
	Value 0 indicates to remove any lock for EARFCN and Cell.
<earfcn_offset>	Integer value indicating requested EARFCN offset
	0 Offset of -2
	1 Offset of -1
	2 Offset of -0.5
	3 Offset of 0
	4 Offset of 1
<pci>	Integer value indicating the physical cell ID. Range: 0-503.

Example

AT+QLOCKF=1,2175,2   //Lock the frequency
OK

4.3. AT+QCSEARFCN   Clear NB-IoT Stored EARFCN List

This command is used to clear stored EARFCN list for the UE. Please refer to *Quectel_BC66_AT_ Commands_Manual* for possible **<err>** values.

AT+QCSEARFCN Clear NB-IoT Stored EARFCN List	
Execution Command	Response
AT+QCSEARFCN	**+QCSEARFCN: <status>**
	OK
	If there is any error, response:
	ERROR

	or
	+CME ERROR: <err>
Maximum Response Time	300ms

Parameter

<status>	Integer value indicating the EARFCN has been cleared
	0 Successful
	2 Failure
	3 No stored EARFCN found

Example

```
AT+QCSEARFCN
+QCSEARFCN: 0

OK
```

5 Solutions to Speed up Network Searching

5.1. Overview of LTE Cat NB1 Network Searching Time

As per 3GPP specifications, LTE Cat NB1 is expected to be deployed in much lower coverage area. The Expected Maximum Coupling Loss for Cat NB1 is 164dB, which means the device needs to accommodate more RSRP range to detect a possible Cat NB1 cell deployment. LTE Cat NB1 has a bandwidth of 200KHz, which means the UE has more candidates to scan and detect in a given deployed area compared to the UE in LTE networks.

If the preferred frequencies or the preferred bands exist, UE will search these preferred frequencies or the preferred bands first. If it cannot find a suitable cell in the selected PLMN, it will try to search another suitable cell for at most two times with different thresholds in all other bands which are supported in the selected PLMN. And if it still cannot find a suitable cell to camp on, it will search cells in another new PLMN.

5.2. Solutions to Speed up Network Searching

It is recommended to enable only the bands supported by the current service operator.

For example, the module may be configured to enable only B2/B4/B12/B13/B66 in the U.S. with **AT+QBAND=5,2,4,12,13,66**. According to the table below, the module can be set to enable different bands in different areas. And further, the module may be configured to enable only the bands supported by the USIM card inserted.

Table 3: Solutions to Speed up Network Searching

Operator	AT Command	Description
T-Mobile	**AT+QBAND=4,2,4,12,66**	To enable B2/B4/B12/B66 only
SoftBank	**AT+QBAND=4,1,8,18,19**	To enable B1/B8/B18/B19 only

Vodafone	**AT+QBAND=3,3,8,20**	To enable B3/B8/B20 only
LGU+	**AT+QBAND=1,5**	To enable B5 only
RJIO	**AT+QBAND=2,3,5**	To enable B3/B5 only
Thailand's Operator	**AT+QBAND=1,8**	To enable B8 only

NOTE

The above configurations may vary with the changes of corresponding operator's network deployments.

6 Typical Problems and Cause Analysis

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

6.1. Network Registration Failure

Problem Description:

The module is always in cell searching status, and cannot register on the network.

Cause Analysis:

1) The band locked does not match with the band supported by the network operator of the USIM card inserted. The USIM card is provided by mobile network operator CMCC which supports LTE B8 while the band locked is B5 (as shown in the log below), so it cannot find a suitable cell to camp on. If there is no LTE Cat NB1 network signal available, the module will also fail in network registration and no logs are available.

2) If there is a signal from another operator, the module may try to camp on the cell which supports the band, while the attach request will be rejected with the cause as shown below.

6.2. Ultra-long Time for Network Registration Initiation

Problem Description:

The module requires a long period of time (approx. 10 minutes) for initiating network registration.

Cause Analysis:

The module initiates network registration approx. 10 minutes after its power-up. Through checking the log, it is found that the EHPLMN in the USIM is 46001. However, the EHPLMN deployed by the current network operator China Unicom is not 46001, which makes the module failed in initiating network registration after it searches B3 and B8 as well as all other bands it supported. In the process, the EHPLMNs of the cells with PCIs of 47/39/281/193 are all not belong to 46001, so the module will not initial the attach procedure. Then it selected another EHPLMN 46006 for cell searching, and finally found a suitable cell with EARFCN of 1454.

Summary:

1) China Unicom network signal is too weak, so it takes a longer time for signal decoding.

2) The EHPLMN setting in the USIM card of China Unicom is incorrect, making the module cannot initiate network registration during the first-time cell searching.

7 Appendix A References

Table 4: Related Document

SN	Document Name	Remark
[1]	Quectel_BC66_AT_Commands_Manual	BC66 AT commands manual

Table 5: Terms and Abbreviations

Abbreviation	Description
CEL	Coverage Enhancement Level
CMCC	China Mobile Communications Corporation
EARFCN	Evolved-UTRA Absolute Radio Frequency Channel Number
EF(s)	Elementary File(s)
EHPLMN	Equivalent Home PLMN
HPLMN	Home PLMN
LTE	Long Term Evolution
NB-CIoT	Narrowband Cellular Internet of Things
NB-IoT	Narrowband Internet of Things
NV	Non-volatile (Memory)
NVRAM	Non-volatile Random-access Memory
PLMN	Public Land Mobile Network
RPLMN	Registered PLMN
UE	User Equipment
USIM	Universal Subscriber Identity Module