SIM7022 Series_Network Search_Application Note

LPWA Module

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About Document

Version History

Revision	Date	Chapter	Description
1.00	2022.07.07	All	New version

Scope

This document applies to the following products

Name	Type	Size(mm)	Comments
SIM7022	NB2	17.6*15.7	Band 1/2/3/4/5/8/12/13/14/17/18/19/20/25/26/28/66/70/85

Contents

1 Introduction

1.1   Purpose of the document

Based on module AT command manual, this document will introduce Network Searching application process on SIM7022 series of module,developers could understand and develop application quickly and efficiently based on this document.

1.2   Related documents

[1] SIM7022 Series_AT Command Manual

1.3   Supported Bands

The frequency band supported by the module are B1, B2, B3, B4, B5, B8, B12, B13, B17, B18, B19, B20, B25, B28, B66, B70, and B85.

1.4   Applicable Terms

For the purposes of the present document, the following terms and definitions apply:

Acceptable Cell: This is a cell on which a UE can always attempt emergency calls. It must satisfy certain conditions specified for A/Gb mode in 3GPP TS 43.022, for Iu mode in 3GPP TS 25.304, and for S1 mode in 3GPP TS 36.304. For modules that support only the Cat NB mode, there is no acceptable cell.

Available PLMN: One or more PLMN(s) for which the UE has found at least one cell and read its PLMN identity(ies).

Camped on a cell: UE has completed the cell selection/reselection process and has chosen a cell. The UE monitors system information and (in most cases) paging information.

EHPLMN: Any of the PLMN entries contained in the Equivalent HPLMN list stored on the USIM.

Equivalent HPLMN list: To allow provision for multiple HPLMN codes, PLMN codes that are present within this list shall replace the HPLMN code derived from the IMSI for PLMN selection purposes. This list is stored on the USIM and is known as the EHPLMN list. The EHPLMN list may also contain the HPLMN code derived from the IMSI. If the HPLMN code derived from the IMSI is not present in the EHPLMN list then it shall be treated as a Visited PLMN for PLMN selection purposes.

Equivalent PLMN list: List of PLMNs considered as equivalent by the UE for cell selection, cell reselection, and handover according to the information provided by the NAS.

Home PLMN: This is a PLMN where the MCC and MNC of the PLMN identity match the MCC and MNC of the IMSI. Matching criteria are defined in Annex A in 3GPP TS 23.122.

In NB-S1 mode: Indicates this paragraph applies only to a system which operates in NB-S1 mode. For a multi-access system this case applies if the current serving radio access network provides access to network services via E-UTRA by NB-IoT. An NB-only module always works in NB-S1 mode.

Narrow Band Internet of Things (NB-IoT): NB-IoT is a non-backward compatible variant of E-UTRAN supporting a reduced set of functionalities. NB-IoT allows access to network services via E-UTRA with a channel bandwidth limited to 180 kHz.

Registered PLMN (RPLMN): This is the PLMN on which certain LR outcomes have occurred. In a shared network the RPLMN is the PLMN defined by the PLMN identity of the CN operator that has accepted the LR.

Selected PLMN: This is the PLMN that has been selected according to subclause 3.1 in 3GPP 23.122, either manually or automatically.

Visited PLMN: This is a PLMN different from the HPLMN (if the EHPLMN list is not present or is empty) or different from an EHPLMN (if the EHPLMN list is present).

HPPLMN: If the MS is in a VPLMN, the MS shall periodically attempt to obtain service on its HPLMN (if the EHPLMN list is not present or is empty) or one of its EHPLMNs (if the EHPLMN list is present) or a higher priority PLMN/access technology combinations listed in "user controlled PLMN selector" or "operator controlled PLMN selector" by scanning in accordance with the requirements applicable to i), ii) and iii) as defined in the Automatic Network Selection Mode in subclause 4.4.3.1.1 in 3GPP 23.122. These PLMNs on which the UE attempts to obtain service are HPPLMNs.

FFHPPLMN: The FastFirstHigherPriorityPLMNSearch leaf indicates whether the UE performs the first search for a higher priority PLMN after at least 2 minutes and at most T minutes upon entering a VPLMN as specified in 3GPP TS 23.122.

Suitable Cell: This is a cell on which a UE may camp. For a E-UTRA cell, the criteria are defined in subclause 4.3 in 3GPP TS 23.122.

OOS: When a UE has searched all the bands it supports but fails to find a suitable cell, it enters the OOS state, where it tries to search for an available PLMN at certain intervals.

2 PLMN Search

SIM7022 supports foreground PLMN search and background PLMN search. Searching procedure being basically the same, the two searching modes differ mainly in the time of triggering the search.

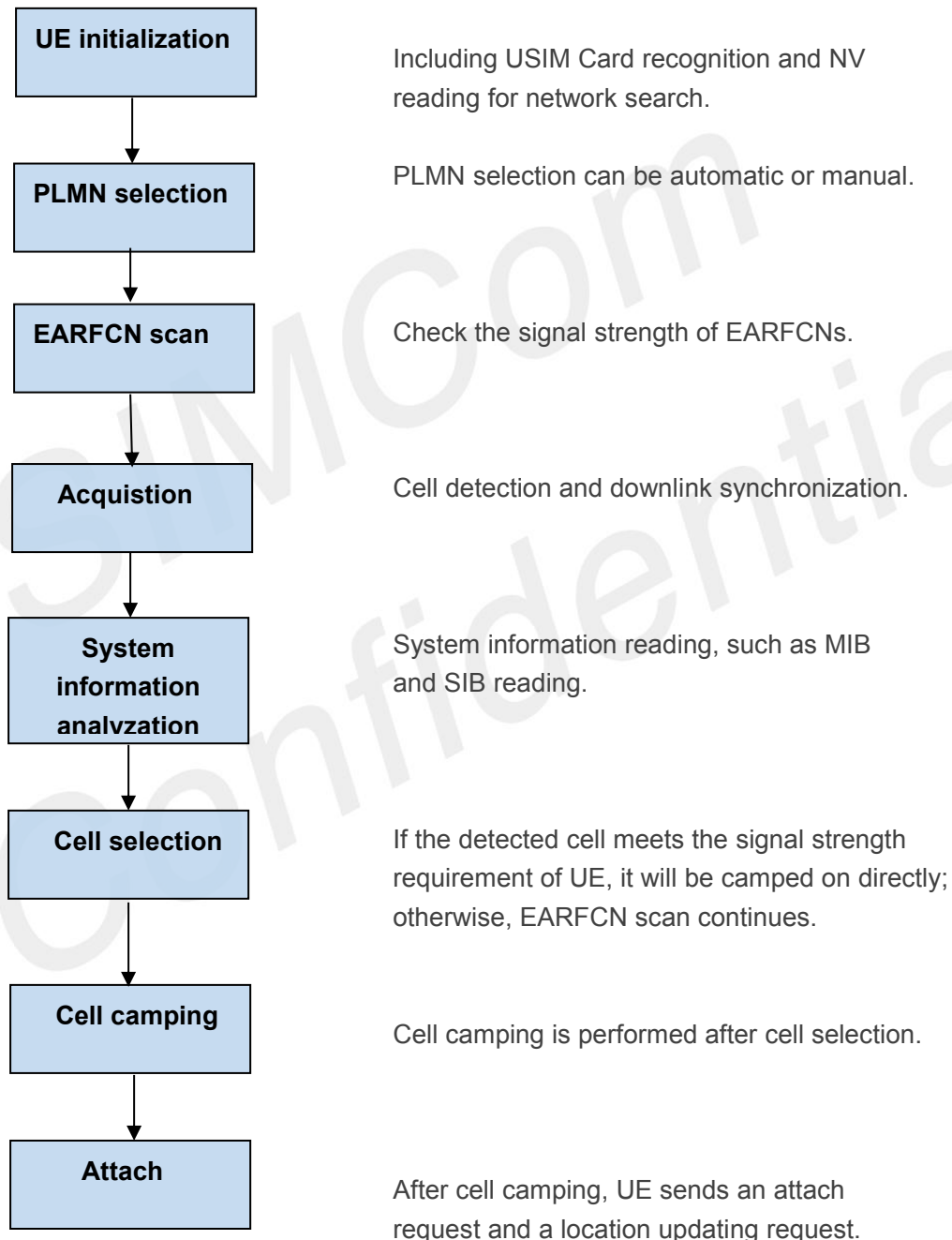|	
UE initialization	Including USIM Card recognition and NV reading for network search.
PLMN selection	PLMN selection can be automatic or manual.
EARFCN scan	Check the signal strength of EARFCNs.
Acquistion	Cell detection and downlink synchronization.
System information analyzation	System information reading, such as MIB and SIB reading.
Cell selection	If the detected cell meets the signal strength requirement of UE, it will be camped on directly; otherwise, EARFCN scan continues.
Cell camping	Cell camping is performed after cell selection.
Attach	After cell camping, UE sends an attach request and a location updating request.

Figure 1: PLMN Search

2.1 Foreground PLMN Search

Foreground PLMN search is performed before the module has camped on any cell with the purpose of finding a suitable cell to camp on. This mode of PLMN search is mainly performed in the following scenarios.

1. Automatic network search triggered when the module is powered on or when **AT+COPS=0** is executed.
2. Manual network search triggered by executing **AT+COPS=1,<format>,<oper>[,<Act>]**.
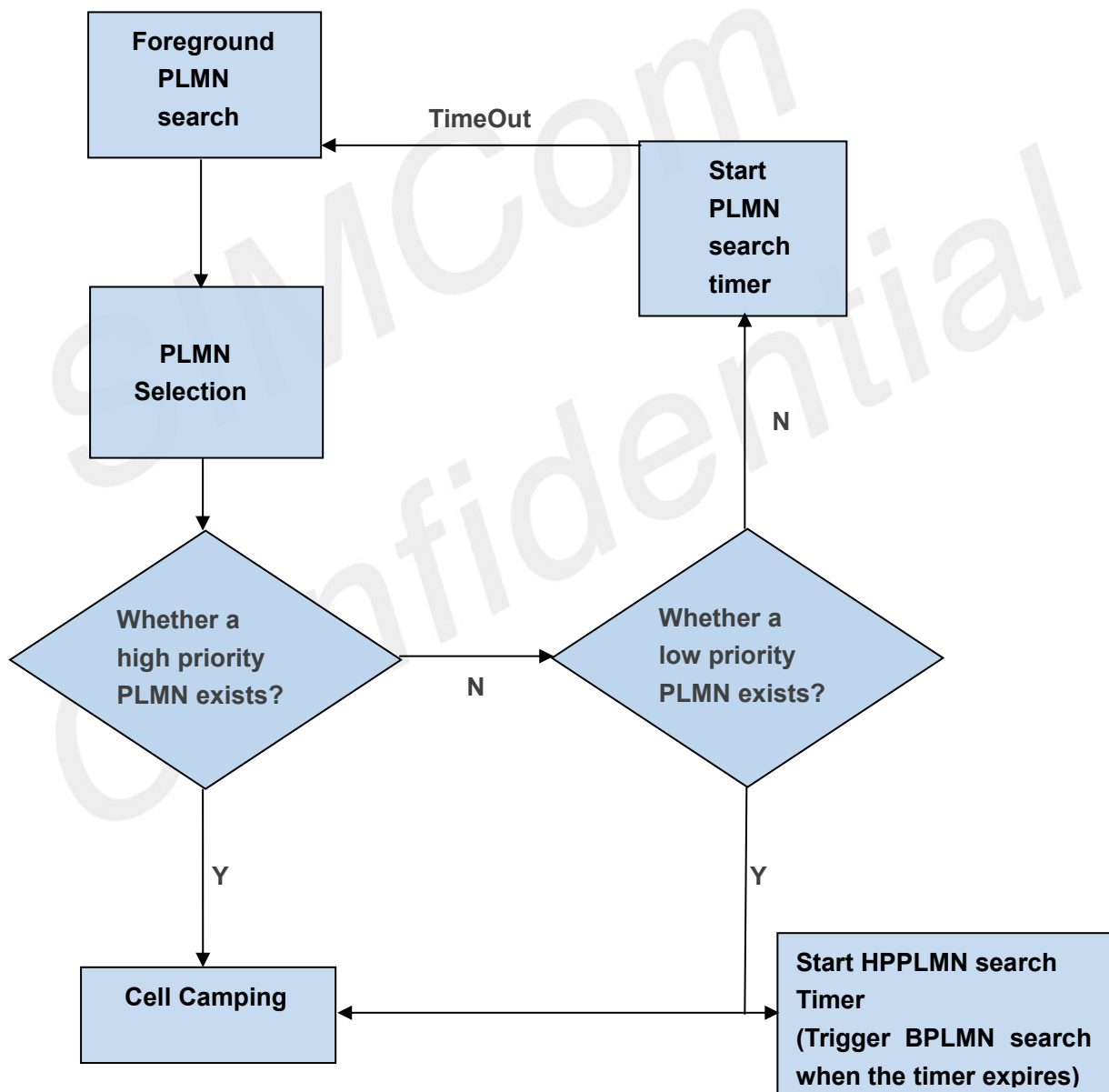3. Network search in OOS state.

Figure 2: Foreground PLMN Search

2.1.1 Search in Manual Mode

Manual foreground PLMN search can be triggered by **AT+COPS=1,<format>,<oper>[,<Act>]**. In manual mode, the module searches for a suitable cell in a specified PLMN. It will not search any PLMN other than the specified one even if no suitable cell can be found there unless it reboots or enters the automatic search mode.

After rebooting, including modem rebooting triggered by **CFUN0/1**, the module searches the specified PLMN first. If it cannot find a suitable cell in this PLMN, it searches the highest priority EHPLMN if the EHPLMN list exists and is not empty, or search the HPLMN.

2.1.2 Search in OOS State

In an environment without network coverage, the module keeps trying to search the full band for an available network until it finally judges that there is no suitable cell and enters the OOS state. For the SIM7022 module, the time it takes to find a cell is 1200 seconds. If no suitable cell is found during this time, the module judges there is no network coverage and starts a timer for the next search.

The network search logic in the OOS state is set by **AT+QCCFG="PlmnSearchPowerLevel",<n>,** and **<n>** can be 0, 1, 2, or 3.

● **<n>** = 0 sets the first timer to 30 seconds, the second timer to 1 minutes, and the subsequent timers to 2 minutes.
● **<n>** = 1 sets the first timer to 5 minutes, the second timer to 10 minutes, and the subsequent timers to 15 minutes.
● **<n>** = 2 sets the first timer to 10 minutes, the second timer to 30 minutes, and the subsequent timers to 1 hours.
● **<n>** = 3 sets the timer to 30 seconds, and the module stops network search after the timer expires until **AT+QCPLMNS** is executed.

2.2 Background PLMN Search

Background PLMN search, or BPLMN search, is performed by the module having already camped on a cell without affecting the communication service in process. Its purpose is to find a higher-priority cell. This mode of PLMN search is mainly performed in the following two scenarios.
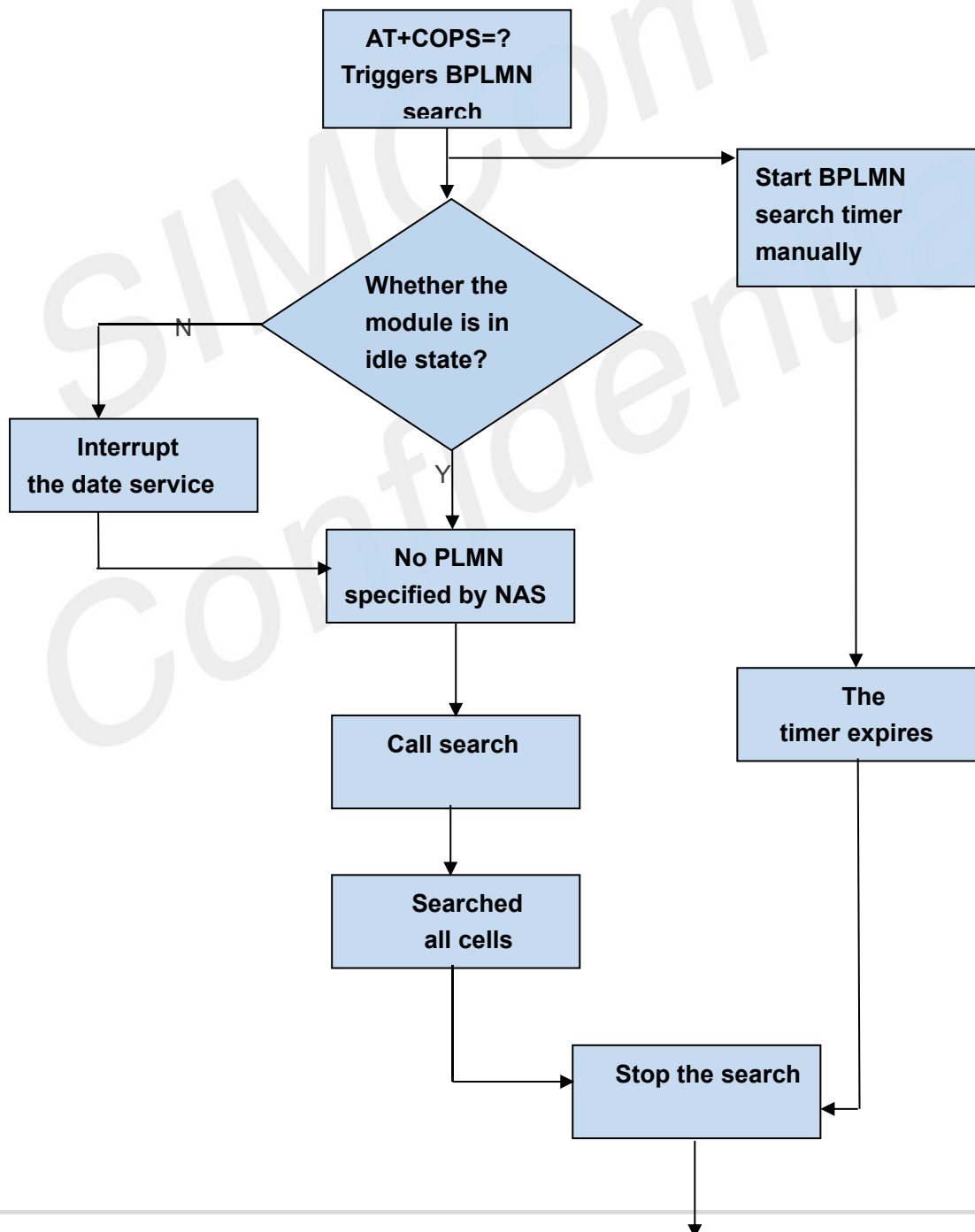
2.2.1 Triggered by Timer

The BPLMN search triggered when the timer T or the FFHPPLMN leaf specified timer expires is referred to as an HPPLMN search. An HPPLMN search can be triggered only when the modem is in idle state, which means the PLMN search will be postponed till the RRC is released.

The searching procedure of NB-IoT Module Series SIM7022 Network Searching Scheme Introduction SIM7022_Network_Searching_Scheme_Introduction 9 / 15 this type of BPLMN search is basically the same as that of the foreground PLMN search, only when the module is in the BPLMN searching mode, the terminal is allowed to perform data transmission and receiving, and any uplink or downlink data will interrupt the searching procedure so that the data service will not be affected.

2.2.2 Triggered by AT+COPS=?

BPLMN search triggered by executing **AT+COPS=?** has a higher priority over the data service. If UE is currently in the RRC connection, the BPLMN search will interrupt the RRC service locally, and the uplink and downlink data services cannot be performed during the network search. But such a search may be suspended upon receiving a Paging message. After the search, all found PLMNs are displayed without changing the PLMN already camped on.

**Return
all found PLMN**

Figure 3: BPLMN Search Triggered by AT+COPS=?

3 Factors Affecting Registration Speed

The main factors affecting network registration speed include PLMN selection, the frequency scanning mechanism and the network environment. As the network environment depends on the network deployment by local operators, this chapter focuses on the other two relatively controllable factors: PLMN selection and frequency scan.

3.1 PLMN Selection

The order of PLMN selection is determined by the settings of not only the module but also the USIM card, and generally, the latter has a higher priority.
The following figure illustrates the procedure of PLMN selection in automatic mode.
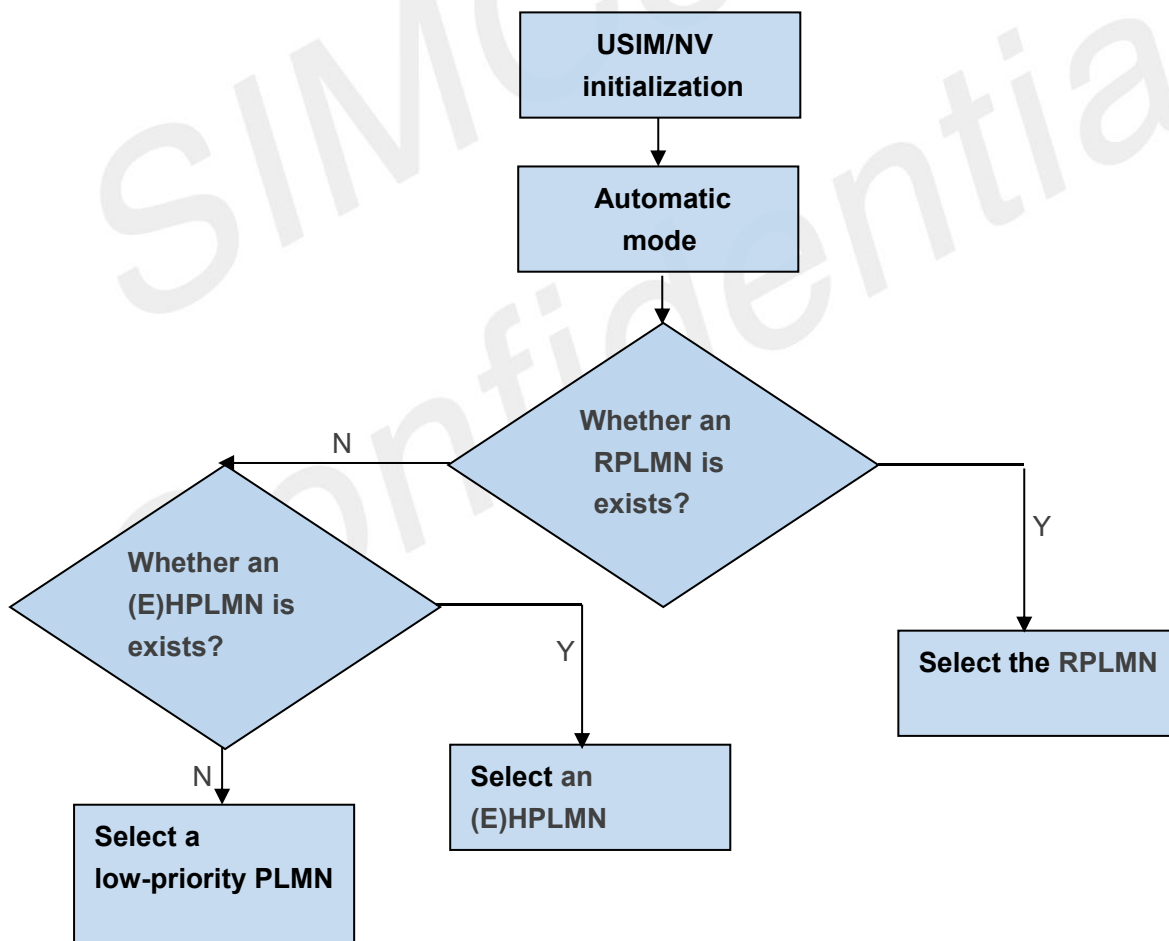

Figure 4: Automatic PLMN Selection

3.2 Frequency Scan

The module starts frequency scan after PLMN selection to find a suitable cell in the selected PLMN. The frequency scan procedure can be divided into two stages: EARFCN scan and Band scan. Only if the module fails to find a suitable cell after the EARFCN scan will it start the Band scan.
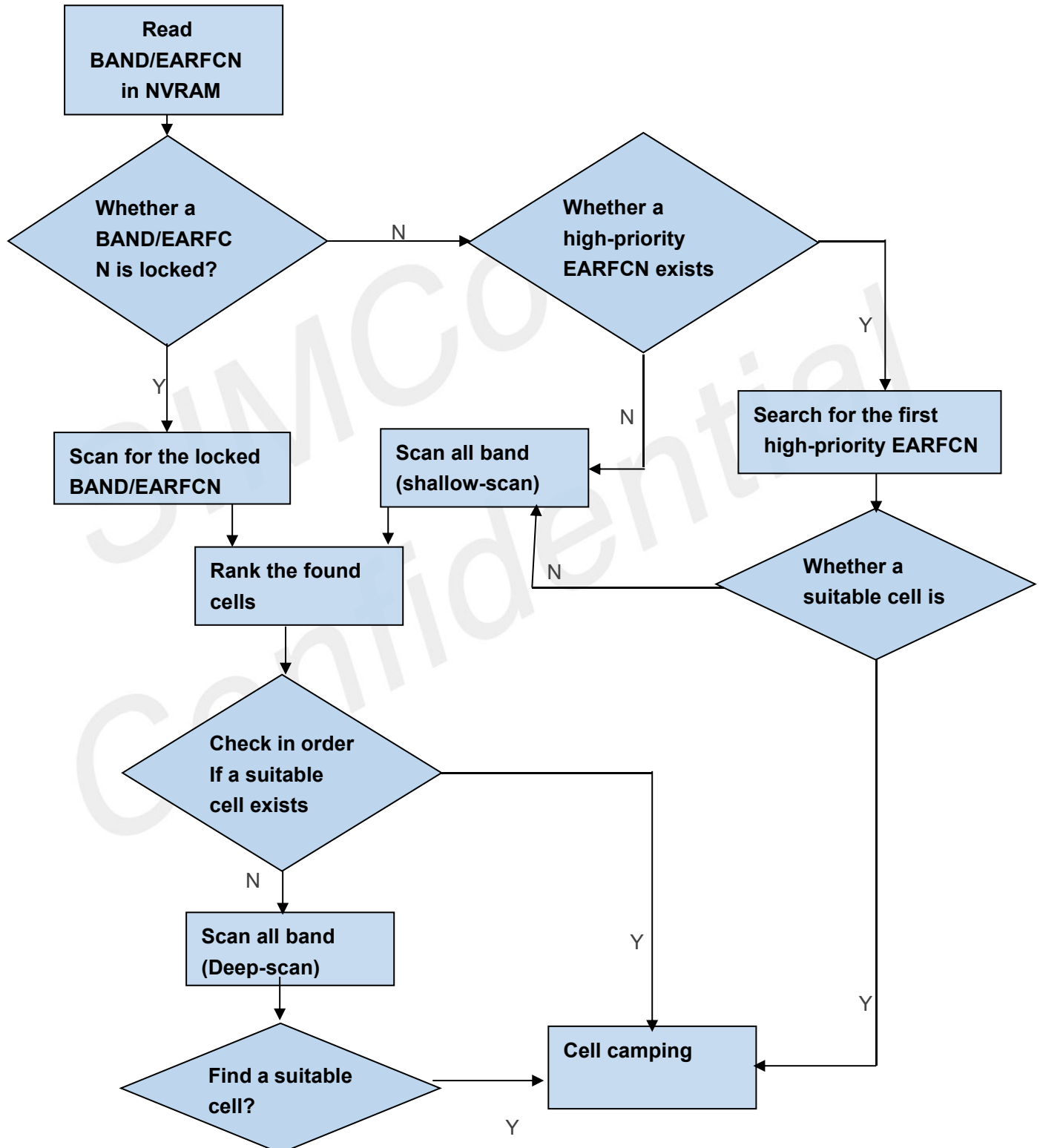

Figure 5: Frequency Scan

3.2.1 EARFCN Scan

After powering on, the module checks the information stored in its NVRAM and the USIM card to confirm the supported bands and priority EARFCNs, the order of PLMN list, and so on. This information is used in the subsequent network search to speed up the process.

The high-priority EARFCNs include the EARFCN(s) set by AT+QCFREQ and the EARFCN(s) previously stored in the module. For SIM7022, these two kinds of EARFCNs share one list and the EARFCN most recently set or stored has the overriding priority. If the HPLMN is not the one selected by the USIM card used when storing the EARFCNs, the module deletes all the stored EARFCNs, and, skipping the EARFCN scan stage, go for the band scan. For the highest-priority EARFCN, once the corresponding cell is detected, cell camping is performed. All the other EARFCNs stored in the module, when detected in band scan, are given an extra score for later ranking.

3.2.2 Band Scan

When entering the Band scan stage, the module first scans quickly all the bands supported and gives a score to each found EARFCN, then scans cells in the descending order of their score. If it cannot find a suitable cell, it enters deep-scan following a certain order related to the USIM card and the setting of band order. When a suitable cell is found, the module camps on it and initiates network registration. If it still cannot find a suitable cell in the current PLMN after a deep-scan, it searches for the next priority PLMN.

Band CEL	Downlink			Uplink				SearchingTime		
	FREQ	Offset	FREQ Range	FREQ	Offset	FREQ Range	BW	CEL	CEL	CEL
	(MHz)			(MHz)			(MHZ)	0	1	2
B1	2110	0	0–599	1920	18000	18000–18599	60	4.74	6.06	8.99
B2	1930	600	600–1199	1850	18600	18600–19199	60	4.83	7.08	52.45
B3	1805	1200	1200–1949	1710	19200	19200–19949	75	3.89	7.23	53.04
B4	2110	1950	1950–2399	1710	19950	19950–20399	45	4.99	5.37	24.05
B5	869	2400	2400–2649	824	20400	20400–20649	25	6.88	15.57	79.80
B8	925	3450	3450–3799	880	21450	21450–21799	35	4.79	25.60	79.68
B12	729	5010	5010–5179	699	23010	23010–23179	17	3.23	5.98	20.92
B13	746	5180	5180–5279	777	23180	23180–23279	10	3.58	20.34	24.61
B17	734	5730	5730–5849	704	23730	23730–23849	12	3.19	7.41	27.20
B18	860	5850	5850–5999	815	23850	23850–23999	15	3.61	12.20	18.13
B19	875	6000	6000–6149	830	24000	24000–24149	15	7.37	26.67	54.86
B20	791	6150	6150–6449	832	24150	24150–24449	30	6.14	8.50	52.83
B25	1930	8040	8040–8689	1850	26040	26040–26689	65	4.09	6.72	60.34
B28	758	9210	9210–9659	703	27210	27210–27659	45	3.93	6.46	94.29
B66	2110	66436	66436–67335	1710	131972	131972–132671	90	4.66	6.31	75.07
B70	1995	68336	68336–68585	1695	132972	132972–133121	25	3.34	4.66	28.63
B85	728	70366	70366–70545	698	134002	134002–134181	18	4.77	7.47	67.59

Table 1: Network Searching Time in Each Band at different CEL

4 AT Commands for Network Search

The AT commands related to network search are listed in the following table:

Table 2: Network Search Related AT Commands

AT COMMAND	Description
AT+COPS	PLMN selection
AT+QCBAND	Set Supported Network and Bands
AT+QCCFG	System configuration
AT+QCFREQ	Lock or Unlock Cell
AT+QCRMFPLMN	Remove FPLMN in NVM or SIM
AT+QCPLMNS	Trigger PLMN search

NOTE

For more details about the related AT commands, see document [1]

5 Methods to Speed Up Network Search

According to 3GPP specifications, NB-IoT terminals support communication services under poorer network conditions. The expected maximum coupling loss (MCL) of LTE Cat NB1 is 164 dB, which means that the terminal can access the network even when the network signal quality is poor. The frequency bandwidth of NB-IoT is 200 kHz, which causes the network searching time on the NB-IoT network to be much longer than that on the legacy LTE network.

5.1 Enable Only Certain Bands

It is highly recommended to enable only certain bands according to the operator's network deployment so as to speed up network search by the module.

Table 3: Method of Speeding up Network Search

Operator	Related AT Command	Description
Verizon	AT+QCBAND=13	Only enable B13
AT&T	AT+QCBAND=12,4,2	Only enable B12, B4, and B2
Telstra	AT+QCBAND=28	Only enable B28
SoftBank	AT+QCBAND=3,8	Only enable B3 and B8

5.2 Specify a PLMN

As some operators have more than one PLMNs, the module may sometimes fail to select a PLMN matching the local network deployment. Even all the PLMNs are in the EHPLMN list, the module would search them according to the order they are stored in the USIM card all the same, though the PLMN ranking first in the USIM card may not match the network deployed. This takes the module extra time to find a second PLMN. To avoid that for speedier network search, it is recommended to specify a PLMN to be searched.

6 Appendix A References

Table 4: Terms and Abbreviations

Abbreviation	Description
3GPP	3rd Generation Partnership Project
APN	Access Point Name
BCD	Binary Coded Decimal
BGPLMN	Background PLMN
BW	Bandwidth
CEL	Coverage Enhancement Level
CN	Core Network
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
EHPLMN	Equivalent Home PLMN
EPCO	Extended protocol configuration options
E-UTRAN	Evolved UTRAN
FGPLMN	Foreground PLMN
FFHPPLMN	Fast First Higher Priority PLMN Search
FREQ	Frequency
HPLMN	Home Public Land Mobile Network
HPPLMN	High Priority PLMN
ITU-T	International Telecommunication Union
LR	Location Registration
LTE	Local Terminal Emulator
MCL	Maximum Coupling Loss
MIB	Master Information Block
NAS	Non-Access Stratum
NB-IoT	Narrow Band Internet of Things
NV	Non-volatile (Memory)
NVRAM	Non-volatile random-access memory
OOS	Out of Service
OPLMN	Operator Controlled PLMN
PCI	Physical Cell Identifier
PCO	Protocol Configuration Options
PLMN	Public Land Mobile Network
PSS	Primary Synchronization Signal
ROHC	Robust Header Compression
RPLMN	Registered Public Land Mobile Network
RRC	Radio Resource Control
RSRP	Reference Signal Receiving Power
SIB	System Information Block

SIM	GSM Subscriber Identity Module
SSS	Secondary Synchronization Signal
UE	User Equipment
USIM	Universal Subscriber Identity Module