

RG5x&RG6x&RM5x Series 5G Network Application Note

5G Module Series

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About the Document

Revision History

Version	Date	Author	Description
-	2021-05-28	Spawn ZHANG	Creation of the document
1.0	2021-07-12	Spawn ZHANG	First official release
2.0	2024-06-24	Amos ZHANG	- Updated the document name from "5G Network Searching Scheme Introduction" to "5G Network Application Note". - Added applicable modules RG525F-NA, RG530F series, RM521F-GL, RM530N-GL, RG650E series, RG651E-NA, RG650V series, RM550V-GL and RM551E-GL. - Delete all the frequency band information supported by the modules, and keep only one related note; Added two notes about the AT command mentioned in this document (Chapter 1). - Added the AT command introduction and the declaration of AT command examples (Chapter 2.1 and Chapter 2.2). - Deleted the following AT commands: AT+QNWCFG="nr5g_csi"; AT+QNWCFG="nr5g_cell_id"; AT+QNWPREFCFG="policy_band"; AT+QNWPREFCFG="nr5g_disable_mode". - Added the following AT commands: - AT+CREG / AT+CGREG / AT+CEREG (Chapter 2.3.1–2.3.3); - AT+CGACT (Chapter 2.3.5); - AT+QENDC / AT+QSRP / AT+QSRQ / AT+QSINR / AT+QCAINFO / AT+QSCAN /

-
- AT+QNETRC / AT+QMBNCFG
(Chapter 2.3.7–2.3.14);
 - AT+QNWPREFCFG="rat_acq_order" /
AT+QNWPREFCFG="lte_band" /
AT+QNWPREFCFG="gw_band"
(Chapter 2.3.15–2.3.17).
7. Updated the module's network registration and attachment flow. Numerous changes were made to this chapter, so it should be read in its entirety (Chapter 3).
 8. Added the module's network registration and attachment check (Chapter 4).
 9. Deleted the chapter "Typical Cases Analysis".
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1 Introduction

This document introduces the network registration/attachment process of Quectel RG5x, RM5x and RG6x series modules, including network registration/attachment flow and check, typical network searching failure cases analysis, as well as related AT commands.

NOTE

1. For details about AT commands mentioned in this document, see **Chapter 2, documents [1], [2], [3], [4], or [5]**.
2. For the following AT commands not described in detail in the aforementioned chapter or documents, please contact Quectel Technical Support.
 - AT+QNWCFG="clr_rplmn"
 - AT+QNWCFG="hplmn_search_timer"[,<timer_value>]
 - AT+QNWCFG="dis_rplmnact"
 - AT+QNWCFG="lte_pref_freq_list"
 - AT+QNWCFG="nr5g_pref_freq_list"
 - AT+QNWCFG="lte_band_priority"
 - AT+QNWCFG="nr5g_band_priority"
 - AT+QCSQ
 - AT+QICSGP

1.1. Applicable Modules

Table 1: Applicable Modules

Module Family	Module
RG5x	RG500Q Series/RG501Q-EU/RG502Q Series
	RG520N Series/RG520F Series/RG525F-NA/RG530F Series
RM5x	RM500Q Series/RM502Q-AE/RM505Q-AE/RM510Q-GL
	RM520N Series/RM521F-GL/RM530N-GL

RM550V-GL/RM551E-GL

RG6x

RG650E Series/RG651E-NA/RG650V Series

NOTE

For band information of the above modules, see the corresponding module specification.

2 5G Network Related 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 1: 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 AT Commands

2.3.1. AT+CREG Network Registration Status

The Read Command returns the network registration status and returns the status of result code presentation and an integer **<stat>** which shows whether the network has currently indicated the registration of MT. Location information parameters **<lac>** and **<ci>** are returned only when **<n>=2** and MT is registered on the network.

The Write Command sets whether to present URC or not and controls the presentation of an unsolicited result code **+CREG: <stat>** when **<n>=1** and there is a change in the MT network registration status.

AT+CREG Network Registration Status	
Test Command AT+CREG=?	Response +CREG: (range of supported <n>s) OK
Read Command AT+CREG?	Response +CREG: <n>,<stat>[,<lac>,<ci>[,<AcT>]] OK If there is any error related to MT functionality: +CME ERROR: <err>
Write Command AT+CREG=[<n>]	Response OK
Maximum Response Time	300 ms
Characteristics	-
Reference <i>3GPP TS 27.007</i>	

Parameter

<n>	Integer type
	0 Disable network registration unsolicited result code
	1 Enable network registration unsolicited result code: +CREG: <stat>
	2 Enable network registration unsolicited result code with location information: +CREG: <stat>[,<lac>,<ci>[,<AcT>]]
<stat>	Integer type. Indicate the circuit mode registration status.
	0 Not registered. MT is not currently searching a new operator to register to
	1 Registered, home network
	2 Not registered, but MT is currently searching a new operator to register to
	3 Registration denied
	4 Unknown
<lac>	5 Registered, roaming
	Two bytes location area code in hexadecimal format.
<ci>	28-bit (UMTS/LTE) cell ID in hexadecimal format.
<AcT>	Integer type. Access technology selected.
	2 UTRAN
	4 UTRAN W/HSDPA
	5 UTRAN W/HSUPA
	6 UTRAN W/HSDPA and HSUPA
	7 E-UTRAN
	10 E-UTRAN connected to a 5GCN
	11 NR connected to 5GCN
	12 NG-RAN
	13 E-UTRAN-NR dual connectivity
<err>	Error codes. See document [1], [2] or [3] for more details.

Example

```
AT+CREG=1
```

```
OK
```

```
+CREG: 1 //URC reports that MT has registered on network.
```

```
AT+CREG=2 //Activate extended URC mode.
```

```
OK
```

```
+CREG: 1,"D509","80D413D",7 //URC reports that operator has found location area code and cell ID.
```

2.3.2. AT+CGREG PS Network Registration Status

This command queries the network registration status and controls the presentation of an unsolicited result code **+CGREG: <stat>** when **<n>=1** and there is a change in the MT's GPRS network registration status in GERAN/UTRAN, or unsolicited result code **+CGREG: <stat>[,<lac>],[<ci>],[<AcT>],[<rac>]]** when **<n>=2** and there is a change of the network cell in GERAN/UTRAN.

AT+CGREG PS Network Registration Status

Test Command AT+CGREG=?	Response +CGREG: (range of supported <n>s) OK
Read Command AT+CGREG?	Response +CGREG: <n>,<stat>[,<lac>],[<ci>],[<AcT>],[<rac>]] OK
Write Command AT+CGREG=[<n>]	Response OK Or ERROR
Maximum Response Time	300 ms
Characteristics	-
Reference <i>3GPP TS 27.007</i>	

Parameter

<n>	Integer type. 0 Disable network registration unsolicited result code 1 Enable network registration unsolicited result code +CGREG:<stat> 2 Enable network registration and location information unsolicited result code +CGREG: <stat>,<lac>,<ci>[,<AcT>],[<rac>]]
<stat>	Integer type. Indicate the GPRS registration status. 0 Not registered, MT is not currently searching an operator to register to. The UE is in GMM state GMM-NUL or GMM-DEREGISTERED-INITIATED. The GPRS service is disabled; the UE is allowed to attach for GPRS if requested by the user. 1 Registered, home network. The UE is in GMM state GMM-REGISTERED or GMM-ROUTING-AREA-UPDATING-INITIATED INITIATED on the home PLMN. 2 Not registered, but MT is currently trying to attach or searching an operator to register to. The UE is in GMM state GMM-DEREGISTERED or GMM-REGISTERED-INITIATED. The GPRS service is enabled, but an allowable PLMN is currently not available. The UE will start a GPRS attach as soon as an

	allowable PLMN is available.
3	Registration denied. The UE is in GMM state GMM-NULL. The GPRS service is disabled; and the UE is not allowed to attach for GPRS if requested by the user.
4	Unknown
5	Registered, roaming
<lac>	String type. Two-byte location area code in hexadecimal format (e.g., "00C3" equals 195 in decimal).
<ci>	String type. Four-byte (UMTS/LTE) cell ID in hexadecimal format.
<AcT>	Access technology selected.
2	UTRAN
4	UTRAN W/HSDPA
5	UTRAN W/HSUPA
6	UTRAN W/HSDPA and HSUPA
<rac>	One byte routing area code in hexadecimal format.

Example

```

AT+CGREG=?
+CGREG: (0-2)

OK
AT+CGREG=2
OK
AT+CGREG?
+CGREG: 2,1,"D5D5","8054BBF",2,"0"

OK
+CGREG: 1,"D5D5","8054BBF",2,"0"

```

2.3.3. AT+CEREG EPS Network Registration Status

This command queries whether the module is registered on EPS domain of LTE and controls the presentation of the following URC.

- **+CEREG: <stat>** is reported when <n>=1 and there is a change in the MT's EPS network registration status in E-UTRAN.
- **+CEREG: <stat>[, [<tac>], [<ci>], [<AcT>]]** is reported when <n>=2 and there is a change of the network cell in E-UTRAN.

AT+CEREG EPS Network Registration Status

Test Command	Response
AT+CEREG=?	+CEREG: (range of supported <n>s)

	OK
Read Command AT+CEREG?	Response +CEREG: <n>,<stat>[,<tac>,<ci>[,<AcT>]]
	OK
Write Command AT+CEREG=[<n>]	Response OK Or ERROR
Maximum Response Time	300 ms
Characteristics	-
Reference 3GPP TS 27.007	

Parameter

<n>	Integer type. 0 Disable network registration URC 1 Enable network registration URC +CEREG: <stat> 2 Enable network registration and location information URC +CEREG: <stat>[,<tac>],<ci>[,<AcT>]]
<stat>	Integer type. EPS registration status. 0 Not registered, MT is not currently searching an operator to register to. 1 Registered, home network. 2 Not registered, but MT is currently trying to attach or searching an operator to register to. 3 Registration denied. 4 Unknown. 5 Registered, roaming.
<tac>	String type in hexadecimal format. Two-byte tracking area code.
<ci>	String type in hexadecimal format. Four-byte cell ID.
<AcT>	Integer type. Access technology selected. 7 E-UTRAN 13 E-UTRAN-NR dual connectivity

Example

```
AT+CEREG=?
+CEREG: (0-2)

OK
AT+CEREG=2
```

```
OK
AT+CEREG?
+CEREG: 2,1,"DE10","5A29C0B",7

OK

+CEREG: 1,"DE10","5A29C0B",7
```

2.3.4. AT+C5GREG 5GS Network Registration Status

This command queries the network registration status and controls the presentation of following URC.

- **+C5GREG: <stat>** is reported when <n>=1 and there is a change in the module's network registration status in 5GS,
- **+C5GREG: <stat>[, [<tac>], [<ci>], [<AcT>], [<Allowed_NSSAI_length>], [<Allowed_NSSAI>]]** is reported when <n>=2 and there is a change of the network cell in 5GS or the network provides an Allowed NSSAI. The parameters <AcT>, <tac>, <ci>, <Allowed_NSSAI_length> and <Allowed_NSSAI> are provided only if available.

AT+C5GREG 5GS Network Registration Status

Test Command AT+C5GREG=?	Response +C5GREG: (range of supported <n>s) OK
Read Command AT+C5GREG?	Response +C5GREG: <n>,<stat>[, [<tac>], [<ci>], [<AcT>], [<Allowed_NSSAI_length>], [<Allowed_NSSAI>]] OK
Write Command AT+C5GREG=[<n>]	Response OK Or ERROR
Maximum Response Time	300 ms
Characteristics	-
Reference 3GPP TS 27.007	

Parameter

<n>	Integer type. <u>0</u> Disable network registration URC
-----	--

	1 Enable network registration URC +C5GREG: <stat> 2 Enable network registration and location information URC +C5GREG: <stat>,[<tac>],[<ci>],[<AcT>],[<Allowed_NSSAI_length>],[<Allowed_NSSAI>]										
<stat>	Integer type. NR5G registration status. 0 Not registered, the module is not currently searching an operator to register to. 1 Registered, home network. 2 Not registered, but the module is currently trying to attach or searching an operator to register to. 3 Registration denied. 4 Unknown. 5 Registered, roaming. 8 Registered for emergency services only.										
<tac>	String type in hexadecimal format. Three-byte tracking area code.										
<ci>	String type in hexadecimal format. Five-byte NR5G cell ID.										
<AcT>	Integer type. Access technology selected. 10 E-UTRAN connected to a 5GCN 11 NR connected to a 5GCN										
<Allowed_NSSAI_length>	Integer type. The number of octets of the <Allowed_NSSAI> information element.										
<Allowed_NSSAI>	String type in hexadecimal format. Dependent of the form, the string can be separated by dot(s), semicolon(s) and colon(s). This parameter indicates the list of allowed S-NSSAIs received from the network. The <Allowed_NSSAI> is coded as a list of <S-NSSAI> s separated by colons. See <S-NSSAI> in <i>3GPP 27.007 subclause 10.1.1</i> . This parameter shall not be subject to conventional character conversion as per AT+CSCS .										
<S-NSSAI>	String type in hexadecimal character format. Depending on the form, the string can be separated by dot(s) and semicolon(s). This parameter is associated with the PDU session for identifying a network slice in 5GS, see <i>3GPP TS 23.501 and 3GPP TS 24.501</i> . For the format and the encoding of S-NSSAI, see also <i>3GPP TS 23.003</i> . This parameter is not subject to conventional character conversion as per AT+CSCS . The parameter takes one of the following forms: <table> <tr> <td>sst</td><td>Only slice/service type (SST) is present.</td></tr> <tr> <td>sst;mapped_sst</td><td>SST and mapped configured SST are present.</td></tr> <tr> <td>sst.sd</td><td>SST and slice differentiator (SD) are present.</td></tr> <tr> <td>sst.sd;mapped_sst</td><td>SST, SD and mapped configured SST are present.</td></tr> <tr> <td>sst.sd;mapped_sst.mapped_sd</td><td>SST, SD, mapped configured SST and mapped configured SD are present.</td></tr> </table>	sst	Only slice/service type (SST) is present.	sst;mapped_sst	SST and mapped configured SST are present.	sst.sd	SST and slice differentiator (SD) are present.	sst.sd;mapped_sst	SST, SD and mapped configured SST are present.	sst.sd;mapped_sst.mapped_sd	SST, SD, mapped configured SST and mapped configured SD are present.
sst	Only slice/service type (SST) is present.										
sst;mapped_sst	SST and mapped configured SST are present.										
sst.sd	SST and slice differentiator (SD) are present.										
sst.sd;mapped_sst	SST, SD and mapped configured SST are present.										
sst.sd;mapped_sst.mapped_sd	SST, SD, mapped configured SST and mapped configured SD are present.										

Example

```

AT+C5GREG=?
+C5GREG: (0-2)

OK
AT+C5GREG=2
OK
AT+C5GREG?
+C5GREG: 2,1,"690E0F","9013B004",11,4,"01.000000"

OK
+C5GREG: 1,"690E0F","9013B004",11,4,"01.000000"

```

2.3.5. AT+CGACT Activate or Deactivate PDP Context

This command activates or deactivates the specified PDP context(s). If a PDP context is already in the requested state, the state for that context remains unchanged. Failure to achieve the requested state will result in an **ERROR** or **+CME ERROR**. Extended error response is enabled by **AT+CMEE**.

If MT is not PS attached when the activation command is executed, MT will first attempt attachment and then activate the specified context. In case of attachment failure, MT responds with **ERROR** or, if extended error response is enabled, with the appropriate failure-to-attach error message.

For EPS, in case of an attempt to disconnect the last PDN connection, MT responds with **ERROR**, or, if extended error response is enabled, it responds with **+CME ERROR**. The activation request for an EPS bearer resource will be answered by the network by either an EPS dedicated bearer activation or an EPS bearer modification request. The request must be accepted by MT before the PDP context can be set to an established state.

For 5GS, the command is used to request or delete the specified QoS flow. The request for a specific QoS flow will be answered by the network by either a PDU session establishment accept message or a PDU session modification command message. The message must be accepted by the MT before the QoS flow can be set to active state.

AT+CGACT Activate or Deactivate PDP Context

Test Command AT+CGACT=?	Response +CGACT: (list of supported <state>s) OK
Read Command AT+CGACT?	Response +CGACT: <cid>,<state> [...]

	OK
Write Command AT+CGACT=[<state>[,<cid1>[,<cid2>[,...]]]]	Response OK Or NO CARRIER If there is any error: ERROR Or +CME ERROR: <err>
Maximum Response Time	150 s, determined by network.
Characteristics	-
Reference 3GPP TS 27.007	

Parameter

<state>	Integer type. PDP context activation status. 0 Deactivated 1 Activated Other values are reserved and will result in an ERROR response to the Write Command.
<cid>	Integer type. Particular PDP context definition (see AT+CGDCONT).
<err>	Error codes. See document [1], [2] or [3] for more details.

Example

```

AT+CGDCONT=4,"IP","UNINET"           //Define a PDP context.
OK
AT+CGACT=1,4                           //PDP activated.
OK
AT+CGACT?                               //Query the current PDP context state.
+CGACT: 1,1
+CGACT: 2,0
+CGACT: 3,0
+CGACT: 4,1
...

OK
AT+CGACT=0,4                           //PDP deactivated.
OK

```

2.3.6. AT+QENG Query Serving Cell and Neighbor Cell Information

This command queries the serving cell and neighbor cell information, such as band, frequency, signal strength and signal-to-noise ratio.

AT+QENG Query Serving Cell and Neighbor Cell Information

Test Command AT+QENG=?	Response +QENG: (list of supported <cell_type>s) OK
Write Command Query the serving cell information AT+QENG="servingcell"	Response In SA mode: +QENG: "servingcell",<state>,"NR5G-SA",<duplex_mode>,<MCC>,<MNC>,<cellID>,<PCID>,<TAC>,<ARFCN>,<band>,<NR_DL_bandwidth>,<RSRP>,<RSRQ>,<SINR>,<scs>,<srxlev> OK In NSA mode: +QENG: "servingcell",<state> +QENG: "LTE",<is_tdd>,<MCC>,<MNC>,<cellID>,<PCID>,<earfcn>,<freq_band_ind>,<UL_bandwidth>,<DL_bandwidth>,<TAC>,<RSRP>,<RSRQ>,<RSSI>,<SINR>,<CQI>,<tx_power>,<srxlev> +QENG: "NR5G-NSA",<MCC>,<MNC>,<PCID>,<RSRP>,<SINR>,<RSRQ>,<ARFCN>,<band>,<NR_DL_bandwidth>,<scs> OK In LTE mode: +QENG: "servingcell",<state>,"LTE",<is_tdd>,<MCC>,<MNC>,<cellID>,<PCID>,<earfcn>,<freq_band_ind>,<UL_bandwidth>,<DL_bandwidth>,<TAC>,<RSRP>,<RSRQ>,<RSSI>,<SINR>,<CQI>,<tx_power>,<srxlev> OK In WCDMA mode: +QENG: "servingcell",<state>,"WCDMA",<MCC>,<MNC>,<LAC>,<cellID>,<uarfcn>,<PSC>,<RAC>,<RSCP>,<ecio>,<phychn>

	,<SF>,<slot>,<speech_code>,<comMod>
	OK
Write Command Query the neighbor cell information AT+QENG="neighbourcell"	Response In LTE mode: [+QENG: "neighbourcell intra","LTE",<earfcn>,<PCID>,<RSRQ>,<RSRP>,<RSSI>,<SINR>,<srxlev>,<cell_resel_priority>,<s_non_intra_search>,<thresh_serving_low>,<s_intra_search>] [...] [+QENG: "neighbourcell inter","LTE",<earfcn>,<PCID>,<RSRQ>,<RSRP>,<RSSI>,<SINR>,<srxlev>,<cell_resel_priority>,<threshX_low>,<threshX_high>] [...] [+QENG:"neighbourcell","WCDMA",<uarfcn>,<cell_resel_priority>,<thresh_Xhigh>,<thresh_Xlow>,<PSC>,<RSCP>,<ecno>,<srxlev>] [...] OK In WCDMA mode: [+QENG:"neighbourcell","WCDMA",<uarfcn>,<srxqual>,<PSC>,<RSCP>,<ecno>,<set>,<rank>,<srxlev>] [...] [+QENG: "neighbourcell","LTE",<earfcn>,<PCID>,<RSRP>,<RSRQ>,<srxlev>] [...] OK
Maximum Response Time	300 ms
Characteristics	-

Parameter

<cell_type>	String type. The information of different cells. "servingcell" The information of 3G/4G/5G serving cells "neighbourcell" The information of 3G/4G neighbor cells
<state>	String type. UE state. "SEARCH" UE is searching but could not (yet) find a suitable 3G/4G/5G cell. "LIMSRV" UE is camping on a cell but has not registered on the

	network.
"NOCONN"	UE is camping on a cell and has registered on the network, and it is in idle mode.
"CONNECT"	UE is camping on a cell and has registered on the network, and a call is in progress.
<duplex_mode>	String type. The NR5G SA network mode. "TDD" "FDD"
<MCC>	Integer type. Mobile Country Code (first part of the PLMN code).
<MNC>	Integer type. Mobile Network Code (second part of the PLMN code).
<cellID>	Integer type. Cell ID. 28-bit (UMTS, LTE) or 36-bit (5G) cell ID. Range: 0-0xFFFFFFFF.
<PCID>	Integer type. Physical cell ID.
<TAC>	String type. Two-byte tracking area code for LTE or three-byte tracking area code for 5G SA in hexadecimal format without double quotes (see 3GPP 23.003 Section 19.4.2.3).
<ARFCN>	Integer type. SA-ARFCN of the cell that was scanned.
<band>	32-bit unsigned integer. NR5G SA band.
<NR_DL_bandwidth>	Integer type. DL bandwidth. It is only valid in RRC connected state. 0 5 MHz 1 10 MHz 2 15 MHz 3 20 MHz 4 25 MHz 5 30 MHz 6 40 MHz 7 50 MHz 8 60 MHz 9 70 MHz 10 80 MHz 11 90 MHz 12 100 MHz 13 200 MHz 14 400 MHz 15 35 MHz 16 45 MHz
<RSRP>	16-bit signed integer. - In LTE mode: Signal strength of LTE Reference Signal Received Power (see 3GPP 36.214). Range: -140 to -44; Unit: dBm. The closer to -44, the better the signal is. The closer to -140, the worse the signal is. - In NR5G mode: Signal strength of NR5G Reference Signal Received Power. Range: -140 to -44; Unit: dBm. The closer to -44, the better the signal is. The closer to -140,

	the worse the signal is.
<RSRQ>	16-bit signed integer. - In LTE mode: Signal strength of current LTE Reference Signal Received Quality (see 3GPP 36.214). Range: -20 to -3; Unit: dB. The closer to -3, the better the signal is. The closer to -20, the worse the signal is. - In NR5G mode: Signal strength of current NR5G Reference Signal Received Quality. Range: -20 to -3; Unit: dB. The closer to -3, the better the signal is. The closer to -20, the worse the signal is.
<SINR>	16-bit signed integer. - In LTE mode: LTE Signal-to-Interface plus Noise Ratio. The conversion formula for actual SINR is $Y = (1/5) \times X \times 10 - 20$ (X is <SINR> queried by AT+QENG. Y is the actual value of LTE SINR after calculating with the formula). Range: -20 to 30; Unit: dB. - In NR5G mode: NR5G Signal-to-Interface plus Noise Ratio. Range: -23 to 40; Unit: dB.
<scs>	Integer type. NR5G sub operator spacing. 0 15 KHz 1 30 KHz 2 60 KHz 3 120 KHz 4 240 KHz
<srxlev>	Integer type. Reception level value for the selected base station in dB (see 3GPP 25.304).
<is_tdd>	String type. The LTE network mode. "TDD" "FDD"
<earfcn>	Integer type. E-UTRA-ARFCN of the cell that was scanned.
<freq_band_ind>	Integer type. E-UTRA frequency band (see 3GPP 36.101).
<UL_bandwidth>	Integer type. UL bandwidth. 0 1.4 MHz 1 3 MHz 2 5 MHz 3 10 MHz 4 15 MHz 5 20 MHz
<DL_bandwidth>	Integer type. DL bandwidth. 0 1.4 MHz 1 3 MHz 2 5 MHz 3 10 MHz 4 15 MHz

	5 20 MHz
<RSSI>	Integer type. LTE Received Signal Strength Indication.
<CQI>	Integer type. Channel Quality Indication. Range: 1–30.
<tx_power>	Integer type. TX power value in 1/10 dBm. It is the maximum of all UL channel TX power. <tx_power> is only meaningful when the device is in traffic.
<LAC>	Integer type. Location Area Code. Range: 0–65535. The parameter determines the two bytes location area code in hexadecimal format (e.g. 00C1 equals 193 in decimal) of the cell that was scanned.
<uarfcn>	Integer type. UTRA-ARFCN of the scanned cell.
<PSC>	Integer type. Primary scrambling code of the scanned cell.
<RAC>	Integer type. Routing Area Code. Range: 0–255.
<RSCP>	Integer type. Received Signal Code Power level of the cell that is scanned.
<ecio>	Integer type. Operator to noise ratio in dB = measured Ec/Io value in dB.
<phych>	Integer type. Physical channel.
	0 DPCH
	1 FDPCH
<SF>	Integer type. Spreading factor.
	0 SF_4
	1 SF_8
	2 SF_16
	3 SF_32
	4 SF_64
	5 SF_128
	6 SF_256
	7 SF_512
	8 UNKNOWN
<slot>	Integer type.
	0–16 Slot format for DPCH
	0–9 Slot format for FDPCH
<speech_code>	Integer type. Destination number on which call is to be deflected.
<comMod>	Integer type. Compress mode.
	0 Not support compress mode
	1 Support compress mode
<cell_resel_priority>	Integer type. Cell reselection priority. Range: 0–7.
<s_non_intra_search>	Integer type. Threshold to control non-intra frequency searches.
<thresh_serving_low>	Integer type. Suitable reception level threshold in dB used by the UE on the serving cell when reselecting towards a lower priority RAT/frequency.
<s_intra_search>	Integer type. Cell selection parameter for the intra frequency cell.
<threshX_low>	Integer type. To be considered for reselection. The suitable receive level value of an evaluated lower priority cell must be greater than this value.
<threshX_high>	Integer type. To be considered for reselection. The suitable receive level value of an evaluated higher priority cell must be greater than this value.
<thresh_Xhigh>	Integer type. Reselection threshold for high priority layers.
<thresh_Xlow>	Integer type. Reselection threshold for low priority layers.

<srxqual>	Integer type. Receiver automatic gain control on the camped frequency.
<ecno>	Integer type. Operator to noise ratio in dB = measured Ec/Io value in dB.
<set>	Integer type. 3G neighbor cell set. 1 Active set 2 Synchronous neighbor set 3 Asynchronous neighbor set
<rank>	Integer type. Rank of this cell as neighbor for inter-RAT cell reselection.

NOTE

1. If “-” is returned, it indicates that the parameter is invalid when you execute the command.
2. When you read the response information of this command, it is recommended to read the information based on the first negative value, which is the RSRP value. For example, in LTE mode, the fourth parameter value before RSRP value represents the band, and the third parameter value after RSRP value represents SINR value. In SA mode, the second parameter value before RSRP value represents the band, and the second parameter value after RSRP value represents SINR value.

Example

AT+QENG="servingcell"

//Query the serving cell information. The current UE is registered under LTE network.

+QENG: "servingcell","NOCONN","LTE","FDD",460,01,5F1EA15,12,1650,3,5,5,DE10,-100,-12,-68,11,-,27

OK

AT+QENG="servingcell" //Query the serving cell information. The current UE is registered under NSA network.

+QENG: "servingcell","NOCONN"

+QENG: "LTE","FDD",460,01,5F1EA15,12,1650,3,5,5,DE10,-99,-12,-67,11,9,230,-

+QENG:"NR5G-NSA",460,01,747,-71,33,-11,627264,78,12,1

OK

AT+QENG="servingcell" //Query the serving cell information. The current UE is registered under SA network.

+QENG: "servingcell","NOCONN","NR5G-SA","TDD",460,01,19013B004,299,690E0F,633984,78,12,-107,-13,2,1,-

OK

AT+QENG="neighbourcell" //Query the neighbor cell information.

+QENG: "neighbourcell intra","LTE",38950,276,-3,-88,-65,0,37,7,16,6,44

+QENG: "neighbourcell inter","LTE",39148,-,-,-,-,37,0,30,7

+QENG: "neighbourcell inter","LTE",37900,-,-,-,-,0,0,30,6

OK

2.3.7. AT+QENDC Query EN-DC Status

This command queries EN-DC status.

AT+QENDC Query EN-DC Status

Read Command AT+QENDC?	Response +QENDC: <mode> OK
Write Command AT+QENDC=<mode>	Response OK
Execution Command AT+QENDC	Response +QENDC: <endc_avl>,<plmn_info_list_r15_avl>,<endc_rstr>,<5G_basic>[,<5G_UWB>] OK
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<mode>	Integer type. Disable or disable the following URC: +QENDC: <endc_avl>,<plmn_info_list_r15_avl>,<endc_rstr>,<5G_basic>,<5G_UWB> 0 Disable 1 Enable
<endc_avl>	Integer type. Indicate whether the current cell supports the EN-DC mode. 0 Not support 1 Support
<plmn_info_list_r15_avl>	Integer type. Indicate whether the currently registered PLMN supports the EN-DC mode. 0 Not support 1 Support
<endc_rstr>	Integer type. EN-DC capability delivered by the network. 0 Not Restricted 1 Restricted
<5G_basic>	Integer type. Indicate whether to show 5G Icon information. 0 Not show 1 Show
<5G_UWB>	Integer type. Indicate whether to show 5G UWB Icon information. The

parameter is valid only under Verizon network.

0 Not show

1 Show

Example

AT+QENDC

+QENDC: 1,1,0,1,0

OK

AT+QENDC=1 //Enable ENDC URC.

OK

// URC Report.

+QENDC: 1,1,0,0,0

+QENDC: 1,1,0,1,0

2.3.8. AT+QRSRP Query RSRP

The command queries RSRP of each antenna of the module under the current service network.

AT+QRSRP Query RSRP

Test Command	Response
AT+QRSRP=?	OK
Read Command	Response
AT+QRSRP?	+QRSRP: <PRX>,<DRX>,<RX2>,<RX3>,<sysmode> [...]
	OK
Maximum Response Time	300 ms
Characteristics	--

Parameter

<PRX>	Integer type. PRX path RSRP value. Range: -140 to -44; Unit: dBm.
<DRX>	Integer type. DRX path RSRP value. Range: -140 to -44; Unit: dBm.
<RX2>	Integer type. RX2 path RSRP value. Range: -140 to -44; Unit: dBm.
<RX3>	Integer type. RX3 path RSRP value. Range: -140 to -44; Unit: dBm.
<sysmode>	String type without double quotes. Service network mode.
	LTE LTE mode
	NR5G NR5G mode

NOTE

1. The command takes effect only under LTE and NR5G network.
2. If the queried <PRX>, <DRX>, <RX2> and <RX3> is -32768, it indicates that the RSRP value is invalid.
3. This command is strongly related to the RF link and is generally only used for user reference and cannot be used as a sensitivity test. In addition, it is best to use it when there is the data service and the results are more accurate.

Example

```
AT+QSRP? //Query RSRP of each antenna of the module under the current service network.
+QSRP: -101,-105,-105,-99,LTE
OK
```

2.3.9. AT+QSRQ Report RSRQ

The command queries and reports the RSRQ of the current service network.

AT+QSRQ Report RSRQ

Test Command AT+QSRQ=?	Response OK
Read Command AT+QSRQ	Response +QSRQ: <PRX>,<DRX>,<RX2>,<RX3>,<sysmode> OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristics	-

Parameter

<PRX>	Integer type. PRX path RSRQ value. Range: -20 to -3 dB.
<DRX>	Integer type. DRX path RSRQ value. Range: -20 to -3 dB.
<RX2>	Integer type. RX2 path RSRQ value. Range: -20 to -3 dB.
<RX3>	Integer type. RX3 path RSRQ value. Range: -20 to -3 dB.
<sysmode>	String type. It indicates the service mode in which the MT will report the RSRQ.
	LTE LTE mode
	NR5G 5G mode

NOTE

1. This command is only supported in LTE and 5G.
2. If the queried <PRX>, <DRX>, <RX2> or <RX3> is -32768, it indicates that the RSRQ value is invalid.
3. This command is strongly related to the RF link and is generally only used for customer reference and cannot be used as a sensitivity test. In addition, it is best to use it when measuring the speed, the results are more accurate.

Example

```
AT+QSRQ //Query RSRQ.
+QSRQ: -16,-19,-19,-15,LTE
OK
```

2.3.10. AT+QSINR Query SINR

The command queries SINR of each antenna of the module under the current service network.

AT+QSINR Query SINR

Test Command AT+QSINR=?	Response OK
Read Command AT+QSINR?	Response +QSINR: <PRX>,<DRX>,<RX2>,<RX3>,<sysmode> [...] OK
Maximum Response Time	300 ms
Characteristics	-

Parameter

<PRX>	Integer type. PRX path SINR value. Range: -20 to 30 in LTE, -23 to 40 in NR5G. Unit: dB.
<DRX>	Integer type. DRX path SINR value. Range: -20 to 30 in LTE, -23 to 40 in NR5G. Unit: dB.
<RX2>	Integer type. RX2 path SINR value. Range: -20 to 30 in LTE, -23 to 40 in NR5G. Unit: dB.
<RX3>	Integer type. RX3 path SINR value. Range: -20 to 30 in LTE, -23 to 40 in NR5G. Unit: dB.
<sysmode>	String type without double quotes. Service network mode.
LTE	LTE mode
NR5G	NR5G mode

NOTE

1. The command takes effect only under LTE and NR5G network.
2. The invalid SINR value is -32768.
3. This command is strongly related to the RF link and is generally only used for customer reference and cannot be used as a sensitivity test. In addition, it is best to use it when there is the data service and the results are more accurate.

Example

```
AT+QSINR?           //Query SINR of each antenna of the module under the current service network.
+QSINR: -3,-7,-1,-2,LTE

OK
```

2.3.11. AT+QCAINFO Query Carrier Aggregation Parameters

This command queries carrier aggregation parameters.

AT+QCAINFO Query Carrier Aggregation Parameters

Test Command AT+QCAINFO=?	Response +QCAINFO: (list of supported <5G_signal_ext>s) OK
Read Command AT+QCAINFO?	Response +QCAINFO: <5G_signal_ext> OK
Write Command AT+QCAINFO=<5G_signal_ext>	Response OK Or ERROR
Execution Command AT+QCAINFO	In LTE mode: +QCAINFO: "PCC",<freq>,<bandwidth>,<band>,<pcell_state>,<PCID>,<RSRP>,<RSRQ>,<RSSI>,<RSSNR> [+QCAINFO: "SCC",<freq>,<bandwidth>,<band>,<scell_state>,<PCID>,<RSRP>,<RSRQ>,<RSSI>,<RSSNR><UL_configured>,<UL_bandwidth>,<UL_EARFCN>] [...] OK In EN-DC mode:

	+QCAINFO: "PCC",<freq>,<bandwidth>,<band>,<pcell_state>,<PCID>,<RSRP>,<RSRQ>,<RSSI>,<RSSNR> [+QCAINFO: "SCC",<freq>,<bandwidth>,<band>,<scell_state>,<PCID>,<RSRP>,<RSRQ>,<RSSI>,<RSSNR><UL_configured>,<UL_bandwidth>,<UL_EARFCN>] [...] [+QCAINFO: "SCC",<freq>,<NR_DL_bandwidth>,<NR_band>,<PCID>] [+QCAINFO: "SCC",<freq>,<NR_DL_bandwidth>,<NR_band>,<scell_state>,<PCID>,<UL_configured>,<NR_UL_bandwidth>,<UL_ARFCN>[,<NR_RSRP>,<NR_RSRQ>[,<NR_SNR>]]] [...] OK In SA mode: +QCAINFO: "PCC",<freq>,<NR_DL_bandwidth>,<NR_band>,<PCID> [+QCAINFO: "SCC",<freq>,<NR_DL_bandwidth>,<NR_band>,<scell_state>,<PCID>,<UL_configured>,<NR_UL_bandwidth>,<UL_ARFCN>[,<NR_RSRP>,<NR_RSRQ>[,<NR_SNR>]]] [...] OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<5G_signal_ext>	Integer type. Hide or show extension parameters <NR_RSRP>, <NR_RSRQ> and <NR_SNR>. 0 Hide 1 Show
<freq>	Integer type. EARFCN.
<bandwidth>	Integer type. Bandwidth. 6 1.4 MHz 15 3 MHz

	25	5 MHz
	50	10 MHz
	75	15 MHz
	100	20 MHz
<band>	String type. LTE band.	
	"LTE BAND 1"–"LTE BAND 5"	
	"LTE BAND 7"	
	"LTE BAND 8"	
	"LTE BAND 12"–"LTE BAND 14"	
	"LTE BAND 17"–"LTE BAND 20"	
	"LTE BAND 25"	
	"LTE BAND 26"	
	"LTE BAND 28"–"LTE BAND 30"	
	"LTE BAND 32"	
	"LTE BAND 34"	
	"LTE BAND 38"–"LTE BAND 43"	
	"LTE BAND 48"	
	"LTE BAND 66"	
<pcell_state>	Integer type. Primary cell state.	
	0	Not registered, not searching
	1	Registered on home network
	2	Not registered, searched
	3	Registration denied
	4	Unknow registration state
	5	Registered on roaming network
<scell_state>	Integer type. Secondary cell state.	
	0	Deconfigured
	1	Configuration deactivated
	2	Configuration activated
<PCID>	Integer type. Physical Cell ID.	
<RSRP>	Integer type. Reference Signal Received Power (see 3GPP 36.214).	
<RSRQ>	Integer type. Reference Signal Received Quality (see 3GPP 36.214).	
<RSSI>	Integer type. Received Signal Strength Indication.	
<RSSNR>	Integer type. Logarithmic value of RSSNR. Range: -10 to +30; Unit: dB.	
<UL_configured>	Integer type. Whether the UL of secondary cell is configured by network.	
	0	Not configured by the network
	1	Configured by the network
<UL_bandwidth>	Integer type. UL bandwidth. "-" will be displayed if <UL_configured>=0.	
	6	1.4 MHz
	15	3 MHz
	25	5 MHz
	50	10 MHz
	75	15 MHz
	100	20 MHz

<UL_EARFCN>	Integer type. UL EARFCN. "-" will be displayed if <UL_configured>=0.
<NR_DL_bandwidth>	Integer type. NR5G DL bandwidth.
	0 5 MHz
	1 10 MHz
	2 15 MHz
	3 20 MHz
	4 25 MHz
	5 30 MHz
	6 40 MHz
	7 50 MHz
	8 60 MHz
	9 70 MHz
	10 80 MHz
	11 90 MHz
	12 100 MHz
	13 200 MHz
	14 400 MHz
	15 35 MHz
	16 45 MHz
<NR_band>	String Type.NR5G band.
	"NR5G BAND 1"-"NR5G BAND 3"
	"NR5G BAND 7"
	"NR5G BAND 8"
	"NR5G BAND 12"
	"NR5G BAND 20"
	"NR5G BAND 25"
	"NR5G BAND 28"
	"NR5G BAND 38"
	"NR5G BAND 40"
	"NR5G BAND 41"
	"NR5G BAND 48"
	"NR5G BAND 66"
	"NR5G BAND 71"
	"NR5G BAND 77"-"NR5G BAND 79"
	"NR5G BAND 257"
	"NR5G BAND 258"
	"NR5G BAND 260"
	"NR5G BAND 261"
<NR_UL_bandwidth>	Integer type. "-" will be displayed if <UL_configured>=0. The value of <NR_UL_bandwidth> is the same as that of <NR_DL_bandwidth>.
<UL_ARFCN>	Integer type. UL ARFCN. "-" will be displayed if <UL_configured> is 0.
<NR_RSRP>	Integer type. Signal strength of NR5G reference signal received power. Range: -140 to -44. Unit: dBm. The closer to -44, the better the signal is. The closer to -140, the worse the signal is.

<NR_RSRQ>	Integer type. Signal strength of current NR5G reference signal received quality. Range: -20 to -3. Unit: dB. The closer to -3, the better the signal is. The closer to -20, the worse the signal is.
<NR_SNR>	Integer type. Current NR SNR. Range: -2300 to 4000. The actual value of NR SNR is calculated via the formula: $NR\ SNR = \frac{<NR_SNR>}{100}$. Range of NR SNR: -23 to 40; Unit: dB.

NOTE

The command takes effect after the module is registered on the network.

Example

AT+QCAINFO

```
+QCAINFO: "PCC",300,100,"LTE BAND 1",1,23,-66,-12,-34,30
+QCAINFO: "SCC",1575,100,"LTE BAND 3",2,43,-64,-7,-24,30,0,-,-
OK
```

2.3.12. AT+QSCAN Search Nearby Cells

This command searches nearby LTE cells and NR5G cells.

AT+QSCAN Search Nearby Cells

Test Command AT+QSCAN=?	Response +QSCAN: (range of supported <mode>s) OK
Write Command AT+QSCAN=<mode>[,<ext>[,<scan_LTE_band>[,<scan_NR5G_band>]]]	Response [+QSCAN: "LTE",<MCC>,<MNC>,<freq>,<PCI>,<RSRP>,<RSRQ>,<srxlev>,<squal>[,<cellID>,<TAC>,<bandwidth>,<LTE_band>[,<short_name>,<full_name>]]] [...] [+QSCAN: "NR5G",<MCC>,<MNC>,<freq>,<PCI>,<RSRP>,<RSRQ>,<srxlev>,<SCS>[,<cellID>,<TAC>,<carrierBandwidth>,<NR_band>,<offsetToPointA>,<SSB_subcarrier_offset>,<SSB_SCS>[,<short_name>,<full_name>]]] [...] OK If there is any error:

	ERROR Or +CME ERROR: <err>
Maximum Response Time	360 s, determined by the network.
Characteristics	-

Parameter

<mode>	Integer type. Cell searching mode. 1 Search only for LTE cells 2 Search only for NR5G cells 3 Search for LTE cells and NR5G cells at the same time
<ext>	Integer type. Hide or show the extension parameter options or show the extension parameters (support 5G cell without TAC). 0 Hide extension parameters 1 Show extension parameters (<cellID>, <TAC>, <bandwidth>, <LTE_band>, <carrierBandwidth>, <NR_band>, <offsetToPointA>, <SSB_subcarrier_offset> and <SSB_SCS>) 3 Show extension parameters (<cellID>, <TAC>, <bandwidth>, <LTE_band>, <carrierBandwidth>, <NR_band>, <offsetToPointA>, <SSB_subcarrier_offset>, <SSB_SCS>, <full_name> and <short_name>)
<scan_LTE_band>	String type without double quotes. Use the colon as a separator to list the NR5G bands to be configured. The parameter format is <LTE_band1>:<LTE_band2>:...:<LTE_bandn>.
<LTE_band>	Integer type. LTE band.
<scan_NR5G_band>	String type without double quotes. Use the colon as a separator to list the NR5G bands to be configured. The parameter format is <NR5G_band1>:<NR5G_band2>:...:<NR5G_bandn>.
<NR5G_band>	Integer type. NR5G band.
<MCC>	Integer type. Mobile Country Code (first part of the PLMN code).
<MNC>	Integer type. Mobile Network Code (second part of the PLMN code).
<freq>	Integer type. Cell frequency.
<PCI>	Integer type. Physical Cell ID.
<RSRP>	Integer type. Reference Signal Received Power (see 3GPP 36.214). Range: -140 to -44; Unit: dBm.
<RSRQ>	Integer type. The current Reference Signal Received Quality (see 3GPP 36.214). Range: -20 to -3; Unit: dB.
<srxlev>	Integer type. Cell selection RX level value. Unit: dB.
<squal>	Integer type. Cell selection quality value. Unit: dB.
<cellID>	String type in hexadecimal format without double quotes. Cell ID.
<TAC>	String type in hexadecimal format without double quotes. TAC.

<bandwidth>	Integer type. Bandwidth.
6	1.4 MHz
15	3 MHz
25	5 MHz
50	10 MHz
75	15 MHz
100	20 MHz
<SCS>	Integer type. Sub-carrier space.
0	15 KHz
1	30 KHz
2	60 KHz
3	120 KHz
<carrierBandwidth>	Integer type. Carrier bandwidth, the number of the RBs in sub-carrier.
<NR_band>	Integer type. NR5G band.
<offsetToPointA>	Integer type. Offset to Point A.
<SSB_subcarrier_offset>	Integer type. SSB sub-carrier offset.
<SSB_SCS>	Integer type. SSB SCS value.
0	15 KHz
1	30 KHz
2	60 KHz
3	120 KHz
<short_name>	String type. The short name of the network operator. Only output when <ext> is 3.
<full_name>	String type. The full name of the network operator. Only output when <ext> is 3.
<err>	Error codes. See document [1], [2] or [3] for more details.

NOTE

1. This command returns “-” for the parameters if the cell information is not obtained.
2. In NSA mode, this command will not display NR5G cell information.
3. It is recommended to use the command when there is no SIM card.

Example

```

AT+QSCAN=1,1 //Search only for LTE cells and show extension parameters.
+QSCAN: "LTE",460,00,3590,207,-128,-13,-1,115,848459E,550B,50,8
+QSCAN: "LTE",460,11,1850,378,-135,-20,-7,109,DD8A33F,691D,100,3

OK
AT+QSCAN=2,1 //Search only for NR5G cells and show extension parameters.
+QSCAN: "NR5G",460,00,504990,901,-95,-11,26,1,170C23000,46550B,273,41,30,6,1
+QSCAN: "NR5G",460,11,633984,441,-112,-13,9,1,690133003,690E0F,273,78,28,4,1
+QSCAN: "NR5G",460,01,633984,441,-112,-13,9,1,690133003,690E0F,273,78,28,4,1

```

```
+QSCAN: "NR5G",460,11,633984,223,-112,-15,9,1,69034E007,690E0F,273,78,28,4,1
```

```
+QSCAN: "NR5G",460,01,633984,223,-112,-15,9,1,69034E007,690E0F,273,78,28,4,1
```

OK

```
AT+QSCAN=1,1,1 //Search only for LTE cells, show extension parameters and configure LTE
Band 1.
```

```
+QSCAN: "LTE",001,01,100,1,-97,-13,43,116,1A2D001,1,100,1
```

OK

```
AT+QSCAN=2,1,1,78 //Search only for NR5G cells, show extension parameters and configure LTE
Band 1 and NR5G Band 78.
```

```
+QSCAN: "NR5G",460,11,633984,841,-74,-11,46,1,6909DB085,690E0F,273,78,28,4,-
```

```
+QSCAN: "NR5G",460,01,633984,841,-74,-11,46,1,6909DB085,690E0F,273,78,28,4,-
```

OK

```
AT+QSCAN=3,1,3,1 //Search for LTE cells and NR5G cells at the same time, show extension
parameters and configure LTE Band 3 and NR5G Band 1.
```

```
+QSCAN: "NR5G",460,11,427210,810,-123,-16,-3,0,69067E483,690E0F,106,1,20,6,-
```

```
+QSCAN: "NR5G",460,01,427210,810,-123,-16,-3,0,69067E483,690E0F,106,1,20,6,-
```

```
+QSCAN: "LTE",460,11,1850,378,-83,-13,46,115,DD8A33F,691D,100,3
```

```
+QSCAN: "LTE",460,00,1300,123,-75,-7,51,122,D6B5C0,550B,100,3
```

```
+QSCAN: "LTE",460,01,1506,157,-122,-17,6,112,5AC820C,DE10,50,3
```

```
+QSCAN: "LTE",460,01,1650,465,-85,-6,37,119,5A29C0B,DE10,100,3
```

OK

```
AT+QSCAN=2,3 //Search only for NR5G cells and show extension parameters.
```

```
+QSCAN:"NR5G",460,00,504990,631,-83,-11,38,1,170C23000,46550B,273,41,30,6,-,"CMCC","CHINA
MOBILE"
```

```
+QSCAN: "NR5G",460,15,504990,631,-83,-11,38,1,170C23000,46550B,273,41,30,6,-,"-","-
```

```
+QSCAN:"NR5G",460,00,152650,30,-121,-14,-,0,175E7A001,46550B,160,28,15,10,0,"CMCC","CHIN
A MOBILE"
```

```
+QSCAN: "NR5G",460,15,152650,30,-121,-14,-,0,175E7A001,46550B,160,28,15,10,0,-,"-"
```

```
+QSCAN:"NR5G",460,11,633984,841,-68,-11,52,1,6909DB085,690E0F,273,78,28,4,1,"CT","CHN-CT"
```

```
+QSCAN:"NR5G",460,01,633984,841,-68,-11,52,1,6909DB085,690E0F,273,78,28,4,1,"UNICOM","CH
N-UNICOM"
```

```
+QSCAN: "NR5G",460,11,633984,223,-92,-12,28,1,69034E007,690E0F,273,78,28,4,1,"CT","CHN-CT"
```

```
+QSCAN:"NR5G",460,01,633984,223,-92,-12,28,1,69034E007,690E0F,273,78,28,4,1,"UNICOM","CH
N-UNICOM"
```

OK

2.3.13. AT+QNETRC Get the Cause of Network Rejection

This command gets the cause of network rejection. This Write Command sets whether to present URC and controls the presentation of the URC **+QNETRC: "emm_cause",<emm_reject_cause>** when **<mode>** & 0x01 = 1 and the module receives a rejection code issued by the network during LTE network registration, the URC **+QNETRC: "esm_cause",<esm_reject_cause>** when **<mode>** & 0x02 = 2 and the module receives a rejection code issued by the network during LTE session management process, or the URC **+QNETRC: "5gmm_cause",<5gmm_reject_cause>** when **<mode>** & 0x4 = 4 and the module receives a rejection code issued by the network during 5G network registration.

AT+QNETRC Get the Cause of Network Rejection

Read Command AT+QNETRC?	Response +QNETRC: "emm_cause",<emm_reject_cause> +QNETRC: "esm_cause",<esm_reject_cause> +QNETRC: "5gmm_cause",<5gmm_reject_cause> OK
Write Command AT+QNETRC=<mode>	Response OK Or ERROR
Execution Command AT+QNETRC	Response +QNETRC: <mode> OK
Characteristics	-

Parameter

<mode>	Integer type. Determines the output type of URC sentences by bitwise OR.
0	No URC report
1	EMM URC
2	ESM URC
4	5GMM URC
<emm_reject_cause>	Integer type. EMM reject cause.
0	No cause
2	IMSI unknown in HSS
3	Illegal UE
5	IMEI not accepted
6	Illegal ME
7	EPS services not allowed
8	EPS services and non-EPS services not allowed
9	UE identity cannot be derived by the network

	10	Implicitly detached
	11	PLMN not allowed
	12	Tracking Area not allowed
	13	Roaming not allowed in this tracking area
	14	EPS services not allowed in this PLMN
	15	No Suitable Cells in tracking area
	16	MSC temporarily not reachable
	17	Network failure
	18	CS domain not available
	19	ESM failure
	20	MAC failure
	21	Synch failure
	22	Congestion
	23	UE security capabilities mismatch
	24	Security mode rejected, unspecified
	25	Not authorized for this CSG
	26	Non-EPS authentication unacceptable
	31	Redirection to 5GCN required
	35	Requested service option not authorized in this PLMN
	39	CS service temporarily not available
	40	No EPS bearer context activated
	42	Severe network failure
	95	Semantically incorrect message
	96	Invalid mandatory information
	97	Message type non-existent or not implemented
	98	Message type not compatible with the protocol state
	99	Information element non-existent or not implemented
	100	Conditional IE error
	101	Message not compatible with the protocol state
	111	Protocol error, unspecified
<esm_reject_cause>		Integer type. ESM reject cause.
	0	No cause
	8	Operator Determined Barring
	26	Insufficient resources
	27	Missing or unknown APN
	28	Unknown PDN type
	29	User authentication failed
	30	Request rejected by Serving GW or PDN GW
	31	Request rejected, unspecified
	32	Service option not supported
	33	Requested service option not subscribed
	34	Service option temporarily out of order
	35	PTI already in use
	36	Regular deactivation

37	EPS QoS not accepted
38	Network failure
39	Reactivation requested
41	Semantic error in the TFT operation
42	Syntactical error in the TFT operation
43	Invalid EPS bearer identity
44	Semantic errors in packet filter(s)
45	Syntactical errors in packet filter(s)
46	Unused (see NOTE 2)
47	PTI mismatch
49	Last PDN disconnection not allowed
50	PDN type IPv4 only allowed
51	PDN type IPv6 only allowed
52	Single address bearers only allowed
53	ESM information not received
54	PDN connection does not exist
55	Multiple PDN connections for a given APN not allowed
56	Collision with network initiated request
57	PDN type IPv4v6 only allowed
58	PDN type non IP only allowed
59	Unsupported QCI value
60	Bearer handling not supported
61	PDN type Ethernet only allowed
65	Maximum number of EPS bearers reached
66	Requested APN not supported in current RAT and PLMN combination
81	Invalid PTI value
95	Semantically incorrect message
96	Invalid mandatory information
97	Message type non-existent or not implemented
98	Message type not compatible with the protocol state
99	Information element non-existent or not implemented
100	Conditional IE error
101	Message not compatible with the protocol state
111	Protocol error, unspecified
112	APN restriction value incompatible with active EPS bearer context
113	Multiple accesses to a PDN connection not allowed
<5gmm_reject_cause> Integer type. 5GMM reject cause.	
0	No cause
3	Illegal UE
5	PEI not accepted
6	Illegal ME
7	5GS services not allowed
9	UE identity cannot be derived by the network

10	Implicitly de-registered
11	PLMN not allowed
12	Tracking area not allowed
13	Roaming not allowed in this tracking area
15	No suitable cells in tracking area
20	MAC failure
21	Synch failure
22	Congestion
23	UE security capabilities mismatch
24	Security mode rejected, unspecified
26	Non-5G authentication unacceptable
27	N1 mode not allowed
28	Restricted service area
31	Redirection to EPC required
43	LADN not available
62	No network slices available
65	Maximum number of PDU sessions reached
67	Insufficient resources for specific slice and DNN
69	Insufficient resources for specific slice
71	ngKSI already in use
72	Non-3GPP access to 5GCN not allowed
73	Serving network not authorized
74	Temporarily not authorized for this SNPN
75	Permanently not authorized for this SNPN
76	Not authorized for this CAG or authorized for CAG cells only
77	Wireline access area not allowed
78	PLMN not allowed to operate at the present UE location
79	UAS services not allowed
90	Payload was not forwarded
91	DNN not supported or not subscribed in the slice
92	Insufficient user-plane resources for the PDU session
95	Semantically incorrect message
96	Invalid mandatory information
97	Message type non-existent or not implemented
98	Message type not compatible with the protocol state
99	Information element non-existent or not implemented
100	Conditional IE error
101	Message not compatible with the protocol state
111	Protocol error, unspecified

Example

```
AT+QNETRC=7
OK
```

```

AT+QNETRC
+QNETRC: 7

OK
AT+QNETRC?
+QNETRC: "emm_cause",7
+QNETRC: "esm_cause",0
+QNETRC: "5gmm_cause",0

OK

```

2.3.14. AT+QMBNCFG="List" Query Imported MBN File List

This command queries the imported MBN file list.

AT+QMBNCFG="List" Query Imported MBN File List

Write Command AT+QMBNCFG="List"	Response +QMBNCFG:"List",<index>,<selected>,<activate>,<MBN name>,<MBN_version>,<MBN_release_date> ... OK
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration will not be saved automatically.

Parameter

<index>	Integer type. The MBN index indicates which imported MBN file is currently listed.
<selected>	Integer type. Indicates whether the MBN file is selected. 0 Unselected 1 Selected
<activate>	Integer type. Indicates whether the MBN file is activated. 0 Inactivated 1 Activated
<MBN name>	String type. The name of the imported MBN file.
<MBN_version>	String type. The version of the imported MBN file.
<MBN_release_date>	String type. The release date of the imported MBN file.

Example

```
AT+QMBNCFG="list"
```

```
+QMBNCFG: "List",0,0,1,"ROW_Generic_3GPP",0x06010821,201706061
```

```
+QMBNCFG: "List",1,0,0,"Volte_OpenMkt-Commercial-CMCC",0x06012064,201706061
```

```
+QMBNCFG: "List",2,0,0,"OpenMkt-Commercial-CU",0x06011510,201706062
```

```
+QMBNCFG: "List",3,0,0,"Telstra-Commercial_VoLTE",0x0680010F,201710261
```

```
+QMBNCFG: "List",4,1,0,"hVoLTE-Verizon",0x060101A0,201801081
```

```
OK
```

2.3.15. AT+QNWPREFCFG="rat_acq_order" Set RAT Priority

This command sets the RAT acquisition order.

AT+QNWPREFCFG="rat_acq_order" Set RAT Priority

Write Command	Response
AT+QNWPREFCFG="rat_acq_order" [,<rat_order>]	If the optional parameter is omitted, query the current setting: +QNWPREFCFG: "rat_acq_order",<rat_order>
	OK
	If the optional parameter is specified, set the RAT acquisition order: OK
	If there is any error: ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect after the module is rebooted. The configuration is saved automatically.

Parameter

<rat_order>	String type without double quotes. RAT priority. Format: <rat_order1>:<rat_order2>:...:<rat_ordern>. RATs supported: WCDMA LTE NR5G
-------------	---

NOTE

Executing **AT+QNWPREFCFG="rat_acq_order",<rat_order>** writes data to NVM. Please proceed with caution.

Example

```

AT+QNWPREFCFG= "rat_acq_order" //Query the current RAT order.
+QNWPREFCFG: "rat_acq_order",NR5G:LTE:WCDMA

OK
AT+QNWPREFCFG= "rat_acq_order",LTE:NR5G:WCDMA //Set RAT order priority.
OK
AT+CFUN=1,1 //Reset the module.
OK
AT+QNWPREFCFG= "rat_acq_order" //Query the current RAT order.
+QNWPREFCFG: "rat_acq_order", LTE:NR5G:WCDMA

OK

```

2.3.16. AT+QNWPREFCFG="gw_band" Set WCDMA Band

This command specifies the preferred WCDMA band to be searched by UE.

AT+QNWPREFCFG="gw_band" Set WCDMA Band

Write Command	Response
AT+QNWPREFCFG="gw_band"	If the optional parameter is omitted, query the current setting:
[,<gw_band>]	+QNWPREFCFG: "gw_band",<gw_band>
	OK
	If the optional parameter is specified, set the preferred WCDMA bands to be searched:
	OK
	If there is any error:
	ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<gw_band>	String type. WCDMA bands to be configured. Format: <WCDMA_band1>:<WCDMA_band2>:...:<WCDMA_bandn>
<WCDMA_band>	Integer type. WCDMA band.
	1 WCDMA 2100 band
	2 WCDMA 1900 band

3	WCDMA 1800 band
4	WCDMA 1700 band
5	WCDMA 850 band
6	WCDMA 800 band
8	WCDMA 900 band
19	WCDMA Japan 850 band

NOTE

1. See the specific module specification for the bands that can be supported.
2. When the module locks to WCDMA, an error is reported if **<gw_band>** is set to null.
3. Executing **AT+QNWPRECFG="gw_band",<gw_band>** writes data to NVM. Please proceed with caution.

Example

```
AT+QNWPRECFG="gw_band"           //Query the configured WCDMA bands of the UE.
+QNWPRECFG: "gw_band",1:2:3:4:5:6:7:8:9:19
```

OK

```
AT+QNWPRECFG="gw_band",1:2       //Set WCDMA B1 and B2.
```

OK

2.3.17. AT+QNWPRECFG="lte_band" Set LTE Band

This command specifies the preferred LTE band to be searched by UE.

AT+QNWPRECFG="lte_band" Set LTE Band

Write Command AT+QNWPRECFG="lte_band" [,<LTE_band>]	Response If the optional parameter is omitted, query the current setting: +QNWPRECFG: "lte_band",<LTE_band> OK If the optional parameter is specified, set the preferred LTE bands to be searched: OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<LTE_band	String type. LTE bands to be configured. Format: <band1>:<band2>:...:<bandn> .
<band>	Integer type. LTE bands supported by the module.
1-5	B1-B5
7	B7
8	B8
12-14	B12-B14
17-20	B17-B20
25	B25
26	B26
28-30	B28-B30
32	B32
34	B34
38-43	B38-B43
48	B48
66	B66
71	B71

NOTE

1. See the specific module specification for the bands that are supported.
2. When the module locks to LTE, an error is reported if **<LTE_band>** is set to null.
3. Executing **AT+QNWPREFCFG="lte_band",<LTE_band>** writes data to NVM. Please proceed with caution.

Example

```

AT+QNWPREFCFG="lte_band"           //Query the configured LTE bands of the UE.
+QNWPREFCFG: "lte_band",1:2:3:4:5:7:8:12:13:14:17:18:19:20:25:26:28:29:30:32:34:38:39:40:41:
42:66:71

OK
AT+QNWPREFCFG="lte_band",1:2       //Set LTE B1 and LTE B2.
OK

```

2.3.18. AT+QNWPREFCFG="nsa_nr5g_band" Configure NR5G NSA Band

This command configures the preferred NR5G NSA bands to be searched by UE.

AT+QNWPREFCFG="nsa_nr5g_band" Configure NR5G NSA Band

Write Command	Response
AT+QNWPREFCFG="nsa_nr5g_band"	If the optional parameter is omitted, query the current

[,<NSA_NR5G_band>]	configuration: +QNWPREFCFG: "nsa_nr5g_band",<NSA_NR5G_band> OK If the optional parameter is specified, configure the preferred NR5G NSA bands to be searched: OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<NSA_NR5G_band>	String type without double quotes. 5G NSA bands to be configured. Format:
	<NSA_band1>:<NSA_band2>:...:<NSA_bandn>
<NSA_band>	Integer type. 5G NSA band. The configurable 5G NSA bands supported by the module.
	1–3 n1–n3
	5 n5
	7 n7
	8 n8
	12 n12
	20 n20
	25 n25
	28 n28
	38 n38
	40 n40
	41 n41
	48 n48
	66 n66
	71 n71
	77–79 n77–n79
	257 n257
	258 n258
	260 n260
	261 n261

NOTE

1. See the specific module specification for the bands that are supported.
2. When the module locks to NR5G NSA, an **ERROR** is reported if **<NSA_NR5G_band>** is set to null.
3. Executing **AT+QNWPREFCFG="nsa_nr5g_band",<NSA_NR5G_band>** writes data to NVM. Please proceed with caution.

Example

```
AT+QNWPREFCFG="nsa_nr5g_band" //Query the currently configured NR5G NSA bands of UE.
+QNWPREFCFG: "nsa_nr5g_band",1:3:7:20:28:40:41:71:77:78:79
```

OK

```
AT+QNWPREFCFG="nsa_nr5g_band",1:2//The preferred NR5G NSA bands to be searched by UE in
NR5G NSA mode are n1 and n2.
```

OK

2.3.19. AT+QNWPREFCFG="nr5g_band" Configure NR5G SA Band

This command configures the preferred NR5G SA bands to be searched by UE.

AT+QNWPREFCFG="nr5g_band" Configure NR5G SA Band

Write Command	Response
AT+QNWPREFCFG="nr5g_band"[,<SA_NR5G_band>]	If the optional parameter is omitted, query the current setting: +QNWPREFCFG: "nr5g_band",<SA_NR5G_band>
	OK
	If the optional parameter is specified, configure the preferred NR5G SA bands to be searched: OK
	If there is any error: ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<SA_NR5G_band> String type without double quotes. 5G NSA bands to be configured.
Format: **<SA_band1>:<SA_band2>:...:<SA_bandn>**.

<SA_band>	Integer type. SA 5G band. The configurable SA 5G bands supported by the applicable modules.
1-3	n1-n3
7	n7
8	n8
12	n12
20	n20
25	n25
28	n28
38	n38
40	n40
41	n41
48	n48
66	n66
71	n71
77-79	n77-n79
257	n257
258	n258
260	n260
261	n261

NOTE

1. See the specific module specification for the bands that are supported.
2. When the module locks to NR5G SA, an **ERROR** is reported if <SA_NR5G_band> is set to null.
3. Executing **AT+QNWPREFCFG="nr5g_band",<SA_NR5G_band>** writes data to NVM. Please proceed with caution.

Example

```
AT+QNWPREFCFG="nr5g_band" //Query the currently configured NR5G SA bands of the UE.
+QNWPREFCFG: "nr5g_band",1:3:7:20:28:40:41:71:77:78:79
```

OK

```
AT+QNWPREFCFG="nr5g_band",1:2 //The preferred NR5G SA bands to be searched by UE in
NR5G SA mode are n1 and n2.
```

OK

2.3.20. AT+QNWPREFCFG="mode_pref" Configure Network Search Mode

This command configures the network search mode.

AT+QNWPREFCFG="mode_pref" Configure Network Search Mode

Write Command AT+QNWPREFCFG="mode_pref"[,<mode_pref>]	Response If the optional parameter is omitted, query the current setting: +QNWPREFCFG: "mode_pref",<mode_pref> OK If the optional parameter is specified, configure the network search mode: OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configuration is saved automatically.

Parameter

<mode_pref>	String type without double quotes. Use the colon as a separator to list the RATs to be configured. Format: <mode_pref1>:<mode_pref2>:...:<mode_prefn> . The RATs supported by the module are as follows: <table> <tr> <td>AUTO</td><td>WCDMA & LTE & NR5G</td></tr> <tr> <td>WCDMA</td><td>WCDMA only</td></tr> <tr> <td>LTE</td><td>LTE only</td></tr> <tr> <td>NR5G</td><td>NR5G only</td></tr> </table>	AUTO	WCDMA & LTE & NR5G	WCDMA	WCDMA only	LTE	LTE only	NR5G	NR5G only
AUTO	WCDMA & LTE & NR5G								
WCDMA	WCDMA only								
LTE	LTE only								
NR5G	NR5G only								

Example

```

AT+QNWPREFCFG="mode_pref" //Query the current network search mode.
+QNWPREFCFG: "mode_pref",AUTO

OK
AT+QNWPREFCFG="mode_pref",LTE //Set RAT to LTE only.
OK
AT+QNWPREFCFG="mode_pref",LTE:NR5G //Set RAT to LTE & NR5G.
OK

```

2.3.21. AT+QNWPREFCFG="ue_capability_band" Query UE Capability Band

This command queries the band configured in the UE capability information.

AT+QNWPREFCFG="ue_capability_band" Query UE Capability Band

Write Command	Response
AT+QNWPREFCFG="ue_capability_band"	+QNWPREFCFG: "gw_band",<gw_band> +QNWPREFCFG: "lte_band",<LTE_band> +QNWPREFCFG: "nsa_nr5g_band",<NSA_NR5G_band> +QNWPREFCFG: "nr5g_band",<SA_NR5G_band> OK
Maximum Response Time	300 ms
Characteristics	-

Parameter

<gw_band>	String type without double quotes. Use the colon as a separator to list the WCDMA bands to be configured. The parameter format is: <WCDMA_band1>:<WCDMA_band2>:...:<WCDMA_bandn>
<WCDMA_band>	Integer type. WCDMA band. 1 WCDMA 2100 band 2 WCDMA 1900 band 3 WCDMA 1800 band 4 WCDMA 1700 band 5 WCDMA 850 band 6 WCDMA 800 band 8 WCDMA 900 band 19 WCDMA Japan 850 band
<LTE_band>	String type without double quotes. Use the colon as a separator to list the LTE bands to be configured. The parameter format is: <band1>:<band2>:...:<bandn>.
<band>	Integer type. LTE band.
<NSA_NR5G_band>	String type without double quotes. Use the colon as a separator to list the NR5G NSA bands to be configured. The parameter format is: <NSA_band1>:<NSA_band1>:...:<NSA_bandn>
<NSA_band>	Integer type. NR5G NSA band.
<SA_NR5G_band>	String type without double quotes. Use the colon as a separator to list the NR5G SA bands to be configured. The parameter format is: <SA_band1>:<SA_bandx>:...:<SA_bandn>
<SA_band>	Integer type. NR5G SA band.

Example

```
AT+QNWPREFCFG="ue_capability_band"
```

```
+QNWPREFCFG: "gw_band",1:8
```

```
+QNWPREFCFG: "lte_band",1:3:8
```

```
+QNWPREFCFG: "nsa_nr5g_band",78
```

```
+QNWPREFCFG: "nr5g_band",78
```

```
OK
```

3 Network Registration/Attachment Flow

The network registration/attachment flow of the module is as follows:

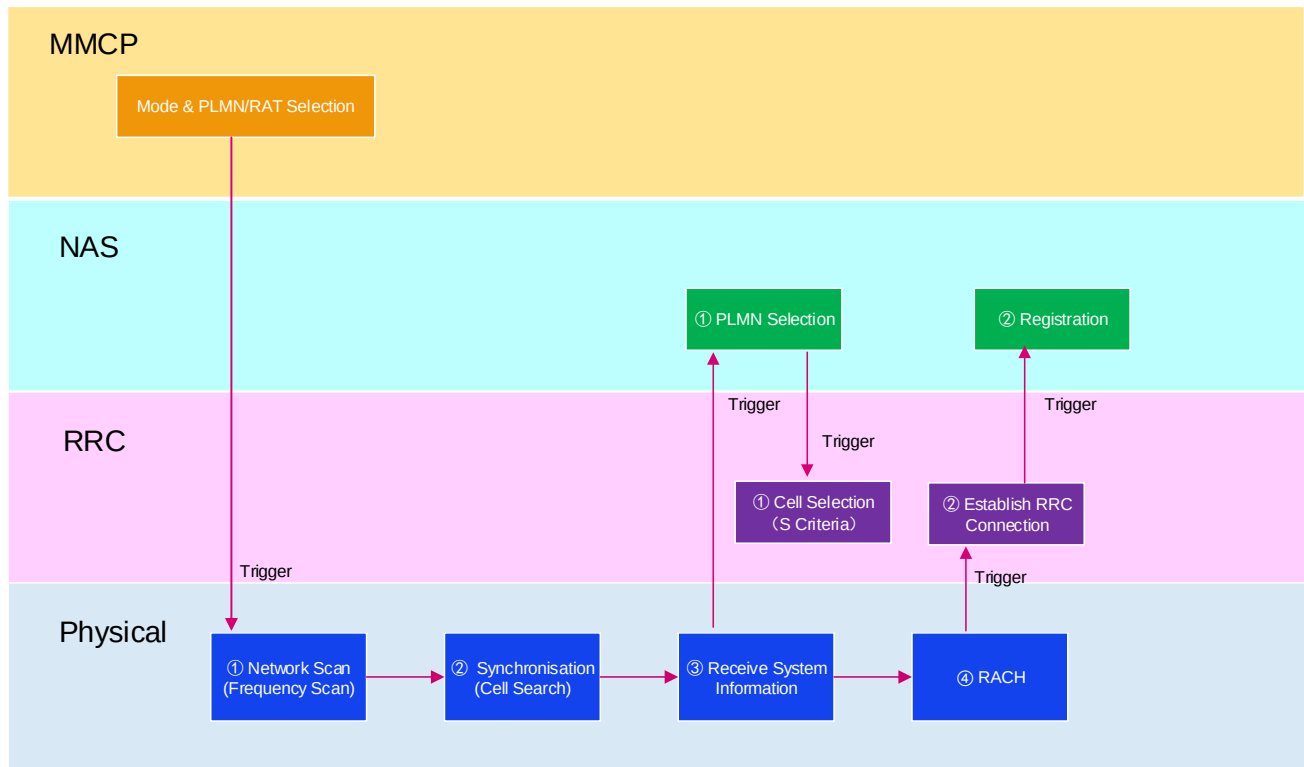


Figure 1: Network Registration/Attachment

3.1. PLMN/RAT Selection

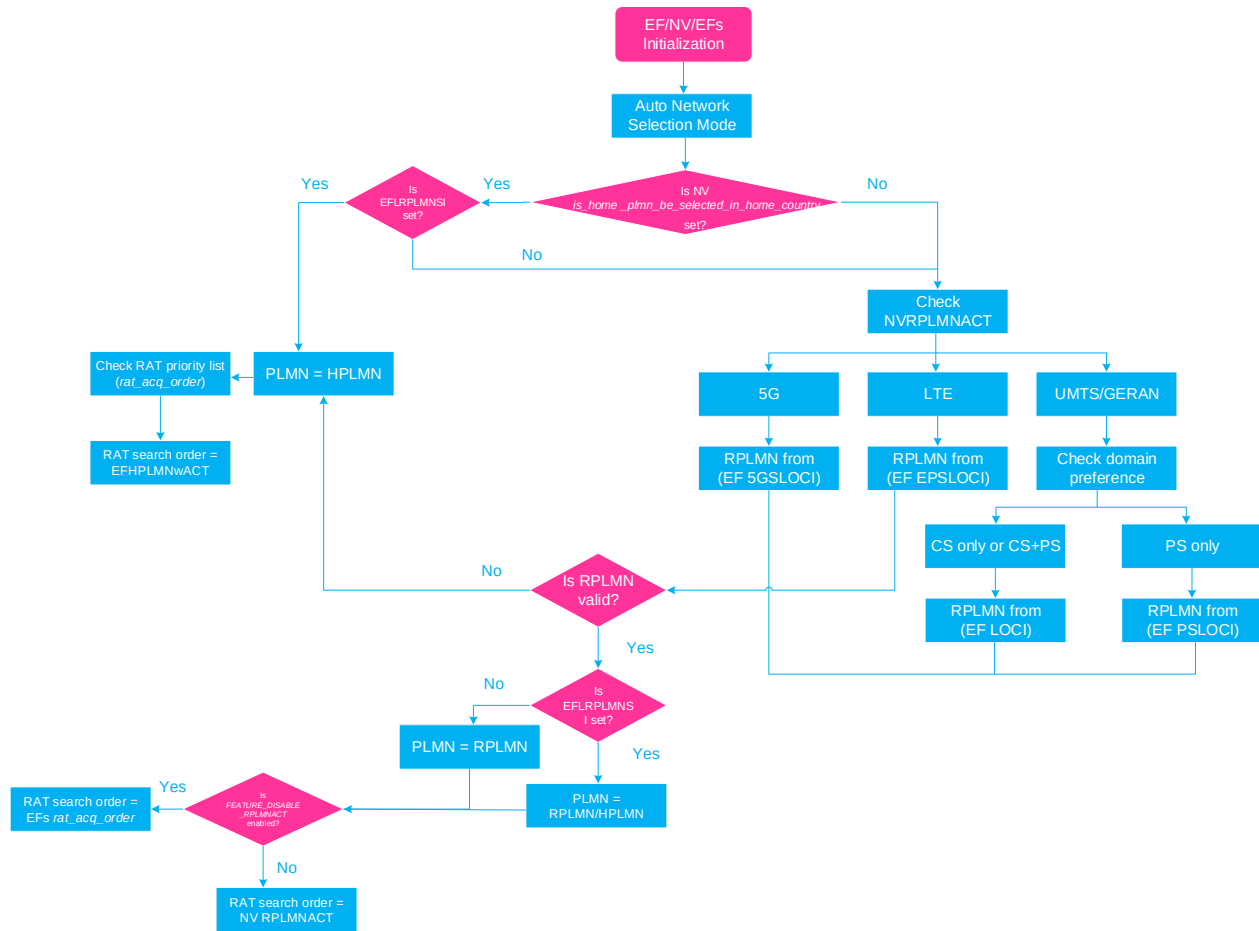


Figure 2: PLMN/RAT Selection

3.1.1. Related SIM Files

Related SIM files include:

- *EFLRPLMNSI* Last Registered PLMN Selection Indication
- *EFIMS* IMSI
- *EFHPLMN* Equivalent HPLMN
- *EFPLMNwAcT* User-controlled PLMN Selector with Access Technology
- *EFOPLMNwAcT* Operator-controlled PLMN Selector with Access Technology
- *EFHPLMNwAcT* HPLMN Selector with Access Technology
- *EFHPPLMN* Higher-priority PLMN Search Period
- *EFFPLMN* Forbidden PLMN
- *EFLOC* Location Information
- *EFPSLOC* Packet-switched Location Information
- *EFEPSLOC* EPS Location Information
- *EF5GS3GPPLOCI* 5GS Location Information

3.1.2. PLMN/RAT Selection Process

3.1.2.1. Automatic Selection of PLMN/RAT

The search order during RAT/PLMN selection is determined by either the module setting (NV parameters) or files in the (U)SIM card. The files in the (U)SIM card have higher priority.

The module should select the last registered PLMN (LRPLMN) or equivalent PLMN (if it is available) using all access technologies that the module is capable of.

As reported in *3GPP 23.122 section 4.4.3.1*, if there is no LRPLMN, or if registration is not possible due to the PLMN being unavailable or registration failure at switch-on or recovery from lack of coverage, the module should select and attempt registration on PLMNs if available and allowable using all access technologies that the module is capable of in the following order:

1. Either the HPLMN (if the EHPLMN list is not present or is empty) or the highest priority EHPLMN that is available (if the EHPLMN list is present);
2. Each PLMN/access technology combination in the "User-controlled PLMN Selector with Access Technology" data file in the (U)SIM card (in priority order);
3. Each PLMN/access technology combination in the "Operator-controlled PLMN Selector with Access Technology" data file in the (U)SIM card (in priority order) or stored in the module (in priority order);
4. Other PLMN/access technology combinations with received high-quality signals in random order;
5. Other PLMN/access technology combinations in order of decreasing signal quality.

3.1.2.2. Roaming Registration on VPLMN

If the module is in a VPLMN, it 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 combination listed in "User-controlled PLMN Selector" or "Operator-controlled PLMN Selector" by scanning in accordance with the requirements that are applicable to *i)*, *ii)* and *iii)* as defined in the Automatic Network Selection Mode in *3GPP 23.122 subclause 4.4.3.1.1*.

In the case that the module has a stored "Equivalent PLMNs" list, the module shall only select a PLMN if it is of a higher priority than those of the same country as the current serving PLMN which are stored in the "Equivalent PLMNs" list. For this purpose, a value of T minutes may be stored in the (U)SIM card. T is either in the range of 6 minutes to 8 hours in 6-minute steps or it indicates that no periodic attempts shall be made. If no value is stored in the (U)SIM card, a default value of 60 minutes is used.

The attempts to access the HPLMN or an EHPLMN or higher-priority PLMN shall be as specified below:

- The periodic attempts shall only be performed in automatic mode when the module is roaming;
- After switch-on, a period of at least 2 minutes and at most T minutes shall elapse before the first attempt is made;

- The module shall make the following attempts if the module is on the VPLMN at time T after the last attempt;
- Periodic attempts shall only be performed by the module while in idle mode;
- If the HPLMN (if the EHPLMN list is not present or is empty) or an EHPLMN (if the list is present) or a higher priority PLMN is not found, the module shall remain on the VPLMN.

3.1.2.3.RPLMN Clearance

RPLMN is stored in the (U)SIM card. The value of RPLMN is stored in EF files *EFLOCI*, *EFPSLOC*, *EFEPSLOC* and *EF5GS3GPPLOC* in the (U)SIM card. RPLMN can be cleared through **AT+QNWCFG="clr_rplmn"**, clearing the contents of the EF files in the (U)SIM card.

3.1.2.4.HPLMN Search Timer Configuration

The setting of the higher priority PLMN search period (unit: 6 minutes) is stored in the EFHPPLMN file. If the higher priority PLMN search period is configured as 00, it indicates no higher priority PLMN search attempts, that is, the HPLMN search timer is turned off. If the higher priority PLMN search period is configured as YZ, the time value is $(16Y + Z) \times 6$ minutes.

QMI_NAS_SET_HPLMN_SEARCH_TIMER in the module is used to set a search timer in minutes. The timer value set by *QMI_NAS_SET_HPLMN_SEARCH_TIMER* will override the value of EFHPPLMN. When the timer value set by *QMI_NAS_SET_HPLMN_SEARCH_TIMER* is 0, it means that HPLMN search timer is turned off; when the timer value is set to X, the search time is X minutes.

At the same time, Quectel provides **AT+QNWCFG="hplmn_search_timer"<timer_value>** designed based on *QMI_NAS_SET_HPLMN_SEARCH_TIMER* to set a search timer in minutes.

3.1.2.5.RAT Priority Change During RPLMN Search

As shown in **Figure 2**, when RPLMN is selected to search the network, the selection of RPLMN RAT will be determined based on the configuration of the macro *FEATURE_DISABLE_RPLMNACT*, which is located in the code provided by the chip manufacturer. When this macro is enabled, it indicates that RPLMNACT is disabled.

AT+QNWCFG="dis_rplmnact" is used to control the function of the macro *FEATURE_DISABLE_RPLMNACT*. **AT+QNWPRECFG="rat_acq_order"** is used to configure the RAT search order (EFs *rat_acq_order* in **Figure 2**).

For example, if you want to configure the RPLMN RAT priority order to NR5G > LTE > WCDMA, the command configuration should be as follows:

- **AT+QNWCFG="dis_rplmnact",1**

- AT+QNWPREFCFG="rat_acq_order",NR5G:LTE:WCDMA

3.2. Network Search/Scan

The goal of the network search phase is to find a suitable cell to camp on. A suitable cell must meet the following requirements:

1. The cell meets the S criteria (see TS 38.304 5.2.3.2 in 3GPP for details).
2. The PLMN of the cell complies with the requirements of the NAS layer.

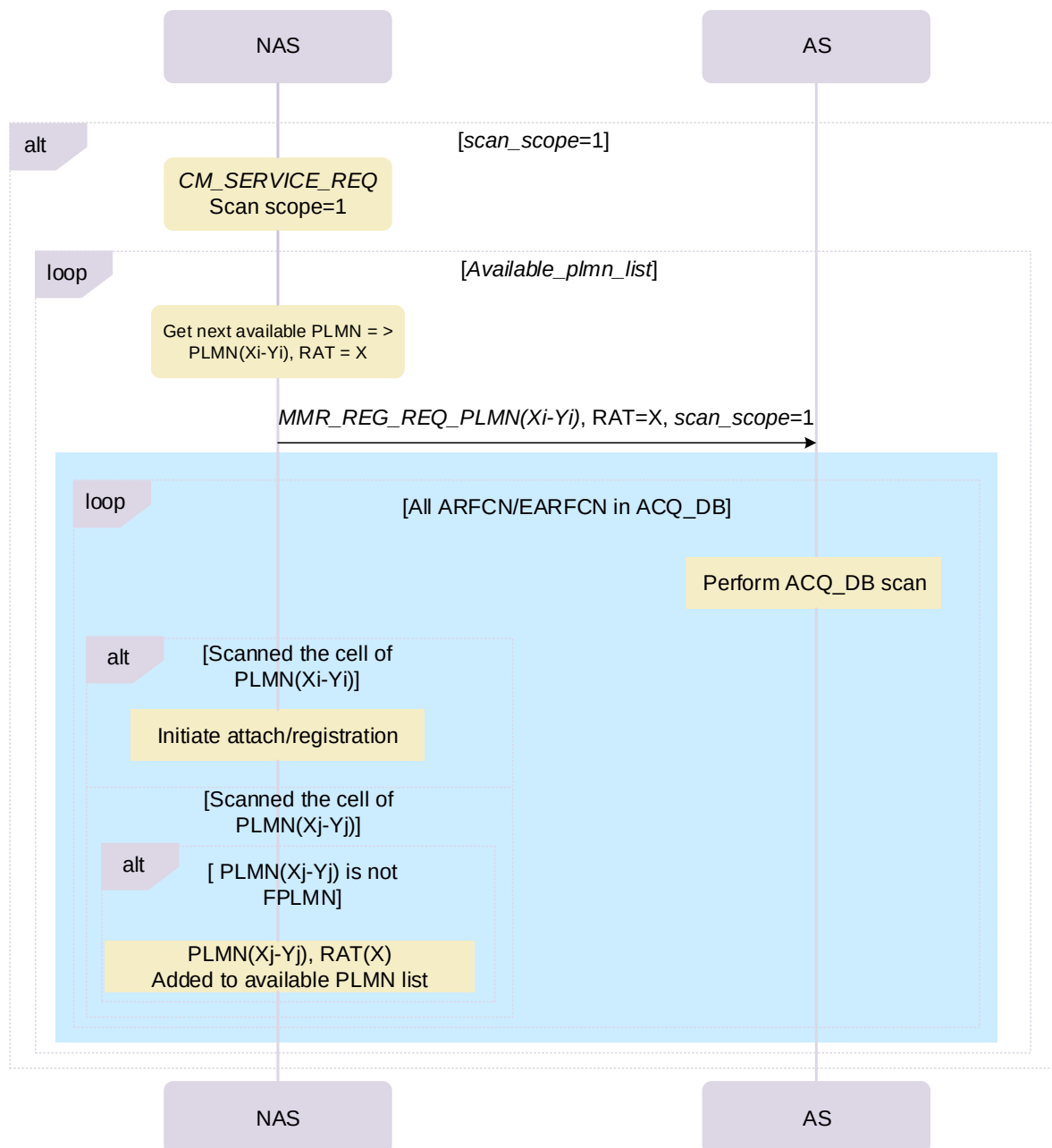


Figure 3: Network Search and Scan (Scan Scope 1)

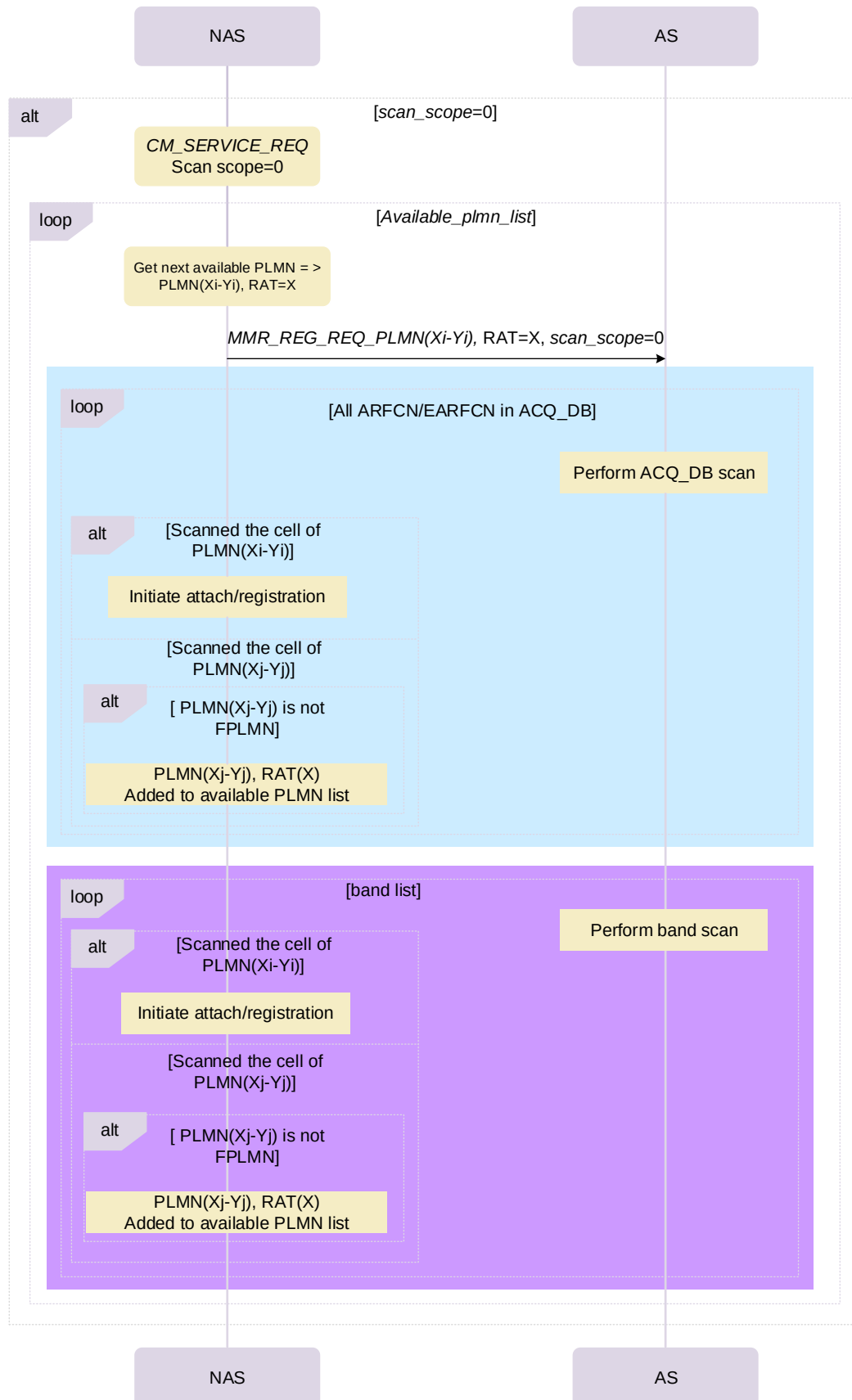


Figure 4: Network Search and Scan (Scan Scope 0)

3.2.1. System Scan

1. ACQ_DB ARFCNs/EARFCNs: The module stores the recently camped cell information named ACQ_DB, which is the historical ARFCNs/EARFCNs.
2. CPFL ARFCNs/EARFCNs: The preferred ARFCNs/EARFCNs which can be configured by **AT+QNWCFG="lte_pref_freq_list"** for LTE and **AT+QNWCFG="nr5g_pref_freq_list"** for NR5G.
3. System scan searches ARFCNs/EARFCNs in ACQ_DB and CPFL (if present).

3.2.2. Band Scan

1. The module searches the ARFCNs/EARFCNs in all the supported bands in ascending order by default.
2. The module searches the ARFCNs/EARFCNs in preferred bands if present.
3. The band priority can be configured by **AT+QNWCFG="lte_band_priority"** for LTE and **AT+QNWCFG="nr5g_band_priority"** for NR5G.

NOTE

AT+QNWCFG="nr5g_band_priority" is not applicable for RG500Q series, RG501Q-EU, RG502Q series, RM500Q series, RM502Q-AE, RM505Q-AE or RM510Q-GL.

3.3. Network Registration/Attachment

When the module selects a suitable cell, it will trigger a network attachment/registration.

3.3.1. WCDMA GMM Attachment

For WCDMA, the module triggers GMM Attach Request at the NAS level. WCDMA network shall send *LOCATION_UPDATE_REQUEST* and *GMM_ATTACH_REQUEST* to the module at the same time.

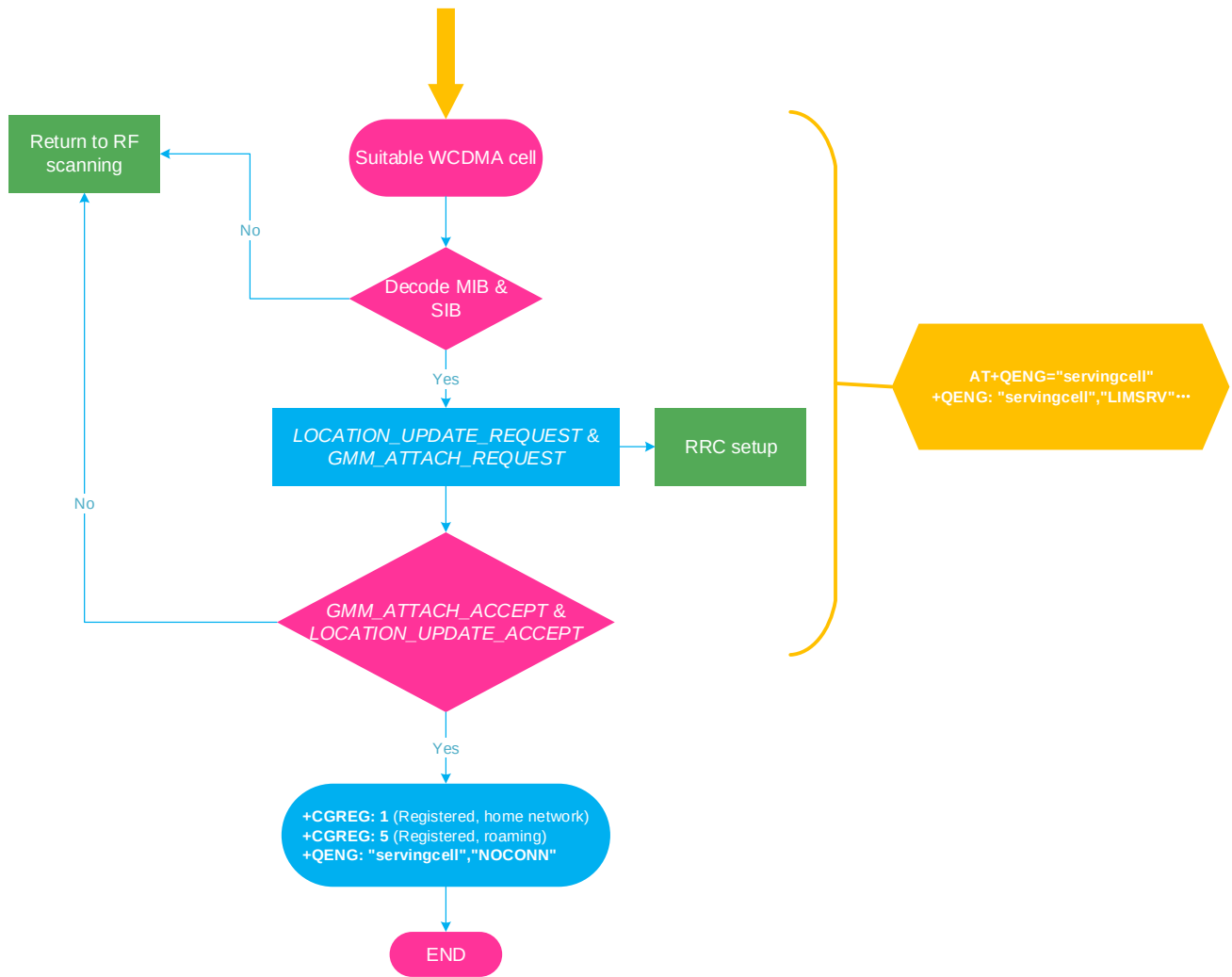


Figure 5: WCDMA GMM Attachment

3.3.2. LTE Attachment

For LTE, the module triggers an attach request at the NAS level. The module always connects to the LTE network. The LTE system shall establish a default bearer when the module registers to the LTE network.

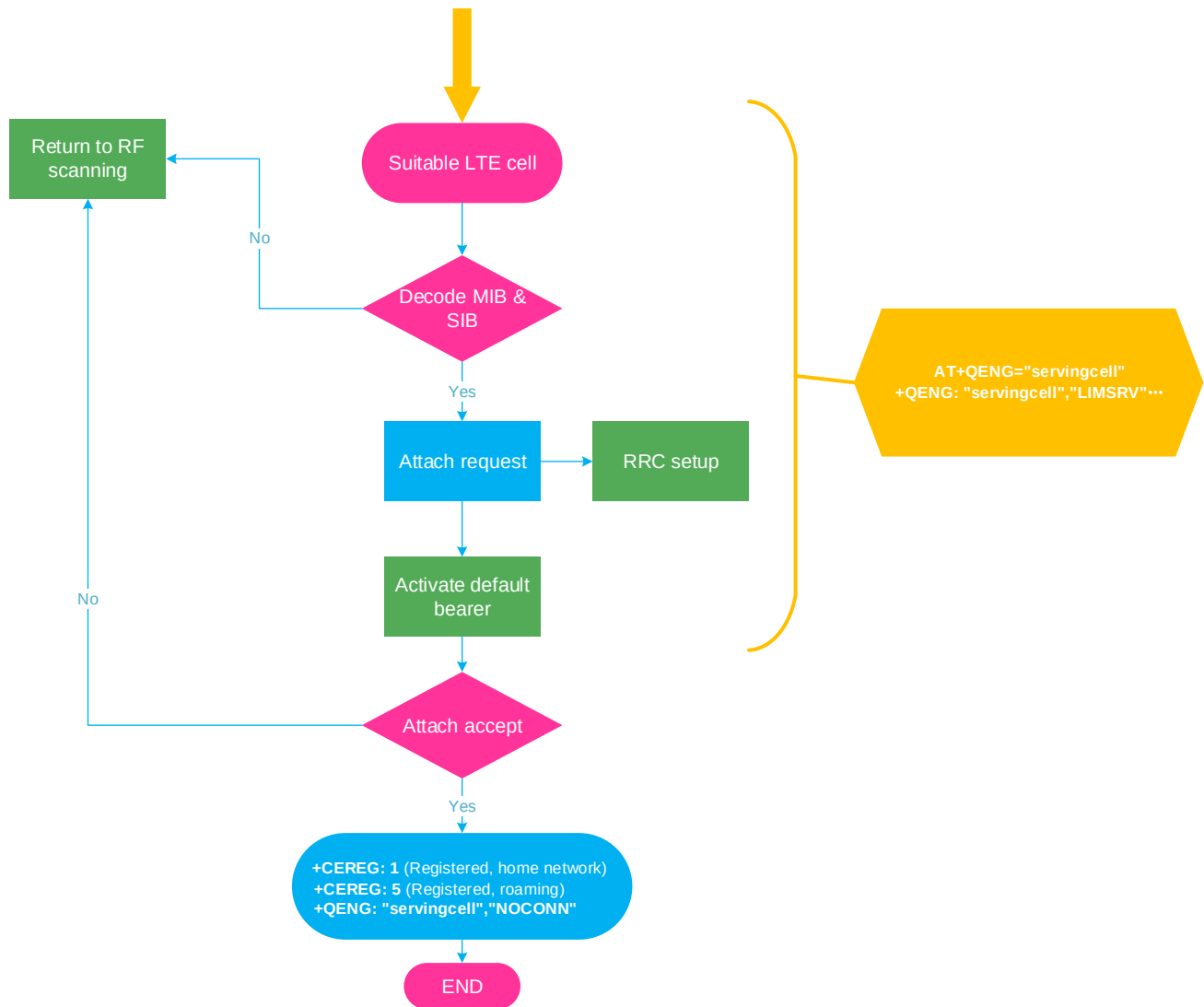


Figure 6: LTE Attachment

3.3.3. NR5G Registration

For NR5G, the module triggers a registration request at the NAS level. With single registration, the 5G system shall not establish a default PDU session when the module registers to the NR5G network.

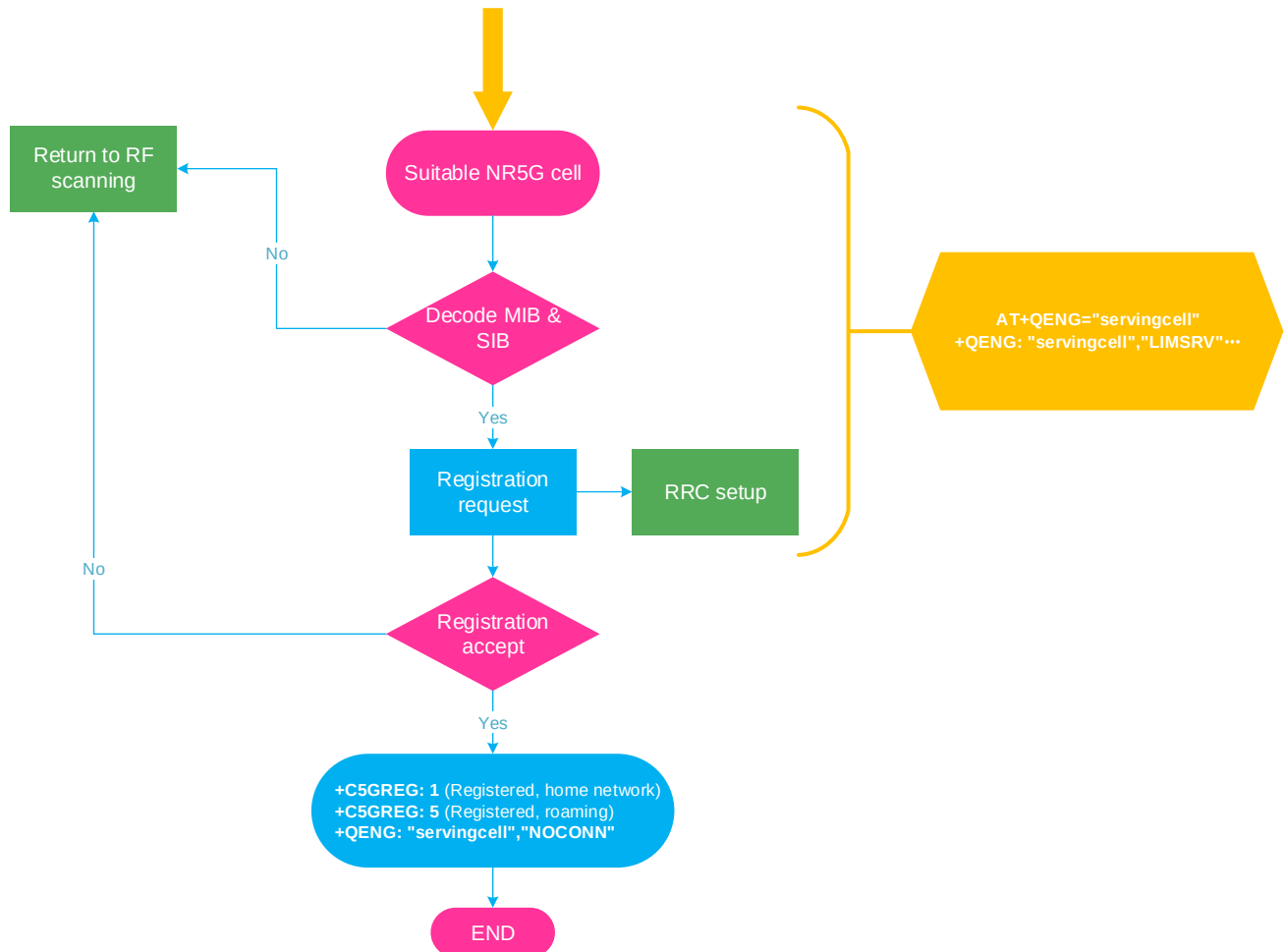


Figure 7: NR5G Registration

3.4. Network Service

3.4.1. PDP Context

The properties of the data call, including IP type, APN or DNN name and others, are defined in the APN profile (alias PDP context).

- The PDP context can be modified through **AT+CGDCONT**.
- The APN authentication can be modified through **AT+QICSGP**.

3.4.2. Data Service

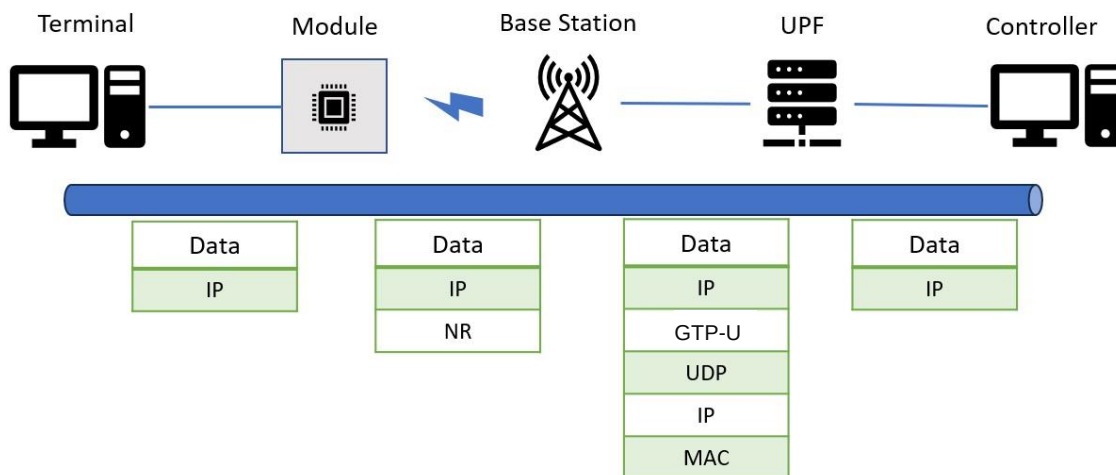


Figure 8: Data Service

3.4.2.1.Data Service in WCDMA

1. PDP context should not be activated when the module registers to the WCDMA network.
2. If the terminal needs to trigger a service request, the module will trigger *ACTIVATE_PDP_CONTEXT_REQUEST* at the NAS level.

3.4.2.2.Data Service in LTE

1. The LTE system shall establish a default bearer when the module registers to the LTE network.
2. When the terminal triggers a network request, the data path between the terminal and the module is established.
3. If the terminal needs to establish 2 or more data links, the module will establish an equivalent number of PDN connections.
4. The first PDN connection will use the default bearer established upon network registration, while subsequent connections will initiate the establishment of new default bearers.
5. In one PDN connection, there may exist one default bearer and several dedicated bearers, all of which are allocated by the network.

3.4.2.3.Data Service in NR5G

1. The 5G system shall not establish a default PDU session when the module registers to the NR5G network.

2. If the terminal needs to establish data links, the module will establish an equivalent number of PDU sessions.

3.4.3. IMS Service

1. If the terminal triggers an IMS service request, the data path with APN or DNN name as "IMS" should be established.
2. For the IMS service data path, the application data should be encapsulated based on RTP, RTCP and other multimedia protocols.

4 Network Registration/Attachment Check

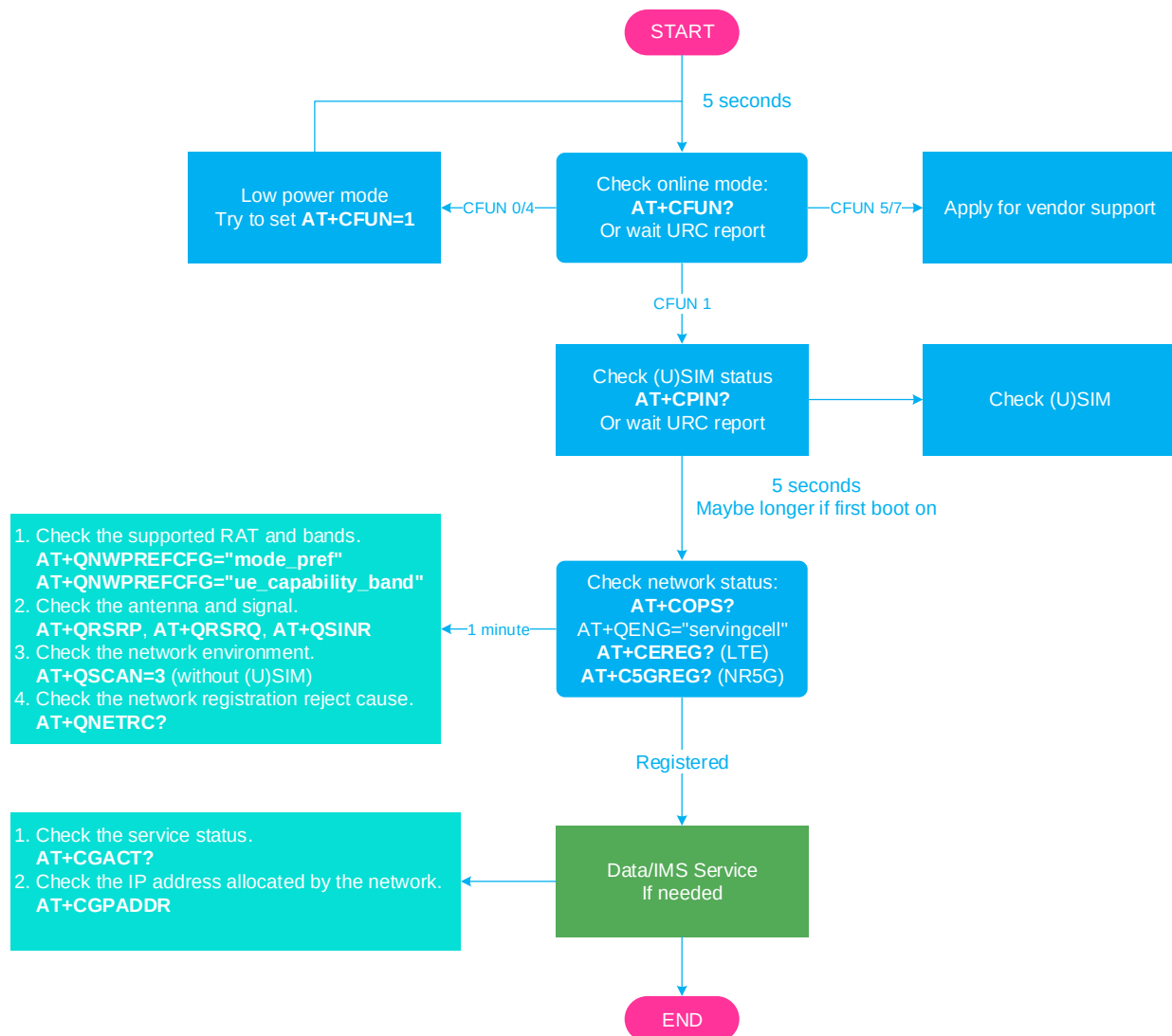


Figure 9: Network Registration/Attachment Check

4.1. Pre-configuration Check

1. Check module status through **AT+CFUN?**. If **+CFUN: 1** is returned, the module is working normally.
2. Check (U)SIM card status through **AT+CPIN?**. If **+CPIN: READY** is returned, the (U)SIM card is working normally.
3. Check RAT capability through **AT+QNWPREFCFG="mode_pref"**. If **+QNWPREFCFG: "mode_pref",AUTO** is returned, the module supports NR5G, LTE and WCDMA.
4. Query the bands supported in the UE capability information through **AT+QNWPREFCFG="ue_capability_band"**. See **Chapter 2.3.21** for details about this command.
5. Get APN profile configuration through **AT+CGDCONT?**. This configuration defines the properties of network registration.
6. Get the activated MBN through **AT+QMBNCFG="list"**.
 - The activated MBN should be checked when the UE band capability or APN profile is incorrect.
 - When the activated MBN is not as expected, check the IMSI and ICCID values of the (U)SIM card through **AT+CIMI** and **AT+ICCID**.

4.2. (U)SIM Card Abnormality Check

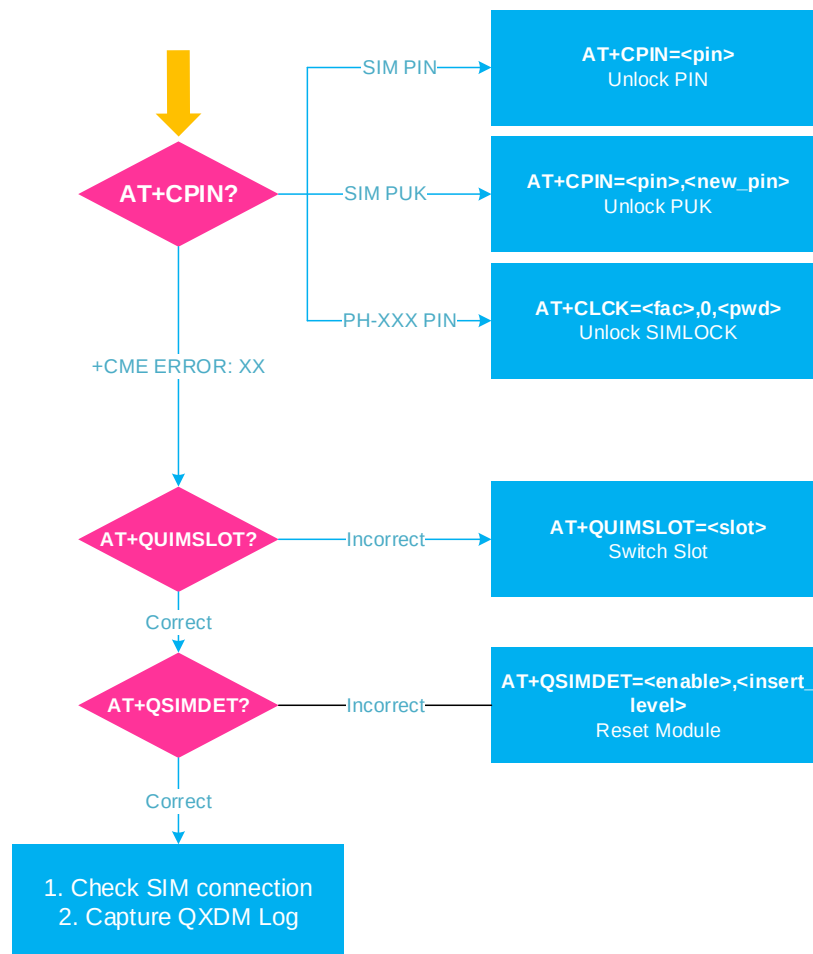


Figure 10: SIM Card Abnormality Check

4.3. Network Search&Registration Check

- Check the network registration status via the following commands.
 - **AT+CREG** Check whether the module is registered on the network in the CS domain.
 - **AT+CGREG** Check whether the module is registered on the GSM/WCDMA network in the PS domain.
 - **AT+CEREG** Check whether the module is registered on the LTE network in the PS domain.
 - **AT+C5GREG** Check whether the module is registered on the NR5G network in the PS domain.
 - **AT+COPS** Return the current operators and their status, and allows automatic or manual network selection.
 - **AT+QENG** Obtain network information such as the serving and neighbor cells.
 - **AT+QENDC** Query the EN-DC registration status.

- **AT+QCAINFO** Query carrier aggregation connection information. LTE CA, EN-DC and NR CA are supported.
 - **AT+QNETRC** Get the network rejection cause.
2. Check the signal quality, RSRP, RSRQ and SINR value of the network via **AT+QCSQ**, **AT+QSRP**, **AT+QSRQ** and **AT+QSINR**.
 3. Check the network environment via **AT+QSCAN**.
 4. Check if the module always initiates a limited service request.

The module usually only initiates a limited service request in the following four situations:

- 1) When the module is powered on, the limited service is triggered first;
- 2) When the (U)SIM card is abnormal, the module will trigger the limited service;
- 3) When there is a problem with the Policy Manager configuration, the UE will trigger the limited service;
- 4) When the modem temperature is too high, the module is in the limited service state.

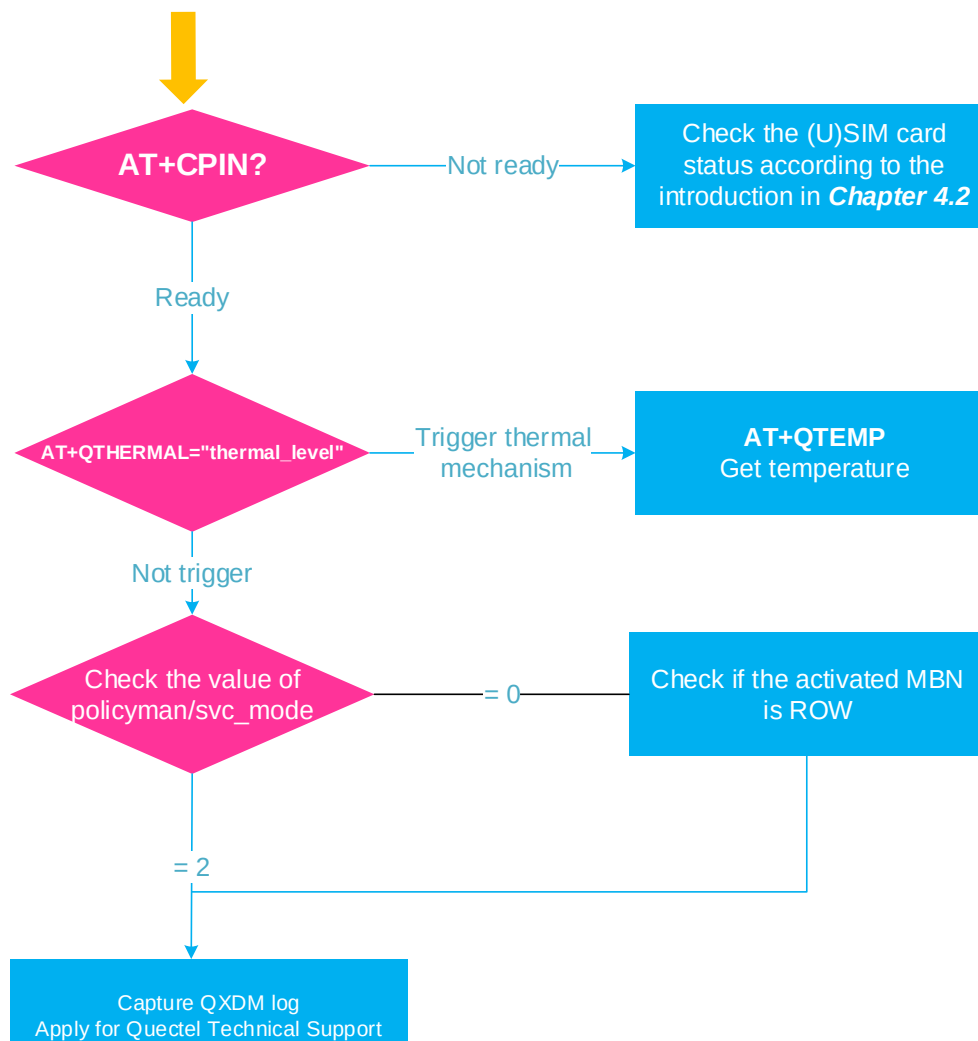


Figure 11: Check the Cause of Limited Network Search

4.4. Network Service Check

The IP address allocated by the network can be queried via **AT+CGPADDR**.

Example for multiple data links.

AT+CGPADDR

+CGPADDR: 1,"0.0.0.0","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0"

+CGPADDR: 2,"0.0.0.0","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0"

+CGPADDR: 3,"0.0.0.0","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0"

+CGPADDR: 4,"10.201.6.214"

+CGPADDR: 5,"10.201.6.201"

+CGPADDR: 6,"10.201.6.217"

OK

The PDP context can be modified via **AT+CGDCONT**.

AT+CGDCONT?

+CGDCONT: 1,"IPV4V6","internet.v6.telekom","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0,,,,,,,,,"",,0

+CGDCONT: 2,"IPV4V6","ims","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0,,,,,,,,,"",,0

+CGDCONT: 3,"IPV4V6","hos","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0,,,,,,,,,"",,0

+CGDCONT: 4,"IPV4V6","sos","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,1,,,,,,,,,"",,0

OK

AT+CGDCONT=1,"IPV4V6","internet"

OK

5 Appendix References

Table 2: Related Documents

Document Name
[1] Quectel_RG520N&RG525F&RG5x0F&RM5x0N&RM521F_Series_AT_Commands_Manual
[2] Quectel_RG50xQ&RM5xxQ_Series_AT_Commands_Manual
[3] Quectel_RG65xE&RG650V&RM550V&RM551E_Series_AT_Commands_Manual
[4] Quectel_RG50xQ&RM5xxQ_Series_Software_Thermal_Management_Guide
[5] Quectel_RG520N&RG525F&RG5x0F&RM5x0N_Series_Software_Thermal_Management_Guide

Table 3: Terms and Abbreviations

Abbreviation	Description
5GCN	5GCN
5GS	5G System
ACQ_DB	Acquisition Database
APN	Access Point Name
ARFCN	Absolute Radio Frequency Channel Number
CA	Carrier Aggregation
CIMI	International Mobile Subscriber Identity
CM	Call Manager
CPFL	Configured Preferred Frequency List
CQI	Channel Quality Indicator
CS	Circuit Switched

DNN	Data Network Name
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
EHPLMN	Equivalent Home PLMN
EN-DC	E-UTRA New Radio Dual Connectivity
EPS	Evolved Packet System
EUTRAN	Evolved Universal Terrestrial Radio Access Network
FPLMN	Forbidden PLMN
GERAN	GSM EDGE Radio Access Network
GMM	GPRS Mobility Management
GTP-U	GPRS Tunneling Protocol-User Plane
HLOS	High-Level Operating System
HPLMN	Home PLMN
ICCID	Integrated Circuit Card Identifier
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
LRPLMN	Last Registered PLMN
LTE	Long-Term Evolution
MAC	Medium Access Control
MBN	Modem Configuration Binary
MCC	Mobile Country Code
MCS	Modulation and Coding Scheme
ME	Mobile Equipment
MMCP	Multimode Call Processor
MNC	Mobile Network Code
MR	Measure Report
MS	Mobile Station
MT	Mobile Termination

NAS	Non-Access Stratum
NCI	NR Cell Identification
NCGI	NR Cell Global Identification
NR	New Radio
NSA	Non-Standalone
NV	Non-volatile
OTA	Over-The-Air Technology
PDN	Packet Data Network
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PDSCH	Physical Downlink Shared Channel
PLMN	Public Land Mobile Network
PMI	Precoding Matrix Indicator
PS	Packet Switch
QMI	Qualcomm Message Interface
RACH	Random Access Channel
RAT	Radio Access Technology
RF	Radio Frequency
RPLMN	Registered PLMN
RRC	Radio Resource Control
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RTCP	Real-time Transport Control Protocol
RTP	Real-time Transport Protocol
SA	Standalone
SIM	Subscriber Identity Module
SINR	Signal to Interference plus Noise Ratio
SN	Service Network

UDP	User Datagram Protocol
UE	User Equipment
UPF	User Plane Function
(U)SIM	(Universal) Subscriber Identity Module
VPLMN	Visiting Public Land Mobile Network
WCDMA	Wideband Code Division Multiple Access