RG50xQ&RM5xxQ Series 5G Network Status Judgement Introduction

5G Module Series

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Quectel Wireless Solutions Co., Ltd.
Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China
Tel: +86 21 5108 6236
Email: info@quectel.com

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About the Document

Revision History

Version	Date	Author	Description
-	2021-03-30	Yosef ZHANG	Creation of the document
1.0	2021-06-10	Yosef ZHANG	First official release
1.1	2022-01-20	Yosef ZHANG	1. Updated the applicable modules. 2. Redefined the value of <endc_rstr> of AT+QENDC.

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1 Introduction

The document introduces the basic concepts of 5G network and network-status-related AT command supported by Quectel RG500Q series, RG501Q-EU, RG502Q series, RM500Q series, RM502Q-AE, RM510Q-GL and RM505Q-AE modules to provide users with the approach to judge whether the module registers on 5G network, further displaying network status through a 5G icon for end users.

1.1. Applicable Modules

Table 1: Applicable Modules

Module Series	Model
RG50xQ	RG500Q Series
	RG501Q-EU
	RG502Q Series
RM5xxQ	RM500Q Series
	RM502Q-AE
	RM510Q-GL
	RM505Q-AE

2 5G Network

5G refers to the 5th Generation Mobile Networks or 5th Generation Wireless Systems, and 5G NR (New Radio) is a new radio access technology (RAT) developed by 3GPP for the 5G mobile network. *ITU IMT-2020* defines theoretical downlink peak transmission rate as 20 Gbps and theoretical uplink peak transmission rate as 10 Gbps for 5G.

2.1. Frequency Bands Division

For details about 5G band division, see *3GPP TS 38.101*. 5G defines two sets of frequency bands: one is FR1 (sub-6) with frequency band less than 6 GHz. Currently n1 to n95 (Release 15) belong to FR1. The other one is FR2, also known as millimeter wave (mmWave), with frequency band between 24.25 GHz and 52.6 GHz. Currently n257 to n261 belong to FR2.

2.2. 5G Networking Mode

There are two approaches for 5G networking mode, NSA and SA. 3GPP gives various recommendations on 5G networking mode, including the widely accepted NSA networking mode (Option 3/3a/3x) and SA networking mode (Option 2). Quectel RG50xQ&RM5xxQ series modules support Option 3a/3x and Option 2. ENDC (EUTRA-NR Dual Connectivity), a kind of NSA networking mode, with LTE used as MCG (Master Cell Group) and NR used as SCG (Secondary Cell Group), corresponds to Option 3/3a/3x. In this mode, terminals register to LTE. During the transmission process of a large amount of data, the 5G cell assumes part of the data transmission, and the 5G cell information can be queried at this time. In contrast, in the case of no data transmission or small amount of data transmission, LTE assumes all data transmission, without 5G involved. At this point, the 5G cell information cannot be queried.

3 5G Network Status Related AT Commands

3.1. AT+COPS   Operator Selection

This command returns the current operators and their status, and allows automatic or manual network selection. This chapter only introduces the Read Command under SA and NSA, for more details about this command, see **document [1]**. You can judge whether the SA has been registered on through the value of **<AcT>** returned by the Read Command.

AT+COPS Operator Selection	
Read Command **AT+COPS?**	Response **+COPS: <mode>[,<format>[,<oper>][,<AcT>]]** **OK** If there is any error related to MT functionality: **+CME ERROR: <err>**

Parameter

<oper>	String type. Operator in format as per **<format>**.
<mode>	Integer type.
	<u>0</u> Automatic operator selection (**<oper>** field is ignored)
	1 Manual operator selection (**<oper>** field shall be present and **<AcT>** optionally)
	2 Deregister from network
	3 Set only **<format>** (for **AT+COPS?** Read Command), and do not attempt registration/deregistration (**<oper>** and **<AcT>** fields are ignored). This value is invalid in the response of Read Command.
	4 Manual/automatic selection. **<oper>** field shall be presented. If manual selection fails, automatic mode (**<mode>**=0) will be entered.
<format>	Integer type. The format of **<oper>**.
	<u>0</u> Long format alphanumeric of **<oper>** which can be up to 16 characters long
	1 Short format alphanumeric of **<oper>**
	2 Numeric format of **<oper>**, GSM location area identification number

<AcT>	Integer type. Access technology selected. Values 4, 5, 6 occur only in the response of Read Command while MS is in data service state and is not intended for the **AT+COPS** Write Command.	
	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]** for more details.	

3.2. AT+QENDC   Query EN-DC Status

AT+QENDC Query EN-DC Status	
Test Command **AT+QENDC=?**	Response **OK**
Execution Command **AT+QENDC**	Response **+QENDC: <endc_avl>,<plmn_info_list_r15_avl>,<endc_rstr>,<5G_basic>** **OK**
Characteristics	-

Parameter

<endc_avl>	Integer type. Whether the current cell supports EN-DC mode.	
	0	Not supported
	1	Supported
<plmn_info_list_r15_avl>	Integer type. Whether the currently registered PLMN supports the EN-DC mode.	
	0	Not supported
	1	Supported
<endc_rstr>	Integer type. EN-DC capability delivered by the network.	
	0	Not restricted
	1	Restricted
<5G_basic>	Integer type. Whether to support 5G icon information successfully.	
	0	Not supported

3.3. AT+QENG   Query Primary Serving Cell and Neighbour Cell

Information

This command is used to query the serving cell and neighboring cell information, for more details about this command, see *document [1]*.

AT+QENG Query Primary Serving Cell and Neighbour 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>** In EN-DC 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>,<NSA_DL_bandwidth>,<scs>** **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.
\<is_tdd\>	String type. The LTE network mode.
	"TDD"
	"FDD"
\<MCC\>	16-bit unsigned integer. Mobile Country Code (first part of the PLMN code)
\<MNC\>	16-bit unsigned integer. Mobile Network Code (second part of the PLMN code)
\<ARFCN\>	Indicates the SA-ARFCN of the cell that has been scanned.
\<band\>	32-bit unsigned integer. Frequency band in 5G NR SA networking mode.
\<NR_DL_bandwidth\>	Integer type. 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 80 MHz
	10 90 MHz
	11 100 MHz
	12 200 MHz
	13 400 MHz
\<cellID\>	Integer type. Cell ID. The parameter determines the 16-bit (GSM) or 28-bit (UMTS) cell ID. Range: 0–0xFFFFFFFF.
\<PCID\>	Number format. Physical cell ID.
\<uarfcn\>	The parameter determines the UTRA-ARFCN of the cell that has been scanned.
\<earfcn\>	The parameter determines the E-UTRA-ARFCN of the cell that has been 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
<TAC>	Tracking Area Code (see *3GPP 23.003 Subclause 19.4.2.3*)
<RSRP>	16-bit signed integer.
	In LTE mode:
	It indicates the signal strength of LTE Reference Signal Received Power (see *3GPP 36.214*). Range: -140 to -44 dBm. The closer the value is to -44, the better the signal is. The closer the value is to -140, the worse the signal is.
	In 5G NR mode:
	It indicates the signal strength of 5G NR Reference Signal Received Power. Range: -140 to -44 dBm. The closer the value is to -44, the better the signal is. The closer the value is to -140, the worse the signal is.
<RSRQ>	16-bit signed integer.
	In LTE mode:
	It indicates the signal strength of current LTE Reference Signal Received Quality (see *3GPP 36.214*). Range: -20 to -3 dB. The closer the value is to -3, the better the signal is. The closer the value is to -20, the worse the signal is.
	In 5G NR mode:
	It indicates the signal strength of current 5G NR Reference Signal Received Quality. Range: -20 to -3 dB. The closer the value is to -3, the better the signal is. The closer the value is to -20, the worse the signal is.
<RSSI>	LTE Received Signal Strength Indication.
<SINR>	16-bit signed integer.
	In LTE mode:
	It indicates LTE SINR (Signal-to-Interface plus Noise Ratio). The conversion formula for actual SINR is $Y = (1/5) \times X \times 10 - 20$ (**X** is the **<SINR>** value queried by **AT+QENG** and **Y** is the actual value of LTE SINR calculated by the formula). Range: -20 to 30 dB.
	In 5G NR mode:
	It indicates the signal of 5G NR SINR. Range: -20 to 30 dB.
<CQI>	Integer type. Channel Quality Indication. Range: 1–30.
<tx_power>	TX power value in 1/10 dBm. It is the maximum of all UL channel TX

	powers. The **<tx_power>** value is only meaningful when the device is in traffic.
<srxlev>	Cell selection RX level value.
<scs>	Integer type. NR sub carrier spacing.
	0 15 kHz
	1 30 kHz
	2 60 kHz
	3 120 kHz
	4 240 kHz

> **NOTE**
>
> "-" returned by this command indicates the parameter is invalid under current condition.

4 5G Icon Display Rules

4.1. 5G Icon Display Judgement Flow Chart

In order to facilitate end users to accurately determine whether to display a 5G icon, Quectel has summarized the following solution. When using a 5G module, you can refer to this solution to design your own code.
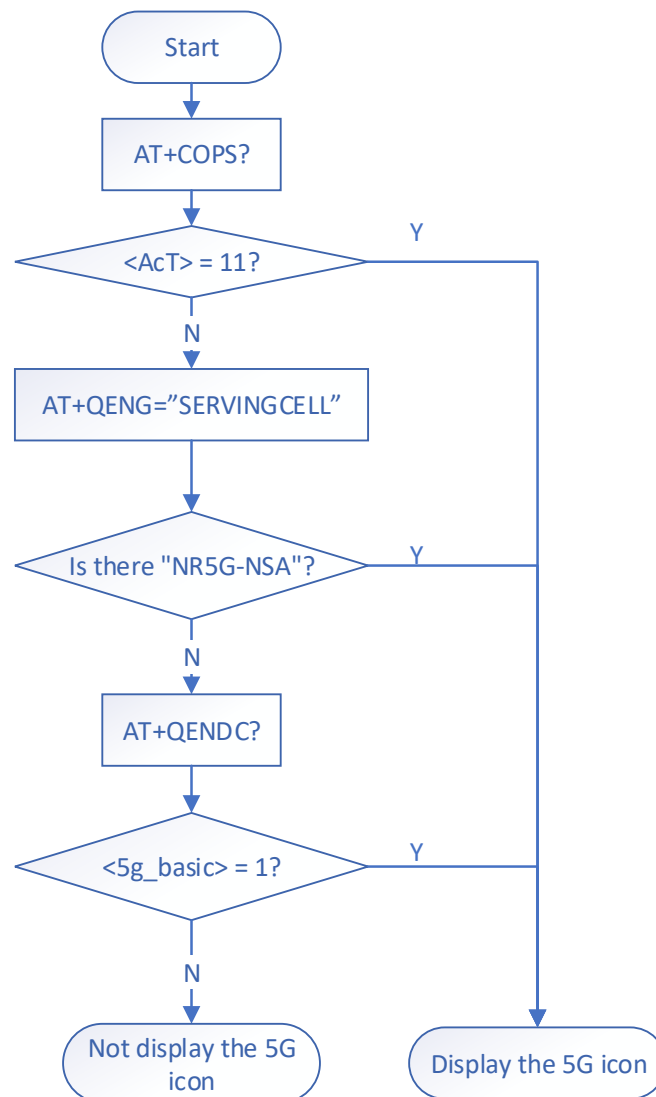

Figure 1: Reference Flow Chart for 5G Icon Display

4.2. 5G Icon Display Rules under NSA

Under NSA, the following conditions decide whether to display the 5G icon:

1. The terminal and subscribers support the ENDC.
- "DCNR=1" is indicated in Attach Request
- "RestrictDCNR=0" is indicated in Attach Accept

2. The LTE cell currently camped on supports NSA.
- "plmn-InfoList-r15" IE is carried in SIB2
- "upperLayerIndication-r15" in "plmn-InfoList-r15" IE indicates "true"

3. The terminal has successfully accessed the 5G cell and completed the ENDC.
- The terminal has successfully accessed to 5G cell, and finished the uplink synchronization. 5G cell information can be queried.

Since 5G network popularizes rapidly, there are defects existed in the network configuration and terminals in some areas, especially, the agreement does not clearly stipulate and allow network customization. GSMA does not clearly stipulate the 5G icon display standard under the NSA network, but proposes four display strategies for reference. Operators can choose or combine them according to the local network deployment. Currently, most operators choose to use Config. A + D in the following figure. The standards defined by GSMA are shown in the figure below.

State	Config. A	Config. B	Config. C	Config. D
1 (IDLE under or Connected to LTE cell not supporting NSA)	4G	4G	4G	4G
2 (IDLE under or Connected to LTE cell supporting NSA and no detection of NR coverage)	4G	4G	4G	5G
3 (Connected to LTE only under LTE cell supporting NSA and detection of NR coverage)	4G	4G	5G	5G
4 (IDLE under LTE cell supporting NSA and detection of NR coverage)	4G	5G	5G	5G
5 (Connected to LTE + NR under LTE cell supporting NSA)	5G	5G	5G	5G
6 (IDLE under or connected to NG-RAN while attached to 5GC)	5G	5G	5G	5G

Figure 2: 5G Icon Display Strategies Defined by GSMA

From above, different Config. strategies have different 5G icon display requirements. From Config. A to Config. D, 5G icon display requirements are gradually relaxed. State 1 to State 5 define the display standard under NSA; State 6 defines the display standard under SA.

When the UE is in the idle state (IDLE), the 5G status should be judged according to the indicator of upperLayerIndication-r15; when the UE is in the connected state (CONNECTED), the 5G status should be judged according to whether the UE has a 5G SCG. Generally speaking, Config. A + D means referring to the Config. A standard when the UE is in the IDLE state, and referring to the Config. D standard when the UE is in the CONNECTED state.

Since the strategies of each operator are different, the 5G icon display strategy can be configured into the corresponding MBN file according to the requirements of each operator. At present, for the three Chinese operators (CMCC, CT and CU), the strategy is Config. A + D, and for ROW MBN, it is also Config. A + D; for non-Chinese MBNs, it is Config A by default.

4.3. 5G Icon Display Rules under SA

Execute **AT+COPS** to query the network status, if SA has been registered to, it means that 5G icon can be displayed.

5 Appendix References

Table 2: Related Document

Document Name
[1] Quectel_RG50xQ&RM5xxQ_Series_AT_Commands_Manual

Table 3: Terms and Abbreviations

Abbreviation	Description
CT	China Telecom
CU	China Unicom
CMCC	China Mobile Communications Corporation
EN-DC	E-UTRA New Radio Dual Connectivity
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FR	Full Rate
HSDPA	High Speed Downlink Packet Access
ITU	International Telecommunication Union
IMT	International Mobile Telecommunications
MCG	Master Cell Group
NR	New Radio
NSA	Non-Standalone
NG-RAN	Next Generation Radio Access Network
PLMN	Public Land Mobile Network