LG69T (AB) GNSS Protocol Specification

GNSS Module Series

Version: 1.2

Date: 2025-02-26

Status: Released

At Quectel, our aim is to provide timely and comprehensive services to our customers. If you require any assistance, please contact our headquarters:

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

Or our local offices. For more information, please visit:
http://www.quectel.com/support/sales.htm.

For technical support, or to report documentation errors, please visit:
http://www.quectel.com/support/technical.htm.
Or email us at: support@quectel.com.

Legal Notices

We offer information as a service to you. The provided information is based on your requirements and we make every effort to ensure its quality. You agree that you are responsible for using independent analysis and evaluation in designing intended products, and we provide reference designs for illustrative purposes only. Before using any hardware, software or service guided by this document, please read this notice carefully. Even though we employ commercially reasonable efforts to provide the best possible experience, you hereby acknowledge and agree that this document and related services hereunder are provided to you on an “as available” basis. We may revise or restate this document from time to time at our sole discretion without any prior notice to you.

Use and Disclosure Restrictions

License Agreements

Documents and information provided by us shall be kept confidential, unless specific permission is granted. They shall not be accessed or used for any purpose except as expressly provided herein.

Copyright

Our and third-party products hereunder may contain copyrighted material. Such copyrighted material shall not be copied, reproduced, distributed, merged, published, translated, or modified without prior written consent. We and the third party have exclusive rights over copyrighted material. No license shall be granted or conveyed under any patents, copyrights, trademarks, or service mark rights. To avoid ambiguities, purchasing in any form cannot be deemed as granting a license other than the normal non-exclusive, royalty-free license to use the material. We reserve the right to take legal action for noncompliance with abovementioned requirements, unauthorized use, or other illegal or malicious use of the material.

Trademarks

Except as otherwise set forth herein, nothing in this document shall be construed as conferring any rights to use any trademark, trade name or name, abbreviation, or counterfeit product thereof owned by Quectel or any third party in advertising, publicity, or other aspects.

Third-Party Rights

This document may refer to hardware, software and/or documentation owned by one or more third parties ("third-party materials"). Use of such third-party materials shall be governed by all restrictions and obligations applicable thereto.

We make no warranty or representation, either express or implied, regarding the third-party materials, including but not limited to any implied or statutory, warranties of merchantability or fitness for a particular purpose, quiet enjoyment, system integration, information accuracy, and non-infringement of any third-party intellectual property rights with regard to the licensed technology or use thereof. Nothing herein constitutes a representation or warranty by us to either develop, enhance, modify, distribute, market, sell, offer for sale, or otherwise maintain production of any our products or any other hardware, software, device, tool, information, or product. We moreover disclaim any and all warranties arising from the course of dealing or usage of trade.

Privacy Policy

To implement module functionality, certain device data are uploaded to Quectel's or third-party's servers, including carriers, chipset suppliers or customer-designated servers. Quectel, strictly abiding by the relevant laws and regulations, shall retain, use, disclose or otherwise process relevant data for the purpose of performing the service only or as permitted by applicable laws. Before data interaction with third parties, please be informed of their privacy and data security policy.

Disclaimer

a) We acknowledge no liability for any injury or damage arising from the reliance upon the information.
b) We shall bear no liability resulting from any inaccuracies or omissions, or from the use of the information contained herein.
c) While we have made every effort to ensure that the functions and features under development are free from errors, it is possible that they could contain errors, inaccuracies, and omissions. Unless otherwise provided by valid agreement, we make no warranties of any kind, either implied or express, and exclude all liability for any loss or damage suffered in connection with the use of features and functions under development, to the maximum extent permitted by law, regardless of whether such loss or damage may have been foreseeable.
d) We are not responsible for the accessibility, safety, accuracy, availability, legality, or completeness of information, advertising, commercial offers, products, services, and materials on third-party websites and third-party resources.

About the Document

Document Information	
Title	**LG69T (AB) GNSS Protocol Specification**
Subtitle	GNSS Module Series
Document Type	GNSS Protocol Specification
Document Status	Released

Revision History

Version	Date	Description
-	2023-01-16	Creation of the document
1.0	2023-05-07	First official release
1.1	2024-04-22	Updated the format of data representation for all proprietary RTCM messages. (*Chapter 3.4*)
1.2	2025-02-26	1. Added SBAS function. 2. Added Navigation Data Frame (NDF) message (*Chapter 3.4*). 3. Added the note on the meaning of positive values of Latitude and Longitude fields in EPVT message (*Chapter 3.4.1.5*).

Contents

About the Document **3**
Contents **4**
Table Index **5**
Figure Index **6**

1 Introduction **7**

2 E2E Protocol **8**
2.1. E2E Communication 8

3 RTCM Protocol **11**
3.1. Structure of RTCM3 Protocol Messages 11
3.2. RTCM Data Fields 12
3.2.1. Supported Frequency Bands 17
3.2.2. Signal Identifier (DF82P) and Tracking Mode (DF86P) 19
3.3. Standard RTCM Messages 22
3.4. Proprietary RTCM Messages 23
3.4.1. Chipset Supplier Proprietary RTCM Messages 23
3.4.1.1. RSS (Subtype ID = 1) 23
3.4.1.2. RCC (Subtype ID = 2) 27
3.4.1.3. POSQM (Subtype ID = 5) 28
3.4.1.4. IFB (Subtype ID = 8) 28
3.4.1.5. EPVT (Subtype ID = 21) 28
3.4.1.6. RFS (Subtype ID = 24) 30
3.4.1.7. FWVER (Subtype ID = 25) 31
3.4.1.8. SIGQM2 (Subtype ID = 26) 31
3.4.2. Other Proprietary RTCM Message 31
3.4.2.1. Navigation Data Frame (NDF) 31

4 Appendix A References **34**
5 Appendix B Special Characters **37**

Table Index

Table 1: Supported Protocols 7
Table 2: Transmission Preamble 9
Table 3: E2E Header in Transmission Order 10
Table 4: Field Description of RTCM3 Protocol Messages 11
Table 5: Data Field Table 12
Table 6: Constellation Mask (SatType) 17
Table 7: Multi-Frequency/Tracking Mode Mask 18
Table 8: Signal ID Constellation Encoding 20
Table 9: Satellite Type and Selector Fields 20
Table 10: Supported RTCM3 Messages 22
Table 11: Proprietary RTCM Message List 23
Table 12: SIS Error Code 25
Table 13: Monitor Alarm Mask 26
Table 14: Terms and Abbreviations 34
Table 15: Special Characters 37

Figure Index

Figure 1: Structure of E2E Protocol Messages 9
Figure 2: Structure of RTCM3 Protocol Messages 11
Figure 3: Signal ID (DF82P) Structure 19

1 Introduction

Quectel LG69T (AB) GNSS module supports GPS, GLONASS, Galileo, BDS and QZSS constellations. It can track GPS L1 C/A, L5, L2C, GLONASS L1; Galileo E1, E5a, E5b; BDS B1I, B2a, B2I and QZSS L1 C/A, L5, L2C frequency bands and provides fast and accurate acquisition and makes this module an ideal solution for positioning and navigation in various vertical markets.

To report GNSS information, the module supports the following protocols:

Table 1: Supported Protocols

Protocol	Type
E2E	Output, binary, proprietary
RTCM 10403.3	Output, binary, standard
	Output, binary, proprietary

NOTE

1. The LG69T (AB) mainly supports L1 + L5 frequency bands, but also supports L1 + L2 frequency bands through different ordering code.
2. Quectel assumes no responsibility if commands other than the ones listed herein are used.

2 E2E Protocol

2.1. E2E Communication

End-To-End (E2E) communication between the LG69T (AB) and the host has a safety-related aspect. To reduce the probability of misleading information due to propagation delays or bit errors in the communication channel, additional protocol layers are defined. These layers complement the application PDUs (RTCM data) and provide features for timestamping to estimate propagation delays and an increased error-detection capability.

AUTOSAR E2E

E2E module formats and encapsulates outcoming messages (RTCM3) based on the selected AUTOSAR E2E profile. Counter is incremented at every message sent according to payload Data ID, and CRC is computed according to E2E profile. The engine is thread safe with no multiplexing capability, meaning that every RTCM3 frame is encapsulated in a single E2E frame. On the receive side the protocol stack looks for the protocol field after the synchronization on the expected prefix. Unexpected or unsupported values are reported to the EFM monitor in SIS. Based on the E2E profile the packet is then inspected and checked for the E2E header. The protocol stack stores the packet up to the expected length and validates CRC. CRC mismatch is reported to the ECRC monitor in SIS. Counter is expected to increment at every packet received according to payload DataID, with the exception of the very first received message whose counter value is not incremented. Any CRC mismatch is reported to the ECM monitor in SIS.

The E2E protocol stack is layered as follows:

- Transmission Preamble, composed by a synchronization sequence and payload information, see *Table 2: Transmission Preamble*.
- E2E protocol Header, see *Table 3: E2E Header in Transmission Order*.
- Application PDU based on RTCM3 framing (*Chapter 3.1 Structure of RTCM3 Protocol Messages*).

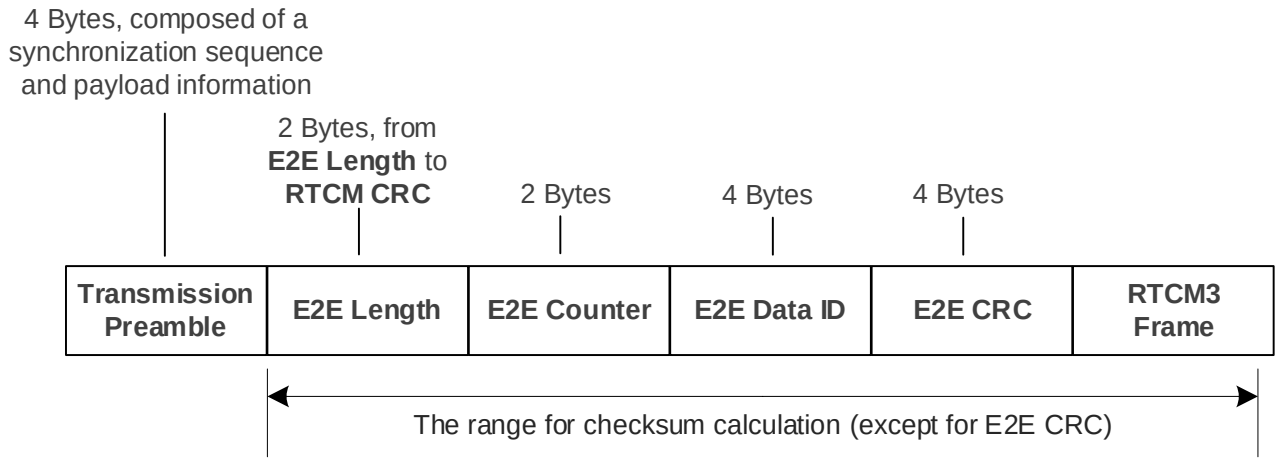

Figure 1: Structure of E2E Protocol Messages

NOTE

See *Chapter 3.1 Structure of RTCM3 Protocol Messages* for detailed information about RTCM3 Frame.

Table 2: Transmission Preamble

Preamble	Byte 0								Byte 1								Byte 2								Payload Information							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Binary Value	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	1	1
Hex. Value	0F								F0								5A								03							

The synchronization sequence of the transmission preamble is composed of a 3 Bytes sequence (in hexadecimal format):

```
0F F0 5A
```

The payload information byte is sent as follows:

- Bit 1 and Bit 0: E2E Profile (3 = AUTOSAR Profile 4)
- Bit 3 and Bit 2: Synchronization Profile (0 = Time Synchronization)
- Bit 5 and Bit 4: Application Protocol (0 = RTCM3)
- Bit 7 and Bit 6: Reserved for future use (Fixed at 0)

Transmission preamble of a message carrying RTCM3 payload:

```
0F F0 5A 03
```

Table 3: E2E Header in Transmission Order

Transmission Order	Byte 0								Byte 1								Byte 2								Byte 3							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	E2E Length																E2E Counter															
4	E2E Data ID																															
8	E2E CRC																															

Example:

0F F0 5A 03 00 4B 00 4B 12 34 56 78 B8 B9 D4 DE D3 00 39 3E 71 50 01 FC 2B FF FF FF FF FE 00 07 FF FF F9 FF F8 7F FF FF FF FF FF FF 00 00 00 01 00 00 00 01 00 00 10 00 01 00 00 10 00 00 00 1F FF FF FF E0 00 00 00 00 00 00 00 00 DB 8E 90

3 RTCM Protocol

This chapter outlines the RTCM standard and propriety protocols supported by LG69T (AB). The standard RTCM protocol supported by the LG69T (AB) module is in accordance with *RTCM Standard 10403.3 Differential GNSS (Global Navigation Satellite Systems) Services - Version 3.* This protocol is used to transfer GNSS raw measurement data and is available from *https://www.rtcm.org/*.

3.1. Structure of RTCM3 Protocol Messages

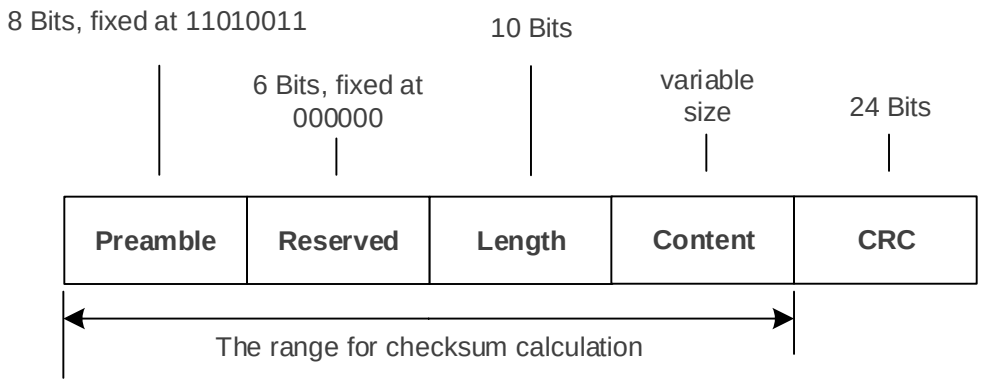

Figure 2: Structure of RTCM3 Protocol Messages

Table 4: Field Description of RTCM3 Protocol Messages

Field	Description
Preamble	RTCM3 protocol preamble. 8 Bits, fixed at 11010011.
Reserved	Reserved. 6 Bits, fixed at 000000.
Length	Message field length. 10 Bits.
Content	Message payload, variable size.
CRC	Checksum. 24 Bits.

3.2. RTCM Data Fields

RTCM message data fields are shown in the table below.

Suffix '**P**' identifies Proprietary Data Fields.

Table 5: Data Field Table

DF	DF Name	DF Range	DF Resolution	Data Type	Notes
DF002	Message Number	0–4095	-	uint12	999 (dedicated proprietary number).
DF003	Reference Station ID	0–4095	-	uint12	Differential reference station ID. 0x3FF = Invalid
DF004	GPS Epoch Time (TOW)	0–604799999	1 ms	uint30	Best time converted to GPS system time.
DF009	GPS Satellite ID	1–64	-	uint6	-
DF021	ITRF Realization Year	-	-	uint6	Reserved
DF038	GLONASS Satellite ID (Satellite Slot Number)	0–63	-	uint6	-
DF054	Leap Seconds, GPS-UTC	0–254	1 s	uint8	Converted to GPS-UTC. 0xFF = Invalid or not provided
DF22P	Monitor Alarm Mask	-	-	Uint32	1-bit per monitor: 0 = OK 1 = Alarm See *Table 13: Monitor Alarm Mask*
DF252	Galileo Satellite ID	0–63	-	uint6	-
DF429	QZSS Satellite ID	1–10	-	uint4	QZSS Satellite ID numbers 1–10 correspond to the PRN codes of the QZSS satellite, as shown in the following ID map: 1: 193

DF	DF Name	DF Range	DF Resolution	Data Type	Notes
					2: 194 … 10: 202
DF488	BDS Satellite ID	1–64	-	uint6	-
DF01P	Timing/PPS Status	0–255	-	uint8	Timing/PPS status: 0 = Available 1–255 = Do not use/Not available
DF02P	Subtype ID	0–255	-	uint8	See *Table 11: Chipset Supplier Proprietary RTCM Message List*.
DF16P	GNSS Epoch Time	-	1 ms	uint30	TOW for any GNSS. 0x3FFFFFFF = Invalid
DF18P	Extended Week Number	-	1 week	uint16	Include roll-over. The field is invalid if the **GNSS Epoch Time** is set to 0x3FFFFFFF in which case 0xFFFF will be reported.
DF19P	Firmware Version	-	-	uint24	0xFFFFFF = Invalid
DF21P	Constellation Alarm Mask	-	-	uint32	Constellation alarm mask. 1 bit per constellation: 0 = Normal, 1 = Abnormal Bit 0: GPS Bit 1: GLONASS Bit 2: QZSS L1 C/A Bit 3: Galileo Bit 4: SBAS Bit 5: Reserved Bit 6: Reserved Bit 7: BDS Bit 8: Reserved Bit 9: GPS L2C Bit 10: Reserved Bit 11: GPS L5 Bit 12: Galileo E5 Bit 13: Reserved Bit 14: BDS B2a

DF	DF Name	DF Range	DF Resolution	Data Type	Notes
					Bit 15: QZSS L2C Bit 16: QZSS L5 Bit 17: Reserved Bit 18: BDS B2I Bit 19: Galileo E5B Bit 20–31: Reserved Note: Bit 0 is the least significant bit
DF25P	Configuration – Page Number	-	-	uint8	Configuration and control page number.
DF26P	Configuration – Page Mask	-	-	uint16	Configuration and control page mask, 1-bit set per configuration word.
DF27P	Configuration – Basic Configuration Unit	-	-	uint32	32-bit basic configuration unit.
DF28P	GPS Quality Indicator (fix status)	0–15	-	uint4	GPS quality indicator: 0 = Fix not available or invalid 1 = GPS SPS Mode, fix valid 2 = Differential GPS, SPS Mode, fix valid
DF29P	Number of Satellites in Use	-	-	uint8	Number of satellites in use. 0xFF = Invalid
DF30P	Dilution of Precision (DOP)	0–25.4	0.1	uint8	0xFF = Invalid
DF31P	Geoidal Separation, Meters	±163.83	0.01 m	int15	Geoid separation (the difference between the Earth's ellipsoid surface and the mean-sea-level (geoid) surface defined by the reference datum used in the position solution). 0x4000 = Invalid
DF32P	Age of Differentials	-	1 ms	int24	Age of differential GPS data.

DF	DF Name	DF Range	DF Resolution	Data Type	Notes
					0xFFFFFF = Invalid
DF33P	Differential Reference Station ID	0–4095	-	uint12	Differential reference station ID. 0x3FF = Invalid
DF37P	Number of Satellites in View	-	-	uint8	Total number of satellites in view. 0xFF = Invalid
DF49P	Continue on Next Message	-	-	uint1	0 = End 1 = Continue on next message (for output only).
DF50P	CDB Write Flag	-	-	uint1	0 = Do not write
DF53P	Response ID	-	-	uint10	Message response identifier. A response message is requested (0x0000 means no response is required).
DF72P	Time ID	0–15	-	uint4	Time ID: 0 = GPS 1 = GLONASS 2 = QZSS 3 = Galileo 4 = SBAS 7 = BDS 14 = UTC 15 = Invalid
DF73P	Latitude	-3.24*10^8 to 3.24*10^8	0.001 arcsec	int32	0x80000000 = Invalid
DF74P	Longitude	-6.48*10^8 to 6.48*10^8	0.001 arcsec	int32	0x80000000 = Invalid
DF75P	Height	-524287 to 524287	0.1 m	int20	0x80000 = Invalid or not available (2D fix)
DF76P	Horizontal Velocity	-524287 to 524287	0.01 m/s	int20	0x80000 = Invalid
DF77P	Vertical Velocity	-524287 to 524287	0.01 m/s	int20	0x80000 = Invalid
DF78P	Course Angle	0–3599	0.1 Degree	int16	0x8000 = Invalid.
DF82P	Signal Identifier	-	-	uint16	See *Chapter 3.2.2 Signal Identifier (DF82P) and*

DF	DF Name	DF Range	DF Resolution	Data Type	Notes
					Tracking Mode (DF86P).
DF86P	Tracking Mode	-	-	uint8	See *Chapter 3.2.2 Signal Identifier (DF82P) and Tracking Mode (DF86P)*.
DF87P	Time Validity	0–15	-	uint4	Time types: 0 = No time 1 = Time read from flash 2 = TOW time (week number not available) 3 = Time set by user 4 = Time set by user RTC 5 = Approximate RTC time 6 = Accurate RTC time 7 = Approximate Time 8 = Accurate time 9 = Position time 10 = Ephemeris time 11–15 = Reserved
DF95P	GNSS Constellation Mask	-	32	uint32	See *Table 6: Constellation Mask (SatType)*.
DF96P	GNSS Multi-Frequency Constellation Mask	-	32	uint32	See *Table 7: Multi-Frequency/Tracking Mode Mask*.
DF112P	Configuration. Block	1–3	-	uint2	Configuration blocks in output message: 1 = Current configuration (RAM) 2 = Default configuration 3 = NVM stored configuration
DF113P	Time Best Satellite Type	-	-	uint5	See *Table 9: Satellite Type and Selector*.

NOTE

RTCM messages are output in hexadecimal format. For your convenience, some parameter notes are converted to decimal or binary format to facilitate viewing.

3.2.1. Supported Frequency Bands

The constellation mask is a 32-bit integer mask, where each enabling bit indicates if the corresponding satellite system or signal is supported, in line with *Table 6: Constellation Mask (SatType)*.

Table 6: Constellation Mask (SatType)

Bit	System	Signal	Description
0	GPS	L1 C/A	0 = Unsupported 1 = Supported
1	GLONASS	L1	0 = Unsupported 1 = Supported
2	QZSS	L1 C/A	0 = Unsupported 1 = Supported
3	Galileo	E1	0 = Unsupported 1 = Supported
4	SBAS	L1	0 = Unsupported 1 = Supported
5–6	Reserved	Reserved	0
7	BDS	B1I	0 = Unsupported 1 = Supported
8	Reserved	Reserved	0
9	GPS	L2C	0 = Unsupported 1 = Supported
10	Reserved	Reserved	0
11	GPS	L5	0 = Unsupported 1 = Supported
12	Galileo	E5a or E5b	0 = Unsupported 1 = Supported
13	Reserved	Reserved	0
14	BDS	B2I or B2a	0 = B2I 1 = B2a
15	QZSS	L2C	0 = Unsupported 1 = Supported

Bit	System	Signal	Description
16	QZSS	L5	0 = Unsupported 1 = Supported
17–31	Reserved	Reserved	0

The multi-frequency mask is a 32-bit integer mask, where each bit indicates if a dual-frequency component (*Table 7: Multi-Frequency/Tracking Mode Mask*) is enabled for the corresponding main frequency signal. The bit meaning of this mask is slightly different from that of the constellation mask because not all frequency combinations are supported and some configurations allow for the choice of different dual frequencies (e.g. E5a or E5b) for a single main frequency signal (e.g., E1).

Table 7: Multi-Frequency/Tracking Mode Mask

Bit	System	Signal	Dual Frequency
0	GPS	L1 C/A	0 = Unsupported, 1 = L2C or L5
1	GLONASS	L1	0 = Unsupported
2	QZSS	L1 C/A	0 = Unsupported, 1 = L2C or L5
3	Galileo	E1	0 = Unsupported, 1 = E5a or E5b
4–6	Reserved		
7	BDS	B1I	0 = Unsupported, 1 = B2a or B2I
8	Reserved		
9	GPS	L2C	0 = Data, 1 = Pilot
10	Reserved		
11	GPS	L5	0 = Pilot, 1 = Data
12	Galileo	E5a or E5b	0 = E5a, 1 = E5b
13	Reserved		
14	BDS	B2a	0 = Pilot, 1 = Data
15	QZSS	L2C	0 = Data, 1 = Pilot
16	QZSS	L5	0 = Pilot, 1 = Data
17–22	Reserved		

Bit	System	Signal	Dual Frequency
23	Acquisition of dual frequency (L5): 0 = Disabled, 1 = Enabled		
24	Split Band Mode: 0= Disabled, 1=Enabled		
25	GPS/QZSS	L2C	Dual channel mode: 0 = Unsupported, 1 = Data + Pilot
26	Galileo	E1	Dual channel mode: 0 = Unsupported, 1 = Data + Pilot
27	Galileo	E1	Automatic data/pilot switch: 0 = Enabled, 1 = Disabled
28–29	Reserved		
30	Galileo	E5a/E5b	0 = Pilot, 1 = Data
31	Fixed at 0		

3.2.2. Signal Identifier (DF82P) and Tracking Mode (DF86P)

Signal Identifier is an unsigned 16-bit number structured as shown below.

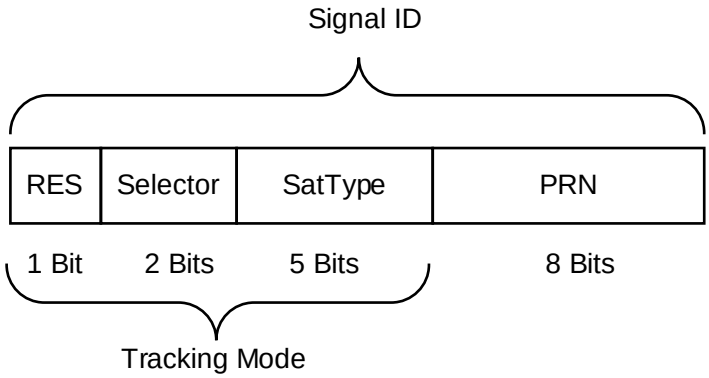

Figure 3: Signal ID (DF82P) Structure

- **PRN Field:**

This field is set to the corresponding RTCM data field according to table below for each constellation (if the RTCM data field length is less than 8 bits, only the less significant bits will be used, and the remaining bits will be set to zero).

"**PRN**" is usually assigned a value starting from '1', and it is used to identify a specific satellite signal. A "**PRN**" value of zero is not allowed and it is reserved to identify special signal IDs (e.g., invalid IDs).

Table 8: Signal ID Constellation Encoding

Constellation	RTCM Data Field for PRN
GPS	DF009
GLONASS	DF038
Galileo	DF252
BDS	DF488
QZSS	DF429

- **SatType Field:** Represents the constellation ID, see *Table 9: Satellite Type and Selector Fields*.
- **Selector Field:** The "selector" identifies specific tracking modes of the signal components, e.g. data vs. pilot, E5a vs. E5b, I vs. Q component etc, see *Table 9: Satellite Type and Selector Fields*.

Table 9: Satellite Type and Selector Fields

SatType			Selector
No.	System	Signal	
0	GPS	L1 C/A	00
1	GLONASS	L1	00
2	QZSS	L1 C/A	00
3	Galileo	E1B (data)	00
		E1C (pilot)	01
4	SBAS	L1	00
5	QZSS	L1 SAIF (Reserved)	Reserved
6	QZSS	L1C (Reserved)	Reserved
7	BDS	B1I	00
		B2I	01

SatType			Selector
No.	System	Signal	
8	BDS 3	B1C (Reserved)	Reserved
9	GPS	L2C CM (data)	00
		L2C CL (pilot)	01
10	Reserved	Reserved	Reserved
11	GPS	L5-Q (pilot)	00
		L5-I (data)	01
12	Galileo	E5a-I (data)	00
		E5a-Q (pilot)	01
		E5b-I (data)	10
		E5b-Q (pilot)	11
13	Galileo	E6 (Reserved)	Reserved
14	BDS 3	B2a	Reserved
15	QZSS	L2C CM (data)	00
		L2C CL (pilot)	01
16	QZSS	L5-Q (pilot)	00
		L5-I (data)	01
17-31	Reserved	Reserved	Reserved

- **RES Field:**

Reserved for future use and kept to zero.

3.3. Standard RTCM Messages

The standard RTCM protocol supported by the LG69T (AB) module is shown below.

Table 10: Supported RTCM3 Messages

Message Type	Mode	Message Name
1013	Output	System Parameters
1019	Output	GPS Ephemerides
1020	Output	GLONASS Ephemerides
1042	Output	BDS Satellite Ephemeris Data
1044	Output	QZSS Ephemerides
1046	Output	Galileo I/NAV Satellite Ephemeris Data
1077	Output	GPS MSM7
1087	Output	GLONASS MSM7
1097	Output	Galileo MSM7
1117	Output	QZSS MSM7
1127	Output	BDS MSM7

3.4. Proprietary RTCM Messages

The propriety RTCM protocol supported by the LG69T (AB) module is shown below.

Table 11: Proprietary RTCM Message List

Chipset Supplier Proprietary RTCM Messages		
Subtype ID	**Mode**	**Message Name**
1	Output	Receiver Status and Safety (RSS).
2	Output	Receiver Configuration and Control (RCC).
5	Output	Position Quality Metrics (POSQM).
8	Output	Inter Frequency Biases (IFB).
21	Output	Extended Position, Velocity and Time (EPVT).
24	Output	RF Status (RFS).
25	Output	Firmware Version (FWVER).
26	Output	Signal Quality Metrics 2 (SIGQM2).
Other Proprietary RTCM Message		
Message Type	**Mode**	**Message Name**
4075	Output	Navigation Data Frame (NDF)

3.4.1. Chipset Supplier Proprietary RTCM Messages

The RTCM message type 999 is a proprietary message specific to the chipset supplier.

3.4.1.1. RSS (Subtype ID = 1)

Reports receiver status and safety information.

Data Name	DF	Bit Position	Bits	Notes
Message Number	DF002	0	12	999 (dedicated proprietary number).

Data Name	DF	Bit Position	Bits	Notes
Subtype ID	DF02P	12	8	Subtype ID = 1. Receiver Status and Safety.
GPS Epoch Time (TOW)	DF004	20	30	Best time converted to GPS system time.
GPS Extended Week Number	DF18P	50	16	Best time converted to GPS system time.
Leap Seconds, GPS-UTC	DF054	66	8	See *Table 5: Data Field Table*
Safety Information	-	74	1	Safety information 0 = Not available 1 = Available
Protocol Version Flags	-	75	7	RTCM protocol version. 3 = RTCM 3.3
Firmware Version	DF19P	82	24	0xFFFFFF = Invalid.
Safe State	-	106	8	Safe state. 0 = BOOT 1 = NORMAL 2 = FAULT 3 = FAULT_STOP
SIS Error Code	-	114	8	SIS error code. 255 = No error See *Table 12: SIS Error Code*
Hardware Error Code	-	122	8	Hardware error code. 80 = No error
Timing/PPS Status	DF01P	130	8	Timing/PPS status. 0 = Available 1–255 = Do not use/Not available
Time Validity	DF87P	138	4	See *Table 5: Data Field Table*
Constellation Alarm Mask	DF21P	142	32	See *Table 5: Data Field Table*
Monitor Alarm Mask	DF22P	174	32	1-bit per monitor: 0 = OK 1 = Alarm See *Table 13: Monitor Alarm Mask*
GNSS Constellation Mask	DF95P	206	32	See *Table 6: Constellation Mask (SatType)*.

Data Name	DF	Bit Position	Bits	Notes
GNSS Multi-Frequency Constellation Mask	DF96P	238	32	See *Table 7: Multi-Frequency/Tracking Mode Mask*.
NCO Clock Drift	-	270	32	0.0001 Hz (signed int) Present only if protocol version flag is 2 or 3
Time Best Satellite Type	DF113P	-	-	Present only if protocol version flag is 3. See *Table 9: Satellite Type and Selector*.
GNSS Constellation Unavailable Mask	DF95P	307	32	Satellite constellation mask for which IFB Monitor status cannot be computed (present only if protocol version flag is 3)

NOTE

1 The **Constellation Alarm Mask** consolidates all constellation masks reported by each monitor with an alarm status bit set. It may contain inactive constellations and must be viewed in conjunction with **GNSS Constellation Mask** and **GNSS Multi-frequency Constellation Mask** to consider only relevant bits.
2 Timing/PPS Status consolidates PPSOBSM, PPSM, SYSTM, PLM and CLKESTM bits from **Monitor Alarm Mask**.
3 Contact Quectel Technical Support (support@quectel.com) for details about **Hardware Error Code**.

Table 12: SIS Error Code

Value	Description
0	HWM configuration
1	SIS message timeout
2	Monitor timeout
3	Memory allocation
4	Unknown message type
5	Unknown message command
6	SIS initialization
7	External RF
8	MTU check

Value	Description
9	Redundant data decoder
10–254	Reserved
255	No error

Table 13: Monitor Alarm Mask

Value	Name	Description (0 = OK, 1 = Alarm)	FAULT_STOP
0	SIS	Global SIS alarm	Yes
1	CIM-L1	Observable Integrity	-
2	HWM	Hardware failure	Yes
3	IFM	Wideband Interference	-
4	RFM	RF Tuners	Yes
5	SYSTM	System Time Integrity	-
6	Res	Reserved	-
7	IFBM	Inter Frequency Biases	-
8	NVMM	NVM write rate integrity	-
9	PPSOBSM	PPS vs. Observable Epoch	-
10	CWM	Narrowband Interference	-
11	PPSM	Timing and PPS integrity	-
12	CLKESTM	RX Clock Estimate Integrity	-
13	ECM	E2E counter mismatch	-
14	ECRC	E2E CRC failure	
15	EFM	E2E frame error	-
16	ASM	Antenna Sensing	-
17	DCM	Data Corruption	Yes
18	PLM	Protection Level Monitor	-

Value	Name	Description (0 = OK, 1 = Alarm)	FAULT_STOP
19	SPFM	Spoofing Monitor	-
20	MTM	Message Timing Monitor	-
21–31	N/A	Reserved	-

NOTE

The monitors with **FAULT_STOP** column set to "Yes" in *Table 13: Monitor Alarm Mask* are considered unrecoverable. It is expected to restart the LG69T (AB) via hardware reset or being powered off and then powered on by the external host, if no RTCM messages are received within a specified period of time.

3.4.1.2. RCC (Subtype ID = 2)

The Receiver Configuration and Control output message is used to report the current configuration. The module has a total of 64 configuration pages. Each configuration page consists of 16 basic configuration units. Each basic configuration unit has a 32-bit word. At the module start-up, all configuration pages will be reported in the output (one RCC message for each page).

Data Name	DF	Bit Position	Bits	Notes
Message Number	DF002	0	12	999 (dedicated proprietary number).
Subtype ID	DF02P	12	8	Subtype ID = 2. Receiver Configuration and Control.
Response ID	DF53P	20	10	Always 0x0000 for output.
Configuration Block	DF112P	30	2	Configuration blocks in output messages: 1 = Current configuration (RAM) 2 = Default configuration 3 = NVM stored configuration.
Configuration – Page Number	DF25P	32	8	Configuration and control page number.
Continue on Next Message	DF49P	40	1	0 = End 1 = Continue on next message
CDB Write Flag	DF50P	41	1	0 = Do not write
Configuration – Page Mask	DF26P	42	16	1-bit per page: Default: FFFF

Data Name	DF	Bit Position	Bits	Notes
Configuration – Basic Configuration Unit	DF27P	58	32*N	Up to 16 basic configuration units.

NOTE

If the **Continue on Next Message** flag is set to 1, there will be a subsequent **RCC** message; otherwise the current message is the last bit of the current reading sequence.

3.4.1.3. POSQM (Subtype ID = 5)

Outputs information for Quectel's internal debugging purposes only.

3.4.1.4. IFB (Subtype ID = 8)

Outputs information for Quectel's internal debugging purposes only.

3.4.1.5. EPVT (Subtype ID = 21)

Reports the receiver PVT standard position in LLH coordinates, plus extended fix information.

Data Name	DF	Bit Position	Bits	Notes
Message Number	DF002	0	12	999 (dedicated proprietary number).
Subtype ID	DF02P	12	8	Subtype ID = 21. Extended Position, Velocity and Time (EPVT).
Reference Station ID	DF003	20	12	Differential reference station ID. 0x3FF = Invalid
ITRF Realization Year	DF021	32	6	Reserved
GPS Quality Indicator (fix status)	DF28P	38	4	GPS quality indicator: 0 = Fix not available or invalid 1 = GPS SPS Mode, fix valid 2 = Differential GPS, SPS Mode, fix valid
Data Status	-	42	1	Data status: 0 = Data valid 1 = Navigation receiver warning

Data Name	DF	Bit Position	Bits	Notes
Fix Frequency Mode	-	43	1	Fix mode: 0 = Single frequency 1 = Multi-frequency
Fix Integrity (RAIM)	-	44	1	Check status: 0 = Not checked 1 = Checked
Reserved	-	45	1	Reserved
Number of Satellites in Use	DF29P	46	8	Number of satellites in use. 0xFF = Invalid
Number of Satellites in View	DF37P	54	8	Total number of satellites in view. 0xFF = Invalid
HDOP	DF30P	62	8	Horizontal Dilution of Precision.
VDOP	DF30P	70	8	Vertical Dilution of Precision.
PDOP	DF30P	78	8	Position Dilution of Precision.
Geoidal Separation, Meters	DF31P	86	15	Geoid separation (the difference between the Earth's ellipsoid surface and the mean-sea-level (geoid) surface defined by the reference datum used in the position solution). 0x4000 = Invalid
Age of Differentials	DF32P	101	24	Age of differential GPS data. 0xFFFFFF = Invalid
Differential Reference Station ID	DF33P	125	12	Differential reference station ID. 0x3FF = Invalid
Time ID	DF72P	137	4	Time ID. 0xF = Invalid
Time Validity	DF87P	141	4	See *Table 5: Data Field Table*
GNSS Epoch Time	DF16P	145	30	1 millisecond resolution. 0x3FFFFFFF = Invalid
Extended Week Number	DF18P	175	16	See *Table 5: Data Field Table*
Leap Seconds, GPS-UTC	DF054	191	8	See *Table 5: Data Field Table*
Latitude	DF73P	199	32	0x80000000 = Invalid
Longitude	DF74P	231	32	0x80000000 = Invalid

Data Name	DF	Bit Position	Bits	Notes
Height	DF75P	263	20	0x80000 = Invalid or not available (2D fix)
Horizontal Velocity	DF76P	283	20	0x80000 = Invalid
Vertical Velocity	DF77P	303	20	0x80000 = Invalid
Course Angle	DF78P	323	16	0x8000 = Invalid
Horizontal Protection Level	-	339	16	Resolution: 0.01 meter 0xFFFF = Invalid
Vertical Protection Level	-	355	16	Resolution: 0.01 meter 0xFFFF = Invalid
Angle Protection Level	-	371	16	Resolution: 0.01 degree 0xFFFF = Invalid
Receiver Clock Bias	-	387	32	Unit: mm 0x80000000 = Invalid
Receiver Clock Drift	-	419	32	Unit: cm/s 0x80000000 = Invalid

NOTE

1. If **GPS Quality Indicator (fix status)** is 0, then the following fields are invalid, regardless of their reported values:
   - Fix Frequency Mode
   - Fix Integrity (RAIM)
   - Geoidal Separation, Meters
   - Latitude
   - Longitude
   - Height
   - Horizontal Velocity
   - Vertical Velocity
   - Course Angle
2. The **Height** field is set to invalid (0x80000) in 2D fix.
3. In **EPVT** message, positive values for **Latitude** represent east longitude, and positive values for **Longitude** represent north latitude.

3.4.1.6. RFS (Subtype ID = 24)

Outputs information for Quectel's internal debugging purposes only.

3.4.1.7. FWVER (Subtype ID = 25)

Reports the current firmware version.

Data Name	DF	Bit Position	Bits	Notes
Message Number	DF002	0	12	999 (dedicated proprietary number).
Subtype ID	DF02P	12	8	Subtype ID = 25 Firmware Version (FWVER).
Firmware Version Data Length	-	20	8	N, number of bytes.
Firmware Version Data String	-	28	8*N	Firmware version data string is char8*N. N depends on the firmware version data length.

3.4.1.8. SIGQM2 (Subtype ID = 26)

Outputs information for Quectel's internal debugging purposes only.

3.4.2. Other Proprietary RTCM Message

3.4.2.1. Navigation Data Frame (NDF)

RTCM3 standard messages, such as 1019, 1020, provide decoded ephemeris data, but there are no messages to provide the raw data frames downloaded from the GNSS satellites, which contain more information, such as almanacs data, integrity data. For that reason, RTCM3 proprietary messages has been implemented, which provides a transport format for raw NDF (Navigation Data Frames).

This message is in line with lately introduced MSM observation messages. MSM messages are generic and Message Type numbers are reserved for up to 16 GNSS systems. Similarly, NDF data messages are also claimed as generic, i.e. their high-level structure is the very same for each GNSS and Signal.

The following table describe the generic NDF message structure and signals containing binary data for each available GNSS constellations and provide recommendations for data framing.

A GNSS application can use NDF data as is, or it can first convert it into, e.g., already standardized MT 1019 and 1020 ephemeris structures for further processing.

Message Header

Data Name	DF	Bit Position	Bits	Notes
Message Number	DF002	0	12	4075 (proprietary number for this purpose).
Reference Station ID	DF003	12	12	Differential reference station ID. 0x3FF = Invalid
Reserved Field	-	24	2	Reserved bits, maybe used to separate different type 4075 message, always 0 for NDF
Frame Count (FC)	-	26	6	Number of frame entries to follow
Frame Entry	-	32	Depends on FC and frame size	Frame data, see Frame Entry table below.
Total	-	-	32 + Frames	-

The message allows grouping multiple frames into one block. These can be

- multiple signals for one satellite,
- multiple satellites for one time or,
- multiple frames for one signal,
- multiple satellite systems.

In addition, combinations of these are possible. For real-time raw frame transport, the combination of these is most useful.

Frame Entry

Data Name	DF	Bit Position	Bits	Notes
Satellite System	-	32	4	0 = GPS 1 = GLONASS 2 = Galileo 3 = SBAS 4 = QZSS 5 = BDS 6 = Reserved
Satellite Number	-	36	6	Satellite ID, index from MSM satellite mask bit field. Range: 0–63. For detailed information, see DF394 specified in *RTCM Standard 10403.3 Differential GNSS (Global Navigation Satellite Systems) Services – Version 3*.

Data Name	DF	Bit Position	Bits	Notes
Extended Sat Info	-	42	4	Reserved bits, maybe used to separate different type 4075 message, always 0 for NDF
Signal Type	-	46	5	Signal type specification, index from MSM signal mask bit field. Range: 0–31. For detailed information, see DF395 specified in *RTCM Standard 10403.3 Differential GNSS (Global Navigation Satellite Systems) Services – Version 3*.
Epoch Time	-	51	30	Epoch time, specific for the satellite system, always 30 bits.
Continuous Tracking	-	81	1	Tracking this satellite frame data was continuous (1 = continuous, 0 not continuous or unset)
Frame Data Size (N)	-	82	12	Number of bits to follow
Frame Data	-	94	N	Bit data from satellite
Total	-	-	62 + N	-

NOTE

1. The length of **Frame Data** is variable.
2. For more details on **NDF** message, refer to *https://software.rtcm-ntrip.org/wiki/NDF*.

4 Appendix A References

Table 14: Terms and Abbreviations

Abbreviation	Description
2D	2 Dimension
ASM	Antenna Sensing Monitor
AUTOSAR	Automotive Open System Architecture
BDS	BeiDou Navigation Satellite System
CDB	Configuration Data Block
CLKESTM	Receive Clock Estimate Integrity
CIM	Central Intelligence Monitor
CRC	Cyclic Redundancy Check
CWM	Continuous Waves Monitor
DCM	Data Corruption Monitor
DOP	Dilution of Precision
E2E	End-To-End
ECM	E2E counter mismatch
ECRC	E2E CRC failure
EFM	E2E Frame Error
EPVT	Extended Position, Velocity and Time
FWVER	Firmware Version
GGA	Global Positioning System Fix Data
GLONASS	Global Navigation Satellite System (Russia)

Abbreviation	Description
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSV	GNSS Satellites in View
HDOP	Horizontal Dilution of Precision
HWM	Hardware Failure Monitor
IFB	Inter Frequency Biases
IFBM	Inter-Frequency Bias Monitor
IFM	Intermediate Frequency Monitor
I/NAV	Integrity Navigation
ITRF	International Terrestrial Reference Frame
LLH	Latitude, Longitude and Height
MTM	Message Timing Monitor
MTU	Multi Timer Unit
NCO	Numerically Controlled Oscillator
NDF	Navigation Data Frames
NVM	Non-Volatile Memory
NVMM	Non-Volatile Memory Monitor
PDOP	Position Dilution of Precision
PDU	Protocol Data Unit
PLM	Protection Level Monitor
POSQM	Position Quality Metrics
PPS	Pulse Per Second
PPSM	Timing and PPS integrity
PPSOBSM	PPS vs. Observable Epoch

Abbreviation	Description
PRN	Pseudo Random Noise
PVT	Position, Velocity and Time
QZSS	Quasi-Zenith Satellite System
RAIM	Receiver Autonomous Integrity Monitoring
RAM	Random Access Memory
RCC	Receiver Configuration and Control
RESP	Response
RF	Radio Frequency
RFM	RF Tuners Monitor
RFS	RF Status
RFU	Reserved for Further Use
RSS	Receiver Status and Safety
RTC	Real-Time Clock
RTCM	Radio Technical Commission for Maritime Services
SBAS	Satellite-Based Augmentation System
SIGQM2	Signal Quality Metrics 2
SIS	Security, Integrity and Safety
SPFM	Spoofing Monitor
SYSTM	System Time Integrity
TOW	Time of Week
UTC	Coordinated Universal Time
VDOP	Vertical Dilution of Precision

5 Appendix B Special Characters

Table 15: Special Characters

Special Characters	Definition
<...>	Parameter name. Angle brackets do not appear in the message.
[...]	Optional field of a message. Square brackets do not appear in the message.
{…}	Repeated field of a message. Curly brackets do not appear in the message.
Underline	Default setting of a parameter.