LC26G&LC76G&LC86G Series

Low Power Mode Application Note

GNSS Module Series

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About the Document

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1 Introduction

The LC26G (AB), LC76G series and LC86G series modules support different low power modes with enhanced power consumption and outstanding positioning performances. This document describes the operation mechanisms and related testing procedures of Backup, Periodic, Adaptive Low Power (ALP), GPS Low Power (GLP), and Fitness Low Power (FLP) modes.

Backup mode is an inactive state where the power consumption is reduced to a fraction of that in the other operating modes.

Periodic mode consists of running (active) and sleeping stages, of which the time span can be adjusted to reduce power consumption.

FLP mode extends GLP mode by adding more constellation combinations, while ALP mode is a subset of FLP mode that differs in navigation mode. The differences between GLP, FLP and ALP modes are detailed in *Table 3: Low Power Modes*.

The relevant commands of the low power modes are listed below. For details, please refer to *document [1] protocol specification*.

Table 1: Related Commands

PAIR Command	Description
PAIR050	Sets position fix interval.
PAIR051	Gets position fix interval.
PAIR066	Sets the GNSS search mode.
PAIR067	Gets the GNSS search mode.
PAIR080	Sets navigation mode.
PAIR081	Gets navigation mode.
PAIR650	Enables Backup mode.
PAIR680	Enables/disables GLP mode.
PAIR681	Gets GLP mode setting.

PAIR Command	Description
PAIR690	Sets Periodic power saving mode configurations.
PAIR691	Gets Periodic power saving mode configurations.
PAIR730	Enables/disables FLP mode.
PAIR731	Gets FLP mode setting.
PAIR732	Enables/disables ALP mode.
PAIR733	Gets ALP mode configuration setting.

Table 2: Navigation Modes

Navigation Mode	Description
Normal mode	Used for general purposes.
Fitness mode	Used for running and walking purposes, making low-speed movement (< 5 m/s) more impactful on position calculation.
Swimming mode	Used for swimming purposes to smooth the trajectory and improve the accuracy of distance calculation.
Drone mode	Used for drone applications with equivalent dynamic range and vertical acceleration at different flight phases (for example, hovering, cruising).

The corresponding configurations of the low power modes supported by LC26G (AB), LC76G series and LC86G series are as follows:

Table 3: Low Power Modes and Corresponding Configurations

Type	Navigation Mode	Constellation Option	Fix Update Rate	Supported Module
Backup mode	● Normal mode ● Fitness mode ● Swimming mode ● Drone mode	● GPS only ● GPS + QZSS ● GPS + GLONASS ● GPS + GLONASS + QZSS ● GPS + Galileo ● GPS + Galileo + QZSS ● GPS + BDS ● GPS + BDS + QZSS ● GPS + GLONASS + Galileo + BDS ● GPS + GLONASS + Galileo + BDS + QZSS	● 1 Hz ● 2 Hz ● 5 Hz ● 10 Hz	● LC26G (AB) ● LC76G (AB, PA, PB) ● LC86G (AA, AB, LA)
Periodic mode	● Normal mode ● Fitness mode ● Swimming mode ● Drone mode	● GPS only ● GPS + QZSS ● GPS + GLONASS ● GPS + GLONASS + QZSS ● GPS + Galileo ● GPS + Galileo + QZSS ● GPS + BDS ● GPS + BDS + QZSS ● GPS + GLONASS + Galileo + BDS ● GPS + GLONASS + Galileo	● 1 Hz ● 2 Hz ● 5 Hz ● 10 Hz	● LC26G (AB) ● LC76G (AB, PA, PB) ● LC86G (AA, AB, LA)

Type	Navigation Mode	Constellation Option	Fix Update Rate	Supported Module
		+ BDS + QZSS		
ALP mode	● Normal mode	● GPS + GLONASS ● GPS + GLONASS + QZSS ● GPS + GLONASS + Galileo + BDS ● GPS + GLONASS + Galileo + BDS + QZSS	● 1 Hz	● LC26G (AB) with LC26GABNR12A01S or higher versions. ● LC76G (AB) with LC76GABNR12A01S, LC76G (PA) with LC76GPANR02A02S and LC76G (PB) with LC76GPBNR02A02S or higher versions. ● LC86G (AA, AB), LC86G (LA) with LC86GLANR02A02S or higher versions.
GLP mode	● Fitness mode	● GPS only	● 1 Hz	● LC26G (AB) ● LC76G (AB, PA, PB) ● LC86G (AA, AB, LA)
FLP mode	● Fitness mode	● GPS + BDS ● GPS + BDS + QZSS ● GPS + GLONASS ● GPS + GLONASS + QZSS ● GPS + GLONASS + Galileo + BDS ● GPS + GLONASS + Galileo + BDS + QZSS	● 1 Hz	● LC26G (AB) ● LC76G (AB, PA, PB) ● LC86G (AA, AB, LA)

NOTE

1. The navigation mode, GNSS satellite configuration and fix update rate are the prerequisites for the operation of the low power modes. If the module is not in tracking mode that matches one of the available navigation profiles, it cannot support low power modes.
2. For LC76G (PA, PB) modules, the fix update rate can only be 1 Hz.

2 Low Power Modes

To extend battery operation time and meet customer requirements, the module supports several low power modes.

Table 4: System Resources Utilized in Low Power Modes

System Resource	Backup	Periodic (Running Stage)	Periodic (Sleeping Stage)	ALP	GLP	FLP
RTC Macro	●	●	●	●	●	●
RTC SRAM	●	●	●	●	●	●
Internal Circuits	-	●	●	●	●	●
CPU core	-	●	●	●	●	●
SRAM	-	●	●	●	●	●
TCXO	-	●	●	●	●	●
GPIO	-	●	●	●	●	●
RF	-	●	-	●	●	●

2.1. Backup Mode

2.1.1. Operation Mechanism

Backup mode is used to improve power efficiency. It shuts down most system components, such as RF controller, processing engine DSP, CPU core and so on. As a result, while the module is in Backup mode, the module's communication port is unresponsive to any incoming commands and no data is transmitted over it. Before it enters the Backup mode, the module saves navigation data, including ephemeris, almanac, location and time to RTC SRAM for the next navigation cycle to shorten the TTFF. The CPU core can be awoken by either setting the timer or powering on the VCC pin. For details, refer to *document [1] protocol specification* and *documents [2], [3], [4] hardware designs*.

Once the CPU core exits the Backup mode, the navigation data will be loaded from RTC SRAM. If all the data is valid, a shorter TTFF can be achieved.

The timing sequence of the Backup mode is as follows:

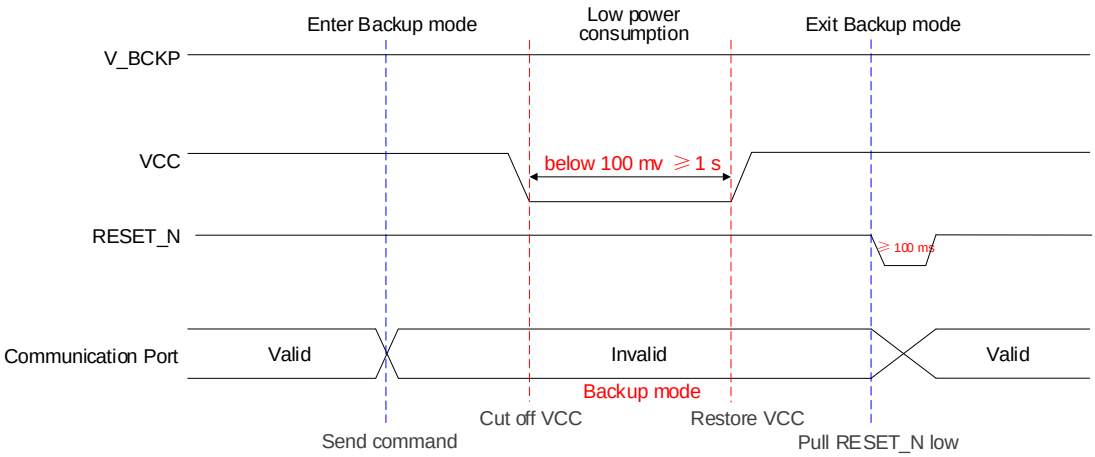

Figure 1: Enter/Exit Backup Mode Timing

2.1.2. Testing Procedures

To enter the Backup mode:

- Power up the module and make sure both VCC and V_BCKP are powered.
- Send **$PAIR650** and disconnect the VCC power supply to enter the Backup mode.

The module returns **$PAIR001,650,0*38** when it enters the Backup mode.

To exit the Backup mode:

- Restore VCC power.
- Drive the RESET_N low for at least 100 ms.

Table 5: Testing Environment in Backup Mode

Item	Description
Module	LC76G (PA)
Voltage	3.3 V
RF Signal Strength	-130 dBm
Equipment	Keysight 66319B Dual Mobile Comm DC Source w/ Battery Emulation
Command	**$PAIR650,0*25**
Execution Time	After the module gets a fix.
Axis	Vertical axis: current consumption (μA) Horizontal axis: duration (seconds/minutes)

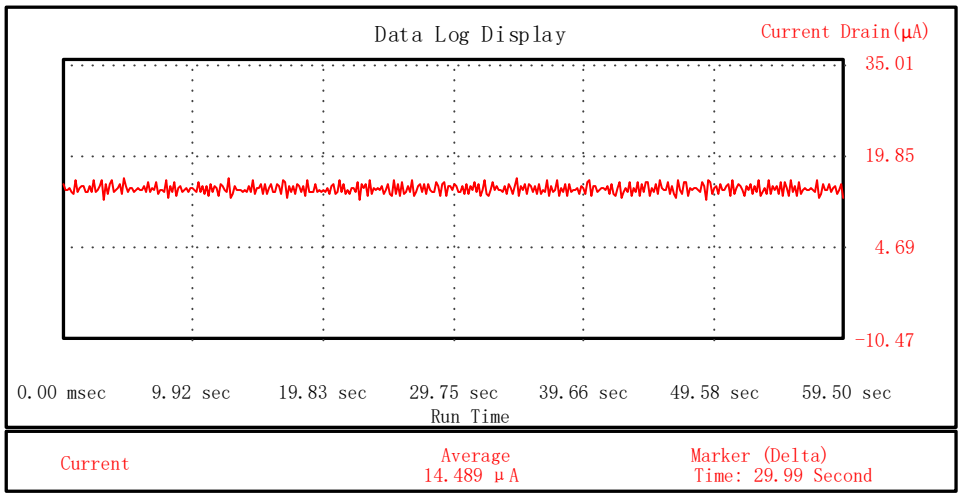

Figure 2: Measured Power Consumption in Backup Mode

2.2. Periodic Mode

2.2.1. Operation Mechanism

In the Periodic mode, power consumption can be reduced by turning off the DSP and periodically putting the CPU core to sleep. The running time and the sleeping time can be defined by users based on their needs.

- During the running time, the DSP and CPU core are active and perform their respective tasks, while the GNSS module generates the position-related information.
- During the sleeping time, the DSP is paused while the CPU core is in the sleeping stage.

The time span of the running (active) and sleeping stages can be dynamically changed or strictly limited, i.e., Smart Periodic Mode and Strict Periodic Mode. In Smart Periodic mode, the module observes the current satellite signal status, satellite health status, collected ephemeris status, etc., to determine the time needed to collect ephemeris data. Therefore, when **$PAIR690** is implemented, the system will automatically adjust the extension time to collect the required ephemeris data, increasing the likelihood that the position will be available immediately after the module wakes up from sleep. To shorten TTFF after waking up, it is recommended to use Smart Periodic mode to dynamically change the time span of the running stage to obtain more navigation information, such as pseudorange, ephemeris, and almanac. In Strict Periodic mode the duration of every cycle is fixed because the time span of the running stage is limited to a specific value. This fixed time span means that the module may not be able to complete satellite data update, such as ephemeris, within a single cycle, could potentially affect the TTFF.

Periodic pattern schematic diagram with different colors representing specific stages:

- Blue: module is in running (active) stage and the GNSS signal is good.
- Red: module is in sleeping stage and the GNSS signal is good.
- Yellow: module is in running (active) stage and there is no GNSS signal.
- Green: module is in sleeping stage and there is no GNSS signal.
- Brown: the extension time of running (active) stage.

Module operation in Smart Periodic mode is illustrated in the following figure:

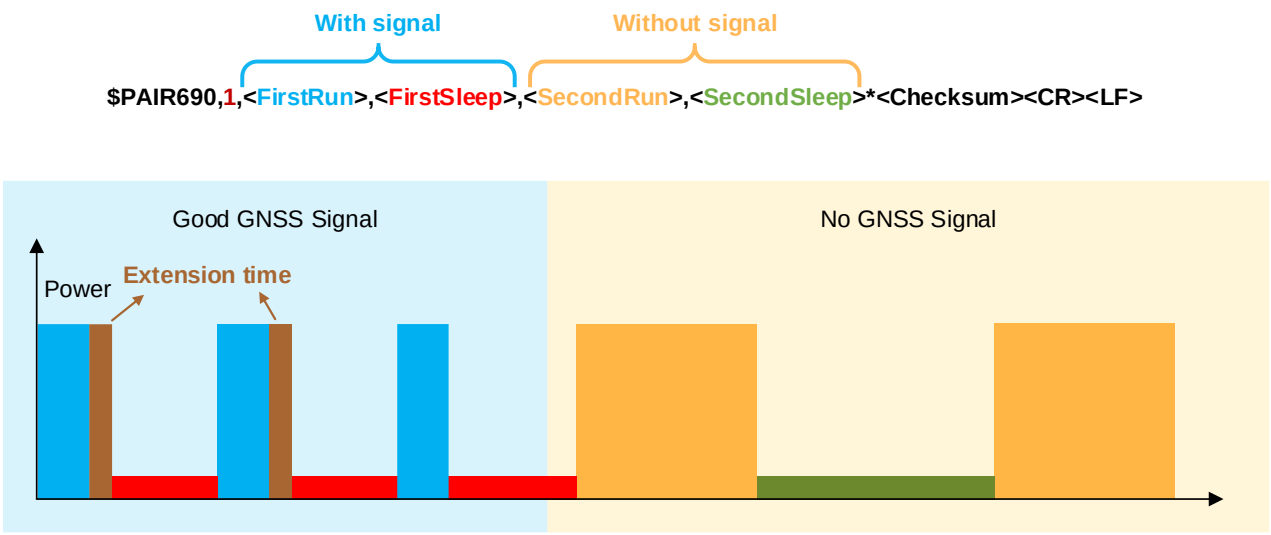

Figure 3: Module Operation in Smart Periodic Mode

Module operation in Strict Periodic mode is illustrated in the following figure:

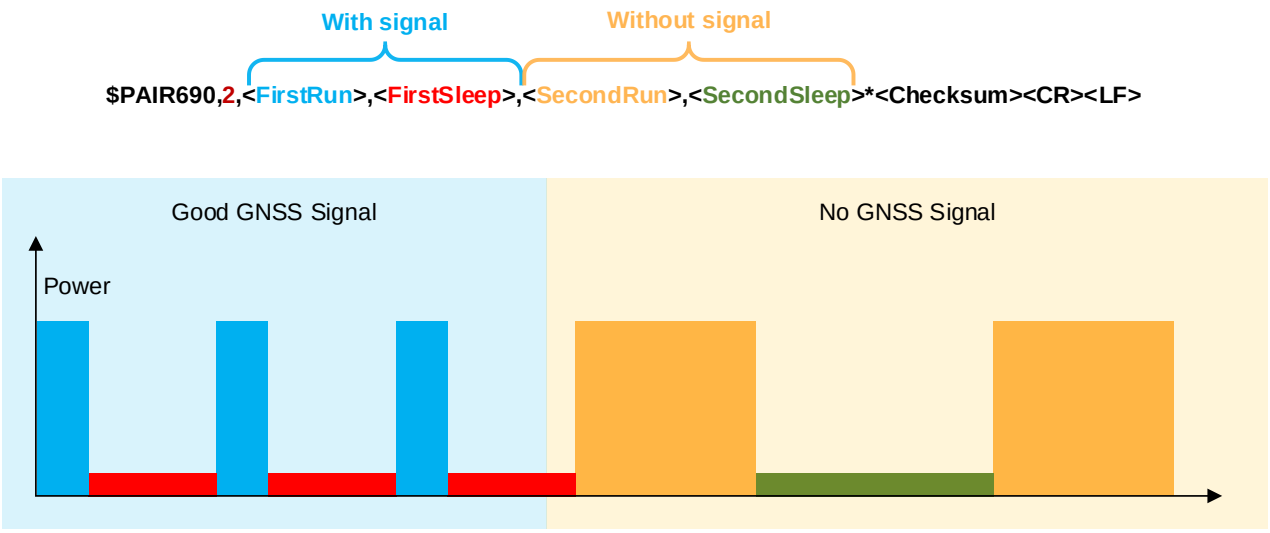

Figure 4: Module Operation in Strict Periodic Mode

2.2.2. Testing Procedures

To enter the Periodic mode:

- Power on the module.
- Send **$PAIR690** to enter the Periodic mode.

The module returns **$PAIR001,690,0*34** when it enters the Periodic mode.

To exit the Periodic mode:

Send **$PAIR690,0*29** to exit the Periodic mode.

Table 6: Testing Environment in Periodic Mode

Item	Description
Module	LC76G (PA)
Voltage	3.3 V
RF Signal Strength	-130 dBm
Equipment	Keysight 66319B Dual Mobile Comm DC Source w/ Battery Emulation
Command	**$PAIR690,2,10,30,30,40*2E**
Execution Time	After the module gets a fix.
Axis	Vertical axis: current consumption (mA) Horizontal axis: duration (seconds/minutes)

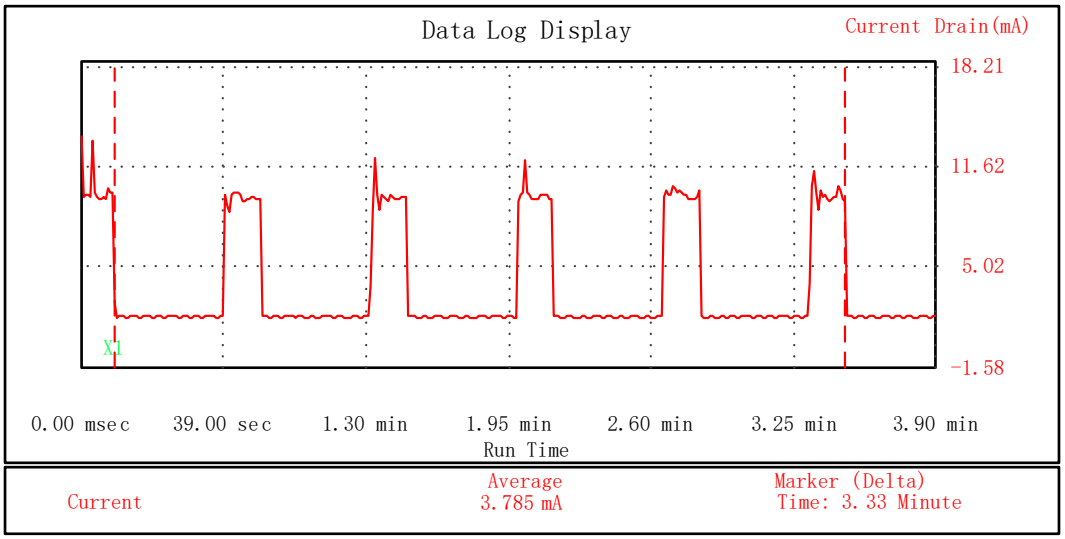

Figure 5: Measured Power Consumption in Periodic Mode

2.3. ALP Mode

2.3.1. Operation Mechanism

In the ALP mode, power is saved by using duty cycles, but the position quality is degraded compared to that in normal tracking mode. The receiver outputs positioning solution at every epoch.

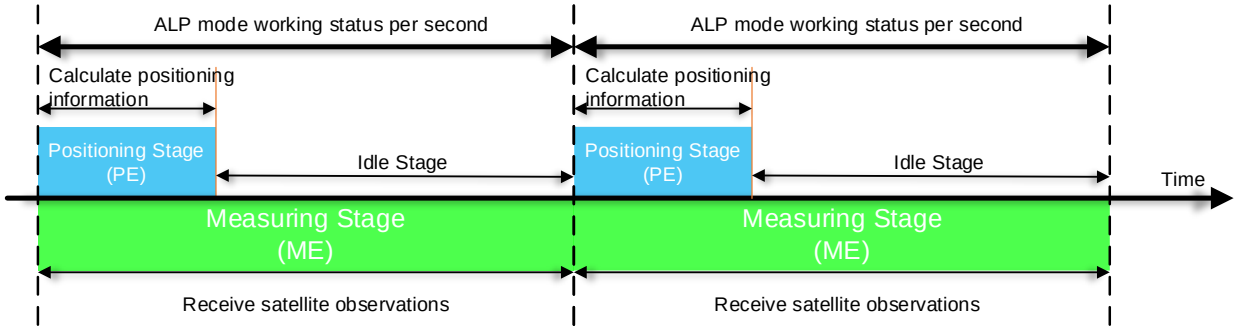

Figure 6: Module Operation in ALP Mode

As shown above, the ALP mode consists of three stages:

- Measuring Stage: ME receives satellite observations.
- Positioning Stage: PE calculates positioning information.
- Idle Stage: the module is in idle stage.

In the ALP mode, the module searches for satellites and adjusts the search time according to the actual conditions to achieve better positioning results while minimizing power consumption. This means that the satellite search time can be extended when satellite availability and signal quality are weak and the satellite search time can be shortened when satellite availability and signal quality are good.

2.3.2. Testing Procedures

Please refer to *Table 3: Low Power Modes* before performing the following test.

To enter the ALP mode:

1. Power on the module.
2. Send **$PAIR066** to switch GNSS satellite configuration.
3. Send **$PAIR080** to switch the navigation mode of the module.
4. Send **$PAIR732** to enter ALP mode.

Once the module returns **$PAIR001,732,0*3D**, the module enters the ALP mode.

To exit the ALP mode:

Send **$PAIR732,0*20** to exit the ALP mode.

2.3.2.1. Entering ALP mode after Power on

When the module enters the ALP mode after being powered on, it does not immediately reduce power consumption. The module uses ME and PE at full performance, resulting in the shortest possible TTFF and the highest sensitivity. It searches for all possible satellites until the almanac is completely downloaded. When there is enough ephemeris data and almanac data, the module gradually reduces power consumption When the ephemeris and almanac data are completely downloaded, the power consumption of the module will gradually stabilize. Detailed process is as follows:

1. To achieve a good positioning performance, the module continuously searches for GNSS satellite signals after startup, and its ME engine and PE engine consume most of the time. Power consumption is the highest in this phase.

2. Once the module receives enough GNSS satellite data, it gradually reduces the usage of ME and PE. In this phase, the power consumption of the module gradually decreases.

3. After transmitting the complete almanac (which takes about 12.5 min) the power consumption of the module stabilizes. ME and PE dynamically adjust based on the quality of the received signals in this phase.

To reduce the satellite search time and to speed up the module's entry into the ALP mode, you can send **$PAIR511*3F** to save the ephemeris and almanac data to flash memory after each satellite search or before the module is turned off, to avoid data loss due to time or power failure. If the V_BCKP power supply is available, the ephemeris and almanac data can also be saved by entering the Backup mode.

Table 7: Testing Environment in ALP Mode – Entering ALP Mode after Power On

Item	Description
Module	LC76G (PA)
Voltage	3.3 V
RF Signal Strength	-130 dBm
Equipment	Keysight 66319B Dual Mobile Comm DC Source w/ Battery Emulation
Command	**$PAIR732,1*21**
Execution Time	Immediately after the module is powered on.
Axis	Vertical axis: current consumption (mA) Horizontal axis: duration (seconds/minutes)

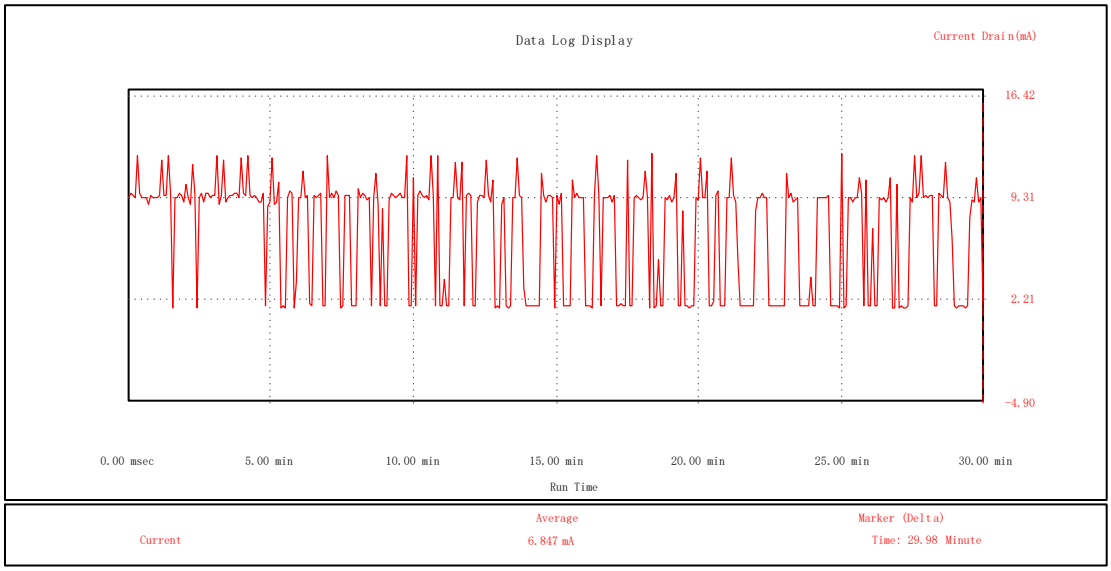

Figure 7: Power Consumption Measured in ALP Mode after Power On

2.3.2.2. Entering ALP mode at Stable Satellite Search

Three conditions should be met before sending **$PAIR066**, **$PAIR080** and **$PAIR732** to allow module to quickly reduce power consumption after entering the ALP mode.

- A valid position is obtained.
- The entire almanac has been downloaded.
- The ephemeris for each satellite in view is valid.

Table 8: Testing Environment in ALP Mode – at Stable Satellite Search

Item	Description
Module	LC76G (PA)
Voltage	3.3 V
RF Signal Strength	-130 dBm
Equipment	Keysight 66319B Dual Mobile Comm DC Source w/ Battery Emulation
Command	**$PAIR732,1*21**
Execution Time	15 minutes after the module is powered on.
Axis	Vertical axis: current value (mA) Horizontal axis: duration (seconds/minutes)

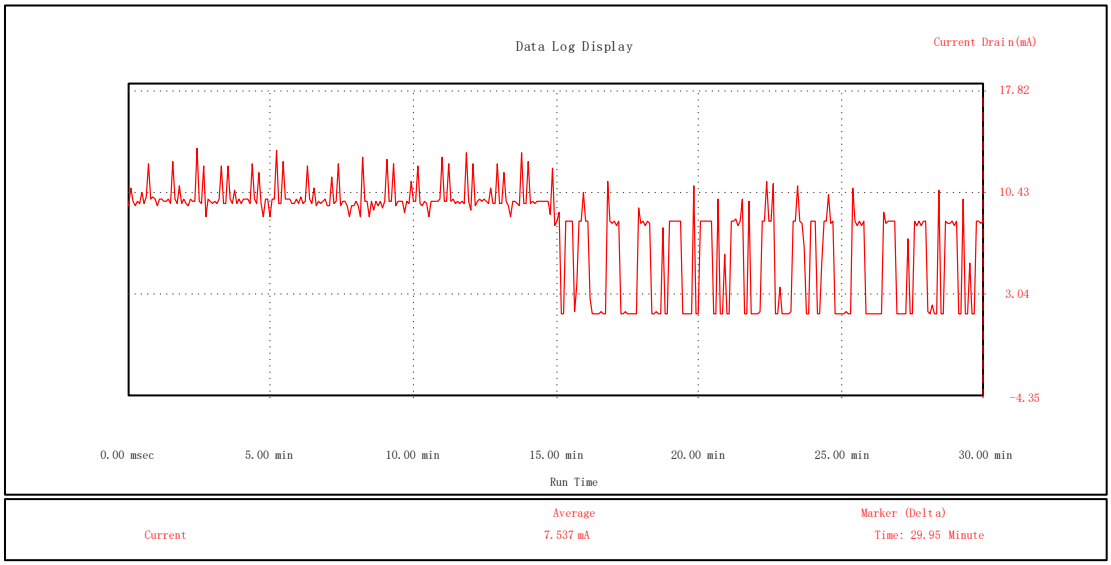

Figure 8: Measured Power Consumption in ALP Mode at Stable Satellite Search

2.4. GLP Mode

2.4.1. Operation Mechanism

In GLP mode, power is saved by using duty cycles, but the position quality is degraded compared to that in normal tracking mode.

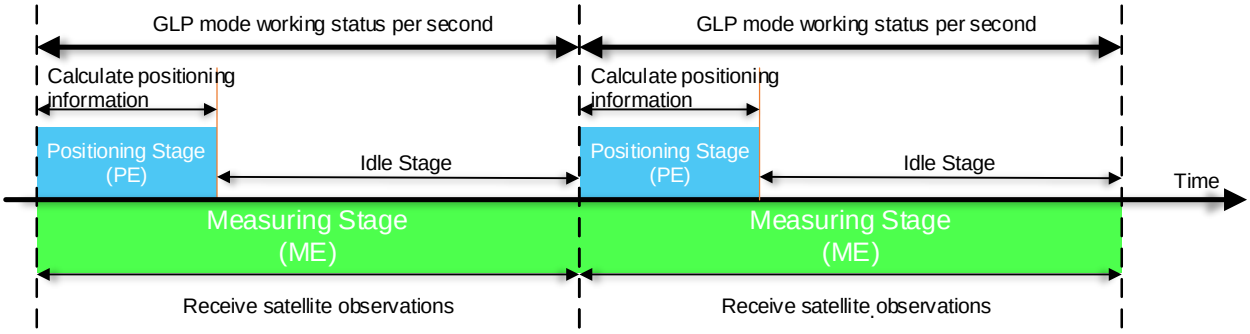

Figure 9: Operation Status in GLP Mode

As shown above, the GLP mode consists of three stages:

- Measuring Stage: ME receives satellite observations.
- Positioning Stage: PE calculates positioning information.
- Idle Stage: the module is in idle stage.

When the module enters GLP mode, it restricts its satellite search to GPS satellites only, reducing the time it takes to acquire satellites and resolve information, and maintaining low power consumption.

2.4.2. Testing Procedures

Please refer to *Table 3: Low Power Modes* before performing the following test.

To enter the GLP mode:

1. Power on the module.
2. Send **$PAIR066** to switch GNSS satellite configuration.
3. Send **$PAIR080** to switch the navigation mode of the module.
4. Send **$PAIR680** to enter the GLP mode.

The module returns **$PAIR001,680,0*35** when it enters the GLP mode.

To exit the GLP mode:

Send the **$PAIR680** to exit the GLP mode.

The module's power consumption in the GLP mode is similar to that in the ALP mode. For the description of power consumption in the GLP mode, please refer to *Chapter 2.3.2 Testing Procedure*.

2.5. FLP Mode

2.5.1. Operation Mechanism

In FLP mode, more power is saved by using duty cycles, but the position quality is degraded compared to that in normal tracking mode.

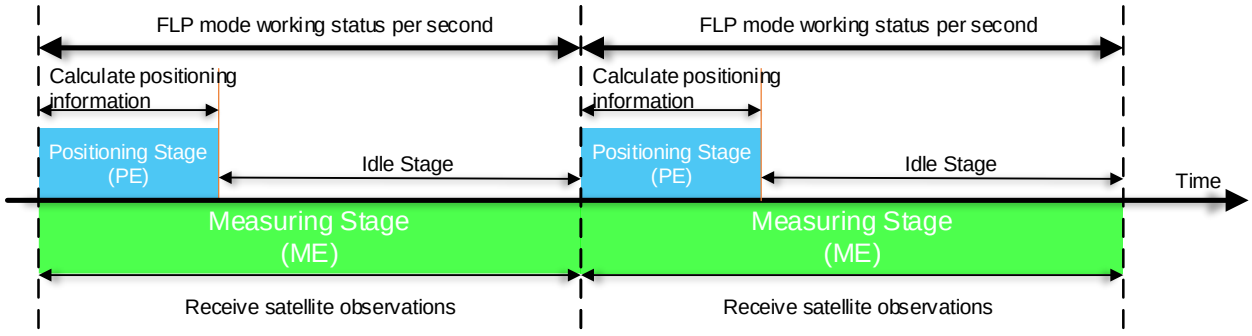

Figure 10: Operation Status in FLP Mode

As shown above, the FLP mode consists of three stages:

- Measuring Stage: ME receives satellite observations.
- Positioning Stage: PE calculates positioning information.
- Idle Stage: the module is in idle stage.

Due to the satellite search limitations in FLP mode, the positioning accuracy is lower compared to that in normal mode. However, because the module limits the number of satellites it searches, the time for satellite search and calculation is reduced, resulting in lower power consumption in this mode.

2.5.2. Testing Procedures

Please refer to *Table 3: Low Power Modes* before performing the following test.

To enter the FLP mode:

1. Power on the module.
2. Send **$PAIR066** to switch GNSS satellite configuration.
3. Send **$PAIR080** to switch the navigation mode of the module.
4. Send **$PAIR730** to enter FLP mode.

The module returns **$PAIR001,730,0*3F** when it enters the FLP mode.

To exit the FLP mode:

Send **$PAIR730** to exit the FLP mode.

The module's power consumption in FLP mode is similar to that in ALP mode. For the description of power consumption in the FLP mode, please refer to *Chapter 2.3.2 Testing Procedure*.

3 Appendix References

Table 9: Related Documents

Document Name
[1] Quectel_LC26G&LC76G&LC86G_Series_Protocol_Specification
[2] Quectel_LC26G(AB)_Hardware_Design
[3] Quectel_LC76G_Series_Hardware_Design
[4] Quectel_LC86G_Series_Hardware_Design

Table 10: Terms and Abbreviations

Abbreviation	Description
ALP	Adaptive Low Power
BDS	BDS Navigation Satellite System
CPU	Central Processing Unit
DSP	Digital Signal Processing
FLP	Fitness Low Power
GLP	GPS Low Power
GNSS	Global Navigation Satellite System
GPIO	General-purpose input/output
GPS	Global Positioning System
ME	Measurement Engine
PE	Position Engine
SRAM	Static Random-Access Memory

Abbreviation	Description
TCXO	Temperature Compensate X'tal (crystal) Oscillator
TTFF	Time to First Fix