L89 R2.0&LC29H&LC79H AGNSS Application Note

GNSS Module Series

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1 Introduction

EPO (Extended Prediction Orbit) is an AGNSS feature implemented by the chipset supplier, which improves the sensitivity of the GNSS receiver and therefore shortens its TTFF. This document mainly describes EPO file downloading, AGNSS implementation, EPO related PAIR commands and how to download EPO data through the QGNSS tool.

1.1. Differences Between Host EPO and Flash EPO

Both Flash EPO and Host EPO allow the GNSS receiver to achieve a shorter TTFF, but their differences make each of them suitable for different applications.

Host EPO (also called Real Time AGNSS) allows the receiver to store in RAM up to 6 hours of assistance data, which are sent to the receiver through NMEA PAIR commands listed in ***Chapter 4***. For Host EPO, there is no data retention after the GNSS receiver reboots and the data should be re-downloaded.

Flash EPO, on the other hand, allows the receiver to store in flash 3-, 7- or 14-day assistance data, which are sent to the receiver through the Binary Protocol defined by the chipset supplier. Flash EPO enables the receiver to reuse all assistance information stored in flash before the information expires. See ***Chapter 2.5*** for the validity period of EPO files.

Table 1: Differences between Flash EPO and Host EPO

Item	Flash EPO	Host EPO
Storage Space	Flash	RAM
Storage Capacity	3, 7 or 14 days' assistance data	6-hour assistance data
Protocol	Binary	NMEA

NOTE

The maximum flash memory EPO data retention period is 14 days for GPS-only and GPS + GLONASS EPO files, 7 days for Galileo EPO files and 3 days for BDS EPO files. If 30-day GPS-only or GPS + GLONASS EPO files are sent, only the first 14 days of EPO data will be stored.

1.2. AGNSS Requirements

The host needs to provide the Reference Time, Reference Position and EPO data to the GNSS receiver. The information provided by the host must meet the following requirements so that the GNSS receiver can make better use of EPO:

- The **Reference Time** should be accurate within 3 seconds and must be specified in UTC time.
- The **Reference Position** should be accurate within 30 km from the receiver's actual position. Keep in mind that if the receiver's view of the sky is limited, the accuracy of the Reference Position needs to be increased.
- The **EPO data** should be valid.

The receiver can benefit from any of the assistance data to improve the TTFF. All assistance data (Reference Time, Reference Position and EPO data) are useful but none of them are mandatory. If some of them are not available or have expired, it is recommended to avoid using them.

The host can send the Reference Time, Reference Position and EPO data to the GNSS receiver through the messages listed in the following table. See ***Chapter 4*** for a detailed description of these messages.

Table 2: AGNSS Related Commands

Packet Type	Data Content
$PAIR471	GPS/GLONASS/Galileo/BDS EPO data for a single satellite.
$PAIR590	Reference UTC Time.
$PAIR600	Reference Position.

2 Download EPO Files

Quectel does not provide any Service Level Agreement for EPO files. Download EPO data to your own server and send them to devices to ensure EPO data availability.

2.1. Get EPO Files from Server

Table 3: Download URL of EPO Files

EPO Type	GNSS Type	EPO File URL	File Name
Unified QEPO	GPS only	http://wpepodownload.mediatek.com/QGPS.DAT?*vendorinfo*	Single name: QGPS.DAT
Unified QEPO	GPS + GLONASS	http://wpepodownload.mediatek.com/QG_R.DAT?*vendorinfo*	Single name: QG_R.DAT
Unified QEPO	BDS only	http://wpepodownload.mediatek.com/QBD2.DAT?*vendorinfo*	Single name: QBD2.DAT
Unified QEPO	Galileo only	http://wpepodownload.mediatek.com/QGA.DAT?*vendorinfo*	Single name: QGA.DAT
EPO	GPS only	http://wpepodownload.mediatek.com/EPO_GPS_3_***X***.DAT?*vendorinfo*	**X** = 1–10 EPO_GPS_3_1.DAT to EPO_GPS_3_10.DAT
EPO	GPS + GLONASS	http://wpepodownload.mediatek.com/EPO_GR_3_***X***.DAT?*vendorinfo*	**X** = 1–10 EPO_GR_3_1.DAT to EPO_GR_3_10.DAT
EPO	BDS only	http://wpepodownload.mediatek.com/EPO_BDS_3.DAT?*vendorinfo*	EPO_BDS_3.DAT
EPO	Galileo only	http://wpepodownload.mediatek.com/EPO_GAL_***X***.DAT?*vendorinfo*	**X** = 3 or 7 EPO_GAL_3.DAT or EPO_GAL_7.DAT

The following is a complete URL sample:
http://wpepodownload.mediatek.com/QGPS.DAT?*vendor*=*AAA*&*project*=*BBB*&*device_id*=*CCC*

- The query string starts with "?" and is separated by "&".
- The values of "*vendor*" and "*project*" (*AAA* and *BBB* in the example) are issued by Quectel. Contact

Quectel Technical Support to get the value.
The value of "*device_id*" (*CCC* in the example) contains two parts – one is assigned by Quectel and the other by the customer. For example: if *CCC* = *XXX_YYY*, the value *XXX* is provided by Quectel and you can contact Quectel Technical Support to get the value, while *YYY* can be assigned by yourself and it must be a unique value, such as IMEI. Each device must have a unique ID.

NOTE

There will be up to 10 files as the GPS-only or GPS + GLONASS EPO files may include a maximum of 30 days of predictions. Slices of 30-day EPO:
_1 for days 1 to 3,
_2 for days 4 to 6,
...
_10 for days 28 to 30.

2.2. EPO File Format

This part mainly illustrates the format of EPO files.

The SVID numbers of EPO files for different constellations are shown below.

Table 4: EPO Data SVID Range

GNSS Type	PRN	EPO Data SVID
GPS	1–32	1–32
GLONASS	1–24	65–88
Galileo	1–36	101–136
BDS	1–54, 55–63	201–254, 190–198

2.2.1. EPO File Format – GPS Only

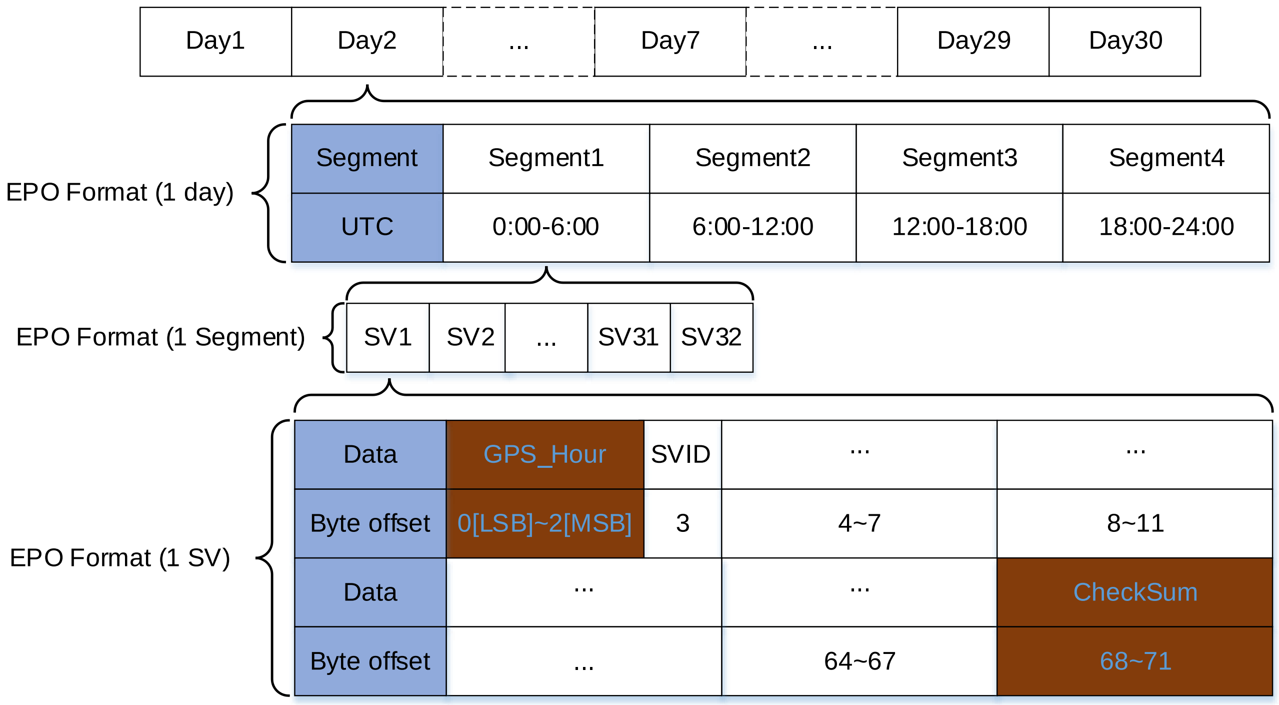


Figure 1: EPO File Format – GPS Only

GPS_Secs = GPS_Hour * 3600
GPS_Week Number = GPS_Secs / 604800
GPS TOW = GPS_Secs % 604800

An EPO file contains GPS Time (GPS_Week, GPS_Hour and GPS_Secs). The maximum unit in GPS Time is GPS week which starts at approximately midnight of January 5th to 6th, 1980.

The following figure illustrates the format of several segments of EPO files.

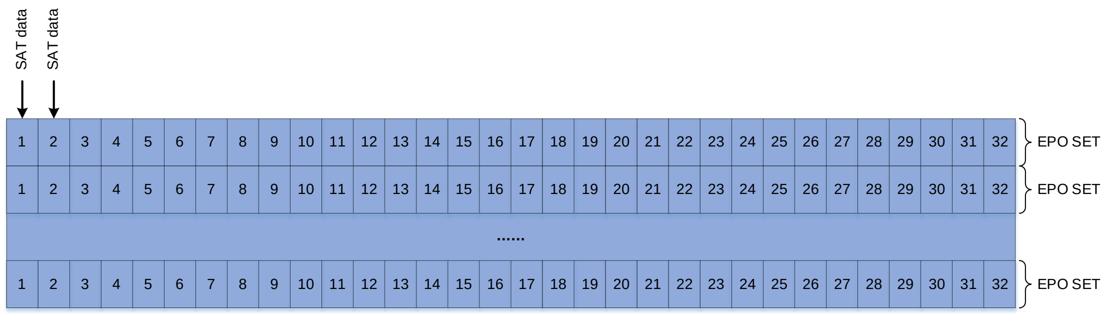


Figure 2: Format of Several Segments of EPO Files

The basic unit of an EPO file is SAT Data and the size of each SAT Data is 72 bytes. One EPO SET contains 32 SAT Data, so the data size of an EPO SET is 2304 bytes. Each EPO file contains several EPO SETs and thus the file size must be a multiple of 2304 bytes. An EPO SET is valid for 6 hours. Therefore, there will be 4 EPO SETs for one day.

2.2.2. EPO File Format – BDS/Galileo Only

Galileo EPO data consist of the 72-byte header and 3- or 7- day fundamental EPO data. BDS EPO data consist of the 72-byte header and 3-day EPO data only. The EPO format for both has no fixed size.

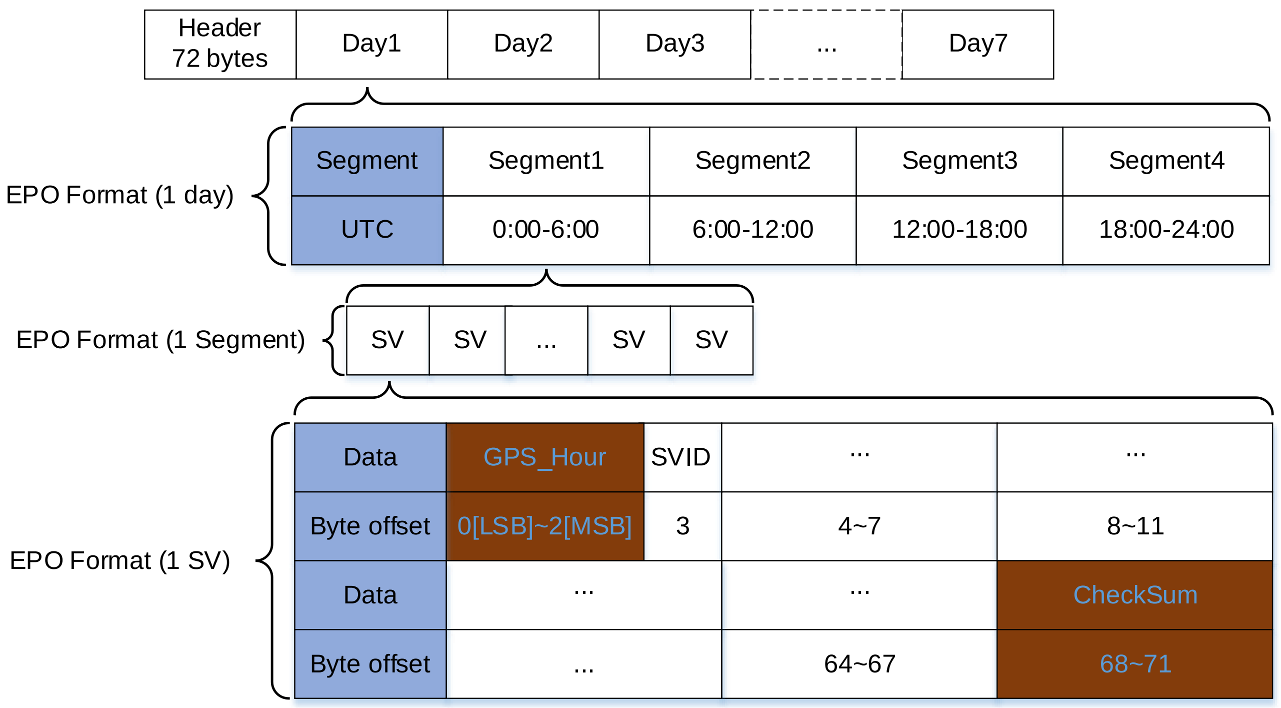


Figure 3: EPO File Format – BDS/Galileo Only

The 72-byte header contains the SV available bitmask that can be used for calculating the available satellite ID. When the SV available bitmask position is 1, it indicates that the satellite is available, and the number of bits indicates the satellite ID.

For example, you can parse the data from *Figure 4: Galileo EPO Header* as follows.

- SVID is FE for Galileo.
- SV available bitmask: 09 67 94 5D DF.
- Total available SVs: 22.
- Available SVs: 1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 15, 19, 21, 24, 25, 26, 27, 30, 31, 33, 36.

Data	***	SVID	SV available bitmask(Lbytes)	***	***
Byte offset	0~2	3	4[LSB]~7[MSB]	8~11	12~15
Example		FE	DF 5D 94 67		

Data	SV available bitmask(Hbytes)	***	***	***
Byte offset	16[LSB]~19[MSB]	20~23	24~27	18~31
Example	09 00 00 00			

Figure 4: Galileo EPO Header

You can parse the data from *Figure 5: BDS EPO Header* as follows.

- SVID is FF for BDS.
- SV available bitmask: 3F FF BF FC 3F FF.
- Total available SVs: 41.
- Available SVs: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46.

Data	***	SVID	SV available bitmask(Lbytes)	***	***
Byte offset	0~2	3	4[LSB]~7[MSB]	8~11	12~15
Example		FF	FF 3F FC BF		

Data	SV available bitmask(Hbytes)	***	***	***
Byte offset	16[LSB]~19[MSB]	20~23	24~27	18~31
Example	FF 3F 00 00			

Figure 5: BDS EPO Header

2.2.3. EPO File Format – GPS + GLONASS

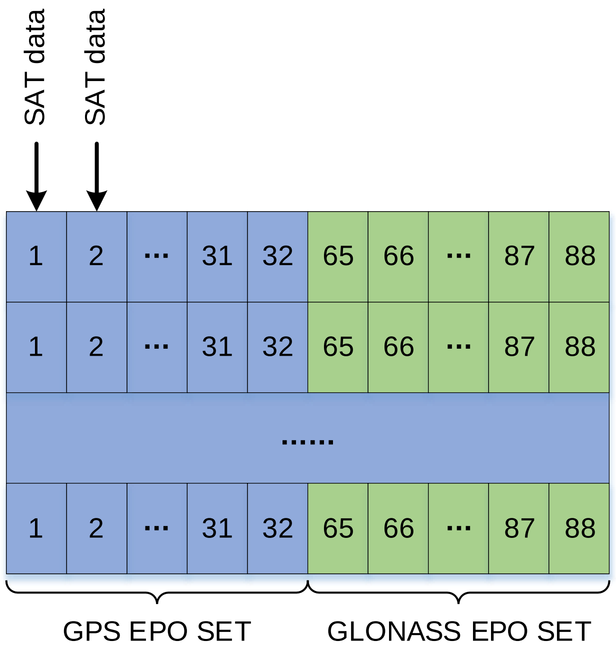


Figure 6: EPO File Format – GPS + GLONASS

The basic unit of an EPO file is SAT Data, and the size of SAT Data is 72 bytes. In GPS + GLONASS EPO files, one EPO SET contains 56 SAT Data, so the EPO SET data size is 4032 bytes. Each EPO file contains several EPO SETs. The file size must be a multiple of 4032 bytes. An EPO SET is valid for 6 hours. Therefore, there will be 4 EPO SETs for one day.

2.3. EPO File Types

The EPO data can be downloaded in the form of files. You can select the most suitable file type to download based on the availability of a data connection and storage space of your application. See *Table 3: Download URL of EPO Files* and *Table 5: EPO File* to decide on the file type to be downloaded.

Table 5: EPO File Types

EPO Type	GNSS Type	Description
EPO	GPS only	3–14 days of prediction orbit (ephemeris). Split into 5 files, each containing 3-day information.
EPO	Galileo only	3- or 7-day prediction orbit (ephemeris).

EPO	BDS only	3-day prediction orbit (ephemeris).
EPO	GPS + GLONASS	3–14 days of prediction orbit (ephemeris). Split into 5 files, each containing 3-day information.
Unified QEPO	GPS only	6-hour prediction orbit (ephemeris). Single file containing the latest available GPS EPO data.
Unified QEPO	GPS + GLONASS	6-hour prediction orbit (ephemeris). Single file containing the latest available GPS + GLONASS EPO data.
Unified QEPO	BDS/Galileo only	6-hour prediction orbit (ephemeris). Single file containing the latest available BDS/Galileo EPO data.

2.4. Recommended Download Procedures of EPO Files

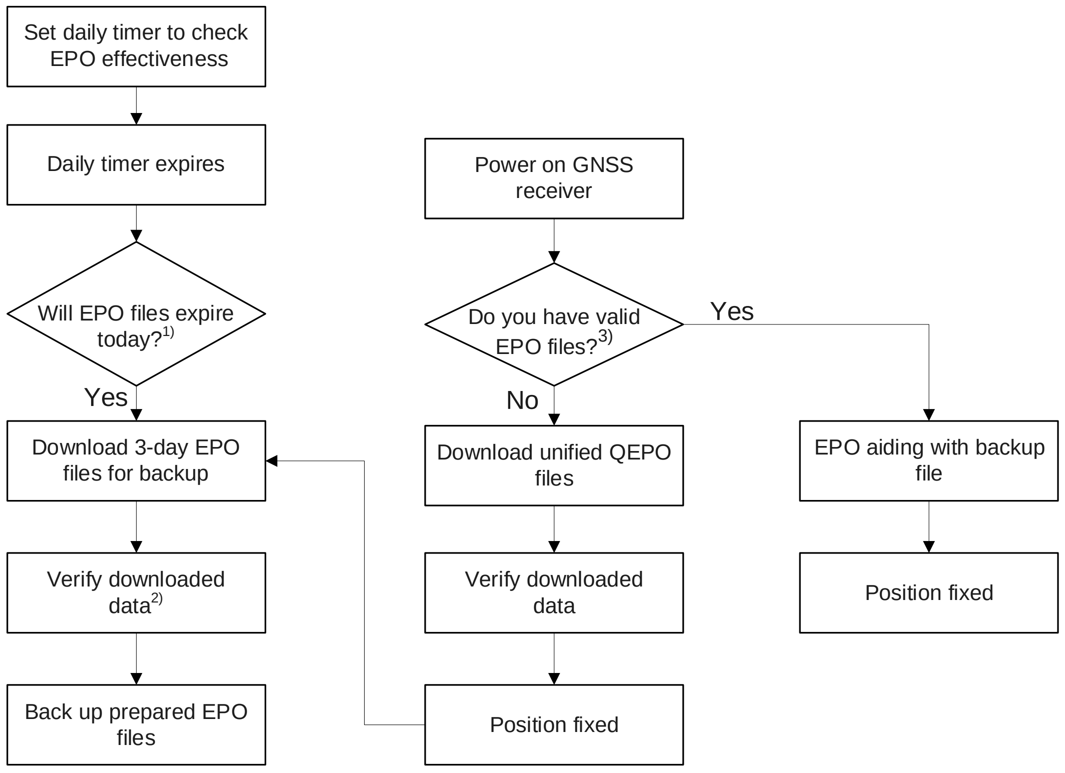

Set daily timer to check EPO effectiveness
Daily timer expires
Will EPO files expire today?1)
Yes
Download 3-day EPO files for backup
Verify downloaded data2)
Back up prepared EPO files
Power on GNSS receiver
Do you have valid EPO files?3)
Yes
No
Download unified QEPO files
Verify downloaded data
Position fixed
EPO aiding with backup file
Position fixed

Figure 7: Recommended Download Procedures of EPO Files

NOTE

1. [1)] Users must know the current UTC time to download the valid EPO files.
2. [2)] Send **$PAIR470** to check if the data are correct.

3. [3)] If the device is powered-off for a long time, EPO files stored in flash may expire.

2.5. EPO File Validity Period

EPO file validity period is related to the current UTC time. The EPO file validity period can be obtained from the last segment of the EPO file. See *Figure 1: EPO File Format – GPS Only* or the sample of how to calculate EPO file validity period (GPS_Hour + 6). It is necessary to download the EPO file 12 hours in advance. The following codes show the conversion between UTC time and GPS time.

```
void utc_to_gpstime(kal_uint32  year,       //Input year
                    kal_uint8   mon,        //Input month: 1~12
                    kal_uint8   day,        //Input day: 1~31
                    kal_uint8   hour,       //Input hour: 0~23
                    kal_uint8   min,        //Input minute: 0~59
                    kal_uint8   sec,        //Input second: 0~59
                    kal_int32*  wn,         //Output GPS week number
                    double*    tow)         //Output GPS time of week
{
    kal_int32 iYearsElapsed;                //Elapsed years since 1980
    kal_int32 iDaysElapsed;                 //Elapsed days since Jan 5/Jan 6, 1980
    kal_int32 iLeapDays;                    //Leap days since Jan 5/Jan 6, 1980
    kal_int32 i;
    //Number of days at the start of each month (ignore leap years).
    kal_uint16 doy[12] = {0, 31, 59, 90, 120, 151, 181, 212, 243, 273, 304, 334};

    iYearsElapsed = year - 1980;
    i = 0;
    iLeapDays = 0;
    while (i <= iYearsElapsed)
    {
        if ((i % 100) == 20)
        {
            if ((i % 400) == 20)
            {
                iLeapDays++;
            }
        }
        else if ((i % 4) == 0)
        {
            iLeapDays++;
        }
        i++;
    }
    /*  iLeapDays = iYearsElapsed / 4 + 1; */.
    if ((iYearsElapsed % 100) == 20)
    {
        if (((iYearsElapsed % 400) == 20) && (mon <= 2))
        {
            iLeapDays--;
        }
    }
    else if (((iYearsElapsed % 4) == 0) && (mon <= 2))
    {
        iLeapDays--;
    }
    iDaysElapsed = iYearsElapsed * 365 + doy[mon - 1] + day + iLeapDays - 6;
    //Convert time to GPS weeks and seconds.
    *wn = iDaysElapsed / 7;
    *tow = (double)(iDaysElapsed % 7) * 86400 + hour * 3600 + min * 60 + sec;
}
```

3 AGNSS Implementation

This chapter describes two AGNSS implementation methods: Host EPO and Flash EPO.

- Implement AGNSS with Host EPO

The host sends EPO data to the GNSS receiver through NMEA PAIR commands, such as **$PAIR471**.

- Implement AGNSS with Flash EPO

The EPO data are downloaded to the flash of GNSS receiver through Binary Protocol.

Flash EPO retains data longer than Host EPO.

3.1. AGNSS with Flash EPO

Flash EPO can store up to 14 days of EPO assistance data in flash, which enables the receiver to use the available data since boot time. The communication protocol of Flash EPO is Binary Protocol. Thus, you need to download assistance data to the GNSS receiver in the binary format specified in this document. See ***Chapter 3.1.2*** and ***Chapter 3.1.3*** for details.

3.1.1. Binary Protocol

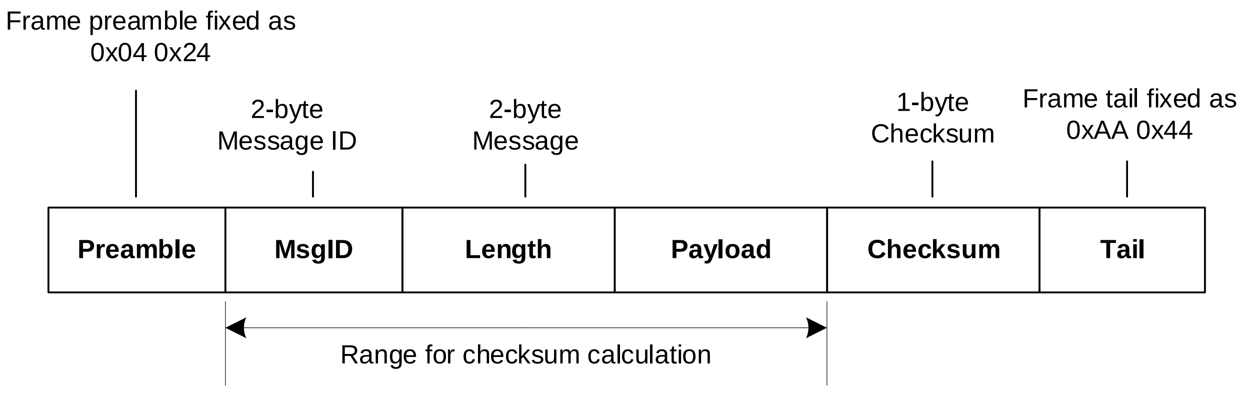

Frame preamble fixed as 0x04 0x24
2-byte Message ID
2-byte Message
1-byte Checksum
Frame tail fixed as 0xAA 0x44
Preamble
MsgID
Length
Payload
Checksum
Tail
Range for checksum calculation

Figure 8: Binary Protocol Structure

Table 6: Description of Binary Protocol Fields

Field	Length (Byte)	Description
Preamble	2	Fixed as 0x2404. Little-endian.
MsgID	2	Message ID.
Length	2	**Payload** length. Unit: byte. Default packet size: 72 bytes. Little-endian.
Payload	Variable	Payload data to be transferred.
Checksum	1	The checksum is the 8-bit exclusive OR of all bytes in the message between (but not including) the **Preamble** and the **Checksum**.
Tail	2	Fixed as 0x44AA. Little-endian.

The EPO binary format is divided into start message, EPO data message and end message.

Table 7: Start of EPO Binary Format

Preamble	MsgID	Length	Payload	Checksum	Tail
0x04 0x24	0xB0 0x04	1	‘G’ – GPS ‘R’ – GLONASS ‘E’ – Galileo ‘C’ – BDS	0x**	0xAA 0x44
2 Bytes	2 Bytes	2 Bytes	2 Bytes	1 Byte	2 Bytes

Table 8: EPO Data Binary Format

Preamble	MsgID	Length	Payload	Checksum	Tail
0x04 0x24	0xB1 0x04	72	EPO Data	0x**	0xAA 0x44
2 Bytes	2 Bytes	2 Bytes	72 Bytes	1 Byte	2 Bytes

Table 9: End of EPO Binary Format

Preamble	MsgID	Length	Payload	Checksum	Tail
0x04 0x24	0xB2 0x04	1	‘G’ – GPS ‘R’ – GLONASS	0x**	0xAA 0x44

			'E' – Galileo 'C' – BDS		
2 Bytes	2 Bytes	2 Bytes	2 Bytes	1 Byte	2 Bytes

3.1.2. EPO Data Transfer Protocol

When transmitting assistance data, the host first sends the start message packet, then splits the EPO data into data packets and sends them, and finally sends the end message packet. The host should follow the EPO Data Transfer Protocol when transferring EPO data to the GNSS receiver.

3.1.2.1 Pseudo Code for EPO Data Transfer Protocol

Pseudo code for the EPO data transfer procedure of GPS + GLONASS, for reference only:

```
#define GNSS_APP_BINARY_BINARY_PREAMBLE1      (0x04)
#define GNSS_APP_BINARY_BINARY_PREAMBLE2      (0x24)
#define GNSS_APP_BINARY_BINARY_ENDWORD1       (0xAA)
#define GNSS_APP_BINARY_BINARY_ENDWORD2       (0x44)

#define GNSS_APP_BINARY_BINARY_PREAMBLE_SIZE   (2)
#define GNSS_APP_BINARY_BINARY_CHECKSUM_SIZE   (1)
#define GNSS_APP_BINARY_BINARY_ENDWORD_SIZE    (2)
#define GNSS_APP_BINARY_BINARY_CONTROL_SIZE
       (GNSS_APP_BINARY_BINARY_PREAMBLE_SIZE + \
       GNSS_APP_BINARY_BINARY_CHECKSUM_SIZE + \
       GNSS_APP_BINARY_BINARY_ENDWORD_SIZE)

#define GNSS_APP_BINARY_BINARY_MESSAGE_ID_SIZE      (2)
#define GNSS_APP_BINARY_BINARY_PAYLOAD_LENGTH_SIZE   (2)
#define GNSS_APP_BINARY_BINARY_PAYLOAD_HEADER_SIZE
       (GNSS_APP_BINARY_BINARY_MESSAGE_ID_SIZE + \
       GNSS_APP_BINARY_BINARY_PAYLOAD_LENGTH_SIZE)

#define GNSS_APP_BINARY_BINARY_MAX_DATA_SIZE (512)
#define GNSS_APP_BINARY_BINARY_MAX_PAYLOAD_DATA_SIZE
       (GNSS_APP_BINARY_BINARY_MAX_DATA_SIZE - \
       GNSS_APP_BINARY_BINARY_CONTROL_SIZE - \
       GNSS_APP_BINARY_BINARY_PAYLOAD_HEADER_SIZE)

typedef enum gnss_app_binary_binary_decode_results {
    GNSS_APP_BINARY_BINARY_DECODE_SUCCESS = 0,
    GNSS_APP_BINARY_BINARY_DECODE_WRONG_PARAMETER = -1,
    GNSS_APP_BINARY_BINARY_DECODE_WRONG_PREAMBLE  = -2,
    GNSS_APP_BINARY_BINARY_DECODE_WRONG_CHECKSUM  = -3,
    GNSS_APP_BINARY_BINARY_DECODE_WRONG_ENDWORD   = -4,
}gnss_app_binary_binary_decode_results_t;
typedef struct gnss_app_binary_binary_payload {
    uint16_t message_id;
    uint16_t data_size; /* actual size of data in payload data buffer */
    uint8_t data[GNSS_APP_BINARY_BINARY_MAX_PAYLOAD_DATA_SIZE];
}gnss_app_binary_binary_payload_t;

uint8_t gnss_app_binary_calculate_binary_checksum(const
    gnss_app_binary_binary_payload_t* const payload)
{
    uint8_t checksum = 0;
    uint8_t* pheader = NULL;
    uint8_t* pdata = NULL;
    uint16_t i;
    if (NULL == payload) {
        return 0;
    }
    /* The checksum is the 8-bit exclusive OR of all bytes in the payload. */
    pheader = (uint8_t*)payload;
    for (i = 0; i < GNSS_APP_BINARY_BINARY_PAYLOAD_HEADER_SIZE; i++) {
        checksum ^= *pheader;
        pheader++;
    }
    pdata = (uint8_t*)payload->data;
    for (i = 0; i < payload->data_size; i++) {
        checksum ^= *pdata;
        pdata++;
    }
    return checksum;
}

int16_t gnss_app_binary_encode_binary_packet(uint8_t* const buffer, uint16_t
    max_buffer_size, const gnss_app_binary_binary_payload_t* const payload)
{
    uint8_t* pbyte;
    uint16_t required_length;
    if (NULL == buffer || payload == NULL) {
        return -1;
    }
    required_length = payload->data_size + GNSS_APP_BINARY_BINARY_CONTROL_SIZE +
        GNSS_APP_BINARY_BINARY_PAYLOAD_HEADER_SIZE;
    if (max_buffer_size < required_length) {
        return -1;
    }
    memset((void*)buffer, 0, max_buffer_size);
    buffer[0] = GNSS_APP_BINARY_BINARY_PREAMBLE1;
    buffer[1] = GNSS_APP_BINARY_BINARY_PREAMBLE2;
    pbyte = &buffer[2];
    memcpy(pbyte, payload, GNSS_APP_BINARY_BINARY_PAYLOAD_HEADER_SIZE);
    pbyte += GNSS_APP_BINARY_BINARY_PAYLOAD_HEADER_SIZE;
    memcpy(pbyte, payload->data, payload->data_size);
    pbyte += payload->data_size;
    *pbyte++ = gnss_app_binary_calculate_binary_checksum(payload);
    *pbyte++ = GNSS_APP_BINARY_BINARY_ENDWORD1;
    *pbyte = GNSS_APP_BINARY_BINARY_ENDWORD2;
    return required_length;
}

FILE* gnss_epo_file = NULL;
#define GNSS_MAX_EPO_NUMBER (37)
#define GNSS_MAX_RECORD_SIZE (72)
static uint32_t gnss_epo_sv_buf[(GNSS_MAX_EPO_NUMBER *
    GNSS_MAX_RECORD_SIZE) / sizeof(uint32_t)];
int16_t gnss_epo_encode_binary(uint16_t msg_id, char* buffer, uint16_t buffer_size,
    char* data_input, int32_t data_length) {
    gnss_app_binary_binary_payload_t payload;
    int16_t binary_message_length;
    memset((void*)&payload, 0, sizeof(gnss_app_binary_binary_payload_t));
    payload.message_id = msg_id;
    payload.data_size = (uint16_t)data_length;
    memcpy(payload.data, data_input, sizeof(uint8_t) * data_length);
    binary_message_length = gnss_app_binary_encode_binary_packet(buffer,
        buffer_size, &payload);
    return binary_message_length;
}

void gnss_epo_binary_demo() {
    gnss_app_binary_data_t data;
    gnss_app_binary_data_result_t result = { 0 };
    uint32_t* epobuf;
    int32_t i;
    char buffer[500];
    uint16_t length = 0;
    int32_t buffer_size = 0;
    uint8_t segment = 0;
    uint8_t curr_sys_type = 'G';  //type is the GPS
    gnss_epo_file = fopen("EPO_GR_3_1.DAT", "rb");
    length = gnss_epo_encode_binary(1200, buffer, 512, &curr_sys_type, 1);
    gnss_app_uart_send_data(buffer, length);
    memset(&gnss_epo_sv_buf, 0, sizeof(gnss_epo_sv_buf));
    while (gnss_epo_read_data(&gnss_epo_sv_buf, 32 * GNSS_MAX_RECORD_SIZE, segment *
        (32 + 24) * GNSS_MAX_RECORD_SIZE)) {
        segment++;
        for (i = 0; i < 32; i++) {
            epobuf = (uint32_t*)(gnss_epo_sv_buf + ((i * GNSS_MAX_RECORD_SIZE) /
                4));
            length = gnss_epo_encode_binary(1201, buffer, 512, (char*)epobuf,
                GNSS_MAX_RECORD_SIZE);
            gnss_app_uart_send_data(buffer, length);
        }
        memset(&gnss_epo_sv_buf, 0, sizeof(gnss_epo_sv_buf));
    }
    length = gnss_epo_encode_binary(1202, buffer, 512, &curr_sys_type, 1);
    gnss_app_uart_send_data(buffer, length);

    curr_sys_type = 'R';  //type is the GLONASS
    length = gnss_epo_encode_binary(1200, buffer, 512, &curr_sys_type, 1);
    gnss_app_uart_send_data(&data, &result);
    memset(&gnss_epo_sv_buf, 0, sizeof(gnss_epo_sv_buf));
    segment = 0;
    while (gnss_epo_read_data(&gnss_epo_sv_buf, 37 * GNSS_MAX_RECORD_SIZE, (segment
        * (32 + 24) * GNSS_MAX_RECORD_SIZE) + (32 * GNSS_MAX_RECORD_SIZE))) {
        segment++;
        for (i = 0; i < 24; i++) {
            epobuf = (uint32_t*)(gnss_epo_sv_buf + ((i * GNSS_MAX_RECORD_SIZE) /
                4));
            length = gnss_epo_encode_binary(1201, buffer, 512, (char*)epobuf,
                GNSS_MAX_RECORD_SIZE);
            gnss_app_uart_send_data(buffer, length);
        }
        memset(&gnss_epo_sv_buf, 0, sizeof(gnss_epo_sv_buf));
    }
    length = gnss_epo_encode_binary(1202, buffer, 512, &curr_sys_type, 1);
    gnss_app_uart_send_data(buffer, length);
    fclose(gnss_epo_file);
}
```

3.1.3. AGNSS Procedure with Flash EPO

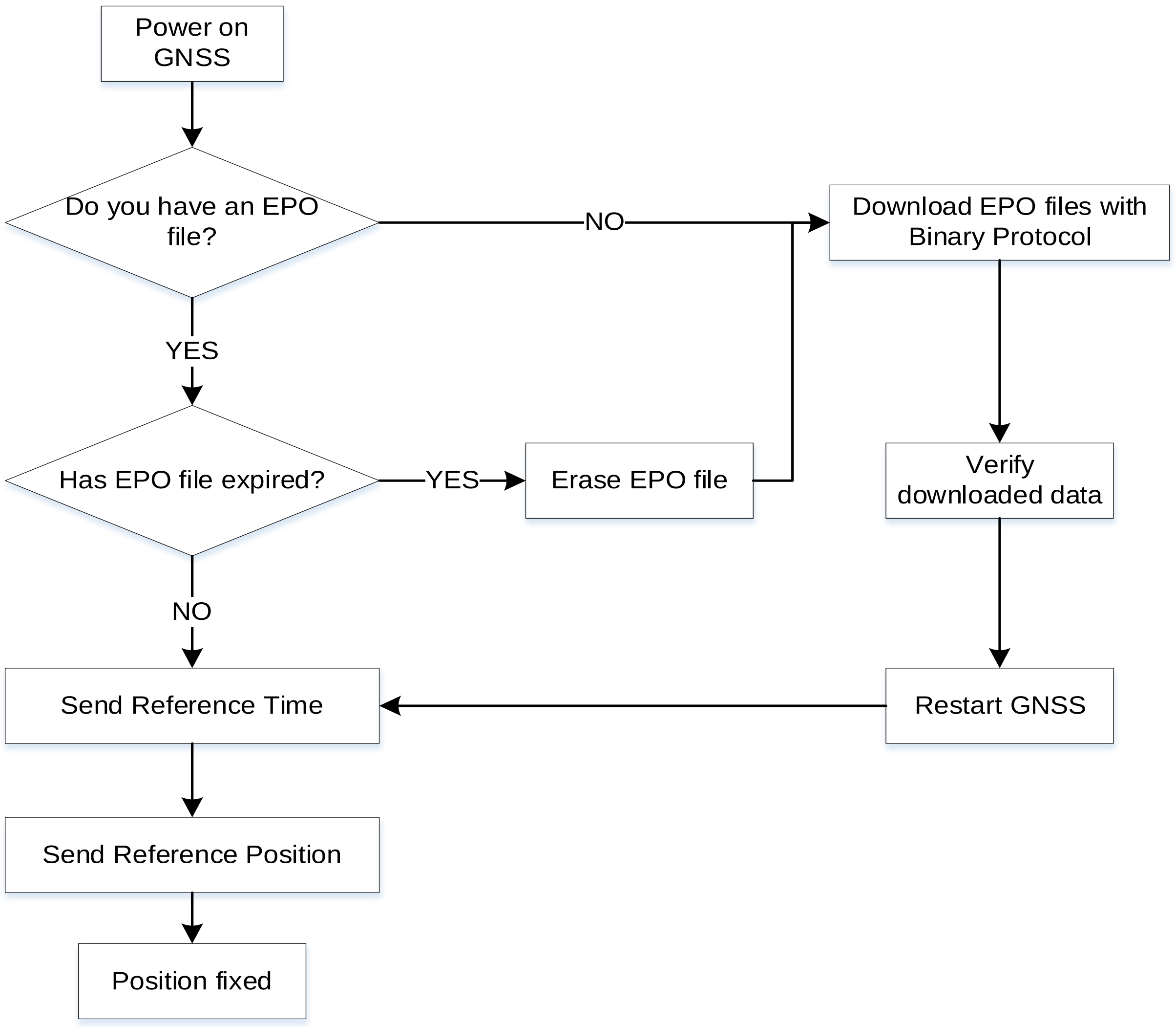


Figure 9: AGNSS Procedure with Flash EPO

1. Power on the GNSS module.
2. Check if there are EPO data in the GNSS module flash memory with **$PAIR470**.
3. If the flash memory contains EPO data, go to the next step to check data validity. Otherwise, download EPO data to the GNSS module and verify the downloaded data, then restart the GNSS module and go to ***Step 5***.
4. Check whether the EPO file in the GNSS module flash memory has expired.
5. If the EPO file is still valid, go to ***Step 6***. Otherwise, erase the expired EPO file with **$PAIR472** and download a new EPO file.
6. Send reference time to the GNSS module with **$PAIR590**.
7. Send reference position to GNSS module with **$PAIR600**.
8. Wait for the GNSS module to fix position.

3.2. AGNSS with Host EPO

Host EPO allows for a simpler text-based implementation that enables the receiver to perform a fast start-up where assistance data must be sent to the receiver each time it boots. When using Host EPO, the receiver can only receive one block of assistance data valid for 6 hours.

Implementing Host EPO only requires a few PAIR sentences and the whole data transfer can be performed in NMEA mode. See ***Chapter 4*** for detailed description of **$PAIR471**, **$PAIR590** and **$PAIR600**.

3.2.1. Recommended Sequence for Host EPO

After the module is powered on, it sends an aiding request to notify the expiration of the stored GNSS assistance data when both assistance data and ephemeris are invalid. Therefore, if the module does not report an aiding request, it is recommended to determine whether the assistance data have expired by sending **$PAIR470** after the host receives the system startup message. The host sends the assistance data in the sequence shown in *Figure 10: Suggested Sequence for Host EPO*.

Host EPO procedure:

1. GNSS module starts up;
2. Host sends Reference Time;
3. Host sends Reference Position;
4. Host sends EPO data.

The supplied Reference Time, Reference Position and EPO data must comply with the requirements listed in ***Chapter 1.2***.

NOTE

In the current implementation, the host needs to wait for a **$PAIR001** packet to be returned before sending another segment of EPO data.

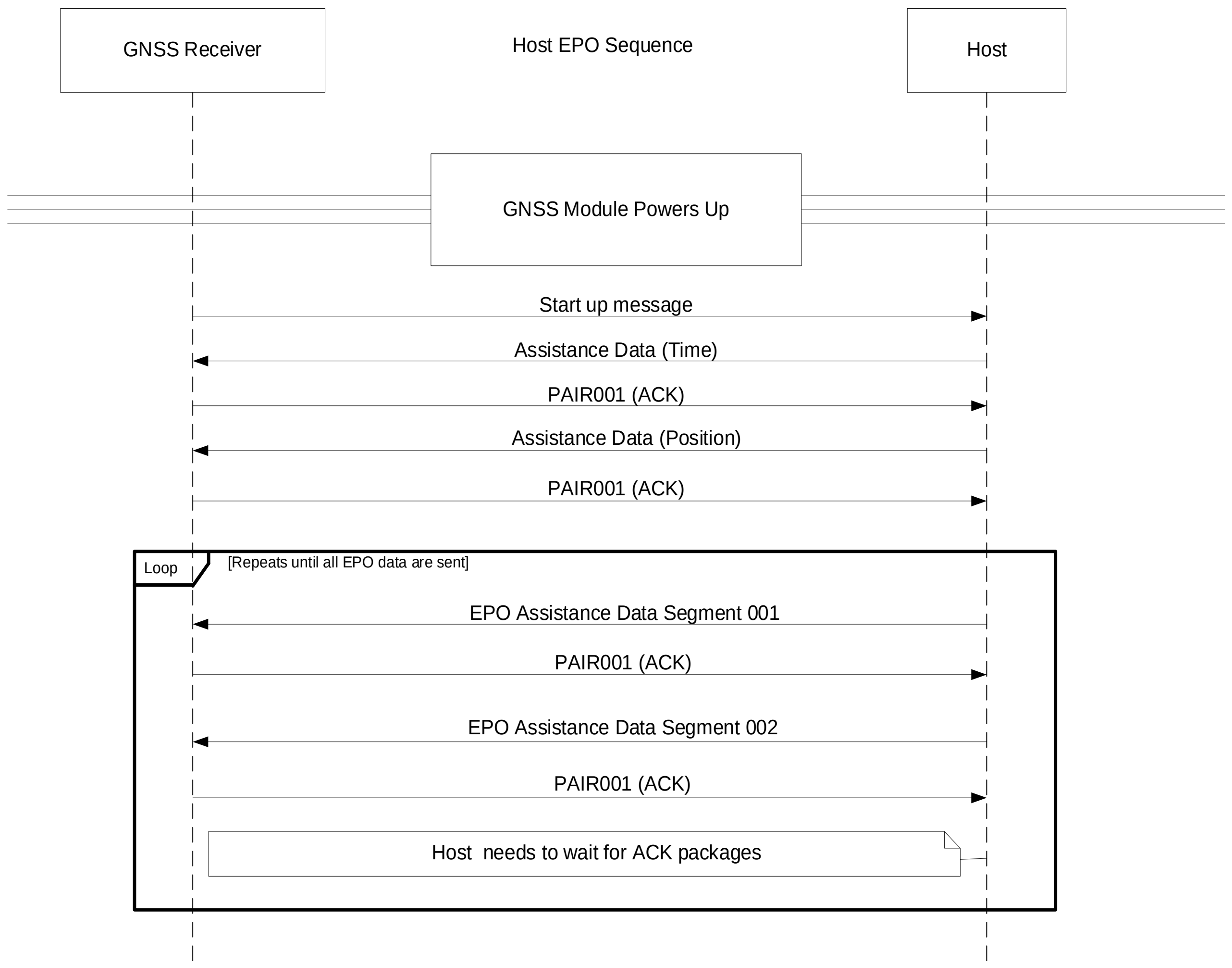

GNSS Receiver
Host EPO Sequence
Host
GNSS Module Powers Up
Start up message
Assistance Data (Time)
PAIR001 (ACK)
Assistance Data (Position)
PAIR001 (ACK)
Loop
[Repeats until all EPO data are sent]
EPO Assistance Data Segment 001
PAIR001 (ACK)
EPO Assistance Data Segment 002
PAIR001 (ACK)
Host needs to wait for ACK packages

Figure 10: Suggested Sequence for Host EPO

3.2.2. Sample Code to Send EPO

The following is the reference code to send one segment of EPO data to GNSS chip. It indicates how to construct PAIR messages for GNSS receiver. PAIR messages for Reference Time and Reference Position are not included in this example.

```
#define GNSS_GLONASS_EPO_BASE_ID (64)
#define GNSS_GALILEO_EPO_BASE_ID (100)
#define GNSS_BDS_EPO_BASE_ID (200)

#define MNL_SERVICE_MAX_COMMAND_LEN (352)
#define EPO_DEMO_RECORD_SIZE (72)

typedef enum{
    EPO_DEMO_MODE_GPS,
    EPO_DEMO_MODE_GLONASS,
    EPO_DEMO_MODE_GALILEO,
    EPO_DEMO_MODE_BEIDOU
}epo_demo_mode_t;

int32_t epo_demo_get_sv_prn(int32_t type, uint8_t *data)
{
    int32_t sv_id, sv_prn = 0;
    sv_id = data[3];

    switch(type) {
        case EPO_DEMO_MODE_GPS:
            sv_prn = sv_id;
            break;
        case EPO_DEMO_MODE_GLONASS:
            sv_prn = sv_id - GNSS_GLONASS_EPO_BASE_ID;
            break;
        case EPO_DEMO_MODE_GALILEO:
            if(sv_id == 255) {
                sv_prn = 255;
            } else {
                sv_prn = sv_id - GNSS_GALILEO_EPO_BASE_ID;
            }
            break;
        case EPO_DEMO_MODE_BDS:
            if(sv_id == 255) {
                sv_prn = 255;
            } else {
                sv_prn = sv_id - GNSS_BDS_EPO_BASE_ID;
            }
            break;
        default:
            sv_prn = 0;
    }
    return sv_prn;
}

void epo_demo_send_data(epo_demo_epo_data_t *data_p, int32_t data_num, int32_t type){

    char temp_buffer[MNL_SERVICE_MAX_COMMAND_LEN] = {0};
    uint8_t data_buffer[EPO_DEMO_RECORD_SIZE] = {0};
    int32_t i;
    int32_t sv_prn = 0;
    for(i = 0; i < data_num; i++) {
        unsigned int *epobuf = (unsigned int *)data_buffer;
        epo_demo_epo_fread(data_p, data_buffer, EPO_DEMO_RECORD_SIZE);
        sv_prn = epo_demo_get_sv_prn(type, data_buffer);

        sprintf((char *) temp_buffer,
              "471,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X,%X",
                (unsigned int)type,
                (unsigned int)sv_prn,
                epobuf[0], epobuf[1], epobuf[2], epobuf[3], epobuf[4], epobuf[5],
                epobuf[6], epobuf[7], epobuf[8], epobuf[9], epobuf[10], epobuf[11],
                epobuf[12], epobuf[13], epobuf[14], epobuf[15], epobuf[16], epobuf[17]);

        gnss_app_send_command_ex(temp_buffer);
        memset(temp_buffer, 0, MNL_SERVICE_MAX_COMMAND_LEN);
    }
}
```

4 AGNSS Related Messages

4.1. PAIR001 PAIR_ACK

Acknowledges a PAIR command. An acknowledgement packet **$PAIR001** is returned to inform the sender that the receiver has received the packet.

Type:

Output

Synopsis:

```
$PAIR001,<CommandID>,<Result>*<Checksum>
```

Parameter:

Field	Format	Unit	Description
<CommandID>	Numeric	-	Type of command to be acknowledged.
<Result>	Numeric	-	0 = Command has been successfully sent. 1 = Command is being processed. Please wait for the result. 2 = Command sending failed. 3 = **<CommandID>** is not supported. 4 = Command parameter error. Out of range/some parameters were lost/checksum error. 5 = MNL service is busy.

Example:

```
$PAIR001,0,3*38
```

4.2. PAIR010 PAIR_REQUEST_AIDING

Notifies the expiration of GNSS assistance data stored in the module. This message is automatically output when the module powers up.

Type:

Output

Synopsis:

```
$PAIR010,<Type>,<GNSS_System>,<WN>,<TOW>*<Checksum><CR><LF>
```

Parameter:

Field	Format	Unit	Description
<Type>	Numeric	-	Type of data to be updated. 0 = EPO data 1 = Time 2 = Position
<GNSS_System>	Numeric	-	Type of GNSS data needed. 0 = GPS data 1 = GLONASS data 2 = Galileo data 3 = BDS data
<WN>	Numeric	Week	Week Number (accommodating roll-over).
<TOW>	Numeric	Second	Time of Week.

Example:

```
//Send GPS EPO data when this sentence is received:
$PAIR010,0,0,2044,369413*33
//Send reference time when this sentence is received:
$PAIR010,1,-1*16
//Send reference position when this sentence is received:
$PAIR010,2,-1*15
```

NOTE

1. The GNSS system sends this command automatically. Do not send it to the GNSS system.
2. The L89 R2.0 module does not support reporting the expiration of GLONASS and BDS data.

4.3. PAIR470 PAIR_EPO_GET_STATUS

Queries the status of EPO data stored on the GNSS chip.

Type:

Query

Synopsis:

```
$PAIR470,<System_ID>*<Checksum><CR><LF>
```

Parameter:

Field	Format	Unit	Description
<System_ID>	Numeric	-	GNSS system ID. 0 = GPS 1 = GLONASS 2 = Galileo 3 = BDS

Result:

Returns a **$PAIR001** message and the query result.

Query result message format:

```
$PAIR470,<System_ID>,<Set>,<FWN>,<FTOW>,<LWN>,<LTOW>,<FCWN>,<FCTOW>,<LCWN>,<LCT
OW>*<Checksum><CR><LF>
```

Parameters in the result:

Field	Format	Unit	Description
<System_ID>	Numeric	-	GNSS system ID. 0 = GPS 1 = GLONASS 2 = Galileo 3 = BDS
<Set>	Numeric	-	Total number of EPO data sets stored in GNSS chip.
<FWN>	Numeric	-	GPS week number of the first set of EPO data stored in flash.
<FTOW>	Numeric	-	GPS TOW of the first set of EPO data stored in flash.
<LWN>	Numeric	-	GPS week number of the last set of EPO data stored in flash.

<LTOW>	Numeric	-	GPS TOW of the last set of EPO data stored in flash.
<FCWN>	Numeric	-	GPS week number of the first set of EPO data that are currently being used.
<FCTOW>	Numeric	-	GPS TOW of the first set of EPO data that are currently being used.
<LCWN>	Numeric	-	GPS week number of the last set of EPO data that are currently being used.
<LCTOW>	Numeric	-	GPS TOW of the last set of EPO data that are currently being used.

Example:

```
$PAIR470,0*25
$PAIR001,470,0*38
$PAIR470,0,1,2098,194400,2098,216000,2098,194400,2098,216000*38
```

NOTE

The L89 R2.0 module does not support the reporting of GLONASS and BDS data.

4.4. PAIR471 PAIR_EPO_SET_DATA

Sends the packet containing EPO data for a single satellite.

Type:

Input

Synopsis:

```
$PAIR471,<System_ID>,<SV_ID>,<W[0]>,...,<W[17]>*<Checksum><CR><LF>
```

Parameter:

Field	Format	Unit	Description
<System_ID>	Numeric	-	GNSS system ID. 0 = GPS 1 = GLONASS 2 = Galileo 3 = BDS
<SV_ID>	Hexadecimal	-	PRN number of the satellite whose EPO data are being sent.

			GPS Range: 1–32. GLONASS Range: 1–24. Galileo Range: 1–30. BDS Range: 1–37. Special 255: BDS IONO data. Special 254: Galileo IONO data.
<W[0]–W[17]>	-	-	18 words (LSB-first) of one EPO segment data (total 72 bytes).

Result:

Returns a **$PAIR001** message.

Example:

```
$PAIR471,1,16,56056272,F2BC0244,4F19AE34,F95C534D,FAE67014,4F19AF6B,F96749BD,9F341F2
D,6F4EA9F,77DB4710,66ADAC2,9ADF3B01,8CC8B19C,29D2D20C,FC5B2E94,1000001C,11005000,7
48B45F4*0A
$PAIR001,471,0*39
```

NOTE

The L89 R2.0 module does not support the reporting of GLONASS and BDS data.

4.5. PAIR472 PAIR_EPO_ERASE_FLASH_DATA

Erases the EPO data stored in the flash memory.

Type:

Command

Synopsis:

```
$PAIR472*<Checksum><CR><LF>
```

Parameter:

None

Result:

Returns a **$PAIR001** message.

Example:

```
$PAIR472*3B
$PAIR001,472,0*3A
```

4.6. PAIR590 PAIR_TIME_SET_REF_UTC

Sends reference UTC time to GNSS chip for faster TTFF. Local time should be avoided due to time-zone offset. To achieve a faster TTFF, the reference time should be accurate within 3 seconds and must be specified in UTC time.

Type:

Set

Synopsis:

```
$PAIR590,<YYYY>,<MM>,<DD>,<hh>,<mm>,<ss>*<Checksum><CR><LF>
```

Parameter:

Field	Format	Unit	Description
<YYYY>	Numeric	Year	UTC year. Minimum value: 1980.
<MM>	Numeric	Month	UTC month. Range: 1–12.
<DD>	Numeric	Day	UTC day. Range: 1–31.
<hh>	Numeric	Hour	UTC hours. Range: 0–23.
<mm>	Numeric	Minute	UTC minutes. Range: 0–59.
<ss>	Numeric	Second	UTC seconds. Range: 0–59.

Result:

Returns a **$PAIR001** message.

Example:

```
$PAIR590,2019,2,10,9,0,58*0B
$PAIR001,590,0*37
```

4.7. PAIR600 PAIR_LOC_SET_REF

Sends reference position to GNSS chip for faster TTFF.

Type:

Set

Synopsis:

```
$PAIR600,<Lat>,<Lon>,<Height>,<AccMaj>,<AccMin>,<Bear>,<AccVert>*<Checksum><CR><LF>
```

Parameter:

Field	Format	Unit	Description
<Lat>	Numeric	Degrees	Reference latitude. Range: -90 to 90. Minus: south; plus: north. It is recommended to express this value in floating point with 6 decimal points.
<Lon>	Numeric	Degrees	Reference longitude. Range: -180 to 180. Minus: west; plus: east. It is recommended to express this value in floating point with 6 decimal points.
<Height>	Numeric	Meter	Reference height.
<AccMaj>	Numeric	Meter	Semi-major RMS accuracy.
<AccMin>	Numeric	Meter	Semi-minor RMS accuracy.
<Bear>	Numeric	Degrees	Bearing.
<AccVert>	Numeric	Meter	Vertical RMS accuracy.

Result:

Returns a **$PAIR001** message.

Example:

```
$PAIR600,24.772816,121.022636,175.0,50.0,50.0,0.0,100.0*06
$PAIR001,600,0*3D
```

NOTE

This command needs to be sent every time after GNSS module reboots.

5 Download EPO Data with QGNSS

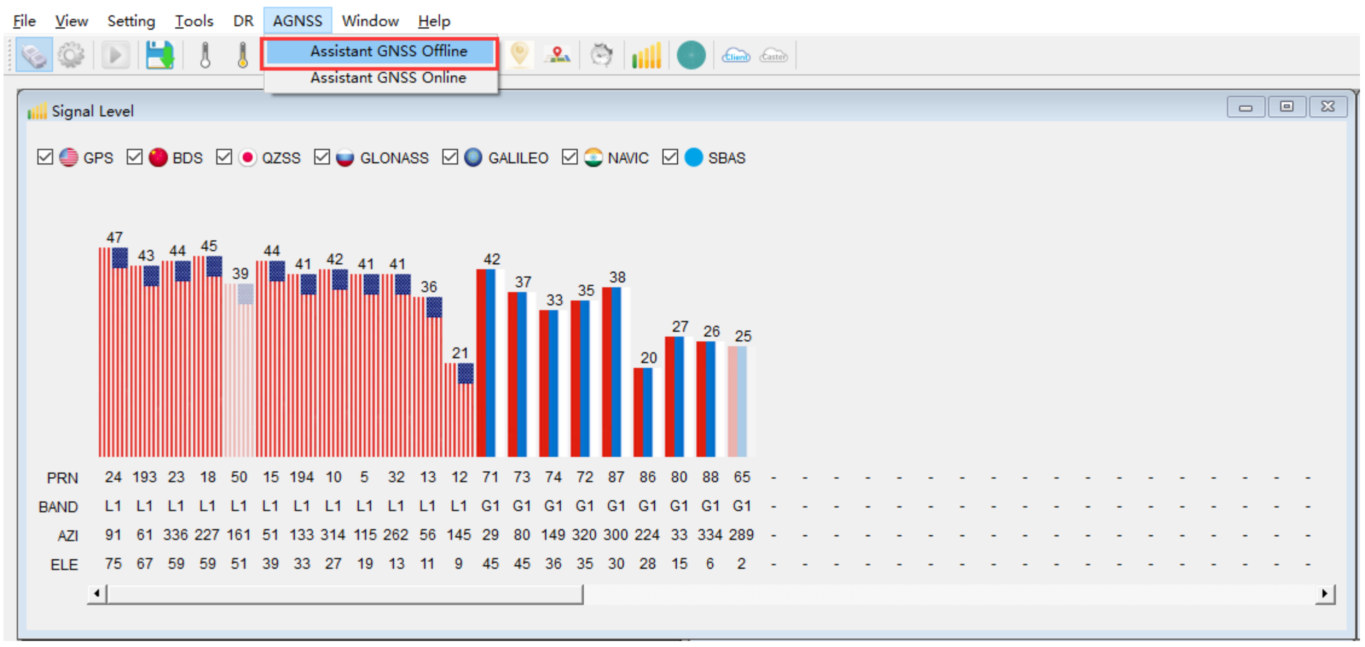
This chapter describes how to download EPO data through QGNSS. Contact Quectel Technical Support for details on QGNSS.

5.1. Download Flash EPO with QGNSS

Steps to download Flash EPO with the QGNSS tool:

1. Run the QGNSS tool.

2. In the main interface, click “**AGNSS**” → “**Assistant GNSS Offline**” as shown below.

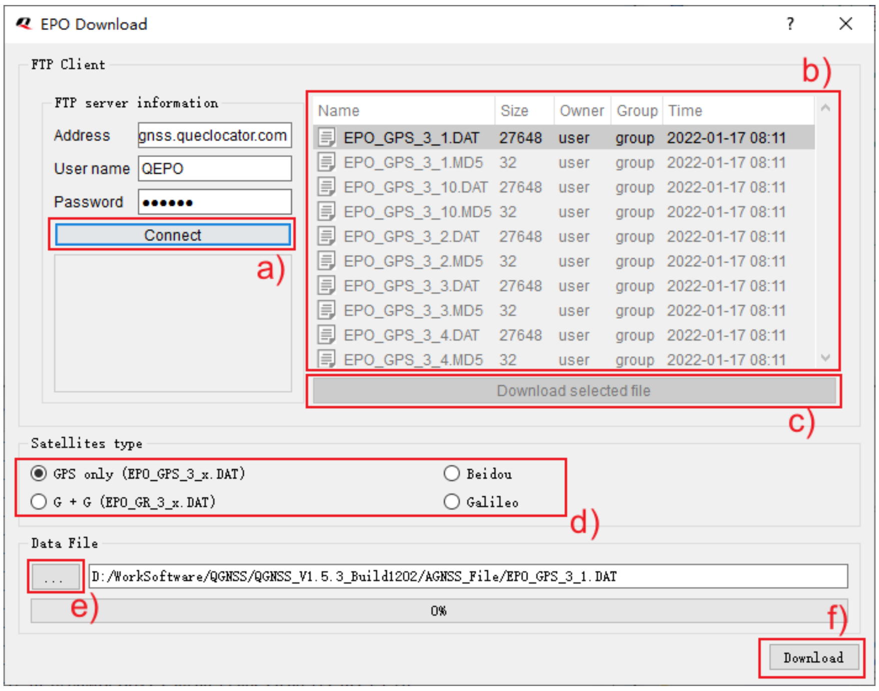


```
 PRN  24 193  23  18  50  15 194  10   5  32  13  12  71  73  74  72  87  86  80  88  65  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
BAND  L1  L1  L1  L1  L1  L1  L1  L1  L1  L1  L1  L1  G1  G1  G1  G1  G1  G1  G1  G1  G1  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
 AZI  91  61 336 227 161  51 133 314 115 262  56 145  29  80 149 320 300 224  33 334 289  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
 ELE  75  67  59  59  51  39  33  27  19  13  11   9  45  45  36  35  30  28  15   6   2  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
```

Figure 11: QGNSS Interface for Setting Flash EPO

3. Download EPO file to the module.
   a) Click the “**Connect**” button to connect to the FTP server.
   b) Select EPO file.
   c) Click the “**Download selected file**” button to download the EPO file to computer.
   d) Select Satellites type.

e) Click the “**…**” button to select EPO file.
f) Click the “**Download**” button to download the EPO file to module.



FTP Client

FTP server information

Address: gnss.queclocator.com
User name: QEPO
Password: ••••••

Connect

Name	Size	Owner	Group	Time
EPO_GPS_3_1.DAT	27648	user	group	2022-01-17 08:11
EPO_GPS_3_1.MD5	32	user	group	2022-01-17 08:11
EPO_GPS_3_10.DAT	27648	user	group	2022-01-17 08:11
EPO_GPS_3_10.MD5	32	user	group	2022-01-17 08:11
EPO_GPS_3_2.DAT	27648	user	group	2022-01-17 08:11
EPO_GPS_3_2.MD5	32	user	group	2022-01-17 08:11
EPO_GPS_3_3.DAT	27648	user	group	2022-01-17 08:11
EPO_GPS_3_3.MD5	32	user	group	2022-01-17 08:11
EPO_GPS_3_4.DAT	27648	user	group	2022-01-17 08:11
EPO_GPS_3_4.MD5	32	user	group	2022-01-17 08:11

Download selected file

Satellites type

[✓ GPS only (EPO_GPS_3_x.DAT)] Beidou
G + G (EPO_GR_3_x.DAT) Galileo

Data File

... D:/WorkSoftware/QGNSS/QGNSS_V1.5.3_Build1202/AGNSS_File/EPO_GPS_3_1.DAT

0%

Download

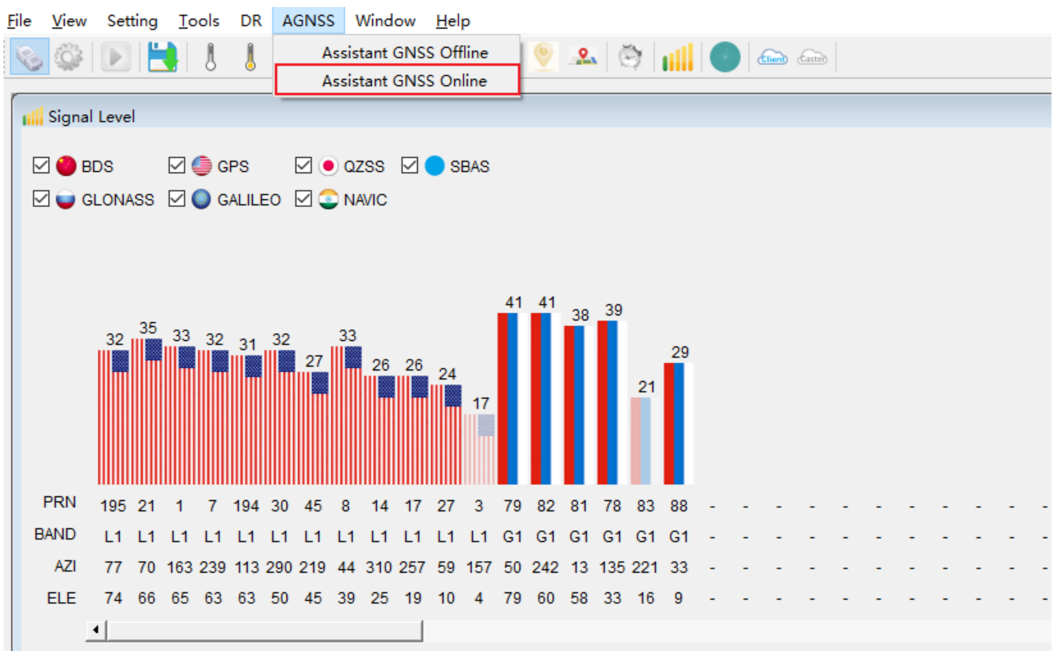
Figure 12: Download Flash EPO File

5.2. Download Host EPO with QGNSS

Steps to download Host EPO with the QGNSS tool:

1. Run the QGNSS tool.

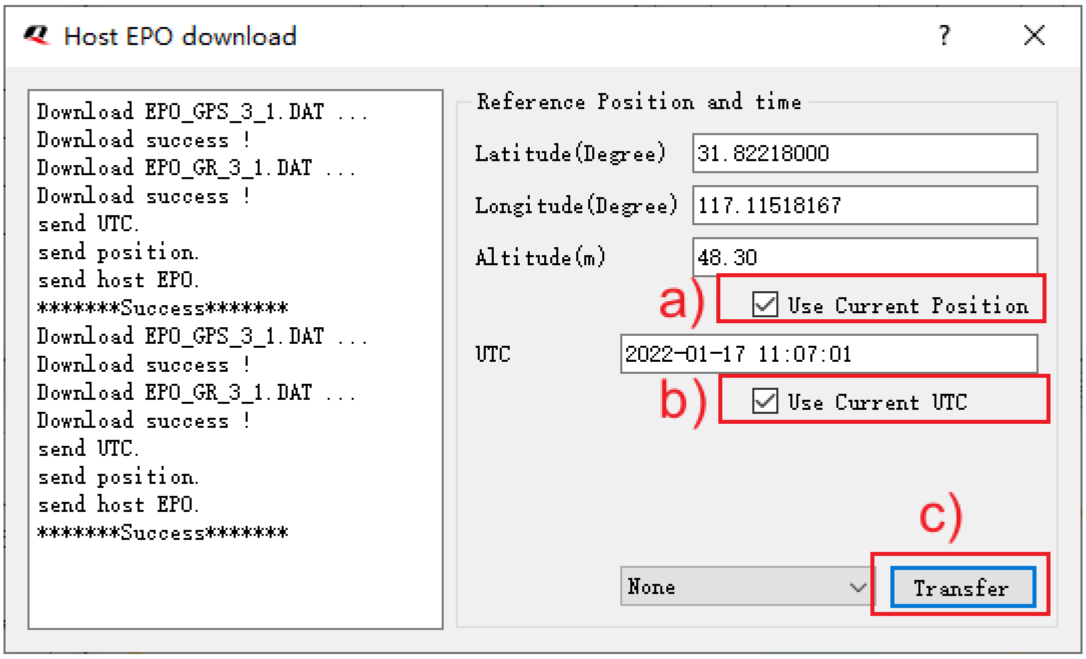
2. In the main interface, click “**AGNSS**” → “**Assistant GNSS Online**” as shown below.



PRN	195	21	1	7	194	30	45	8	14	17	27	3	79	82	81	78	83	88	-	-	-	-	-	-	-	-	-	-	-
BAND	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	G1	G1	G1	G1	G1	G1	-	-	-	-	-	-	-	-	-	-	-
AZI	77	70	163	239	113	290	219	44	310	257	59	157	50	242	13	135	221	33	-	-	-	-	-	-	-	-	-	-	-
ELE	74	66	65	63	63	50	45	39	25	19	10	4	79	60	58	33	16	9	-	-	-	-	-	-	-	-	-	-	-

Figure 13: QGNSS Interface for Setting Host EPO

3. Configure parameters:
   a) Check “**Use Current Position**” to use current position.
   b) Check “**Use Current UTC**” to use current time.
   c) Click “**Transfer**” to download host EPO file.



```
Download EPO_GPS_3_1.DAT ...
Download success !
Download EPO_GR_3_1.DAT ...
Download success !
send UTC.
send position.
send host EPO.
*******Success*******
Download EPO_GPS_3_1.DAT ...
Download success !
Download EPO_GR_3_1.DAT ...
Download success !
send UTC.
send position.
send host EPO.
*******Success*******
```

Latitude(Degree) 31.82218000
Longitude(Degree) 117.11518167
Altitude(m) 48.30
☑ Use Current Position
UTC 2022-01-17 11:07:01
☑ Use Current UTC
None

Figure 14: Download Host EPO File

6 AGNSS Implementation Example

This chapter gives examples of how to download EPO files to the module.

6.1. Flash EPO Implementation

Blue: Sent data
Red: ACK information

```
//Host sends $PAIR472*3B to erase the EPO data stored in the flash memory:
$PAIR472*3B

//Module returns a $PAIR001 message:
$PAIR001,472,0*3A

//Host sends EPO start message in hexadecimal format:
04 24 B0 04 01 00 52 E7 AA 44

//Module returns an ACK message:
04 24 E8 03 04 00 B0 04 00 00 5B AA 44

//Host sends EPO data in hexadecimal format:
04 24 B1 04 48 00 BF 96 05 41 6E 3A 74 05 C3 21…….AA 44

//Module returns an ACK message:
04 24 E8 03 04 00 B1 04 00 00 5A AA 44

//Host sends EPO data in hexadecimal format:
04 24 B1 04 48 00 BF 96 05 42 09 3A 74 0C CA 77……. AA 44

//Module returns an ACK message:
04 24 E8 03 04 00 B1 04 00 00 5A AA 44
……

//Host sends EPO end data in hexadecimal format:
04 24 B2 04 01 00 52 E5 AA 44
```

```
//Module returns an ACK message:
04 24 E8 03 04 00 B2 04 00 00 59 AA 44

//Host queries the EPO data status stored in the GNSS chip:
$PAIR470,0*25

//Module returns $PAIR001 and $PAIR470 messages:
$PAIR001,470,0*38
$PAIR470,0,1,2098,194400,2098,216000,2098,194400,2098,216000*38
```

6.2. Host EPO Implementation

Blue: Sent data
Red: ACK information

```
//Host sends the power-on GNSS system command $PAIR002:
$PAIR002*38

//Module returns a $PAIR001 message:
$PAIR001,002,0*39

//Module outputs $PAIR010 messages automatically:
$PAIR010,1,-1*16
$PAIR010,2,-1*15

//Host sends reference UTC time command $PAIR590:
$PAIR590,2021,10,18,08,59,00*3B

//Module returns a $PAIR001 message:
$PAIR001,590,0*37

//Host sends reference position information command $PAIR600:
$PAIR600,31.822203,117.115219,175.0,50.0,50.0,0.0,100.0*0F

//Module returns a $PAIR001 message:
$PAIR001,600,0*3D

//Host sends EPO data:
$PAIR471,0,1,10596C0,A174051A,1B2EDE67,9F0BB6,17C37A4,1B2EDE22,F85B368E,845FB0C9,6F1
8C40,23557111,2A4CBD5,A60348AB,FEF7E24,2F236B88,2439FDC6,1000001C,0,4860BF93*44

//Module returns a $PAIR001 message:
```

```
$PAIR001,471,0*39

//Host sends EPO data:
$PAIR471,0,2,20596C0,F0740341,1B2EEE36,5F3FAA,17E07E6,1B2E1100,F8C1048F,84A50985,6F1B
D33,29192005,D651ED6,A600506D,256C95F,20430E67,C36C910D,1000001C,0,FAC0DA552A 33 43
0D 0A*3C

//Module returns a $PAIR001 message:
$PAIR001,471,0*39
……

//Host sends EPO data:
$PAIR471,0,7,70596C0,377403C2,1B2E41F1,F757006,C57EB,1B2EBF14,F89F543F,8986E880,6F1E6
93,DC3908E,DA7BB7,A603A757,8FBA37BF,21C8A8F0,A2247EAD,1000001C,22000000,DDACBBB6*0
B

//Module returns a $PAIR001 message:
$PAIR001,471,0*39
```

7 Appendix References

Table 10: Terms and Abbreviations

Abbreviation	Description
ACK	Acknowledgement
AGNSS	Assisted GNSS (Global Navigation Satellite System)
EPO	Extended Prediction Orbit
GLONASS	Global Navigation Satellite System (Russia)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IMEI	International Mobile Equipment Identity
IONO	Ionospheric
MNL	MTK Navigation Lib
RAM	Random Access Memory
SV	Space Vehicle
SVID	Space Vehicle Identification
TOW	Time of Week
TTFF	Time to First Fix
UART	Universal Asynchronous Receiver/Transmitter
UTC	Coordinated Universal Time
URL	Uniform Resource Locator