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EPO user guide

Vision 0.1

2023/5/26

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1.0 Extended Predicted Orbit (EPO) and Quick Extended Predicted Orbit (QEPO)

EPO (Extended Prediction Orbit) is one of MediaTek's innovations. It is an off-line server-based Assisted GPS (A- GPS) solution. EPO is the world's leading technology on the satellite orbit prediction that supports the orbit prediction for up to 14 days. At this time, this is one of best ways to have the ephemeris and almanac data available for positioning before receiving the broadcast data, i.e., the EPO can replace the broadcast ephemeris/almanac data. With this information, the receiver can estimate the satellite location without decoding the data. Therefore, it significantly improves the TTFF performance, especially for the cold and warm starts.

The architecture layout of the EPO is shown in Figure 1. There are two types of EPO files, EPO and QEPO, provided by the EPO server. EPO supports the orbit prediction for up to 14 days, which provides the GPS and GLONASS constellations. After SDK 1.4.0 version, the FW supports Galileo EPO data which is up to 7-day prediction.

After SDK1.5.0 version, the FW supports Beidou EPO data which is up to 3-day prediction. In addition, we do not support the mode of Beidou EPO used only. In order to facilitate the receiver's performance, it needs to be downloaded with other constellations' EPO data, e.g., GPS and/or GLONASS EPO data. For those 3-day or 7-day EPO data, the corresponding files are uploaded to the server daily. QEPO provides a 6-hour orbit prediction. The QEPO file is generated on the server every hour. Thus, the valid time of downloaded QEPO file is always greater than 5 hours. The QEPO supports four constellations: GPS; GLONASS; Beidou; and Galileo. Users can download the EPO or QEPO file via the internet to their desired devices.

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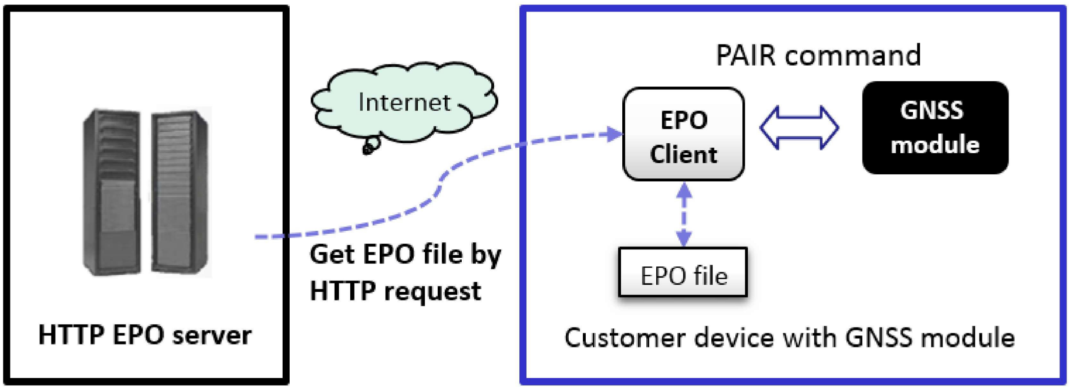

Figure 1. EPO data flow.

Table 1 lists the types of EPO/QEPO files that are available on the server. The "X" field in the "EPO_GPS_3_X.DAT" or "EPO_GR_3_X.DAT" represents the sequence number of the 3-day EPO file. For up to 14-day orbit prediction, the range of "X" is 1~5_ For example, the orbit prediction data of "EPO_GPS_3_1.DAT" and "EPO_GPS_3_5.DAT" are 1~3 days and 13~15 days, respectively. Also, there are two types of Galileo epo files on the server, i.e., "EPO_GAL_3.DAT" and "EPO_GAL_7.DAT", which are 3-day and 7-day predictions, respectively.

Table 2 shows the EPO supported list under the two different aidings, which are introduced in the following two sections.

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Table 1. Types of EPO files.

EPOType	Constellation	Description	Filename
QEPO	**GPS**	**GPS only 6-hr prediction orbit (ephemeris)** **Single file name, always get the latest QEPO file**	**QGPS.DAT**
QEPO	GPS+GLO	GPS+GLONASS 6-hr prediction orbit (ephemeris) Single file name, always get the latest QEPO file	QG_R.DAT
QEPO	BDS	Beidou only 6-hr prediction orbit (ephemeris) Single file name, always get the latest QEPO file	Q_BD2.DAT
QEPO	GAL	Galileo only 6-hr prediction orbit (ephemeris) Single file name, always get the latest QEPO file	Q_GA.DAT
EPO	GPS	GPS only 3-14 days prediction orbit (ephemeris)	EPO_GPS_3_X.DAT
EPO	GPS+GLO	GPS+GLONASS 3-14 days prediction orbit (ephemeris)	EPO_GR_3_**X.DAT**
EPO	GAL	GALILEO 3/7 -day prediction orbit (ephemeris)	EPO_GAL_3.DAT EPO_GAL_7.DAT
EPO	BDS	BEIDOU 3day prediction orbit (ephemeris)	EPO_BDS_3.DAT

Table 2. EPO supported list.

	GPS	GLONASS	Beidou	Galileo
Flash aiding	Support	Support	Support	Support
Host aiding	Support	Support	Support	Support

1.1 EPO file Data format

15-Day EPO Solution Data Format - One file
EPO format (15 Days), GPS EPO and GLONASS EPO use the same format.

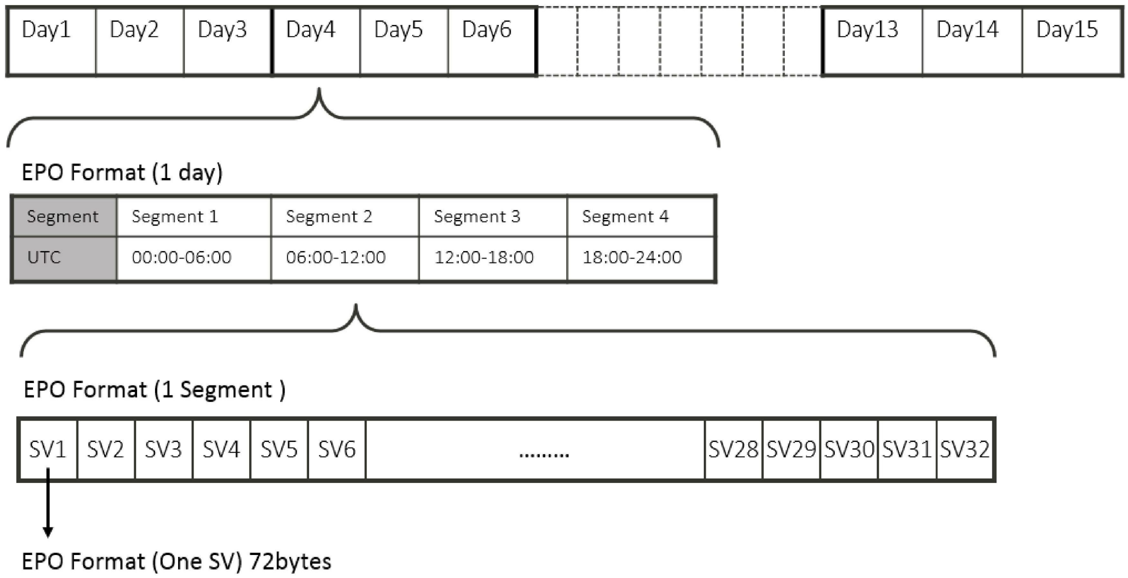

Figure 2. 15-Day EPO file format

EPO Solution Data Format - Galileo/Beidou
As shown in Figure 3, Galileo EPO data consist of the 72-byte header and 7 days of fundamental EPO data. The Beidou EPO data has the same format as the one of the Galileo EPO data. The EPO format does not have a fixed size. For example, if one wants to get Galileo epo data at Day 4, one needs to decode the header information which contains the number of satellites available in a day. Then, based on those information, one can compute the corresponding byte offset in order to get the correct EPO data.

The header of Galileo/Beidou epo file contains the mask of available satellites, which is represented by Bytes 4th ~ 7th and 16th~ 19th. The SVID of Galileo epo and Beidou epo headers are 254 and 255. Refer to Figure 3, Figure4, and Figure 5 for detailed information.

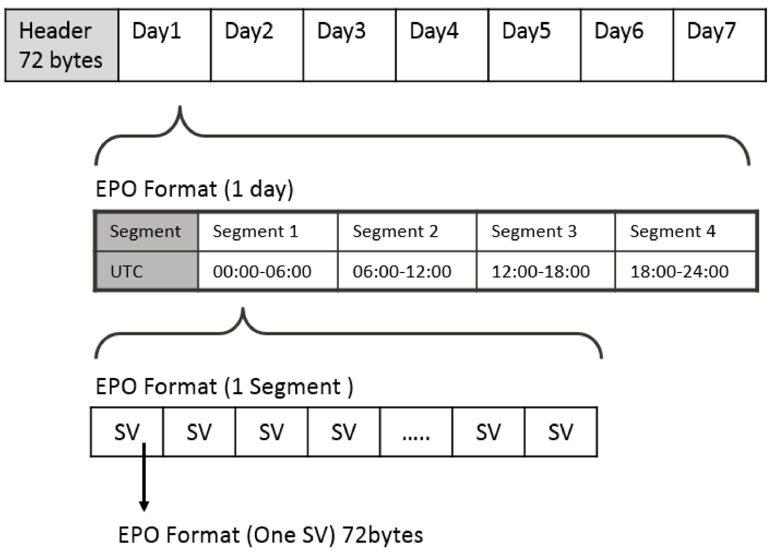

Figure 3. Galileo/Beidou EPO format

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Example: How to get the available data

Galileo EPO header

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	28~31
example	09 00 00 00			

SV available bitmask: 09 67 94 SD DF

Total available SV is 22

Available SV: 1,2,3,4,S,7,8,9,11,12,13,15,19,21,24,25,26,27,30,31,33,36

Figure 4. How to get the Galileo available data

Beidou epo header

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	28~31
example	FF 3F 00 00			

SV available bitmask: 3F FF BF FC 3F FF

Total available SV is 41

Availabie SV: 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

Figure 5. How to get the Beidou available data

QEPO Solution Data Format - GPS/GLONASS
This format has a fixed size. GPS-only QEPO data consists of 32 sets of EPO data. GPS+GLONASS QEPO data consists of 56 sets of EPO data.

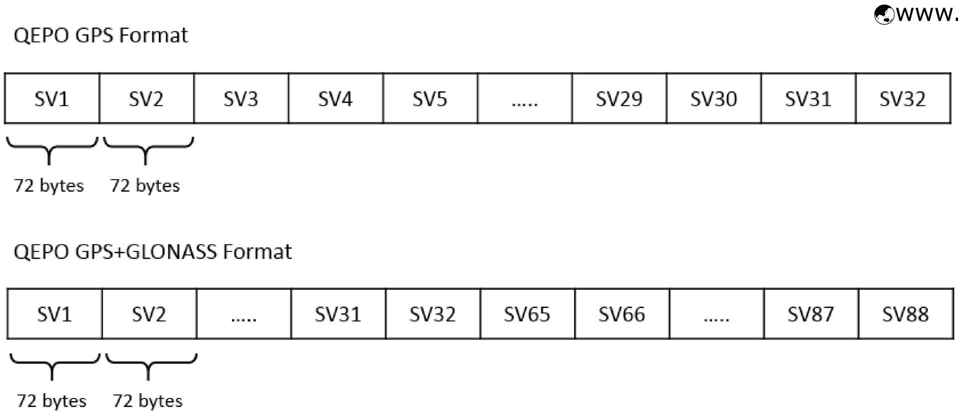

Figure 6. QEPO Data format - GPS/GLONASS

QEPO Solution Data Format - Beidou/Galileo

This format does not have a fixed size. Beidou and Galileo QEPO data consist of (n+l) sets of fundamental EPO data, which includes an extra set of data (72 bytes) representing the header of QEPO data.

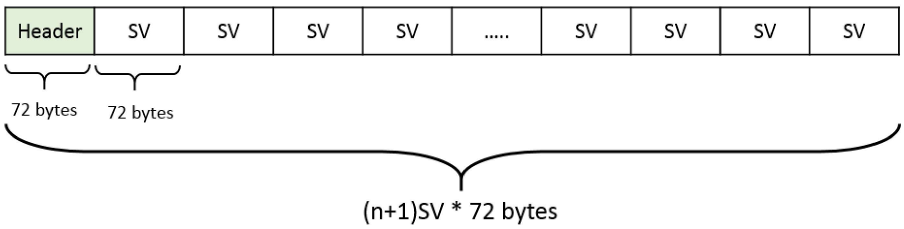

Figure 7. QEPO Data format - Beidou/Galileo

EPO/QEPO Solution Data Format - One SV (Refer to Figure 8)

The data size of each satellite is 72 bytes. The 0th~ 2nd bytes represent the GPS hour. The 3rd byte represents the SV ID. The 4th~ 67th bytes indicate the content of the EPO/QEPO data. And, the last four bytes represent the checksum of the data format.

The SV ID of EPO file for different constellations can be referred to in Table 9.

Data	Gps_Hour	SVID	***	***	***
Byte offset	0[LSB]~2 [MSB]	3	4~7	8-11	12~15

Data	***	***	***	***
Byte offset	16~19	20~23	24~27	28~31

Data	***	***	***	***
Byte offset	32~35	36~39	40~43	44~47

Data	***	***	***	***
Byte offset	48~51	52~55	56~59	60~63

Data	***	checksum
Byte offset	64~67	68-71

Figure 8. One SV EPO file format

Table 9. EPO SVID Range

	PRN	EPO SVID
GPS		
GLONASS	1~24	6s~ss
GALILEO	1~36	101~136
BEIDOU	1~s4, ss~63	201~254, 190~193

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1.2 Flash Aiding

This section introduces EPO flash aiding. It only supports GPS, GLONASS, GALILEO, BEIDOU EPO files. For AG3335A, the maximum available memory size for the EPO data is 250K bytes. When turning on the module, the module automatically reads the file system and, at the same time, confirms whether the EPO file is valid. Because of the aiding of the EPO data, it facilitates TTFF performance.

The EPO function of the flash aiding can be verified by the EPO management tool of POWERGPS. Refer to the POWERGPS user manual for details about the usage of the EPO management tool.

The binary protocol of the EPO flash aiding is described as follows:

Preamble		Message ID	Length	Data	Checksum	End Word	
1 Byte	1 Byte	2 Bytes	2 Bytes	Variable	1 Byte	1 Byte	1 Byte
0x04	0x24					0xAA	0x44

1. Preamble (2-Byte word): 0x2404
2. Message ID:
   (1) 1000 : Acknowledge message (ACK)
   (2) 1200 ~ 1202: designated for EPO Binary Protocol
3. Length: Data length in bytes.
4. Use little endian.
5. Use one-byte alignment.
6. Checksum:

   The checksum is the 8-bit exclusive OR of all bytes in the packet between the "Preamble" and "Checksum" fields.
7. End Word (2-Byte word): 0x44AA

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

- Start of EPO binary format:

Preamble		Message ID	Length	Data	Checksum	End Word	
1 Byte	1 Byte	2 Bytes	2 Bytes	Variable	1 Byte	1 Byte	1 Byte
0x04	0x24	1200	1	'G' – GPS 'R' - GLONASS 'E' – GALILEO 'C' – BEIDOU		0xAA	0x44

- EPO Data binary format:

Preamble		Message ID	Length	Data	Checksum	End Word	
1 Byte	1 Byte	2 Bytes	2 Bytes	Variable	1 Byte	1 Byte	1 Byte
0x04	0x24	1201	72			0xAA	0x44

- End of EPO binary format:

Preamble		Message ID	Length	Data	Checksum	End Word	
1 Byte	1 Byte	2 Bytes	2 Bytes	Variable	1 Byte	1 Byte	1 Byte
0x04	0x24	1202	1	'G' – GPS 'R' - GLONASS 'E' – GALILEO 'C' – BEIDOU		0xAA	0x44

The sequence of the EPO flash aiding is shown in Figure 9.

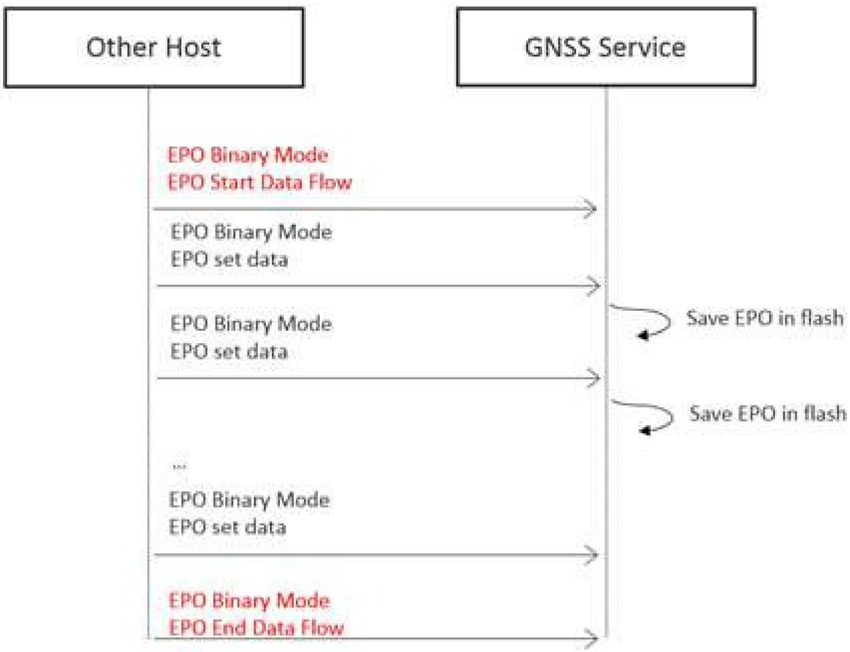

Figure 9. The sequence of the EPO flash aiding

1.3. Host Aiding

This section provides details about EPO host aiding. For host aiding, the EPO data is stored in the memory of the host. Implementing the corresponding PAIR command, the EPO aiding data is parsed in order to select the correct set, and then sent to the GNSS modules for positioning.

Figure 9 shows the sequence of the EPO host aiding. After powering on, the Airoha IoT SDK with GNSS support will output a message, PAIR_AIDING_REQUEST, to the host to indicate that the module is ready for receiving assistance data and PAIR commands from the host. The host then sends the assistance data, which includes the time and EPO data to the GNSS module. If any of the assistance data is not available at the time of request, the sending action is skipped. For example, if the system time of the application is invalid or the EPO data is corrupted, the assistance data is not sent to the GNSS module.

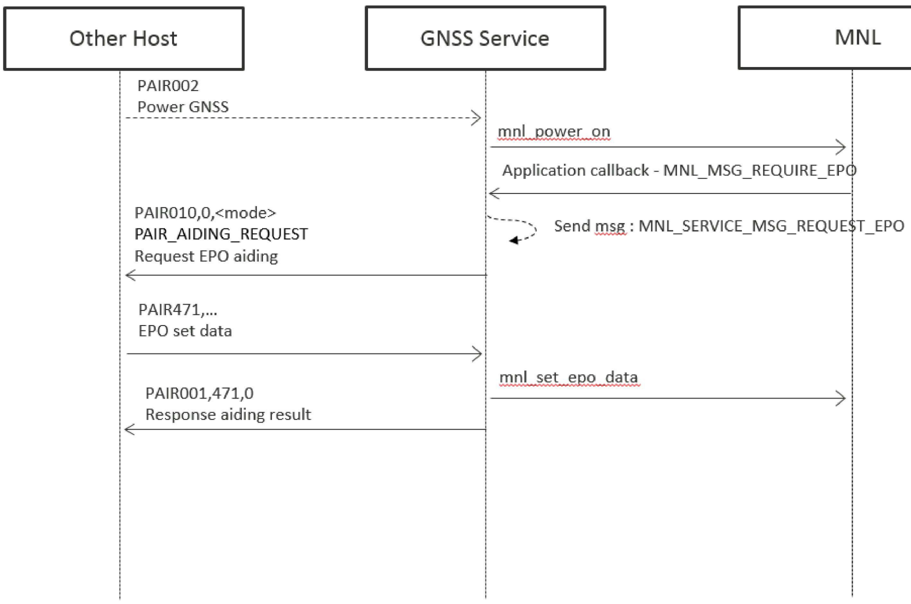

Figure 10. How to send EPO data to GNSS module in host aiding.

In the previous design, the purpose of the acknowledgement (ACK) packet is to prevent an overflow of the UART buffer on the GNSS module. This is not the concern for the current firmware design. The host software does not need to take care of the ACK packet. The host can send the assistance messages to the GNSS module without waiting for the ACK message.

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The ACK message format is "$PAIR001,XXX,0*CS", where 'XXX' is the packet type to be acknowledged, '0' indicates the status of the command. '0' represents the successful status while '1' represents the failure status, and CS is the checksum of the sentence. For example, "$PAIR001,471,0*39" means that the PAIR471 command is successfully received.