GPS Week Rollover

Application Note
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<td>DE910G Series</td>
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<tr>
<td>GE910-GNSS Series</td>
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<tr>
<td>GE310-GNSS Series</td>
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<tr>
<td>ME910C1 Series</td>
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<tr>
<td>LE910C1 Series</td>
</tr>
<tr>
<td>LN940/LN941 Series</td>
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APPLICABILITY TABLE

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1. INTRODUCTION

1.1. Scope
This document describes the GPS Week rollover effect on Telit’s Cellular Modules integrating a GPS receiver. The aim of this document is to demonstrate how to test the week rollover events with a possible alternative for the modules involved.

1.2. Audience
This document is intended for Telit customers, especially system integrators, about to implement their applications using the Telit products as listed in the Applicability Table.

1.3. Contact Information, Support
For general contact, technical support services, technical questions and report of documentation errors contact Telit Technical Support at:

- TS-EMEA@telit.com
- TS-AMERICAS@telit.com
- TS-APAC@telit.com
- TS-SRD@telit.com
- TS-ONEEDGE@telit.com

Alternatively, use:
https://www.telit.com/contact-us

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:
https://www.telit.com

Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates the user feedback on our information.
1.4. **Symbol Conventions**

- **Danger:** This information MUST be followed or catastrophic equipment failure or personal injury may occur.

- **Warning:** Alerts the user on important steps about the module integration.

- **Note/Tip:** Provides advice and suggestions that may be useful when integrating the module.

- **Electro-static Discharge:** Notifies the user to take proper grounding precautions before handling the product.

*Table 1: Symbol Conventions*

All dates are in ISO 8601 format, that is YYYY-MM-DD.

1.5. **Related Documents**

- Telit_Modules_Software_User_Guide_2G_3G_4G_r21
- Telit_3G_Modules_AT_Commands_Reference_Guide_r12
2. BACKGROUND INFORMATION

The GPS week number is an element of the navigation signal used by Global Positioning System (GPS) to correctly handle the current date. The GPS Week count began at 00:00:00 UTC on Sunday, January 6, 1980 (week 0).

To limit the size of satellite data, the GPS allocated only 10 bits for this number, corresponding to 1024 weeks (~19.7 years). After week 1023, the GPS week number will roll over back to 0.

Each of these 1024-weeks period is termed as an “epoch”.

The first epoch of GPS time (weeks 0-1023) ended in August 1999 (corresponding to the first GPS weekly rollover). The next rollover will be at 23:59:42 UTC on April 6, 2019, marking the end of the current epoch (weeks 1024-2047) and the beginning of the next.

2.1. Test Methods and Conditions

The purpose of the test was to validate correct operation before, during, and after the GPS week rollover. The units under test were connected through a common RF splitter to a Spirent GNSS signal simulator as part of our standard test setup.

All receivers were initialized and allowed to navigate before and through the simulated 2019-week rollover event: all units were monitored for correct behavior during the test.

**Warning:** Simulator testing of future real-world events contains an inherent limitation and actual events of the day may deviate from the expected scenarios.

This risk factor cannot be eliminated, nor must it be excluded.
2.2. **Week Rollover Modules Status**

The table below shows the cellular modules with integrated GNSS and week rollover behavior\(^1\).

<table>
<thead>
<tr>
<th>Family</th>
<th>Status</th>
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<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE910-GNSS</td>
<td>NOT AFFECTED</td>
<td>HE910G</td>
<td>AFFECTED</td>
</tr>
<tr>
<td>LE910C1</td>
<td>NOT AFFECTED</td>
<td>GE310-GNSS</td>
<td>NOT AFFECTED</td>
</tr>
<tr>
<td>LE910</td>
<td>AFFECTED IN 2019</td>
<td>LN940/LN941</td>
<td>NOT AFFECTED</td>
</tr>
<tr>
<td>DE910</td>
<td>AFFECTED IN 2019</td>
<td>LM940</td>
<td>NOT AFFECTED</td>
</tr>
<tr>
<td>ME910C1</td>
<td>NOT AFFECTED</td>
<td>LM960</td>
<td>NOT AFFECTED</td>
</tr>
</tbody>
</table>

*Table 2: Week Rollover Module Status*

For additional information on affected modules and suggested workarounds, refer to the following chapters.

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\(^1\) DE910 and LE910 are not affected by GPS week rollover in April but undergo internal rollover at a later date, on 2nd of November 2019.
3. HE910G

The GPS Week number count first began at 00:00:00 UTC, January 6, 1980.

This number size is ten bits (modulo 1024) and after week 1023, the GPS week count will rollover to 0.

The next scheduled GPS Week rollover will occur at UTC 23:59:42 on April 6, 2019.

3.1. Test Methods and Conditions

HE910G unit under test was connected to a GPS signal simulator and allowed to navigate before and through the simulated week rollover event.

The module was monitored for correct behavior during the test.

3.2. Results After Week Rollover

After the week rollover, a wrong date is reported in the $GPRMC NMEA message. The reported date can appear in either of the following formats (highlighted):

$GPRMC,,V,,,,N*53
$GPRMC,000231.42,A,4829.0005,N,00022.0016,E,0.16,212.28,220899,,A*59
$GPRMC,000231.099,A,4829.0005,N,00022.0015,E,0.15,212.28,2208-1,,A*73
The date 220899 (dd/mm/yy) corresponds to the week 0 of the second epoch. In fact, the first week rollover occurred on August 21, 1999 (end of the first GPS epoch).

As shown in the example, the value “-1” for the year, instead of “99”, can also be displayed in the NMEA messages.

### 3.3. Customer Application Suggested Modifications

After the GPS week rollover, the receiver reset its count from week 0 of the previous epoch, therefore date 07/04/2019 is shown as 22/08/1999.

This section describes the processing algorithm to be applied on the customer side to display the correct date.

Before the week rollover, the provided date must be valid, and no action is required.

After the rollover, the year displayed will be earlier than current one and the correction should be applied. Since it is possible to receive a “-1” instead of “99” in the date field, customer should consider such a value as “99” (year 1999).

To obtain the current date, the customer should add 1024 weeks to the date provided by the GPS receiver.

The Appendix: GPS Time Conversion provides an example of a conversion between the calendar date and the GPS time. The flowchart of the algorithm is shown below.
3.4. Note for August 17, 2019

It has been discovered that on the jump between the 16 of August and the 17 of August 2019 the HE910-G reported the fix with a wrong date in the $GPRMC NMEA message.

The reported date appeared in the following format (highlighted):

$GPRMC, 000414.965,A,3540.9996,N,13940.9986,E,0.01,0.0,080936089,,A*6D

This date value could not be converted as described in section 3.3 Customer Application Suggested Modifications above.

The module maintained the date with this specific value throughout the day.

From August 18, 2019 (January 2, 2000), the date format reverted to the previous format and the method described under section 3.3 Customer Application Suggested Modifications could be applied again.

3.5. Note on Incorrect UTC and Date at Week Change

With every week change, just before midnight (between Saturdays and Sundays), the HE910-G reports the position fix with an incorrect UTC and date.

This behavior starts at UTC 235944 (reported as 170234), as highlighted in the example below, and lasts for about 13 seconds before the date reverts to the previous format (see section 3.3 Customer Application Suggested Modifications).

$GPRMC, 235940.362,A,3903.0014,N,00901.9990,E,0.02,267.79,2711-1,,A*78
$GPRMC, 235941.362,A,3903.0014,N,00901.9990,E,0.01,0.0,2711-1,,A*44
$GPRMC, 235942.362,A,3903.0014,N,00901.9990,E,0.01,0.0,2711-1,,A*47
$GPRMC, 235943.362,A,3903.0014,N,00901.9990,E,0.02,316.13,2711-1,,A*73
$GPRMC, 170234.658,A,3903.0014,N,00901.9990,E,0.02,322.40,160100,,A*68
$GPRMC, 170235.658,A,3903.0014,N,00901.9990,E,0.03,304.49,160100,,A*65
$GPRMC, 170236.658,A,3903.0014,N,00901.9990,E,0.02,306.29,160100,,A*63
$GPRMC, 170237.658,A,3903.0014,N,00901.9990,E,0.02,297.33,160100,,A*60
$GPRMC, 170238.658,A,3903.0014,N,00901.9990,E,0.03,306.29,160100,,A*6C
$GPRMC, 170239.658,A,3903.0014,N,00901.9990,E,0.02,262.42,160100,,A*50
$GPRMC, 170240.658,A,3903.0014,N,00901.9990,E,0.02,262.42,160100,,A*6C
$GPRMC, 170241.658,A,3903.0014,N,00901.9990,E,0.02,264.21,160100,,A*6E
$GPRMC, 170242.658,A,3903.0014,N,00901.9990,E,0.02,286.59,160100,,A*6E
$GPRMC, 170243.658,A,3903.0014,N,00901.9990,E,0.01,310.76,160100,,A*6F
$GPRMC, 170244.658,A,3903.0014,N,00901.9990,E,0.02,305.39,160100,,A*64
GPRMC,170245.658,A,3903.0014,N,00901.9990,E,0.03,277.64,160100,,A*68
GPRMC,170246.658,A,3903.0013,N,00901.9990,E,0.01,334.04,160100,,A*6E
GPRMC,000000.362,A,3903.0013,N,00901.9990,E,0.02,296.44,2811-1,,,A*7A
GPRMC,000001.362,A,3903.0013,N,00901.9990,E,0.02,300.91,2811-1,,,A*7D
GPRMC,000002.362,A,3903.0013,N,00901.9990,E,0.02,281.22,2811-1,,,A*7E
GPRMC,000003.362,A,3903.0013,N,00901.9990,E,0.02,262.42,2811-1,,,A*74
GPRMC,000004.362,A,3903.0013,N,00901.9990,E,0.02,293.75,2811-1,,,A*79
GPRMC,000005.362,A,3903.0013,N,00901.9989,E,0.01,300.02,2811-1,,,A*78
GPRMC,000006.362,A,3903.0013,N,00901.9989,E,0.02,293.75,2811-1,,,A*73
4. **DE910/LE910**

The GPS Week number count first began at 00:00:00 UTC, January 6, 1980.

This number size is ten bits (modulo 1024) and after week 1023, the GPS week count will rollover to 0.

The next scheduled GPS Week rollover will occur at UTC 23:59:42 on April 6, 2019.

However, DE910/LE910 was set with the minimum GPS week number equal to 1054 (corresponding to the week starting on Sunday, March 18, 2000). As a result, the GPS week rollover is internally delayed to GPS week 2077 (1054 + 1023).

In other words, the next (internal) GPS week rollover for DE910 will occur at UTC 23:59:42 November 2, 2019. Then, week number count will revert to 0 (corresponding to the minimum GPS week 1054) and the module will output the date 180300.

### 4.1. Test Methods and Conditions

DE910G unit under test was connected to a GPS signal simulator and allowed to navigate before and through the simulated week rollover event (November 2, 2019).

The module was monitored for correct behavior during the test.

### 4.2. Results After Internal Week Rollover

![Image of test results]
$GPRMC,235951.0,A,5000.001821,N,00300.004016,W,0.0,,180300,,,A*5E

This message should display the date 021119 but this value is reverted to the week 1053, ending on Saturday, March 18, 2000.2

$GPRMC,000000.0,A,5000.001947,N,00300.003503,W,0.0,,190300,,,A*51

This message should display the date 031119, but this value is reverted to the week 1054, starting on Sunday, March 19, 2000.

### 4.3. Customer Application Suggested Modifications

This section describes the processing algorithm to be applied on the customer side to display the correct date.

Before the week rollover, the provided date should be valid, and no action is required.

After the rollover, the year displayed will be earlier than current one and the correction should be applied.

To obtain the current date, the customer should add 1024 weeks to the date provided by the GPS receiver.

The Appendix: GPS Time Conversion provides an example of a conversion between the calendar date and the GPS time.

The flowchart of the algorithm is shown below.

---

2 It can be noted that the rollover issue occurs before midnight due to the leap seconds offset between the UTC and the GPS time.
Start

Read year on $GPRMC

Does it report a valid year?

Y

N

The UTC time/date of $GPRMC or Position information is converted to GPS Time.

Add 1024 weeks on GPS Time.

The GPS time is converted to UTC time/date.

Apply the UTC time/date on Application.

End
5. APPENDIX: GPS TIME CONVERSION

Currently, several software tools are available for controlling and converting dates/time in different formats. This section provides a better understanding of the basic operation performed by such tools with an example of a Calendar Date to GPS Time conversion.

7.1. Calendar Date to GPS Time

Converting a calendar date to obtain the GPS time can be calculated as shown in the following example, using the calendar date 13:30:00^3 hours, April 10, 2019.

Number of years from January 6, 1980 to April 10, 2019: 39 years
Number of days in 39 years (39 years x 365 days/year): 14,235 days
Add one day for each leap year (a year which is divisible by 4)^4 in that period: + 10 days
Add full days between January 6 to April 10 (consider April 10 is not ended yet): + 94 days
Total number of days = 14,339 days
Total number of seconds (14339 days x 86400 seconds/day) =1,238,889,600 seconds
Total number of weeks (1,238,889,600 seconds / 604,800 seconds/week) = 2048 + 0.42857... weeks

It can then be noted that GPS Week number is 2048 (week 0 of second epoch).

Days of the week (14,339 days - 2048 weeks x 7 days/week): 3 days
Number of seconds in 3 days (3 days x 86400 seconds/day): 259,200 seconds
Add number of seconds into the 4th day of week [Wednesday, April 10, 2019]: (13.5 hours x 3600 seconds/hour): + 48,600 seconds
Total seconds into week = 307,800 seconds

The resulting value for GPS Time is Week 2048, 307800 seconds.

^3 For simplicity, the offset between UTC and GPS time (leap seconds) has been omitted.
^4 Every 100 years, a leap year is skipped, unless when the year is also divisible by 400.
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- It can interfere with other electronic devices, particularly in environments such as hospitals, airports, aircrafts, etc.
- There is a risk of explosion such as gasoline stations, oil refineries, etc. It is the responsibility of the user to enforce the country regulation and the specific environment regulation.

Do not disassemble the product; any mark of tampering will compromise the warranty validity. We recommend following the instructions of the hardware user guides for correct wiring of the product. The product has to be supplied with a stabilized voltage source and the wiring has to be conformed to the security and fire prevention regulations. The product has to be handled with care, avoiding any contact with the pins because electrostatic discharges may damage the product itself. Same cautions have to be taken for the SIM, checking carefully the instruction for its use. Do not insert or remove the SIM when the product is in power saving mode.

The system integrator is responsible for the functioning of the final product. Therefore, the external components of the module, as well as any project or installation issue, have to be handled with care. Any interference may cause the risk of disturbing the GSM network or external devices or having an impact on the security system. Should there be any doubt, please refer to the technical documentation and the regulations in force. Every module has to be equipped with a proper antenna with specific characteristics. The antenna has to be installed carefully in order to avoid any interference with other electronic devices and has to guarantee a minimum distance from the body (20 cm). In case this requirement cannot be satisfied, the system integrator has to assess the final product against the SAR regulation.

The equipment is intended to be installed in a restricted area location.

The equipment must be supplied by an external specific limited power source in compliance with the standard EN 62368-1:2014.

The European Community provides some Directives for the electronic equipment introduced on the market. All of the relevant information is available on the European Community website:

https://ec.europa.eu/growth/sectors/electrical-engineering_en
7. GLOSSARY

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>GNSS</td>
<td>Global Navigation Satellite System</td>
</tr>
<tr>
<td>RMC</td>
<td>Recommended minimum specification Data</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>NMEA</td>
<td>National Marine Electronics Association</td>
</tr>
<tr>
<td>UTC</td>
<td>Universal Time Coordinated</td>
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## 8. DOCUMENT HISTORY

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Changes</th>
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| 3        | 2021-07-16 | Updated the document to new Telit template standards  
|          |            | Minor editorial changes                      |
| 2        | 2019-08-20 | Updated additional issues sections           |
| 1        | 2019-07-22 | Added section on additional issue            |
| 0        | 2019-02-28 | First issue                                  |

From Mod.0809 rev.3
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