SL869-T Timing SW User Guide

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Making machines talk.

APPLICABILITY TABLE

PRODUCT
SL869-T

SW Version
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1. Introduction

1.1. Scope

This document describes the portion of the serial communications interface between the SL869-T GNSS receiver module timing firmware and Host Processor software that is related to the timing feature. The described interface is reserved for users authorized under a Telit Non-Disclosure Agreement to use timing module firmware and is a supplement to other SL869 software user guides.

1.2. Audience

This document is intended only for distribution to Telit employees and to SL869-T GNSS timing module customers who have signed a Non-Disclosure Agreement (NDA) with Telit Wireless.

1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

TS-EMEA@telit.com
TS-NORTHAMERICA@telit.com
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Alternatively, use:

http://www.telit.com/en/products/technical-support-center/contact.php

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

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

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1.4. Document Organization

This document contains the following chapters (sample):

"Chapter 1: "Introduction" provides a scope for this document, target audience, contact and support information, and text conventions.

"Chapter 2: "Communication Interface" gives an overview of the serial communications interface.

"Chapter 3: "Commands Description" describes in detail each of the input commands related to timing for the SL869-T.

"Chapter 4: "Messages Description" describes in detail each of the output messages related to timing which are produced by the SL869-T.

"Chapter 5: "Document History" provides of the changes made to this User Guide.

1.5. Text Conventions

Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.

Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.

Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

1.6. Related Documents

1. SL869 Product Description, 80405ST10105A
2. SL869 Software User Guide, 1VV0301002
3. SL869 Software Authorized User Guide, 1VV0301052

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2. Overview

2.1. Background

The SL869-T timing module is a member of the SL869 product family that is intended for use in timing applications. The timing firmware within the module provides an accurate PPS signal by holding an internal reference position that represents the location of the antenna for the timing module, and then by applying satellite measurements only to the calculation of time. Because the internal reference position is "held" by the module firmware, this timing feature of the SL869-T is also known as *Position Hold* mode. While in Position Hold mode, the SL869-T timing module firmware also performs time-receiver autonomous integrity monitoring (T-RAIM) to ensure a high degree of integrity of the PPS signal. Position Hold mode and the held internal reference position are maintained through commanded software resets.

2.2. Communication Interface

The serial communication interface between the SL869-T timing module and the Host processor is based on the NMEA-0183 protocol standard. More information regarding the NMEA protocol and its use by the SL869 module family can be found in Section 2 of the Software Guides for public and authorized users listed as References in the Introduction above. Note that the default settings for the serial communications port used by the SL869-T timing firmware are:

- 115200 Baud
- Eight data bits
- No parity bits
- One stop bit

The timing feature is managed using proprietary NMEA commands and messages. A command interface allows the user to set and poll the internal reference position used for Position Hold mode, as well to obtain information regarding the status of the T-RAIM algorithm.

2.3. PPS Signal

Unlike the standard SL869 module, by default the SL869-T timing module outputs a pulse every second. It is able to output an accurate pulse with only one satellite in track when in Position Hold mode.

2.4. Reference Position

As mentioned above, in Position Hold mode an internal reference position is held by the SL869-T timing module firmware, which removes position uncertainty and allows the firmware to apply satellite measurements exclusively to the calculation of time and the

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production of an accurate PPS signal. The internal reference position can be established in a number of ways.

2.4.1. Auto-Survey

The SL869-T timing module firmware includes an auto-survey algorithm that can determine the reference position from a series of position fix samples. The factory default is for the auto-survey algorithm to be enabled at start-up, whereby the module operates for at least one hour (3600 position fixes) as a positioning receiver, after which it enters Position Hold mode using the calculated reference position.

Commands to change the number of required samples or to disable the auto-survey algorithm are provided and are described later in this document.

If the number of required samples is changed, or if the module is given any sort of commanded software reset (e.g. a $PSTMHOT command) while the auto-survey algorithm is underway, the algorithm is restarted.

2.4.2. Commanded

If the antenna position is accurately known a priori when the SL869-T timing module is installed, the module can be commanded into Position Hold mode and to specifiy the antenna position as its held reference position. The module can also be configured via command to start-up in Position Hold mode using the specified antenna position as its reference position.

Note that the auto-survey algorithm should be disabled when using a commanded reference position.

The relevant commands are described later in this document.

2.5. Positioning Output

It is important to note that the timing output is managed independently from the navigation algorithm, and therefore the SL869-T timing module behaves as a positioning receiver even while it is in Position Hold mode. Thus the reported position will reflect the antenna position as if it were output by a standard SL869 module, which may or may not be the same as the internally held reference position.

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3. Commands Description

The table below lists the commands used for managing the timing feature, and that are available to authorized users of the SL869-T timing module. These commands are echoed by the SL869-T back to the Host after the command is executed.

Command ID	Description
$PSTMENABLEPOSITIONHOLD	Disable or Enable Position Hold mode and set reference position for timing.
$PSTMPPS	Manage PPS
$PSTMSETPAR	Set system parameter

Additionally, extensions to the $PSTMPPS and $PSTMSETPAR commands for managing the timing feature of the SL869-T timing module are described in this Guide. The $PSTMPPS and $PSTMSETPAR commands are documented in the Software Authorized User Guide (Reference 3).

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3.1. $PSTMENABLEPOSITIONHOLD

This command is used to enable Position Hold and set the reference (held) position for timing. The entered reference position will be used until it is changed by a subsequent command, or until the module is given a system reset. It can also be used to disable Position Hold, but note that the position fields must be populated even when Position Hold is being disabled.

Note that if the auto-survey algorithm is in the process of estimating a reference position, the user entered reference position will be overridden by the estimate when the algorithm completes its calculation. Refer to section 3.2.7 for more information regarding the auto-survey algorithm.

Synopsis:

```
$PSTMENABLEPOSITIONHOLD,<OnOff>,<Lat>,<N/S>,<Long>,<E/W>,<Alt>
<cr><lf>
```

Parameter	Format	Description
OnOff	One digit decimal	0 – Position Hold will be disabled 1 – Position Hold will be enabled
Lat	DDMM.MMMM	Latitude (DegreesMinutes.FractionalMinute)
N/S	'N' or 'S'	Latitude direction (North or South)
Long	DDDMM.MMMM	Longitude (DegreesMinutes.FractionalMinute)
E/W	'E' or 'W'	Longitude direction (East or West)
Alt	dddddd.dd - Signed decimal, up to 8 digits	Mean Sea Level (MSL) altitude in meters, range -1500 to 100000

If the OnOff field is set to '1' and the command is successful, the SL869-T uses the position provided in the command as the reference position and responds with the following message:

```
$PSTMPOSITIONHOLDENABLED*49<cr><lf>
```

If the OnOff field is set to '0' and the command is successful, the SL869-T responds with the following message:

```
$PSTMPOSITIONHOLDDISABLED*1C<cr><lf>
```

However, if an input parameter is missing or is not a valid value, the SL869-T responds with the following message:

```
$PSTMENABLEPOSITIONHOLDERROR*55<cr><lf>
```

The Position Hold feature remains in the previous state when an error occurs.

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Example:

Enable Position Hold:

```
$PSTMENABLEPOSITIONHOLD,1,3340.2555,N,11739.2333,W,255.55*06
```

3.2. $PSTMPPS

This command is used to manage the PPS output of the SL869-T and is described in the Software Authorized User Guide. The command types described in the subsections below can be used to set and get information about the Position Hold and TRAIM features and are supplemental to the command types supported by standard firmware.

3.2.1. Get Position Hold Data

This command can be used to poll the Position Hold status and the reference position used for timing.

Synopsis:

```
$PSTMPPS,1,13<cr><lf>
```

The response to this command has the following format:

```
$PSTMPPS,1,13,<OnOff>,<Lat>,<N/S>,<Long>,<E/W>,<Alt>
*<checksum><cr><lf>
```

Parameter	Format	Description
OnOff	One digit decimal	0 – Position Hold is disabled 1 – Position Hold is enabled
Lat	DDMM.MMMM	Latitude (DegreesMinutes.FractionalMinute)
N/S	'N' or 'S'	Latitude direction (North or South)
Long	DDDMM.MMMM	Longitude (DegreesMinutes.FractionalMinute)
E/W	'E' or 'W'	Longitude direction (East or West)
Alt	dddddd.dddd - Signed decimal, up to 10 digits	Mean Sea Level (MSL) altitude in meters, range -1500 to 100000

If Position Hold is disabled, the reported position is 0 degrees latitude and longitude, and 0 meters WGS-84 altitude (-18 meters MSL).

3.2.2. Get TRAIM Status

This command can be used to poll for TRAIM status information.

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Synopsis:

```
$PSTMPPS,1,15<cr><lf>
```

The response to this command has the following format:

```
$PSTMPPS,1,15,<Enabled>,<Status>,<AvgError>,<UsedSats>,
<RemovedSats>*<checksum><cr><lf>
```

Parameter	Format	Description
Enabled	One digit decimal	0 – TRAIM is disabled 1 – TRAIM is enabled
Status	One-digit decimal	0 – UNDER alarm 1 – OVER alarm 2 - UNKNOWN
AvgError	Decimal	Average time error in nanoseconds
UsedSats	Decimal	Number of satellites used by the TRAIM algorithm
RemovedSats	Decimal	Number of satellites removed by the TRAIM algorithm

Example:

```
$PSTMPPS,1,15,1,0,4,6,2*61
```

Satellites that have an estimated time error larger than the alarm threshold are removed by the TRAIM algorithm and are not used for timing correction. Also, if the average time error exceeds the alarm threshold, the `Status` indicates an OVER alarm condition. By default the SL869-T uses an alarm threshold of 15 nanoseconds.

3.2.3. Get TRAIM Used Satellites

This command can be used to poll for the satellites used for timing.

Synopsis:

```
$PSTMPPS,1,16<cr><lf>
```

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The response to this command has the following format:

```
$PSTMPPS,1,16,<Enabled>,<UsedSats>,<Sat1>,...,<SatN>
*<checksum><cr><lf>
```

Parameter	Format	Description
Enabled	One digit decimal	0 – TRAIM is disabled 1 – TRAIM is enabled
UsedSats	Decimal	Number of satellites used by the TRAIM algorithm
Sat1…SatN	Decimal	List of used satellite IDs

Example:

```
$PSTMPPS,1,16,1,5,31,22,14,32,20*53
```

3.2.4. Get TRAIM Residuals

This command can be used to poll for the time error residuals for satellites that are being used for timing correction.

Format:

```
$PSTMPPS1,17,<Enabled>,<UsedSats>,<Res1>,...,<ResN>
*<checksum><cr><lf>
```

Parameter	Format	Description
Enabled	One-digit Decimal	0 – TRAIM is Disabled 1 – TRAIM is Enabled
UsedSats	Decimal	Number of satellites used for timing correction.
Res1…ResN	Signed Decimal	List of time error residuals for corresponding satellites in the used satellite list returned by the $PSTMPPS poll command below or reported in the $PSTMTRAIMUSED message.

Example:

```
$PSTMPPS,1,17,1,6,-12,6,-3,9,-13,14*6c
```

3.2.5. Get TRAIM Removed Satellites

This command can be used to poll for the satellites removed by TRAIM for timing.

Synopsis:

```
$PSTMPPS,1,18<cr><lf>
```

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The response to this command has the following format:

```
$PSTMPPS,1,18,<Enabled>,<RemovedSats>,<Sat1>,...,<SatN>
*<checksum><cr><lf
```

Parameter	Format	Description
Enabled	One digit decimal	0 – TRAIM is disabled 1 – TRAIM is enabled
RemovedSats	Decimal	Number of satellites removed by the TRAIM algorithm
Sat1…SatN	Decimal	List of removed satellite IDs

Example:

```
$PSTMPPS,1,18,1,2,31,1*41
```

3.2.6. Set Position Hold Data

This command can be used to enable or disable Position Hold and to set the reference (held) position for timing. It is functionally equivalent to the $PSTMENABLEPOSITIONHOLD command.

Synopsis:

```
$PSTMPPS,2,13,<OnOff>,<Lat>,<N/S>,<Long>,<E/W>,<Alt><cr><lf>
```

Parameter	Format	Description
OnOff	One digit decimal	0 – Position Hold will be disabled 1 – Position Hold will be enabled
Lat	DDMM.MMMM	Latitude (DegreesMinutes.FractionalMinute)
N/S	‘N’ or ‘S’	Latitude direction (North or South)
Long	DDDMM.MMMM	Longitude (DegreesMinutes.FractionalMinute)
E/W	‘E’ or ‘W’	Longitude direction (East or West)
Alt	dddddd.dd - Signed decimal, up to 8 digits	Mean Sea Level (MSL) altitude in meters, range -1500 to 100000

Example:

Enable Position Hold:

```
$PSTMPPS,2,13,1,3340.2555,N,11739.2333,W,255.55
```

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3.2.7. Set Auto Position Survey Sample Count

This command can be used to enable or disable the automatic determination of the reference (held) position for timing.

Synopsis:

```
$PSTMPPS,2,14,<Samples><cr><lf>
```

where `Samples` is the number of position samples to be used by the auto-position survey algorithm. If `Samples` is set to 0, the algorithm is disabled. Otherwise, if a non-zero value is provided and the SL869-T is not in Position Hold mode, the algorithm is restarted using the specified number of position samples. It is recommended that the number of samples should be chosen to allow the algorithm to run for one hour or longer. For best results 24 hours is recommended.

Example:

Start and run the auto-position algorithm for 2 hours (at 1Hz fix rate):

```
$PSTMPPS,2,14,7200
```

It is important to note that the reference position for Position Hold will be updated when the algorithm completes its position estimation. If a reference position was entered manually via command, it will be overridden.

NOTE:

Factory default is that the automatic survey algorithm for position hold is enabled with a sample count of 3600 (one hour). If it is desired for the module to use a reference position provided by the user, the sample count should be set to 0 at start-up.

3.2.8. Set TRAIM

This command can be used to disable or enable the T-RAIM algorithm.

Synopsis:

```
$PSTMPPS,2,15,<OnOff>,<Alarm><cr><lf>
```

Parameter	Format	Description
OnOff	One digit decimal	0 – The TRAIM algorithm will be disabled 1 – The TRAIM algorithm will be enabled
Alarm	Floating point	Time error threshold in seconds

Example:

Disable the T-RAIM algorithm:

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```
$PSTMPPS,2,15,0,0
```

Example:

Enable the T-RAIM algorithm and set the alarm threshold to 20 nanoseconds:

```
$PSTMPPS,2,15,1,0.00000002
```

3.3. $PSTMSETPAR

This command is used to set or modify a system parameter in the SL869 module configuration data and is described in the Authorized User Guide. It can be used to configure certain parameters related to the Position Hold and TRAIM featured for timing purposes as shown below.

It is important to note that after parameters have been configured, the $PSTMSAVEPAR command must be sent to store the updated values in flash.

3.3.1. Output Messages

As explained in the SW Authorized User Guide, message output can be controlled using the command

```
$PSTMSETPAR,1201,<mask><mode><cr><lf>
```

where `mask` is a value representing the bit assignment(s) for the message or messages to be controlled. The message will be enabled if `mode` is 1, or it will be disabled if `mode` is 2. The table below lists the bit masks for output messages supported by the SL869-T timing firmware, which are in addition to those supported by standard firmware.

Message	Default	Mask
PSTMTRAIMSTATUS [1]	On	0x2000000
PSTMTRAIMUSED [1]	On	0x2000000
PSTMTRAIMRES [1]	On	0x2000000
PSTMTRAIMREMOVED [1]	On	0x2000000
PSTMPOSHOLD	Off	0x4000000

Note 1: TRAIM messages are all controlled by the same bit.

Example:

Enable output of the $PSTMPOSHOLD message:

```
$PSTMSETPAR,1201,4000000,1
```

The message will be output after the SL869-T is given a software reset command (e.g. $PSTMHOT) or the setting is saved to flash.

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3.3.2. Position Hold Reference Position

By factory default the Position Hold (timing) feature is disabled at start-up and then becomes enabled when the position auto-survey algorithm completes. The default can be reconfigured to enable Position Hold at start-up using a specified reference position.

The reference position can be configured by setting three parameters using the following commands:

Latitude:
`$PSTMSETPAR,1304,<Lat><cr><lf>`

Longitude:
`$PSTMSETPAR,1305,<Lon><cr><lf>`

Altitude:
`$PSTMSETPAR,1306,<Alt><cr><lf>`

These commands set the latitude, longitude and Mean Sea Level altitude, respectively, of the reference position. The latitude and longitude values must be expressed as degrees floating point. The range of latitude values is -90.0 to 90.0 degrees, where positive values represent the North direction. The range of longitude values is -180.0 to 180.0 degrees, where positive values represent the East direction. Altitude must be expressed in meters floating point within the range -1500.0 to 100000.0.

In order for the new reference position to take effect, the SL869-T must be rebooted after the position is saved to flash.

3.3.3. Enable Position Hold At Start-up

The default state of Position Hold at start-up can be set to Enabled by sending the following command:

`$PSTMSETPAR,1200,4000000,1<cr><lf>`

Position Hold is enabled when the setting is saved to flash.

The default state can subsequently be set back to Disabled by using the command:

`$PSTMSETPAR,1200,4000000,2<cr><lf>`

In order for the new default Position Hold state to become Disabled, it must be saved to flash. If the module is in Position Hold mode, the SL869-T must then be rebooted to use the new default and disable Position Hold.

It is important to note that if the default start-up state is Enabled, the module uses the configured default reference position (see section 3.3.2 above).

3.3.4. Position Auto Survey Samples

The factory default value of the auto-survey sample count is 3600, which represents a one hour time frame from start-up within which the SL869-T establishes a self-surveyed reference position for Position Hold mode (timing mode). The default value can be reconfigured using the command:

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```
$PSTMSETPAR,1215,<Samples><cr><lf>
```

and then saving to flash. Note that the specified number of samples takes effect when the parameter is saved to flash. Please refer to section 3.2.7 for more information regarding the use of this value.

Example:

Configure the position auto-survey to run for one day (24 hours) from start-up by default:

```
$PSTMSETPAR,1215,15180
```

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4. Messages Description

The table below summarizes the messages that are related to the timing feature and are output periodically by the SL869-T. These messages are available to authorized users of the SL896 Timing firmware.

Message ID	Description
$PSTMPOSHOLD	Position Hold status and reference position
$PSTMTRAIMSTATUS	TRAIM algorithm status
$PSTMTRAIMUSED	Satellites used for timing correction
$PSTMTRAIMRES	Time error residuals for satellites used
$PSTMTRAIMREMOVED	Satellites removed by TRAIM algorithm

All messages are output once per second unless otherwise noted in the subsections below.

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4.1. $PSTMPOSHOLD

This proprietary message reports the status of the Position Hold feature which is used for timing. If Position Hold is enabled, the held reference position is also reported.

Format:

```
$PSTMPOSHOLD,<OnOff>,<Lat>,<N/S>,<Long>,<E/W>,<Alt>*<checksum>
<cr><lf>
```

Parameter	Format	Description
OnOff	One digit decimal	0 – Position Hold is disabled 1 – Position Hold is enabled
Lat	DDMM.MMMM	Latitude (DegreesMinutes.FractionalMinute)
N/S	'N' or 'S'	Latitude direction (North or South)
Long	DDDMM.MMMM	Longitude (DegreesMinutes.FractionalMinute)
E/W	'E' or 'W'	Longitude direction (East or West)
Alt	dddddd.dd - Signed decimal, up to 8 digits	Mean Sea Level altitude in meters

Example:

```
$PSTMPOSHOLD,1,3309.1094,N,09638.0040,W,188.99*5B
```

If Position Hold is disabled, the reported position is 0 degrees latitude and longitude, and 0 meters WGS-84 altitude (-18 meters MSL).

Note that this message is disabled by factory default. It can be enabled using the following command:

```
$PSTMSETPAR,1201,4000000,1
```

See the section on $PSTMSETPAR command in the Software Authorized User Guide for more background on enabling/disabling output messages.

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4.2. $PSTMTRAIMSTATUS

This proprietary NMEA message reports the status of the TRAIM algorithm.

Format:

```
$PSTMTRAIMSTATUS,<OnOff>,<Status>,<Alarm>,<AvgError>,
<UsedSats>,<RemovedSats>,<RefSecond>*<checksum><cr><lf>
```

Parameter	Format	Description
OnOff	One-digit Decimal	0 – TRAIM is Off 1 – TRAIM is On
Status	One-digit Decimal	0 – UNDER alarm 1 – OVER alarm 2 - UNKNOWN
Alarm	Decimal	Time error threshold in nanoseconds
AvgError	Decimal	Average time error in nanoseconds
UsedSats	Decimal	Number of satellites used by the TRAIM algorithm
RemovedSats	Decimal	Number of satellites removed by the TRAIM algorithm
RefSecond	Decimal	Second at which PPS signal is generated, range 0 to 59

Example:

```
$PSTMTRAIMSTATUS,1,1,15,-2,5,2,28*77
```

Satellites that have an estimated time error larger than the `Alarm` threshold are removed by the TRAIM algorithm and are not used for timing correction. Also, if the average time error exceeds the `Alarm` threshold, the `Status` indicates an OVER alarm condition.

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4.3. $PSTMTRAIMUSED

This proprietary NMEA message reports the satellites that are being used for timing correction.

Format:

```
$PSTMTRAIMUSED,<OnOff>,<UsedSats>,<Sat1>,...,<SatN>*<checksum>
<cr><lf>
```

Parameter	Format	Description
OnOff	One-digit Decimal	0 – TRAIM is Off 1 – TRAIM is On
UsedSats	Decimal	Number of satellites used for timing correction
Sat1…SatN	Decimal	List of used satellite IDs

Example:

This example shows five satellites being used, PRNs 22, 6, 18, 15 and 3.

```
$PSTMTRAIMUSED,1,5,22,6,18,15,3*7E
```

4.4. $PSTMTRAIMRES

This proprietary NMEA message reports the time error residuals for satellites that are being use for timing correction.

Format:

```
$PSTMTRAIMRES,<OnOff>,<UsedSats>,<Res1>,...,<ResN>*<checksum>
<cr><lf>
```

Parameter	Format	Description
OnOff	One-digit Decimal	0 – TRAIM is Off 1 – TRAIM is On
UsedSats	Decimal	Number of satellites used for timing correction.
Res1…ResN	Signed Decimal	List of time error residuals for corresponding satellites reported in the $PSTMTRAIMUSED message.

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Example:

Given the $PSTMTRAIMUSED example above, this example shows residuals for PRNs 22, 6, 18, 15 and 3, respectively.

```
$PSTMTRAIMRES,1,5,-21,-7,22,-6,-9*0E
```

4.5. $PSTMTRAIMREMOVED

This proprietary NMEA message reports the satellites that have been removed from use for timing correction.

Format:

```
$PSTMTRAIMREMOVED,<OnOff>,<RemovedSats>,<Sat1>,...,<SatN>
*<checksum><cr><lf>
```

Parameter	Format	Description
OnOff	One-digit Decimal	0 – TRAIM is Off 1 – TRAIM is On
UsedSats	Decimal	Number of satellites removed by the TRAIM algorithm
Sat1…SatN	Decimal	List of removed satellite IDs

Example:

This example shows three satellites have been removed, PRNs 24, 27 and 21.

```
$PSTMTRAIMREMOVED,1,3,24,27,21*35
```

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5. Document History

Revision	Date	Changes
0	2013-09-24	Draft issue
1	2013-10-28	Re-wrote Section 2 as an Overview. Added $PSTMPPS command types related to TRAIM. Added $PSTMSETPAR command for controlling output messages related to timing.
2	2014-10-01	Expanded introductory section on internal reference position (auto-survey, resets, etc.). Added details on use of no. of samples, added example for 24 hour survey.

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