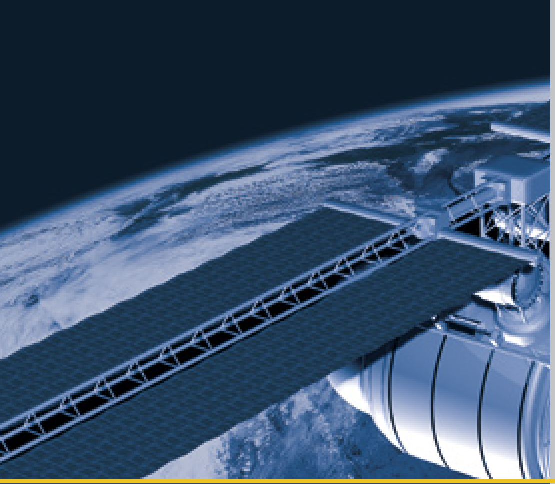

REFERENCE MANUAL
USER GUIDE

Lassen DR+GPS

The right one.™

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USER GUIDE
REFERENCE MANUAL

LASSEN® DR+GPS
STARTER KIT

Revision A
Part Number 58059-00

March 2007

Trimble.

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Release Notice

This is the March 2007 release (Revision A) of the Trimble Lassen DR+GPS Starter Kit User Guide, part number **58059-00**.

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As of July 1, 2006, the Product is compliant in all material respects with DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) and Amendment 2005/618/EC filed under C(2005) 3143, with exemptions for lead in solder pursuant to Paragraph 7 of the Annex to the RoHS Directive applied. The foregoing is limited to Product placed on the market in the Member States of the European Union on or after 1 July 2006. Trimble has relied on representations made by its suppliers in certifying this Product as RoHS compliant.

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- a description of the nonconforming Product including the model number and serial number
- an explanation of the problem

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TABLE OF CONTENTS

About this Manual

This Starter Kit Reference Manual describes how to integrate and operate the Trimble DR+GPS navigation receiver. The instructions in this manual assume that you know how to use the primary functions of Microsoft Windows.

If you are not familiar with GPS, visit Trimble's website, www.trimble.com, for an interactive look at Trimble and GPS.

Technical Assistance

If you cannot locate the information you need in this product documentation, contact the Trimble Technical Assistance Center at 800-767-4822.

CHAPTER

1

LASSEN® DR+GPS STARTER KIT

In this chapter:

- Product Overview
- Starter Kit
- Quick Start Guide
- Interface Protocols
- Power
- Software Toolkit

INTRODUCTION

The Trimble® Lassen® DR+GPS combines dead reckoning (DR) with GPS to produce accurate and instantaneous positions, even under the most difficult conditions. For service providers tracking high-value or perishable cargo, Lassen DR+GPS dramatically improves quality of service (QoS) and customer satisfaction and retention, helping tracking service providers to maximize revenue opportunities.

Dead reckoning (DR) estimates position based on heading and distance traveled since the last known position. The more accurate the speed, time and heading inputs, the more accurate the dead reckoning. This is where GPS helps. GPS continuously calibrates the gyro and speed sensors to produce optimal dead reckoning.

- Instantaneous and accurate positions in deep urban canyons and dense forests.
- Continuous position outputs in tunnels, parking garages and on lower bridge decks.
- Reliable positioning for tracking high-value assets and for mapping RF field strength.

Starter Kit Contents

The Starter Kit makes it simple to evaluate the Trimble DR+GPS module performance. The Starter Kit can be used as a platform for configuring the receiver software or as platform for troubleshooting your design. The Starter Kit includes the DR+GPS module mounted on an interface motherboard. The motherboard accepts power from 9 - 32 VDC and provides regulated +3.3V power to the DR+GPS module. The motherboard also contains:

- Miniature magnetic mount GPS 28dB Antenna with SMB connector and 5 meter cable
- 9-pin DR+GPS interface cable
- AC/DC power supply adapter (input: 100-240VAC, output: 12 VDC)
- USB Cable
- CD containing software tools used to communicate with the receiver, the System Designer Reference Manual, NMEA Reader, and the DrMonitor Program
- Lassen DR+GPS Starter Kit Module

Starter Kit Interface Unit

The Starter Kit interface unit consists of a DR+GPS module attached to an interface motherboard. This kit simplifies evaluation and software development with the receiver by providing a USB interface that is compatible with most PC communication ports. Power (9-32 VDC) is supplied through the power connector on the front of the interface unit. The motherboard features a switching power supply that converts this voltage input to the 3.3 volts required by the receiver and the 5 volts required by the antenna.

The DR+GPS module, installed on the Starter Kit interface unit, is a single port receiver. A FAKRA RF connector supports the GPS antenna connection. The center conductor of the FAKRA connector also supplies +5.5 VDC for the Low Noise Amplifier of the active antenna. On the DR+GPS module, a 14-pin (2x14), 2 mm AMP 1-215079-4 Micromatch connector (J1) supports the serial interface (CMOS level), the pulse-per-second (PPS) signal (CMOS level), and the input power (+3.3 VDC). The 14-pin Amp Micromatch I/O connector on the module connects to the motherboard via a ribbon cable (*see Appendix C for the pinout details*).

Ordering Starter Kit Components

The DR GPS Module is available in a Starter Kit or as an individual receiver and associated antenna. The Starter Kit includes all the components necessary to quickly test and integrate the receiver:

- AC/DC power supply adapter
- 9-pin DR+GPS interface cable
- USB interface cable
- Miniature magnetic mount antenna with 5 meters of cable
- CD-ROM containing the HIP Protocol (HIPPO) for DR+GPS, the System Designer Reference Manual, and the DrMonitor software

The following table provides ordering information for the DR+GPS module and the associated antennas and cables.

Table 1: Ordering Products

Product	Part Number
Shielded PCA with SMB Lassen DR+GPS module	55000-80
PCA with SMB Lassen DR+GPS module	46999-80
Lassen DR+GPS module Starter Kit	61100-05
Magnetic mount, miniature antenna	56237-00
AC/DC power adapter and clips	59495 and 59495-05
USB Interface Cable	61174
DR+GPS Starter Kit CD	61694-05
9-pin DR+GPS interface cable	60230-10

NOTE Part numbers are subject to change. Confirm part numbers with your Trimble representative when placing your order. Other rooftop cables and antenna combinations are also available.

QUICK START GUIDE

Before you begin, confirm that you have the following PC configuration in place:

- Windows XP, Service Pack 2, or Windows 2000 operating system
- Service Pack 4 installed
- A free USB port
- A CD drive

Copy the Supplied Files

1. Insert the supplied CD.
2. Copy all files all files to a directory on the hard drive.

Install the FTDI Driver

The starter kit uses a USB 2.0 dual serial port emulator interface chip from Future Technology Devices International Ltd. (FTDI). In order to use the Monitor software tool to communicate with the GPS receiver, you must first install the FTDI driver on your PC. *

1. Select the file “CDM_Setup.exe”. If properly installed, an FTDI CDM Driver Installation popup window displays the following message: FTDI CDM Drivers have been successfully installed. Click the OK button.

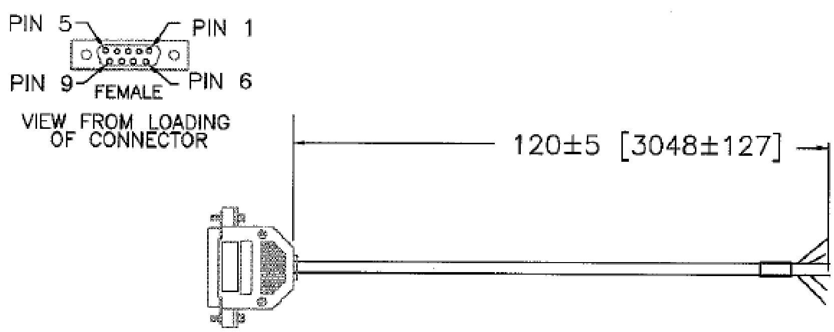
   You can check for the latest FTDI USB drivers at: www.ftdichip.com/Drivers/VCP.htm. Download the appropriate VCP (Virtual COM Port) driver for your operating system (Windows 2000 or XP). Select the “Installation Executable” link in the comments column for the driver self install package.

Connect the Starter Kit Components

1. Connect the GPS antenna to the interface unit. Antenna types are product dependent.
2. Place the antenna outside. The antenna should have a clear (180) view of the sky. A reduced number of satellites will be available if this direct view is obstructed.
3. Connect the supplied USB cable to the USB connector on the interface unit.
4. Connect the other end of the USB cable to your PC.

5. Connect the supplied 5 wire interface cable to the correct vehicle outputs.
6. If the unit is to be used in a lab, use the supplied international AC/DC adapter to supply the power.
7. Turn on the interface unit and confirm that the green power LED lights.
8. The FTDI driver automatically assigns a virtual COM ports to the USB port. During assignment the virtual COM ports display on your monitor screen. To view LPT and COM port assignments, select System Properties>Device Manager.
9. To view the NMEA output, use a terminal emulator program such as HyperTerminal. This is usually found under Start>Accessories>Communications.
10. Select one of the USB virtual COM ports.
11. Set the COM port parameters to 38400 baud, no parity, and one stop bit. This is the ONLY setting that is allowed.

1. 5-Wire Interface Cable



WIRING CHART

DB9 (MALE)	WIRE COLOR	SIGNAL SCHEME
1 ←	BLK	GND
2 ←	BROWN	TACH O
3 ←	RED	DIR
4 ←	ORANGE	Vcc BATT
5 ←	YELLOW	Vcc –KEY
6 ←	GREEN	GND
7 NC	BLUE	
8 NC	PURPLE	
9 ←	WHITE	Vcc –KEY

SOFTWARE TOOLKIT

The CD provided in the Starter Kit contains the DR Monitor program used to monitor GPS performance and to assist system integrators in developing a software interface for the GPS module. DR Monitor runs on the Windows 95/98/2000/XP platforms. NMEA Reader is supplied to analyze the NMEA output.

NOTE Current units are configured to output NMEA by default. DR Monitor will not show the output results. Use HyperTerminal to view the output.

Interface Protocol

The DR+GPS Module can be configured to output NMEA messages at scheduled intervals from 1 to 60 seconds, or at 5Hz. *See Appendix A for a full description of NMEA*.

The DR+GPS Module also has a binary command/report protocol, HIPPO (HIP Protocol Object). This protocol is appropriate for system integrators that require real time control of the DR+GPS module. *See Appendix B for a full description of HIPPO*.

NMEA Tools

To capture NMEA output, use HyperTerminal or a similar terminal emulator program. By default the NMEA messages output are GGA, VTG, RMC, GSA, and GSV. NMEA analysis may be carried out using NMEA Reader and Google Earth.

HIPPO Tools

Use DrMonitor to configure and monitor the HIPPO protocol.

CHAPTER

2

COMMON OPERATIONS

In this chapter:

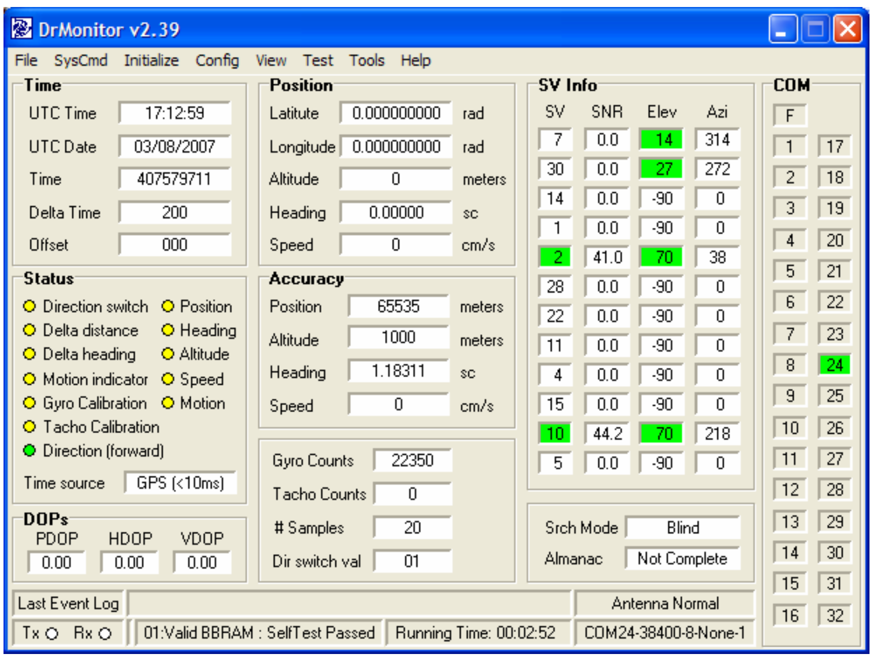
- NMEA Port Configuration
- Change the Output Protocol
- Use the NMEA Reader

NMEA PORT CONFIGURATION

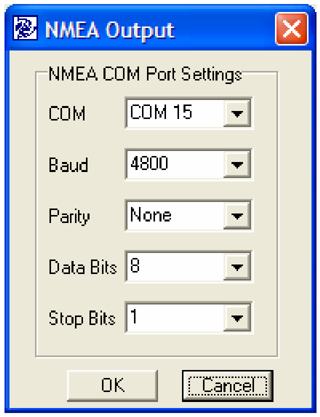
By default, the DR+GPS module outputs NMEA messages. However if you have previously changed the unit to output HIPPO, follow these steps to return to NMEA.

Enable NMEA Mode

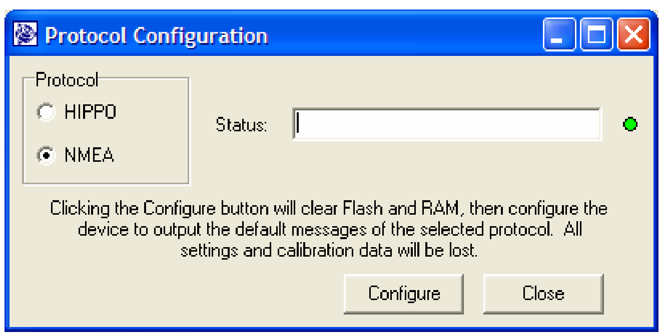
1. Open DrMonitor
   If HIPPO output mode is selected, HIPPO data displays as in the screen below.



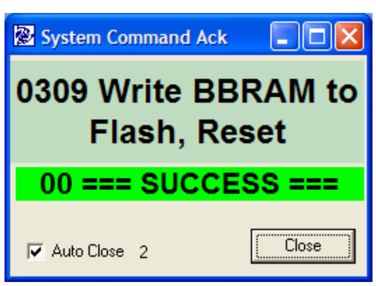
2. Select Config>Com setup



3. Select the correct COM port number for the USB Virtual Serial Port.
4. Select 38400 Baud, No Parity, 8 Data Bits, and 1 Stop Bit.
5. Click the OK button.
6. Select Config>HIPPO>NMEA Output to open the Configuration window.



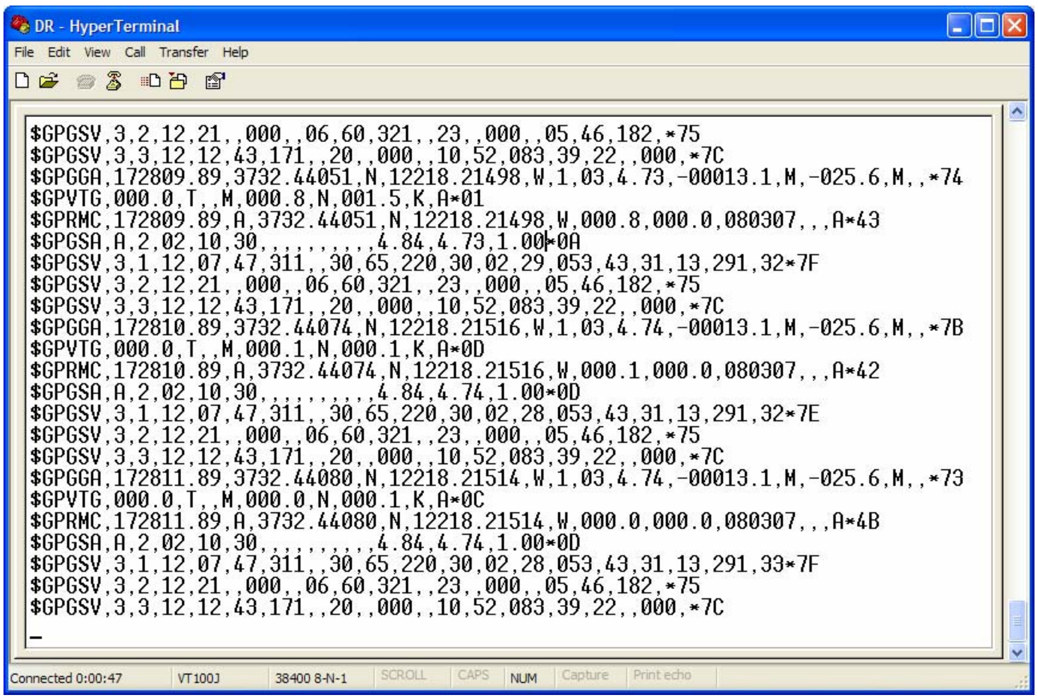
7. Click the NMEA button and then the Configure button. The SUCCESS screen displays.



8. Click the Close button. All output is displayed as NMEA data.

View NMEA Output

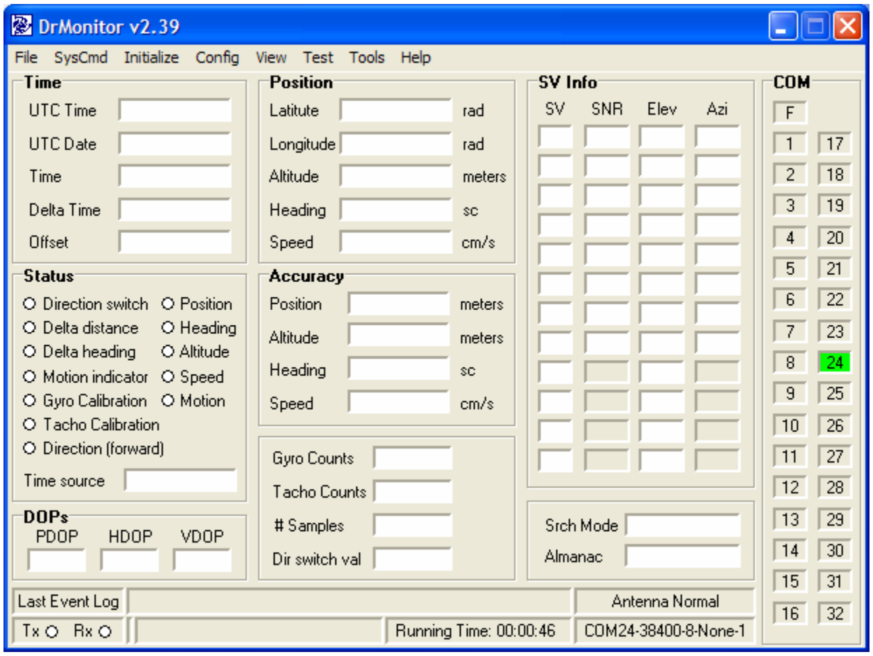
1. Open HyperTerminal or a similar terminal emulator.
2. Set the communication port settings to 38400 Baud, No Parity, 8 Data Bits, and 1 Stop Bit.
3. If you are using HyperTerminal you will see output as shown below.



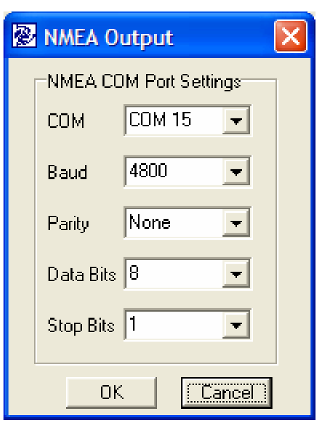
NOTE To change the NMEA output you must quit HyperTerminal and start DrMonitor again.

Changing NMEA Output and Report Rates

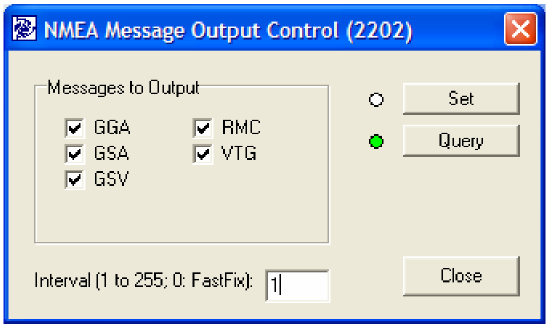
1. Open DrMonitor



2. Select Config>Com setup.



3. Select the correct Com port number for the USB Virtual Serial Port.
4. Select 38400 Baud, No Parity, 8 Data Bits, and 1 Stop Bit.
5. Click the OK button.
6. Select Config>NMEA Message Output Control to open the Configuration window.



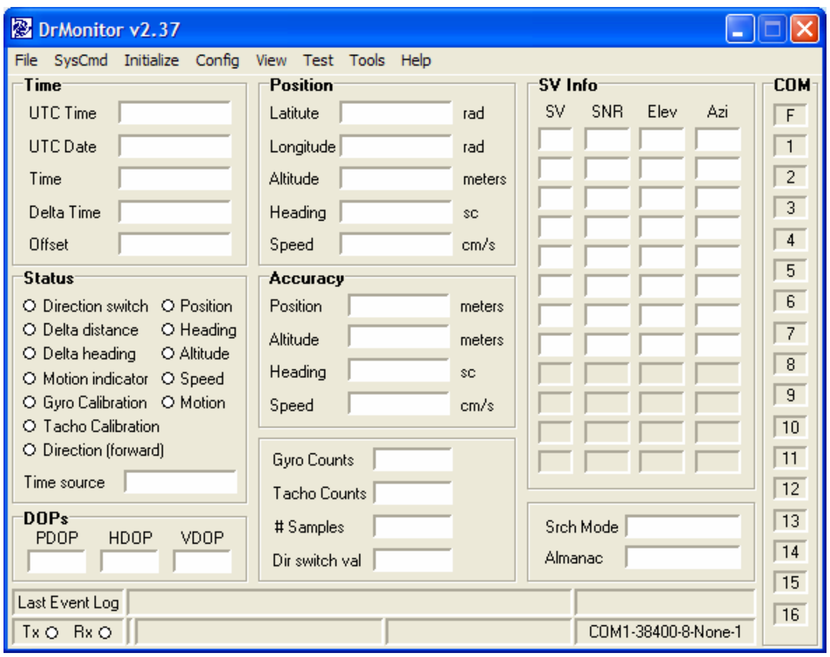
7. Select the NMEA messages to be output.
8. Enter a number between 1 and 255 for the output rate (in seconds). Selecting 0 enables the 5Hz output for GGA, VTG and RMC. GSA and GSV will output at 1Hz.
9. Click the Set button.
10. Wait for the operation to finish.
11. Click the Close button.
12. If necessary, you may quit DrMonitor and return to HyperTerminal.

CHANGE THE OUTPUT PROTOCOL

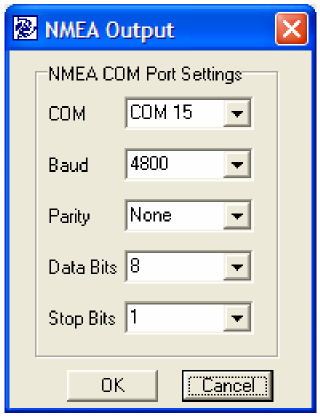
Change from the Default NMEA Output to HIPPO

Before you begin, confirm that you have no other terminal program such as HyperTerminal communicating with the DR+GPS unit. Quit any such program so that it does not occupy the COM port that will be used for DrMonitor.

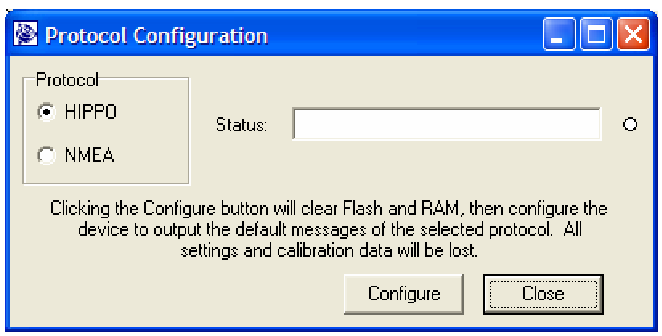
1. Open DrMonitor



2. Select Config>Com setup

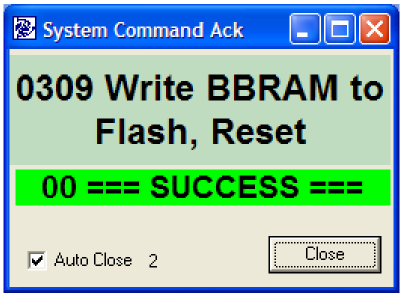


3. Select the correct Com port number for the USB Virtual Serial Port.
4. Select 38400 Baud, No Parity, 8 Data Bits, and 1 Stop Bit.
5. Click the OK button.
6. Select Config>Protocol to open the Protocol Configuration window.

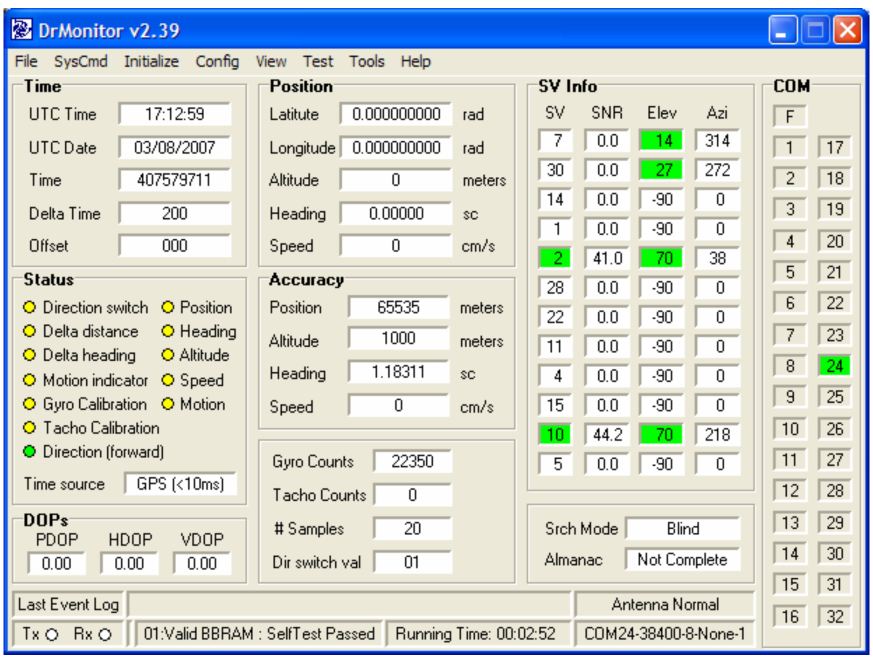


7. Select the HIPPO button.
8. Click the Configure button.

9. Wait for the operation to close. The protocol changes and the SUCCESS screen displays.



10. Click the Close button.
Updates to the DrMonitor screen display as illustrated below. All output is HIPPO.



HIPPO Commands to Change Protocol

HIPPO Commands to Change NMEA to HIPPO:

81 03 07 F3 82

81 01 2B 30 02 00 00 00 00 C8 00 00 00 D7 82

81 01 2A 31 01 00 0C 00 00 94 82

81 01 2A 32 01 00 0C 00 00 93 82

81 01 2A 33 01 00 0C 00 00 92 82

81 01 2A 11 01 00 00 20 00 A0 82

81 01 2A 12 01 00 00 20 00 9F 82

81 01 2A 36 03 00 00 00 04 95 82

81 01 2A 36 04 00 00 00 04 94 82

81 01 2A 36 05 00 00 00 02 95 82

81 01 2A 36 07 00 00 00 01 94 82

81 01 2A 36 08 00 00 00 04 90 82

81 01 22 02 00 00 00 00 00 D8 82

81 03 09 F1 82

HIPPO Commands to Change HIPPO to NMEA:

81 03 07 F3 82

81 01 2B 30 02 00 00 00 00 00 00 00 00 9F 82

81 01 2A 31 01 00 00 00 00 A0 82

81 01 2A 32 01 00 00 00 00 9F 82

81 01 2A 33 01 00 00 00 00 9E 82

81 01 2A 11 01 00 00 00 00 C0 82

81 01 2A 12 01 00 00 00 00 BF 82

81 01 2A 36 03 00 00 00 00 99 82

81 01 2A 36 04 00 00 00 00 98 82

81 01 2A 36 05 00 00 00 00 97 82

81 01 2A 36 07 00 00 00 00 95 82

81 01 2A 36 08 00 00 00 00 94 82

81 01 22 02 01 00 00 01 1D B9 82

81 03 09 F1 82

In both cases, there should be a 5-second pause after the first command, then a 100ms delay between each of the successive 13 commands.

Save the Calibration Settings

You can save the calibration settings of the Gyro and Tachometer in Flash memory for future use, should the power supply to the DR+GPS be removed and the settings lost.

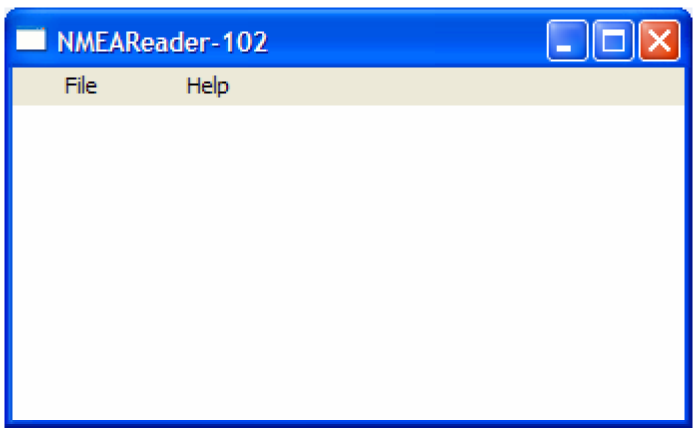
Correct calibration of the Gyro can only be carried out after the Tachometer input has completed its calibration. The Tachometer calibrates after 40 GPS fixes which are above the speed of 8m/s. The Gyro bias calibration completes after a short standstill. The Gyro Scale Factor calibrates after twenty 90^{o} turns.

1. Use DrMonitor in HIPPO output mode to view the Gyro Calibration and Tacho Calibration status lights.
2. Wait for these indicator lights to turn green.
3. From the DrMonitor menu, select SysCmd> Clear Position, Reset.
4. From the DrMonitor menu, select SysCmd> Write BBRAM to Flash, Reset.

USE NMEA READER

NMEAReader can be used to parse a single or batch of text files containing NMEA data and save them to an Excel CSV file along with the headings for the satellite information.

1. Open the NMEAReader application



2. Select File>Single Post Proc.
3. Use the Windows navigation screen to select the raw NMEA file. This can be the saved output from HyperTerminal for instance.
4. Use the Windows navigation screen to select the file path for the parsed CSV file.
5. Select Yes or No to parse another file.
6. Use Excel to open and view the satellite data.

index	tod	lon	lat	alt	msl	speed	heading	GGAhdop	pdop	hdop	vdop	sGSAMode	numsvsinfix	numused	numsvsview	gpsqual	svid00	azim00	elev00	sgnl00	used00
1	65536.3	122.303673	37.540796	55.1	0	0	0	0	0	0	0	0	7	0	0	1	0	0	0	0	0
2	65536.5	122.303673	37.540796	55.1	0	0	0	0	0	0	0	0	7	0	0	1	0	0	0	0	0
3	65536.7	122.303673	37.540796	55.1	0	0	0	0	0	0	0	0	7	0	0	1	0	0	0	0	0
4	65536.9	122.303674	37.540797	55.1	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	35	1
5	65537.1	122.303674	37.540797	55.1	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	35	1
6	65537.3	122.303674	37.540797	55.1	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	35	1
7	65537.5	122.303674	37.540797	55.1	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	35	1
8	65537.7	122.303674	37.540797	55.1	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	35	1
9	65537.9	122.303674	37.540797	55	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	36	1
10	65538.1	122.303674	37.540797	55	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	36	1
11	65538.3	122.303674	37.540797	55	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	36	1
12	65538.5	122.303674	37.540797	55	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	36	1
13	65538.7	122.303674	37.540797	55	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	36	1
14	65538.9	122.303675	37.540797	55	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	35	1
15	65539.1	122.303675	37.540797	55	0	0	0	0	4.8	2.7	4	3	7	7	12	1	7	324	65	35	1

APPENDIX

A

NMEA 0183

This appendix provides a brief overview of the NMEA 0183 v2.3 protocol, and describes both the standard and optional messages offered by the DR+GPS.

INTRODUCTION

NMEA 0183 is a simple, yet comprehensive ASCII protocol which was originally established to allow marine navigation equipment to share information. Since it is a well established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics. The DR+GPS NMEA output supports NMEA 0183 version 2.3.

For those applications requiring output only from the GPS receiver, NMEA 0183 is a popular choice since, in many cases, an NMEA 0183 software application code already exists. The DR+GPS is available with firmware that supports a subset of the NMEA 0183 messages: GGA, GSA, GSV, RMC, and VTG.

For a complete copy of the NMEA 0183 standard, contact:

NMEA National Office
PO Box 3435
New Bern, NC 28564-3435
U.S.A.
Telephone: +1-919-638-2626
Fax: +1-919-638-4885

THE NMEA 0183 COMMUNICATION INTERFACE

NMEA 0183 allows a single source (talker) to transmit serial data over a single twisted wire pair to one or more receivers (listeners). The table below lists the standard characteristics of the NMEA 0183 data transmissions.

Table 2: NMEA 0183 Characteristics

Signal	DR+ GPS NMEA
Baud Rate	38400
Data Bits	8
Parity	None (Disabled)
Stop Bits	1

NMEA 0183 MESSAGE FORMAT

The NMEA 0183 protocol covers a broad array of navigation data. This broad array of information is separated into discrete messages which convey a specific set of information. The entire protocol encompasses over 50 messages, but only a sub-set of these messages apply to a GPS receiver like the DR GPS. The NMEA message structure is described below.

$IDMSG,D1,D2,D3,D4,.......,Dn*CS[CR][LF]

"$"	The "$" signifies the start of a message.
ID	The talker identification is a two letter mnemonic which describes the source of the navigation information. The GP identification signifies a GPS source.
MSG	The message identification is a three letter mnemonic which describes the message content and the number and order of the data fields.
","	Commas serve as delimiters for the data fields.
Dn	Each message contains multiple data fields (Dn) which are delimited by commas.
"*"	The asterisk serves as a checksum delimiter.
CS	The checksum field contains two ASCII characters which indicate the hexadecimal value of the checksum.
[CR][LF]	The carriage return [CR] and line feed [LF] combination terminate the message.

NMEA 0183 messages vary in length, but each message is limited to 79 characters or less. This length limitation excludes the "$" and the [CR][LF]. The data field block, including delimiters, is limited to 74 characters or less.

Null field, (no characters between commas), indicate data is not currently available.

Future versions of these messages may have extra fields added to the end.

FIELD DEFINITIONS

Many of the NMEA date fields are of variable length, and the user should always use the comma delineators to parse the NMEA message date field. Table\ specifies the definitions of all field types in the NMEA messages supported by Trimble

Table 3: Field Type Summary

Type	Symbol	Definition
Status	A	Single character field: A=Yes, data valid, warning flag clear V=No, data invalid, warning flag set
Special Format Fields		
Latitude	llll.lll	Fixed/variable length field: Degreesminutes.decimal-2 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Longitude	yyyyy.yyy	Fixed/Variable length field: Degreesminutes.decimal-3 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Time	hhmmss.ss	Fixed/Variable length field: hoursminutesseconds.decimal-2 fixed digits of minutes, 2 fixed digits of seconds and a variable number of digits for decimal-fraction of seconds. Leading zeros always included for hours, minutes, and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Defined		Some fields are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in this standard by the presence of one or more valid characters. Excluded from the list of allowable characters are the following that are used to indicated field types within this standard: “A”, “a”, “c”, “hh”, “hhmmss.ss”, “llll.ll”, “x”, “yyyyy.yy”

Type	Symbol	Definition
Numeric Value Fields		
Variable	x.x	Variable length integer or floating numeric field. Optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required (example: 73.10=73.1=073.1=73).
Fixed HEX	hh	Fixed length HEX numbers only, MSB on the left
Information Fields		
Fixed Alpha	aa	Fixed length field of upper-case or lower-case alpha characters.
Fixed Number	xx	Fixed length field of numeric characters

NOTE Spaces are only be used in variable text fields.

Units of measure fields are appropriate characters from the Symbol column unless a specified unit of measure is indicated.

Fixed length field definitions show the actual number of characters. For example, a field defined to have a fixed length of 5 HEX characters is represented as hhhhh between delimiters in a sentence definition.

NMEA 0183 MESSAGE OPTIONS

The DR GPS can output any or all of the messages listed in the table below. In its default configuration (as shipped from the factory), the DR GPS outputs only NMEA messages. Typically NMEA messages are output at a 1 second interval with the “GP” talker ID and checksums. These messages are output at all times during operation, with or without a fix. If a different set of messages has been selected and this setting has been stored in Flash memory, the default messages are permanently replaced until the receiver is returned to the factory default settings.

NOTE The user can configure a custom mix of the messages listed in the table below.

Table 4: NMEA Messages

Message	Description
GGA	GPS fix data
GSA	GPS DOP and active satellites
GSV	GPS satellites in view
RMC	Recommended minimum specific GPS/Transit data
VTG	Track made good and ground speed

NMEA 0183 MESSAGE FORMATS

GGA-GPS Fix Data

The GGA message includes time, position and fix related data for the GPS receiver.

$GPGGA,hhmmss.ss,llll.lll,a,nnnnn.nnn,b,t,uu,
v.v,w.w,M,x.x,M,y.y,zzzz*hh <CR><LF>

Table 5: GGA Message

Field #	Description
1	UTC of Position
2, 3	Latitude, N (North) or S (South)
4, 5	Longitude, E (East) or W (West)
6	GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS
7	Number of Satellites in Use
8	Horizontal Dilution of Precision (HDOP)
9, 10	Antenna Altitude in Meters, M = Meters
11, 12	Geoidal Separation in Meters, M=Meters. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level.
13	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update
14	Differential Reference Station ID (0000 to 1023)
hh	Checksum

GSA - GPS DOP and Active Satellites

The GSA messages indicates the GPS receiver's operating mode and lists the satellites used for navigation and the DOP values of the position solution.

$GPGSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,
xx,x.x,x.x,x.x*hh<CR><LF>

Table 6: GSA Message

Field #	Description
1	Mode: M = Manual, A = Automatic. In manual mode, the receiver is forced to operate in either 2D or 3D mode. In automatic mode, the receiver is allowed to switch between 2D and 3D modes subject to the PDOP and satellite masks.
2	Current Mode: 1 = fix not available, 2 = 2D, 3 = 3D
3 - 14	PRN numbers of the satellites used in the position solution. When less than 12 satellites are used, the unused fields are null
15	Position dilution of precision (PDOP)
16	Horizontal dilution of precision (HDOP)
17	Vertical dilution of precision (VDOP)
hh	Checksum

GSV - GPS Satellites in View

The GSV message identifies the GPS satellites in view, including their PRN number, elevation, azimuth and SNR value. Each message contains data for four satellites. Second and third messages are sent when more than 4 satellites are in view. Fields #1 and #2 indicate the total number of messages being sent and the number of each message respectively.

$GPGSV,x,x,xx,xx,xx,xxx,xx,xx,xx,xxx,xx,xx,xx,

xxx,xx,xx,xx,xxx,xx*hh<CR><LF>

Table 7: GSV Message

Field #	Description
1	Total number of GSV messages
2	Message number: 1 to 3
3	Total number of satellites in view
4	Satellite PRN number
5	Satellite elevation in degrees (90° Maximum)
6	Satellite azimuth in degrees true (000 to 359)
7	Satellite SNR (C/No), null when not tracking
8, 9, 10, 11	PRN, elevation, azimuth and SNR for second satellite
12, 13, 14, 15	PRN, elevation, azimuth and SNR for third satellite
16, 17, 18, 19	PRN, elevation, azimuth and SNR for fourth satellite
hh	Checksum

RMC - Recommended Minimum Specific GPS/Transit Data

The RMC message contains the time, date, position, course, and speed data provided by the GPS navigation receiver. A checksum is mandatory for this message and the transmission interval may not exceed 2 seconds. All data fields must be provided unless the data is temporarily unavailable. Null fields may be used when data is temporarily unavailable.

$GPRMC,hhmmss.ss,A,llll.ll,a,yyyyy.yy,a,x.x,x.x,xxxxxx,x.x,a,i*hh<CR><LF>

Table 8: RMC Message

Field #	Description
1	UTC of Position Fix.
2	Status: A = Valid, V = navigation receiver warning
3, 4	Latitude, N (North) or S (South).
5, 6	Longitude, E (East) or W (West).
7	Speed over the ground (SOG) in knots
	Track made good in degrees true.
	Date: dd/mm/yy
	Magnetic variation in degrees, E = East / W= West
	Position System Mode Indicator; A=Autonomous, D=Differential, E=Estimated (Dead Reckoning), M=Manual Input, S=Simulation Mode, N=Data Not Valid
hh	Checksum (Mandatory for RMC)

VTG - Track Made Good and Ground Speed

The VTG message conveys the actual track made good (COG) and the speed relative to the ground (SOG).

$GPVTG,x.x,T,x.x,M,x.x,N,x.x,K,i*hh<CR><LF>

Table 9: VTG Message

Field #	Description
1	Track made good in degrees true.
2	Track made good in degrees magnetic.
3, 4	Speed over the ground (SOG) in knots.
5, 6	Speed over the ground (SOG) in kilometer per hour.
7	Mode Indicator: A=Autonomous Mode, D=Differential Mode, E=Estimated (dead reckoning) Mode, M=Manual Input Mode, S=Simulated Mode, N-Data Not Valid
hh	Checksum

EXCEPTION BEHAVIOR

When no position fix is available, some of the data fields in the NMEA messages will be blank. A blank field has no characters between the commas.

APPENDIX

B

HIPPO

This document describes the format of the Host Independent Positioning Protocol Object (HIPPO) protocol and messages implemented in the DR GPS module.

HIPPO is one of three communication modes of the DR GPS module, and is the one present in normal usage. The serial port operates at 38400 baud, eight data bits, no parity, one stop bit.

The other two modes are monitor mode, used for manufacture and low-level diagnosis and control, and flash-loading mode, used for updating the firmware. The receiver enters monitor mode through HIPPO command. The receiver will also enter monitor mode if the firmware ROM checksum fails. The only way to enter flash-loading mode is through the monitor mode. For detailed descriptions of these two modes, see the document “DR GPS Flash Loading Requirements”, Trimble PN 45058-XX-SP, Rev 1.20.

HIPPO PROTOCOL RULES

The HIPPO message structure is derived from the TSIP message structure. Both are binary protocols with pre-parsers that “unstuff” the bytes in the serial stream (S-bytes) to create packets of message bytes (M-bytes). Both are asynchronous protocols, allowing the host and module to send multiple commands without waiting for the completion of the previous command.

The HIPPO design offers easier and more reliable parsing. In contrast to TSIP, which requires a small state machine after the pre-parser to determine the start and end of the message packet, HIPPO uses unique S-bytes to identify the start and end before the pre-parser. The HIPPO message structure currently uses three control characters: 0x80 = HIPPO Control Character (HCC); 0x81 = Start of Message (SOM); and 0x82 = End of Message (EOM). HIPPO reserves five other bytes (0x83-0x87) for future use as control characters. This contrasts with TSIP, which has two (DLE and ETX). HIPPO has a higher control character overhead (3% versus 0.4% for TSIP), but parser design is much simpler.

Because the DR GPS module is designed to send messages at 10 Hz, the message length has been limited to 128 bytes to ensure that two messages can be transmitted per 100 ms cycle.

Number representations use IEEE formats, and are sent least significant byte first (Intel specification or “little endian”).

The module acknowledges all commands with a reply message after parsing and processing are complete. “Completion” is the point at which all immediate actions are complete in the protocol layer. These actions include replying to queries, setting global variables, flags, or semaphores, and sending messages to other tasks. If the command is a successful query for a single report, the report response itself is the acknowledgment response; otherwise, the module sends an acknowledgment response packet 0x10 to the host.

There are two general types of messages: report messages and command messages.

General Message Structure Rules

The byte SOM only occurs as an S-byte (in the serial stream) at the start of a message. The byte EOM only occurs as an S-byte at the end of a message. From the SOM byte until the following EOM byte, the following structure rules apply:

The first two S-bytes are the Parser Code PCOD and Parser Subcode PSUB. These specify a unique parser for the data bytes. PCOD and PSUB never have values of 0x80 to 0x87, so they are never “stuffed”.

Depending on PCOD and PSUB, the next byte may be an index byte INDEX. INDEX never has a value of 0x80 to 0x87, so it is never “stuffed”. Examples of an index are a channel number and a satellite PRN. All indexed messages with the same parser code and subcode must have the same length, format, and data structure.

The byte HCC only occurs as an S-byte as a “stuffing” character, as defined in Section 2.3. It may appear before CS or any of the data bytes.

The value of the checksum M-byte CS is such that the 8-bit sum of the M-bytes from SOM to EOM inclusive is zero. If the checksum is between 0x80 and 0x87, it is HCC-stuffed.

The number of data bytes per message is limited to 128. Counting the bytes for the SOM, parser code, parser subcode, checksum, EOM, and index, the total number of M-bytes can as many as 134. Data is not valid until the message is complete and the checksum agrees.

HIPPO ignores S-bytes between messages (from EOM to the following SOM), unless the values are between 0x80 and 0x87. This feature allows ASCII messages such as NMEA or TAIP to be interspersed with HIPPO messages. TSIP messages and other binary protocols in general cannot be interspersed with HIPPO messages.

Report Message Structure (Module to Host)

The table below provides the message structure for a simple data packet of N M-bytes. Each message has five framing bytes: SOM; two message ID bytes (PCOD and PSUB); a checksum byte; and EOM. The data type and data structure in the message (i.e., the parser) is specified by the Parser code PCOD and parser subcode PSUB.

Table 10: HIPPO Report Message Structure

Byte	Meaning	Value
SOM	start of message	0x81
PCOD	Parser code	0x00 – 0x7F
PSUB	Parser subcode	0x00 – 0x7F, 0xFF
D[0]	First byte of data	0x00 – 0xFF
D[1]	Second byte of data	0x00 – 0xFF
…	…	…
D[N-1]	Last byte of data	0x00 – 0xFF
CS	Checksum	0x00 – 0xFF
EOM	End of message	0x82

Some parser code / subcodes have data indexed by channel or satellite, as shown in the table below. The index is the first byte after the parser subcode. The parser code/subcode specifies whether a message uses indexing.

Table 11: HIPPO Report Message Structure (Indexed Data)

Byte	Meaning	Value
SOM	start of message	0x81
PCOD	Parser code	0x00 – 0x7F
PSUB	Parser subcode	0x00 – 0x7F
INDEX	Data indexed by channel, etc.	0x00-0x7F, 0xFF
D[0]	First byte of data	0x00 – 0xFF
D[1]	Second byte of data	0x00 – 0xFF
…	…	…
D[N-1]	Last byte of data	0x00 – 0xFF
CS	Checksum	0x00 – 0xFF
EOM	End of message	0x82

Command Message Structure (Host to Module)

Command messages sent from host to module are built upon the report message structure. Except for system commands such as system reset, every command either sets or queries a reportable data structure. To accomplish this, the HIPPO set or query command protocol simply "wraps around" the report message protocol (see tables below).

Table 12: HIPPO Command Message Structure

Byte	Meaning	Value
SOM	start of message	0x81
CCOD	Set Command code	0x01
PCOD	Parser code	0x00 – 7F
PSUB	Parser subcode	0x00 – 7F, 0xFF
D[0]	First byte of data	0x00 – FF
D[1]	Second byte of data	0x00 – FF
…	…	…
D[N-1]	Last byte of data	0x00 – FF
CS	Checksum	0x00 – FF
EOM	End of message	0x82

Table 13: HIPPO Query Message Structure for Indexed Data

Byte	Meaning	Value
SOM	Start of message	0x81
CCOD	Query Command code	0x02
PCOD	Parser code	0x00 – 7F
PSUB	Parser subcode	0x00 – 7F
INDEX	Index	0x00 – 7F, 0xFF
CS	Checksum	0x00 – FF
EOM	End of message	0x82

Chained Messages

Chaining is not supported in the DR GPS module. If multiple messages are requested, they will be issued as time allows between the high-priority automatic report messages. An acknowledgment message appears at the end of the sequence of replies.

Post-Formatting: HCC Stuffing Before Transmission

Whenever an M-byte in the data fields or the checksum field is equal to one of the control characters 0x80-0x87, it generates two S-bytes as follows: the M-byte generates the S-byte pair [0x80, M-byte & 0x7F].

Pre-Parsing: HCC Unstuffing After Reception

Pre-parsing (assembly of the M-bytes) occurs as S-bytes are received. HIPPO pre-parsing begins with the appearance of the SOM S-byte and ends with the appearance of the EOM S-byte.

- Whenever the S-byte is SOM, a new message structure opens with room for 132 M-bytes. The first M-byte of a message is always SOM.
- Whenever the S-byte HCC appears, it does not generate a new M-byte. Rather, it generates a signal to OR the following S-byte with 0x80 to create the next M-byte. Otherwise, the M-byte is the same as the S-byte.
- If the S-byte is EOM, the message structure is closed. The last M-byte of a message is always EOM.
- The last M-byte before the EOM is the checksum. It is computed so that the sum of all M-bytes, including the SOM, the EOM, and the checksum, is zero.

After pre-parsing is complete, the message packet is ready to be parsed into structures according to the rules in Sections 3 and 4. The parser code and subcodes are the second and third M-bytes, directly after the SOM. The data will start on the fourth (non-indexed data) or fifth (indexed data) M-byte.

Possible pre-parser errors include:

- Two SOMs appear without an EOM in between.
- HCC occurs in the first two bytes (parser code and subcode).
- The byte following HCC is not equal to the 7 LSB's of a HIPPO control character.
- Control characters appear between message (after EOM but before the next SOM).
- No EOM appears in the first 134 M-bytes.

COMMAND MESSAGES

HIPPO has three classes of command message packets: set parameters, query parameters, and system command.

The set command is simple: it “wraps around” the report message structure of the parameter(s) to be set.

The query command structure is even simpler: it calls out the report code and subcode (and index, if applicable) of the desired reports.

The module always acknowledges a command in one of two ways.

An explicit acknowledgment message is sent in reply to either:

1. A command;
2. An unsuccessful query;
3. A query that generates a series of report messages.
4. If the query successfully generates a single report message, that message is the implicit acknowledgment.

The acknowledgment contains a status indicating the completion of the operation.

Set Class

The set class packets set receiver, system, and any other defined parameters within the target system.

Two types of parameters can be set.

1. Configuration parameters such as DOP mask;
2. Initialization parameters such as position, velocity, time, and ephemeris.

The target system returns an acknowledgment packet, but does not echo data values as in TSIP.

The parser code and subcode determine the length of the command packet. The packet has the following general format (indexed data has an extra byte after parser subcode):

Table 14: Set Class Message Structure

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x01	
	Parser Code	U8	0x00-7F	Report Code
	Parser Subcode	U8	0x00-7F	See report packet definitions.
0	Data Value			Data corresponding to the subcode.
…	…			…
N_{R-1}	Data Value			N_R is the size of data for the specified report.

For example, to set the operating dimension to “2-D Altitude Hold”, the host issues the following command to the module:

Table 15: Example of GPS Configuration Message Parameter

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x01	
	Parser Code	U8	0x24	Report packet for GPS Configuration
	Parser Subcode	U8	0x01	Parameter Subcode for Operating Dim
0	Operating Dimension	U8	3	Alt-Hold (2D)

Query Class

The Query class packet allows user to retrieve configuration, report, and system data with the same packet. Like the Set class packet, it is indexed by the report code and subcode. This is possible because each parameter or set of parameters has a corresponding report message.

Four types of parameters can be queried.

1. System parameters (e.g., version numbers)
2. Configuration parameters (e.g. DOP mask)
3. Fix parameters (e.g., satellite strength, current position, velocity, time, ephemeris)
4. Initialization parameters (e.g., position, velocity, time, ephemeris)

The target system returns an acknowledgment packet. When a query for a single report is successful, the reply to that query is the acknowledgment. If the query fails, an explicit acknowledgment report message is sent as an acknowledgment. If the query generates a series of response messages, the last response is followed by an explicit acknowledgment report message that signals the end to the host's parser.

A query has two formats, depending on whether the information is indexed (e.g., by channel or satellite).

Table 16: Query Class Message Structure

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x02	
	Parser Code	U8	0x00-7F	
	Parser Subcode	U8	0x00-7F 0xFF	Single Subcode All subcodes

Table 17: Indexed Query Class Message Structure

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x02	
	Parser Code	U8	0x00-7F	Report Code
	Parser Subcode	U8	0x00-7F	See report packet definitions.
	Index	U8	0x00-7F 0xFF	Single index (e. g., channel or satellite) All indices

Like the set class message, the query packet has two bytes body contains the parser code and subcode for a configuration packet or a report packet. For example, to query the operating dimension setting in the GPS configuration block:

Table 18: Example of Query for "Operating Dimension" parameter

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x02	
	Parser Code	U8	0x24	Report packet for GPS Configuration
	Parser Subcode	U8	0x01	Parameter Subcode for Operating Dim

System Class

A system class packet is a set packet associated with the system operations. The following section describes each of packets.

Reset Receiver

This command resets the receiver software.

Table 19: 0x03: Receiver Reset Command Messages

Byte	Name	Type	Value	Meaning
	Code	U8	0x03	
	Subcode	U8	0x01	Reset
			0x02	Clear RAM, reset
			0x03	Force to Monitor Mode
			0x04	Shut Down
			0x05	Clear ephemeris and oscillator, reset
			0x06	Clear oscillator, reset
			0x07	Clear flash data and RAM, reset
			0x08	Clear position, reset
			0x09	Write BBRAM to flash, reset (graceful)
			0x0A	Io-DSP Pass-through mode

Force to Monitor Mode –Force the target system to exit from GPS function, and into the embedded monitor mode. The serial communication is reset to 38.4K baud, no parity. Once in the monitor mode, all HIPPO APIs are disabled. Refer to flash loading documents for more detail.

Shutdown: Once this packet is received, the target system shuts down the navigation system. The system can be restarted by hardware action (e.g., reset pin) only.

An acknowledgment packet in the current serial protocol is sent before the command is implemented, however transmission may not complete before the reset occurs.

REPORT CLASS

Report class packets are divided into four subclasses.

System data: contains system information, such as system status or an event log queue entry.

Configuration reports: have all the system configurable parameters.

Data reports: have navigation information generated by the Navigation Platform.

Initialization input reports: have start-up information and GPS system data (position, heading, almanac, etc.); also map-matching inputs for latitude, longitude, altitude, and heading.

Some report packets are indexed by channel number (tracking status, signal strength) or satellite number (almanac, ephemeris).

The parameters in the configuration and initialization reports can be set by 0x01 packet.

The host can query all report packets using the 0x02 packet, except as noted.

Report Message Code Assignment

This table lists all report data structures in HIPPO supported by the DR GPS module, and whether the data structure can be queried ('Q') or set ('S'). Data that can be neither queried nor set is automatic output only.

Table 20: Message Codes

Code	Subcode	Indexed by	Message	Q	S
0x10	0x01		Acknowledge Set		
0x10	0x02		Acknowledge Query		
0x10	0x03		Acknowledge System Command		
0x11	0x01		Navigation Code ROM Version	Q	
0x11	0x02		Boot Code ROM Version	Q	
0x11	0x03		Io-DSP Code ROM Version	Q	
0x12	0x01		Start-up Message		
0x12	0x02		SW Mode	Q	
0x12	0x03		Product Information	Q	
0x12	0x04		Hardware ID	Q	
0x14	0x01	Event Log	Soft Event Log Entry	Q	
0x14	0x02	Event Log	Fatal Error Log Entry	Q	
0x15	various		Data Stored to Non-erasable Flash	Q	
0x16	0x01		Health Message	Q	
0x16	0x02		Repeat Start-Up Message	Q	
0x21	0x01		DR GPS Engine Rate	Q	S
0x22	0x01		Output Interval Control	Q	
0x22	0x02		Format of NMEA Output Control Parameters	Q	S
0x23	0x01		Variable length RTCM data	Q	S
0x23			Reserved as a "wrapper" for non-HIPPO protocols		
0x24	0x01-08		GPS Configuration Parameters	Q	S
0x25			Kalman Filter Configuration Parameters	Q	S
0x26	0x01		Available Report Codes	Q	
0x26	0x02	Rpt code	Available report Subcodes	Q	
0x26	0x03		DPP model speed levels	Q	
0x26	0x04		DPP minimum speed for estimate	Q	
0x26	0x05		DPP maximum speed for estimate	Q	
0x27			DR Filter Parameters	Q	S
0x28	0x12	SV PRN	Compressed Almanac	Q	S
0x28	0x13		Compressed Almanac Health Page	Q	S
0x28	0x14		Compressed GPS Ionospheric/UTC Model Param,	Q	S
0x28	0x16	SV PRN	Compressed Ephemeris	Q	S

Table 21: Message Codes (continued)

Code	Subcode	Indexed by	Message	Q	S
0x29	0x01		Time Initialization	Q	S
0x29	0x02		Latitude / Longitude Initialization	Q	S
0x29	0x03		Altitude Initialization	Q	S
0x29	0x04		LO Frequency Initialization	Q	S
0x29	0x05		Heading Initialization	Q	S
0x29	0x07		Map-match Input	Q	S
0x29	0x08		Tacho Input	Q	S
0x2A	Rpt Code	Rpt Subcode	Automatic Output – Event	Q	S
0x2B	Rpt Code	Rpt Subcode	Automatic Output – Time Interval	Q	S
0x2C	Rpt Code	Rpt Subcode	Automatic Output – Distance Traveled	Q	S
0x2D	Rpt Code	Rpt Subcode	Automatic Output – Heading Change	Q	S
0x2E	0x01		Event Report Mask	Q	S
0x2F	0x02		Data Positioning Collection Test Interval Control		S
0x2F	0x04		Gyro Bench Test Interval Control		S
0x2F	0x06		Tacho/Reverse Production Test Interval Control		S
0x30	0x02		Fast Fix with raw DR Data	Q	
0x30	0x03		Buffered DR data with Health and Start-up message	Q	
0x31	0x01		GPS Fix	Q	
0x32	0x01		UTC Time and Constellation Summary	Q	
0x32	0x02		Constellation Summary	Q	
0x32	0x03		UTC Time	Q	
0x33	0x01	Channel	GPS Channel Measurement Short Status	Q	
0x36	0x03		ZRO Calibration	Q	S
0x36	0x04		Gyro Sensitivity Calibration	Q	S
0x36	0x05		Direction Switch Calibration	Q	S
0x36	0x07		DPP Calibration	Q	S
0x36	0x08		ZRO Rate Calibration	Q	
0x3F	0x01		ADC and Gyro Self-Test Data	Q	
0x3F	0x02		Data Positioning Collection Test Data (ROM 14)		
0x3F	0x03		Data Positioning Collection Test Data (ROM 15+)		
0x3F	0x04		Gyro Bench Test Data		
0x3F	0x06		Tacho/Reverse Production Test Data		
0x66	various		Diagnostic tag		
0x70	0x01	Channel	GPS Raw Measurement Diagnostic		
0x70	0x02		GPS Raw Position / Velocity Diagnostic		
0x70	0x03		DR Data		
0x70	0x04		Reset Diagnostic		

Table 22: Message Codes (continued)

Code	Subcode	Indexed by	Message	Q	S
0x70	0x05		DR BBRAM Diagnostic V1		
0x70	0x07		Map Match Data Echo Diagnostic		
0x70	0x08		DR BBRAM Diagnostic V2		
0x70	0x09		GPS No Fix		
0x70	0x0A		DR BBRAM Diagnostic V3		
0x70	0x7F		Toggle Diagnostic Output	Q	S

System Report Packets

0x10: Acknowledge / Error Response to Command Packets

This packet serves three different functions:

1. Acknowledge a command when the operation is carried out, such as set a flag to reset and change baud rate;
2. Indicate a result of an operation is successful, such as set commands; and
3. Indicate a parsing error.

Not all sets, queries, or auto-outputs generate a 0x10 response. Specifically, when a query or auto-output for a single report is successful, the reply to that query is the acknowledgment. When the query or auto-output fails, or when it generates a series of response messages, a 0x10 message follows the last response to explicitly end the host parser actions.

The last data byte of the message is a parser status code. If the status code is not zero, an error has occurred and the module has not implemented the command. The value of the status code indicates at the point in the procedure where the parser failed.

1. An M-byte stream of no more than 128 bytes could not be created (control character error);
2. The checksum did not compute properly;
3. The parser code and subcode were be recognized;
4. The message length as not correct for that parser code/subcode;
5. One or more of the data values was not reasonable and appropriate.
6. The data contradicts values of position, time, etc. that have been validated by the GPS. This data can be forced using the “host override” option if available.

There are three forms of the acknowledgment report:

1. for sets, queries, and auto-outputs of non-indexed reports,
2. for sets, queries, and auto-outputs of indexed reports, and
3. for system commands.

If the command includes a change in the serial port protocol, the module sends the acknowledgment in the old protocol.

The data length is three bytes if the report code (data byte 0) is for an non-indexed report.

Table 23: 0x10: Non-indexed Set and Query Acknowledge

Byte	Name	Type	Value	Meaning
	Code	U8	0x10	
	Subcode	U8	0x01 0x02 0x04	Set acknowledge Query acknowledge Auto-output acknowledge
0	Command Code	U8	0x00-7F	Non-indexed report
1	Command Subcode	U8	0x00-7F 0xFF	Single subcode All subcodes
2	Status Code	U8	0 1 2 3 4 5 6 7 8	Acknowledged or a successful operation Pre-parser error Checksum error Unknown Code/Subcode Parser data length error Data value error (TBD) Contradicts current data Data table full (e.g., Output Interval Control) Data not available

For indexed sets and queries, the data length is four bytes. The parser will expect this data length if the report code (byte 0) is for an indexed report.

Table 24: 0x10: Indexed Set and Query Acknowledge

Byte	Name	Type	Value	Meaning
	Code	U8	0x10	
	Subcode	U8	0x01 0x02	Set acknowledge Query acknowledge
0	Command Code	U8	0x00-7F	Indexed report
1	Command Subcode	U8	0x00-7F 0xFF	Single subcode All subcodes
2	Index	U8	0x00-7F	Channel or satellite index
3	Status Code	U8	0 1 2 3 4 5 6 7 8	Acknowledged or a successful operation Pre-parser error Checksum error Unknown Code/Subcode Parser data length error Data value error (TBD) Contradicts current data Data table full (e.g., Output Interval Control) Data not available

For system commands, the data length is two bytes.

Table 25: 0x10-03: System Command Acknowledge

Byte	Name	Type	Value	Meaning
	Code	U8	0x10	
	Subcode	U8	0x03	System command acknowledge
0	System Cmd Code	U8		See Sec. 0
1	Status Code	U8	0 1 2 3 4 9	Acknowledged or a successful operation Pre-parser Error Checksum Error Unknown Subcode Parser data length error Failed to execute properly

A “query all” command may generate a series of responses, but only a single acknowledgment is sent to the host, with a “0xFF” byte in the report subcode or index field.

0x11: Version Report

This packet reports version numbers for the various firmware blocks within the module.

Table 26: 0x11: Version Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x11	
	Subcode	U8	0x01 0x02 0x03	Navigation Code ROM Boot ROM Io-DSP ROM
0	Major Version	U8	0-100	Software major number
1	Minor Version	U8	0-100	software minor number
2	Release Code	U8	0 > 0	release beta version number
3	Release Day	U8	[1, 31]	software release day
4	Release Month	U8	[1, 12]	software release month
5-6	Release Year	U16	> 2000	software release year

0x12-01: Start-Up Report

The module issues this report only at startup. This report cannot be queried; to query the data content after start-up, use message 0x16-02. The first two bytes show the error code associated with the previous shutdown. The second two bytes indicate health of the RTC and RAM.

Table 27: 0x12-01: Start-Up Report Message

Byte / Bit		Name	Type	Value	Meaning
		Code	U8	0x12	
		Subcode	U8	0x01	Parameter Subcode
0-1		Error Code	U16	0 other	Normal shutdown (SW or power) Abnormal shutdown (**Error! Reference source not found.**)
2		Reserved	U8		
3	0	RAM Signature	U1		1 = BBRAM signature valid
3	1	Gyro / ADC test	U1		1 = ADC or Gyro self-test error
3	2	RTC Valid	U1		1 = RTC valid at startup
3	3	Flash BBRAM	U1		1 = BBRAM loaded from Flash
3	4-7	Reserved			

0x12-02: Software Mode Report

This report indicates whether the module is currently in Monitor Mode or Normal mode. If the device is in monitor mode, it will recognize and reply (in HIPPO) to a HIPPO query for this report. If the device is in Monitor mode, it will also recognize and reply (in HIPPO) to a HIPPO query for this report.

Table 28: 0x12-02: Software Mode Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x12	
	Subcode	U8	0x02	Parameter Subcode
0	Mode	U8	1 2	Normal Mode Monitor Mode

0x12-03: Production Information Report

This report contains information stored in ROM; it cannot be set or changed through HIPPO command. It is available by query or auto-output.

Table 29: Table 27: 0x12-03: Production Info Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x12	
	Subcode	U8	0x03	
0	Serial Number	U32		
4	Production Day	U8		
5	Production Month	U8		
6-7	Production Year	U16		
8-23	Product Name	16xCHAR		Descriptive string

0x12-04: Hardware ID Report

This report contains information stored in ROM; it cannot be set or changed through HIPPO command. It is available by query or auto-output.

Table 30: 0x12-04: Hardware ID packet

Byte	Name	Type	Value	Meaning
	Code	U8	0x12	
	Subcode	U8	0x04	Parameter Sub code
0-15	Hardware ID	16xCHAR		Hardware ID

0x14-01: Soft Event Log Report

These reports are auto-output upon the event. The report can also be queried by index number. Because of the volume of information, these reports cannot be queried with the “0xFF” option. The host can clear the soft event log completely by using the “set all” (0xFF) command with no data.

Table 31: 0x14-01: Soft event log entry report

Byte	Name	Type	Value	Meaning
	Code	U8	0x14	
	Subcode	U8	0x01	Parameter subcode
	Index	U8	0 [1,127]	Most recent soft event Soft Event Log index number
0-1	Year	U16	0 >2000	No GPS/UTC; time is since power-up year
2	Month	U8	[1, 12]	
3	Day	U8	[1, 31]	
4	Hour	U8	[0, 23]	
5	Minute	U8	[0, 59]	
6	Second	U8	[0, 60]	
7	Identity Code	U8	0xFF 0-0x7F	No event
8	Condition Code	U8		

0x14-02: Fatal Error Log Report

On a fatal error, the receiver will reset. The report can be queried by index number after the reset. Because of the volume of information, these reports cannot be queried with the “0xFF” option. The fatal error log is retained in flash and cannot be cleared by the host.

Table 32: 0x14-02: Fatal error log entry report

Byte	Name	Type	Value	Meaning
	Code	U8	0x14	
	Subcode	U8	0x02	Parameter subcode
	Index	U8	0 [1, 31]	Most recent fatal error Fatal error Log index number
0	Year	U16	0 >2000	No GPS/UTC; time is since power-up year
2	Month	U8	[1, 12]	
3	Day	U8	[1, 31]	
4	Hour	U8	[0, 23]	
5	Minute	U8	[0, 59]	
6	Second	U8	[0, 60]	
7	Event Code	U16	0 >0	No entry. Event Code
9 – 30	Info block			

0x15: Data Stored in Non-erasable Flash Report

A section of non-erasable ROM is reserved for customer data blocks. There is no HIPPO command to set the data; data can only be set in Monitor mode. The data blocks are written serially into an area of ROM that cannot be erased or overwritten.

Each subcode corresponds to a different data block type. Unlike standard HIPPO, the parser is defined by the customer, so the message length and data content are not specified by the parser code and subcode. The maximum data block length is 128 bytes.

When queried with a subcode, the report scans the section of ROM and returns the last data block entry with that subcode. The customer can effectively “update” a data block by writing a new data block with the same subcode and updated data, provided that there is room left in the allocated ROM section (approximately 2K bytes).

If no data block is found with the queried subcode, the module returns an acknowledgment with “Data not available”.

The “query all subcodes” mode 0xFF is not available.

Table 33: 0x15: Data Stored in Non-erasable Flash Report

Byte	Name	Type	Value	Meaning
	Code	U8	0x15	
	Subcode	U8	0x01-7F	
0	User-defined	U8		
…	…			
N-1	User-defined	U8		0 < N <=128

0x16-01: Health Status Report

This report contains status of various real-time operations in the DR GPS module.

Table 34: 0x16-01: Health status report

Byte		Name	Type	Value	Meaning
		Code	U8	0x16	
		Subcode	U8	0x01	
0	0	Direction Switch Status	U1	0 1	Normal Abnormal
0	1	Gyro status	U1	0 1	Normal Abnormal
0	2	Tacho status	U1	0 1	Normal Abnormal
0	3-7	Reserved			
1	0-1	Antenna status	U2	0 1 3	Normal Antenna open Antenna short
1	2	Oscillator status	U1	0 1	Normal Abnormal
1	3-7	Reserved			
2		Soft Event Index	U7	0 [1,127]	No soft event in log Most recent soft event index

0x16-02: Repeat Start-Up Report with System Time

This report is a copy of the start-up message. The first two bytes show the error code associated with the previous shutdown. The second two bytes indicate health of the RTC and RAM. The system time is the number of milliseconds since power-up.

Table 35: 0x16-02: Repeat Start-Up with System Time Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x16	
		Subcode	U8	0x02	Parameter Subcode
0-1		Error Code	U16	0 other	Normal shutdown (SW or power) Abnormal shutdown (**Error! Reference source not found.**)
2		Status	U8		Reserved
3	0	RAM Signature	U1		1 = BBRAM signature valid
3	1	Gyro / ADC test	U1		1 = ADC or Gyro self-test error
3	2	RTC Valid	U1		1 = RTC valid at startup
3	3	Flash BBRAM	U1		1 = BBRAM loaded from Flash
4		Soft Event Index	U7	0 [1,127]	No soft event in log at start-up Last soft event index in log at start-up
5-8		SysClock	U32	1 ms	System Time

Configuration Report packets

0x22-01: Output Interval Control Table

Table 36: 0x22: Format of GPS Configuration Message Parameter

Byte	Name	Type	Value	Units	Meaning
	Code	U8	0x22		
	Subcode	U8	0x01		
0	Index	U8	0x00-0x0F, 0xFF		Table Slot Number
1	Code	U8	0x00-7F		Code in Slot
2	Subcode	U8	0x00-7F		Subcode in Slot
3-6	Automatic Output Event Trigger Mask	U32	0x00-0xFFFFFFFF		See Table x.x.x
7-10	Time Threshold	U32		1 ms	Minimum Time required
11-14	Time Trigger	U32	0 > 0	1 ms	Not used Trigger value
15-18	Distance Threshold	U32		1 cm	Minimum Distance required
19-22	Distance Trigger	U32	0 > 0	1 cm	Not used Distance Trigger value
23-26	Heading Threshold	U32		1 cdeg	Minimum Heading required
27-30	Heading Trigger	U32	0 > 0	1 cdeg	Not used Heading Trigger value

0x22-02: NMEA Output Control

Table 37: 0x22: Format of NMEA Output Control Parameters

Byte	Name	Type	Value	Units	Meaning
	Code	U8	0x22		
	Subcode	U8	0x02		
0	Interval	U8	0-255	seconds	Output interval 0 = 5Hz for GGA, VTG, and RMC; 1 Hz for GSA, GSV 1-255 = interval for all messages.
1-4	Message mask	U32	0x00-7F		Bit 0 = output GGA Bit 2 = output VTG Bit 3 = output GSV Bit 4 = output GSA Bit 8 = output RMC

0x24: GPS Configuration

The Parser Code for GPS configuration parameters is 0x24. A typical parameter report is shown in **Error! Reference source not found.**

Table 38: 0x24: Format of GPS Configuration Message Parameter

Byte	Name	Type	Value	Meaning
	Code	U8	0x24	
	Subcode	U8	0x01-0x08	Parameter Subcode
0	Parameter Value	Refer to **Error! Reference source not found.**		

Table 36 shows the subcode, range, and default value for each of the GPS configuration parameters. DGPS does not apply to all products. Products to which DGPS does not apply have a default DGPS Mode of 1 (Ignore), and the value cannot be changed.

Table 39: List of GPS Configuration Message Parameters

Subcode	Name	Type	Units	Range	Default	Meaning
0x01	Operating Dimension	U8		0 3 4	0	Auto 2D/3D Alt-Hold (2D) Full Pos (3D)
0x02	DGPS Mode	U8		0 1 2	1	Require Ignore If Available
0x03	Dynamics Code	U8		17	17	Automobile
0x04	Elevation Mask	FLT	(degrees)	[0°, 90°]	5.0	Tracking limit
0x05	SNR Mask	U16	0.2 dBHz	[100, 240] = [20, 48] dBHz	145 = 29 dBHz	Fix limit
0x06	DOP Mask	FLT		[0.0, 99.0]	20.0	Fix limit
0x07	DOP Switch	FLT		[0.0, 99.0]	20.0	Fix limit
0x08	DGPS Age Limit	U16	1 s	0-240	30	Fix limit

0x25: Kalman Filter Configuration

The Parser Code for the Kalman Filter configuration parameters is 0x25. A typical parameter report is shown in **Error! Reference source not found.**

Table 40: 0x25: Format of Kalman Filter Configuration Parameter

Byte	Name	Type	Value	Meaning
	Code	U8	0x25	
	Subcode	U8	0x01-16	Parameter Subcode
0	Parameter Value	Refer to **Error! Reference source not found.**		

Error! Reference source not found. shows the subcode, range, and default value for each of the Kalman Filter configuration parameters.

Table 41: List of Kalman Filter Configuration parameters

Subcode	Name	Type	LSB	Range	Default	Meaning
0x01	MinGainIndex	U32	1 ms	< 40000	0	minimum settling time of code-carrier filter
0x02	MinSVs	U32		[3, # of channels]	3	Minimum number of SVs for fix
0x03	NoEditAMU5	U32	0.2 AMU	< 16.0 AMU	14.0 AMU	maximum AMU value at which editing is allowed
0x04	MinAMU5	U32	0.2 AMU	< 16.0 AMU	2.0 AMU	Minimum acceptable AMU value
0x05	MaxEdits	U32		$[0, 2^{32}-1]$	60	Maximum number of fix rejections before KF reset
0x06	MaxGPSPropTime	U32				Not currently used
0x07	MaxAcc	FLT	(m/s^2)	[0, 20]	6.0	vehicle acceleration limit
0x08	MaxVel	FLT	(m/s)	[0, 126]	150.0	vehicle velocity limit
0x09	SigmaHorizAcc	FLT	(m/s^2)	[0, 20]	0.5	typical horizontal acceleration
0x0A	SigmaFreqAcc	FLT	(m/s^2)	[0, 20]	1.0	typical frequency drift
0x0B	CarrSigSq	FLT	(m/s)	[0, 2]	$(0.07)^2$	Doppler error variance
0x0C	MaxAcceptSigmaSq	FLT	(σ^2)	$[0, 10^{12}]$	$(4.0)^2$	edit limit for residuals
0x0D	InitPosVar	FLT	(m^2)	$[0, 10^{12}]$	$(1000.)^2$	initial position error variance
0x0E	InitBiasVar	FLT	(m^2)	$[0, 10^{12}]$	$(1000.)^2$	initial clock bias error variance
0x0F	ClockModelError	FLT	(m^2)	$[0, 10^6]$	$(1.0)^2$	extra clock process noise (to de couple clock model)
0x10	RejectSSR	FLT	(σ^2)	$[0, 10^{12}]$	$(6.0)^2$	rejection limit for normalized a posteriori residual
0x11	SigSlope1Sq	FLT	$(slope^2)$	[0, 4]	$(0.1)^2$	typical velocity slope
0x12	SigSlope2Sq	FLT	$(slope^2)$	[0, 4]	$(0.05)^2$	typical change-in-position slope
0x13	MaxSlope3Sq	FLT	$(slope^2)$	[0, 4]	$(0.3)^2$	rejection limit for velocity slope
0x14	MinVVelSq	FLT	(m/s)	[0, 16]	1.0	minimum vertical velocity for slope rejection
0x15	Alt2Dvar	FLT	(m^2)	$[0, 10^{8]}$	$(1.0)^2$	Variance of 2D altitude-hold altitude measurement
0x16	Tacho Delay Time	S32	1 ms		0	Not currently used
0x17	Bit Flag Controls	U32		$[0, 2^{32}-1]$	0	1 = suppress map match commands

0x26-01: Available Report Codes

This message reports the report codes and subcodes that are available in the firmware. There is no set command for this report.

Table 42: 0x26-01: Available Report Code Report Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x26	
		Subcode	U8	0x01	
0	0	Parser Code 0x00	U1		1 = Available
0	1	Parser Code 0x01	U1		1 = Available
0	2	Parser Code 0x02	U1		1 = Available
N	M	Parser Code (8 N + M)	U1		1 = Available
…					
15	6	Parser Code 0x7E	U1		1 = Available
15	7	Parser Code 0x7F	U1		1 = Available

0x26-02: Available Report Subcodes

This message reports the report subcodes in each report code that are available in the firmware. There is no set command for this report.

Table 43: 0x26-02: Available Report Subcode Report Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x26	
		Subcode	U8	0x02	
		Index	U8	0x00-7F	Parser Code
0	0	Parser Subcode 0x00	U1		1 = Available
0	1	Parser Subcode 0x01	U1		1 = Available
…					
N	M	Parser Subcode (8 N + M)	U1		1 = Available
…					
15	6	Parser Subcode 0x7E	U1		1 = Available
15	7	Parser Subcode 0x7F	U1		1 = Available

0x26-03, 0x26-04, 0x26-05: DPP Speed Model

The DPP model has multiple DPP values, each applicable over a limited speed range. The 0x26-03 message reports the maximum speed level of application for each DPP value. The 0x26-04 and 0x26-05 messages report the minimum and maximum speed levels used for calibrating each DPP. These values are compiled in the firmware, so there is no set procedure for these reports.

Table 44: 0x26-03: DPP Model Message

Byte	Name	Type	Units	Value	Meaning
	Code	U8		0x26	
	Subcode	U8		0x03	
0	N = # of speed levels	U8			
1	Max Applicable Speed of DPP[0]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top speed Unlimited
N	Max Applicable Speed of DPP[N-1]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top of range Unlimited

Table 45: 0x26-04: DPP Minimum Calibration Speed Message

Byte	Name	Type	Units	Value	Meaning
	Code	U8		0x26	
	Subcode	U8		0x04	
0	N = # of speed levels	U8			
1	Min Calibration Speed of DPP[0]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top speed Unlimited
N	Min Calibration Speed of DPP[N-1]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top of range Unlimited

Table 46: 0x26-05: DPP Maximum Calibration Speed Message

Byte	Name	Type	Units	Value	Meaning
	Code	U8		0x26	
	Subcode	U8		0x05	
0	N = # of speed levels	U8			
1	Max Calibration Speed of DPP[0]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top speed Unlimited
N	Max Calibration Speed of DPP[N-1]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top of range Unlimited

0x27: DR Filter Configuration

The Parser Code for the DR Filter configuration parameters is 0x27. A typical parameter report is shown in **Error! Reference source not found.** and **Error! Reference source not found.** show the subcode, range, and default value for each of the DR Filter configuration parameters.

Table 47: 0x27: Format of DR Filter Configuration Parameter

Byte	Name	Type	Value	Meaning
	Code	U8	0x27	
	Subcode	U8	0x00-19 0x40-6F	Integer Parameter Subcode Float Parameter Subcode
0-3	Parameter Value			

Table 48: List of DR Filter Configuration Integer Parameters

Subcode	Name	Type	Units	Range	Default	Meaning
0x01	GPSVelEditHoldoff	S32	1 count	[0, 1000]	20	
0x02	MinSpdDirSwThresh	S32	1 m/s	[0, 126]	8	
0x03	DirSwWarning	S32	1 m/s	[0, 126]	14	
0x04	MaxDirSwSpd	S32	1 m/s	[0, 126]	20	
0x05	ZROGPSStatThldSpdHi	S32	1 cm/s	[0, 12600]	10	
0x06	ZROGPSStatThldSpdLo	S32	1 cm/s	[0, 12600]	10	
0x07	ZROMaxDistThld	S32	1 cm	[0, 1000]	5	
0x08	MinGPSInitNFix	S32	1 count	[0, 1000]	10	
0x09	GPSJumpHoldOff	S32	1 count	[0, 1000]	50	
0x0A	MaxHBMSecs	S32	1 ms	[0, 9000]	3000	
0x0B	MinHBMSecs	S32	1 ms	[0, 9000]	1000	
0x0C	ZROMaxEdit	S32	1 ADC sample	[0, 10^5]	1000	Gyro sampled at 100 Hz
0x0D	ZRRHoldOffSecs	S32	1 s	[0, 2^{31}-1]	100	
0x0E	ZROVarDecorTime	S32	1 s	[0, 100000]	1200	
0x0F	TachoDisconnectThrshld	S32	1 count	[0, 1000]	15	
0x10	GPSVDelayMSecs	S32	1 ms	[-2000, 2000]	300	
0x11	TachoDelayMSecs	S32	1 ms	[-2000, 2000]	0	
0x12	WinMaxTime	S32	1 ms	[0, 1000000]	90000	
0x13	WinMinPts	S32	1 count	[0, 1000]	10	
0x14	WinMin3D	S32	1 count	[0, 1000]	8	
0x15	WinENMinDist	S32	1 m	[0, 1000]	30	
0x16	MinPtsGrossErr	S32	1 count	[0, 1000]	3	
0x17	GSFCalcMinHdgChng	S32	2^{-15} sc	[0, 65536]	14563	80 degrees
0x18	GSFCalcMaxMsecs	S32	1 ms	[0, 100000]	30000	
0x19	MinTimeBetweenWinPos	S32	1 s	[0, 10000]	10	

Table 49: List of DR Filter Configuration Float Parameters

Subcode	Name	Type	Units	Range	Default	Meaning
0x40	NoEditAddVelAccy	FLT	$(m/s)^2$	[0, 100]	1.0	
0x41	ZROMaxDeltaGyro	FLT	(GCnts)	[0, 49152]	4.9152	1.5 mV
0x42	BadTachoMinSpd	FLT	(m/s)	[0, 126]	8.0	
0x43	ZROCalcGyroNoiseVar	FLT	$(GCnts)^2$	[0, 107374.2]	10.73742	$(1.0\ mV)^2$
0x44	ZROCalcEditSigSq	FLT	$(unitless)^2$	[0, 10000]	100.0	
0x45	MaxGPSInitPosSig2	FLT	$(m)^2$	$[0, 10^{12}]$	100.0	
0x46	MinGPSInitDist	FLT	(m)	$[0, 10^6]$	60	
0x47	ZROVarValidThreshold	FLT	$(GCnts)^2$	[0, 67108900]	671089.	$(250\ mV)^2$
0x48	SnapThreshold2	FLT	$(m)^2$	$[0, 10^{12}]$	100	
0x49	MaxHBSpd	FLT	(m/s)	[0, 126]	0.05	
0x4A	MinWindowVelCfm	FLT	(m/s)	[0, 126]	12.0	
0x4B	HdgCalcMinSpd	FLT	(m/s)	[0, 126]	3.0	
0x4C	HdgCalcMinSpdNoTacho	FLT	(m/s)	[0, 126]	10.0	
0x4D	HdgCalcMinHdgSigSq	FLT	$(rad)^2$	[0, 12]	0.09	
0x4E	HdgMinSigSq	FLT	$(rad)^2$	[0, 12]	0.25	
0x4F	PosMinSigSq	FLT	$(m)^2$	$[0, 10^{12}]$	10000.	
0x50	DPPCalMinSigSq	FLT	$(m/pulse)^2$	[0, 1]	0.01	
0x51	SpdCalcMinSpdSigSq	FLT	$(m/s)^2$	[0, 900]	9.0	
0x52	SpdCalcMinSpeed	FLT	(m/s)	[0, 126]	8.0	
0x53	GPSVelEditSigSq	FLT	$(unitless)^2$	[0, 1000]	16.0	
0x54	GPSVelEditMaxHdSq	FLT	$(rad)^2$	[0, 12]	0.04	
0x55	MinGPSSpdMotNoTacho	FLT	(m/s)	[0, 126]	3.0	
0x56	GvarColdHdg	FLT	$(rad)^2$	[10, 100]	100.0	
0x57	GvarColdZRO	FLT	$(GCnts)^2$	[67.1089, 67108900]	671089.	(250 Mv)
0x58	GvarColdZRR	FLT	$(GCnts/s)^2$	$[0, 10^6]$	0.0021263	
0x59	GvarWarmHdg	FLT	$(rad)^2$	[0, 12]	0.01	
0x5A	GvarWarmZRO	FLT	$(GCnts)^2$	[67.1089, 67108900]	9663.68	$(30\ mV)^2$
0x5B	GvarWarmZRR	FLT	$(GCnts/s)^2$	$[0, 10^6]$	0.0021263	
0x5C	GPNVarHdg	FLT	$(rad)^2/s$	[0, 1]	10^{-8}	
0x5D	GPNVarZRO	FLT	$(GCnts)^2/s$	[0, 1]	0.000268435	$(5\ \mu V)^2/s$
0x5E	GPNVarZRR	FLT	$(GCnts)^2/s^3$	[0, 1]	.00000425261	
0x5F	GyroSnsSig2	FLT	$(unitless)^2$	[0, 1]	0.0004	As a proportion of nominal value
0x60	CarrSigMult Factor	FLT	$(unitless)^2$	[0, 10000]	9.0	
0x61	TinitVar	FLT	$(m/pulse)^2$	[.00001, 4]	1.0	

0x62	TPNVar	FLT	$(m/pulse)^2 / s$	[0, 1]	10^{-8}	
0x63	TmaxVar	FLT	$(m/pulse)^2$	[.00001, 4]	0.0004	
0x64	ZRRHoldOff ZROAccy	FLT	$(GCnts)^2$	[.00107374, 107374.18]	10.737418	$(1.0\ mV)^2$
0x65	WinSnapThd	FLT	$(unitless)^2$	$[0, 10^6]$	36.0	
0x66	WinClusterVar	FLT	$(unitless)^2$	$[0, 10^6]$	9.0	
0x67	MaxInitGross ErrSq	FLT	$(m)^2$	$[0, 10^{12}]$	$4.0x10^6$	
0x68	MaxCorrection SigSq	FLT	$(unitless)^2$	$[0, 10^6]$	4.0	
0x69	GSFCalcMin HdgRate	FLT	(rad/s)	[0, 3]	0.0174533	
0x6A	GSFCalcMax HdgRate	FLT	(rad/s)	[0, 3]	1.04719755	
0x6B	GSFCalcMax ZROVar	FLT	$(unitless)^2$	$[0, 10^6]$	4.0	
0x6C	MaxGSFVar	FLT	$(GCnts/(rad/s))^2$	[0, 1]	4.53915×10^{-10}	$(2.5\ mV/(°/s))^2$
0x6D	MinGSFVar	FLT	$(GCnts/(rad/s))^2$	[0, 1]	4.53915×10^{-16}	$(0.0025\ mV/(°/s))^2$
0x6E	MaxDelGSF	FLT	(GCnts/(rad/s))	[0, 1]	2.13053×10^{-8}	0.025 mV/(°/s)
0x6F	MinNormVel ResidSq	FLT	$(unitless)^2$	[0, 100]	0.01	

(*) A GCnt is a 14-bit ADC count. Full scale (5 V) is 16384 GCnt, so 1 mV = 3.2768 GCnt.

0x2A, 0x2B, 0x2C; 0x2D: Output Interval Control

These reports contain the data structures describing the output interval for automatic messages. Automatic outputs are controlled by thresholds and triggers on three criteria: time, distance traveled, or heading change. A combination of criteria can be set for each message, and different report message codes can have different output controls. The number of message codes that can be chosen for auto-output is limited to 16.

The message codes chosen for auto-report are stored in a table that contains the values of time interval, distance traveled, and heading change since the last report. These values are kept separately for each message code. The table is scanned every time the gyro service routine is called (at 10 Hz or 5 Hz rate). For each message code, the current values of time interval, distance traveled, and heading change are differenced with the corresponding three table values. The three differences are compared against the three corresponding thresholds for that message code to determine whether an output is allowed. If so, the differences are then compared to against the three corresponding triggers (if any) to see if an output is required. If the message is output, the table values are updated to the current values.

The logic for report output is as follows:

(Time interval > T_{thresh}) AND

(Distance traveled > D_{thresh}) AND

(Heading change > H_{thresh}) AND

(EVENT OR (Time interval > $T_{trigger}$) OR (distance traveled > $D_{trigger}$) OR (Heading change > $H_{trigger}$))

Defaults are zero for all reports, except as specified in **Error! Reference source not found.**.

Table 50: Automatic Output Event Trigger Report Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x2A	Event Control
		Subcode	U8	0x00-7F	Parser Code
		Index	U8	0x00-7F 0xFF	Parser Subcode All subcodes
0	1	Event 1	U1		Almanac Page Collected
0	2	Event 2	U1		Ephemeris Page Collected
0	3	Event 3	U1		Ionosphere-UTC Page Collected
0	6	Event 6	U1		Almanac Health page Collected
0	7	Event 7	U1		Tacho/Gyro Collected (10 Hz, DR GPS)
1	1	Event 9	U1		GPS Measurement Collected (1 Hz)
1	2	Event 10	U1		Least Squares (LS) Fix generated (1 Hz)
1	3	Event 11	U1		LS Fix not generated
1	4	Event 12	U1		Tracking SV List Updated
2	1	Event 17	U1		Self-test complete (DR GPS)
2	3	Event 19	U1		Receiver status changed
2	4	Event 20	U1		Power-on acknowledge
2	5	Event 21	U1		Start-up complete
2	6	Event 22	U1		Ready to shutdown
3	0	Event 24	U1		DPP Calibrated
3	1	Event 25	U1		Direction Switch Calibrated
3	2	Event 26	U1		Gyro Calibrated
3	4	Event 28	U1		Time status change (time set)
3	5	Event 29	U1		Hard Error

Table 51: Automatic Output Time Interval Trigger Report Message

Byte	Name	Type	Value	Units	Meaning
	Code	U8	0x2B		Time Interval Control
	Subcode	U8	0x00-7F		Parser Code
	Index	U8	0x00-7F 0xFF		Parser Subcode All subcodes
0-3	Threshold	U32		1 ms	Minimum required
4-7	Trigger	U32	0 > 0	1 ms	Not used Trigger value

Table 52: Automatic Output Distance Traveled Trigger Report

Byte	Name	Type	Value	Units	Meaning
	Code	U8	0x2C		Distance Traveled Control
	Subcode	U8	0x00-7F		Parser Code
	Index	U8	0x00-7F 0xFF		Parser Subcode All subcodes
0-3	Threshold	U32		1 cm	Minimum required
4-7	Trigger	U32	0 > 0	1 cm	Not used Trigger value

Table 53: Automatic Output Heading Change Trigger Report

Byte	Name	Type	Range/Value	Units	Meaning
	Code	U8	0x2D		Heading Change Control
	Subcode	U8	0x00-7F		Parser Code
	Index	U8	0x00-7F 0xFF		Parser Subcode All subcodes
0-3	Threshold	U32		1 cdeg	Minimum required
4-7	Trigger	U32	0 > 0	1 cdeg	Not used Trigger value

Table 54: List of Automatic Output Trigger Defaults

Code/ Subcode	Event	Time Interval		Distance Traveled		Heading Change	
	Trigger	Threshold	Trigger	Threshold	Trigger	Threshold	Trigger
12-01	21	*	0	0	0	0	0
30-02	-	*	200	0	0	0	0
31-01	10,11	*	0	0	0	0	0
32-01	10,11	*	0	0	0	0	0
33-01	10,11	*	0	0	0	0	0
36-03	26	*	0	0	0	0	0
36-04	26	*	0	0	0	0	0
36-05	25	*	0	0	0	0	0
36-07	24	*	0	0	0	0	0
36-08	26	*	0	0	0	0	0

NOTE Since output thresholds and triggers are checked at the DR service rate, there is a minimum time interval corresponding to the DR engine rate. The effective minimum time interval threshold is 200 ms for DR engine rate of 5 Hz and 100 ms for DR engine rate of 10 Hz.

0x2E-01: Soft Event Report Mask

The soft event report can be suppressed. The following data structure shows whether it is masked, and can be set or queried. All events are unmasked at power-up.

Table 55: 0x2E-01: Event Report Mask Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x2E	
		Subcode	U8	0x01	
		Index	U8	0-0x7F 0xFF	Soft Event Identity Code All
0	0-1	Mask	U2	0 1 3	Do not report Report on change (single) Report as detected (continuous)

0x2F-02: Data Positioning Collection Test Interval Control

This test is part of the factory testing. At the end of the test, the module outputs diagnostic data in packet 0x3F-02.

There are two modes possible: automatic and manual. Automatic-control mode sets the Time Interval between one and 3600 seconds. The test begins immediately upon receipt of the set command and lasts until the end of the time interval. Manual-control mode uses the set command with the Time Interval Data field set to a large number (e.g., 3600) and then issuing an “Stop Immediately” command when desired. This message cannot be queried. If a test is currently running, this command will return an acknowledgment “contradicts current data”.

This test does not interfere with the normal functioning of the module. The test collects statistics for a report at the end of the test.

Table 56: 0x2F-02: Data Positioning Collection Mode Control

Byte	Name	Type	Value	Meaning
	Code	U8	0x2F	
	Subcode	U8	0x02	
0-1	Time Interval	U16	0 [1, 3600]	Stop Immediately Perform test for this interval (seconds)

0x2F-04: Gyro Bench Test Interval Control

The module can bench-test gyro performance. This test is similar to the gyro part of the power-up ADC/gyro test. The test starts immediately upon receipt of the set command for 2F-04. When the test is finished, it automatically reports message 3F-04. The unit must be stationary for this test to be meaningful. This message cannot be queried.

There are two modes possible: automatic and manual. Automatic-control mode sets the Time Interval between one and 60 seconds. The test begins immediately upon receipt of the set command and lasts until the end of the time interval. Manual-control mode uses the set command with the Time Interval Data field set to a large number (e.g., 60) and then issuing an “Stop Immediately” command when desired. If a test is currently running, this command will return an acknowledgment “contradicts current data”.

Table 57: 0x2F-04: Gyro Bench Test Interval Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x2F	
	Subcode	U8	0x04	
0-1	Time Interval	U16	0 [1, 60]	Stop Immediately Perform test for this interval (seconds)

0x2F-06: Tacho/Reverse Production Test Interval Control

The test starts immediately upon receipt of the set command for 2F-06. When the test is finished, it automatically reports message 3F-06. This message cannot be queried. If a test is currently running, this command will return an acknowledgment "contradicts current data".

There are two modes possible: automatic and manual. Automatic-control mode sets the Time Interval between one and 60 seconds. The test begins immediately upon receipt of the set command and lasts until the end of the time interval. Manual-control mode uses the set command with the Time Interval Data field set to a large number (e.g., 60) and then issuing an "Stop Immediately" command when desired.

Table 58: 0x2F-06: Tacho/Reverse Production Test Control

Byte	Name	Type	Value	Meaning
	Code	U8	0x2F	
	Subcode	U8	0x06	
0-1	Time Interval	U16	0 [1, 60]	Stop Immediately Perform test for this interval (seconds)

0x21-01: DR Engine Rate Control

The DR software engine can be adjusted to run at 5 Hz or 10 Hz sampling rate. The five Hz rate eases CPU load. The choice of rate affects the minimum report interval in report 0x2B. After the engine rate is changed, the system will be reset automatically.

Table 59: 0x21-01:DR Engine Rate Control

Byte	Name	Type	Value	Meaning
	Code	U8	0x21	
	Subcode	U8	0x01	
0	DR Engine Rate	U8	5 10	Hz 10 Hz

Data Report Packets

Data report packets can be queried or output based on time interval, distance traveled, heading change. Data validity must be checked before the data field are translated or used.

0x30-02: Fast Fix with Raw DR Data Message

This message is prepared for output every fast cycle (5 Hz or 10 Hz) when in HIPPO mode, except for a short period at start-up. The Output Interval Control determines the actual rate of output. This message has higher priority than other messages, so a series of reports that lasts longer than 100 milliseconds may have one or more of these messages interspersed. This should cause no problem, since all series of reports are terminated by an acknowledgment.

Table 60: 0x30-02: Fast Fix with Raw DR Data Message

Byte		Name	Type	Units/ LSB	Range / Value	Meaning
		Code	U8	0x30		
		Subcode	U8	0x02		
0	0	Position Status	U1			1 = Valid
0	1	Altitude Status	U1			1 = Valid
0	2	Heading Status	U1			1 = Valid
0	3	Speed Status	U1			1 = Valid
0	4	Direction Switch Status	U1			1 = Valid
0	5	Delta-Distance Status	U1			1 = Valid
0	6	Delta-Heading Status	U1			1 = Valid
0	7	Motion Status	U1			1 = Valid
1	0	Motion Indicator	U1			1 = Motion
1	1	Direction	U1			1 = Backward
1	2	Gyro Calibration Status	U1			1 = Calibrated
1	3	Tacho Calibration Status	U1			1 = Calibrated
1	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
1	6	Snap to DR+GPS	U1		0 1	DR-Propagated Jump
2		GPS Data Age Index	U8	s	0-253 254 255	Age >253 s GPS N/A

Byte		Name	Type	Units/LSB	Range / Value	Meaning
3-6		GPS Time of Week	U32	1 ms	0-604800000	
7-10		Latitude	S32	2^{-31} sc	[-½, ½] sc.	
11-14		Longitude	S32	2^{-31} sc	[-1, 1) sc.	
15-16		Altitude	S16	1 m	[-400,10000] m	MSL
17-18		Heading	U16	2^{-15} sc	[0, 2) sc.	
19-20		Speed	U16	1 cm/s	[0, 655.34] m/s	
21-22		Delta time	U16	1 ms	[0, 1100] ms	even
23-24		Delta Distance	S16	1 cm	[-327.67, 327.67] m	
25-26		Delta Heading	S16	1 cdeg	[-327.67°, 327.67°]	
27-28		Position accuracy	U16	1 m	[0, 65534] m	
29-30		Altitude Accuracy	U16	1 m	[0, 65534] m	
31-32		Heading Accuracy	U16	2^{-15} sc	[0, 2) sc.	
33-34		Speed Accuracy	U16	1 cm/s	[0, 655.34] m/s	
35-36		Delta distance accy	U16	1 cm	[0, 655.34] m	
37-38		Delta heading accy	U16	1 cdeg	[0°, 360°]	
39	0-6	# of Gyro Samples	U7		0-127	< 110 typ
39	7	Direction Switch Value	U1			1 = High
40-43		Gyro Counts	U32		0-450560	Sum ADC values
44-45		Tacho Counts	U16		0-65535	< 3300 typ

The data source of the fast fix can be inferred from the current tacho status, the current gyro status, and the GPS age as follows:

Table 61: Fast Fix Data Sources

Tacho Status	Gyro Status	GPS Age	Lat / Lon Source	Altitude Source	Speed / Delta Distance Source	Heading / Delta Heading Source
1	1	< 255	GPS + DR	GPS	DR + GPS Cal	DR + GPS Cal
1	0	< 255	GPS + DR	GPS	DR + GPS Cal	GPS
0	1	< 255	GPS	GPS	GPS	DR + GPS Cal
0	0	< 255	GPS	GPS	GPS	GPS
1	1	255	BBRAM + DR	BBRAM	DR	DR
1	0	255	BBRAM	BBRAM	DR	None
0	1	255	BBRAM	BBRAM	None	DR
0	0	255	BBRAM	BBRAM	None	None

0x31-01: GPS Fix Message

Table 62: 0x31-01: GPS Fix Message

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8	0x31		
		Subcode	U8	0x01		
0-3		GPS Time of Week	U32	1 ms	<604800000	
4	0-5	Fix Source	U6		0 1 3 4 8 9 10 11 12 13 14 15 16 17	No position in memory Input position, approximate Input position, accurate Have internal position Old valid GPS fix Converging Converging Converging Output fix criterion failed 2-D fix, no reference altitude KF velocity RAIM failed KF edited too many SVs KF position RAIM failed Position Valid
4	6	Altitude Hold	U1		0 1	Full position (3-D) LS fix Altitude-Hold (2-D) LS fix
4	7	DGPS Status	U1			1 = DGPS-corrected
5	0	Position status	U1			1 = Valid
5	1	Altitude status	U1			1 = Valid
5	2	Heading status	U1			1 = Valid
5	3	Speed status	U1			1 = Valid
5	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
6-9		Latitude	S32	2^{-31} sc	[-½, ½] sc	
10-13		Longitude	S32	2^{-31} sc	[-1, 1) sc	
14-15		Altitude	S16	m	[-400,10000] m	MSL
16-17		Heading	U16	2^{-15} sc	[0, 2) sc	
18-19		Speed	U16	1 cm/s	[0, 655.34] m/s	
20-21		Position accuracy	U16	1 m	[0, 65535] m	
22-23		Altitude accuracy	U16	1 m	[0, 65535] m	
24-25		Heading Accuracy	U16	2^{-15} sc	[0, 2) sc	
26-27		Speed Accuracy	U16	1 cm/s	[0, 655.35] m/s	

Position, heading and speed values are from GPS measurements. Code-carrier filtering has been applied, but not velocity (PV) or DR filtering. These fixes will be quite noisy in urban environments.

0x32-01: UTC Time and Constellation Summary Message

Table 63: 0x32-01: UTC Time and Constellation Summary Message

Byte		Name	Type	Units	Range / Value	Meaning
		Code	U8	0x32		
		Subcode	U8	0x01		
0-1		UTC year	U16		2000+	
2		UTC month	U8		[1, 12]	
3		UTC day	U8		[1, 31]	
4		UTC hour	U8		[0, 23]	
5		UTC minute	U8		[0, 59]	
6		UTC second	U8		[0, 60]	= 60 only for the leap second
7		UTC / GPS offset	U8			GPS = UTC + offset
8-9		PDOP	U16	2^{-8}		
10-11		HDOP	U16	2^{-8}		
12-13		VDOP	U16	2^{-8}	0 >0	2D position 3D position
14		Max DGPS age	U8	Sec	<255 255	Seconds Overage or invalid
15	0-3	GPS Status	U4		0 2 3 5 6 7 8	Doing position fixes Need time PDOP too high No usable SVs One usable SV Two usable SVs Three usable SVs
15	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
16	0-1	Search Mode	U2		0 1 2	None Blind Anywhere
16	7	Almanac Status	U1			1 = Complete
17	0-3	Number of SVs Visible	U4		[0,12]	

0x32-03: UTC Time Message

Table 65: 0x32-03: UTC Time Message

Byte		Name	Type	Units	Range / Value	Meaning
		Code	U8	0x32		
		Subcode	U8	0x03		
0	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
1-4		GPS Time of Week	U32	1 ms	<604800000	
5-6		GPS Week Number	U16		>1024	
7		UTC / GPS offset	U8		0 >0	Not available GPS = UTC + offset
8-9		UTC year	U16		2000+	
10		UTC month	U8		[1, 12]	
11		UTC day	U8		[1, 31]	
12		UTC hour	U8		[0, 23]	
13		UTC minute	U8		[0, 59]	
14		UTC second	U8		[0, 60]	

0x33-01: GPS Channel Measurement Short Status

This report message type is indexed by channel number (0-7 for eight-channel receivers and 0-11 for twelve-channel receivers).

If the query is "query-all" (0xFF), only assigned channels will be reported. If channel status is queried for an unassigned channel, the data fields (including SV PRN) are zero-filled.

Table 66: 0x33-01: GPS Channel Measurement Short Status

Byte		Name	Type	Units	Range / Value	Meaning
		Code	U8	0x33		
		Subcode	U8	0x01		
		Index	U4		0-11	Channel
0		SV PRN	U5		0 1 – 32	Channel unassigned SV PRN
1	0	SV Visible	U1			1 = Elevation > Mask
1	1	reserved	U1			
1	2	SV Has Been Tracked	U1			1 = Already Tracked
1	3	reserved	U1			
1	4	SV Currently Tracking	U1			1 = Tracking
1	5	SV Meets SNR Mask	U1			1 = SNR Meets Mask
2		SNR	U8	0.2 dB-Hz	[0,48] dBHz	
3		Azimuth	U8	2°	[0°, 358°]	
4		Elevation	S8	1°	[-90°,90°]	
5	0-1	Almanac Status	U2		0 1 3	None Old Current
5	2-3	Ephemeris Status	U2		0 1 2 3	None Old Decoded Verified

0x36: DR Calibration Messages

The DR calibration messages contain the current settings for the gyro and tacho parameters. They are typically transmitted when the parameters are updated. ZRO, ZRO rate, and DPP are updated upon generation of a valid GPS velocity. ZRO and ZRO rate are also updated during periods of zero speed.

When the host uses the “set” procedure with these messages, the “source” field must be set to “Clear”, “Host Input”, or “Host Override”. The “set” procedure is not supported for ZRO rate (0x36-08).

For “Clear”, the rest of the fields are ignored.

For “Host Input”, if the device has already calibrated the parameters, the set procedure is aborted. The acknowledgment message has status set to “Contradicts current data”.

For “Host Override”, the value and accuracy must be valid quantities.

The “Cal Status” and “newness” fields are always ignored in the set procedure.

Table 67: 0x36-03: ZRO Calibration Message

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8		0x36	
		Subcode	U8		0x03	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		Zero Rate Output (ZRO)	FLT	(mV)	(-2500.0, 2500.0)	
5-8		ZRO accuracy	FLT	(mV)	> 0	1 σ accuracy

Table 68: 0x36-04: Gyro Linearity Calibration Message

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8		0x36	
		Subcode	U8		0x04	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		Sensitivity (GyroSns)	FLT	(mV /(°/s))	[10.0,100.0]	
5-8		Sensitivity Accuracy	FLT	(mV /(°/s))	> 0	1 σ accuracy

Table 69: 0x36-05: Direction Switch Calibration Message

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8		0x36	
		Subcode	U8		0x05	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
0	7	Direction Switch Sense	U1		0 1	0 = FWD, 1 = REV 0 = REV, 1 = FWD
1		Confidence Speed	U8	1 m/s	< DirSwWarning (see 0x27; default=14 m/s) < 256 if Source is Host Override	Last calibration speed

Table 70: 0x36-07: DPP Calibration Message

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8		0x36	
		Subcode	U8		0x07	
		Index	U8		[0, N_{DPP}-1]	Speed Level Index
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		DPP	FLT	(m / pulse)	[.005, 5.0]	< 5 m/pulse typ
5-8		DPP accuracy	FLT	(m / pulse)	[.001, 1.0]	1 σ accuracy

Table 71: 0x36-08: ZRO Rate Calibration Message

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8		0x36	
		Subcode	U8		0x08	
0	0-2	Source	U3		0 3	Invalid GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		ZRO Rate of Change	FLT	(mV / sec)		
5-8		ZRO Rate accuracy	FLT	(mV / sec)		1 σ accuracy

0x3F-01: ADC and Gyro Self-test Data

The module performs a self-test on the ADC and gyro at start-up. (The module can also perform the gyro test after start-up.) If the tests are completely successful, the gyro/ADC self-test bit in the start-up message (0x12-01) is zero. If the bit is set to one, the host should examine the following message for diagnosis of the errors. The ADC at fixed voltage is from the test at start-up; the “at rest” data fields are from the most recent test. This information is not battery-backed, and is available by query only.

Table 72: 0x3F-01: ADC and Gyro Self-Test Report Message

Byte	Name	Type	Units / LSB	Range / Value	Meaning
	Code	U8	0x3F		
	Subcode	U8	0x01		
0	ADC validity	U8		0 1	No error ADC not functioning
1-4	ADC at fixed voltage	U32			
5-6	Samples at fixed voltage	U16			
7-10	ADC / gyro at rest	U32			
11-12	Samples at rest	U16			

0x3F-03: Data Positioning Collection Test Data (ROM 15 and after)

This replaces report 0x3F-02 starting with ROM 15.

The Data Positioning Collection Mode Test starts immediately upon receipt of the set command 0x2F-02. When the test is finished, it automatically reports the data in this message. This information cannot be set or queried.

Table 73: 0x3F-03:Data Positioning Collection Test Data

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8	0x3F		
		Subcode	U8	0x03		
0	0	Heading Valid before motion	U1			1 = valid
0	2	ZRO valid before motion	U1			1 = valid
0	3	DPP valid before motion	U1			1 = valid
0	4	Final Heading Valid	U1			1 = valid
1-4		Pulses counted	U32			
5-6		Maximum Speed	U16	1 cm/s		
7-10		Total Distance	U32	1 cm		
11		DirSw transitions F→R	U8			
12		DirSw transitions R→F	U8			
13-14		Heading at ZRO cal	U16	2^{-15} sc	[0, 2) sc	
15-16		DeltaHeading	U16	2^{-15} sc	[0, 2) sc	
17-18		Final Heading	U16	2^{-15} sc	[0, 2) sc	
19-20		Test Duration	U16	1 s	[1,3600]	
21-22		Initial Heading after ZRO calibration	U16	2^{-15} sc	[0, 2) sc	
23	0	2-D GPS fix	U1			1 = 2-D fix failed
23	1	3-D GPS fix	U1			1 = 3-D fix failed
23	2	GPS didn't calibrate DR	U1			1 = no GPS / DR cal
23	3	Almanac incomplete	U1			1 = incomplete
23	4	GPS error status	U1			1 = GPS error
24		Max SVs tracked	U8			
25		Max SNR	U8	0.2 dB-Hz		

0x3F-04: Gyro Bench Test Data

The module can bench-test gyro performance. This test is similar to the gyro part of the power-up ADC/gyro test.

The Gyro Bench Test starts immediately upon receipt of the set command 0x2F-04. When the test is finished, it automatically reports the data in this message. This information cannot be set or queried.

Table 74: 0x3F-04: Gyro Bench Test Report Message

Byte	Name	Type	Units / LSB	Range / Value	Meaning
	Code	U8	0x3F		
	Subcode	U8	0x04		
0-3	ADC / gyro at rest	U32		ADC counts	
4-5	Samples at rest	U16		1-6200 samples	
6-7	Test Duration	U16	1 s	[1,60]	

0x3F-06: Tacho/Reverse Production Test Data

The Tacho/Reverse Production Test starts immediately upon receipt of the set command 0x2F-06. When the test is finished, it automatically reports the data in this message. This information cannot be set or queried.

Table 75: 0x3F-06: Tacho/Reverse Production Test Report

Byte	Name	Type	Units / LSB	Range / Value	Meaning
	Code	U8	0x3F		
	Subcode	U8	0x06		
0	Tacho counts	U32		Tacho Counts	
4-5	Samples	U16		4-600 samples	
6-7	Changes in Direction Switch Value	U16			
8-9	Samples	U16		4-600 samples	
10-11	Test Duration	U16	1 s	[1,60]	

0x30-03: Buffered Cumulative DR message

This message provides the first 20 seconds (or more) of buffered DR information. If the host takes significant time to boot up, this provides the recent path for map-matching purposes. The host should also request start-up information (0x16-02) and health information (0x16-01) on late boot-up. Once the message is queried, the data is frozen, and subsequent queries return the same data.

Validity Bits:

- The “all data” flag bit is set if the data buffer contains all data since power-up.
- The “rolling start” bit will be set if a tacho pulse (other than a heartbeat) is detected in the first 200 ms.
- Delta-distance is “valid” if the tacho was calibrated at start-up.
- Delta-heading is “valid” if the gyro was calibrated before vehicle started moving.
- Time source and position, and heading validity bits are taken from the most recent 0x30-02 message. These can be used with the current timetag, position, and heading to formulate a HIPPO map-match message.

An array of up to 20 delta-distances and delta-headings are in the message. These values will have been corrected with the estimate of ZRO and DPP current at the time. Each will be over an interval lasting about one second, except for the first and last intervals. The intervals are reported in reverse order, from newest (most-recent) first, to oldest (first recorded). If the module has collected less than twenty intervals of data, the unrecorded array elements will be set to zero. These zero-distance elements will have no effect on map-matching algorithms.

The oldest (first-recorded) interval lasts from power-up until the first integer second at which motion is detected.

The most recent interval for delta-distance and delta-heading gives the data between the most recent integer second and the request, so it may not be a complete second. If no motion has been recorded since power-up, this is the only interval reported and it may be much longer than one second.

Distance accuracy is relative to the total distance traveled (the sum of all the intervals). The accuracy of each one-second segment should be scaled proportionately.

Delta Heading accuracy is over each one-second interval, and is roughly the same for each of the intervals except the most recent, which may be more accurate.

Table 76: 0x30-03: Buffered Cumulative DR Message

Byte		Name	Type	Units / LSB	Range / Value	Meaning
		Code	U8		0x30	
		Subcode	U8		0x03	
0	0	Current Position Valid	U1			1 = Valid
0	1	Current Heading Valid	U1			1 = Valid
0	2	Delta Distance Valid	U1			1 = Valid
0	3	Delta Heading Valid	U1			1 = Valid
0	4	All data	U1			1 = contains all data since start
0	5	Rolling start	U1			1 = motion detected at start-up
0	6-7	Time Source	U2			Time Source for Map Match
1-2		Time Tag	U16	1 ms	[0, 65535] ms	Time Tag for Map Match
3-6		Current Latitude	S32	2^{-31} sc	[-½, ½] sc.	
7-10		Current Longitude	S32	2^{-31} sc	[-1, 1) sc.	
11-12		Current Heading	U16	2^{-15} sc	[0, 2) sc	
13-14		Delta Distance [0]	S16	1 cm	[-327.67, 327.67] m	(Now – 1 s) to (Now)
15-16		Delta Heading [0]	S16	1 cdeg	[-327.67°, 327.67°]	(Now – 1 s) to (Now)
17-18		Delta Distance [1]	S16	1 cm	[-327.67, 327.67] m	(Now – 2 s) to (Now – 1 s)
19-20		Delta Heading [1]	S16	1 cdeg	[-327.67°, 327.67°]	(Now – 2 s) to (Now – 1 s)
…						
…						
89-90		Delta Distance [19]	S16	1 cm	[-327.67, 327.67] m	(Now – 20 s) to (Now – 19 s)
91-92		Delta Heading [19]	S16	1 cdeg	[-327.67°, 327.67°]	(Now – 20 s) to (Now – 19 s)
93-94		Current Heading Acc'y	U16	2^{-15}sc	[0, 2) sc	
95-96		Current Position Acc'y	U16	1 m	[0, 65534] m	
97-98		Distance accy	U16	1 cm	[0, 655.36] m	
99-100		Delta heading accy	U16	1 cdeg	[0°, 360°]	

Initialization Information

The following reports contain the information that the module is currently storing in BBRAM for initialization in the next session. If any information is updated in real time through data decode or fixes the module reports the updated information.

When these reports are used with the "set" command, the host sends the message with the "Source" byte set to "Host Input". If the information is already in use in the system and validated by fixes or decode, the module may reject the host input. This will be indicated in the acknowledgment message. Validated data can be over-written using the "Host override" option.

If BBRAM is lost, byte 3 of the start-up message 12-01 will indicate the module is doing a cold-start. The host can upload the initialization information to the module using the set procedure to speed GPS satellite acquisition. This information includes:

1. Almanac messages (28-12, 28-13, 28-14);
2. Time message (29-01);
3. Frequency message (29-04); and
4. Latitude / longitude message (29-02).

Of the above list, the frequency message is optional but the others are required for "warm-start" performance. The order of data entry is important. The latitude / longitude message 29-02 must be provided after the time, almanac, and (optionally) frequency messages, because this message triggers an immediate satellite re-selection using the new data. The other initialization messages (altitude, DR calibration, ephemeris) will also speed the first fix, and can be sent either before or after the latitude / longitude message.

Many of the data structures in this section have "source" and "newness" fields. A set command can use values 0 (clear), 1 (host input), or 2 (host override) for the source field. If the source is currently 2 (host override) or 3 (derived from GPS) and a new set command has source value 1 (host input), the acknowledgment message returns error "value contradict" for set command. The newness field cannot be set; if newness is 0, a reset has occurred since the value was last updated.

0x28-12: Almanac Initialization

The elements of the almanac message match subframes 4 and 5 as downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. A 10-bit Week Number of Applicability is added as a time tag.

If the information is unknown, all data fields are zero. To erase almanac health information in the DR GPS module, set this data with source byte equal to zero (Invalid / Clear).

Table 77: 0x28-12: Almanac Fixed Point Report Message

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x12	Almanac
		Index	U8		1 – 32	SV PRN
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	6-7	GPS Week Extension	U2			2 MSBs of WNoa
1		WN_{oa}	U8			IDC-200C
2-25		Compressed Almanac	24xU8			

0x28-13: Almanac Health Initialization

The elements of the almanac health message match subframe 4 and 5, page 25 as downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. An 8-bit Week Number of Applicability is included in the compressed data, and two extra bits are given in Byte 0 to extend this to a full GPS week number.

If the information is unknown, all data fields are zero. To erase almanac health information in the DR GPS module, set this data with source byte equal to zero (Invalid / Clear).

Table 78: 0x28-13: Compressed Almanac Health Report Message

Byte		Name	Type	Units/ LSB	Range / Value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x13	Almanac Health Page
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	6-7	GPS Week Extension	U2			2 MSBs of WNoa
1		WN_{oa}	U8			IDC-200C
2-25		Compressed Health & A-S	24xU8			Subframe 4 Page 25
26-49		Compressed Health	24xU8			Subframe 5 Page 25

0x28-14: GPS Ionospheric Model and UTC Parameters Initialization

The elements of the ionosphere / UTC message match subframe 4, page 18 as downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. A 10-bit Week Number of Collection is added as a time tag.

If the information is unknown, all data fields are zero. To erase ionosphere and UTC model information in the DR GPS module, set this data with source byte equal to zero (Invalid / Clear).

Table 79: 0x28-14: GPS Ionospheric Fixed Point Model Report

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x14	Iono/UTC Model
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	6-7	GPS Week Extension	U2			2 MSBs of Week
1		Week of collection	U8			8 LSBs of Week
2-25		Compressed Iono / UTC	24xU8			

0x28-16: Ephemeris Initialization

The elements of the ephemeris message match the three subframes that are downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. A 10-bit Week Number of Applicability is included in the compressed data.

If the information is unknown, all data fields are zero. To erase ephemeris information in the DR GPS module, set this data with source byte equal to zero (Invalid / Clear).

Table 80: 0x28-16: GPS Ephemeris Fixed Point Model Report

Byte		Name	Type	Units/ LSB	Range / Value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x16	Ephemeris
		Index	U8	1-32		SV PRN
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
1		Reserved				
2-25		Compressed Ephemeris	24xU8			Subframe 1
26-49		Compressed Ephemeris	24xU8			Subframe 2
50-73		Compressed Ephemeris	24xU8			Subframe 3

0x29-01: Time Initialization

The data in this message will change after initialization through fixes. The Invalid/Clear command and the Time Accuracy are currently not supported.

Table 81: 0x29-01: Time Initialization Report Message

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x01	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	4	Time Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-2		Week number	U16	1 wk	<1024	GPS week number
3-6		Time of week	U32	1 ms	<604800000 ms	GPS time of week
7-10		Time Accuracy	U32	1 ms	0-604800000 ms	1-sigma accuracy

0x29-02: Latitude / Longitude Initialization

The data in this message will change after initialization through fixes. To erase latitude / longitude initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear). To override current latitude and longitude estimates, use "host override".

Latitude and longitude initialization must be done before altitude initialization.

Table 82: 0x29-02: Latitude / Longitude Initialization Report

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x02	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Lat/Lon Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-4		Latitude	S32	2^{-31} sc	[-½, ½] sc.	
5-8		Longitude	S32	2^{-31} sc	[-1, 1) sc.	
9-12		Latitude Accuracy	U32	2^{-31} sc	[0, 1) sc.	1-sigma accuracy
13-16		Longitude Accuracy	U32	2^{-31} sc	[0, 1) sc.	1-sigma accuracy
17-20		Lat/Lon Correlation	FLT	unitless	[-1.0,1.0]	

0x29-03: Altitude Initialization

The data in this message will change after initialization through fixes. To erase altitude initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear). To override current altitude estimate, use "host override".

Latitude and longitude initialization must be done before altitude initialization.

Table 83: 0x29-03: Altitude Initialization Report Message

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x03	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Altitude Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-2		Altitude	S16	1 m	-400 – 10000 m	MSL
3-4		Altitude Accuracy	U16	1 m	0 – 10000 m	1-sigma accuracy

0x29-04: Local Oscillator (LO) Frequency Offset Initialization

The data in this message will change after initialization through fixes. To erase frequency initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear).

Table 84: 0x29-04: Local Oscillator (LO) Frequency Offset Initialization Report Message

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x04	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Frequency Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-4		Frequency	S32	1 PPB	±50 PPM	
5-6		Frequency Accuracy	U16	1 PPB	0 – 16 PPM	1-sigma accuracy

0x29-05: Heading Initialization

The data in this message will change after initialization through fixes. To erase heading initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear). To override current heading estimates, use “host override”.

Table 85: 0x29-05: Heading Initialization Report Message

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x05	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Heading Accuracy status	U1		0 1	Acc’y Unknown Acc’y Valid
1-2		Heading	U16	2^{-15} sc	[0, 2) sc.	
3-4		Heading Accuracy	U16	2^{-15} sc	[0, 1] sc.	1-sigma accuracy

Real-Time Input Data

The following reports are used primarily for the input of serial data for real-time aiding (e.g., DGPS corrections, map-match corrections) that are sent form the host to the DR GPS module.

0x29-07: Short Map-Match Data

This message contains the most recent map-match data. It can be set, queried, or auto-reported.

Table 86: 0x29-07: Map-Match Report Message

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x07	
0	0	Lat-Lon Valid	U1			1 = Valid
0	1	Altitude Valid	U1			1 = Valid
0	2	Heading Valid	U1			1 = Valid
0	3	Lat-Lon Accy Valid	U1			1 = Valid
0	4	Altitude Accy Valid	U1			1 = Valid
0	5	Heading Accy Valid	U1			1 = Valid
0	6	Time Source	U2			From Msg 30-02
1-2		Time Tag	U16	1 ms	[0, 65535] ms	16 LSBs from Msg 0x30-02
3-6		Latitude	S32	2^{-31} sc	[-½, ½] sc.	
7-10		Longitude	S32	2^{-31} sc	[-1, 1) sc.	
11-12		Altitude	S16	1 m	[-400, 10000] m	MSL
13-14		Heading	U16	2^{-15} sc	[0, 2) sc.	
15-16		East Accy	U16	1 m	(0, 1000] m	1-σ accuracy
17-18		North Accy	U16	1 m	(0, 1000] m	1-σ accuracy
19-20		East / North Covariance	S16	1 m	[-1000, 1000]	
21-22		Altitude Accy	U16	1 m	[1, 1000] m	1-σ accuracy
23-24		Heading Accy	U16	2^{-15} sc	(0, 1] sc.	1-σ accuracy

The Time of Week and Time Source data fields must exactly match the Time of Week (16 LSBs) and Time Source fields of a recent 0x30-02 message. The map-match information is assumed to be the position/heading estimate at the time of that 0x30-02 message.

The "East / North Covariance" data field is a signed quantity, derived from the off-diagonal element $Cov_{E,N}$ of the 2x2 East-North error covariance matrix as follows:

$$\mathrm{SIGN}\ (Cov_{E,N})\ \mathrm{SQRT}\ (\mathrm{ABS}(Cov_{E,N}))$$

0x29-08: Tacho Data

This message contains Tacho data from the CAN bus. It is used if a tacho signal is not available. It can be set, queried, or auto-reported.

Table 87: 0x29-08: Tacho Report Message

Byte		Name	Type	Units/LSB	Range / Value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x08	
0	0	Timetag Offset Valid	U1			1 = Valid
0	1	Tacho Valid	U1			1 = Valid
0	2	Direction SwitchValid	U1			1 = Valid
0	7	Reverse Switch Value	U1		0 1	Low High
1-2		Host System Clock Timetag	U16	ms	[0,65767]	(Host time) mod 2^{16}
3-4		Timetag offset	U16	ms	[0,65767]	(GPS – Host) mod 2^{16}
5-8		Tacho pulses	U32			Accumulated Tacho pulses

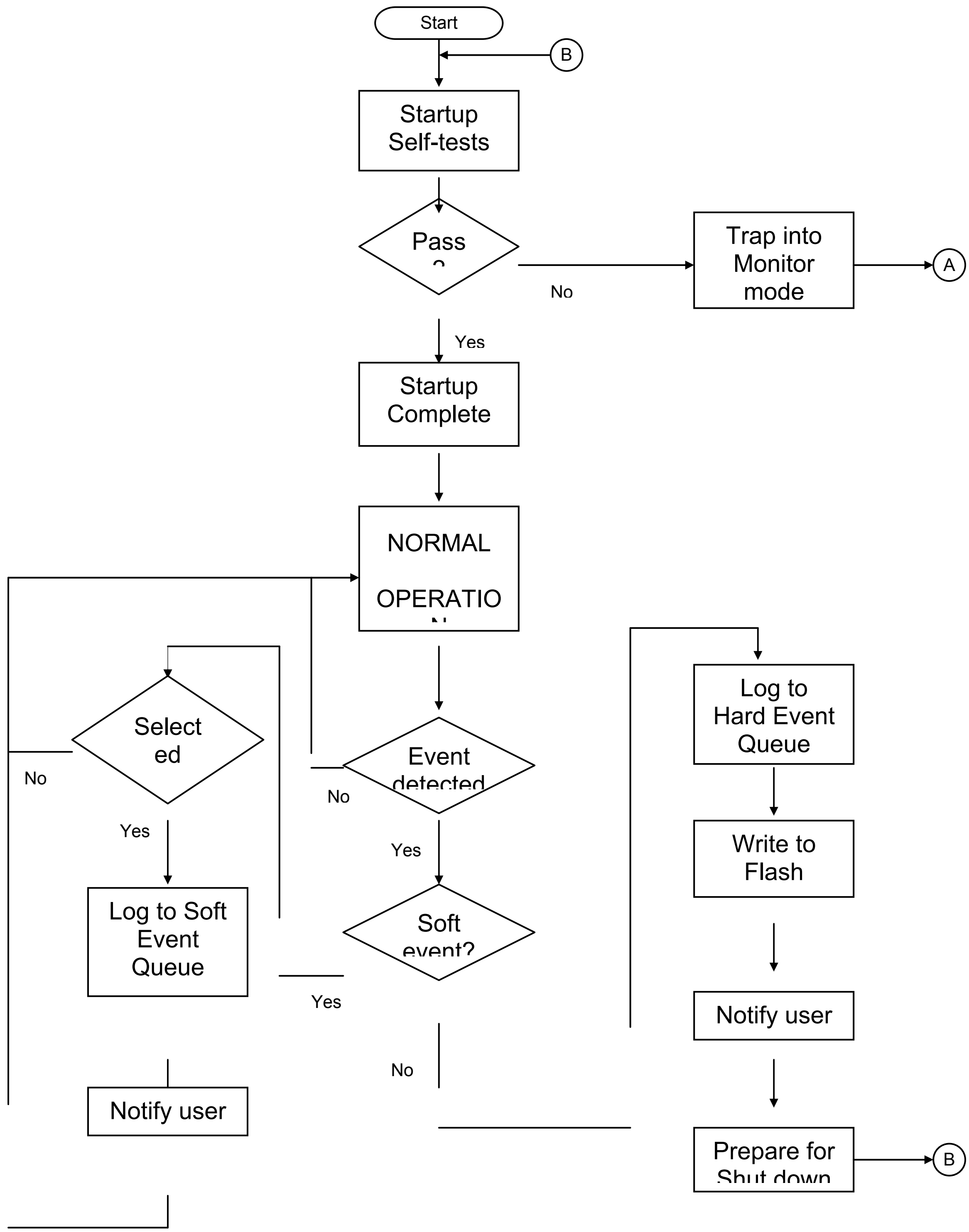
EVENT LOG QUEUE

Theory of Operation

There are two types of events, hard and soft. Each type has its separate log. The soft event log resides in RAM and the fatal error log resides in flash. Each event has an event ID (two-byte unsigned value), a time tag indicating the time when the event occurred, and a status word if applicable.

Flow of execution for error logging is shown in the following figure.

2. Flow of Execution



Fatal Errors

Fatal errors indicate abnormal operation of the module. In general these errors (such as illegal address) are not recoverable. Under these conditions, the receiver writes to the log first, and then sends an event packet to notify user before it restarts (warm or cold reset). The fatal errors are divided based on the source of error:

1. Interrupt system errors have a high byte of 0x10. The low byte is the vector number at fault.
2. Hardware-related system error, e.g. RAM, ROM, or gyro, has a high byte of 0x12 or 0x13.
3. RTOS events (errors related to the Operating System related function calls) have a high byte of 0x20.
4. Navigation library events and run-time positioning diagnostics have a high byte of 0x40.

Hard Reset means “Clear RAM and Reset SW”. The column “Ver” indicates which ROM versions have this fatal error code feature.

Table 88: Fatal Error Code

Error/Event		Descriptions	Action
LOG_ILL_TRAP	0x10xx	Illegal hardware interrupts (xx = vector number)	Hard Reset
LOG_ERR_RAM_FAILED	0x1200	RAM failed on self-test.	Monitor Mode
LOG_ERR_ROM_FAILED	0x1201	ROM failed on checksum test.	Monitor Mode
LOG_GET_SEMAPHORE_ERR	0x2001	Failure on acquiring a semaphore.	Reset
LOG_RELEASE_SEMAPHORE_ERR	0x2002	Failure on releasing a semaphore.	Reset
LOG_SEND_MESSAGE_ERR	0x2003	Failure on sending a message.	Reset
LOG_RECEIVE_MESSAGE_ERR	0x2004	Failure on receiving a message.	Reset
LOG_DELETE_MESSAGEQ_ERR	0x2005	Failure on deleting a message queue.	Reset
LOG_DELETE_TASK_ERR	0x2006	Failure to remove task from system.	Reset
LOG_SUSPEND_TASK_ERR	0x2007	Failure on suspending a task.	Reset
LOG_RESUME_TASK_ERR	0x2008	Failure on resuming a task.	Reset
LOG_CREATE_SEMAPHORE_ERR	0x2009	Failure on creating a semaphore.	Reset
LOG_CONNECTION_ERR	0x200A	Failure to connect to Io-DSP cell.	
LOG_CREATE_TASK_ERR	0x200B	Failure to creating a task.	Reset
LOG_ALLOCATE_BUF_ERR	0x200C	Failure on memory allocation.	Reset
LOG_MESSAGEQ_FULL	0x2120	A given message queue is full.	Reset
LOG_SIO_OPEN_ERR	0x2121	Failure to open serial port.	Monitor Mode
LOG_NAV_HARD_COCOM	0x4001	COCOM event, no recovery.	Hard Reset
LOG_NAV_HARD_ERR	0x4003	Other error in navigation library	Hard Reset

The fatal error log is located in the flash memory space at memory location 0x3000 - 0x4000. There are 31 reportable entries with 32 bytes per entry. The host cannot erase this log. A write-after-erase algorithm ensures the integrity of the log.

Table 89: Format of fatal error log entry

Field	Type	Descriptions
Msec	U32	Time tag in GPS milliseconds. (0xffffffff if not available)
Week	U16	Time tag in GPS week number. (0xffff if not available)
Code	U16	Event/error code. Hard Reset means "Clear RAM and Reset SW". The column "Ver" indicates which ROM versions have this fatal error code feature.
Status	U16	Status code associated with the event. 0 if not apply.
Info block	22 bytes	

The last field holds information associated with type of error. It can be a stack frame, a memory dump up to 22 bytes, or the program count for the address of error. The following tables describe the format for each fatal error types.

Table 90: Block Format for Status Code 10xx

Field	Type	Descriptions
Vector	U8	Illegal vector number
PC	U32	Program counter at fault
SP	U32	Supervisor stack address

Table 91: Block Format for Status Code 12xx

Field	Type	Descriptions
Soft value	U32	Soft checksum or memory content.
Actual value	U32	Data read from the target.
Address	U32	Status code 1201 only.

Table 92: Block Format for Status Code 2xxx

Field	Type	Descriptions
Src task	U8	Caller task ID
Dest task	U8	Receive task ID – 0 if not applicable.
Resource ID	U8	System resource such as semaphore, message queue,

Soft Events

Soft events, which include soft errors, periodic events, and user requested events, occur frequently. Only selected events will be logged into BBRAM. None of these events triggers a software reset. If the host desires to be notified of specific events with a HIPPO output message, it can specify the events to report with the event mask function (Sec 0).

Soft events have a 7-bit identity code and a two-bit condition status code. The soft event identity code is between 1 and 127. The last two columns in the table below indicate whether the event is a persistent condition such as a shorted antenna (C) or a single event like a RTC fault (S), and which ROM versions have this soft event code feature.

Table 93: Soft Event Identity Code

Soft event/Event		Descriptions	S/C
LOG_NO_ERROR	0x00	No error recorded in this entry	
LOG_SOFT_RESET	0x01	System performed a warm reset.	S
LOG_COLD_RESET	0x02	System performed a cold reset.	S
LOG_FACTORY_RESET	0x03	System cleared flash and RAM, reset.	S
LOG_SHUT_DOWN	0x04	System shut down by command.	S
LOG_BBRAM_INVALID	0x05	Invalid BBRAM detected on startup.	S
LOG_GRACEFUL_SHUTDOWN	0x06	System did graceful shutdown	S
LOG_TEST_PASSED	0x10	System passed all diagnostic tests.	S
LOG_TEST_START	0x11	Begin system test.	S
LOG_TEST_END	0x12	Indicates the end of a test event.	S
LOG_FORCE_TO_MONITOR	0x20	Force to monitor command executed.	S
LOG_NAV_FIRST_FIX	0x40	GPS receives the first fix on start up.	S
LOG_POSITION_SNAP	0x42	Output solution snapped to DR+GPS	S
LOG_POSITION_RECOVERY	0x43	Position recovery, snapped to GPS	S
LOG_HEADING_RECOVERY	0x44	Heading recovery, snapped to GPS	S
LOG_DPP_RECOVERY	0x45	DPP recovery, snapped to GPS	S
LOG_ZRO_RECOVERY	0x46	ZRO recovery	S
LOG_NAV_USER_TIME	0x50	User entered time on startup.	S
LOG_NAV_USER_POS	0x51	User entered position on startup.	S
LOG_NAV_FIX_SANITY	0x61	GPS receiver fix unreasonable.	C
LOG_GYRO_ANOMALY	0x62	Gyro readings not within specification	C
LOG_NO_TACHO_WHILE_MOVING	0x63	No Tacho when GPS detects motion	C
LOG_EXCESSIVE_TACHO	0x64	Consistently excessive tacho data	C
LOG_REVERSE_GPS_DISAGREE	0x65	Reverse signal opposite to GPS	C
LOG_LARGE_JUMP	0x66	Large jump at power-up	S
LOG_OSCILLATOR_ANOMALY	0x67	Oscillator values out of specification.	C
LOG_ERR_ANT_OPEN	0x70	Antenna open detected.	C
LOG_ERR_ANT_SHORT	0x71	Antenna short detected.	C
LOG_CONNECTION_ERR	0x72	Failure to connect to GPS DSP.	S
LOG_RTC_ERROR	0x73	RTC disagreed with GPS time	S
LOG_ERR_GYRO	0x74	Gyro failed.	C
LOG_ERR_A2D	0x75	A2D failed on self-test.	S
LOG_GYRO_SHORT_TO_3V	0x76	Gyro reads 3.3 V consistently	C

Some of these soft events are “informational”, and result from user action. Those soft events that are generated internally.

The condition code has four states. For a single event, the condition status code is zero. For a soft event condition, the condition code is defined in **Error! Reference source not found.**.

Table 94: Soft Event Condition Code

Numeric Value	Descriptions
0x00	Status unknown (backwards compatible to old software) or single event
0x10	Newly detected condition
0x20	Condition previously detected, still present
0x30	Condition newly cleared

As an example, when an antenna short condition is first detected, a soft event with identity and condition codes (0x71, 0x10) is generated. Every second, when the antenna fault detection is repeated, the soft event (0x17, 0x20) is generated. When the condition is cleared and no fault is found, the soft event (0x17, 0x30) is generated.

The soft event log resides at the beginning of the RAM area in a circular buffer with 127 entries. The log records all single-event soft events and all changes in soft event conditions, but does not record soft events with status code 0x2 (condition previously detected, still present). The log persists as long as there is a battery-backup power. The log is erasable by user via a HIPPO command or by the startup RAM test (cold start only). The host can retrieve logs at any time via HIPPO query. **Error! Reference source not found.** shows the format of the log entry for soft events:

Table 95: Format of Soft Event Log Entry

Field	Type	Descriptions
Msec	U32	Time tag in GPS milliseconds.
Week	U16	Time tag in GPS week number.
Identity	U8	Soft event identity code.
Condition	U8	Soft event condition code.
Reserved	U16	

Event Messages

Invalid BBRAM detected on startup.

Condition cause: Hardware failure.

Effect before Action: If not cleared, very long time to first fix or worse.

Soft Event Detected: BBRAM checksum mismatch at power-up.

Action: Clear BBRAM.

Position recovery, solution snapped to GPS.

Condition cause: Incorrect position at start-up, or substantial drift of DR+GPS position estimate.

Effect before Action: Large position offset between GPS and DR outputs for a number of seconds.

Soft Event Detected: Compute average of "window" of recent unfiltered GPS positions, propagated to current time using GPS velocities. Soft event occurs if this window average passes a series of criteria (see DR+GPS KF algorithm document 45172-XX-SP) and the offset relative to the DR position is large enough.

Action: The DR position is snapped to the window average.

Heading recovery, solution snapped to GPS.

Condition cause: Incorrect heading at start-up, or substantial drift of DR+GPS heading estimate.

Effect before Action: Large heading offset between GPS and DR outputs for a number of seconds.

Soft Event Detected: Compute average of "window" of recent raw GPS headings, propagated to current time gyro measurements. Soft event occurs if this window average passes a series of criteria (see DR+GPS KF algorithm document 45172-XX-SP) and the offset relative to the DR heading is large enough.

Action: The DR heading is snapped to the window average.

DPP recovery, solution snapped to GPS.

Condition cause: Incorrect DPP at start-up, or substantial drift of DR+GPS DPP estimate.

Effect before Action: Large speed offset between GPS and DR outputs for a number of seconds.

Soft Event Detected: Compute average of “window” of recent DPP estimates, derived directly from the raw GPS speed and number of pulses. Soft event occurs if this window average passes a series of criteria (see DR+GPS KF algorithm document 45172-XX-SP) and the offset relative to the DR DPP is large enough.

Action: The DPP estimate is snapped to the window average.

GPS receiver fixes not reasonable; try to recover.

Condition cause: pseudorange error or ephemeris error.

Effect before Action: GPS positions incorrect.

Soft Event Detected: Fix altitude is above 18000 m or below –1000 m and fix speed is above 515 m/s.

Soft Event Cleared: Cleared at reset.

Action (ROM15): Erase BBRAM and RTC, re-start unit.

Gyro readings do not stay within specification

Condition cause: Hardware failure.

Effect before Action: Position goes in circles.

Soft Event Detected: Average gyro reading over ten seconds at standstill is not between 2.0 V and 3.0 V.

Soft Event Cleared: Cleared at reset.

Action: Gyro labeled “bad”. DR suspended. Speed measurement continues and tacho continues to be calibrated.

No Tacho data when GPS is detecting movement

Condition cause:	Tacho is disconnected or malfunctioning.
Effect before Action:	Position solution will be not change when moving.
Soft Event Detected:	GPS speed > 8.0 m/s and no tacho pulses reported (except heartbeats) for 15 GPS fixes.
Soft Event Cleared:	Tacho pulse is reported, or unit is reset.
Action:	Tacho labeled as “absent”. DR is suspended. Heading measurement continues and gyro continues to be calibrated.

Excessive tacho data is received for a long period of time

Condition cause:	Wheels spinning, other tacho malfunction.
Effect before Action:	Position fixes move at higher speed than actual position.
Soft Event Detected:	Not implemented in ROM 15. Function partly done by DPP recovery.

Reverse signal opposite to direction determined by GPS.

Condition cause:	Disconnected reverse switch.
Effect before Action:	Reverse driving is mistaken for forward driving, resulting in incorrect position.
Soft Event Detected:	Driving in reverse at raw GPS speed > 14 m/s.
Soft Event Cleared:	Driving forward at raw GPS speed > 14 m/s.
Action:	Direction Switch sense changed.

Large jump at power-up

Condition cause:	Position in BBRAM incorrect (e.g., travel by ferry).
Effect before Action:	Positions are offset by many kilometers after power-up.
Soft Event Detected:	Offset between first three GPS points and DR position > 2000 m.
Action:	Reset position to average GPS position.

Oscillator values are not within specification.

Condition cause:	Excessive temperature response or aging of crystal.
Effect before Action:	Extended time-to-first fix.
Soft Event Detected:	Not implemented in ROM 15.

Antenna open detected.

Condition cause:	Hardware failure.
Effect before Action:	No GPS positions.
Soft Event Detected:	Hardware signal queried at one Hz.
Soft Event Cleared:	Hardware signal queried at one Hz.
Action:	DR functions without GPS positions.

Antenna short detected.

Condition cause: Hardware failure.

Effect before Action:	No GPS positions.
Soft Event Detected:	Hardware signal queried at one Hz.
Soft Event Cleared:	Hardware signal queried at one Hz.
Action:	DR functions without GPS positions.

Failure to connect to GPS DSP.

Condition cause:	Hardware failure.
Effect before Action:	No GPS positions.
Soft Event Detected:	No response from DSP within 5 seconds.
Action:	DR functions without GPS positions.

RTC disagreed with GPS time

Condition cause:	Low battery voltage while powered down.
Effect before Action:	Long time to first fix.
Soft Event Detected:	Not implemented in ROM15.

Gyro Failure.

Condition cause:	Hardware failure.
Effect before Action:	Position goes in circles.
Soft Event Detected:	Tested with ADC at startup. Also tested at standstill; average gyro values (one-second averages) are collected over ten seconds at standstill. If average is not between 0.75 V and 4.25 V, declare detection.
Soft Event Cleared:	Cleared at reset.
Action:	Gyro labeled “bad”. DR suspended. Speed measurement continues and tacho continues to be calibrated.

ADC Failure.

Condition cause:	Hardware failure.
Effect before Action:	Position goes in circles.
Soft Event Detected:	At power-up.
Action:	Gyro labeled “bad”. DR suspended. Speed measurement continues and tacho continues to be calibrated.

Gyro Shorted to 3.3 V.

Condition cause:	Hardware failure.
Effect before Action:	Position goes in circles.
Soft Event Detected:	Average and range of gyro values (one-second averages) are collected over ten seconds at standstill. If average is between 3.05 V and 3.55 V, and range is less than six mV, declare detection.
Soft Event Cleared:	Cleared at reset.
Action:	Gyro labeled “bad”. DR suspended. Speed measurement continues and tacho continues to be calibrated.

APPENDIX

C

SPECIFICATIONS

Table 96: Power Supply for Internal DR Module

Characteristic	Conditions	Min.	Typical	Max.	Unit
Supply voltage	Pin 7	3.0	3.3	3.6	VDC
Power consumption	Excluding antenna		190	250	mW
Supply voltage noise ripple	From 1Hz to 1MHz			100	mVpp
Input capacitance on power supply			22		µF
Power supply for Low Noise Amplifier of active antenna	Power Supply for antenna is an external input for this module. Pin 2		5.0		VDC
Supplied current for Low Noise Amplifier of active antenna	5.0V Miniature GPS Vehicle Ant. 3.0V Miniature GPS Vehicle Ant. (at room temperature)			30 15	mA
Load capacitance of the antenna				0.3	µF
Backup Power Supply		2.5		3.6	VDC
Backup Current	Over temp. range –40 ,+85C			70	uA

NOTE All specifications are over the entire temperature range, -40C to +85C

Table 97: Power Supply for DR+GPS Starter Kit Unit

Characteristic	Conditions	Min.	Typical	Max.	Unit
Supply voltage		9.0	13.5	32.0	VDC
Supply current	Excluding antenna		70		mA

NOTE All specifications are over the entire temperature range, 0C to +60C

Table 98: RF Characteristics

Characteristic	Conditions	Min.	Typical	Max.	Unit
Tracking sensitivity	At the RF connector input of the receiver	-140			dBm
Acquisition sensitivity	At the RF connector input of the receiver	-130			dBm
Noise Figure			16	21	dB
Dynamic range				20	dB
Resistance to broadband noise jamming	jamming to signal ratio at antenna input within input filter bandwidth of 20MHz; GPS Signal Power ≥ -160dBW			20	dB
Input impedance			50		Ω

Table 99: Tachometer

Characteristic	Min.	Typical	Max.	Unit
Voltage input		12.0		V
Frequency			3000	Hz

Data I/O

The DR+GPS Module supports the following characteristics:

- CMOS/TTL levels on TXD and RXD
- Fixed UART baud rates

Table 100: Data I/O

Characteristic	Conditions	Min.	Typical	Max.	Unit
Data rate NMEA and HIPPO	+/- 3% error rate		38.4		kbps
Input voltage	low level at 50 uA high level at 50 uA	 2.0		0.8	V
Output voltage	low level at 4 mA at Supply Voltage high level at 4 mA at Supply Voltage	 2.4		0.4	V
Input current	low level high level	-50 -50		50 50	μA
Data latency after PPS	Delta between PPS and packet transmission			100	ms

Table 101: PPS

The PPS is present once power is applied to the unit.

Table 102: PPS Characteristics

Characteristic	Conditions	Min.	Typical	Max.	Unit
Timing accuracy	To UTC time with valid position fixes			±500	ns
Pulse duration			80	90	us
Rise time of leading edge	Rising edge is synchronized to UTC second.			25	ns
Output voltage			2.76		V

Table 103: Gyro

Supported GYRO units are:

- Epson XV-810
- Epson XV-8100CB (3V)
- Epson XV-8000CB (5V)
- Murata ENX-0126
- Panasonic EWTS-82

Table 104: 3 Volt Gyros

Characteristic	Min.	Typical	Max.	Unit
Vgyro	0		3.3	V
Gyro rate		2.5		mV/(degree/s), +/- 10%
Zero Rate Output (Epson)		1.35		V

Note: Check with your local Trimble Sales for the latest version of Lassen DR+GPS firmware that supports your Gyro option.

The Murata part cannot fit inside the Lassen DR+GPS starter kit due to an incompatible pin-out, but could be suitable for use in a customer application.

Confirm that the Gyro used with the Lassen DR+GPS starter kit has the same pin-out as the Panasonic EWTS-82 and uses the specification to what is listed in the table above.

Table 105: 5 Volt Gyros

Characteristic	Min.	Typical	Max.	Unit
Vgyro	0		5	V
Gyro rate		25		mV/(degree/s), +/- 10%
Zero Rate Output (Epson)		1.76		V
Zero Rate Output (Panasonic)		2.5		V

Notes: Check with your local Trimble Sales for the latest version of the Lassen DR+GPS firmware that supports your Gyro option.

GPS Antenna

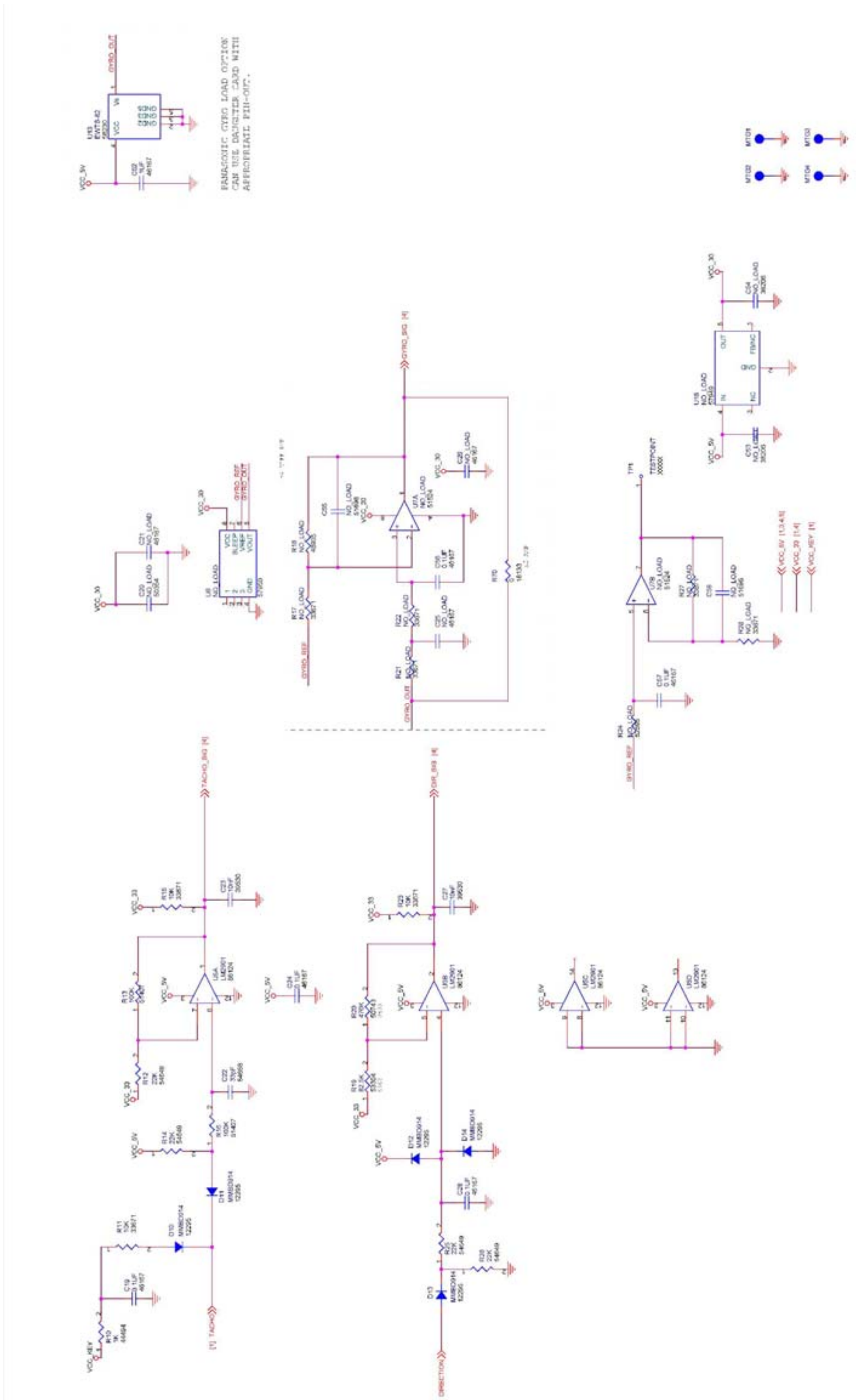
The antenna receives the GPS satellite signals and passes them to the receiver. The GPS signals are spread spectrum signals in the 1575MHz range and do not penetrate conductive or opaque surfaces.

Therefore, the antenna must be located outdoors with a clear view of the sky. The Lassen DR+GPS Module receiver requires an ***active*** antenna. The received GPS signals are approximately -130 dBm, at the surface of the earth (in typical environments). Trimble's active antennas include a preamplifier that filters and amplifies the GPS signals before delivery to the receiver.

Trimble offers a range of suitable antennas for use with the Lassen DR+GPS Module.

Keep in mind that the DR+GPS module needs an LNA to work properly. The gain of the LNA should be approximately 18 dB as a minimum, and 35 dB maximum.

2. Reference Board Diagram (5V Gyro)



3. Reference Board Diagram (3V Gyro)

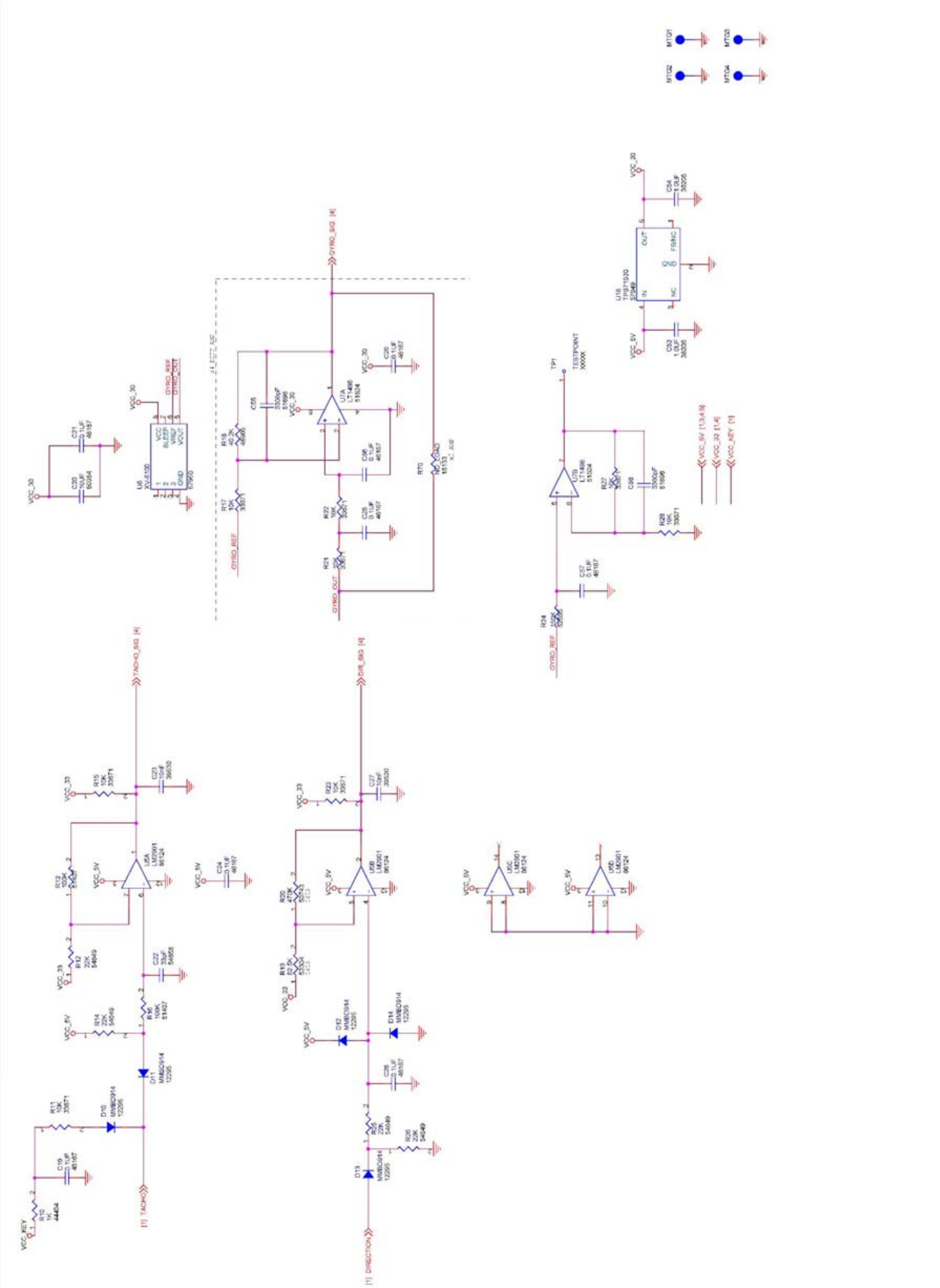
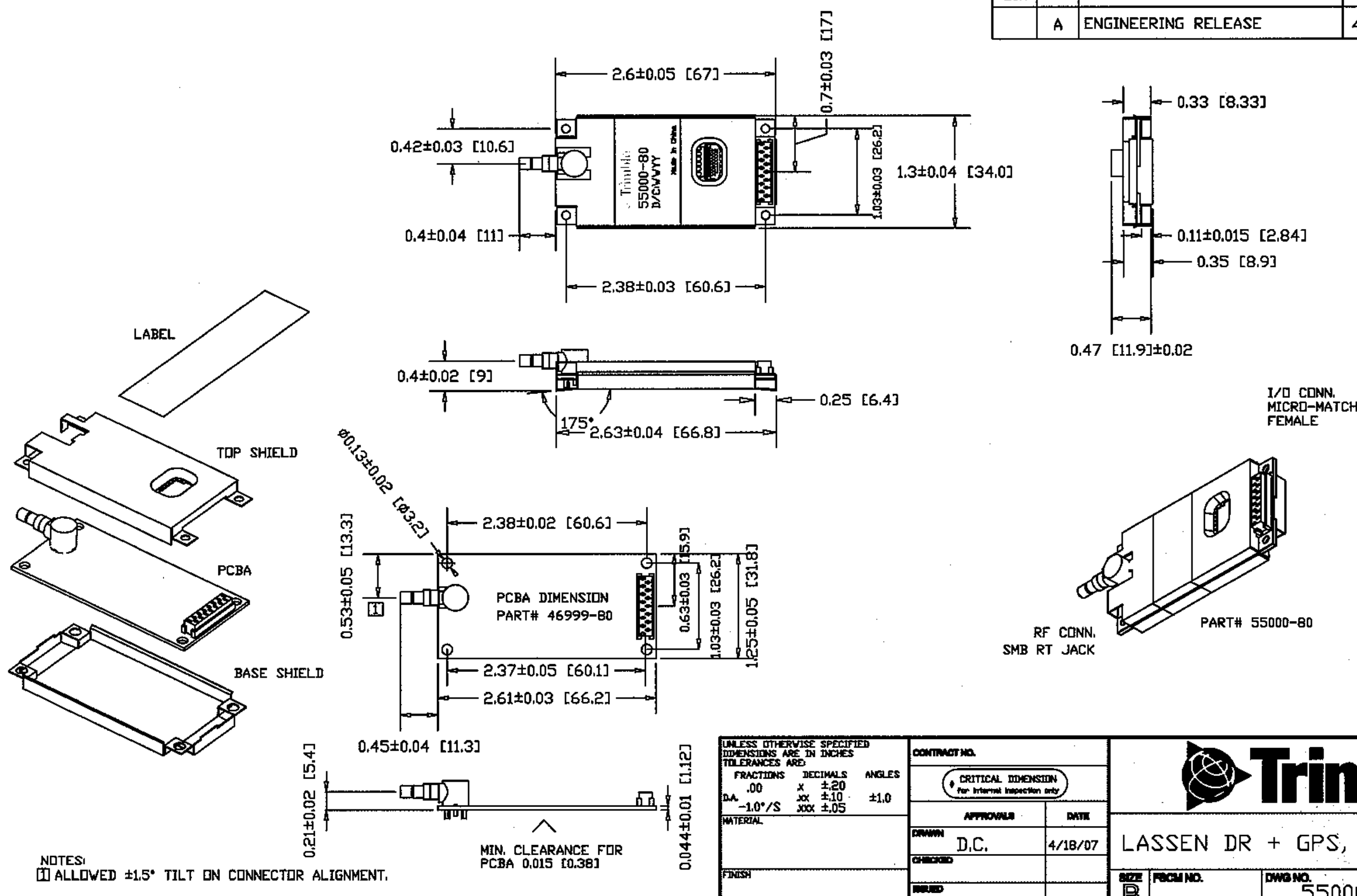


Table 106: Table 115: DR Module Pin Assignments

Pin	Input/Output	Function	Description
1	Output	TX2	Factory use only
2	Input	Vantenna	Voltage for GPS antenna (+5V)
3	Output	TX1	Serial port1 transmit
4	Input	Vbackup	Backup power (2.5 - 3.6V)
5	Input	RX1	Serial port1 receive
6	Output	PPS	Pulse per second
7	Input	VCC	Main Power (+3.3V)
8	Input	GND	Power Ground
9	Input	Gyro input	Analogue gyro input
10	Input	Tacho 1	Tacho pulses (Tacho only or ABS-L) (0/3.3V)
11	Input	Reset	External Reset
12	Input	Reverse Signal	Forward/backward signal (0/3.3V)
13	Input	Gyro_GND	Gyro Ground
14	Input	Vgyro	Voltage for gyro circuitry (3.3 or 5V)

REVISIONS				
ECN	REV	DESCRIPTION	DATE	APPROVED
	A	ENGINEERING RELEASE	4/18/07	D.C.



NOTES:
1 ALLOWED ±1.5° TILT ON CONNECTOR ALIGNMENT.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
.00	.X ±.20	
D.A. −1.0°/S	.XX ±.10	±1.0
	.XXX ±.05	

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO.

CRITICAL DIMENSION for internal inspection only

APPROVALS		DATE
DRAWN	D.C.	4/18/07
CHECKED		
ISSUED		

ALL DIMENSIONS IN mm

Trimble

LASSEN DR + GPS, MECH. SPEC.

SIZE	FSCM NO.	DWG NO.	REV
B		55000-80-MS	A

SCALE 2X SHEET 1 OF 1

DWG NO.	SHT.	REV.
55000-80-MS		A

FILE: 55000-80-MS