Galileo Test Signal Generator (GTS)

USER MANUAL

Galileo Test Signal Generator (GTS) User Manual

Publication Number:	OM-20000092
Revision Level:	1
Revision Date:	2006/03/25

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Galileo Test Signal Generator	One (1) Year from date of sale

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There are no user serviceable parts in the Galileo Test Signal Generator and no maintenance is required. When the status code indicates that a unit is faulty, replace with another unit and return the faulty unit to NovAtel Inc.

Before shipping any material to NovAtel or Dealer, please obtain a Return Material Authorization (RMA) number from the point of purchase.

Once you have obtained an RMA number, you will be advised of proper shipping procedures to return any defective product. When returning any product to NovAtel, please return the defective product in the original packaging to avoid ESD and shipping damage.

Foreword

Congratulations!

Congratulations on your purchase of the Galileo Test Signal Generator (GTS) designed to generate a Galileo signal.

NovAtel is an industry leader in state-of-the-art GPS receiver and Signal Generator design. We believe that our GTS will meet your high expectations, and are working hard to ensure that future products and enhancements will maintain that level of satisfaction.

This is your primary hardware and software reference.

Scope

This manual contains sufficient information on the installation and operation of the GTS and its software to allow you to effectively integrate and fully operate it. It is beyond the scope of this manual to provide details on service or repair. Contact your local NovAtel dealer for any customer-service related inquiries.

The GTS utilizes a comprehensive user-interface command structure, which requires communications through its communications (COM) ports. GTS commands and logs can be found in *Chapter 5, Messages* starting on *Page 23*.

Chapter 1 Introduction

The Galileo Test Signal Generator (GTS) is a high performance Galileo L1/E5a signal generator. Please see *Appendix B, Galileo on Page 50* for more on the Galileo system. The GTS generates:

- L1 codes with Pseudo Random Number (PRN) values of 1 to 50 (selectable via the Initialization Command, see *Page 25*)
- 70 MHz BOC (1,1) modulated IF output signal generation using the I/NAV message with the selected 1023 bit PRN code
- In-phase (I) channel, or I channel with dataless quadrature (Q) channel
- 1575.45 MHz BOC (1,1) modulated Radio Frequency (RF) output signal generation using the I/NAV navigation message with the selected 1023 bit PRN code

and for E5a:

- E5a codes with PRN values of 1 to 50 (select using the Initialization Command, see *Page 25*)
- 70 MHz Bi-Phase Shift Key (BPSK) modulated IF output signal generation using the F/NAV message with the selected 10230 bit PRN code
- In-phase (I) channel, or I channel with dataless quadrature (Q) channel
- 1176.45 MHz BOC (1,1) modulated RF output signal generation using the F/NAV message with the selected 10230 bit PRN code

Figure 3 on *Page 14* shows an example of a system containing the GTS and Galileo Test Receiver (GTR).

Once you connect the GTS to a data source and a computer, it is ready to operate as a fully functional signal generator (see *Chapter 2, Minimum Connections on Page 14* and *Chapter 3, Setup Considerations on Page 16,* for more information on this topic). *Figure 1* shows the GTS without any connecting cables.

Figure 1: Galileo Test Signal Generator

1.1 Features

The GTS has the following standard features:

- Rack-mountable metal enclosure
- NovAtel's advanced signal generator technology

1.2 Accessories and Options

The GTS can be used with the following accessories:

- Power cable to connect the GTS to a +100 to +240 V AC power source
- Navigation data generator
- Optional coaxial cables for the TNC and BNC connectors on the GTS
- Optional GTR

Should you need to order an accessory or a replacement part, contact NovAtel.

1.3 Functional Overview

The signal generator is comprised of two independent L1 and E5a generators. These generators control the frequency and phase of the L1 and E5a code and carrier, and generate two independent L1 and E5a 70 MHz IF signals. The signal generator provides two loopback signals. These RF signals will be upconverted replicas of the 70 MHz L1 and E5a outputs. The 70 MHz L1 is upconverted to the Galileo L1 frequency of 1575.42 MHz and the 70 MHz E5a is upconverted to the Galileo E5a frequency of 1176.45 MHz.

The two L1 and E5a generators are housed within a common chassis. Each signal generator:

1. Accepts raw Galileo message symbols at a rate of one message packet per second (L1) or one message packet per 10s (E5a)
2. FEC Encodes the data
3. Block interleaves the data
4. Adds synchronization bits to the data
5. Generates and applies the specified PRN encoding to the data
6. Modulates the resulting encoding on to an in-phase ‘I’ channel carrier signal
7. Modulates the resulting encoding on to a quadraphase ‘Q’ channel carrier signal
8. Generates the accompanying ‘Q’ channel signal and adds it to the ‘I’ channel

Each of these sections are discussed in further detail in the following sections. *Figure 2* on *Page 13* shows the interfaces of the GTS.

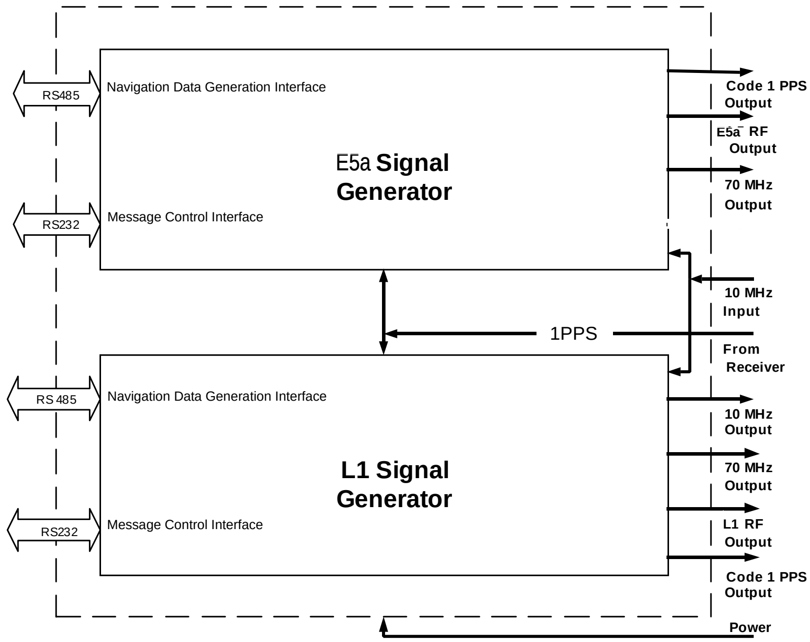


Figure 2: Interface Block Diagram

After a cold start or after a power reset, the GTS performs an IBIT memory self-test.

Provided a 1PPS reference source is made available to the GTS, it can receive Navigation messages from the Navigation Data Generator within 2 minutes of powering up.

Chapter 2 Minimum Connections

Figure 3 displays how you might typically set up the GTS at the office to test the signal.

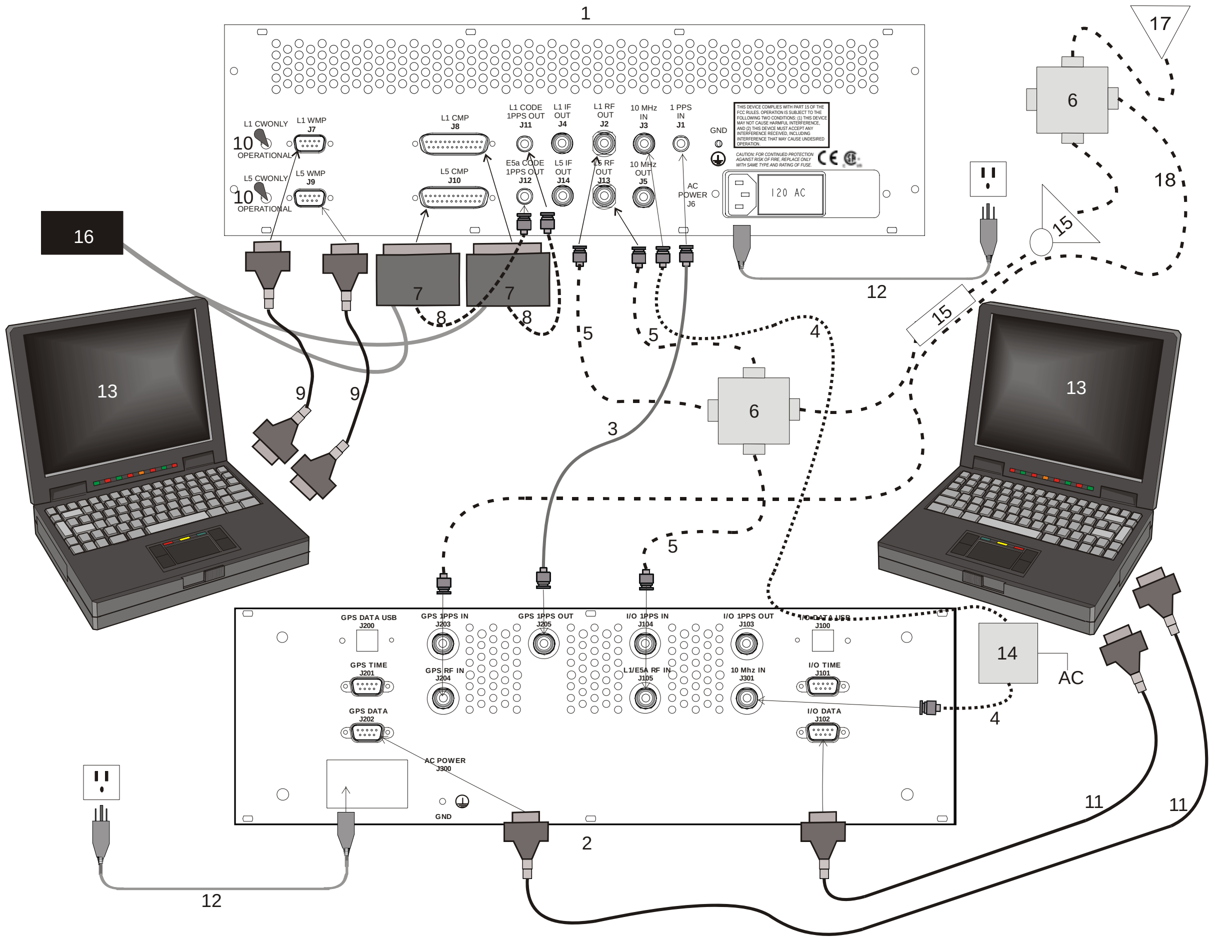


Figure 3: Typical Signal Generator Setup

Reference	Description
1	Supplied Galileo Test Signal Generator (GTS)
2	Galileo Test Receiver (GTR)
3	Coaxial cable from the 1PPS IN port on the GTS to the GPS 1PPS OUT port on the GTR
4	Coaxial cable from the 10 MHz IN ports on both the GTS and the GTR to (*14*)
5	Coaxial cable from a splitter to the L1 RF OUT and L5 RF OUT ports on the GTS, and coaxial cable from the same splitter to the L1/E5a RF IN port on the GTR
6	Splitter
7	L1 and E5a dongles connected to the L1 CMP and L5 CMP ports on the GTS respectively
8	DB-25 cables from the L1 and E5a dongles to the L1 CODE and L5 CODE ports on the GTS
9	DB-9 cables from the L1 WMP and L5 WMP ports on the GTS to a *(13)*
10	L1 and L5 continuous wave (CW) switches
11	DB-9 cables from the GPS DATA and I/O DATA ports on the GTR to a *(13)*
12	Power cables (120 V AC)
13	Personal computer (PC)
14	External 10 MHz reference with its own AC power source
15	Coaxial cable to a splitter with an interconnecting attenuator and 15 V DC amplifier
16	5 V DC power adapters
17	Live GPS antenna connected with coaxial cable to splitter in (*15*)
18	Coaxial cable from the GPS RF IN port on the GTR to the splitter in (*15*)

A typical configuration would result from the following steps (see also *Figure 3*):

1. Place the GTS on a desk or other suitable work surface.
2. Connect the 1PPS IN port on the GTS to the GPS 1PPS OUT port on the GTR with interconnecting coaxial cable. A typical coaxial cable is shown in *Figure 4*.

Figure 4: Coaxial Cable

3. Connect the 10 MHz IN port on the GTS and the 10 MHz IN port on the receiver with interconnecting coaxial cables to the external 10 MHz reference.
4. Connect a GPS antenna to two splitters with a 15 V DC amplifier and an attenuator between them.
5. Connect the L1 and E5a dongles to the L1 CMP and L5 CMP ports respectively.
6. Connect the L1 Code and L5 Code 1PPS OUT ports on the GTS to the L1 and E5a dongles.
7. Connect the splitter closest to the antenna to the GPS RF IN port on the GTR with coaxial cable (see *Step #4*).
8. Connect the L1 and L5 RF OUT ports on the GTS and the L1/E5a RF IN port on the GTR to the splitter furthest from the antenna with interconnecting coaxial cables (see *Step #4*). The GTS L1 RF OUT, L5 RF OUT and the live GPS signal are now combined into one RF signal that is input into the GTR.
9. Connect the L1 and L5 WMP ports on the GTS to serial ports on your PC with serial cables.
10. Connect the GPS DATA and I/O DATA ports on the GTR to serial ports on your other PC with serial cables.
11. Connect AC power to the power input port on the back of the GTS using the supplied power cable. Similarly, power the GTR. Ensure that your PCs and external 10 MHz reference are also powered.
12. Press the power switch on the back of the GTS, see *Figure 5*. The Power LED on the front panel glows green while power is applied.

Figure 5: Power Switch

13. Configure and monitor your L1 and E5a data using the Galileo SigGen Graphical User Interface (GUI) program on your PC, see also *Chapter 6, Galileo SigGen GUI* starting on *Page 38*.

The sections of *Chapter 3, Setup Considerations on Page 16* give further details on steps #1 to #11 while *Chapter 4, Operation on Page 21* helps with step #12. See the GTS specific command and logs in *Chapter 5, Messages on Page 23*. For other commands and logs available with the Galileo Test Receiver, please refer to its user manual (*OM-20000082).*

Chapter 3 Setup Considerations

The GTS is a device that is intended for use in dry stable environments. It is available with the following NovAtel accessories and options:

- Galileo Test Receiver
- Coaxial cable to connect the GTS to the GTR
- Supplied power cable
- Navigation Data Generators
- Galileo SigGen GUI

3.1 Front Panel Functionality

As seen in *Figure 6*, there is a power LED that glows green when power is applied to the GTS.

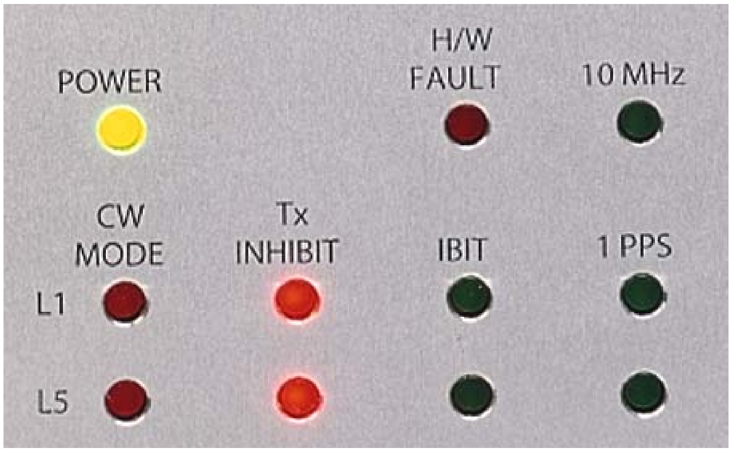


Figure 6: Signal Generator Front Panel

3.1.1 H/W Fault

This LED glows red when there is an internal hardware fault. See also *Section 5.1.4.6, Hardware Status Fields on Page 33.*

3.1.2 10 MHz

This LED glows green when there is a 10 MHz reference present. The 10 MHz reference input level is in the range +12 to +14 dBm and has an impedance of 50 ohms.

3.1.3 CW Mode

When the L1 CW Only or E5a CW Only switch is manually selected, the GTS removes all modulation from the L1 or E5a signal carrier respectively. The corresponding LED on the front panel glows red at the same time.

3.1.4 Transmit Inhibit (Tx INHIBIT)

This L1 or E5a Tx INHIBIT LED glows red if the L1 or E5a IF output is disabled. Incomplete L1 or E5a message data transfer forces the unit to inhibit L1 or E5a signal transmission respectively for one second following the error.

This transmit inhibit function is controlled by a discrete signal that is applied via the Navigation Data Generators. This function is fail safe, so that if the control lines become open the transmission is inhibited.

3.1.5 Initiated Built in Test (IBIT)

IBIT is performed at power-up or upon a hardware reset. IBIT includes ROM and RAM testing. The front panel specifies whether the L1 or E5a IBIT passed or failed. A green LED signifies an IBIT pass and an unlit LED signifies an IBIT failure.

3.1.6 1PPS

The 1PPS LEDs cycle at a 1 Hz rate to indicate the presence of a 1PPS output signal.

3.2 Rear Panel Functionality

The connections on the rear panel and their connector types are shown in *Figure 7*.

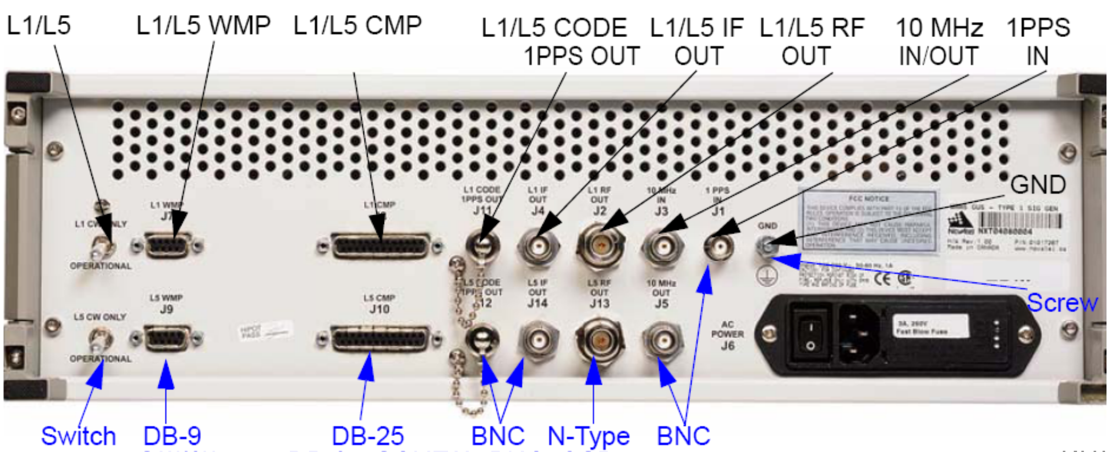


Figure 7: Close-up of Connectors on Rear Panel

Each connector is keyed to ensure that the cable can be inserted in only one way, to prevent damage to both the GTS and the cables. Furthermore, the connectors that are used to mate the cables to the GTS require careful insertion and removal. Observe the following when handling the cables.

- To insert a cable, make certain you are using the appropriate cable for the port - the serial cable has a different connector (DB9) than the PPS cable (BNC), or the RF cable (N-Type) connectors.

WARNING: DO NOT PULL DIRECTLY ON THE CABLES.

3.2.1 Power

After initial connection of the power supply to the GTS and pressing the power switch on the back of the unit (see *Figure 7* above), the Power LED on the front of the unit (see *Figure 6* on *Page 16*) glows green.

The GTS requires an input supply voltage that comes from a normal power source of 120 volts at 60 Hz AC through its 3-pin power connector.

The Power Input connector on the GTS contains two 3 A fast-blow fuses that can be serviced as long as the GTS is disconnected from power.

For a listing of the required input supply voltages, see *Input/Output Connectors on Page 47*. For more information on the supplied 3-pin power cable, see *Section A.1.2.1, Power Cable on Page 49.*

3.2.2 CW Switch

The GTS provides a L1 CW and a E5a CW switch which removes all modulation from the L1 IF and RF or E5a IF and RF carriers respectively.

3.2.3 Navigation Data Generator

The GTS is supplied with two Navigation Data Generators for testing purposes. These dongles, see *Figure 8* below, are programmed with test Galileo I/NAV and F/NAV messages that are modulated onto the L1 and E5a signals. *Figure 8* also shows the 120 V AC power adapter that comes with each one.

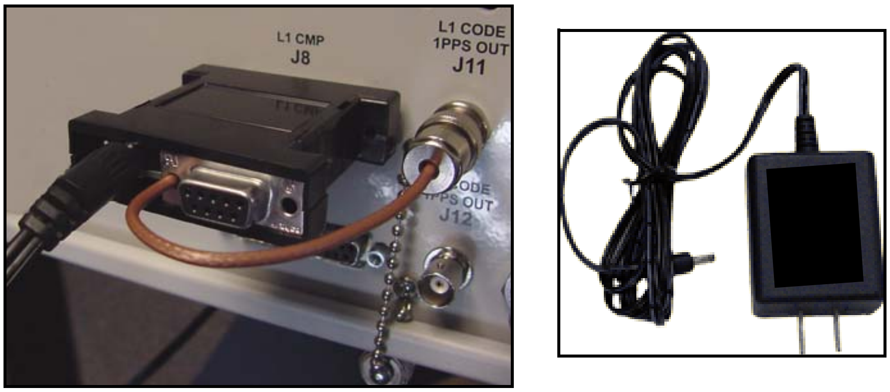


Figure 8: Navigation Data Generator (left) and Power Adapter (right)

Each Navigation Data Generator comes with:

1. A 120 V AC power supply adapter
2. An RS-485 interface with the GTS
3. A Joint Test Action Group (JTAG) programming interface
4. A 1-PPS input signal (from the GTS)

The GTS must be connected to the Navigation Data Generators (as shown in *Figure 3* on *Page 14*) in order to transmit Galileo signals.

The Navigation Data Generator has been programmed with a repeating sequence of satellite frame data messages.

Navigation Data Generators can be re-programmed through a JTAG interface.

3.2.4 Navigation Data Generator and Message Processor

Each GTS has independent command and status interfaces, and communicates over this interface with a host computer (Message Processor - MP). Similarly, the message interface for each GTS is independent, and communicates with a message generator (the Navigation Data Generator).

The GTS is capable of L1 or E5a communications via two ports, L1 WMP and L5 WMP respectively.

3.2.5 Code PPS Output

The L1 and L5 Code PPS Out ports allow synchronization of an external Navigation Data Generator with the modulated L1 or E5a signal available respectively.

3.2.6 1PPS Update

The 1PPS update level is an active low pulse with TTL levels and an impedance of 3.4 KΩ. It is also factory-configurable to 50 Ω.

The pulse width of the 1PPS update is 200 ms nominally with a repetition rate of 1PPS. The high to low transition is the reference edge. The high to low transition time is 5 ns or less. The high to low transition jitter with respect to the 10 MHz is 1 ns or less.

For further information on the electrical specifications or connector type for the 1PPS IN port, please see *Input/Output Connectors* on *Page 47*.

3.2.7 10 MHz In and 10 MHz Out

There are two reference signal BNC connectors on the back of the GTS for 10 MHz In and 10 MHz Out.

The default oscillator for the GTS is the internal OCXO. If you prefer you can provide your own external oscillator through the 10 MHz In connector. The GTS uses the 10 MHz input when detected. The GTS accepts a 10 MHz reference with the phase noise characteristic shown in *Table 1* below.

Table 1: 10 MHz Reference Phase Noise

Offset from Carrier	Phase Noise (≤)
1 Hz	-108 dBc/Hz
10 Hz	-134 dBc/Hz
100 Hz	-144 dBc/Hz
1000 Hz	-150 dBc/Hz

The 10 MHz output provides a high-stability reference signal. It permits the synchronization of other equipment operating at this frequency. The 10 MHz output is buffered from the current system reference signal. These may be the internal OCXO or an external 10 MHz input. Its output amplitude is in the range 0 to +6 dBm and its output impedance is 50 ohms.

For further information on the signals or connector type for the 10 MHz In and 10 MHz Out ports, please see *Input/Output Connectors* on *Page 47*.

3.2.8 RF Out

The L1 and E5a RF Out connectors provides Radio Frequency (RF) signals from the GTS. It is normally used to provide the L1 and E5a signals to a NovAtel Galileo Test Receiver via coaxial cable.

The GTS contains RF circuits to modulate and convert the digital In-Phase and Quadrature (I and Q) data streams to an RF signal spectrum.

The level of the unmodulated L1 RF Out of the GTS is in the range -100 dBm ± 1.5 dB with an RF output frequency of 1575.42 MHz. The E5a RF Out is in the range -100 dBm ± 1.5 dB with a RF output frequency of 1176.45 MHz.

The GTS L1 RF output is BOC (1,1) modulated at a 1.023 MHz rate. The E5a RF output is at 10.23 MHz. The RF output modulator phase imbalance is within ±3 degrees.

For further information on the signals or connector type for the RF Out connectors, please see *Input/Output Connectors* on *Page 47*.

3.2.9 IF Out

The L1 and E5a IF Out connectors provide Intermediate Frequency (IF) signals from the GTS. It is normally used to provide L1 and E5a signals that are uplinked to the GEO satellite.

The signal amplitude is within the range -20 dBm ± 1.5 dB for any specified I/Q configuration. The signal amplitude is stable to within 0.7 dB at ambient temperature and within 1.4 dB over the operating temperature range.

The factory configurable L1 signal (2, 4 or 22 MHz) is filtered by IF filters having the characteristics described in *Table 2* on *Page 20*.

Table 2: L1 IF Bandwidth Requirements

Nominal Bandwidth	3 dB Bandwidth	20 dB Bandwidth	40 dB Bandwidth
2 MHz	$\geq$ 2 MHz	± 1.5 MHz typical	$\leq$ 3.6 MHz
4 MHz	$\geq$ 4 MHz	± 2.6 MHz typical	$\leq$ 6.0 MHz
22 MHz	$\geq$ 22 MHz	± 12.5 MHz typical	$\leq$ 28 MHz

The IF output provides the phase noise characteristic shown in *Table 3*.

Table 3: IF Output Phase Noise

Offset from Carrier	Phase Noise ($\leq$)
1 Hz	-65 dBc/Hz
10 Hz	-85 dBc/Hz
100 Hz	-90 dBc/Hz
1 KHz	-95 dBc/Hz
10 KHz	-100 dBc/Hz
100 KHz	-108 dBc/Hz

The L1 CW Only switch forces the unit to remove all modulation from the signal carrier (with I and Q signals both forced to zero).

Disabling of the L1 output signal from the GTS occurs under specific operating conditions identified in *Section 5.2, Error Handling on Page 37*.

The E5a signal is filtered with a 22 MHz IF filter having the characteristics described in *Table 4*.

Table 4: E5a IF Bandwidth Requirements

Nominal Bandwidth	3 dB Bandwidth	20 dB Bandwidth	40 dB Bandwidth
22 MHz	$\geq$ 22 MHz	± 12.5 MHz typical	$\leq$ 28 MHz

The output impedance for L1 and E5a is 50 Ohms.

Chapter 4 Operation

Before operating the GTS for the first time, ensure that you have followed the installation instructions of *Chapter 2, Minimum Connections* on *Page 14* and *Chapter 3, Setup Considerations* on *Page 16.* The following instructions are based on a configuration such as that shown in *Figure 3, Typical Signal Generator Setup on Page 14*. It is assumed that a personal computer is used during the initial operation and testing for greater ease and versatility.

4.1 Communications with the GTS

Communication with the GTS is straightforward, and consists of issuing commands through the communication ports from an external serial communications device. This could be either a terminal or an IBM-compatible PC that is directly connected to the GTS serial port using an extension cable. For information about commands and logs that are useful for basic operation of the GTS, please see *Chapter 5, Messages* on *Page 23*.

4.1.1 Serial Port Default Settings

The GTS communicates with your PC or terminal via the communication ports. For communication to occur, both the GTS and the operator interface have to be configured properly. The GTS data ports' settings are as follows:

- **19200 bps, odd parity, 8 data bits, 1 stop bit, cts/rts handshaking, echo off**

4.1.2 Communicating Using a Remote Terminal

One method of communicating with the GTS is through a remote terminal. The GTS allows proper RS232 interface with your data terminal. To communicate with the terminal, the GTS requires the RX, TX, and GND lines to be used. Ensure that the terminal's communications set-up matches the GTS's RS232 protocol.

4.1.3 Communicating Using a Personal Computer

An IBM-compatible PC can be set up to emulate a remote terminal as well as provide the added flexibility of creating multiple-command batch files and data logging storage files. Any standard communications software package that emulates a terminal can be used to establish bidirectional communications with the GTS. No particular terminal type is assured. All data is sent as raw characters.

You can create command batch files using any text editor; these can then be directed to the data port that is connected to the GTS using a communications software package. This is discussed later in this chapter.

4.2 Message Control and Data Lines

The Message Interface provides the necessary control and data lines to allow downloading of data symbols from the Navigation Data Generator to the GTS. These lines are:

1. MSGRDY from Navigation Data Generator to GTS
2. MSGCLK from GTS to Navigation Data Generator
3. MSGDATA from Navigation Data Generator to GTS

After a compared message is stored in the Navigation Data Generator output buffer, the Navigation Data Generator sets the Message Ready flag to the GTS.

The Message Ready signal enables the GTS internal 1 MHz clock (period 1 ms) which is then returned to the Navigation Data Generator.

The Navigation Data Generator counts 120 clocks for L1 and 244 clocks for E5a. It then resets the Message Ready flag after the 120th clock for L1 and after the 244th clock for E5a. For each clock, the Navigation Data Generator transfers each data bit from its output buffer on the leading edge, and the GTS samples the data bit on the trailing edge. The data bits are then transferred from the Navigation Data Generator to the GTS at the 1 MHz rate. The GTS buffers each L1 and E5a message from the Navigation Data Generator.

After MSGRDY has been asserted, the GTS sends its first clock within 1 microsecond of the assertion. After the last clock, MSGRDY is not reasserted until after another 4 microseconds. The interface timing is shown in *Figure 9*.

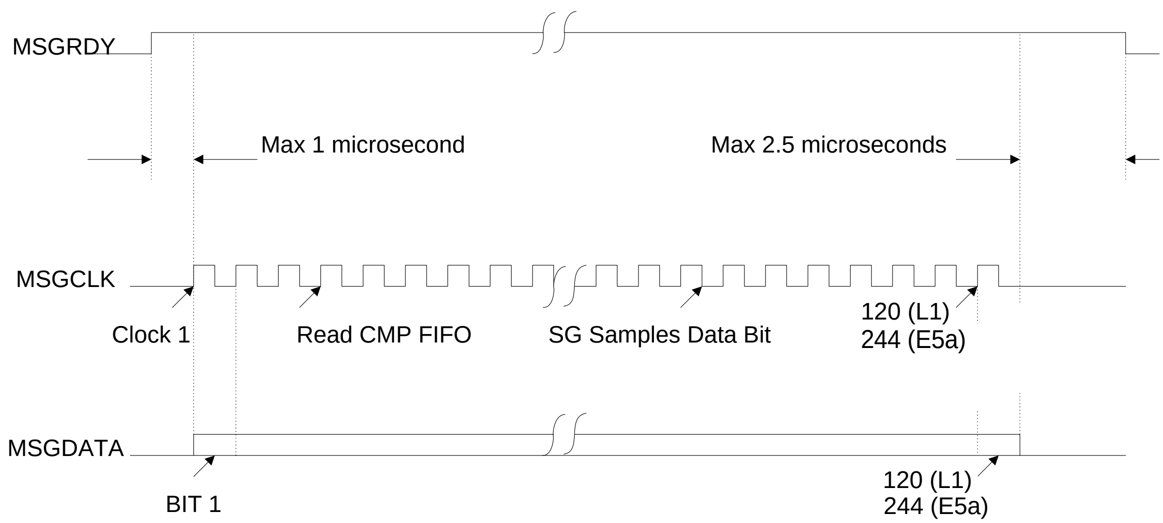


Figure 9: RS-485 Symbol Timing Diagram

Chapter 5 Messages

5.1 MP Message Structure

Command and status messages are exchanged between the Message Processor (MP) and the GTS using an RS-232 link. Both command and status messages are encapsulated in a fixed length packet. This packet contains a synchronization field, a L1/E5a indication field, message data fields and a CRC field for reliable packet transfer. *Table 5* shows the format of a message packet. Binary messages (command or status) are received by the GTS in byte order [0] through [35]. The GTS swaps these bytes as necessary in order to recover the original data fields. The tables shown in this chapter indicate the order in which bytes are received and transmitted by the GTS.

Table 5: Packet Format

Field	Bytes	Byte Position	Description
1	4	Byte [0:3]	Packet Synchronization Bytes Field (start of packet)
2	1	Byte [4:4]	L1/E5a Indication Field
3	29	Byte [5:33]	Command Message Payload Fields or Status Message Payload Fields.
4	2	Byte [34:35]	16 bit CRC Field.

5.1.1 Packet Synchronization Field

The packet synchronization field consists of four (4) bytes containing the hex value 0xAA5555AA. The GTS looks for these synchronization bytes and interprets them to be the start of a new packet. Status messages transmitted to the MP also have these synchronization bytes encoded to the hex value 0xAA5555AA. *Table 6* shows the Packet Synchronization field. *Table 7* shows the Packet Synchronization field byte and bit order.

Table 6: Packet Synchronization Field

Field	Bytes	Byte Position	Description	Value
1	4	Byte [0:3]	Start of packet	0xAA5555AA

Table 7: Packet Synchronization Field Bit Format

Byte [0]	Byte [1]	Byte [2]	Byte [3]
D7 - D0	D15 - D8	D23 - D16	D31 - D25
D0 = LSB			D31 = MSB
0xAA	0x55	0x55	0xAA

5.1.2 L1/E5a Indication Field

This field consists of one (1) byte containing the L1 or E5a indication flag. If a command is targeted for a L1 GTS then this byte contains the integer value 1, otherwise the integer value 5 is used to indicate a E5a target. If a L1 signal generates a status message, this byte contains the integer value 1, otherwise the integer value 5 is used to indicate a E5a signal generation source. *Table 8* shows the L1/E5a Indication field.

Table 8: L1/E5a Indication Field

Field	Bytes	Byte Position	L1/E5a Destination	MP Destination
2	1	Byte [4:4]	L1=1, E5a=5	1=L1, E5a=5

5.1.3 Command Message

Table 9 shows the command message fields. The sections that follow indicate the data fields for all valid command message identifiers.

Table 9: Command Message Fields

Field	Bytes	Byte Position	Description
3-1	1	Byte [5:5]	Command Message Identifier Field
3-2	1	Byte [6:6]	Control Command Data Field
3-3	1	Byte [7:7]	SV number if Initialization
3-4	1	Byte [8:8]	Sub-Chip Field
3-5	2	Byte [9:10]	Code Chip Advance Field
3-6	2	Byte [11:12]	MSec Advance Field
3-7	2	Byte [13:14]	E5a I coder init XA(I) Field
3-8	2	Byte [15:16]	E5a Q coder init XB(Q) Field
3-9	6	Byte [17:22]	Code Chip Rate Field
3-10	2	Byte [23:24]	Code Chip Rate Ramp Field
3-11	6	Byte [25:30]	Carrier Frequency Field
3-12	3	Byte [31:33]	Carrier Frequency Ramp Field

5.1.3.1 Command Message Identifier Field

The Command Message Identifier field consists of one byte containing the command (instruction) message ID. Based on this ID, the GTS knows which data fields to interpret and what command needs to be executed. *Table 10* on *Page 24* shows the Command Message Identifier bit fields.

Table 10: Command Message Identifier Bit Fields

Bit	Command message (MP to GTS)	Command Message ID Field
D0	Control Command	0x01
D1	Initialization Command	0x02
D2	Code Chip Rate and Carrier	0x04
D3	Reserved for future use	0x08
D4	Reset Command	0x10
D5	Reserved for future use	0x20
D6	Reserved for future use	0x40
D7	Reserved for future use	0x80

5.1.3.2 Control Command

The Control Command provides for synchronous initialization of the E5a XA and XB code Generator states, code modulation, symbol modulation, I channel modulation and Q channel modulation. Upon receiving this command, the coder commences execution at the occurrence of the next 1-PPS update pulse. If a valid Initialization Command was not received prior to receiving this command, this command is not executed and the status message indicates the error. The Control command packet contains one byte of data. *Table 11* below shows the L1/E5a Control Command bit fields. This command must be preceded by an Initialization command to ensure that the I and Q coders have been reset, initialized and advanced to the correct state.

Table 11: L1/E5a Control Command Bit Fields

Bit	Description	Range	Purpose
D0	Initialize Range	0 - 1	1 = Start coders at next valid 1-PPS pulse
D1	Disable PRN Code	0 - 1	1 = Coder output not used in modulation
D2	Disable Message	0 - 1	1 = Symbol not used in modulation
D3-D7	Reserved for future use		

INITIALIZE RANGE FIELD

If this field (flag) is set, the GTS, upon receiving the next 1-PPS pulse, starts the I and Q coders.

DISABLE PRN CODE FIELD

If this field (flag) is set, the GTS does not use the I or Q codes in modulation. The I modulation consists of symbols (if enabled) and NH codes. The Q modulation only consists of NH codes.

DISABLE MESSAGE MODULATOR FIELD

If this field (flag) is set, the GTS does not use the I message symbols in modulation. The I modulation consists of I codes (if enabled) and NH codes.

5.1.3.3 Initialization Command

This command specifies the initial range (modulo 1 second) value to be used by the GTS. *Table 12* shows the initialization data fields for an L1 configured GTS. *Table 13* on *Page 25* shows the initialization data fields for an E5a configured GTS at 500 SPS.

Table 12: L1 Initialization Command Fields

Byte Position	Description	Valid Range	Value / Scale Factor
Byte [7]	SV Number	1 - 50	SV Number
Byte [8]	Sub-Chip	0 – 255	Initial DDS Sub-Chip
Byte [9:10]	Code Chip Advance	0 – 4091	Initial Code Chip Advance
Byte [11:12]	MSec Advance	Bits [0:15] = 0 – 999	Initial MSec Advance

Table 13: E5a Initialization Command Fields 500 SPS

Byte Position	Description	Valid Range	Value / Scale Factor
Byte [7]	SV Number	1 – 50	E5a SV Number
Byte [8]	Sub-Chip	0 – 255	Initial Sub-Chip Load

Continued on Page 26

Byte Position	Description	Valid Range	Value / Scale Factor
Byte [9:10]	Code Chip Advance	0 – 10229	Initial Code Chip Advance
Byte [11:12]	MSec Advance	Bits [0:15] = 0 – 999	Initial MSec Advance
Byte [13:14]	I coder init XB(I). Byte[13] = init bits 0-7 Byte[14] = init bits 8-12		XA2 I channel coder initialization value at zero chip count.
Byte [15:16]	Q coder init XB(Q). Byte[15] = init bits 0-7 Byte[16] = init bits 8-12		XB2 Q channel coder initialization value at zero chip count.

SV NUMBER FIELD

This value specifies the PRN to transmit. For L1, the 4092 bit PRN sequence for the specified PRN is loaded into the FPGA. For E5a, the 100-bit secondary code sequence for the pilot-channel (Q Channel) is loaded into the FPGA for the specified PRN.

SUB-CHIP FIELD

This value specifies the initial sub-chip phase to be loaded into the Code DDS in increments of 1/256 code chip.

CODE CHIP ADVANCE FIELD

This value specifies the initial code chip advance from zero chip count.

MSEC ADVANCE FIELD

This value specifies the initial msec epoch advance from zero msec count.

E5A I CODER INIT XB(I) FIELD

This field contains the initial state (14 bits) of the E5a I Channel XB(I) code generator. See *Table 14* for the I channel XB(I) coder initialization field bit format.

Table 14: E5a I Channel XB(I) Coder Initialization Field

LS Byte [13]								MS Byte [14]							
D7	D6	D5	D4	D3	D2	D1	D0	-	-	D13	D12	D11	D10	D9	D8
							LSB	MSB							
XBI(7)	(6)	(5)	(4)	(3)	(2)	(1)	XBI(0)	-	-	XBI(13)	12	11	10	9	XBI(8)

E5A Q CODER INIT XB(Q) FIELD

This field contains the initial state (14 bits) of the E5a Q Channel XB(Q) code generator. If this field is set to zero, the Q Channel XB(Q) coder does not participate in modulation. *Table 15* shows the byte and bit ordering for the Q channel XB(Q) coder initialization field.

Table 15: E5a Q Channel XB(Q) Coder Initialization Field

LS Byte [15]								MS Byte [16]							
D7	D6	D5	D4	D3	D2	D1	D0	-	-	D13	D12	D11	D10	D9	D8
							LSB	MSB							
XBQ(7)	(6)	(5)	(4)	(3)	(2)	(1)	XBQ(0)	-	-	XBQ(13)	12	11	10	9	XBQ(8)

5.1.3.4 Code Chip Rate and Carrier Frequency Command

The Code Chip Rate and Carrier Frequency Command specifies in absolute terms, the new Code Chip Rate and Carrier Frequency (for either L1 or E5a) to be assigned at the next 1PPS update pulse. *Table 16* shows all fields applicable to this command.

Table 16: L1/E5a Code Chip Rate and Carrier Frequency Command Fields

Byte Position	Description	Valid Range	Scale Factor
Data Byte [17:22]	Code Chip Rate	1.023 ±0.25/1540 Mcps (L1) 10.23 ±0.25/115 Mcps (E5a)	LSB = 75 x 2^{-48} Mcps
Data Byte [23:24]	Reserved		
Data Byte [25:30]	Carrier Frequency	70 ±0.25 MHz	LSB = 300 x 2^{-48} MHz
Data Byte [31:33]	Reserved		

CODE CHIP RATE FIELD

The Code Chip Rate field specifies the absolute initial code clock frequency. Table x shows the byte and bit ordering for the Code Chip Rate field.

Table 17: Code Chip Rate Ramp Field

Byte [17]	Byte [18]	Byte [19]	Byte [20]	Byte [21]	Byte [22]
D7 - D0	D15 - D8	D23 - D16	D31 - D24	D39 - D32	D47 - D40
D0 = LSB					D47 = MSB

CARRIER FREQUENCY FIELD

The Carrier Frequency Command specifies in absolute terms, the new Carrier Frequency (for either L1 or E5a) to be assigned at the next 1PPS update pulse. See *Table 18* for the Carrier Frequency field byte and bit order format.

Table 18: Carrier Frequency Field Bit Format

Byte [25] LS Byte	Byte [26]	Byte [27]	Byte [28]	Byte [29]	Byte [30] MS Byte
D7 – D0	D15 – D8	D23 – D16	D31 – D24	D39 – D32	D47 - D40
D0 = LSB					D47 = MSB

5.1.3.5 Reset Command

The Reset Command allows the GTS to be put into a reset state when operational. When this command is received, the GTS performs the actions as shown in *Figure 10 on Page 28*. There are no data fields associated with this command.

5.1.3.6 Watchdog Timer

The watchdog performs a GTS board reset if it is not serviced for 3 seconds due to a software failure. The software services the watchdog as frequently as possible to prevent the watchdog from resetting the digital board under normal operating conditions.

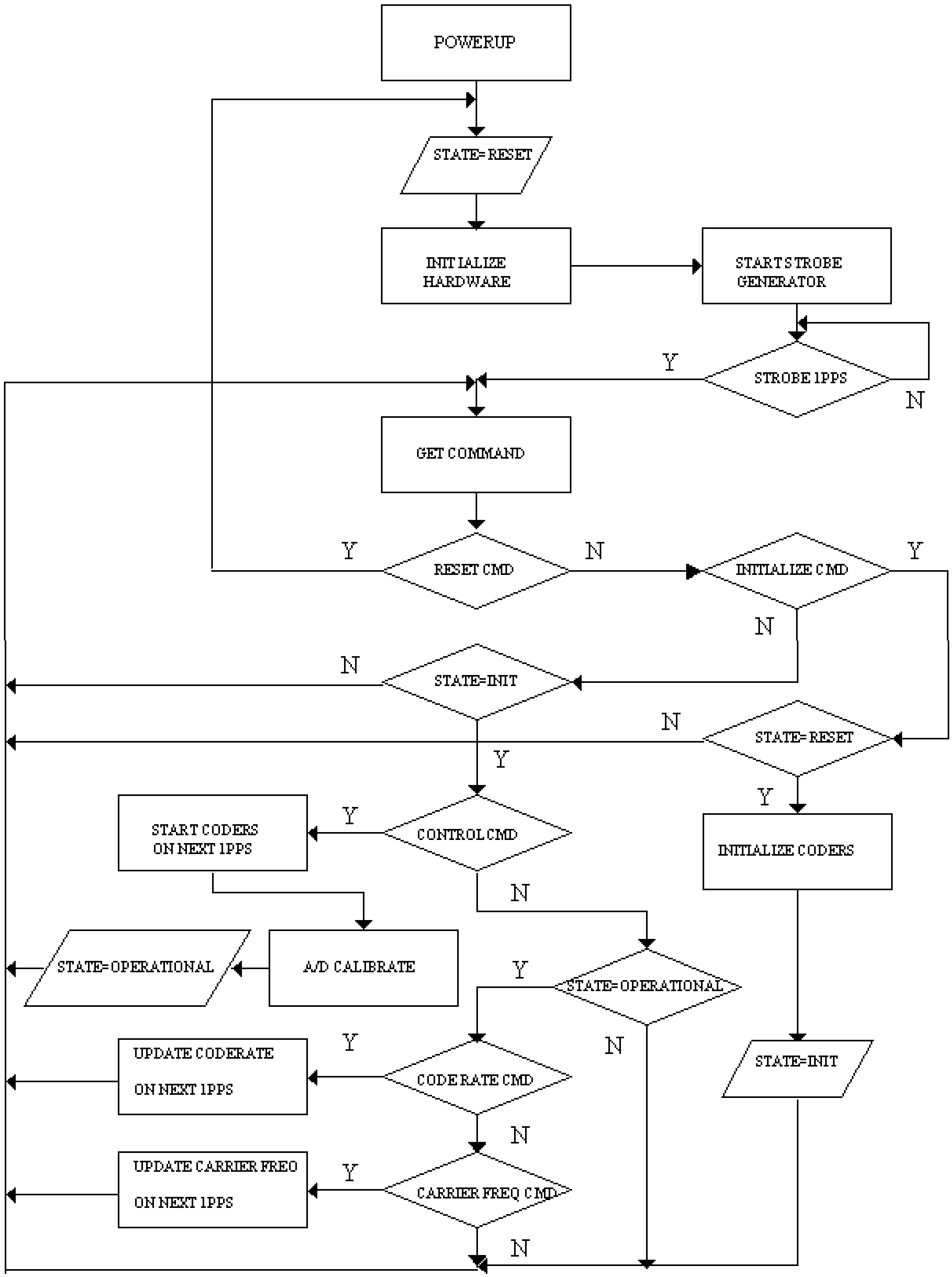


Figure 10: Input Command Flowchart

5.1.4 Status Message

The Status Message contains the status message fields. The L1/E5a GTS sends the Status Message to the MP after every 1PPS update pulse. The status message contains the uplink range, the current setting of option switches, any errors that may have occurred in the last 1 second epoch and hardware status. The status message is transmitted from byte [0] through [33]. The MP may need to swap bytes accordingly in order to recover the original data field (prior to transmission by the GTS). The following sections indicate the data fields for a status message.

Table 19: Status Message Fields

Field	Bytes	Byte Position	Description
3-1	2	Byte [5:6]	Uplink Range Code Chip Sub-Phase
3-2	2	Byte [7:8]	Uplink Range Code Chip Counter
3-3	2	Byte [9:10]	Uplink Range MSec Counter
3-4	1	Byte [11:11]	Switch Status
3-5	2	Byte [12:13]	Error Status
3-6	1	Byte [14:14]	Hardware Status
3-7	1	Byte [15:15]	For future use. Set to zero.
3-8	4	Byte [16:19]	Reset Command Second Epoch Counter Range = 0 – (2^{31}-1)
3-9	4	Byte [20:23]	Hardware Reset Second Epoch Counter Range = 0 – (2^{31}-1)
3-10	2	Byte [24:25]	Firmware Version Number
3-11	2	Byte [26:27]	FPGA Version Number
3-12	1	Byte [28:28]	GTS State
3-13	5	Byte [29:33]	For future use. Set to zero.

Table 20: Uplink Range Fields

Data Byte Position	Description
Byte [5:6]	Uplink Range Code Chip Sub-Phase Resolution = 1 x 2^{-16} code chip
Byte [7:8]	Uplink Range Code Counter
Byte [9:10]	Uplink Range MSec Counter

5.1.4.1 Uplink Range Code Chip Sub-Phase Field

This field contains the sub-phase of the code chip latched, within the current 1 ms epoch, upon detection of a 1PPS update pulse. *Table 21 on Page 30* shows the Uplink Range Code Chip Sub-Phase field byte and bit order.

Table 21: Uplink Range Code Chip Sub-Phase Field

LS Byte [5]								MS Byte [6]							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8
							LSB	MSB							

5.1.4.2 Uplink Range Code Chip Counter Field

This field contains the code count latched, within the current 1 ms epoch, upon detection of a 1PPS update pulse. *Table 22* shows the Uplink Range Code Counter field byte and bit order.

Table 22: Uplink Range Code Chip Counter Field

LS Byte [7]								MS Byte [8]							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8
							LSB	MSB							

5.1.4.3 Uplink Range MSec Counter Field

This field contains the msec count latched, within the current 1 ms epoch, upon detection of a 1PPS update pulse. *Table 23* shows the Uplink Range MSec Counter field byte and bit order.

Table 23: Uplink Range MSec Counter Field

LS Byte [9]								MS Byte [10]							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8
							LSB	MSB							

5.1.4.4 Switch Status Fields

The Switch Status field contains the current state of all GTS switches. The switch settings are polled when the Status Message is created at the start of the current 1 second epoch. *Table 24* shows the Switch Status field byte and bit order. *Table 25* on *Page 31* shows the Switch Status bit fields.

Table 24: Switch Status Field

Byte [11]							
D7	D6	D5	D4	D3	D2	D1	D0
MSB							LSB

Table 25: Switch Status Bit Fields

Bit	Switch Status Description	Range
D0	TX Inhibit	0 = Enable 1 = Disable
D1	IF Switch Position	0 = Enable 1 = Disable
D2	CW Mode only	0 = Not CW Mode 1 = CW Mode
D3-D7	Reserved for future use. Set to zero.	

TX INHIBIT FIELD

This flag indicates the TX Inhibit status of the Message interface. If a ‘1’, this flag indicates if the transmitter has been disabled through the Message Interface. If a ‘0’ this flag indicates that the Message interface has not disabled the transmitter.

IF SWITCH POSITION FIELD

This flag indicates the current setting of the IF switch. If a ‘1’, this flag indicates that the IF switch has been disabled. If a ‘0’, this flag indicates that the IF switch is enabled.

CW MODE ONLY FIELD

This flag indicates the current setting of the CW Only mode Switch. If a ‘1’, this flag indicates that the CW Mode Only Switch is closed and that the GTS is in CW mode only. If a ‘0’, this flag indicates that the CW Mode Only Switch is open and that the GTS is not in CW mode

5.1.4.5 Error Status Fields

The Error Status field contains any errors that may have occurred during the last 1 second epoch. The Error Status field bits are reset to zero after the status message is sent. *Table 26* shows the Error Status field byte and bit order. *Table 27* on *Page 32* shows the Error Status bit fields.

Table 26: Error Status Field

LS Byte [12]								MS Byte [13]							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8
							LSB	MSB							

Table 27: Error Status Bit Fields

Bit	Error Status Description	Range
D0	Navigation Data Generator Data Error, see *Section 5.2, Error Handling on Page 37*	0 = No Error 1 = Error
D1	Update Data not complete at 1PPS	0 = Complete 1 = Incomplete
D2	Status Data not Complete at 1PPS	0 = Complete 1 = Incomplete
D3	Parity Error on Received Data	0 = No Parity Error 1 = Parity Error
D4	Framing Error on Received Data	0 = No Error 1 = Error
D5	Overrun Error on Received Data	0 = No Error 1 = Error
D6	Receive Data Sync Error	0 = Valid Sync Byte 1 = No Valid Sync Byte
D7	Receive Data CRC16 Error	0 = Valid CRC Field 1 = No Valid CRC Field
D8	Invalid Field Value in Last Command Received	0 = Valid Field Value 1 = Invalid Field Value
D9	Invalid Range Fields	0 = Valid Range Fields 1 = Invalid Range Fields
D10-D15	Reserved for future use. Set to zero.	

NAVIGATION DATA GENERATOR DATA ERROR FIELD

See *Section 5.2, Error Handling on Page 37.*

UPDATE DATA NOT COMPLETE AT 1PPS FIELD

If 1 ‘1’, this flag indicates that a command received during the previous 1 second epoch was incomplete.

STATUS DATA NOT COMPLETE AT 1PPS FIELD

If a ‘1’, this flag indicates that a status message was not transmitted completely during the previous 1-second epoch. This flag is reset after the status message has been transmitted.

PARITY ERROR ON RECEIVED DATA FIELD

If a ‘1’, this flag indicates that the UART detected a parity error in one or more command bytes during the previous 1-second epoch. This flag is reset after the status message has been transmitted.

FRAMING ERROR ON RECEIVED DATA FIELD

If a ‘1’, this flag indicates that the UART detected a framing error in one or more command bytes during the previous 1-second epoch. This flag is reset after the status message has been transmitted.

OVERRUN ERROR ON RECEIVED DATA FIELD

If a ‘1’, this flag indicates that the UART detected an overrun error in one or more command bytes during the previous 1-second epoch. This flag is reset after the status message has been transmitted.

RECEIVE DATA SYNC ERROR FIELD

If a ‘1’, this flag indicates that the GTS did not receive a valid sync byte in a command packet during the previous 1-second epoch. This flag is reset after the status message has been transmitted.

RECEIVE DATA CRC ERROR FIELD

If a ‘1’, this flag indicates that the GTS detected an invalid CRC field in a command packet during the previous 1-second epoch. This flag is reset after the status message has been transmitted.

INVALID FIELD VALUE FIELD

If a ‘1’, this flag indicates that the GTS detected an invalid field value in the last command received, during the previous 1-second epoch. This flag is reset after the status message has been transmitted.

INVALID RANGE FIELDS FIELD

If a ‘1’, this flag indicates that the range fields contained in this status message are invalid and should not be used.

5.1.4.6 Hardware Status Fields

The Hardware Status field contains the current state of the GTS hardware. The hardware is polled when the Status Message is created at the start of the current 1 second epoch. *Table 28* shows the Hardware Status field bit order. *Table 29* on *Page 34* shows the Hardware Status bit fields.

Table 28: Hardware Status Field

Byte [14]							
D7	D6	D5	D4	D3	D2	D1	D0
MSB							LSB

Table 29: Hardware Status Bit Fields

Bit	Hardware Status Description	Range
D0	Reference 10 MHz Present	0 = Not Present 1 = Present
D1	Clock Circuit Fault	0 = No Fault 1 = Fault
D2	RF Circuit Fault	0 = No Fault 1 = Fault
D3	Reserved for future use	
D4		
D5		
D6	GTS Operational	0 = Not Operational 1 = Operational
D7	Reference 1PPS present	0 = Not Present 1 = Present

10 MHZ PRESENT FIELD

This flag indicates if the 10 MHz clock signal is present. If a '1', then the 10 MHz signal is present. If a '0', then the 10 MHz signal is absent.

CLOCK CIRCUIT FAULT FIELD

This flag indicates if the clock circuit board is faulty. If a '1', then the clock circuit board is faulty. If a '0', then the clock circuit board is not faulty.

RF CIRCUIT FAULT FIELD

This flag indicates if the RF circuit board is faulty. If a '1', then the RF circuit board is faulty. If a '0', then the RF circuit board is not faulty.

GTS OPERATIONAL

This flag indicates if the GTS is operational and that Code Rate Commands and Carrier Frequency Commands are accepted. If this bit is set to '0', Code Rate Commands and Carrier Frequency Commands are not applied. If this bit is set to '1', the GTS is operational and Code Rate Commands and Carrier Frequency Commands are applied. This bit is only set to '0' at power-up and after a Reset Command is received. It is set to '1' after a Control Command is received and all internal calibrations have been performed.

REFERENCE 1PPS PRESENT FIELD

The flag indicates if the 1PPS reference is present. If this bit is set to '1', the 1PPS signal is present. If this bit is set to '0', the 1PPS signal is not present.

5.1.4.7 Reset Command Second Epoch Counter

This field contains the number of one second epochs counted since the last hardware reset occurred or since the last RESET command was received. The counter is started upon successful detection of an external 1PPS update pulse. The range of this field is 0 – (2^{31}-1). The MSB is set to zero to prevent false detection of packet SYNC header bytes. *Table 30* on *Page 35* shows the byte order and format for this field.

Table 30: Reset Command Second Epoch Counter

LS Byte [16] D0 = LSB								Byte [17]								Byte [18]								LS Byte [19] D31 = MSB = '0'							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8	D23	D22	D21	D20	D19	D18	D17	D16	D31	D30	D29	D28	D27	D26	D25	D24

5.1.4.8 Hardware Reset Second Epoch Counter

This field contains the number of one second epochs counted since the last hardware reset occurred. The counter is started upon successful detection of an external 1PPS update pulse. The range of this field is 0 – (2^{31}-1). The MSB is set to zero to prevent false detection of packet SYNC header bytes. *Table 31* shows the byte order and format for this field.

Table 31: Hardware Reset Second Epoch Counter

LS Byte [20] D0 = LSB								Byte [21]								Byte [22]								LS Byte [23] D31 = MSB = '0'							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8	D23	D22	D21	D20	D19	D18	D17	D16	D31	D30	D29	D28	D27	D26	D25	D24

5.1.4.9 Firmware Version Number

This field contains the firmware version number. The firmware version number consists of two parts, the revision number (major) and the release (minor). *Table 32* on *Page 35* shows the byte order and format for this field.

Table 32: Firmware Version Number Field

LS Byte [24]								MS Byte [25]							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8
							LSB	MSB							

5.1.4.10 FPGA Version Number

This field contains the FPGA version number. The FPGA version number consists of two parts, the revision number (major) and the release (minor). *Table 33* shows the byte order and format for this field.

Table 33: FPGA Version Number Field

LS Byte [26]								MS Byte [27]							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8
							LSB	MSB							

5.1.4.11 GTS State

This field contains the state of the GTS during the previous one second epoch. *Table 34* shows the byte order and format for this field. *Table 35* on *Page 36* shows the GTS state values.

Table 34: GTS State Field

Byte [28]							
D7	D6	D5	D4	D3	D2	D1	D0
MSB							LSB

Table 35: GTS State Value

State Value	Description
0	Invalid State Error. This indicates a software error.
1	RESET state
2	INITIALIZED state
3	CALIBRATION state
4	OPERATIONAL state

5.1.5 CRC-16/CCITT Checksum Field

A CRC-16/CCITT Cyclic Redundancy Check field is used to validate the received message to a high degree of confidence that it was not corrupted during transmission. The sending system calculates the CRC-16 on all message bytes excluding the CRC data bytes, and appends it to the message. The receiving system calculates the CRC-16 on all message bytes received, excluding the CRC data bytes. The calculated CRC is compared with the received CRC. If the calculated CRC does not match the received CRC, the received message is declared as corrupted. A corrupted message is not used. *Table 36* shows the CRC-16/CCITT field and *Table 37* on *Page 36* shows its bit format. The characteristics for the CRC-16/CCITT are shown in *Table 38* on *Page 37*.

Table 36: CRC-16/CCITT Checksum Field

Field	Bytes	Byte Position	Description	Range
4	2	Byte [34:35]	CRC16 Checksum	Hex 0000 – FFFF

Table 37: CRC-16/CCITT Checksum Field

LS Byte [34]								MS Byte [35]							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8
							LSB	MSB							

Table 38: CRC-16-CCITT Characteristics

Name	CRC-16/CCITT
CRC Width	16 Bits
Polynomial	$1021 = X^{16} + X^{12} + X^5 + X^0$
Initial CRC Value	0xFFFF Hex
Input Bytes Reflected?	NO
Output CRC Result Reflected?	NO
Output XOR Value	0x0000
Single Bit Errors Detected	100%
Double Bit Errors Detected	100%
Odd Numbered Bit Errors Detected	100%
Burst Errors Shorter Than 16 Bits	100%
Burst Errors of Exactly 17 Bits	99.9968%
All Other Burst Errors	99.9984%

5.2 Error Handling

Table 39 shows the GTS error conditions and their corresponding handling methods.

Table 39: Errors

Error Description	Handling Method	Notes
Navigation Data Generator message truncated	I and Q set to zero and Transmitter disabled	Report status
Navigation Data Generator MSGRDY stuck high	I and Q set to zero and Transmitter disabled	Report status
Navigation Data Generator MSGRDY stuck low	I and Q set to zero and Transmitter disabled	Report status
MSGDATA not ready when needed	I and Q set to zero and Transmitter disabled	Report status

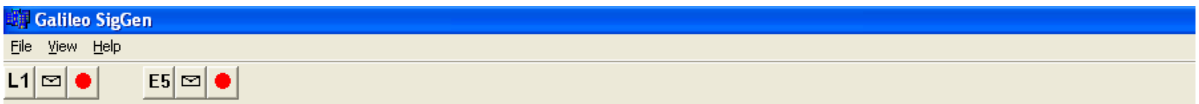
Chapter 6 Galileo SigGen GUI

The GTS may be controlled via the Galileo SigGen GUI, which is a Graphical User Interface that receives messages and sends commands to the GTS.

6.1 Toolbar

The Galileo SigGen GUI allows you to interact with the two different sections of the GTS:

- L1
- E5a.



Pressing the *L1* or *E5* button displays the signal control window. The  button displays the corresponding logging control window and the  button displays the error status window.

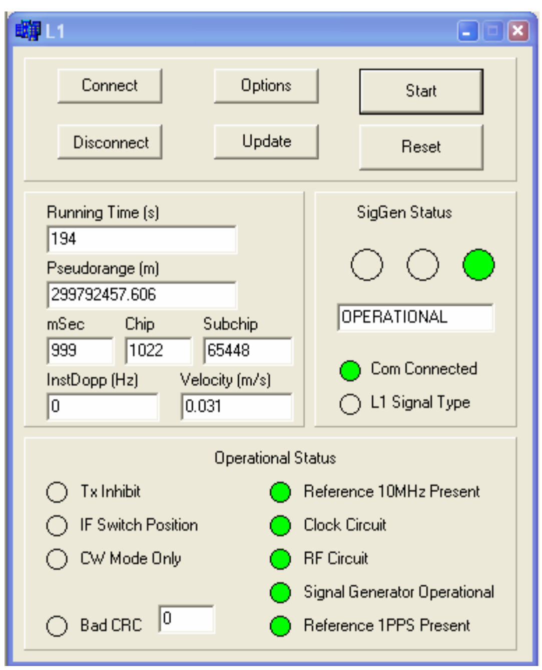
6.2 Windows

Each of the signal types, L1 and E5a, has 3 different windows:

- signal control
- logging control
- error status

6.2.1 Signal Control Window

The *Signal Control* window is the main interface to the GTS. From this window, commands are sent to the GTS and the most pertinent status information from the GTS is displayed. If the COM port is not connected, and no messages are being received, the bits displayed are the values from the last received message.



The middle left panel of the window displays the operational conditions of the GTS. The time from the last reset, the pseudorange (in metres, milliseconds, chips and subchips), the Instantaneous Doppler and the velocity.

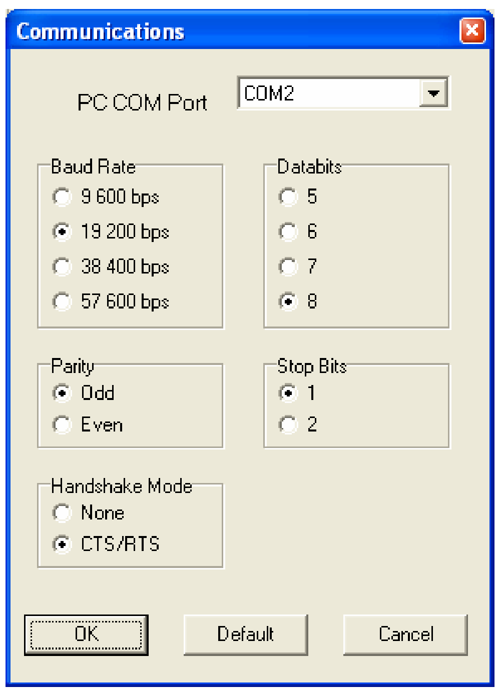
The middle right panel of the window displays the status of the GTS. A green light indicates that the GTS is in operational mode, a yellow light indicates initialization/calibration/unknown state, and a red light indicates a reset state. An unknown state means that no message from the GTS has been received since the window was opened.

If the communications port is connected, a green LED is displayed beside *Com Connected* and a red LED is displayed when it is not connected. If the COM port is connected to the wrong signal (that is, the L1 window is actually connected to the E5a section of the GTS), a red LED flashes at a rate of 1 Hz next to *L1 Signal Type*.

The bottom panel of the window displays the operational status and is updated every second based on the received message from the GTS. The switch status bits are displayed on the left hand side and display a red LED when the corresponding bit is set to 1. If a message with a bad CRC is received, a red LED flashes once next to *Bad CRC* and a running total of the bad CRCs received is displayed. On the right hand side, are the hardware status bits where a green LED indicates a good or desired state and a red LED indicates a bad or undesired state.

6.2.1.1 Connect Button

Choose the *Connect* button to bring up the *Communications* dialog from where you can set communications parameters:



The default values are:

- Baud Rate - 19 200 bps
- Databits - 8 bits
- Stop Bits - 1 bit
- Parity - odd parity
- Handshake Mode = CTS/RTS

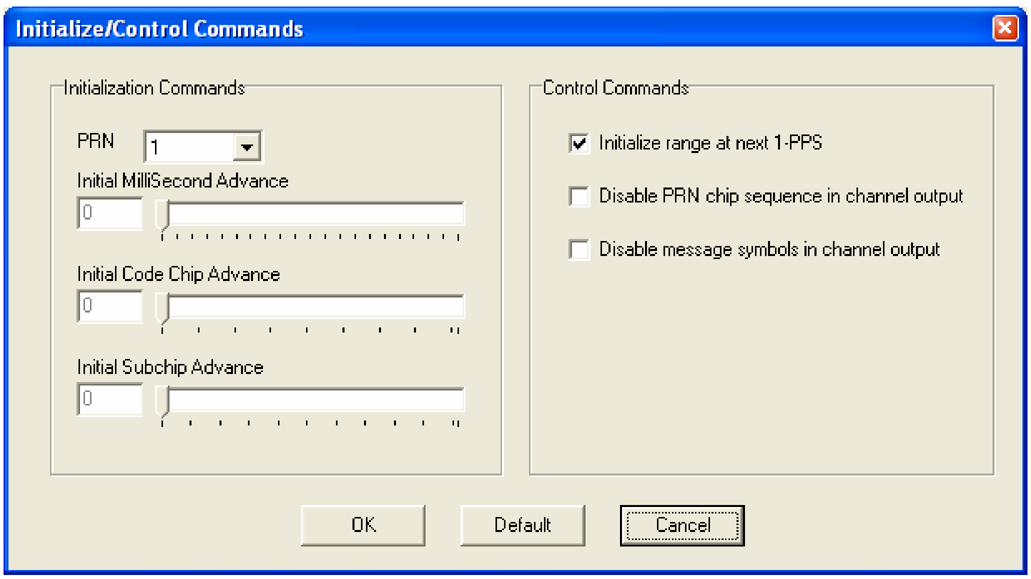
Click on the *Default* button to reset to the default parameters. Parameters are applied once you click on the *OK* button.

6.2.1.2 Disconnect button

Click on the *Disconnect* button to disconnect the current COM port. To reconnect, refer to *Section 6.2.1.1, Connect Button* on *Page 39*.

6.2.1.3 Options Button

Click on the *Options* button to bring up the *Initialize/Control Commands* dialog and options. The *Options* button can only be selected when the receiver is in a reset state. (A red light in the *SigGen Status* panel of the *Signal Control* window indicates a reset state, see also *Section 6.2.1, Signal Control Window* starting on *Page 38*.)



The default values are:

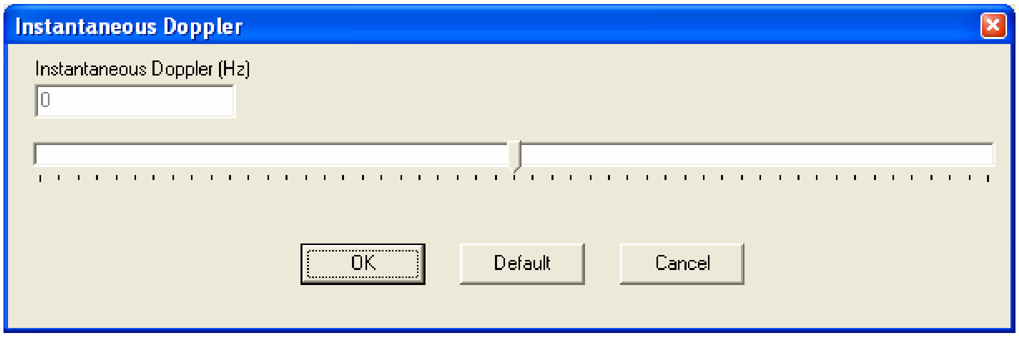
- PRN - 1
- Initial MilliSecond Advance - 0 ms
- Initial Code Chip Advance - 0 chips
- Initial Subchip Advance - 0 subchips
- Initialize range at next 1PPS - checked
- Disable PRN chip sequence in channel output - unchecked
- Disable message symbols in channel output - unchecked

Click on the *Default* button to reset to the default parameters. Parameters are not applied until you click on the *OK* button.

6.2.1.4 Update Button

The *Update* button allows the instantaneous Doppler of the signal to be modified with a value of 250 kHz in steps of 1 Hz using a sliding bar. The selected Doppler is displayed numerically in the text area above the sliding bar. The default Doppler value is 0 Hz.

The Doppler is immediately applied once to the signal when you click on the *OK* button, and is maintained until the signal is reset or another Doppler is applied. This command is only applied if the GTS is in an operational state. (A green light in the *SigGen Status* panel of the *Signal Control* window indicates that the GTS is in operational mode, see also *Section 6.2.1*, *Signal Control Window* starting on *Page 38*.)



Click on the *Default* button to reset the Doppler to the default value. A new Doppler value is not applied until you click on the *OK* button.

6.2.1.5 Start Button

Click on the *Start* button to send the following commands to the GTS:

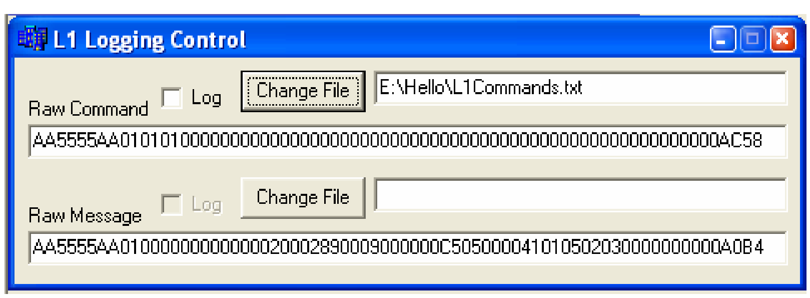
1. Reset
2. Initialize Command (with the initialization parameters selected in the *Initialize/Control Commands* dialog from the *Options* button)
3. Control Command (with the control parameters selected in the *Initialize/Control Commands* dialog from the *Options* button)

6.2.1.6 Reset Button

Click on the *Reset* button to send a reset command to the GTS.

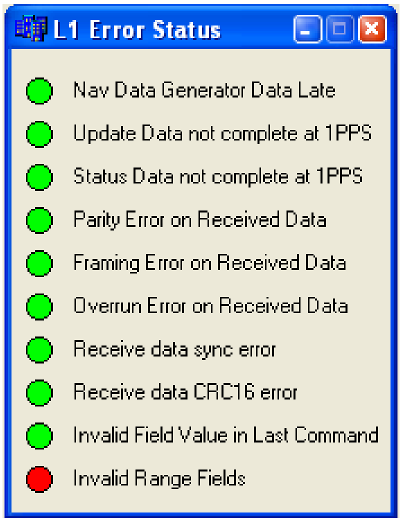
6.2.2 Logging Control Window

The logging control window displays the raw commands sent to the GTS and the raw messages sent by the GTS in hexadecimal format. Click on the *Change File* button to save these messages to a file. Select a file name and then check the *Log* button. The file name and directory is displayed in the text area to the right of the button. If there is a previously created file, it is overwritten. Check the Log button to save the commands and messages and append them to the current file.



6.2.3 Error Status Window

The error status window displays the status bits reported in the error status bit field that is sent by the GTS at a rate of 1 Hz. Undesirable states (or errors) are indicated by a red LED, and desirable states are indicated by a greed LED.



6.3 Using the Galileo SigGen GUI

Use the Galileo SigGen GUI to configure and monitor the GTS.

6.3.1 Connecting to the Message Interface of the GTS

To connect to the GTS for use with the GUI, follow these steps:

1. Connect the L1 and E5a WMP ports on the GTS to the RS-232 ports on the control PC.
2. Launch the Galileo SigGen GUI application. The screen in *Figure 11* on *Page 42* appears.

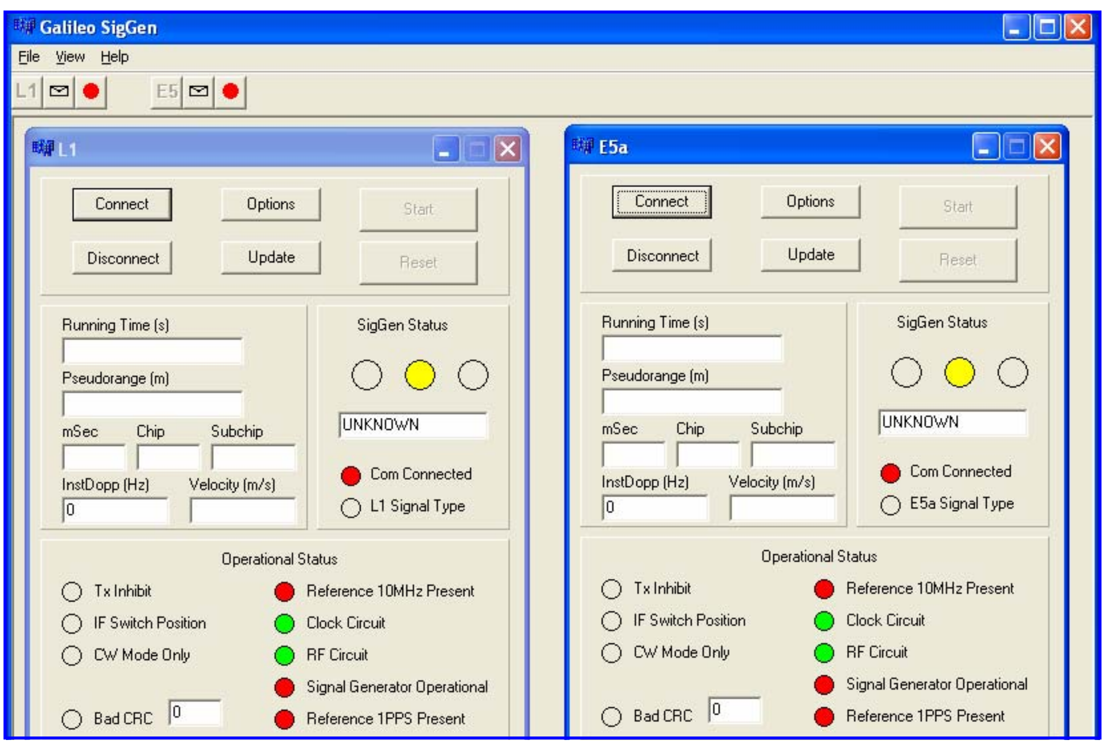


Figure 11: Galileo SigGen GUI

3. Click on the *Connect* button of the *L1* window. Configure the COM settings as shown in *Figure 12*, and select the PC COM port to which the GST is connected.

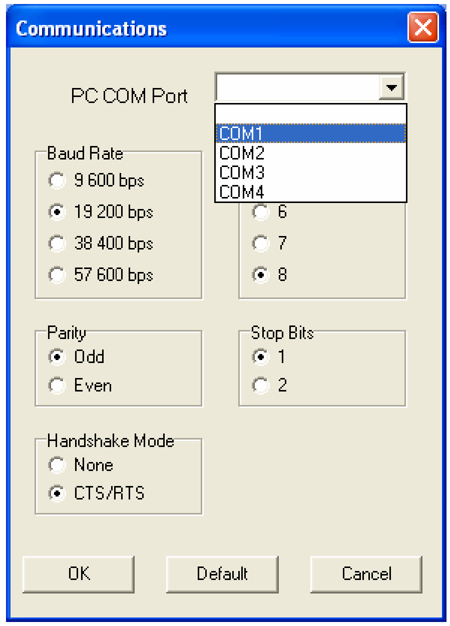


Figure 12: COM Port Settings

4. Click on the *Connect* button of the *E5a* window. Configure the COM settings as shown in *Figure 12*, and select the PC COM port to which the GST is connected.

6.3.2 Configuring the GTS

When the GTS has successfully completed IBIT, and is correctly connected from its Navigation Data Generator ports to the navigation message simulator boxes, it is put in a reset state, as shown in *Figure 13*. (A red light in the *SigGen Status* panel of the *Signal Control* window indicates a reset state, see *Section 6.2.1, Signal Control Window* starting on *Page 38*.) See also *Figure 3, Typical Signal Generator Setup* on *Page 14*.

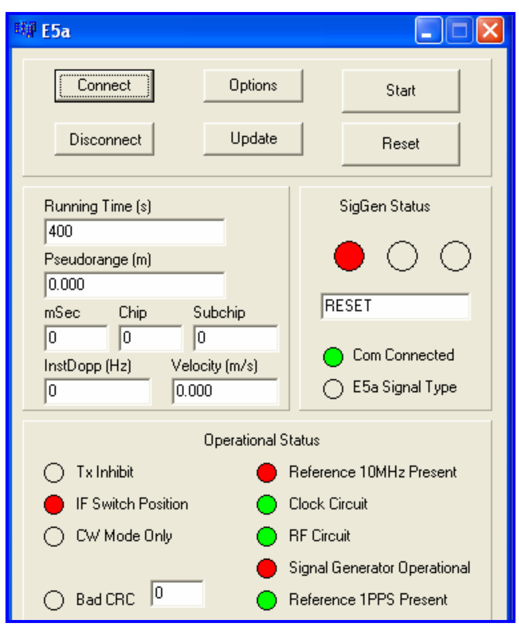


Figure 13: GTS in Reset Mode

At this point, the GTS is ready to be configured to output Galileo L1 and E5a signals:

1. Click on the *Options* button of the L1 window. The window shown in *Figure 14* appears.

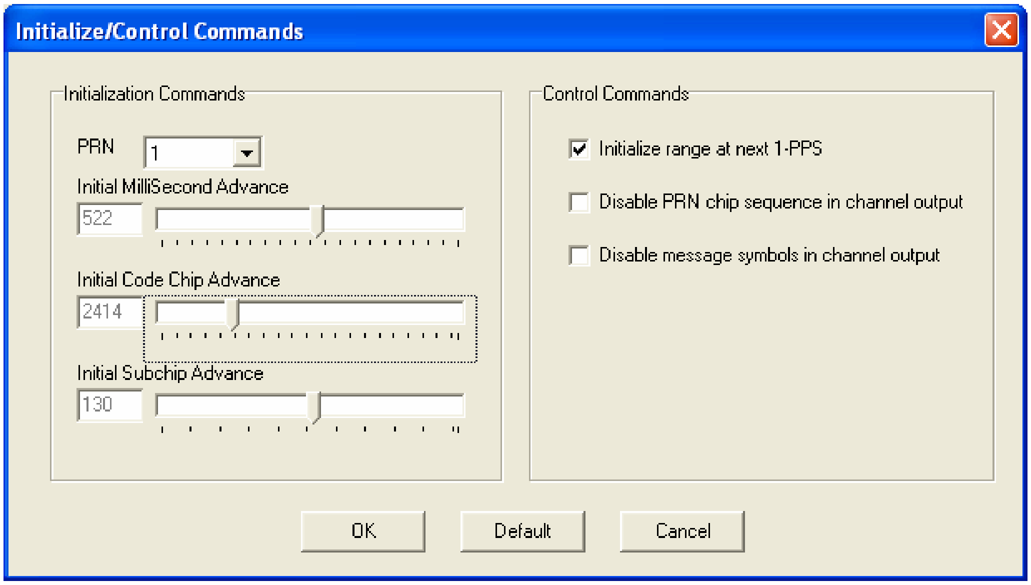


Figure 14: Initialize/Control Commands

Select a PRN, initialization parameters and control options. Click on the OK button.

2. Click on the *Start* button in the *L1* window to apply the configuration commands to the GTS. The GTS then transitions through the initialization, calibration and operational states.

3. Repeat steps 1-2 for the E5a window.

6.3.3 Applying a Doppler to Output Signal

To apply a Doppler to the transmitted signal:

1. After the GTS is in operational mode, click on the *Update* button of the L1 or E5a window to send an update command.

2. Select the desired Doppler in the Instantaneous Doppler window shown in *Figure 15*:

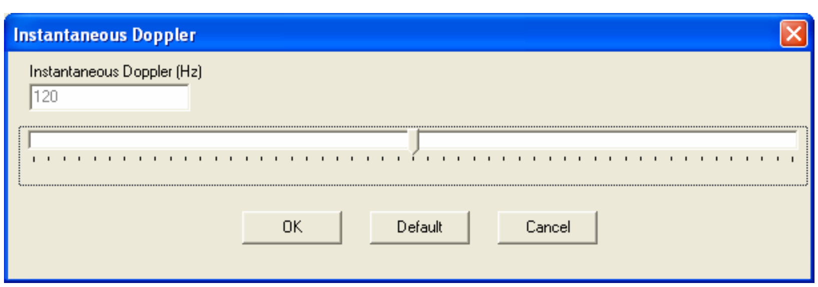


Figure 15: Doppler Selection Window

3. The instantaneous Doppler and resulting velocity is shown in *Figure 16* on *Page 45*:

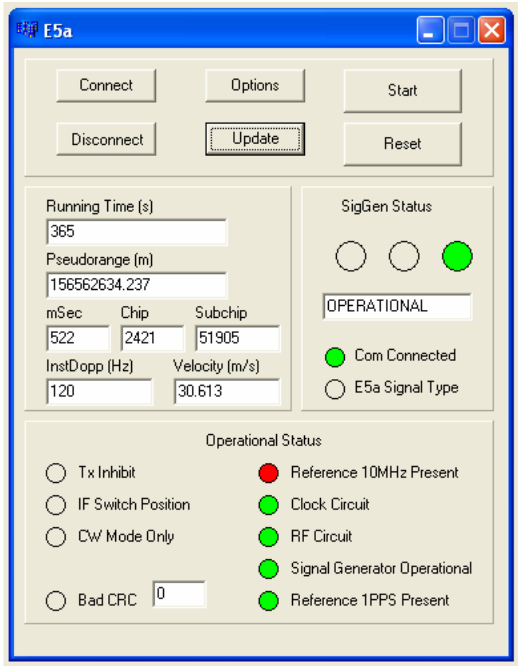


Figure 16: GTS Status

The update command can be sent at any time using the *Update* button as long as the GTS is in operational mode. (A green light in the *SigGen Status* panel of the *Signal Control* window indicates that the GTS is in operational mode, see also *Section 6.2.1, Signal Control Window* starting on *Page 38*.)

Appendix A Technical Specifications

A.1 Galileo Test Signal Generator

PHYSICAL	
Size	449 mm (17.7”) x 426 mm (16.8”) x 133 mm (5.2”)
Weight	8.03 kilograms (17.7 lb.)

MECHANICAL DRAWINGS

The dimensions in *Figure 17* are in millimeters.

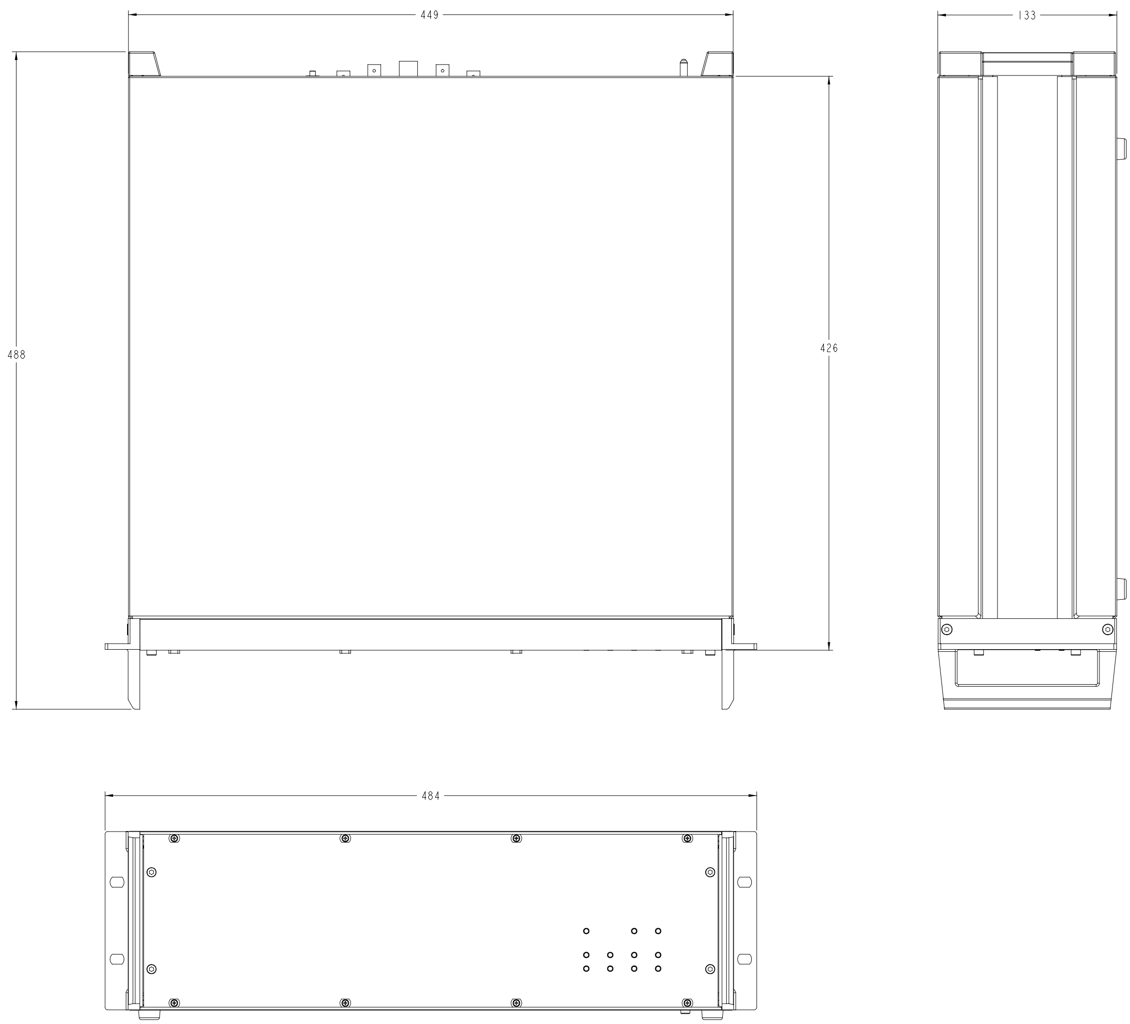


Figure 17: GTS Dimensions

ENVIRONMENTAL	
Operating Temperature	0° C to +50° C
Storage Temperature	-40°C to +85°C
Humidity	Not to exceed 90% non-condensing

INPUT/OUTPUT CONNECTORS		
Power Input	Input power connector	
	3-pin power cord provided (for North American standard A/C)	
	Voltage:	100 to 240 V AC
	Frequency:	50 to 60 Hz
	Current:	0.6 A @ 110 V AC
	VA:	<100
	Fuse Rating:	3 A/250 V fast-blow (there are 2 of these)
L1 MP	DE9P connector	
E5a MP	DE9P connector	
PPS Input	BNC female connector	
	Signal Description	A one-pulse-per-second normally high, active low pulse (1 ms) where the falling edge is the reference.
	Output level:	
	Voltage	High > 2.0 V DC
		Low < 0.55 V DC
	Impedance	50 Ω
L1 RF Output	TNC female jack:	
	Frequency	1227.6 MHz (L2)
		(1575.42 MHz (L1) option available)
	Bandwidth	22 MHz centered at L2 (L1 option available)
	Level	-100 dBm ±1.5 dB
	Impedance	50 Ω
E5a RF Output	TNC female jack:	
	Frequency	1176.45 MHz (E5a)
	Bandwidth	22 MHz centered at E5a
	Level	-100 dBm ±1.5 dB
	Impedance	50 Ω
10 MHz Input	BNC female connector	
	Sensitivity	0 to +6 dBm
	Impedance	50 Ω
10 MHz Output	BNC female connector	
	RF Output Power	3 ± 3 dBm
	Impedance	50 Ω
	Phase Noise (internal OCXO only):	
	@10 Hz:	-125 dBc/Hz max.
	@100 Hz:	-155 dBc/Hz max.
	@1 kHz:	-165 dBc/Hz max.
	Temperature Stability	±1 x 10^{-8} over operating temperature range
	Aging	5 x 10^{-10} per day

A.1.1 Connector Pin-Outs

Table 40 and *Table 41* show details of the connector pin-outs on the GTS.

Table 40: L1 and E5a MP Connector Pin-Out Descriptions

Connector Pin No.	Direction	Name
1	Reserved	
2	Out	TxD
3	In	RxD
4	Reserved	
5	GND	
6	Reserved	
7	In	CTS
8	Out	RTS
9	Reserved	

Table 41: L1 and E5a Navigation Data Generator Connector Pin-Out Descriptions

Connector Pin No.	Direction	Name
1	GND	
2	Out	MSGCLKa
3	In	MSGRDYa
4	Reserved	
5	In	MSGRDATAa
6	In	RESETa
7	GND	
8	Reserved	
9	In	TXINHb
10	Reserved	
11		
12		
13	In	MSGDATAb
14	Out	MSGCLKb
15	Reserved	
16	In	MSGRDYb
17	In	TXINHa
18	Reserved	
19		
20		
21		
22	In	RESETb
23	Reserved	
24		
25		

A.1.2 Cables

A.1.2.1 Power Cable

The power cable supplied with the GTS connects from the Power Input port on the back of the GTS to an external power source (+100 to +240 V AC). An input voltage of less than +100 V AC causes the unit to suspend operation while an input voltage greater than +240 V AC may physically damage the unit, voiding the warranty. The power supply automatically adapts its input power to the national power source in the country of use as long as it is within the above range and you have an adapter for your local power receptacle.

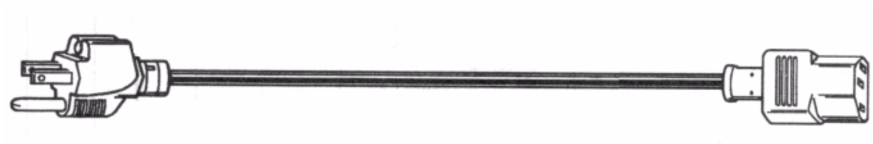


Figure 18: Power Cable

Appendix B Galileo

This appendix is intended to give you information on the Galileo[1] signals and their use. For extended Global Positioning System (GPS) and Satellite-Based Augmentation System (SBAS) information, both of which are used by the Galileo Test Receiver, please refer to the *GPS+ Reference Manual* available from our website at http://www.novatel.com/Downloads/docupdates.html.

B.1 Overview

Galileo will be Europe's own global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. It will be inter-operable with GPS and GLONASS, the two other global satellite navigation systems.

A user will be able to take a position with the same receiver from any of the satellites in any combination. By offering dual frequencies as standard, however, Galileo will deliver real-time positioning accuracy down to the metre range, which is unprecedented for a publicly available system.

It will guarantee availability of the service under all but the most extreme circumstances and will inform users within seconds of a failure of any satellite. This will make it suitable for applications where safety is crucial, such as running trains, guiding cars and landing aircraft.

The first experimental satellite, part of the so-called Galileo System Test Bed (GSTB) will be launched in the second semester of 2005. The objective of this experimental satellite is to characterize the critical technologies, which are already in development under European Space Agency (ESA) contracts. Thereafter up to four operational satellites will be launched in the 2007-2008 time frame to validate the basic Galileo space and related ground segment. Once this In-Orbit Validation (IOV) phase has been completed, the remaining satellites will be installed to reach the Full Operational Capability (FOC) in 2010.

The fully deployed Galileo system consists of 30 satellites (27 operational + 3 active spares), positioned in three circular Medium Earth Orbit (MEO) planes in 23616 km altitude above the Earth, and at an inclination of the orbital planes of 56 degrees with reference to the equatorial plane. Once this is achieved, the Galileo navigation signals will provide a good coverage even at latitudes up to 75 degrees north, which corresponds to the North Cape, and beyond. The large number of satellites together with the optimisation of the constellation, and the availability of the three active spare satellites, will ensure that the loss of one satellite has no discernible effect on the user.

Two Galileo Control Centres (GCC) will be implemented on European ground to provide for the control of the satellites and to perform the navigation mission management. The data provided by a global network of twenty Galileo Sensor Stations (GSS) will be sent to the Galileo Control Centres through a redundant communications network. The GCC's will use the data of the Sensor Stations to compute the integrity information and to synchronize the time signal of all satellites and of the ground station clocks. The exchange of the data between the Control Centres and the satellites will be performed through so-called up-link stations. Five S-band up-link stations and 10 C-band up-link stations will be installed around the globe for this purpose.

As a further feature, Galileo will provide a global Search and Rescue (SAR) function, based on the operational search and rescue satellite aided tracking Cospas-Sarsat system. To do so, each satellite will be equipped with a transponder, which is able to transfer the distress signals from the user transmitters to the Rescue Co-ordination Centre (RCC), which will then initiate the rescue operation. At the same time, the system will provide a signal to the user, informing them that their situation has been detected and that help is under way. This latter feature is new and is considered a major upgrade compared to the existing system, which does not provide a feedback to the user.

Five categories of services have been defined:

1. A free Open Service (OS)
2. A highly reliable Commercial Service (CS)

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1. Galileo Overview information from ESA Navigation website - http://www.esa.int/export/esaNA/GGGMX650NDC_index_0.html

3. A Safety-of-Life Service (SOL)
4. A government encrypted Public Regulated Service (PRS)
5. A Search and Rescue Service (SAR)

B.1.1 Open Service

This single-frequency service will involve the provision of a positioning, navigation and precise timing service. It will be available for use by any person in possession of a Galileo receiver. No authorisation will be required to access this service. Galileo is expected to be similar to GPS in this respect.

The principal applications will be general navigation and positioning, network timing, traffic information systems, systems including information on alternative routes in the event of congestion, and wireless location, for example, with mobile telephony.

Studies clearly show that the availability of these services will be significantly enhanced by the existence of a greater number of satellites, as is the case when both GPS and Galileo are in operation. This is particularly important for land-based services, such as private car navigation, where service is mostly required in down town cores and where satellite shadowing is minimised by the combination of the systems.

The Open Service will be transmitted in the E5a frequency band at 1176.45 MHz.

B.1.2 Commercial Service

Service providers using the multi-frequency commercial services will have the opportunity to give added value to their range of products for which they can charge the end customer and will, in turn, pay a fee to the Galileo operator. The signal will contain data relating to the additional commercial services being offered. In return for the fee, the Galileo operator will be able to offer certain service guarantees. This aspect of service guarantee and the commensurate liabilities is one area where Galileo is significantly differentiated from GPS. A key component in achieving this is an independent system within Galileo for monitoring the satisfactory working of the system and informing the end user of this by an integrity signal incorporated in the data stream.

The main applications for this service concern professional users who are ready to pay for a service guaranteed by the Galileo operator, notably in the areas of technical surveys, in activities involving customs and excise operations, network synchronisation, sea fleet management, vehicle fleet management, and road tolls.

Controlled access to this service for end-users and the providers of value-added services will be based on protected access keys in the receivers. This will also enable revenue to be collected from users.

The commercial service will be transmitted in the E6 frequency band at 1278.75 MHz.

B.1.3 Safety-of-Life Service

The safety-of-life service will be offered to users who are highly dependant on precision, signal quality and signal transmission reliability. It will offer a high level of integrity, and consequently, provide the user with a very rapid warning of any possible malfunctions. It will need to be certified in accordance with the regulations applicable to the various modes of transport (the International Civil Aviation Organization (ICAO) regulations in the case of air transport; the International Maritime Organization (IMO) regulations in the case of sea transport). This service will require specialised receivers providing access to this enhanced-quality signal.

The safety-of-life service will be transmitted in two frequency bands – L1 at 1575.42 MHz, and E5b at 1207.14 MHz. Users may receive signals from the two frequency bands independently.

B.1.4 Public Regulated Service

The PRS will be a restricted access service, offered to government agencies that require a high availability navigation signal. The PRS service will utilize ranging codes that are encrypted with a highly secure government encryption scheme. To enhance availability, the PRS service is intended to have anti-jamming and anti-spoofing capabilities.

The PRS will be transmitted in two frequency bands – L1 at 1575.42 MHz, and E6 at 1278.75 MHz. Users may receive signals from the two frequency bands independently.

B.1.5 Search and Rescue Service

A specific public service designed to assist in search and rescue operations will make it possible to locate person and vehicles in distress. The vehicles will be fitted with beacons, which having been activated in the event of an emergency will send an alerting signal to the rescue centre.

The Galileo Programme provides this search and rescue service for users based on humanitarian and public service principles of the international COSPAS-SARSAT system while at the same time making search and rescue operations more effective.

Appendix C Acronyms

1PPS	One Pulse Per Second
AGC	Automatic Gain Control
ARNS	Aeronautical Radio Navigation Services
ASCII	American Standard Code for Information Interchange
BDE	Borland Database Engine
BSG	Baseband Signal Generator
C/A Code	Coarse/Acquisition Code
CCITT	Command, Control, and Intelligence Technical Test
CDMA	Code-Division-Multiple-Access
CMR	Compact Measurement Record
COSPAS	Cosmitscheskaja Sistema Poiska Awarinitsch Sudow (Russian: space system for search of vessels in distress)
CR	Carriage Return
CRC	Cyclic Redundancy Check
CS	Commercial Service
CTS	Clear To Send
CW	Continuous Wave
dB	Decibel
DCD	Data Carrier Detected
DDS	Direct Digital Sampling
DoD	Department of Defense
DTE	Data Terminal Equipment
DTR	Data Terminal Ready
ESA	European Space Agency
ESD	Electrostatic Discharge
FDA	Frequency Distribution Amplifier
FEC	Forward Error Correction
FIFO	First In, First Out
FOC	Full Operational Capability
FPGA	Field Programmable Gate Array
GCC	Galileo Control Centre
GEO	Geo-stationary Earth Orbit
GLONASS	Global Navigation Satellite System
GND	Ground
GPS	Global Positioning System
GSS	Galileo Sensor Stations
GSTB	Galileo System Test Bed
GTR	Galileo Test Receiver
GTS	Galileo Test Signal Generator
GUS	Ground Uplink Station
I and Q	In-Phase and Quadrature
IBIT	Initiated Built-In Test
ICAO	International Civil Aviation Organization
IF	Intermediate Frequency
IMO	International Maritime Organization
INH	Inhibit
IOV	In-Orbit Validation
ISG	IF Signal Generator
JTAG	Joint Test Action Group
KPA	Klystron Power Amplifier
LED	Light Emitting Diode
LF	Line Feed
LNA	Low Noise Amplifier

LO	Local Oscillator
LSB	Least Significant Bit
LSG	Loopback Signal Generator
MEO	Medium Earth Orbit
MSB	Most Significant Bit
MP	Message Processor
N/C	Not Connected
NH	Neuman-Hoffman
OCXO	Oven Controlled Crystal Oscillator
OEM	Original Equipment Manufacturer
OS	Open Service
PAC	Pulse Aperture Correlator
PC	Personal Computer
PIN	Position Indicator
PLL	Phase Lock Loop
PPS	Pulse Per Second
PRN	Pseudo Random Number
PRS	Public Regulated Service
RCC	Rescue Co-ordination Centre
RF	Radio Frequency
RFU	Radio Frequency Uplink
RMA	Return Material Authorization
RTS	Request To Send
RXD	Received Data
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite Aided Tracking
SBAS	Satellite-Based Augmentation System
SOL	Safety-of-Life
SPS	Symbols Per Second
SV	Space Vehicle
TTL	Transistor-Transistor Logic
TX	Transmit
TXD	Transmitted Data
UART	Universal Asynchronous Receiver-Transmitter
V AC	Volts Alternating Current
V DC	Volts Direct Current
WAAS	Wide Area Augmentation System

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