

ST100

USER MANUAL



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1 Introduction

1.1 Purpose

This document describes the physical, electrical, and functional characteristics of the ST100 satellite transmitter module with Bluetooth Low Energy. The information contained in this document is intended to provide the VAR/Integrator with the necessary technical information required to configure and use the module in a custom application.

This document is intended to be used by engineers and technical management and assumes a general knowledge of basic engineering practices by the user. Please note that Globalstar is only responsible for ensuring that the ST100 Module meets the published manufacturing specifications described herein.

1.2 Applicable Documents

GS-02-0795 - Simplex Antenna Specification and Test Procedure

GS-07-1247 System Description and Application Note

GS-07-1248 - Remote Telemetry Service Frequency Plan for Simplex Transmitters

Wikipedia article on Intel Hex format: https://en.wikipedia.org/wiki/Intel_HEX

NMEA-0183 rev. 3.0 Specification.

FCC Guidance for use of Radio Modules: KDB996369 D03 and Do4

1.3 Description

The ST100 board is a simplex Satellite transmitter designed to send small packets of user defined data to a network of low earth orbiting (LEO) satellites using the Globalstar simplex satellite network. The received data is then forwarded to a user defined network interface that may be in the form of an FTP host or HTTP host where the user will interpret the data for further processing. The ST100 board must be powered by a battery, or line-powered by a DC source. The ST100 Board features a solar charging circuit that allows battery charging from an attached solar panel. The unit will not power from a solar panel alone, without a battery.

The ST100 board contains a satellite transmitter, GPS receiver, motion sensor, Bluetooth Low Energy transceiver, solar charger, and printed circuit antennas for each of the radio subsystems. The ST100 board has u.FL connectors on the outputs of the Bluetooth transceiver and GPS receiver / satellite transmitter, which give the user the option to use external antennas. The ST100 board also has the option for the user to use an external serial port.

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Under VAR setup and configuration, and normal use by the end user, communication with the device is via a Bluetooth Low Energy (BLE) GATT/Modem interface with a mixture of ASCII and binary command/query protocols.

The ST100 Board is a small, low-profile device with the dimensions shown below:

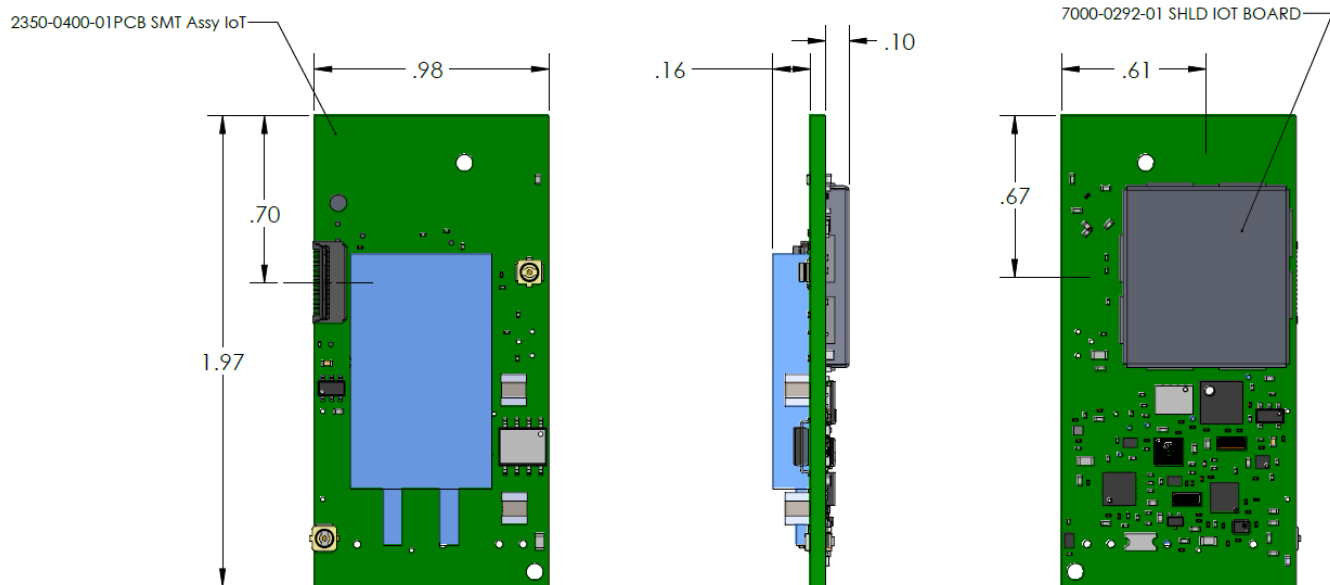


Figure 1 Board Physical Dimensions

1.4 Certifications

Bluetooth LE

RoHS

WEEE

2 Application

2.1 Theory of Operation for Globalstar Simplex

The ST100 Board operates on the Globalstar LEO satellite network. LEO (Low Earth Orbit) means that there are a number of satellites in low earth orbit that constantly orbit the planet and can communicate with Globalstar devices that are within range of its current position.

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Figure 2 LEO Constellation

Since the satellite position is constantly changing, simplex devices on the ground will transmit (with no knowledge of any of the satellites locations) and the transmission may be received by one or more satellites. These satellites will then relay the message to the nearest satellite gateway as shown below. Once received by the satellite gateway, the simplex message will be delivered to the simplex gateway where redundant messages are discarded and the data from the message is sent to the OEM via the Internet.

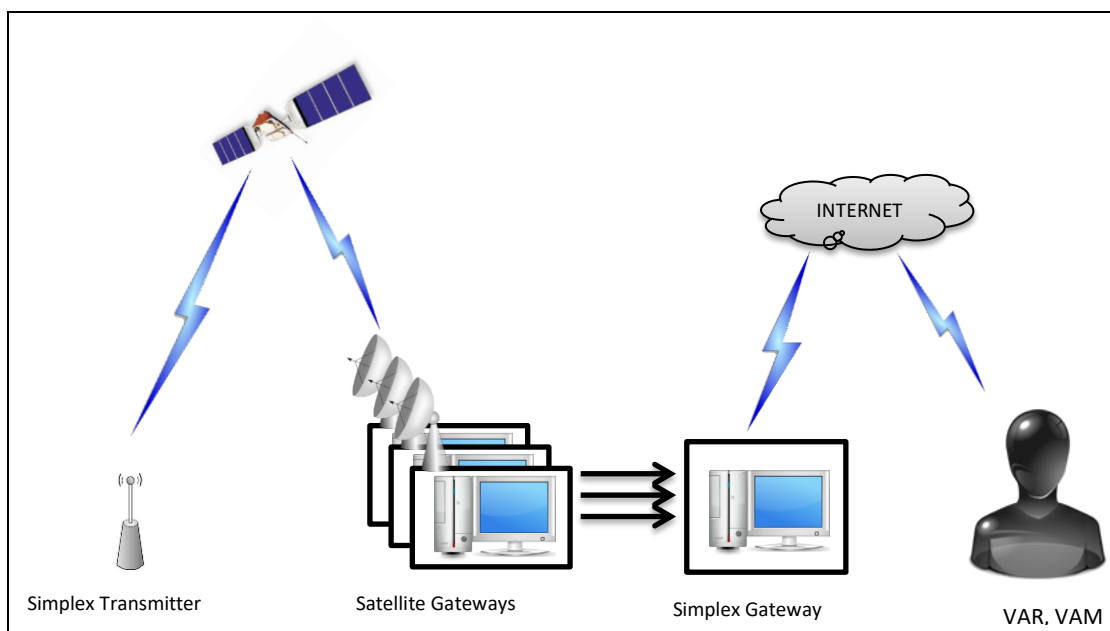


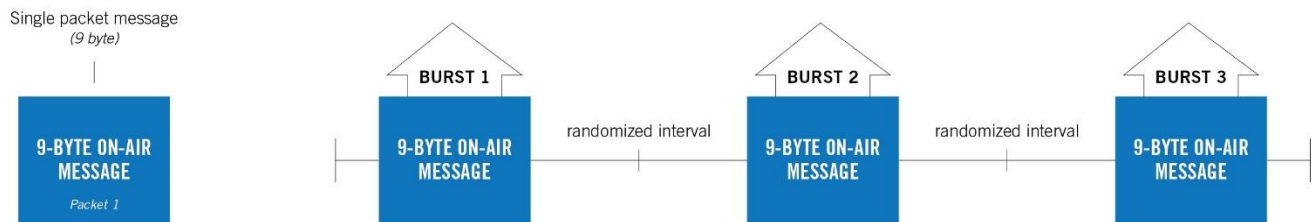
Figure 3 Simplex Messaging

Messages are composed of 1 or more 9-byte payloads. The user application may send a message via the Bluetooth Low Energy interface to the ST100 board from 1 to 144 bytes in length. The ST100 board will break the message into 9 byte packets. A 144 byte message would be broken into 16 packets.

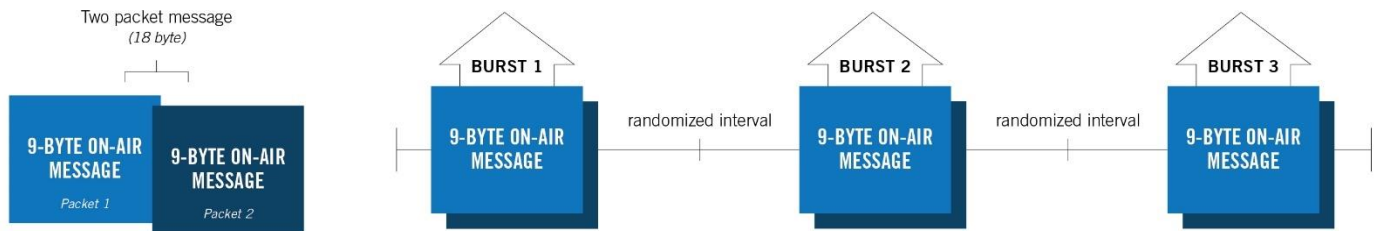


There are brief periods of time where there is no satellite in range of the simplex transmitters due to obstructions and/or satellite coverage geometry. Since a simplex device has no way of knowing if a transmitted message has been successfully received, the ST100 Board is designed to send multiple (redundant) transmissions for each message being sent over the Globalstar network. The default value for the number of redundant transmissions per message is 3. This means that each message sent to the ST100 Board will normally be transmitted 3 times. Each transmission will contain the exact same data payload. The redundant transmissions of each message will be sent on a randomized interval with a configurable maximum and minimum duration. The default configuration is for each re-transmission will occur between 5 to 10 minutes from the previous one with an even pseudo-randomized distribution.

The transmission sequence for a single-packet message using the default setting of 3 redundant transmissions is shown below.

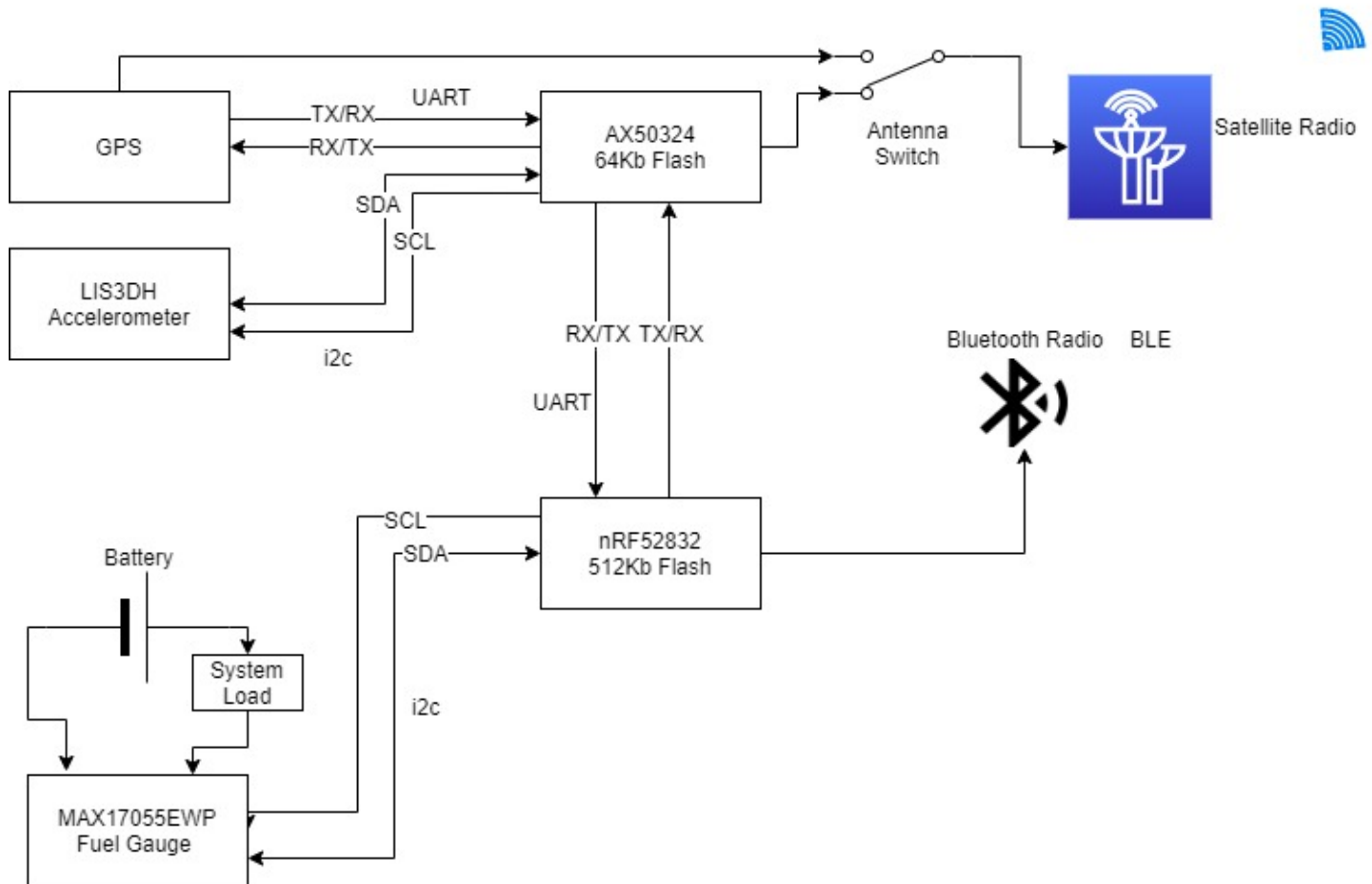


The transmission sequence for a two-packet message using the default setting of 3 redundant transmissions is shown below.



For normal conditions where the transmitter has an open view of the sky, this will result in a better than 99% chance that the message will be received.

2.2 Block Diagram



2.3 Handling of Electrostatic Sensitive Devices

Some components on the ST100 PCB are sensitive to electrostatic discharge (ESD). The following general guidelines can help reduce damage due to ESD.

1. Use a grounding bracelet if possible, to minimize charge build-up on personnel.
2. Handle the ST100 PCB by the long edges without touching components or printed circuit paths. The long edges measure approximately 2" (50.8mm). The short edges measure approximately 1" (25.4mm). Note: There are ESD sensitive devices located closer to the short edges than the long edges.
3. Store the ST100 PCB in static sensitive packaging whenever possible.

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2.4 Wiring

If the ST100 will be line-powered, proper installation and field wiring practices are important to follow. Users and installers should familiarize themselves with the requirements of all applicable codes, laws, and standards.

2.5 Noise Sources

Electrical noise is an important consideration in any installation of the ST100. When possible, sufficient physical separation should be maintained between electrical noise sources and the ST100.

2.6 Obstructions

If the internal ST100 Bluetooth and/or GPS/Satellite antennas are used, care should be taken as to what is placed above, below, and around the short edges of the PCB. The short edges are where the ST100 internal antennas are located. For best performance, the ST100 should have an unobstructed view of the sky, either outdoors or in a glass-enclosed area such as a vehicle dashboard.

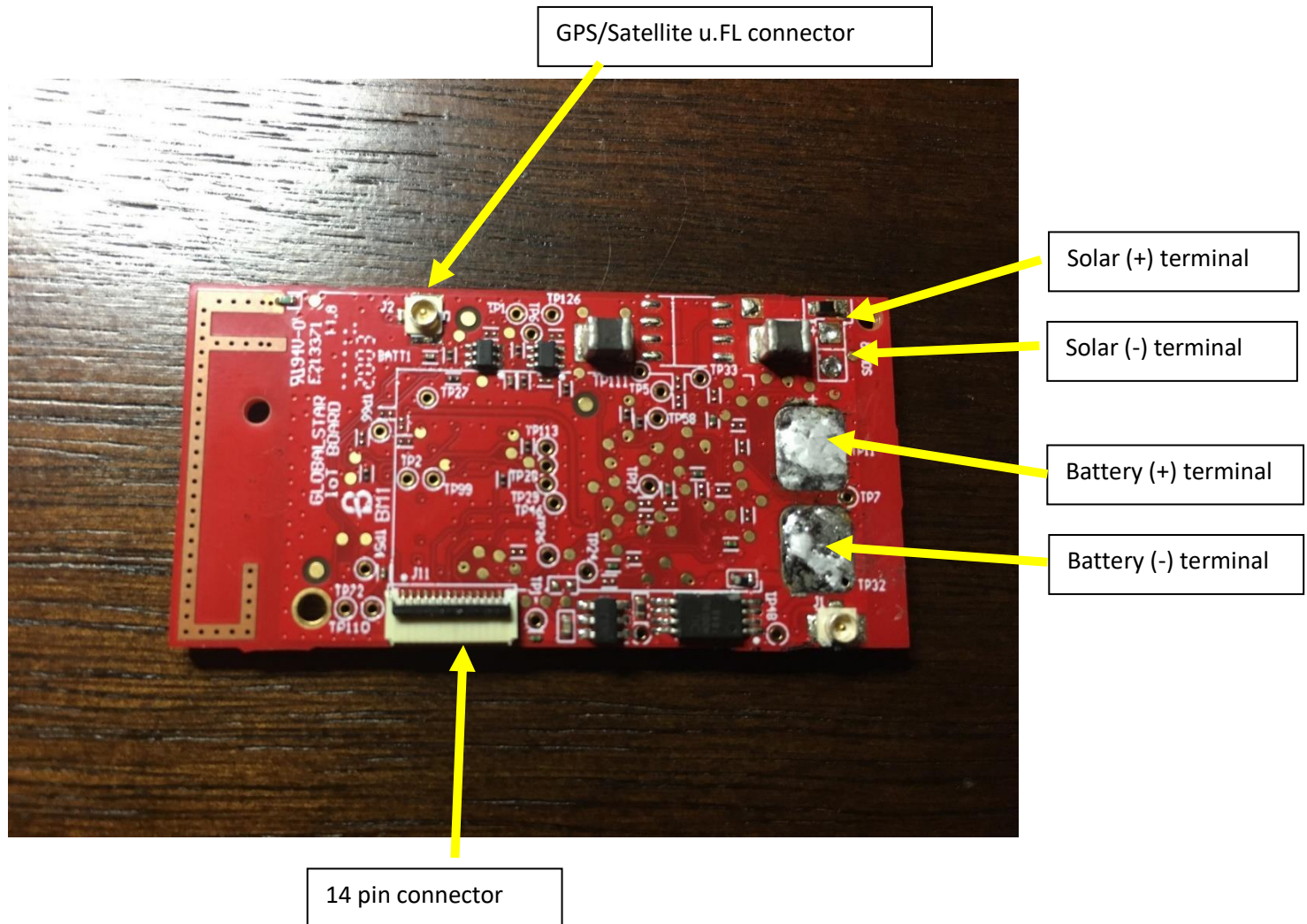
2.7 PCB Antenna

The ST100 has 2 PCB Trace antennas on the board for Satellite and Bluetooth transmissions. These are the default antennas for the ST100.

Regulatory Note: The ST100 was certified using its Satellite and Bluetooth PCB Trace antennas. The use of any external antennas will require additional regulatory testing plus approval from Globalstar Engineering.

2.8 External Connections

The picture (below) depicts the PCB external interfaces.



2.8.1 External Antenna Option

The ST100 has provisions where an external antenna can be used on either the Bluetooth and/or the GPS / Satellite antennas. If an external antenna is used, care should be taken when connecting the external antenna to the u.FL connector - Hirose part # U.FL-R-SMT(10) on the ST100 PCB. If this option is desired, Globalstar needs to know before boards are ordered.

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Regulatory Note: The ST100 was certified using its Satellite and Bluetooth PCB Trace antennas. The use of any external antennas will require additional regulatory testing plus approval from Globalstar Engineering.

2.8.2 Battery

The ST100 has terminals on the PCB where a battery can be soldered to. The user / installer should carefully note the location of the positive and negative terminals marked on the PCB and solder the battery accordingly. It will be up to the user / installer to verify the power requirements as mentioned in Section 3 “General Specifications”: Table 4: Power Requirements. Note: RoHS-compliant and lead-free solder must be used in order to maintain the RoHS-compliance of the ST100.

The ST100 can be powered in the following configurations:

1. Connecting a 3.4V to 5.5VDC source to the battery terminals. The source must meet the requirements mentioned in Table 4.
2. Connecting a battery to the battery terminals and connecting a 0.75V to 5VDC source to the solar terminals. The source on the solar terminals must meet the requirements mentioned in Table 4.

Table 1 – Nominal Battery Characteristics

Manufacturer / Part #	Description	Protection circuit included	IEC62133 approvals	Dimensions	Notes
PK Cell part # LP503035	3.7V, 500mAh, Li-Polymer	Yes	Yes	35 x 30 x 5mm +/- 0.1mm	Battery is normally stocked with a connector attached, but can be ordered without connector
PK Cell part # LP552535	3.7V, 420mAh, Li-Polymer	Yes	No	35 x 25 x 3.5mm +/- 0.1mm	Battery is normally stocked with a connector attached, but can be ordered without connector
Data Power Technology Limited part # DTP401525	3.7V, 110mAh, Li-Polymer	Yes	No	25 x 15 x 4mm +/- 0.1mm	Battery will only work down to 0°C

Notes:

1. This list is not a complete list of acceptable batteries. These are batteries that Globalstar has identified and tested as acceptable.
2. The VAR/installer should review the pairing of solar panel / battery and determine if the solar panel is

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adequate for use with the selected battery.

3. Regulatory Note: If a battery is used, it will be the responsibility of the VAR/installer to obtain / verify the relevant battery approvals / certifications for where the end-product will be used (i.e. IEC62133 approval)

4. Due to the solar charger chip's 100mA max input current, the max recommended battery size is 500mAh.

2.8.3 Solar Panel

The ST100 has terminals on the PCB where a solar panel can be soldered to. The user / installer should carefully note the location of the positive and negative terminals marked on the PCB and solder the solar panel accordingly. It will be up to the user / installer to verify the solar power requirements as mentioned in Section 3 "General Specifications": Table 4: Power Requirements. Note: RoHS-compliant and lead-free solder must be used in order to maintain the RoHS-compliance of the ST100

Table 2 – Nominal Solar Panel Characteristics

Manufacturer / Part #	Description	Voc (open-circuit voltage)	Vmpp (max power point)	Isc (short-circuit current)	Typical Full-Sun Current available for charging the battery (Note 3)	Dimensions
PowerFilm part # 2.4V 94x73mm BSC	2-cell, 2.4V, 288mW	3.6V	2.4V	140mA	50-60 mA	94 x 73 x 0.8mm
PowerFilm part # SP2.4-37	4-cell, 2.4V, 54mW	3.6V	2.4V	30mA	7-11 mA	50 x 36.5 x 0.8mm
PowerFilm part # SP2.4-37	5-cell, 2.4V, 67.5mW	4.5V	3V	30mA	10-14 mA	60 x 36.5 x 0.8mm
IXYS part # SM111K06L	High Efficiency, 3.35V, 156mW	4.15V	3.35V	46.7mA	20-30mA	42 x 21 x 2 mm

Notes:

1. This list is not a complete list of acceptable solar panels. These are panels that Globalstar has identified and

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tested as acceptable.

2. The VAR/installer should review the pairing of solar panel / battery and determine if the solar panel is adequate for use with the selected battery.

3. This value is based on the efficiency of the solar charger chip, which is typically 80-85%.

4. The solar panel should be chosen for outdoor use, if the end-application will be mostly outdoors.

2.8.4 14 Pin Connector

Table 3 – 14 pin Connector (Molex 5034801400)

Pin #	Signal Name	Description	Notes
1	3V0	3V supply	The 3V supply is only meant to power loads less than 20mA
2	SWDIO	Bluetooth processor programming line	
3	GND	PCB Ground	
4	SWDCLK	Bluetooth processor programming line	
5	GND	PCB Ground	
6	SAT_DBG_DATA	ASIC programming line	
7	SAT_DBG_CLK	ASIC programming line	
8	SAT_DBG_EN	ASIC programming line	
9	SAT_RST_N	ASIC reset	
10	EXT_TX_CONN	External Serial Port Transmit	This is the Receive signal on the Bluetooth processor.
11	EXT_RTS_CONN	External Serial Port Request to Send	This is a GPIO signal connected to the Bluetooth processor
12	MCU/BLE_#RESET	Bluetooth processor reset	
13	EXT_CTS_CONN	External Serial Port Clear to Send	This is a GPIO signal connected to the Bluetooth processor
14	EXT_RX_CONN	External Serial Port Receive	This is the Transmit signal on the Bluetooth processor.

Notes

1. The mating cable for Molex 5034801400 is Molex part # 0152660153, or equivalent.

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3 General Specifications

Table 4 – Operating Conditions

Component Temperature Range (without battery)	-30 to +70°C (Note 1)
Board Functional Temperature Range	-20 to +60°C
Board Storage Temperature Range (without battery)	-40 to +85°C
Power requirements (Battery Input)	3.4V to 5.5VDC (Notes 2, 3, 4) Standby current: 30-40uA
Input protection (Battery Input)	PTC resettable fuse Hold current -30C: 1.5Amps, 20C: 1.1Amps, 70C: 0.65Amps
Power requirements (Solar Input)	0.75V to 5VDC (Notes 5, 6, 7) Minimum power required: 50mW Maximum power: 510mW
External Serial Port Parameters	3V (Note 8)
Current Drain	
Satellite RF output	24.5dBm (Note 9) Frequency configurable to 1611.25MHz, 1616.25MHz, or 1618.75MHz
GPS / Satellite antenna gain	+1.06 dBi
Bluetooth Low Energy (BLE)	0dBm TX power -69dBm RX sensitivity
Bluetooth antenna gain	-1.09 dBi

Notes:

1. The -30 to +70°C temperature range is for the ST100 components and doesn't include the battery or solar panel.
2. The power source on the battery input should be able to supply 500mA pulse current (at 3.7V) for 1.5 seconds. If the end-application expects to have 16 packet messages, the supply should be able to provide this pulse current up to 16 times in succession.
3. If a battery is used, the VAR/installer should verify the battery's performance at the application's lowest expected ambient temperature before proceeding with the selected battery.
4. The ST100 has the option to install a battery protection circuit. The VAR/installer will need to inform Globalstar before ordering PCBs if this feature is desired.
5. Both the 0.75V and 50mW requirements must be met on the solar input for charging a depleted battery.

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6. The maximum current the solar charger chip on the ST100 board will accept is about 100mA, regardless of solar panel size.
7. If connecting a 5V source to the solar input, the source must be current limited to 100mA.
8. The external serial port consists of 4 GPIO pins connected to the ST100 Bluetooth processor.
9. The 24.5dBm is the conducted power going into the antenna.

4 Application Programming Interface

The ST100 Board provides a Bluetooth Low Energy (BLE) GATT/Modem interface for controlling the operation of the device. Commands are used to send information over the simplex network, operate the GPS engine, and monitor the internal operation of the device. The following types of commands are provided by the ST100 Interface:

- Simple ASCII Text commands for basic operation.
- Legacy binary commands, primarily emulating the interface of the STINGR product

4.1 ASCII Command List and Format

The ST100 Board accepts a set of ASCII commands to query the board for status, and to cause it to perform various commands.

Commands take the form of a “keyword” and a variable number of arguments, in the same form of command line arguments in a Windows or Linux command prompt window.

4.1.1 ASCII Format

Command <arg1> <arg2> <arg3> ... <argn> <CR>

Where the “CR” is an Ascii Carriage Return or Enter (Decimal value of 13).

4.1.1.1 “?”

Print a list of commands.

Command: ?

Arguments: None

Example: ?

Example response:

Commands List:

esn
data

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abort
bursts
hardware
firmware
test_cw
test_packet
test_mod
setup
hib
fgd
tfg
frr
raw
bpm
auth
edfg

4.1.1.2 “esn”

Prints the unit ESN in the form “0-123456”.

Command: esn

Arguments: None

Example: esn

Example response:

esn: 0-123456

4.1.1.3 “data”

Sends raw data via the Simplex Satellite modem. The example shown here would send that hex string and would require 2 9 byte simplex packets.

Command: data

Arguments: a hexadecimal string

Example: data 112233445566778899aabbccddeeff

Example response:

Data sent

4.1.1.4 *“abort”*

Aborts a redundant burst in progress. Note does not cancel a running tracking session.

Command: abort

Arguments: None

Example: abort

Example response:

Message Aborted

4.1.1.5 *“bursts”*

Returns the remaining bursts for a message in progress.

Command: bursts

Arguments: None

Example: bursts

Example response:

2 remaining

4.1.1.6 *“hardware”*

Returns the ST100 Board hardware version

Command: hardware

Arguments: none

Example: hardware

Example response:

Hardware Version: 1.0.0-F0

4.1.1.7 *“firmware”*

Returns the Aggregate board firmware version, and individual processor firmware versions.

Command: firmware

Arguments: none

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Example: firmware

Example response:

Firmware version: 1.0.0 (010000-010000)

4.1.1.8 “setup”

Command: setup

Arguments: <default channel> <Number of TX Tries> <Minimum time between tries> <Maximum time between tries>

Sending the command with no arguments returns the current settings. If sent with arguments, the response is the same, confirming the settings.

Example: setup 0 3 60 120

Example response:

Setup: Channel: 0 Bursts: 3 Min Interval: 60 Max Interval: 120

All arguments must be present. If any are missing, or any are out of range, the command will return a fail message and reason.

The Channel Field: May contain 0 – 3 corresponding to simplex Return Link channels A – D respectively. Note that this will affect the channel for the next raw transmission. Subsequent GPS fixes will steer the active channel to the appropriate one based on GPS location.

The correct Globalstar Simplex channel is dictated by RAS (Radio Astronomy Site) avoidance and by a “geofrequency” channel map. Whenever the ST100 board obtains a fix, it sets the channel based on these criteria. If a user uses the product to send “raw” simplex messages without obtaining a fix, it is up to the user to be aware of where the device is and adhere to this channel map. This is the command used to do that. See document GS-07-1248 - REMOTE TELEMETRY SERVICE FREQUENCY PLAN FOR SIMPLEX TRANSMITTERS for more information on the method for channel selection.

The number of TX Tries field: Number of tries in the burst. Valid range is 1 – 15

Minimum time between tries: Based on a value from a legacy simplex transmitter (the original Globalstar STU), this is a number of “5 second ticks”. E. g. 60 = 5 minutes (5 * 5 seconds = 300 seconds). Minimum value = 1 (5 seconds)
Maximum Value = 60 (5 minutes).

Maximum time between tries: Also, expressed in number of “5 second ticks”. Minimum value = value of minimum time + 1. Maximum value = 120 (600 seconds).

The wait between each “try” will be an evenly distributed pseudo-random amount of time between the minimum and maximum value expressed above. Resolution of the pseudo-random timing for this device is 1.5 seconds.

4.1.1.9 “raw”

Send raw binary command to the ASIC

Command: raw

Arguments: A hex string command to send to the ASIC (See “Binary Serial Packet Commands” section). CRC is omitted, and is generated and appended by the Nordic firmware as it sends the command to the ASIC

Example: raw AA0501

Example response:

Response: AA090100123456

This allows any command in the “Binary Serial Packet Commands” section to be sent to the ASIC. It is this command that implements the simplest form of the “STINGR with Bluetooth” function of the ST100 tag.

The response is the Hex string returned as an acknowledgement from the ASIC.

The example above is an ESN query.

4.1.1.10 “bpm”

Invokes Binary Passthrough Mode

Command: bpm

Arguments: none

Example: bpm

Invokes Binary Passthrough Mode

This permits an extensive dialog of “AA” commands and responses to be passed through the Bluetooth to and from the ASIC when many commands must be passed rapidly and the “raw” command method, described in the previous subsection, would add an objectionable amount of overhead.

The most common example would be to run the ASIC’s bootloader to load a new firmware image, a process that requires many “AA” commands to be sent rapidly.

Binary passthrough mode expires, and the ST100 board returns to ASCII mode when 60 seconds have passed without a binary message being sent to the device.

Binary passthrough mode can be terminated immediately by sending “AA 05 6F [crc-lo] [crc-hi]” in the binary command format. The Nordic processor will catch this particular command and terminate the passthrough.

4.1.1.11 “auth”

Unlocks privileged commands.

Command: auth

Arguments: A 32 bit unlocking key in Hexadecimal

Example: auth 11764BA3

Example response:

Auth success!

The following commands require a unique authorization key to be issued via this command before they will be recognized: “bpm”, “raw”, “edfg”

The commands requiring “auth” are unlocked for 30 seconds after sending the auth command. Sending the commands multiple times (e. g. “raw”) DOES NOT “bump out” the 30 second timer. However, once the user has kicked the ST100 board into binary passthrough mode, the “auth” will expire concurrently with the binary passthrough expiry.

For instructions on how to generate the authorization key, contact Globalstar.

4.2 Binary Serial Packet Commands

These commands represent the Legacy Globalstar format.

These commands are accessible on an individual basis by issuing them as the argument to the “raw” ASCII command.

Several of these commands can be sent in order by putting the command interface into Binary Passthrough Mode by issuing the “bpm” ASCII command.

NOTE: When using the “raw” command to send individual messages, the CRC is not sent by the user. The Nordic processor firmware calculates and appends the correct CRC to the message going to the ASIC processor.

The CRC discussed below and given by example in the subsequent sections is only applicable from the user’s point of view when sending a series of messages in “binary passthrough mode” (“bpm” command).

4.2.1 Serial Packet Format

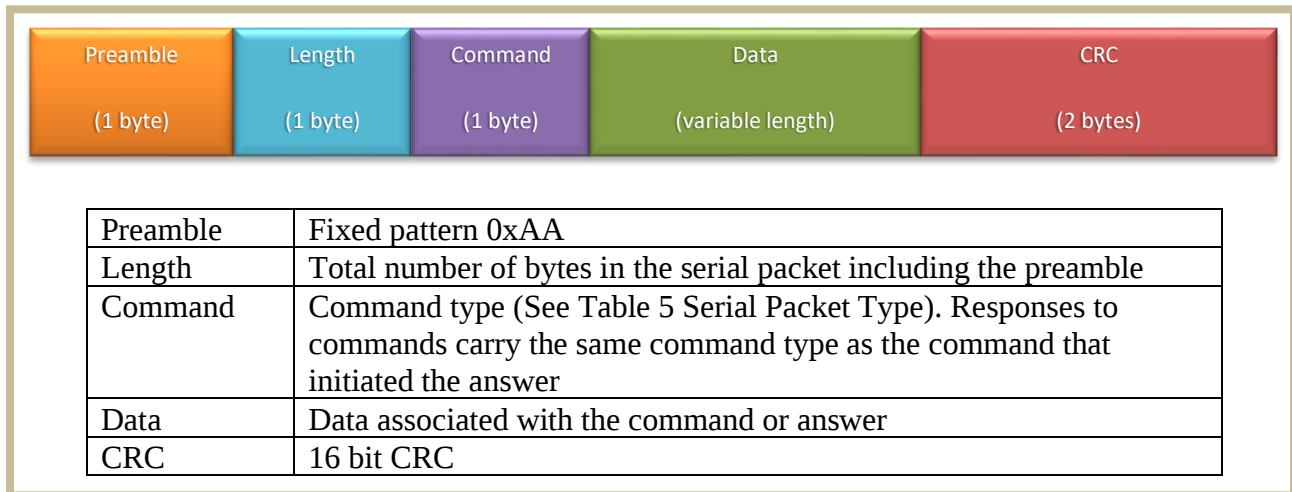


Figure 4 Serial Packet Format

4.2.2 Serial Packet Command List

For all serial packet commands as described below:

- AA is the **Preamble**.
- NN is the **Length**.
- XX is an unspecified byte value
- CLSB is the least significant **CRC** byte
- CMSB is the most significant **CRC** byte
- CLSB and CMSB are **omitted** when using the RAW command. **Length** must still be specified to include them, however.
- If an improperly formatted command is received, the ST100 BOARD will return a NAK response:

AA 05 FF A1 CB

4.2.2.1 Send Data (0x00)

The Send Data command requests the ST100 board to send from 1 to 144 data bytes over the Globalstar Simplex network.

0x00

Leader	Len	Cmd	payload 1	payload 2	payload 3	..	payload N	CRC1	CRC2
AA	NN	00	XX	XX	XX	XX	XX	CLSB	CMSB

Example Command: AA 0E 00 01 02 03 04 05 06 07 08 09 BE E8

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Response: AA 05 00 D9 C4

The example above commands the ST100 Board to send 9 bytes of **user defined data** over the Globalstar Simplex network. If the ST100 Board receives a properly formatted Send Data command, it returns an acknowledge response as shown above. If the command is not properly formatted, it will return the NAK response AA 05 FF A1 CB.

4.2.2.2 Query Electronic Serial Number (ESN) (0x01)

The Electronic Serial Number command requests the ST100 BOARD to respond with the units Electronic Serial Number (ESN).

0x01

Leader	Len	Cmd	CRC1	CRC2
AA	05	01	50	D5

Command: AA 05 01 50 D5

Response:

Leader	Len	Cmd	ESN				CRC1	CRC2
AA	09	01	XX	XX	XX	XX	86	7A

Example Response: AA 09 01 **00 23 18 60** 86 7A

Where the ESN returned is 2300000.

4.2.2.3 Abort Transmission (0x03)

The Abort Transmission command requests the ST100 BOARD to abort the current message transmit sequence over the Globalstar Simplex network. This command aborts a redundant burst transmission. It DOES NOT abort track mode.

0x03

Leader	Len	Cmd	CRC1	CRC2
AA	05	03	42	F6

Command: AA 05 03 42 F6

Response: AA 05 03 42 F6

4.2.2.4 Query Bursts Remaining (0x04)

The Query Bursts Remaining command requests the ST100 BOARD to return the current number of bursts remaining the current message transmit sequence over the Globalstar Simplex network.

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0x04

Leader	Len	Cmd	CRC1	CRC2
AA	05	04	FD	82

Command: AA 05 04 FD 82

Response:

Leader	Len	04	count	CRC1	CRC2
AA	05	04	XX	CC	CC

Example Response: AA 06 04 00 F4 33

Where the bursts remaining returned is: 0

4.2.2.5 Query Firmware Version (0x05)

The Query Firmware Version command requests the ST100 BOARD to return the current firmware version.

0x05

Leader	Len	Cmd	CRC1	CRC2
AA	05	05	74	93

Command: AA 05 05 74 93

Response:

Leader	Len	4	FW major	FW minor	FW Build	CRC1	CRC2
AA	8	5	XX	XX	XX	CC	CC

Example Response: AA 08 05 01 07 04 E0 6A

Where the firmware version returned is: 1.7.4

4.2.2.6 Setup (0x06)

The Setup command requests the ST100 BOARD to use the specified setup parameters. These are stored in non-volatile memory.

0x06

Command:

header	len	04	RESERVED				RF channel	# of Bursts	Interval Min	Interval Max	RESERVED	CRC1	CRC2
AA	0E	06	XX	XX	XX	XX	XX	XX	XX	XX	XX	CC	CC

Where:

- RF channel : Valid values are: 0 = Channel A, 1 = Channel B, 2 = Channel C, 3 = Channel D
- # of bursts: Valid values are: 0x01 thru x14 (1 to 20 bursts)
- Minimum Burst Interval: Units of 5 seconds. Valid values are: 0x01 thru 0x3C (5 to 300 seconds)
- Maximum Burst Interval: Units of 5 seconds. Valid values are: 0x02 thru 0x78 (10 to 600 seconds)

Example Command: AA 0E 06 00 00 00 00 00 03 18 30 00 CE 9C

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Where the setup information is:

- RF channel : 00 Channel A
- # of bursts: 03 3 bursts per message
- Minimum Burst Interval: 18 $0x18 = 24, 24 \times 5 = 120$ seconds
- Maximum Burst Interval: 30 $0x30 = 48, 48 \times 5 = 240$ seconds

4.2.2.7 Query Setup (0x07)

The Query Setup command requests the ST100 BOARD to return the current setup parameters.

0x07

Leader	Len	Cmd	CRC1	CRC2
AA	05	07	66	B0

Command: AA 05 07 66 B0

Response:

Leader	Len	Cmd	RESERVED				RF channel	# of Bursts	Interval Min	Interval Max	RESERVED	CRC1	CRC2
AA	0E	07	XX	XX	XX	XX	XX	XX	XX	XX	XX	18	59

Where:

- RF channel : Valid values are: 0 = Channel A, 1 = Channel B, 2 = Channel C, 3 = Channel D
- # of bursts: Valid values are: 0x01 thru x14 (1 to 20 bursts)
- Minimum Burst Interval: Units of 5 seconds. Valid values are: 0x01 thru 0x3C (5 to 300 seconds)
- Maximum Burst Interval: Units of 5 seconds. Valid values are: 0x02 thru 0x78 (10 to 600 seconds)

Example Response: AA 0E 07 00 23 18 60 **00 03 18 30** 00 5D 60

Where the setup information returned is:

- RF channel : 00 Channel A
- # of bursts: 03 3 bursts per message
- Minimum Burst Interval: 18 $0x18 = 24, 24 \times 5 = 120$ seconds
- Maximum Burst Interval: 30 $0x30 = 48, 48 \times 5 = 240$ seconds

4.2.2.8 Query Hardware Version (0x09)

The Query Hardware Version command requests the ST100 BOARD to return the current hardware version information.

0x09

Leader	Len	Cmd	CRC1	CRC2
AA	05	09	18	59

Command: AA 05 09 18 59

Response:

Leader	Len	Cmd	Device Code		Silicon Rev	CPU Rev	Radio Rev	CRC1	CRC2
AA	0A	09	00	01	XX	XX	XX	CC	CC

Where:

- Device Code : Always 1 for ST100 BOARD
- Silicon Revision: Simplex Silicon revision
- CPU Revision: Simplex CPU revision
- Radio Revision: Simplex Radio revision

Example Response: AA 0A 09 00 01 8F 62 62 F7 58

Where the revision information returned is:

- Device Code: 01
- Silicon Revision: 8F
- CPU Revision: 62
- Radio Revision: 62

4.2.2.9 Set GPS Timeout command

This command sets the GPS timeout - the maximum time the unit will attempt to obtain a GPS fix before giving up.

Set GPS Timeout command format

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x07
2	0 – 7	Command Code.	0x23 = Set GPS timeout
3-4	0 – 15	GPS timeout value	GPS timeout value in seconds. Must be between 60 and 300 seconds (1 to 5 minutes). Factory default is 4 minutes (240 seconds)
5-6	0 – 15	CRC	

Example response: AA 05 23 [CRC] [CRC]

4.2.2.10 Get GPS Timeout query

Get GPS Timeout Query Format

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x24 = GPS Timeout Query
3 -4	0 - 15	CRC	

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Get GPS Timeout Query response

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x07
2	0 – 7	Command Code.	0x24 = GPS Timeout Query
3-4	0 – 15	GPS timeout value	GPS timeout value in seconds
5-6	0 – 15	CRC	

4.2.2.11 "SPOT GEN3 emulation.

The ST100 board has the ability to emulate the tracking and messaging modes of a SPOT GEN3 device for particular applications.

Refer to document (number TBD) "ST100 SPOT GEN3 emulation modes" for details on how to use these modes.

4.2.2.12 Special consideration for "Byte 7" in the next several commands.

The following commands cause the ST100 to transmit either a single busted message, or to enter track mode or to modify a track mode, wherein bytes 1,2,3,4,5 and 6 of the over the air message contain the latitude and longitude location data.

The user may set bytes 0, 7, and 8 (and subsequent packets in the case of the "Send Redundant Burst with GPS" (0x33) command) to any value of his choosing with a special exception for "byte 7".

The commands for which this rule applies are:

0x30 - Proprietary Track

0x33 - Send Redundant Burst with GPS

0x34 - Proprietary Motion Activated Track

0x35 - Proprietary Motion Activated Dock

In any of the above modes, if the user specifies a value for "Byte 7" with the most significant 4 bits all ones ((<byte 7> & 0xF0) = 0xF0) the following special behavior is activated:

The 4 most significant bits of byte 7 become status flags with the meanings as follows:

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0x10 = RESERVED

0x20 = Low Battery (Tracking rate reduced to low battery rate)

0x40 = GPS location invalid

0x80 = GPS location of low confidence

4.2.2.13 “Proprietary Track” command

This command allows the initiation of a periodic track message with user defined data prepended and appended to the latitude and longitude fields. A periodic 9-byte custom track message, transmitted nominally at the interval specified, will result.

The behavior of this mode differs somewhat from the same mode’s behavior in the STINGR product. In the ST100 board implementation, if the interval is set to 30 minutes or greater, a redundant burst transmission will be initiated at each interval, with the number of attempts and the timing between the attempts as specified in the “setup” command. If the interval is less than 30 minutes, a single transmission will be sent per interval.

If the interval is 40 minutes or greater, the ST100 board will randomize the start of each burst by +/- 10 minutes around the nominal. For example, if a track mode with an interval of 1 hour is started at 12:00, the next burst position report will begin randomly between 12:50 and 1:10, the one after that will begin between 1:50 and 2:10, etc.

While in Proprietary Track mode with an interval of 30 minutes or less, the GPS will retain its clock and ephemeris data in order to perform a “hot” GPS fix. This will increase the sleep current by roughly 50uA in such a track mode.

If the unit is already in a track mode, and this command is sent, it will be NAKed. To change the track rate, the “Cancel Proprietary Track” command must be sent, and a new track command then issued.

Operating Mode	Standby Current
Proprietary Tracking <= 30 minute interval	GPS Standby Mode
Proprietary Tracking > 30 minute interval	Standby Mode

Proprietary Track command format

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x0A (10 decimal)
2	0 – 7	Command Code.	0x30 = Initiate proprietary track.
3 -4	0 - 15	Interval	Interval in minutes between the track points. 2 to 65535 minutes. (A setting of 2 actually results in a 2.5 minute interval, any other value results in an interval of that many minutes).
5	0 - 7	Byte 0 value	The value to transmit as byte 0
6	0 - 7	Byte 7 value	The value to transmit as byte 7.
7	0 - 7	Byte 8 value	The value to transmit as byte 8.
8-9	0 - 15	CRC	

Example Command: AA 0A 30 **00 0A** AA BB CC 90 84

Where:

- **Period :** 0x000A (10 minute intervals)
- Payload Byte 0: 0xAA
- Payload Byte 7: 0xBB
- Payload Byte 8: 0xCC

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Initiate proprietary track response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x30 = ACK or 0xFF = NAK
3 -4	0 - 15	CRC	

Example Response: AA 05 30 5A F5

Example Payload: 0xAA**2B4856****BFF032**BBCC

Where: **2B4856** is the 24-bit latitude 30.433051586151 (North)
BFF032 is the 24-bit longitude -90.086817741394 (West)

See section 4.6: “24 bit location format” for documentation of the encoding/decoding of Globalstar on-air location data.

4.2.2.14 “Proprietary Motion Activated Track” command

This command allows the initiation of a periodic track with user defined data prepended and appended to the latitude and longitude fields. A periodic 9-byte custom track message, transmitted nominally at the interval specified, will result.

In this mode, tracking will suspend when the accelerometer detects that the device is not moving, and then resume when it detects that the device is moving again.

The behavior of this mode differs somewhat from the same mode’s behavior in the STINGR product. In the ST100 board implementation, if the interval is set to 30 minutes or greater, a redundant burst transmission will be initiated at each interval, with the number of attempts and the timing between the attempts as specified in the “setup” command. While in Proprietary Track mode with an interval of 30 minutes or less, the GPS will retain its clock and ephemeris data in order to perform a “hot” GPS fix. This will increase the GPS standby current to the “GPS Standby Mode” value in Table 4. For tracking intervals greater than 30 minutes, the GPS will be powered off in between transmissions and the sleep current will be the “Standby Mode” value in Table 4.

If the interval is 40 minutes or greater, the ST100 board will randomize the start of each burst by +- 10 minutes around the nominal. For example, if a track mode with an interval of 1 hour is started at 12:00, the next bursted position report will begin randomly between 12:50 and 1:10, the one after that will begin between 1:50 and 2:10, etc.

If the unit is already in a track mode, and this command is sent, it will be NAKed. To change the track rate, the “Cancel Proprietary Track” command must be sent, and a new track command then issued.

While in Motion Activated Track mode, the accelerometer sub-system will remain powered during the standby periods in between transmissions and the accelerometer standby current will be the “Standby mode supply current w/Accelerometer” value in Table 4.

The following table summarizes the standby mode supply current for different modes

Operating Mode	Standby Current
Continuous Tracking <= 30 minute interval	GPS Standby Mode + Standby mode supply current w/Accelerometer
Continuous Tracking > 30 minute interval	Standby mode supply current w/Accelerometer
Motion Activated/Dock Tracking <= 30 minute interval	GPS Standby Mode + Standby mode supply current w/Accelerometer
Motion Activated/Dock Tracking > 30 minute interval	Standby mode supply current w/Accelerometer

Proprietary Motion Activated Track command format

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x0A (10 decimal)
2	0 – 7	Command Code.	0x34 = Initiate proprietary motion activated track.
3 -4	0 - 15	Interval	Interval in minutes between the track points. 2 to 65535 minutes. (A setting of 2 actually results in a 2.5 minute interval, any other value results in an interval of that many minutes).
5	0 - 7	Byte 0 value	The value to transmit as byte 0
6	0 - 7	Byte 7 value	The value to transmit as byte 7.
7	0 - 7	Byte 8 value	The value to transmit as byte 8.
8-9	0 - 15	CRC	

Example Command: AA 0A 34 00 0A AA BB CC 3C 94

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Where:

- **Period :** 0x000A (10 minute intervals)
- Payload Byte 0: 0xAA
- Payload Byte 7: 0xBB
- Payload Byte 8: 0xCC

Initiate proprietary track response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x30 = ACK or 0xFF = NAK
3 -4	0 - 15	CRC	

Example Response: AA 05 30 5A F5

Example Payload: 0xAA**2B4856BFF032**BBCC

Where: **2B4856** is the 24-bit latitude 30.433051586151 (North)
BFF032 is the 24-bit longitude -90.086817741394 (West)

See section 4.6: “24 bit location format” for documentation of the encoding/decoding of Globalstar on-air location data.

4.2.2.15 “Proprietary Motion Activated Dock Mode Track” command

This command is essentially the same as the “Proprietary Motion Activated Track” command above, except that in “Dock Mode”, the movement detected by the accelerometer is confirmed by motion or lack of motion being indicated by sequential GPS fixes. The idea is that this mode prevents a “boat at dock” from falsely entering a state of motion and resuming track due to the boat bobbing in the waves while docked.

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x0A (10 decimal)
2	0 – 7	Command Code.	0x35 = Initiate proprietary dock mode track.
3 -4	0 - 15	Interval	Interval in minutes between the track points. 2 to 65535 minutes. (A setting of 2 actually results in a 2.5 minute interval, any other value results in an interval of that many minutes).
5	0 - 7	Byte 0 value	The value to transmit as byte 0
6	0 - 7	Byte 7 value	The value to transmit as byte 7.
7	0 - 7	Byte 8 value	The value to transmit as byte 8.
8-9	0 - 15	CRC	

4.2.2.16 “Update Proprietary Track Data” command

This command is used to change the user programmable data in a proprietary track message. If a proprietary track session is not in progress, it is ACK'd but will do nothing.

Update proprietary track data command format

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x08
2	0 – 7	Command Code.	0x31 = Update proprietary track.
3	0 – 7	Byte 0 value	The value to transmit as byte 0
4	0 – 7	Byte 7 value	The value to transmit as byte 7.
5	0 – 7	Byte 8 value	The value to transmit as byte 8.
6-7	0 – 15	CRC	

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Example Command: AA 08 31 AA BB CC 21 FA

Where:

- Payload Byte 0: 0xAA
- Payload Byte 7: 0xBB
- Payload Byte 8: 0xCC

Update Proprietary Track Data response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x31 = ACK or 0xFF = NAK
3 -4	0 - 15	CRC	

Example Response: AA 05 31 D3 E4

4.2.2.17 "Cancel Proprietary Track/Proprietary Motion Activated Track" command

This command is used to terminate a Proprietary Track, Proprietary Motion Activated Track, or Proprietary Dock Mode Track session.

Cancel Proprietary Track command format

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x05
2	0 - 7	Command Code.	0x32 = cancel proprietary track.
3-4	0 - 15	CRC	

Leader	Len	Cmd	CRC1	CRC2
AA	05	32	48	D6

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Example Command: AA 05 32 48 D6

Cancel Proprietary Track response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x32 = ACK or 0xFF = NAK
3 -4	0 - 15	CRC	

Example Response: AA 05 32 48 D6

4.2.2.18 “Proprietary Track Status” query

Proprietary Track Status Query

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x38 = Proprietary Track Status Query
3 -4	0 - 15	CRC	

Proprietary Track Status Query Response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x0C
2	0 - 7	Command Code.	0x38 = Proprietary Track Status Query
3	0 - 7	Suspend / Power State	0x00 = Fully suspended 0x01 = Low battery / Partial Suspend 0x02 = Fully unsuspended
4	0 - 7	Specific track mode	0x30 = Proprietary Track 0x34 = Motion activated proprietary track 0x35 = Proprietary Dock
5 – 6	0 - 15	Track interval	Value of interval in minutes
7	0 - 7	Byte 0 value	The value being transmitted as byte 0.
8	0 - 7	Byte 7 value	The value being transmitted as byte 7. (See note below)
9	0 - 7	Byte 8 value	The value being transmitted as byte 8.
10 - 11	0 - 15	CRC	

Note: If the upper nibble of the Byte 7 value is 0xF, in other words if the "Byte 7 value & 0xF0 = 0xF0, the upper nibble of byte 7 is being populated with ST100 Status flags (See status flags section)

Note 2: If the device is NOT in track mode, bytes 4 - 9 will all be populated with 0's.

Example response: AA 0C 38 02 30 00 3C 03 F7 45 <crc-lo> <crc-hi>

02 = Fully unsuspended

30 = Proprietary Track Mode

00 3C = 60 minute interval

03 = Value of Byte 0

F7 = lower nibble of Byte 7 will be a value of 7, upper nibble populated with status flags

45 = Byte 8 value of 0x45

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4.2.2.19 "Tracking Statistics" query

Tracking Statistics Query

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x39 = Tracking Statistics Query
3 -4	0 - 15	CRC	

Tracking Statistics Response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x13
2	0 - 7	Command Code.	0x39 = Tracking Statistics Query
3	0 - 7	Reset Flag	0x00 = Device has not reset since the last time this query was issued 0x01 = Device has reset since the last time this query was issued
4	0 - 7	Suspended state	0x00 = Tracking is fully suspended 0x01 = Tracking is partially suspended (operating at low battery rate) 0x02 = Tracking is running at normal schedule
5	0 - 7	Resolution of next field	0x00 = Next field represents a value in seconds 0x01 = Next field represents a value in minutes (This allows the next field to express a much wider range of values while still only 2 bytes in size.)
6 - 7	0 - 15	Time remaining in current interval	The time remaining until the next GPS fix and location report cycle. Resolution, minutes or seconds, is shown in the previous field.
8	0 - 7	Track burst tries remaining	If a burst track message is in progress, this is the number of attempts left in the burst
9 - 10	0 - 15	Time to next transmission in burst.	Time, in seconds, until the next attempt in the burst, if a burst is not currently running, will be zero.
11	0 - 7	Number of attempts remaining in interleaved burst	If an interleaved burst is running, the number of attempts remaining in the burst is shown here. If no interleaved message is running, this field will read 0.
12 - 13	0 - 15	Time to next interleaved burst	If an interleaved burst is running, this is the number of seconds until the next burst attempt. If no interleaved burst is running, this field is zero.

14	0 - 7	Number of packets in interleaved burst message	The number of packets in the interleaved burst message. Note: As a "quirky feature" this value does not clear when the burst finishes, and if no interleaved burst is running, this will show the number of packets that were in the last interleaved burst that ran. It can be determined if a burst is currently running by examining bytes 11, and 12-13. They will be non-zero if an interleaved burst is running.
15 - 16	0 - 15	Total messages in mode	This holds the total messages transmitted since the track mode began. It will be a total of the scheduled track messages and the interleaved messages.
17 - 18	0 - 15	CRC	

4.2.2.20 "GPS Statistics" query

GPS Statistics Query

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x3A = GPS Statistics Query
3 - 4	0 - 15	CRC	

GPS Statistics Response

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Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x15
2	0 - 7	Command Code.	0x3A = GPS Statistics Query
3	0 - 7	Reset Flag	0x00 = Device has not reset since the last time this query was issued 0x01 = Device has reset since the last time this query was issued
4 - 5	0 - 15	Grand total fixes	Number of fixes attempted since the last reset
6 - 7	0 - 15	Total fix fails	Total number of times a fix could not be obtained within the fix timeout since the last reset.
8 - 9	0 - 15	Mean fix time	Average time to obtain a fix over the last 16 fixes in seconds
10 - 11	0 - 15	Last fix time	Time to obtain the last fix in seconds
12 - 13	0 - 15	Fix timeout	Set fix timeout in seconds
14	0 - 7	GPS Active flag	0 = GPS Not active 1 = GPS Active
15 - 16	0 - 15	Fix timeout remaining	Time remaining until the fix times out. If the GPS system is not running, will be zero
17	0 - 7	Fix quality level	0 = no fix 1 = 2D fix 2 = 3D fix 3 = 3D fix and Globalstar "fix confidence" level reached. Note: Since the GPS subsystem is switched off as soon as the Globalstar Fix Confidence level is reached in normal operation, it will be rare to catch a "3" in this field.
18	0 - 7	Total sats.	Total GPS satellites with a sufficient signal level to be useful, in view.
19 - 20	0 - 15	CRC	

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4.2.2.21 "Transmitter Statistics" query.

Transmitter Statistics Query

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x5
2	0 - 7	Command Code.	0x3B = Transmitter Statistics Query
3 - 4	0 - 15	CRC	

Transmitter Statistics Response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	0x0C
2	0 - 7	Command Code.	0x3B = Transmitter Statistics Query
3	0 - 7	Reset Flag	0x00 = Device has not reset since the last time this query was issued 0x01 = Device has reset since the last time this query was issued
4 - 5	0 - 15	Total messages in mode	Total messages transmitted in the current track mode, including interleaved messages.
6 - 7	0 - 15	Total Packets Transmitted	Total packets transmitted since the last reset. Rolls over at 65,535
8 - 9	0 - 15	Total TX failures	Total times the transmitter attempted to lock the PLL so it could transmit and the PLL would not lock Any number here other than zero is a serious indication of a problem. (It's possible the PLL might not lock in extreme high or low temperature conditions, but generally speaking, anything other than zero here is probably bad.)
10 - 11	0 - 15	CRC	

4.2.2.22 "Send Redundant Burst with GPS" command

This command is used to initiate a redundant bursted message (as setup in STX configuration). Bytes 1 – 6 of the first packet of the message shall contain latitude and longitude in standard Globalstar 24-bit format. Since each on-air message must be a multiple of 9 bytes, the message will contain up to 16 9-byte packets depending on the size of the payload.

Send Redundant Burst with GPS command format

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	Variable 0x08 – 0x90 (144 bytes)
2	0 - 7	Command Code.	0x33 = Send Redundant Burst with GPS.
3	0 - 7	Byte 0 value	The value to transmit as byte 0 of first packet
4	0 - 7	Byte 7 value	The value to transmit as byte 7 of first packet
5	0 - 7	Byte 8 value	The value to transmit as byte 8 of first packet
6 - n		Additional data	Up to 135 additional bytes of data (16 9 byte packets). Maximum value of n = 141. If this number is not divisible by 9, the end of the final packet of the message will be zero padded.
n+1- n+2	0 - 15	CRC	

Example Command: AA 08 33 **AA BB CC** 57 C3

Where:

- Payload Byte 0: 0xAA
- Payload Byte 7: 0xBB
- Payload Byte 8: 0xCC

Example Command: AA 11 33 **01 02 03 04 05 06 07 08 09 0A 0B 0C** C6 8E

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Where:

- Payload Byte 0: 0x01
- Payload Byte 7: 0x02
- Payload Byte 8: 0x03
- Payload Byte 9: 0x04
- Payload Byte 10: 0x05
- Payload Byte 11: 0x06
- Payload Byte 12: 0x07
- Payload Byte 13: 0x08
- Payload Byte 14: 0x09
- Payload Byte 15: 0x0A
- Payload Byte 16: 0x0B
- Payload Byte 17: 0x0C

Send Redundant Burst with GPS response

Byte	Bits	Parameter	Description
0	0 - 7	Leader	Always a value of 0xAA.
1	0 - 7	Length	5
2	0 - 7	Command Code.	0x33 = ACK or 0xFF = NAK
3 - 4	0 - 15	CRC	

Example Response: AA 05 33 C1 C7

Example Payload: 0x01**2B485D****BFF02E**02030405060708090A0B0C

Where: **2B485D** is the 24-bit latitude 30.433126688004 (North)
BFF02E is the 24-bit longitude -90.086903572083 (West)

See section 4.6: “24 bit location format” for documentation of the encoding/decoding of Globalstar on-air location data.

4.2.2.23 “Query Location” command

This command returns the GPS coordinates and timestamp of the most recent fix obtained by the device (which might be as “old” as the track interval time). It returns zeros if no fix has been obtained since reset, or the last fix attempt failed. See section on 24-bit location format for a description of the latitude and longitude encoding.

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Query Location Command

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x05
2	0 – 7	Command Code.	0x25 = Query Location command
3 - 4	0 – 15	CRC	

This response is sent to response to a “Query Location” command.

The timestamp fields represent the exact second the fix being reported was obtained.

Query Location Response

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x11
2	0 – 7	Command Code.	0x25 = Query Location command
3		Month	Value of 1 - 12
4		Day	Value of 1 – 31
5		Year	Year minus 2000. Example, 2020 is reported as 20.
6		Hour	0 – 23 GMT
7		Minute	0 - 59
8		Second	0 - 59
9 - 11	0-23	Latitude	24-Bit Signed Integer encoded Latitude. 180 degrees of latitude coded in signed binary. Byte 3 is MSB. Positive Latitude corresponds to North Latitudes.

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12 - 14	0-23	Longitude	24-Bit Signed Integer encoded Longitude. 360 degrees of longitude in signed binary. Byte 6 is MSB. Positive longitude corresponds to East longitudes.
15 - 16	0-15	CRC	Will contain the response CRC

Command: **AA 05 25 76 B2**

Response: **AA 0C 25 2B 48 5B BF F0 2B 00 2E A1**

Latitude = 0x2B485B (30.4331), Longitude = 0xBFF02B (-90.0870)

4.2.2.24 "Set Lifetime" command

This command sets the lifetime of the device. Upon getting its first GPS fix after the "set lifetime" command is issued, the device will calculate an end of life date based on the value sent in this command.

Set Lifetime Command

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x06
2	0 – 7	Command Code.	0x70 = Set Lifetime Command
3	0 - 7	Time to live, expressed in Months	Valid values are the entire span of the byte minus 1. 0 to 254 months (restrictions, if any TBD). See description below for how the end date is calculated and interpreted.
4 - 5	0 – 15	CRC	

This response is sent to response to a "Set Lifetime" command.

Byte	Bits	Parameter	Description
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0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x05
2	0 – 7	Command Code.	0x70 = “Set Lifetime”
3 - 4	0-15	CRC	Will contain the response CRC

The first time the unit gets a GPS fix after this command is issued, an end date will be calculated.

The factory default lifetime is 1 month. If this command is never issued, the unit will expire 1 month after getting its first GPS fix.

Until it has gotten that first fix and calculated its expiration date, any command that would cause it to transmit **without** first obtaining a GPS fix will be NAKed.

A value of 0 is a special case and will cause “**today**” to be the end date. The device lifetime will expire, and it will cease to operate at midnight GMT on the day that it gets its first fix after this command is issued.

If the value is nonzero, the first time the unit gets a GPS fix after this command is issued it will calculate an end date, its final date of operation, that is on this day of the month, that many months hence.

If the “expiration month” has fewer days than the day it got its fix (e.g. it got its first fix on the 31st of the month and the expiration month has 30 days) the last day of the expiration month will be its last day of operation.

Once the unit has “expired”, it will not engage its satellite transmitter, and any command that would result in one or more satellite transmissions will be NAKed. It will drop out of track mode if in track mode. Simple query commands (e. g. querying for its ESN or firmware versions) will still work.

Examples:

- Lifetime is set for 12 months and unit gets its first fix after setting the lifetime on Jan. 21, 2020: Last day of operation will be Jan 21, 2021. Beginning Jan. 22, 2021, the unit will be shutdown.
- Lifetime is set for 18 months and unit gets its first fix after setting the lifetime on Mar. 31, 2020: Last day of operation will be Sep. 30, 2021. Beginning Oct. 1, 2021, unit will be shut down.
- Lifetime is set for 1 month (or never set) and unit gets its first fix: Last day of operation will be the same day next month. If it gets a fix on the 31st of the month, and the following month has fewer than 31, days, last day of operation will be the last day of next month.

4.2.2.25 “Query Lifetime Status” command

This command is used to query the lifetime status of the unit.

Query Lifetime Status Command

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x05
2	0 – 7	Command Code.	0x71 = “Query Lifetime Status”
3 - 4	0-15	CRC	Will contain the CRC

Query Lifetime Status Response

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x0A (10 decimal)
2	0 – 7	Command Code.	0x71 = Query Lifetime Status
3	0 - 7	Programmed lifetime	The number of months for which the device was originally programmed.
4	0 - 7	End Month	Contains the month of the expiration date. If this field contains 0xFF, this indicates that the unit has not obtained a fix since the lifetime was set, and the end date has not yet been calculated. (Possible values 1 – 12 decimal).
5	0 - 7	End Day	Day of the month of the expiration date. If this field contains 0xFF, this indicates that the unit has not obtained a fix since the lifetime was set, and the end date has not yet been calculated. (Possible values, 1 – 31 decimal).
6	0 - 7	End year	The year of the device expiration. Expressed as years since 2000. E. g. 2021 is represented by “21” (decimal). If this field contains 0xFF, this indicates that the unit has not obtained a fix since the lifetime was set, and the end date has not yet been calculated.
7	0 - 7	Alive or Dead	A non-zero value (typically 0xFF) indicates the device is operational. A value of 0 indicates the device has expired.
8-9	0 - 15	CRC	Will contain the response CRC

4.2.2.26 "Set Minimum Track Rate" command

This command sets the minimum track rate that is allowed to be set with a Proprietary Track (0x30), Motion Activated Proprietary Track (0x34) or Proprietary Dock Mode (0x35).

The minimum track that can be set in any case with one of the above commands is "2" which is interpreted as 2.5 minutes (all other values that may be sent are interpreted as the actual number of minutes).

This command will not be NAKed for values < 2 but setting this "minimum" value to less than 2 shall simply enforce the absolute minimum of 2.

The factory value for this shall be "0".

Set minimum track rate command

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Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x07
2	0 – 7	Command Code.	0x84 = Set minimum track rate command
3 - 4	0 - 15	Rate	Rate in minutes, MSB first
5 - 6	0 – 15	CRC	

Response: **AA 05 84 <CRC>**

Note, if a track mode (0x30, 0x34, or 0x35) is already active, this command will be NAKed if a value of greater than the track already running is sent.

The purpose of this command is to allow a VAR to limit the minimum track interval that a customer might set so as to not over-discharge the battery and solar charging system chosen for the particular application.

4.2.2.27 "Query Minimum Track Rate"

Query minimum track rate

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x05
2	0 – 7	Command Code.	0x85 = "Query minimum track rate"
3 - 4	0-15	CRC	Will contain the CRC

Query minimum track rate response

Byte	Bits	Parameter	Description
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0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x07
2	0 – 7	Command Code.	0x85 = Query minimum track rate
3 - 4	0 - 15	Rate	Rate in minutes, MSB first
5 - 6	0 – 15	CRC	

4.2.2.28 "Suspend/Unsuspend" command

The purpose of this command is to suspend tracking due to battery low, as well as to suspend tracking when the unit is in the "waiting to activate" state. If this command is issued with an argument for "full suspend" when the unit is not in track, and then a "proprietary track" command is issued while in that suspended state, this condition shall be defined as "waiting to activate" state, and the unit will begin tracking when this command is received with the "unsuspend" or "partial suspend" argument.

The Nordic processor uses this command to transition from "battery very low", "battery low" and "battery OK" states.

Suspend/Unsuspend command

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x06
2	0 – 7	Command Code.	0x80 = Suspend / Unsuspend
3 - 4	0 - 7	Mode argument	0x00 = Full Suspend stop tracking messages completely 0x01 = Partial suspend reduce tracking rate to low battery rate 0x02 = Unsuspend. Track at normal tracking rate
5 - 6	0 – 15	CRC	

Response: **AA 05 80 <CRC>**

4.2.2.29 Suspended State query

Suspended State query

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Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x05
2	0 – 7	Command Code.	0x81 = Suspended state query
3 - 4	0-15	CRC	Will contain the CRC

Suspended state query response

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x06
2	0 – 7	Command Code.	0x81 = Suspended state query
3 - 4	0 - 7	Mode argument	0x00 = Full Suspend stop tracking messages completely 0x01 = Partial suspend reduce tracking rate to low battery rate 0x02 = Unsuspend. Track at normal tracking rate
5 - 6	0 – 15	CRC	

4.2.2.30 "Set Low Battery Rate" command

This command sets the rate to drop to in a low battery condition.

If a track mode (by 0x30, 0x34, or 0x35) is already running, this command will be NAKed if the rate is less than the already running rate.

Sending a 0x30, 0x34, or 0x35 command with a rate greater than the rate specified by this command will cause those commands to be NAKed).

Set low battery rate command

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x07
2	0 – 7	Command Code.	0x82 = Set low battery track rate command
3 - 4	0 - 15	Rate	Rate in minutes, MSB first
5 - 6	0 – 15	CRC	

Response: **AA 05 82 <CRC>**

4.2.2.31 "Query Low Battery Rate"

Query low battery rate

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x05
2	0 – 7	Command Code.	0x83 = Query battery track rate
3 - 4	0 – 15	CRC	

Query low battery rate response

Byte	Bits	Parameter	Description
0	0 – 7	Leader	Always a value of 0xAA.
1	0 – 7	Length	0x07
2	0 – 7	Command Code.	0x83 = Query low battery track rate

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3 - 4	0 - 15	Rate	Rate in minutes, MSB first
5 - 6	0 - 15	CRC	

4.2.2.32 "Turn On GPS" command

This command will turn on the GPS engine and once a fix is obtained, the location will be available in memory for later querying. Use the "Query GPS Statistics" command to monitor the progress of the GPS engine. Once a fix is indicated, use the "Turn Off GPS" command to power down the GPS engine.

Turn On GPS			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command Code.	0xFD
3	0-7	Sub Command Code.	0x21 (Turn On GPS)
4-5	0 - 15	CRC	

Command: **AA 06 FD 21 6F A8**

Response: **AA 05 FD B3 E8**

4.2.2.33 "Turn OFF GPS" command

This command will turn off the GPS engine.

Turn Off GPS			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command Code.	0xFD
3	0-7	Sub Command Code.	0x22 (Turn Off GPS)
4-5	0 – 15	CRC	

Command: **AA 06 FD 22 F4 9A**

Response: **AA 05 FD B3 E8**

4.2.2.34 "Turn On GPS Pass-through" command

This command will turn on the GPS engine and will output the NMEA messages from the GPS engine over the Bluetooth GATT connection. The NMEA messages conform to NMEA-0183 rev. 3.0. The following NMEA messages are output at a one second update rate:

- GPRMC
- GNRMC
- GPGGA
- GNGGA
- GPGSA
- GNGSA
- GPGSV
- GPGLL
- GNGLL

Note: Depending on GPS engine configuration and status of the fix, all message types shown here may or may not be present. For example, the ST100 board is shipped with its GPS engine configured to obtain location using both GPS and GLONASS constellations. This results in several messages types (for example, GNGGA and GNGSA) to have an "N" as the second character, indicating that the data within those messages was calculated from "aNy" satellite constellation. Calculation from GPS only would result in a "P" in that position (for "gPs").

Turn On GPS Pass-through			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command Code.	0xFD
3	0-7	Sub Command Code.	0x00 (Turn On GPS Pass-through)
4-5	0 – 15	CRC	

Command: **AA 06 FD 00 E4 98**

Response: **AA 05 FD B3 E8**

Example NMEA messages:

\$GNRMC,204738.00,A,3028.62674,N,09003.83218,W,0.132,,100420,,,A*73
\$GNVTG,,T,,M,0.132,N,0.244,K,A*3F
\$GNGGA,204738.00,3028.62674,N,09003.83218,W,1,06,1.59,11.0,M,-27.3,M,,*48
\$GNGSA,A,3,17,30,07,06,03,,,,,,,,,2.83,1.59,2.34*1A
\$GNGSA,A,3,79,,,,,,,,,2.83,1.59,2.34*13
\$GPGSV,3,1,09,01,31,046,20,03,13,101,27,06,22,200,32,07,24,163,23*74
\$GPGSV,3,2,09,11,05,046,,13,16,263,25,15,01,287,,17,62,305,18*76
\$GPGSV,3,3,09,30,54,184,36*4A
\$GNGLL,3028.62674,N,09003.83218,W,204738.00,A,A*6D

4.2.2.35 “Turn Off GPS Pass-through” command

This command will turn off the GPS engine and will cease output of the NMEA messages from the GPS engine to the serial port.

Turn Off GPS Pass-through			
Byte	Bits	Parameter	Description

0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command Code.	0xFD
3	0-7	Sub Command Code.	0x20 (Turn Off GPS Pass-through)
4-5	0 – 15	CRC	

Command: **AA 06 FD 20 E6 B9**

Response: **AA 05 FD B3 E8**

4.3 ST100 BOARD Serial Test Command

4.3.1 "Self Test" command

This command is used to initiate an internal self test of the ST100 BOARD. When this command is received by the ST100 BOARD, there will be a 2 - 5 second delay before the response is returned (self test in progress).

Self Test Command			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command Code.	0xFD
3	0-7	Sub Command Code.	0x0E (Perform Self Test)
4-5	0 - 15	CRC	

Example Command: AA 06 FD 0E 9A 71

Transmitter Self Test Response			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x07
2	0-7	Command Code.	0xFD
3	0-7	Sub Command Code.	0x0E (Perform Self Test)
4	0-7	Result Code.	The following bit flags indicate a pass or fail of each subsystem. 0x01 = Transmitter (0 = failed 1 = passed) 0x02 = GPS (0 = failed 1 = passed) 0x04 = Accelerometer (0 = failed 1 = passed)
5-6	0 - 15	CRC	

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4.4 Bootloading. Field update of device firmware

4.4.1 Nordic nRF52832 firmware update via bootloader (“Buttonless” DFU)

The Nordic Bluetooth Low Energy application is written to support the Nordic Buttonless DFU (Device Firmware update) bootloader. The Nordic DFU app for Android or IOS can be used to update the firmware.

It is essential that any custom firmware written by an OEM or VAR include the DFU library, provided with the Globalstar ST100 SDK, to support this functionality.

4.4.2 ON AX50324 firmware update via serial bootloader

The AX50324 mixed signal ASIC is updated over the Bluetooth Low Energy (BLE) GATT/Modem interface, using binary commands in the same format described in section 4.2.

Globalstar provides an Android and IOS app that encapsulates the functionality of the Nordic DFU app and adds a loader that utilizes the protocols below to flash applications into the AX50324 processor. This app can be used to update either processor on an ST100 board.

The binary commands relevant to bootloading the AX50324 ASIC are outlined here:

4.4.2.1 0x60 “Enter Bootloader Command”

This command causes the application to jump into the bootloader.

Jump to Bootloader			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x05
2	0-7	Command Code.	0x60
3-4	0 – 15	CRC	

Jump to bootloader response:

If you issue this command from the application, the response will be a simple echo of the command, and then the ASIC processor will reset and come back up in the bootloader. You must delay for about one second to allow the bootloader to begin running before issuing the next command.

If this command is issued when already in the bootloader, it causes a commitment to re-load an application. In other words, if you issue this command in the application, but not again, you can issue “0x62” (see below) to jump right back

into the application. However, if you issue 0x60 in the application, and then again in the bootloader, you have committed to load a new application, A response of length 6 will be returned with a condition code as follows:

Jump to Bootloader Response			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command	0x60
3	0-7	Response Code.	0xFF = Bootloader is running and application area is blank or not completely loaded. 0x03 = Bootloader is running and new executable code has been loaded during this execution of the bootloader, bootloader is ready to jump to application if commanded. 0x02 = Bootloader is running but application code that existed when the bootloader started is still in place. However, having issued this command again, you have now committed to re-load the application.
4-5	0 – 15	CRC	

4.4.2.2 0x61 “Flash One Line”

This command is used to flash one line from an Intel HEX format file into the program memory of the processor.

As the table below illustrates, there is roughly a 1 to 1 correspondence between fields within the Intel Hex Record line, and fields within this message. The ASCII represented HEX values within the Intel Hex file are represented as binary numbers in this binary record.

The Wikipedia article on the Intel Hex format may be the best reference available for concise description of the Intel Hex format: https://en.wikipedia.org/wiki/Intel_HEX

Flash One Line message			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	Length contains the length of this Entire binary message, including CRC (as in all other message of this protocol). It will be "byte count" (byte 4 value, below) +10
2	0-7	Command	0x61
3	0-7	Processor Number	Must be 0 for the ST100 Board ASIC
4	0-7	Byte Count	The "byte count" field (the first 2-digit hex number) of the Intel Hex Record line goes here (as a binary value).
5-6	0-15	Address	The start address of this hex record. (The 2 bytes represented by the 4 hex characters of the Intel Hex Record line goes here as a binary value.)
7	0-7	Record Type	The "Record Type" field of the Intel Hex record
8-n	variable	Data	The data fields of the Intel Hex record. Number of bytes in this portion will be equal to the value in byte 4 (byte count) Note, the "checksum" field of the HEX record is omitted as its function is provided by the CRC field of this message.
n+1-n+2	0 – 15	CRC	

There are some special behaviors of the bootloader when receiving this message type to be aware of:

- The first "0x61" type command the bootloader receives after it is entered causes it to erase the existing application and write the data in the "0x61" message to the specified address in flash. As a result of the page-by-page erase taking some time, the ACK of the first message may take up to 2 seconds to return. ACK's of subsequent "0x61" messages will return almost immediately, as the bootloader is simply writing the subsequent data to the already-erased flash. If the bootloader is entered and no "0x61" message is ever sent to it, the existing application will remain intact and the bootloader may be exited and the application re-run. Once a

“0x61” message is sent, the user has committed to load the complete application before jumping out of the bootloader.

- The “end of file” marker in every Intel Hex file looks like this: “:00000001FF”. This marker encodes an address of 0, a byte count of 0, a “record type” of 0x01 (End of File), (and a checksum of 0xFF). When the end of the Intel Hex file is reached, this marker must be encoded by the user application into a “0x61” message via the format in the table above and sent to the device. When the bootloader encounters this marker, it verifies the validity of the application, calculates a CRC/Signature for the application, and sets its internal flags to indicate that the application is valid and OK to jump to. As this check and calculation takes some time, the transmission of this marker will result in the ACK taking up to 2 seconds to return and the loading application must be accepting of that delay.

Response to the Flash One Line message:

Flash One Line Message response			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command	0x61
3	0-7	Response Code.	Response codes with the MSB set are "NAKs" or "fails" and indicate that the bootloader didn't do anything with the record. Codes without the MSB set are various success codes, indicating that the message was acted on as expected. 0x01 = OK but not done loading. (Returned for each line loaded until End of File is received.) 0x00 = OK and done. (This is the response to End of File when loaded code has passed acceptance tests. 0xF0 = Address outside of application memory range. (In the ST100 board, this code is also returned if "processor number" is not 0.) 0xFF = Message format error or unknown error.
4-5	0 – 15	CRC	

4.4.2.3 0x62 "Enter Application"

Enter Application Command			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x05
2	0-7	Command Code.	0x62
3-4	0 – 15	CRC	

Enter application response:

Enter Application response			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command	0x62
3	0-7	Response Code.	0x00 = OK booting application 0xF0 = CRC/Signature failed. If this is received, the bootloader “believed” it had a valid application loaded but a re-check of the CRC/Signature failed. (This should be quite rare and indicates a significant glitch occurred during the loading process, or the device has bad flash memory.) 0xFF = Other error. Usually returned because the application flash area is blank, or an incomplete application is loaded. This will occur if the “0x61” command is used to load some of the file, but the “End of File” marker was never seen. If either 0xFF or 0xF0 are received, the user should attempt to load the application again.
4-5	0 – 15	CRC	

4.4.2.4 0x63 “Status Query”

A query to determine if the bootloader is running, or the application is running. Response code will be 0x00 if the application is running, and 0x05 if the bootloader is running.

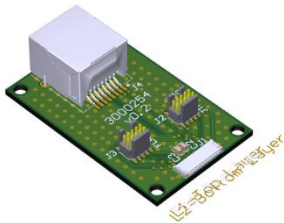
Bootloader/Application Status Query			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x05
2	0-7	Command Code.	0x63
3-4	0 – 15	CRC	

Enter Application response			
Byte	Bits	Parameter	Description
0	0-7	Leader	Always a value of 0xAA.
1	0-7	Length	0x06
2	0-7	Command	0x63
3	0-7	Response Code.	0x00 = Application running 0x05 = Bootloader running
4-5	0 – 15	CRC	

4.4.3 JTAG programming adaptor.

Globalstar can supply a programming adaptor that permits programming the processors at a low level without the bootloader. It is most strongly recommended that if this method is used, that a combined image, with application and bootloader merged, be loaded so that the device remains field-upgradable later.

Globalstar part number TBD:



A JTAG programmer may be connected by a standard JTAG connector to the JTAG input of this breakout board.

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The AXSEM proprietary programmer connects to the RJ-45 connector on this board for programming the AX50324 ASIC.

4.4.4 Nordic low-level load via JTAG

Using the breakout board above, the Nordic can be programmed and debugged through a compatible JTAG programmer. Globalstar recommends Segger Studio as the development and debugging environment for this processor. The Nordic processor can also be programmed via Nordic's NRF Go Studio application.

4.4.5 ON AX50324 low-level load via AXSEM proprietary programming interface.

The AX50324 processor is programmed via an AXSEM proprietary programming board and the Axsdb proprietary Axsem debugger. These devices are available from ON Semiconductor: <https://www.onsemi.com/support/evaluation-board/axdbg-2-gevk>

4.5 Example CRC calculation routines for serial packets

NOTE: When using the "raw" command to send individual messages, the CRC is OMITTED. The Nordic processor firmware calculates and appends the correct CRC to the message going to the ASIC processor.

This routine would be used if sending a series of messages in "binary passthrough mode" ("bpm" command).

The following example is written in the C programming language where:

int = 32 bits, short = 16 bits, char = 8 bits

```

unsigned short crc16_lsb(unsigned char *pData, int length)
{
    unsigned char i;
    unsigned short data, crc;

    crc = 0xFFFF;

    if (length == 0)
        return 0;

    do
    {
        data = (unsigned int)0x00FF & *pData++;
        crc = crc ^ data;

        for (i = 8; i > 0; i--)
        {
            if (crc & 0x0001)
                crc = (crc >> 1) ^ 0x8408;
            else
                crc >>= 1;
        }
    }while (--length);

    crc = ~crc;

    return (crc);
}

```

USAGE: **calculate the CRC for a message and update the message CRC**

```

    unsigned short crc = crc16_lsb(msg, msg [1]-2);
    msg [msg [1]-2] = (unsigned char) (crc&0xFF);
    msg [msg [1]-1] = (unsigned char) (crc>>8);

```

The following example is written in the Java programming language:

```
char crc16_lsb(byte pData[], int length)
{
    int pData_i = 0;
    char s1,s2;

    byte i;
    char data, crc;

    crc = (char) 0xFFFF;
    if (length == 0)
        return 0;
    do
    {
        data = (char)((char)0x00FF & pData[pData_i++]);
        crc = (char)(crc ^ data);
        for (i = 8; i > 0; i--)
        {
            if ((crc & 0x0001) != 0)
                crc = (char)((crc >> 1) ^ 0x8408);
            else
                crc >>= 1;
        }
    }while (--length != 0);

    crc = (char)~crc;

    return (crc);
}
```

USAGE: **calculate the CRC for a message and update the message CRC**

```
byte msg[];     int len;
char crc = crc16_lsb(msg,len-2);
msg[len-2] = (byte)((short)crc & (short)0xff);
msg[len-1] = (byte)((short)crc >> 8);
```

4.6 24-bit location format

The 24-bit format used for latitude and longitude encodes 180 degrees of LATITUDE as a 24-bit (3-byte) signed integer and 360 degrees of LONGITUDE as a 24-bit (3-byte) signed integer.

4.6.1 CALCULATING LATITUDE

Latitude may be calculated by converting the 3 encoded latitude bytes represented in hexadecimal to a decimal number and multiplying this decimal integer by the DEGREES_PER_COUNT_LAT conversion factor.

$$\text{DEGREES_PER_COUNT_LAT} = 90.0 / 2^{23}$$

Since the latitude is signed and can range from –90 to 90 degrees, if the above result is greater than or equal to 90 degrees, 180 must be subtracted from the result.

Negative Latitude corresponds to Latitude in the SOUTHERN Hemisphere.
Positive Latitude corresponds to Latitude in the NORTHERN Hemisphere.

Latitude Calculation Example:

24-bit latitude: 0x2AB69C (Hexadecimal)

This number converted to decimal (base 10) is: 2,799,260.

$$2,799,260 * (90.0 / 2^{23}) = 30.032802$$

Since this result is less than 90 degrees, no subtraction is necessary.

$$30.032802 \text{ degrees} = 30.032802 \text{ degrees NORTH}$$

4.6.2 CALCULATING LONGITUDE

The longitude may be calculated by converting the 3 encoded longitude bytes represented in hexadecimal to a decimal number. This decimal integer is multiplied by the DEGREES_PER_COUNT_LONG conversion factor.

$$\text{DEGREES_PER_COUNT_LONG} = 180.0 / 2^{23}$$

If the above result is greater than or equal to 180 degrees, 360 must be subtracted from the result since the longitude is signed and can range from –180 to 180 degrees.

Negative Longitude corresponds to Longitude in the WESTERN Hemisphere.
Positive Longitude corresponds to Longitude in the EASTERN Hemisphere.

Longitude Calculation Example:

24-bit longitude: 0xBFF46B (Hexadecimal)

This number converted to decimal (base 10) is: 12,579,947.

$$12,579,947 * (180.0 / 223) = 269.936378$$

Since this result is greater than 180 degrees, subtract 360 degrees from the result to create the correct signed representation.

$269.936378 \text{ degrees} - 360 \text{ degrees} = -90.063622 \text{ degrees} = 90.063622 \text{ degrees WEST}$
--

4.7 Flash Memory Map (TBD)

5 Test Modes

5.1 Hardwired Method

The ST100 BOARD provides several test modes intended to aid in manufacturing testing and certification testing.

All test modes are activated by grounding selective pins on the ST100 BOARD prior to applying power. Once power is applied, the ST100 BOARD will sample the states of the pins and based on the states of the pins, the ST100 BOARD will enter the selected test mode. For normal operation these pins must be left floating or in a high (logic 1) state.

A typical implementation is to rig small switches to these pins so that turning the switch on connects the pins to ground. Such a “rigged” board is then sent to the regulatory test house with instructions on how to set the switches to enable each mode. The switches should be set to select the desired mode, then power applied, then measurements taken. Power should be switched off before selecting another mode.

In the table below, the **TEST1**, **TEST2**, **RX** and **RTS** pins come up on the board as follows.

TEST1 – On Test Point 28 and edge connector pin 7.

TEST2 – On Test Point 29 and edge connector pin 6.

RX – On Test Point 46

RTS – On Test Point 15

The following tables define the different test modes available in the ST100 BOARD.

TEST1	TEST2	Mode
0	0	Mod Mode (continuous transmission) - A test packet is continuously transmitted until power is removed from the board. The test packet shall comply with the Air Interface Packet format with a user information equal to the hex stream 0x80AAF0F0F0AAF0F0F0 where the most significant bit is transmitted first

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0	1	Test Packet - The test packet shall comply with the Air Interface Packet format with a user information equal to the hex stream 0x80AAF0F0F0AAF0F0F0 where the most significant bit is transmitted first
1	0	CW mode - An un-modulated carrier is continuously transmitted.
1	1	Normal Operation

Table 6.1

The channels are selected via the Rx and RTS pins as follows

RX	RTS	Channel
0	0	B
0	1	C
1	0	Reserved
1	1	Channel specified in the flash setup. To specify channel A, it must be the default channel specified in the flash setup. See Setup command for details.

Table 6.2

5.2 Soft Command Method.

WARNING: The **only** way to stop Mod Mode and CW Mode is to power cycle the unit. To perform the tests listed in this section the battery must be disconnected, and the battery terminals be connected to a power supply supplying between 3.7 and 4.2 volts DC, capable of delivering 0.5 amperes. Mod Mode and CW mode are terminated by switching off the power supply.

The smartphone configuration application in “advanced” mode is used to issue the following commands.

5.2.1 Step 1: Enable the regulatory test modes.

These modes are disabled by default from the factory, to prevent them from being accidentally activated on a unit in the field. Using the configuration application in “advanced” mode:

- Tap the “auth” button
- Send the command: “raw aa0676d4”
- Watch for the ACK, which should be “aa0576” and 2 bytes of CRC

5.2.2 Step 2: Set the channel that you wish to perform the test on.

Use the “setup” command for this. Using the configuration application in “advanced” mode:

- Tap the “auth” button.
- Send the command: “setup <ch> 3 60 120”
- Where “<ch>” =
 - 0 = Channel A
 - 1 = Channel B
 - 2 = Channel C
 - 3 = Channel D

5.2.3 Step 3: Start the desired mode.

Using the configuration application in “advanced” mode:

Tap the “auth” button.

- For CW Mode, send the command: “raw aa06fc01”
- For Mod Mode, send the command: “raw aa06fc03”
- To send a single test packet, send the command: “raw aa06fc02”
- When entering each of the commands above, you should see an ACK: “aa05fc” and 2 bytes of CRC

Repeat steps 2 and 3 for the tests you want to perform on each channel.

5.2.4 Step 4: Disable the test commands.

After turning the power off following the last test, use the configuration application in “advanced” mode to do the following:

- Tap the “auth” button
- Send the command: “raw aa067600”
- Watch for the ACK, which should be “aa0576” and 2 bytes of CRC

5.2.5 Step 5: Restore the desired setup.

- Tap the “auth” button.
- Send the command: “setup <ch> <transmit attempts> <min time between attempts> <max time between attempts>”
- Note: Factory default settings are: “setup 0 3 60 120”

6 GENERAL WARNINGS

Warning – Modifications: Changes or modifications to the ST100 not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Warning – Blasting Area: To avoid interference with blasting operations, turn your ST100 off when in a “Blasting Area” or in areas posted “Turn off two-way radio.” Obey all signs and instructions.

Warning – Potential Explosive Atmosphere: Turn off the ST100 or any product with the ST100 installed when in any area with a potentially explosive atmosphere and obey all signs and instructions. (End products specifically designed to work in Explosive Atmospheres are to follow their certification guidelines.)

Warning – Pacemakers: The Health Industry Manufacturers Association recommends that a minimum separation of six (6”) inches be maintained between the ST100 and a pacemaker to avoid potential interference with the pacemaker.

Warning – Hearing Aids: Some digital wireless devices may interfere with some hearing aids. In order to prevent such interference, you may want to consult the manufacturer of your hearing aid.

Warning - Specific Absorption Rate (SAR):

FCC / Canada: The ST100 has been shown to be compliant to localized Specific Absorption Rate (SAR) for uncontrolled environment/ general exposure limits specified in ANSI/IEEE STD C95.1-1992 and has been tested in accordance with measurement procedure specified in IEEE 1528-2013 and IEC 62209- 2:2010 using a separation distance of 20 cm.

European Union (CE RED): The ST100 has been shown to be compliant for localized specific absorption rate (SAR) for uncontrolled environment / general exposure limits specified in ANSI/IEEE Std. C95.1-1999 and has been tested in accordance with the measurement procedures specified in EN50566:2017 and EN62209- 2:2010 using a separation distance of 20 cm.

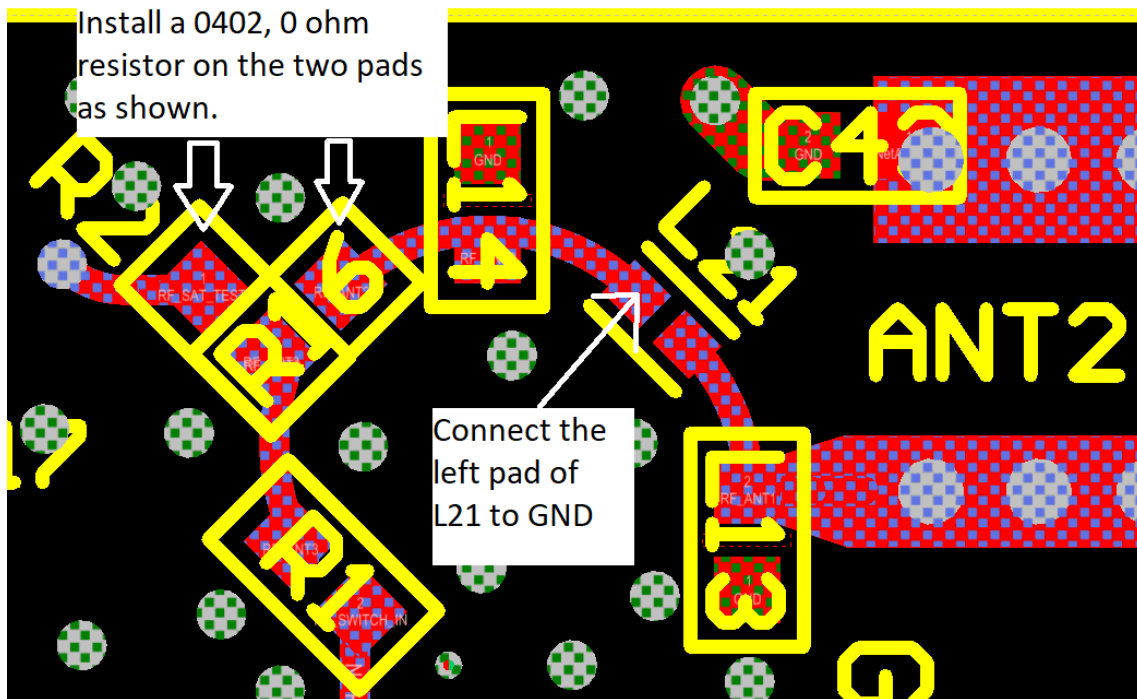
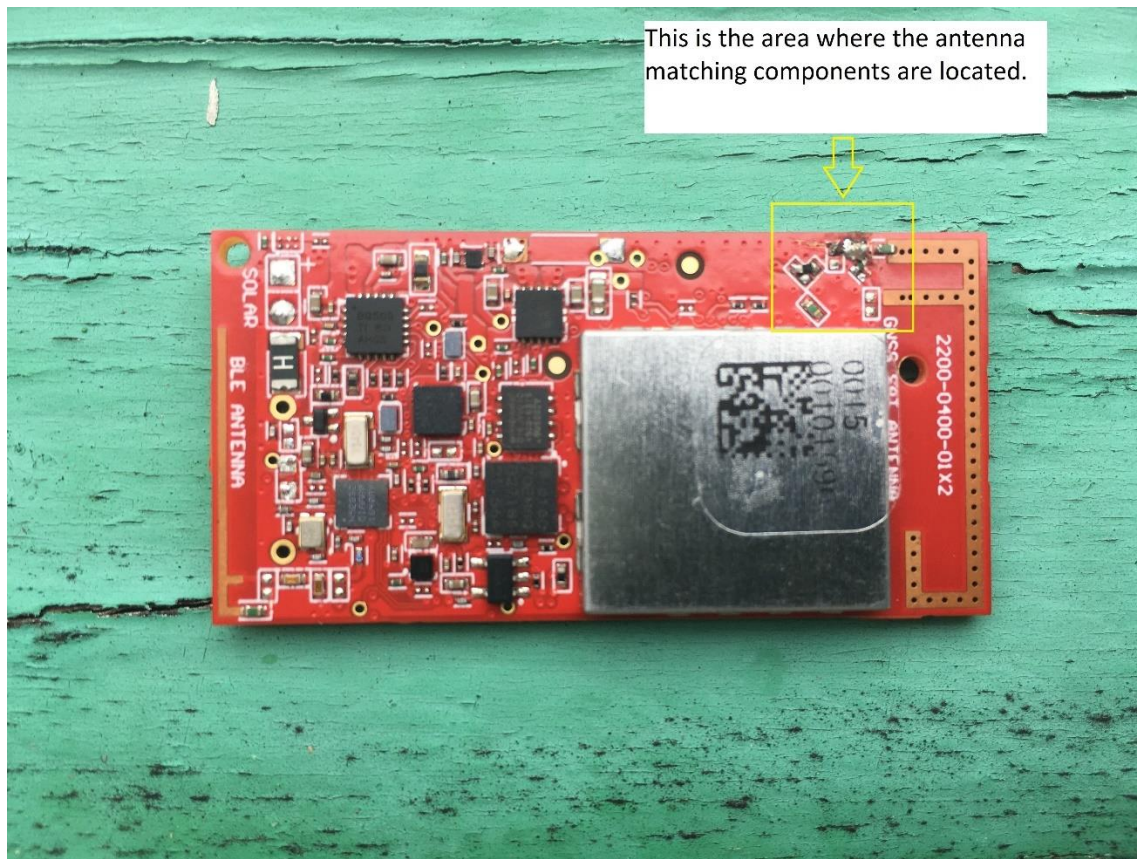
NOTE: If concerned about RF exposure during use, place the ST100 away from your body. The RF exposure level drops off dramatically with distance from the ST100 antenna.

7 ANTENNA TUNING GUIDANCE

7.1 GPS / Satellite Antenna Tuning

If the VAR wants to tune the internal GPS / satellite antenna on the PCB for a specific enclosure / environment, the following should be used as guidance.

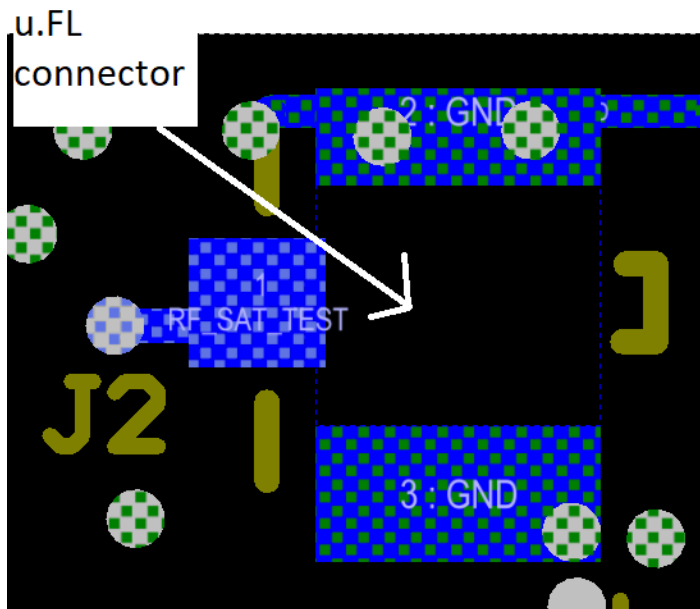
1. An appropriate vector network analyzer (VNA) should be used to measure return loss (S11) of the antenna. The VNA output should be 50 ohms, and the frequency range should go up to about 3MHz but can be higher if the VNA allows. A two port VNA is not necessary but can be used (only one port measurements will be done for antenna tuning). The VNA should have the Port Extensions feature, which will allow for more accurate antenna tuning. In this manual, the TR5048 VNA from Copper Mountain Technologies is used.
2. Two ST100 boards will be used for the antenna tuning: one board will be used as a calibration board, and the other board will be used for tuning the GPS / satellite antenna.
3. The ST100 board should be placed in the plastics/enclosure where it will be used, and in an orientation that best represents the end-application. When tuning the antenna, try not to have metallic surfaces nearby. Placing a cardboard box under the ST100 is one way to move the antenna away from the surface it's resting on.
4. Both ST100 boards will have hardware modifications (swapping resistors, etc.) done to it during the tuning process. This procedure assumes that the user has some experience with soldering surface mount components (0201 inductors, resistors).
5. On both PCBs, make sure there are no components installed on R2, R16, L13, and L14.
6. On the calibration ST100 PCB, install a 0 ohm, 0402 resistor as shown below, and connect the left pad of L21 to GND, as shown. Note: some solder mask can be scraped away on the GND plane to access GND.



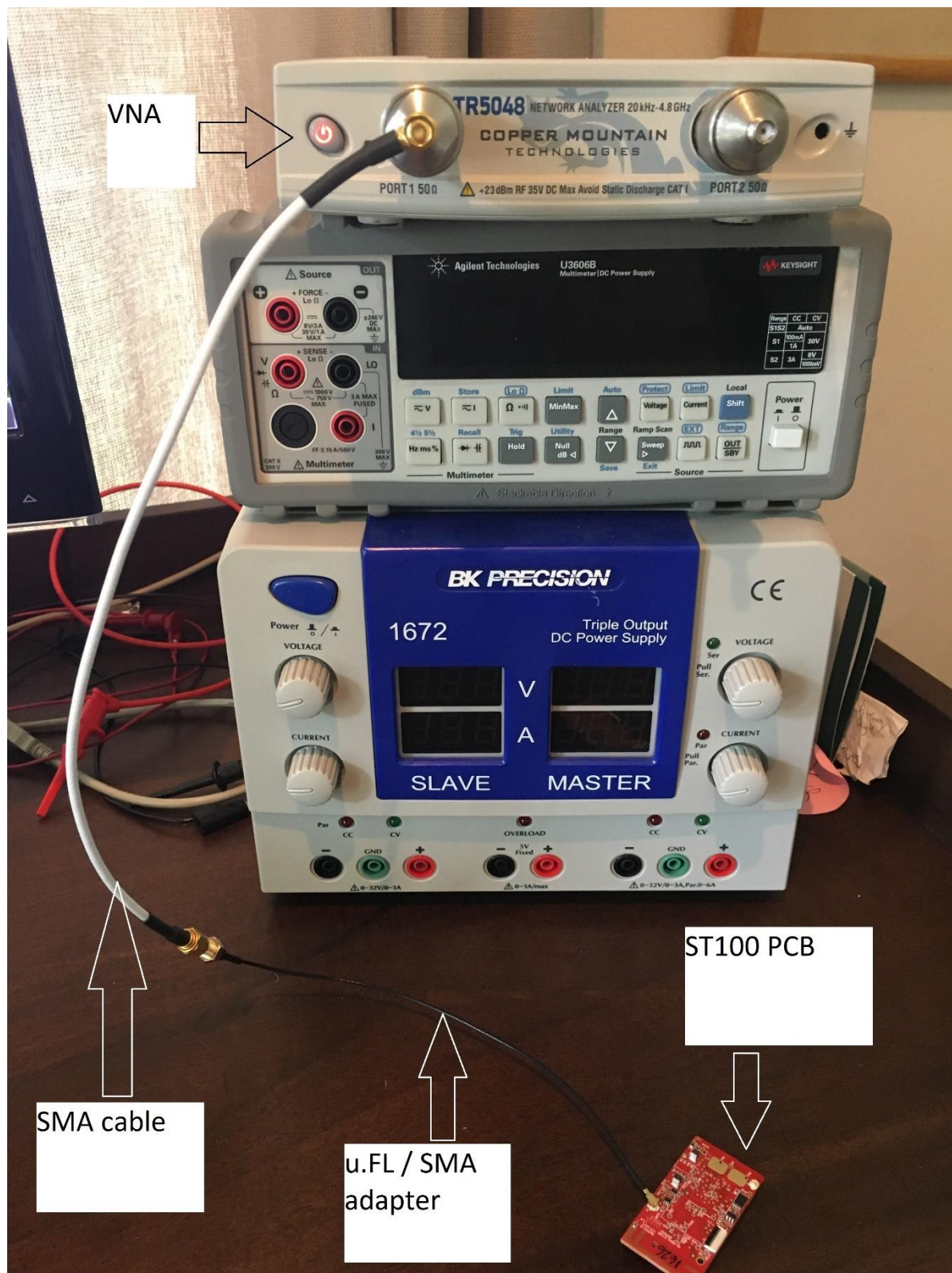
7. On the other board (ST100 antenna tuning board), install a 0 ohm, 0402 resistor as shown below, and install a 0 ohm, 0201 resistor onto L21.



8. For both PCBs, if a u.FL connector is not installed on J2 (bottom side of PCB), there will need to be an RF cable (i.e. semi-rigid RF coax pigtail) soldered to the board so that the VNA RF signal can be connected to the semi-rigid RF coax pigtail.



9. On the calibration PCB, connect a u.FL / SMA adapter to the J2 u.FL connector. If J2 is not installed, ensure the semi-rigid RF coax is soldered onto the PCB.



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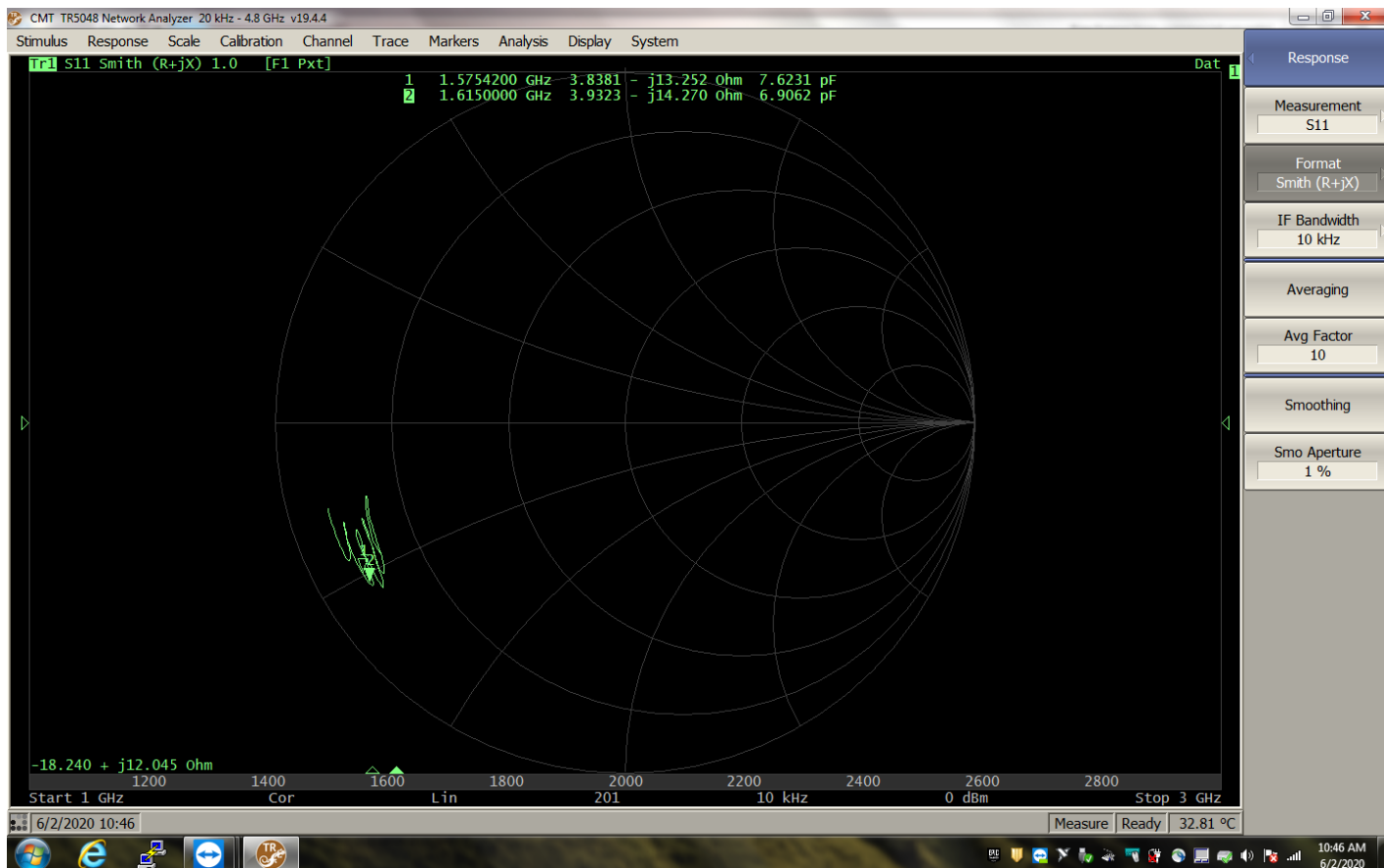
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10. Turn on the VNA, set the start frequency to 1GHz, end frequency to 3GHz, the measurement bandwidth as low as possible (10kHz should be ok), the measurement is set to S11, the system impedance = 50 ohms, the format for the S11 response is Smith Chart, and the RF power of the VNA is on. Add markers in the S11 response at 1615MHz and 1575.42MHz.
11. Ensure the calibration kit you are using for the VNA is selected in the VNA software (and all the settings for the calibration kit have been verified).
12. Ensure a RF coax cable (i.e. SMA cable) is connected to port 1 of the VNA and connect the other end of the SMA cable to the calibration kit.
13. In the VNA software, perform a one-port calibration using the VNA calibration kit. You should do open, short, and load.
14. Once the calibration is done, connect the SMA cable from the VNA port 1 to the u.FL / SMA adapter that is connected to the ST100 calibration PCB (if J2 is not installed, connect the RF coax cable to the semi-rigid RF coax soldered to the PCB)
15. In the VNA software, find the Port Extensions feature. Turn on Port Extensions, then perform a short circuit calibration. In the VNA software, the 1575.42MHz and 1615MHz markers should be located on the far left side of the Smith Chart, something similar as shown below.



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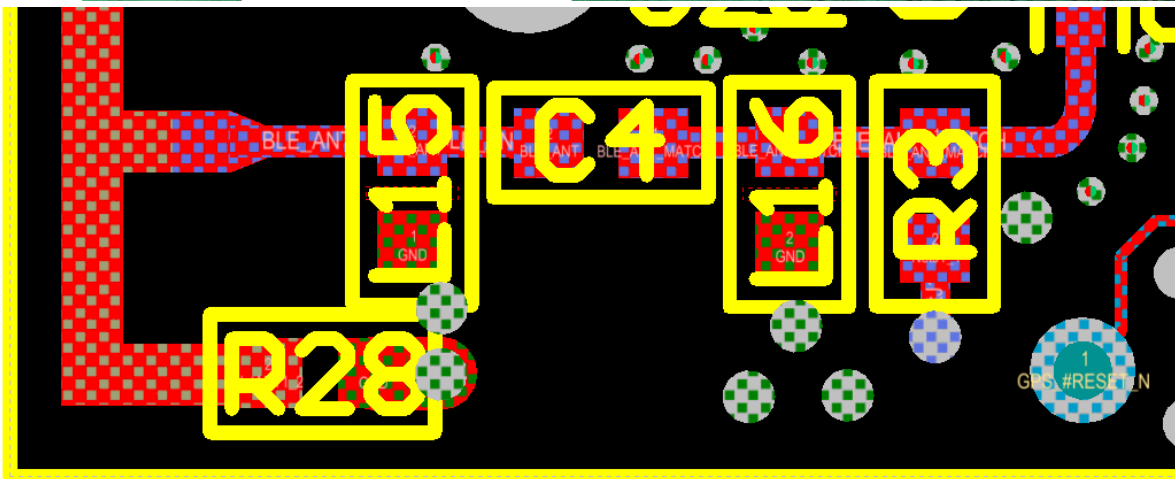
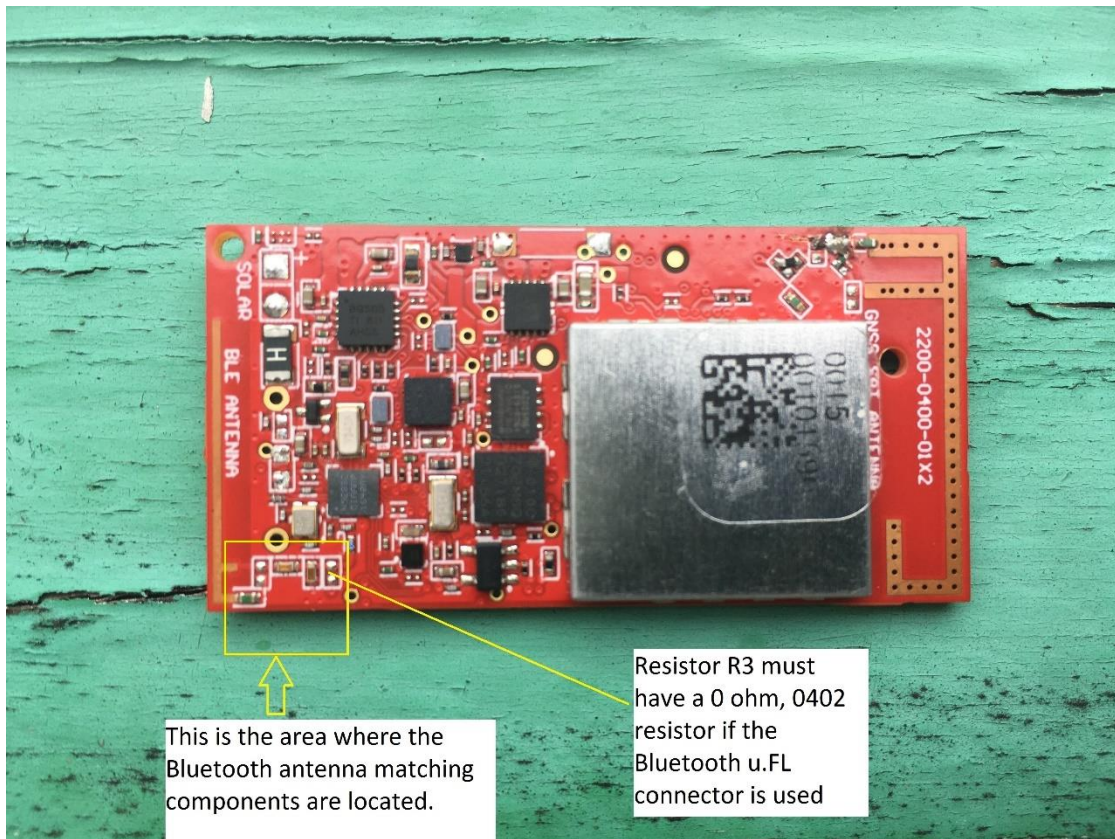
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16. Remove the u.FL / SMA adapter cable from the ST100 calibration board and connect it to the other ST100 board for antenna tuning (Note: the other ST100 board will require a semi-rigid RF coax if J2 is not installed).
17. Once the u.FL/SMA adapter is connected to the other ST100 PCB, record the impedances of the 1575.42MHz and 1615MHz markers. This is the initial antenna impedance without tuning. You can also take a photo to have as a reference for later.
18. When tuning a RF network, the goal is to get the impedance on the Smith Chart to move as close as possible to the center of the Smith Chart circle. This is the 50 ohm point ($50 + j0$). Another good rule of thumb is to have a minimum of -10dB return loss (S11) for all orientations of the antenna.
19. Once the initial impedances have been recorded, use a Smith Chart simulation tool to determine which components (i.e. shunt inductor or series capacitor) should be added to move the impedance as close as possible to the Smith Chart center point. (Note: Iowa Hills Smith Chart is a free tool that can be downloaded.)
20. The values from the simulation may not be exact, so you may have to experimentally solder the simulation values onto the ST100 PCB, and check on the VNA if these values are getting the impedance closer to the center point.
Note: L21, L14, and L13 are the matching components that can be used. L13 can be used, but past experience shows to start with using L21, and then L14. The components that Globalstar has used in the past have been Murata LQP03TN inductors and Murata GJM15, 0402 HiQ, tight tolerance capacitors.
21. Once both 1575.42MHz and 1615MHz impedances are close to the center point and you have -10dB return loss for both frequencies in all end-application orientations, the tuning can be stopped. Record the final tuning values.
22. Remove the 0402, 0 ohm resistor that was installed in step 7, and install a 0 ohm, 0402 on R16. The ST100 board with a tuned antenna is now ready to be tested outdoors.

7.2 Bluetooth Antenna tuning

1. The Bluetooth antenna may not need tuning (it will depend if the Bluetooth range is acceptable as is), but the process is the same as tuning the GPS/Satellite antenna, with the exception the frequency markers in the VNA will be changed to 2.402GHz, 2.44GHz, and 2.48GHz.

2. The matching components for the Bluetooth antenna are located in the area shown below.



8 Globalstar Certification Process for Customer Products

Before a customer's end product can be used on the Globalstar network, it must receive a Globalstar Product Certification. The certification process ensures that the customer's product meets Globalstar's internal system standards and has received the applicable regulatory approvals for the countries it will be operating in.

Typical certification process flow:

- Customer designs their product using the ST100 module.
 - NOTE: Over the Air (OTA) testing strongly recommended during design phase to catch performance bugs before submission for certification.
- Customer notifies their Globalstar Regional Sales Manager (RSM) that they want to start the Globalstar certification process.
- Customer completes on-line Globalstar Customer Equipment Application Form (Link provided by RSM)
- Globalstar reviews product
- Globalstar performs Over the Air (OTA) testing.
 - Potential issues are highlighted / corrective actions made.
- Customer obtains all applicable regulatory approvals for end-product.
 - NOTE: Globalstar is not permitted to allow a customer's end-product to operate on the Globalstar network unless all applicable end-product regulatory approvals for the countries the product will work in have been submitted for review.
- Application and OTA test data are reviewed by Globalstar engineering. All remaining areas of concern are resolved.
- Globalstar Certificate issued.

9 REGULATORY APPROVAL

9.1 Radio Astronomy Site Avoidance

The ST100 complies with FCC CFR25.213. The customer end-product must comply with the requirements for Radio Astronomy avoidance. See Globalstar document GS-07-1248 REMOTE TELEMETRY SERVICE FREQUENCY PLAN FOR SIMPLEX TRANSMITTERS for more details

Regulatory Notices

The ST100 BOARD has received Federal Communications Commission authorization under FCC Rules Part 25 and Part 15C as a modular transmitter. Final installation must be in compliance with 25.213. The installation and operating configurations of this transmitter must satisfy MPE categorical Exclusion Requirements of 2.1091. The antenna used for

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this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be collocated or operating in conjunction with any other antenna or transmitter.

The ST100 modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

The only antennas authorized to be used with the ST100 module are the module PCB trace antennas. If any other antennas are used, then additional regulatory testing will be required.

NOTE: Any additional host device the module is integrated into will require regulatory testing and certification (C2PC for FCC and C4PC for ISSED).

The ST100 BOARD module has been labeled with its own FCC and Industry Canada (IC) ID numbers, and if the FCC/IC ID numbers are not visible when the module is installed inside another device, then the outside of the finished product into which the module is installed must also display a label referring to the enclosed module:

Contains Transmitter Module FCC ID: L2V-ST100 IC: 3989A-ST100
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The VAR's user's manual shall include the following statements:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment OFF and ON, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

WARNING: Changes or modifications not expressly approved by Globalstar may render the device non-compliant to FCC and other regulatory body standards for operation and may void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause

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undesired operation.

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de classe B est conforme à la norme NMB-003.

Hereby, Globalstar declares that this ST100 BOARD is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU. The declaration of conformity may be consulted at www.globalstar.com/regulatory

NOTICE: This equipment complies with FCC, IC and CE RF Exposure Limits. A minimum of 20 centimeters (8 inches) separation between the device and the user and all other persons should be maintained.

AVIS: Cet équipement est conforme aux RSS-102 Limites d'exposition RF. Un minimum de 20 centimètres (8 pouces) entre l'appareil et l'utilisateur et toutes les autres personnes devrait être maintenue.

Transmit Frequencies: 1611.25 Mhz - 1618.75 Mhz (4 Channels)
Max Power Out: 25.82 dBm EIRP

FCC ID: L2V-ST100
CAN ICES-3(B)/NMB-3B
IC: 3989A-ST100



Complies with FCC standards.
FOR HOME OR OFFICE USE

The ST100 BOARD has been so constructed that the product complies with the requirement of Article 10(2) as it can be operated in at least one Member State as examined and the product is compliant with Article 10(10) as it has no restrictions on being put into service in all of the EU except Ireland. The ST100 BOARD cannot be marketed in Ireland.



~~CE~~ Not to be Marketed in Ireland

Anatel Certification stamp for operation in Brazil:

TBD

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Portuguese	Produto não acabado, de uso interno, cuja integração em outros equipamentos pode requerer nova certificação.
English	Unfinished product, for internal use, the integration of which into other equipment may require further certification.

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