User Guide

Buffalo B1919 GNSS Module

For use with:
B1919 module (P/N 99777-XX)
Carrier board (P/N 87777-XX)
Starter Kit (P/N 877777-05)

Version 1.0
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Trimble

Legal Notices

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This is the June 2013 release (Revision B) of the *Buffalo B1919 GNSS Module User Guide*, part number 99777-XX.

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Warnings and Cautions

An absence of specific alerts does not mean that there are no safety risks involved. Always follow the instructions that accompany a Warning or Caution. The information they provide is intended to minimize the risk of personal injury and/or damage to the equipment. In particular, observe safety instructions that are presented in the following formats:

WARNING – A Warning alerts you to a likely risk of serious injury to your person and/or damage to the equipment.

CAUTION – A Caution alerts you to a possible risk of damage to the equipment and/or loss of data.

Operation and storage

WARNING – The Buffalo GNSS module is ready to accept NMEA commands approximately 10 seconds after power-up. If a command is sent to the receiver within this 2 second window, the receiver will ignore the command. The Buffalo GNSS module will not respond to commands sent within the 2 second window and will discard any associated command data.

WARNING – Operating or storing the Buffalo GNSS module outside the specified temperature range can damage it. For more information, see the product specifications on the data sheet.

Routing any cable

CAUTION – Be careful not to damage the cable. Take care to avoid sharp bends or kinks in the cable, hot surfaces (for example, exhaust manifolds or stacks), rotating or reciprocating equipment, sharp or abrasive surfaces, door and window jambs, and corrosive fluids or gases.

Handling

CAUTION – The Buffalo GNSS module is packed according to ANSI/EIA-481-B and JSTD-033A. All of the handling and precaution procedures must be followed. Deviation from following handling procedures and precautions voids the warranty.

CAUTION – Operators should not touch the bottom silver solder pads by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module before soldering.

⚠ **CAUTION –** Do not bake the units within the tape and reel packaging. Repeated baking processes will reduce the solderability.

⚠ **CAUTION –** Follow the thermal reflow guidelines from IPC-JEDEC J-STD-020C.

Contents

CHAPTER 1

Features and Specifications

In this chapter:

This chapter describes the features and performance specifications of the Buffalo GNSS module.

Key features

The Buffalo B1919 module functions as a multiple-frequency GNSS receiver—L1 frequency GPS and GLONASS—providing the NMEA protocol the two serial ports, and also providing a PPS timing output. The Buffalo GNSS receiver can acquire and track GPS and GLONASS as a combined solution. It is planned that Galileo support will be made available through a firmware upgrade.

The B1919 receiver has an onboard low-noise amplifier (LNA) that is compatible with both active and passive antenna implementations. It includes an onboard RTC and TCXO, and also has built-in antenna detection for open and short-circuit conditions.

The Buffalo B1919 receiver features powerful positioning performance in a 19.0 mm x 19.0 mm x 2.54 mm package. The module's 28 reflow-solderable surface-mount edge castellations provide and interface for your design without the need for costly I/O and RF connectors.

- Pick-and-place assembly, tape and reel packaging, reflow-solderable
- World class tracking and acquisition sensitivity
- Supports active and passive antenna designs
- Built-in antenna open and short detection
- 32 tracking channels
- Supports NMEA 0183 protocol
- Carrier board and starter kit available
- RoHS compliant (lead-free)

Specifications

Buffalo B1919 receiver performance

These are L1 frequency (1575.42 MHz and 1602 MHz), C/A code, 32-tracking channels, continuous tracking receivers.

Element		GNSS
Update rate	NMEA	1 Hz (default), up to 5 Hz
Accuracy (24 hour static, full sky view, rooftop antenna)	Horizontal (with SBAS)	<2 m 50%, <4.5 m 90%
	Altitude (with SBAS)	<2.5 m 50%, <5 m 90%
	Velocity	0.05 m/sec
	PPS (static)	<25 ns RMS, <15 ns 1 sigma
Acquisition (autonomous operation)	Reacquisition	2.4 sec
	Hot start	4 sec 50%
	Warm start	25 sec 50%
	Cold start	33 sec
Sensitivity	Tracking	-157 dBm
	Acquisition sensitivity	-146 dBm
Operational	Speed limit	515 m/s maximum

Interface

Element	Values
Connectors	28 surface mount edge castellations
Serial port	1 UART, 2.8 V LVTTL compatible
PPS	2.8 V LVTTL compatible
Protocols	National Marine Electronics Association (NMEA) 0183

Physical

Element	Values
Dimensions (W x L x H)	19 mm x 19 mm x 2.54 mm
Weight	1.7 grams, including metal shield

Environmental

Element	Values
Operating temperature	-40 °C to +85 °C
Storage temperature	-55 °C to +105 °C
Vibration	0.008 g^2/Hz, 5 Hz to 20 Hz 0.05 g^2/Hz, 20 Hz to 100 Hz -3 dB/octave, 100 Hz to 900 Hz
Operating humidity	5% to 95%, R.H., non-condensing, at +60 °C

Absolute maximum limits

CAUTION – Absolute maximum ratings indicate conditions beyond which permanent damage to the device may occur. Electrical specifications do not apply when you are operating the device outside its rated operating conditions.

Parameter		Min	Max	Unit
Power supply	Power supply voltage (V_{CC}) on Pin 12	-0.3	3.6	V
	Standby voltage (V_{CC}) on Pin 12	-0.3	3.6	V
Antenna	Input power at RF input		+10	dBm

Operating conditions

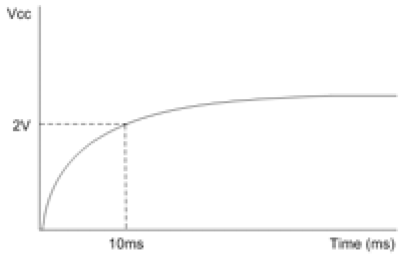
Minimum and maximum limits apply over the full operating temperature range unless otherwise noted.

Recommended operating conditions

Parameter	Conditions	Min	Typical	Max	Unit
Primary supply voltage[1]		2.7		3.3	V
Current draw, continuous tracking (excluding antenna supply)	Over operating temperature range	62	64	70	mA
Power consumption, continuous tracking	Over operating temperature range	125	190	250	mW
Current draw	Typical: 20 °C				
Standby mode with V_{bat} applied	V_{bat} = 3 V		70		uA
Supply ripple noise	1 Hz to 1 MHz			50	mV_{pp}
Hardware XRESET	Assert XRESET pin	100			us

Parameter	Conditions	Min	Typical	Max	Unit
Input gain at RF input		0 (passive antenna)		25	dB
External LNA noise				2	dB

[1]The primary supply voltage slope from 0 V to 2 V must have a rise time that is less than 10 ms:



Input/Output pin threshold voltages

Parameter	Status	Min	Max	Unit
Input pin voltage (RXD, Reserved Pins, XRESET)	High	2.0	3.6	V
	Low	-0.3	0.8	V
Output pin voltage (TXD)	High (Ioh = 1.6~14 mA)	2.4	V_{CC}	V
	Low (Iol = 1.6~14 mA)	-0.3	0.4	V

ESD protection

ESD testing was performed using test standard IEC 1000-4-2. All inputs and outputs are protected to 1 kV ESD level. If you require a higher level of compliance, you must add additional electrostatic and surge protection.

CHAPTER 2

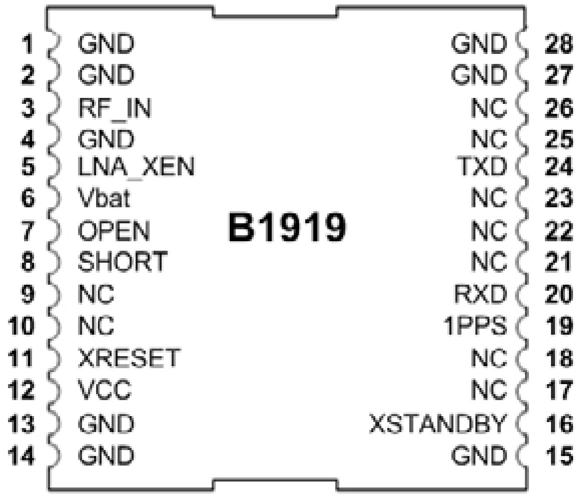
Interface Characteristics

In this chapter:

- Buffalo B1919 pin assignments

This chapter provides a detailed description of the Buffalo GNSS module interface.

Buffalo B1919 pin assignments



Pin description

Pin	Name	Description	Function	Note
1-2	GND	Ground	Ground	Connect to common ground
3	RF_IN	GPS/GLONASS signal input 50 Ω unbalanced (coaxial) RF input	Input	
4	GND	Ground	Ground	Connect to common ground
5	LNA_XEN	Turns on an external LNA	Output	
6	Vbat	Optional backup power	Input	2.0 V to VCC
7	OPEN	Antenna open	Input/Output	
8	SHORT	Antenna shorted	Input/Output	
9	NC	Do not connect		
10	NC	Do not connect		
11	XRESET	Active low; do not connect if not used	Input	
12	VCC	Main power supply	Input	2.7 V to 3.3 V
13-15	GND	Ground	Ground	Connect to common ground
16	XSTANDBY	Selects Run or Standby mode; do not connect if not used	Input	
17	NC	Do not connect		
18	NC	Do not connect		
19	1PPS	PPS Interface Time pulse	Output	1 Hz timing pulse. Do not connect if not used.
20	RXD	Serial port Receive @ 2.8 V LVTTL	Input	

Pin	Name	Description	Function	Note
21	NC	Do not connect		
22	NC	Do not connect		
23	NC	Do not connect		
24	TXD	Serial port Transmit @ 2.8 V LVTTL	Output	
25	NC	Do not connect		
26	NC	Do not connect		
27 - 28	GND	Ground	Ground	Connect to common ground

Detailed pin descriptions

RF input (pin 3)

The RF input pin is the 50 Ω unbalanced GPS RF input, and can be used with active or passive antennas.

- **Passive antennas**: You can connect the RF input pin to the passive GPS antenna by a low-loss 50 Ω unbalanced transmission system if loss is minimal (< 2 dB). Trimble recommends that you use an external LNA with a passive antenna.
- **Active antennas**: You can also connect the RF input pin to the output of an external low-noise amplifier, which amplifies GPS signals from the antenna.

  The LNA gain must be great enough to overcome transmission losses from the LNA output to this pin. The specification for noise for the module is < 3 dB at room temperature and <4 dB over the specified temperature range, –40 °C to +85 °C (–40 °F to +185 °F).

  Locate the external LNA so that the loss from the GPS antenna connection to the LNA input is minimized, preferably <1 dB. The noise figure of the LNA should be as low as possible, preferably <2 dB. This specification is provided to enable a cascaded noise figure design calculation.

  YOu must use a GPS and GLONASS antenna for the module to work as designed.

  Active antennas must be powered with a single bias-tee circuit.

LNA_XEN (pin 5)

Use this logic level output to control power to an external LNA or other circuitry. The logic of this signal is such that when the module is running (that is, not in standby mode), the signal is low. In standby mode, the signal is high. You can use this pin to control the gate of a p-channel FET that is used as a switch.

V_{bat} (pin 6)

Supply can range from 2.0 V to $V_{cc.}$ Maintains non-volatile RAM and the RTC for hot and warm starts. If not used, leave disconnected or connect to V_{cc}.

Open (pin 7) / Short (pin 8)

When you use an active antenna, Trimble recommends that you implement an antenna detection circuit with short circuit protection. Two pins are provided for reporting the antenna status: OPEN and SHORT.

You can use the logic level inputs in the antenna detect truth table below, with a detection circuit (with or without protection) to monitor the status of the external LNA of an active antenna by the module.

The truth table for the logic of these signals is provided in the table below. These input pins conform to the Input / Output Pin threshold levels described on page 10.

A typical active antenna draws between 10 mA to 20 mA.The antenna protect/detect circuit trips as a short circuit at around 100 mA. It is therefore advisable to keep the antenna current below 75 mA. An open circuit is determined if the antenna current falls below approximately 2 mA.

The antenna detect truth table below shows the condition of the logic signals:

Antenna reports	Short	Open
Antenna open reported	1	1
Antenna normal reported	1	0
Antenna shorted reported	0	0
Undefined	0	1

When you use a passive antenna with the OPEN pin floating, the receiver reports an open condition. If a normal condition from the receiver is required when using a passive antenna, leave the SHORT pin unconnected (there is an internal pull-up) and set the logic level of the OPEN pin to low.

XRESET (pin 11)

This logic-level, active low input is used to issue hardware or power-on reset to the module. It may be connected to external logic or to a processor to issue reset. To reset the module, take this pin low for at least 100 microseconds. Do not connect the pin if not used. See Absolute maximum limits, page 10 for pin threshold values.

Vcc (pin 12)

This is the primary voltage supply pin for the module.

XStandby (pin 16)

This logic level input is used to control the run/standby state of the module. If this signal is high, the unit runs normally. If it is low, the unit goes to standby mode. See Absolute maximum limits, page 10 for pin threshold values.

PPS (pin 19)

Pulse-per-second. This logic level output provides a 1 Hz timing signal to external devices. The pulse width of this signal is 6 µsec.

RXD (pin 20)

This logic level input is the serial port receive line (data input to the module).

TXD (pin 24)

This logic level output is the serial port transmit line (data output from the module). Do not hold the Tx port "low" or pull to ground while the GNSS module is starting up.

No Connect pins

There are several reserved pins on the Buffalo B1919 GNSS module. Do not connect these pins.

Protocols

NMEA 0183 is available on the Buffalo B1919 GNSS module.

Serial port default settings

The Buffalo B1919 GNSS module supports one serial port. The default settings are as follows:

Port direction	Pin #	Protocol	Characteristics				
			Baud rate	**Data bits**	**Parity**	**Stop bits**	**Flow control**
TXD	24	NMEA out	38400	8	None	1	None
RXD	20	NMEA in	38400	8	None	1	None

- Baud rate, data bits, parity, and stop bits are user configurable.
- Flow control is not available on the serial ports.

A detailed description of the protocol is given in Appendix A, NMEA 0183 Protocol.

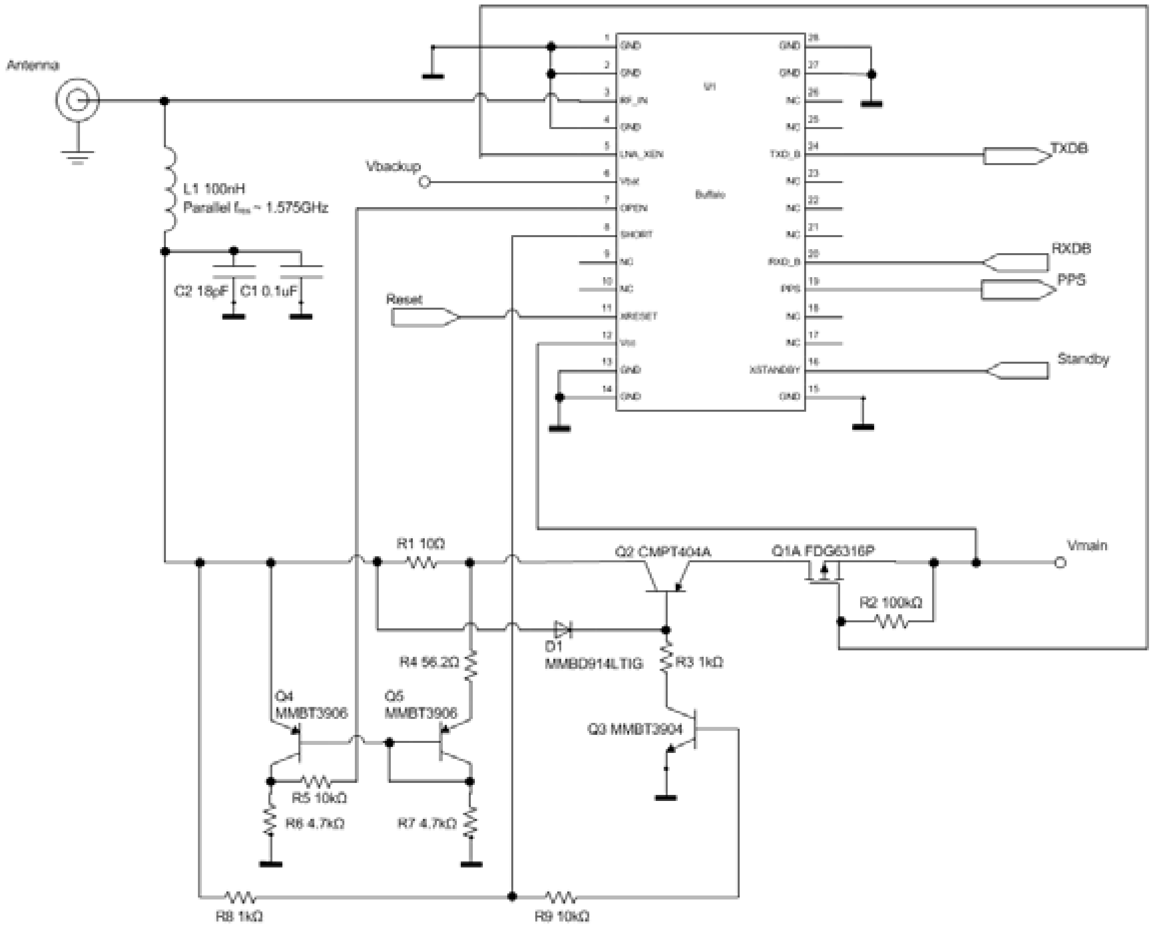
CHAPTER 3

Application Circuits

In this chapter:

This chapter describes the Buffalo GNSS module with different antenna connections.

Buffalo GNSS module with an active antenna



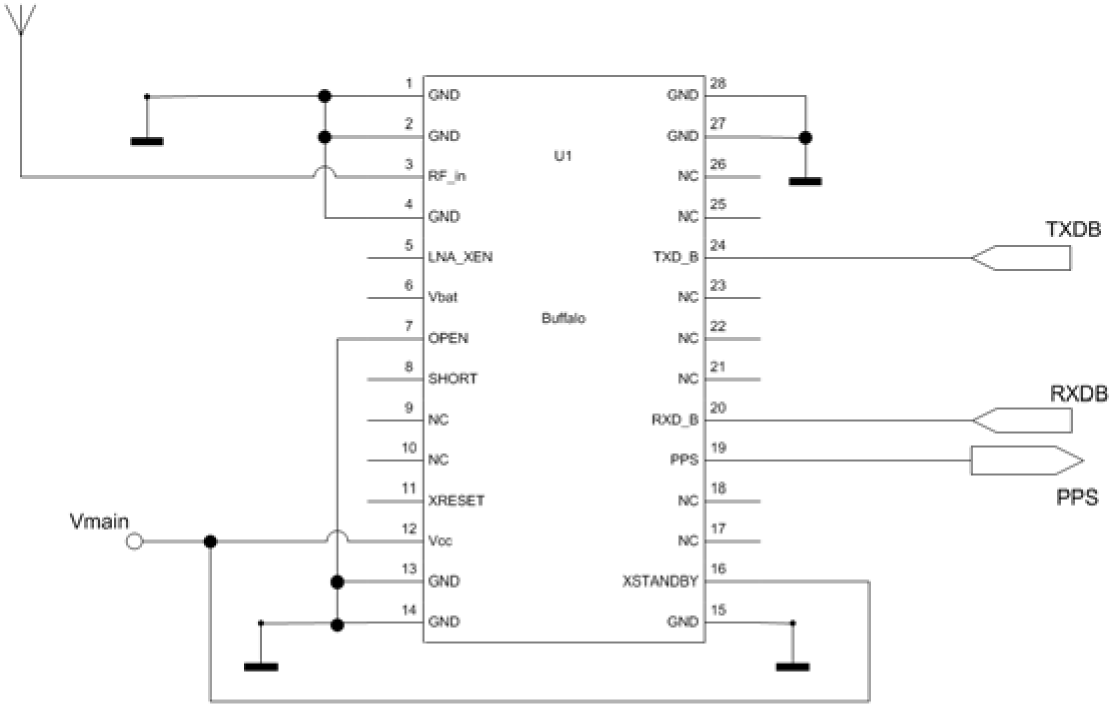
In the schematic:

- V_{bat} is connected to battery backup to preserve current GNSS data.
- The PPS output pin is not used and is left disconnected.
- Do not connect reserved pins.
- The external LNA gain range is 17 dB ~ 25 dB.

You can optimize the values by applying a GNSS signal from a simulator and adjusting the component values (up and down) to determine the best combination that provides the maximum displayed C/N value from the constant-level GPS signal. Alternatively, use a network analyzer to optimize the input return loss.

For more information on PCB layout and tuning, see Chapter 4, RF Layout Considerations.

Buffalo GNSS module with a passive antenna



In the schematic:

- The external XRESET pin pulled low for 100 ms after power is applied to V_{cc}.
- V_{bat} is connected to battery backup to preserve current GPS data.
- The PPS output pin is not used and is left disconnected.
- Do not connect reserved pins.

You can optimize the values by applying a GNSS signal from a simulator and adjusting the component values (up and down) to determine the best combination that provides the maximum displayed C/N value from the constant-level GNSS signal. Alternatively, use a network analyzer to optimize the input return loss.

For more information on PCB layout and tuning, see Chapter 4, RF Layout Considerations.

CHAPTER **4**

RF Layout Considerations

In this chapter:

This chapter outlines RF design considerations for the layout of the Buffalo GNSS module.

General recommendations

The design of the RF transmission line that connects the GPS antenna to the Buffalo module is critical to system performance. If the overall RF system is not implemented correctly, the Buffalo module performance may be degraded.

The radio frequency (RF) input on the Buffalo module is 50 Ω, unbalanced. There are ground castellations (pins 2 and 4) on both sides of the RF input castellation (pin 3). This RF input may be connected to the output of an LNA that has a GPS antenna at its input, or to a passive antenna through a low-loss 50 Ω, unbalanced transmission line system.

If the GPS antenna needs to be located at a significant distance from the Buffalo module, the use of an LNA at the antenna location is necessary to overcome the transmission losses from the antenna to the Buffalo module. Trimble recommends that, in the case of a passive antenna, the transmission line losses from the antenna to the module be less than 2 dB. Otherwise, add an LNA to the system.

Determine the specifications for the external LNA as follows:

- The specification of noise figure for the Buffalo B1919 GNSS module is 3 dB at room temperature and 4 dB over the temperature range -40 °C to +85 °C.
- The noise figure for the external LNA should be as low as possible, with a recommended maximum of 1.5 dB. Trimble recommends that the gain of the LNA exceeds the loss that is measured from the LNA output to the module input by 10 dB. For example, if the loss from the external LNA output is 7 dB, the recommended minimum gain for the LNA is 17 dB. In order to keep losses at the LNA input to a minimum, Trimble recommends that you connect the antenna directly to the LNA input, to ensure the minimum loss.
- To connect to the LNA output or to a passive antenna, use a 50 Ω, unbalanced transmission system. This transmission system may take any form, such as microstrip, coaxial, stripline, or any other 50 Ω characteristic impedance unbalanced, low-loss system.

You must keep noise sources with frequencies at or near 1575 MHz and 1602 MHz away from the RF input. In the case of a passive antenna, make sure that the antenna is not placed in a noisy location (such as too close to digital circuitry) as performance may be degraded. You can use as shielded transmission line system (stripline, coaxial) to route the signal if noise ingress is a concern.

When using an active antenna and if you want to power this antenna from the RF transmission line, you will need a bias-tee connector at the Buffalo module end. A simple series inductor (parallel resonant at 1575 MHz and 1602 MHz), and shunt capacitor (series resonant at 1575 MHz and 1602 MHz) to which the bias voltage is supplied is sufficient.

In the printed circuit board (PCB) layout, Trimble recommends that you keep the copper layer on which the Buffalo module is mounted clear of solder mask and copper (vias or traces) under the module. This is to ensure mating of the castellations between the Buffalo module and the board to which it is mounted, and to ensure that there is no interference with features beneath the Buffalo module that may cause it to lift during the reflow solder process.

For a microstrip RF-transmission line topology, Trimble recommends that the layer immediately below the one to which the Buffalo module is mounted is ground plane:

- For the Buffalo B1919 module, pins 2 and 4 should be directly connected to the ground plane with low inductance connections.
- Pin 3, the RF input, can be routed on the top layer using the proper geometry for a 50 Ω system.

Design considerations for RF track topologies

You must take the following into consideration when designing the RF layout for the Buffalo module:

- The PCB track connection to the RF antenna input must:
  - Have a 50 Ω impedance.
  - Be as short as possible.
  - Be routed away from potential noise sources such as oscillators, transmitters, digital circuits, switching power supplies, and other sources of noise.
  - Transition from the circuit board to the external antenna cable, which is typically a RF connector, if an external antenna is used.
- The PCB track connection to the RF antenna input must not have:
  - Sharp bends.
  - Components overlaying the track.
  - Routing between components (to avoid undesirable coupling).
- RF and bypass grounding must be direct to the ground plane through its own low-inductance via.
- You can use an active or a passive antenna. If you use a passive antenna, the connection to the antenna input must be very short.
- You can mount a patch antenna on the same PCB as the Buffalo module. Designers must be aware of noise-generating circuitry and must take proper design precautions (for example, shielding).
- If there are any ground planes on the same layer as the microstrip trace, refer to the Coplaner Waveguide design. ***This aspect is not covered in this manual.***
- As a general help to prevent radiation and coupling, it helps to think of voltages and currents as electrical and magnetic fields. The electric field forms ***between*** a positive and negative charge. The magnetic field forms ***around*** a trace with current flow. You can minimize the radiation by keeping the fields under control, which means minimizing the area in which the fields form out and by separating areas with stronger fields.
- Keep the path of supply currents and their GND return currents as close as possible together. The same applies for signal currents and their GND return currents.
- Keep signal traces, which are likely to interfere with each other, apart and separate them with GND areas.
- Route supply traces and their corresponding GND return paths to separate functional blocks with separate traces and connect them only at the feed point.
- Have at least one uninterrupted GND plane on or in your PCB. The GND plane should be separated by functional blocks, but within a functional block, do not route signals across the GND plane. Route signals on another layer.

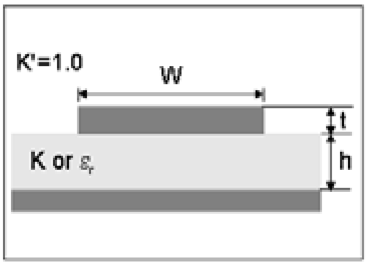
  Signal traces on a GND plane can block the way for GND return currents thereby opening up current loops and increase radiation. Even worse, slots in a GND plane can act as a slot-antenna structure and radiate or receive radiation on the resonating frequency.

- Surround the PCB edges with GND on top and bottom and stitch them together with many vias. This reduces edge radiation from traces nearby the PCB edge. On a PCB with separated GND planes, do the same on every GND area to prevent radiation from one area into another.
- Do not route signal traces across the borders of GND areas. Route them first to the GND star point and from there back to another GND area. Thereby you reduce GND coupling between the functional groups and you reduce the size of the current loop thereby reducing radiation.
- In digital circuits, lower the rising time of edges if possible. Fast rising edges (sharp square wave signals) generate many harmonics at higher frequencies. Lowering the rising time of digital outputs at the source, for example by inserting series resistors near digital output pins of ICs, will reduce the generated harmonics and thereby reduce the radiation of high frequencies.
- Always aim to minimize the sources of radiation. It is much easier and less costly to not generate radiation than trying to get rid of radiation by shielding.

PCB considerations

The minimum implementation is a two-layer PCB substrate with all the RF signals on one side and a solid ground plane on the other. You may also use multilayer boards. Two possible RF transmission line topologies include microstrip and stripline.

Microstrip transmission lines



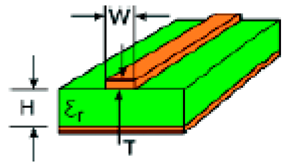
Ground plane design recommendation

Use a complete ground plane immediately under the PCB layer on which the Buffalo GPS module is mounted. On the same layer as the module, flood or “copper pour” around the signal tracks and then connect to the ground plane using low inductance vias. A single ground plane is adequate for both analog and digital signals.

Designing a microstrip transmission line

Use a 50 Ω unbalanced transmission system for connections to the LNA output. The following PCB parameters affect impedance:

- Track width (W)
- PCB substrate thickness (H)
- PCB substrate permittivity (ε_r)
- PCB copper thickness (T) and proximity of same layer ground plane (to a lesser extent)



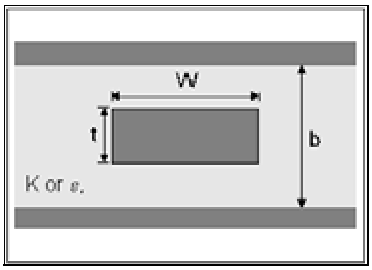
The following table shows typical track widths for an FR4 material PCB substrate (permittivity ε_r of 4.6 at 1.5 GHz) and different PCB thickness. The thickness of the top layer is assumed as being one ounce copper. If using a multi-layer PCB, the thickness is the distance from the signal track to the nearest ground plane.

Substrate material	Permittivity	Substrate thickness H (mm)	Track width W (mm)
FR4	4.6	1.6	2.91
		1.2	2.12
		1.0	1.81
		0.8	1.44
		0.6	1.07
		0.4	0.71
		0.2	0.34

Microstrip design recommendations

Trimble recommends that the antenna connection PCB track is routed around the outside of the module outline, kept on a single layer, and has no bends greater than 45 degrees. For production reasons, Trimble recommends that you do not route the track under the module.

Stripline transmission lines



Ground plane design recommendation

The stripline topology requires three PCB layers: two for ground planes and one for signal. One of the ground plane layers may be the layer to which the Buffalo GPS module is mounted. If this is the case:

- The top layer must be flooded with ground plane and connected to all ground castellations on the Buffalo module.
- The RF input should be connected to the signal layer below using a via.
- The layer below the signal layer is the second ground plane.
- Connect the two ground planes with vias, typically adjacent to the signal trace.
- Other signals of the Buffalo module may be routed to additional layer using vias.

For the symmetric stripline topology where the signal trace is an equal distance from each ground plane, the following applies:

Substrate material	Permittivity	Substrate thickness H (mm)	Track width W (mm)
FR4	4.6	1.6	0.631
		1.2	0.438
		1.0	0.372
		0.8	0.286
		0.6	0.2
		0.4	0.111
		0.2	N/A

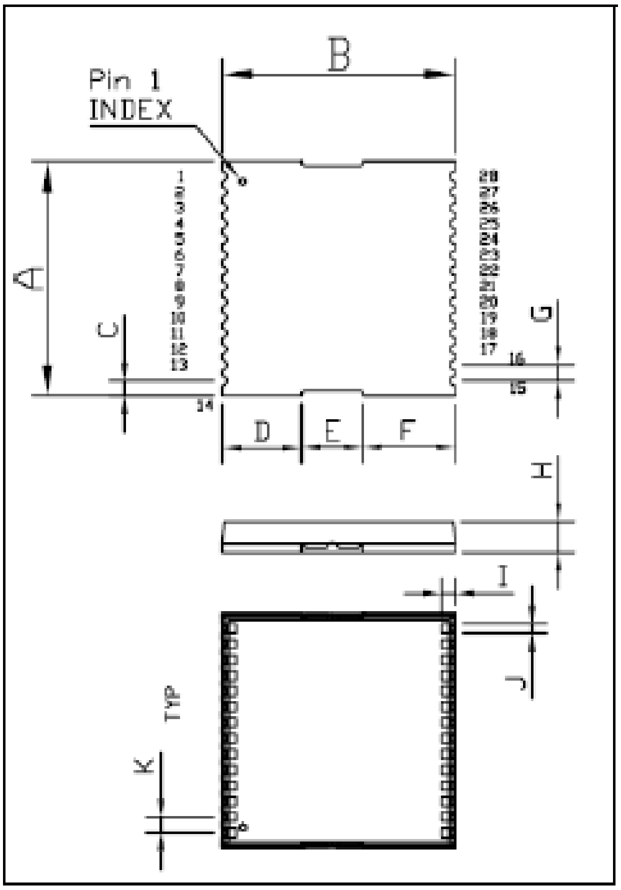
CHAPTER 5

Mechanical Specification

In this chapter:

This chapter provides product drawings and instructions for soldering the Buffalo GNSS receiver to a printed circuit board.

Buffalo B1919 module—mechanical outline drawing



Top View

Bottom View

Buffalo GNSS receiver, footprint

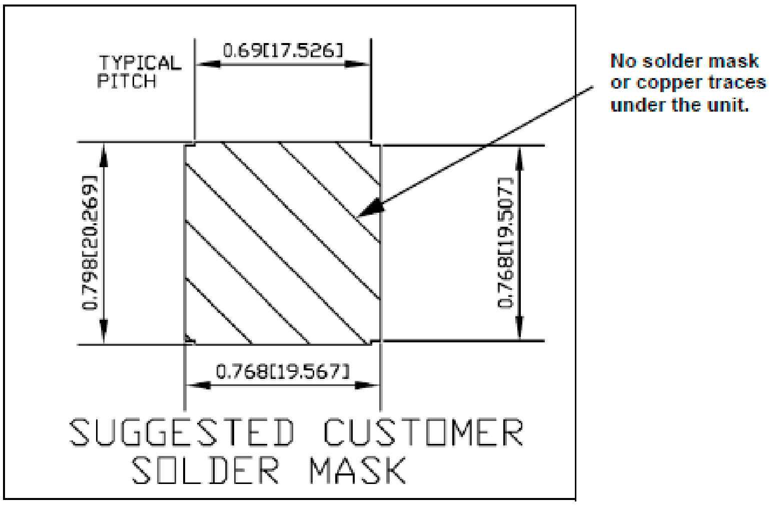
Outline Dimensions (Inch ±0.004 / mm ±0.10)

A	B	C	D	E	F	G	H	I	J	K
0.75	0.75	0.049	0.256	0.197	0.295	0.050	0.100	0.045	0.030	0.050
19.00	19.00	1.25	6.50	5.00	7.50	1.27	2.54	1.14	0.76	1.27

Soldering a Buffalo B1919 module to a printed circuit board

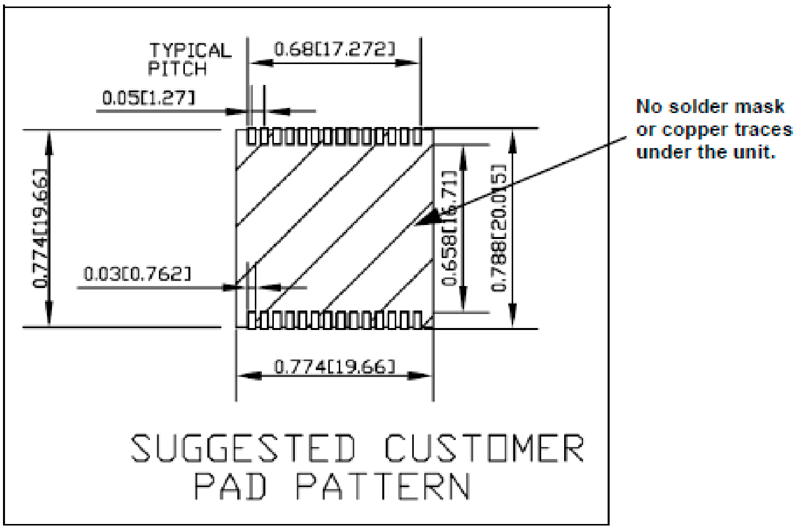
Solder mask

When soldering the Buffalo module to a PCB, keep an open cavity underneath the Buffalo module (that is, do not place copper traces or solder mask underneath the module). The diagram below illustrates the required solder mask.



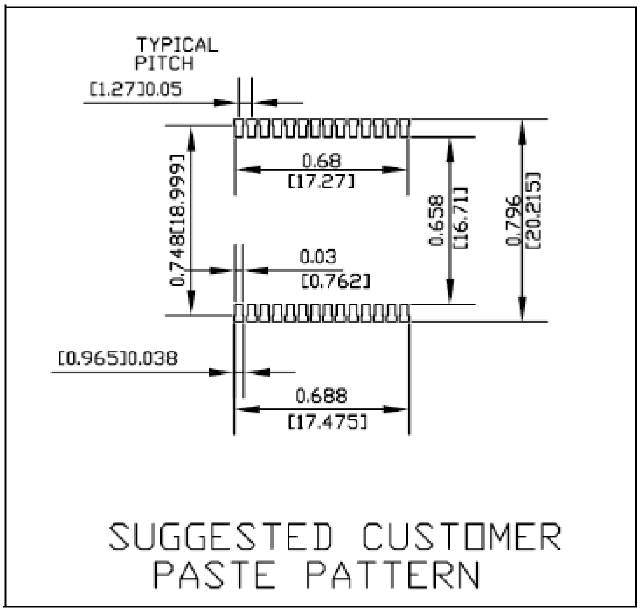
Pad pattern

The required user pad pattern is shown below.



Paste mask

To ensure good mechanical bonding with sufficient solder to form a castellation solder joint, use a solder mask ratio of 1:1 with the solder pad. When using a 5 ±1 mil stencil to deposit the solder paste, Trimble recommends a 4 mil toe extension on the stencil.



CHAPTER 6

Packaging

In this chapter:

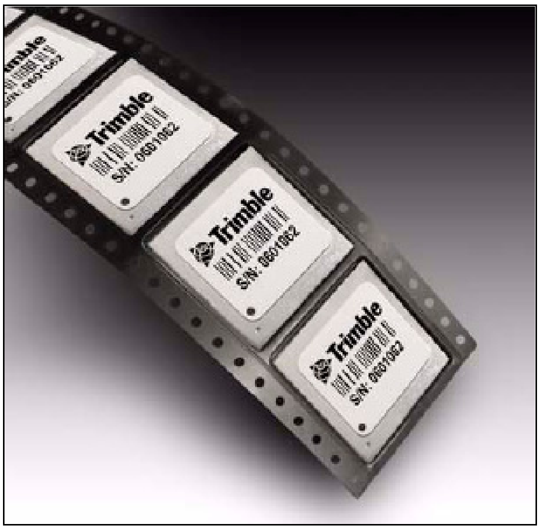
Follow the instructions in this chapter to ensure the integrity of the packaged and shipped Buffalo GNSS modules.

Introduction

The Buffalo GNSS modules are packaged in tape and reel for mass production.

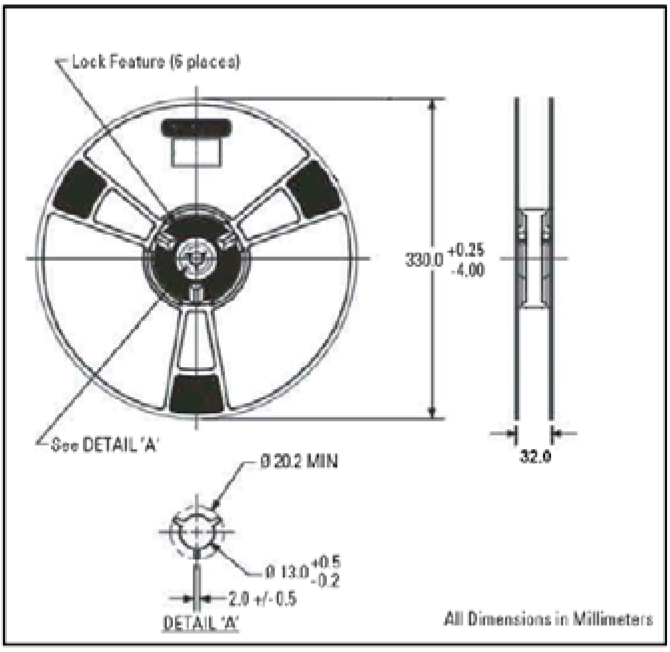
CAUTION – The reel is sealed in a moisture proof Dry Pac bag. Please follow all the directions printed on the package for handling and baking.

The Buffalo GNSS modules are packaged in a reel with 100 or 500 pieces.



Reel

You can mount the 13-inch reel in a standard feeder for the surface mount pick and place machine.

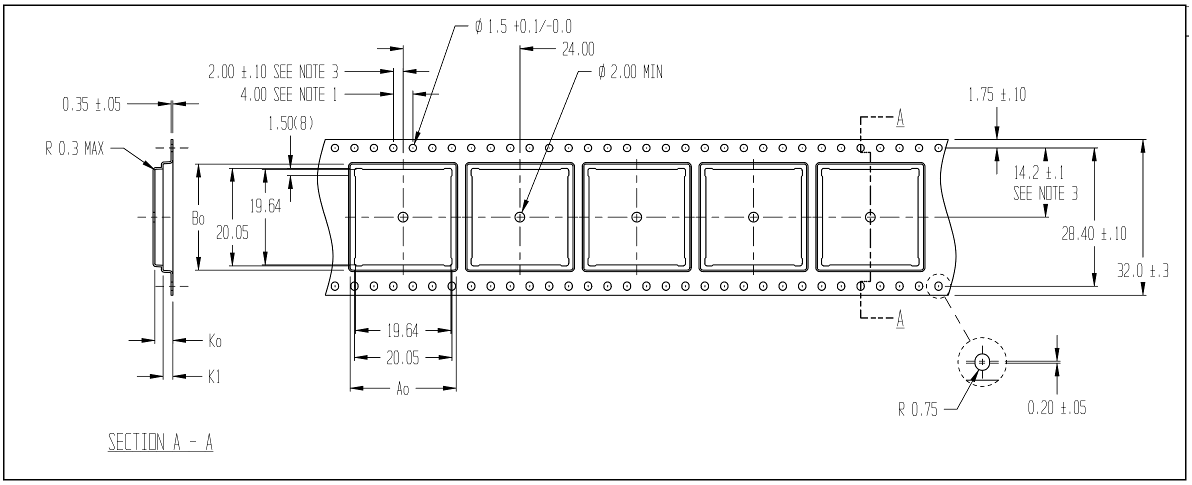


Weight

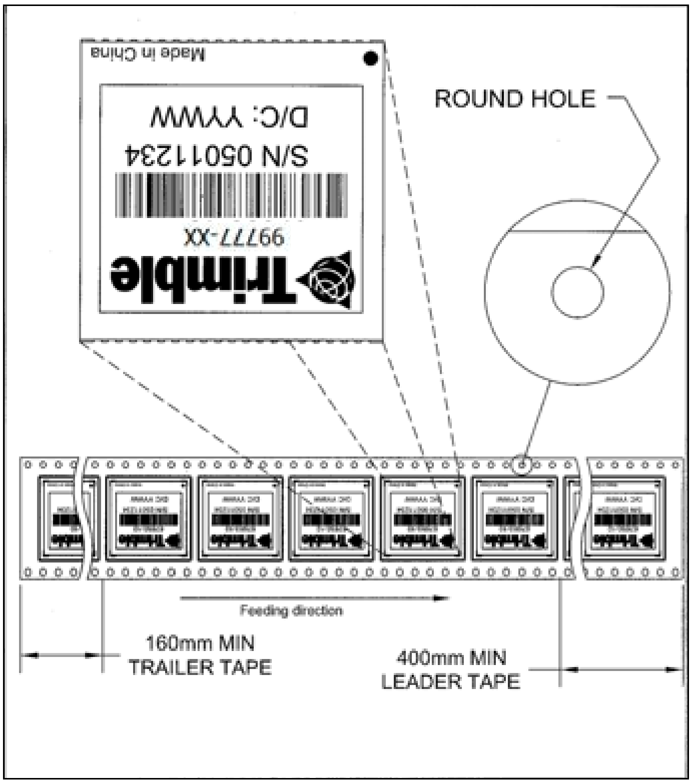
Description	Weight (approx)
100 pieces with reel packaging, desiccant, and humidity indicator	0.79 kg (1.74 lb.)
100 pieces with reel packaging, desiccant, humidity indicator, and brown pizza box	1.02 kg (2.25 lb.)
500 pieces with reel packaging, desiccant, and humidity indicator	1.47 kg (3.24 lb.)
500 pieces with reel packaging, desiccant, humidity indicator, and white pizza box	1.70 kg (3.74 lb.)

Tapes

The tape dimensions illustrated in the diagram below are in inches. The metric units appear in brackets [ ].



The feeding direction is illustrated below:



CHAPTER 7

Shipping and Handling

In this chapter:

This chapter provides detailed guidelines for shipping and handling the Buffalo GNSS module to ensure compliance with the product warranty.

Shipping and handling guidelines

Handling

The Buffalo GNSS module is shipped in tape and reel for use with an automated surface mount machine. This is a lead-free module with silver plating. Do not allow bodily fluids or lotions to come in contact with the bottom of the module.

CAUTION – The Buffalo GNSS module is packed according to ANSI/EIA-481-B and JSTD-033A. All of the handling and precaution procedures must be followed. Deviation from the following handling procedures and precautions voids the warranty.

Shipment

The reel of Buffalo GNSS modules is packed in a hermetically sealed moisture barrier bag (DryPac) and then placed in an individual carton. Handle with care to avoid breaking the moisture barrier.

Storage

The shelf life for the sealed DryPac is 12 months if stored at <40 °C and with <90% relative humidity.

Moisture indicator

A moisture indicator is packed individually in each DryPac to monitor the environment—it has five indicator spots that are blue when the pack leaves the factory. If the indicator changes to pink, follow the instructions printed on the moisture barrier and bake as required. See Baking procedure, page 36.

Floor life

The reel of Buffalo GNSS modules is vacuum sealed in a moisture barrier bag (DryPac). Once the bag is opened, moisture will bond with the modules. In a production floor environment, an open reel needs to be processed within 72 hours, unless it is kept in a nitrogen-purged dry chamber. If the moisture indicator changes to pink, follow the baking instructions printed on the moisture barrier.

The Buffalo GNSS module is a lead-free component and is RoHS compliant. This unit is also plated with immersion silver that makes soldering easier. The silver may tarnish over time and appear yellowish, but this should not affect the solderability.

CAUTION – Operators should not touch the bottom silver solder pads by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module before soldering.

Moisture precondition

You must take precautions to minimize the effects of the reflow thermal stress on the module. Plastic molding materials for integrated circuit encapsulation are hygroscopic and absorb moisture. This is dependent on the time and the environment.

Absorbed moisture will vaporize during the rapid heating of the solder reflow process, generating pressure to all the interface areas in the package, followed by swelling, delamination, and even cracking of the plastic. Components that do not exhibit external cracking can have internal delamination or cracking which affects yield and reliability.

CAUTION

4 Level

THIS BAG CONTAINS MOISTURE SENSITIVE DEVICES.
Do not open except under controlled conditions.
shelf life in sealed bag: 12 months @ <40C and <90% RH.
1) Peak package body temperature 245C.
2) After this bag is opened, devices that will be subjected to IR reflow vapor-phase reflow, or equivalent processing must be:
a. Mounted within 72 hrs @ factory conditions of <30C/60% RH or
b. Stored at <20% RH.
3) Devices require baking, before mounting if:
a. Humidity card is >20% when read at 23C+-5C or
b. 2a or 2b are not met.
4) if baking is required, devices may be baked for 24 hrs minimum at 125C-0/+5C.
Bag Seal Date: mm/dd/yy
expiration date: 12 months from seal date.

Baking procedure

If baking is necessary, Trimble recommends baking in a nitrogen-purge oven.

Temperature	125 °C
Duration	24 hours
After baking	Store in a nitrogen-purged cabinet or dry box to prevent absorption of moisture

⚠ **CAUTION –** Do not bake the units within the tape and reel packaging. Repeated baking processes will reduce the solderability.

Soldering paste

The Buffalo GPS module itself is not hermetically sealed. Trimble strongly recommends using the “No Clean” soldering paste and process. The castellation solder pad on this module is plated with silver plating. Use Type 3 or above soldering paste to maximize the solder volume. The following is an example:

Solder paste	Kester EM909
Alloy composition	Sn96.5Ag3Cu.5 (SAC305) 96.5% Tin / 3%Silver / 0.5% Copper
Liquidus Temperature	221 °C
Stencil Thickness	5 mil (0.005") Stencil opening requires 4 mil toe over-paste in the X and Y directions.

Consult the solder paste manufacturer and the assembly process for the approved procedures.

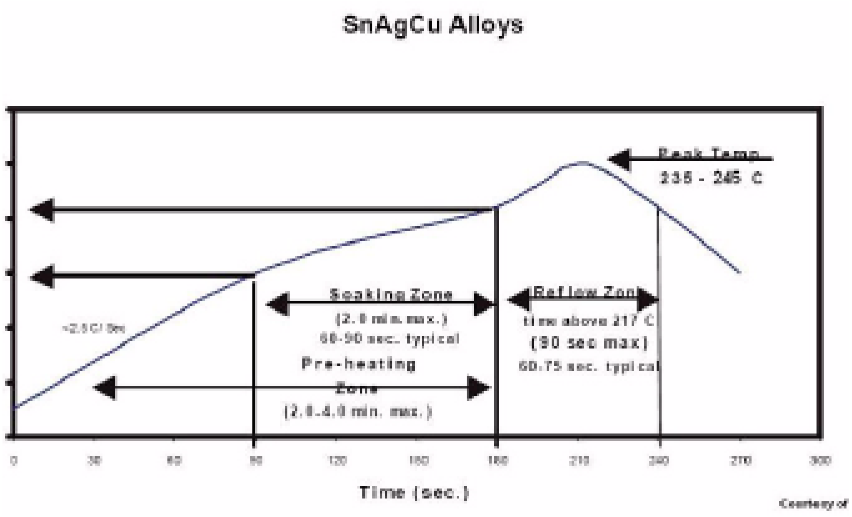
Solder reflow

A hot air convection oven is strongly recommended for solder reflow. For the lead-free solder reflow, Trimble recommends using a nitrogen-purged oven to increase the solder wetting. Reference IPC-610D for the lead free solder surface appearance.

CAUTION – Follow the thermal reflow guidelines from the IPC-JEDEC J-STD-020C.

The size of this module is 916.9 mm^3. According to J-STD-020C, the peak component temperature during reflow is 245 + 0 °C.

Recommended soldering profile



Select the final soldering thermal profile very carefully. The thermal profile depends on the choice of the solder paste, thickness and color of the carrier board, heat transfer, and the size of the penalization.

⚠ **CAUTION –** For a double-sided surface-mount carrier board, the unit must be placed on the secondary side to prevent falling off during reflow.

Optical inspection

After soldering the Buffalo GNSS module to the carrier board, follow the IPC-610 specification and use a 3x magnification lens to verify the following:

- Each pin is properly aligned with the mount pad.
- The pads are properly soldered.
- No solder is bridged to the adjacent pads. X-ray the bottom pad if necessary.

Cleaning

When the Buffalo GNSS module is attached to the user board, a cleaning process voids the warranty. Please use a "no-clean" process to eliminate the cleaning process. The silver-plated Buffalo GPS module may discolor with cleaning agent or chlorinated faucet water. Any other form of cleaning solder residual may cause permanent damage and will void the warranty.

Soldering guidelines

Repeated reflow soldering

The Buffalo GNSS receiver lead-free silver plated module can withstand two reflow solder processes. If the unit must mount on the first side for surface-mount reflow, add glue on the bottom of the module to prevent it falling off when processing the second side.

Wave soldering

The Buffalo GNSS module cannot soak in the solder pot. If the carrier board is mixed with through-hole components and surface mount devices, it can be processed with one single lead-free wave process. The temperature of the unit will depend on the size and the thickness of the board. Measure the temperature on the module to ensure that it remains under 180 °C.

Hand soldering

For the lead-free Buffalo GNSS module, use a lead-free solder core, such as Kester 275 Sn96.5/Ag3/Cu0.5. When soldering the module by hand, keep the soldering iron below 260 °C.

Rework

The Buffalo GNSS module can withstand one rework cycle. The module can heat up to the reflow temperature to precede the rework. Never remove the metal shield and rework on the module itself.

Conformal coating

Conformal coating on the Buffalo GNSS module is not allowed and will void the warranty

Grounding the metal shield

The Buffalo GNSS module is designed with numerous ground pins that, along with the metal shield, provide the best immunity to EMI and noise. Any alteration by adding ground wires to the metal shield is done at the customer's own risk and may void the warranty.

APPENDIX **A**

NMEA 0183 Protocol

In this appendix:

This appendix provides a brief overview of the NMEA 0183 protocol, and describes both the standard and optional messages offered by the Buffalo GNSS modules.

Introduction

NMEA 0183 is a simple, yet comprehensive ASCII protocol which defines both the communication interface and the data format. The NMEA 0183 protocol was originally established to allow marine navigation equipment to share information. Since it is a well established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics.

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

Communication between a host processor and the ST GPS System can be established in different ways, depending on the implementation of the Baseband Processor as a standalone unit or as an integrated subsystem on a “System on Chip”.

For simplicity reasons this document will refer to “Stand-alone Processors” only, and the interface described in the examples is a UART. There are other implementations to communicate, like USB or SPI. The hardware interface used will not influence the data content send or received.

All information contained in this document is related to the NMEA port of the Baseband Processor.

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

NMEA National Office
Seven Riggs Avenue, Severna Park, MD 21146
Phone: +1-410-975-9425 or 800-808-6632 (NMEA)
Fax: +1-410-975-9450

NMEA 0183 communication interface

NMEA 0183 allows a single source (talker) to transmit serial data over a single twisted wire pair to one or more receivers (listeners).

Commands

A Command is a defined Data Packet which is sent from a host processor to the GPS Baseband Controller in order to control the GPS system behaviour. The regular structure of a command is:

```
command-ID, <parameters> <cr><lf>
```

In order to receive the commands the GPS receiver is connected to the PC via the NMEA port.

Note – *Make sure that the serial cable is the right one, sometimes it is necessary to use a cross-cable.*

The user interaction can be achieved through the use of a PC terminal emulator that is connected to the appropriate COM port.

The table below lists the standard characteristics of the NMEA 0183 data transmissions.

Signal	NMEA standard
Baud rate	38400
Data bits	8
Parity	None (Disabled)
Stop bits	1

The NMEA baud rate at 38400 is the default value, automatically set at the system start-up. It can be modified at system runtime using the appropriate command.

The simplest way to send a command to the device is to write the command string in a text file and send it using the “send file” capability of the terminal emulator. For this reason, it is required that the terminal emulator (or production test program) running on the computer is capable of sending text files down the RS-232 link to the GNSS receiver.

NMEA 0183 message structure

A Message is a defined set of data sent from the GPS System to a host processor using the same interface which is used to transfer commands to the system. Messages may not be enabled by default, but can be switched on and off using a command at run-time.

The basic structure of a message is:

```
message-ID, <parameters> <cr><lf>
```

There are two basic sets of messages implemented:

- Standard NMEA Messages
- Proprietary NMEA Messages

See NMEA 0183 message options, page 46 for details.

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

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

Where:

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

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

Field definitions

Many of the NMEA data fields are of variable length, and the user should always use the comma delineators to parse the NMEA message data field. The following table specifies the definitions of all field types in the NMEA messages supported by Trimble:

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

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

Note –
- Spaces should only be used in variable text fields.
- Units of measure fields are appropriate characters from the Symbol column unless a specified unit of measure is indicated.
- Fixed length field definitions show the actual number of characters. For example, a field defined to have a fixed length of 5 HEX characters is represented as hhhhh between delimiters in a sentence definition.

NMEA 0183 message options

The Buffalo GPS module can output the messages listed in the table below. In its default configuration (as shipped from the factory), the Buffalo module outputs only the messages in the table below. Typically NMEA messages are output at a 1 second interval with the "GP" talker ID and checksums. These messages are output at all times during operation, with or without a fix.

Message	Description
GGA	GPS fix data (default)
GSA	GPS DOP and active satellites (default)
GSV	GPS satellites in view (default)
RMC	Recommended minimum specific GPS/Transit data (default)
VTG	Track Made Good and Ground Speed
ZDA	Time and date

Note – *Only RMC, GGA, GSV, VTG, and GSA are default. If you change the output contents, the receiver only keeps them while* V_{cc} *or* V_{bat} *is present. If* V_{cc} *or* V_{bat} *are removed, the output goes back to the default settings. Users can save the output contents to a Flash drive before* V_{cc} *or* V_{bat} *are removed.*

Two basic sets of messages are implemented.

Standard NMEA Messages

Standard NMEA Messages are defined in the “NMEA 0183” Standard, issued from the National Marine Electronics Association. The latest issue is Rev. 3.1 dated January 2002.

NMEA0183 refers to it as Sentences (single line message) and Messages (multiple line messages).

To get an overview on the standard NMEA messages supported by Buffalo´s GPS Systems please refer to Standard NMEA messages list, page 47.

Standard NMEA messages start the *message-ID* with:

```
$<Talker ID>
```

Supported *talker IDs* are: GP, GL, and GN for standard NMEA sentences.

Standard NMEA messages list

Syntax	Default	Description
$GPGGA	On	NMEA: Global Position System Fix Data.
$--GSA	ON	NMEA: GPS DOP and Active Satellites. “GP” and “GL” talker IDs are supported according to the software configuration.
$--GSV	ON	NMEA: GPS Satellites in View. “GP”, “GL” and “GN” talker ID are supported according to the software configuration.
$GPRMC	ON	NMEA: Recom. Min. Spec. GPS/TRANSIT Data.
$GPVTG	ON	NMEA: Track made good and ground speed.
$GPZDA	OFF	NMEA: Time and Date.

Proprietary NMEA Messages

The GNSS System can provide additional messages with more detailed data content. This is required to transmit GNSS and System information content which is not defined in the NMEA standard output.

Proprietary Messages start with:

`$PTNL…`

To get an overview on the proprietary messages, see Proprietary NMEA messages, page 53.

Commands

Note – *If not explicitly declared, commands that modify the status of parameters and modifications are not saved in the backup memory. Any new setting will be replaced by default values after system reset or system power cycling.*

Standard NMEA messages specification

The messages are defined within the "NMEA 0183" Specification.

$GPGGA

Global Positioning System Fixed data.

NMEA message list bitmask: 0x1

Format

```
$GPGGA,<Timestamp>,<Lat>,<N/S>,<Long>,<E/W>,<GPSQual>,<Sats>,
<HDOP>,<Alt>,<AltVal>,<GEOSep>,<GEOVal>,<DGPSAge>,<DGPSRef>,<checksum><cr><lf>
```

Parameter	Format/Value	Description
Timestamp	hhmmss	UTC Time of GPS Sample. Example: 160836
Lat	DDMM.MMM	Lat in Degree-Minutes.partsMinutes. Example: 4208.536
N/S	N or S	Lat Direction: North or South
Long	DDMM.MMM	Long in Degree-Minutes.partsMinutes. Example: 1105.345
E/W	E or W	Long Direction: East or West
GPSQual	Decimal, 1digit	0 = invalid 1 = GPS 2 = DGPS
Sats	Decimal, 2 digits	Satellites in view. Example: 8
HDOP	Decimal, 3 digits	Horizontal Dilution of Precision, max: 99.0
Alt	Decimal, 5 digits	Height above WGS-84 Elipsoid, max: 999.99
Alt-Val	M	Height measure in M = meters
GEOSep		
GEOVal		
DGPSAge		
DGPSRef		
checksum	Hexadecimal, 2 digits	Checksum of the message bytes without *<checksum><cr><lf> characters.

Example

```
$GPGGA,183417.366,4814.03970,N,1128.52205,E,0,00,99.0,495.53,M,47.6,M,,*53
```

$--GSA

GPS DOP and Active Satellites. The talker ID for this NMEA message depends on the enabled constellation: "GN" is used when both GPS and GLONASS constellations are enabled.

Satellites from different constellations are sent on separate messages.

NMEA message list bitmask: 0x4

Format

```
$--GSA,<Mode>,<CurrentMode>,[<SatPRN1>],...,[<SatPRNN>],<PDOP>,<HDOP>,<VDOP>,<checksum><cr><lf>
```

Parameter	Format	Description
Mode	hhmmss	Operating Mode: M = Manual, A = Auto (2D/3D)
CurrentMode	Decimal, 1digit	Current Mode: 1 = no fix available 2 = 2D 3 = 3D
SatPRN1...N	Decimal, 2 digits	Satellites list used in position fix, max N: 12
PDOP	Decimal, 3 digits	Position Dilution of Precision, max: 99.0
HDOP	Decimal, 3 digits	Horizontal Dilution of Precision, max: 99.0
VDOP	Decimal, 3 digits	Vertical Dilution of Precision, max: 99.0
checksum	Hexadecimal, 2 digits	Checksum of the message bytes without *<checksum><cr><lf> characters.

Example

```
$GPGSA,A,3,05,21,07,24,30,16,12,,,,,,2.4,1.9,1.5*38
```

$--GSV

GPS Satellites in View.

The talker ID for this NMEA message depends on the enabled constellation, as follows:

- “GP” is used only for GPS satellites. A set of $GPGSV messages is sent to report all GPS satellites.
- “GL” is used only for GLONASS satellites. A set of $GLGSV messages is sent to report all GLONASS satellites.
- “QZ” is used only for QZSS satellites. A set of $QZGSV messages is sent to report all QZSS satellites.

NMEA message list bitmask: 0x80000

Format

```
$--GSV,<GSVAmount>,<GSVNumber>,<TotSats>,[<Sat1PRN>,<Sat1Elev>,<Sat1Azim>,<Sat1C/N
0>],...[<SatNPRN>,<SatNElev>,<SatNAzim>,<SatNC/N0>],
<checksum><cr><lf>
```

N max. = 4

Parameter	Format	Description
GSVAmount	Decimal, 1 digit	Total amount of GSV messages, max. 3
GSVNumber	Decimal, 1 digit	Continued GSV number of this message
TotSats	Decimal, 2 digits	Total Number of Satellites in view, max. 12
SatxPRN	Decimal, 2 digits	PRN Number of satellite x
SatxElev	Decimal, 2 digits	Elevation of satellite x in Degree, 0 … 90
SatxAzim	Decimal, 3 digits	Azimuth of satellite x in degree, ref. “North”, 000 … 359
SatxC/NO	Decimal, 2 digits	Carrier to Noise Ratio for satellite x in dB, 00 … 99
checksum	Hexadecimal, 2 digits	Checksum of the message bytes without *<checksum><cr><lf> characters.

Example:

```
$GPGSV,3,1,12,02,04,037,,05,27,125,44,06,78,051,23,07,83,021,30*7C
$GPGSV,3,2,12,10,16,067,30,12,11,119,36,16,24,301,41,21,44,175,50*73
$GPGSV,3,3,12,23,06,326,28,24,61,118,40,30,45,122,43,31,52,253,37*7C
```

Note – *Due to the fact that up to 12 Satellites may be in view, this message can be repeated up to 3 times, containing 4 different Satellites per message. GSVAmount reports the total number of GSV messages to be transmitted, while GSVNumber reports the actual number of the current message frame.*

$GPRMC

Recommended Minimum Specific GPS/Transit data

NMEA message list bitmask: 0x40

Format

```
$GPRMC,<Timestamp>,<Status>,<Lat>,<N/S>,<Long>,<E/W>,<Speed>,<Trackgood>,<Date>,<M
agVar>,<MagVarDir><checksum><cr><lf>
```

Parameter	Format/Value	Description
Timestamp	hhmmss	UTC Time of RMC Sample. Example: 160836
Status	A or V	Receiver warning: A = valid, V = Warning
Lat	DDMM.MMMM	Lat in Degree-Minutes.partsMinutes. Example: 4208.5368
N/S	N or S	Lat Direction: North or South
Long	DDMM.MMMM	Long in Degree-Minutes.partsMinutes. Example: 1105.3456
E/W	E or W	Long Direction: East or West
Speed	ddd.d	Speed over ground in knots
Trackgood	Decimal, 4 digits	Course made good, max. 999.9
Date	Decimal, 6 digits	Date of Fix : ddmmyyyy
MagVar	Decimal, 4 digits	Magnetic Variation, max.: 090.0
MagVarDir	E or W	Magnetic Variation Direction
checksum	Hexadecimal, 2 digits	Checksum of the message bytes without *<checksum><cr><lf> characters.

Example

```
$GPRMC,183417.366,V,4814.040,N,01128.522,E,0.0,0.0,170907,0.0,W*6C
```

$GPVTG

Recommended Minimum Specific GPS/Transit data.

NMEA message list bitmask: 0x10

Format

`$GPVTG,<TMGT>,T,<TMGM>,M,<SoGN>,N,<SoGK>,K*<checksum><cr><lf>`

Parameter	Format/Value	Description
TMGT	ddd.d in degrees	Track in reference to "true" earth poles
T		Indicates "terrestrian"
TMGT	ddd.d in degrees	Track in reference to "magnetic" earth poles
M		Indicates "magnetic"
SoGN	ddd.d in knots	Speed over Ground in knots
N		Indicates "knots"
SoGK	ddd.d in km/h	Speed over Ground in kilometers per hour
K	ddd.d	Indicates "kilometers"
checksum	Hexadecimal, 2 digits	Checksum of the message bytes without *<checksum><cr><lf> characters.

$GPZDA

UTC, day, month, year, and local time zone.

NMEA message list bitmask: 0x05

Format

`$GPZDA,hhmmss.s,dd,mm,yyyy,zh,zm*hh<CR><LF>`

Field	Description
hhmmss.s	Hours, minutes, seconds, sub-seconds of position in UTC.
dd	Day (01 to 31)
mm	Month (01 to 12)
yyyy	Year
zh	Local Zone Hour, offset from UTC to obtain Local time
zm	Local Zone Minute

Proprietary NMEA messages

Software Command List

The table below summarizes all the commands supported by the proprietary NMEA layer:

Message	Description	Q	S
BA	Antenna status	Q	
EM	Set device into Monitor mode (for firmware update)		S
NM	NMEA automatic message output control	Q	S
PT	Serial port and output protocol configuration	Q	S
RT	Reset device		S
VR	Version information	Q	

BA - Antenna Status

This message queries the antenna status. Setting the data is not supported. This message is output automatically if selected in the NMEA message output mask.

Query format:

```
$PTNLQBA*hh<CR><LF>
```

Response to query format:

```
$PTNLRBA,a,a,a*hh<CR><LF>
```

Field	Description
a	Status (0 = status unavailable, 1 = status available)
a	Antenna feedline fault: 0 = normal 1 = open 2 = short 3 = unknown
a	Antenna feedline fault (internal open/short detection circuitry): 0 = normal 1 = open 2 = short 3 = unknown ***Note –*** *This field is optional and may not be available on all products. When this field is present, the previous field indicates the status from the external open/short detection circuitry.*

EM – Enter Monitor Mode

This message switches the device from *Normal* to *Monitor* mode. Querying the data is not supported.

Set format:

`$PTNLSEM*hh<CR><LF>`

Response to set format:

`$PTNLREM,a*hh<CR><LF>`

Field	Description
a	Status (A - success; V - failure)

NM - NMEA Configuration

This message queries or sets the NMEA configuration.

Query format:

`$PTNLQNM*hh<CR><LF>`

Set or response to query format:

$PTNLaNM,hhhhhhhh,x.x,x*hh<CR><LF>

Field	Description
a	Mode (S = set; R = response)
hhhhhhhh	Message Flags (32 bits maximum), one bit for each message: Bit 0 - GGA Bit 2 - VTG Bit 3 - GSV Bit 4 - GSA Bit 5 - ZDA Bit 8 - RMC Bit 13 - BA
x.x	Automatic Report Interval (1 - 255 seconds).
x	Position fix data source. This field indicates the source of fix data in messages containing position fix information (GGA, RMC). 0 - GNSS fix data

Response to set format:

`$PTNLRNM,a*hh<CR><LF>`

Field	Description
a	Status (A - success; V - failure)

PT - Port Configuration

This message queries or sets the port configuration.

This message queries or sets the NMEA configuration.

Query format:

`$PTNLQPT*hh<CR><LF>`

Set or response to query format:

$PTNLaPT,xxxxxx,a,a,a*hh<CR><LF>

Field	Description
a	Mode (S = set, R = response)
x…x	Baud rate (2400, 4800, 9600, 19200, 38400, 57600, 115200)
a	Number of data bits (7 or 8)
a	Parity (N = None, O = Odd, E = Even)
a	Number of stop bits (1 or 2)
h	Input protocol(s). This is a hex bit-map. Bits can be combined to enable multiple input protocols. This field may not be 0. Bit 0: TAIP Bit 1: TSIP Bit 2: NMEA Bit 3: Auxiliary protocol (HIPPO, SBIP, UBX, TEP, etc depending on the product)
h	Output protocol(s). This is a hex bit-map. It is not recommended to enable more than one output protocol at a time because enabling multiple protocols will result in a large amount of output data which may overrun the serial port buffers and get corrupted during transmission. Bit 0: TAIP Bit 1: TSIP Bit 2: NMEA Bit 3: Auxiliary protocol (HIPPO, SBIP, UBX, TEP, etc depending on the product)

In case of Set, the Response message with new parameters is sent using the old parameters first, and then the switch to the new parameters is made. If the switch fails for whatever reason, NMEA error response is sent. If the switch succeeds, no additional response is sent.

Response to set format:

`$PTNLRPT,a*hh<CR><LF>`

Field	Description
a	Status (A - success; V - failure)

RT - Reset Device

This message resets the device. Querying the data is not supported.

Set format:

`$PTNLSRT,a,x,x,x..x*hh<CR><LF>`

Field	Description
a	Reset type: C - cold reset (clear RAM including GPS data and user configuration) W - warm reset (clear ephemeris only) H - hot reset (RAM data not cleared) F - factory reset (clear RAM and NVRAM including GPS data and user configuration) G - perform a graceful shutdown reset
x	NVRAM (flash configuration) operation: 0 - no operation 1 - store GNSS data (almanac, eph, etc) to NVRAM 2 - store user configuration to NVRAM 3 - store both GNSS data and user configuration to NVRAM 4 - erase GNSS data in NVRAM 5 - erase user configuration in NVRAM (set to factory defaults) 6 - erase both GPS data and user configuration in NVRAM 7 - erase system configuration in NVRAM (set to factory defaults)
x	Optional field: standby mode wakeup condition flags. This field is applicable only when the reset type is S. Bit 0 - wake up on Serial Port A activity Bit 1 - wake up on Serial Port B activity Bit 2 - wake up after elapsed time specified in the standby timeout Setting bit to 1 turns on the corresponding wakeup condition, setting bit to 0 turns off the corresponding wakeup condition.
x..x	Optional field: standby timeout. This field is applicable only when the reset type is S. It specifies the time, in seconds, to stay in the standby mode. Maximum value 2^32-1.

Response to set format:

`$PTNLRRT,a*hh<CR><LF>`

Field	Description
a	Status (A - success; V - failure)

VR - Version Information and Production Configuration

This message allows querying versions of various product components. Not all component versions can be queried. Refer to a particular product's specification or software design document for a list of supported components for which version information can be queried.

This message also allows to program and report production configuration data such as the device serial number, production date, etc. Only Trimble-internal software tools support setting the data.

Query format:

`$PTNLQVR,a*hh<CR><LF>`

Field	Description
a	Component ID for which to query the version: S - system (application firmware) version H - hardware version N - GPS / navigation software version P - production configuration data

Response to query format for all components other than the hardware (H) or production configuration (P):

`$PTNLRVR,a,a..a,a…a,xx,xx,xxxx*hh<CR><LF>`

Field	Description
a	Component ID (same as in Query format)
a..a	Component name (variable length character string)
a…a	Version number in the format xx.yy.zz where xx - major version number (2 digits, pre-pend 0 if the number is less than 10) yy - minor version number (2 digits, pre-pend 0 if the number is less than 10) zz - build version number (2 digits, pre-pend 0 if the number is less than 10) ***Note –*** *There must be a period character separating the major/minor and minor/build numbers.*
xx	Month (1-12)
xx	Day (1-31)
xxxx	Year

Response to query format for the hardware version (H):

`$PTNLRVR,H,xxxx,a..a,xxxxxxxx,xx,xx,xxxx,xx*hh<CR><LF>`

Field	Description
xxxx	Hardware code
a..a	Hardware ID (variable length character string)
xxxxxxxx	Serial number
xx	Build month (1-12)
xx	Build day (1-31)
xxxx	Build year
xx	Build hour (0-23)

Response to query format for the production configuration data:

`$PTNLaVR,P,hhhh,x,hh,xxxxxxxx,yymmdd,hhmmss,a…a,a…a,x.x*hh<CR><LF>`

Field	Description
a	Mode (R = response)
hhhh	Programming password (hex value A5A5). Note: this field is relevant only when setting the data. For a response, this field is a blank, NULL field.
x	Mode (1 = program data; 2 = erase data; 3 = restore ROM default values). Note: this field is relevant only when setting the data. For a response, this field reports 0.
hh	Programming switch. This is a bit-wise hex value. Note: this field is relevant only when setting the data. For a response, this field reports 0. Bit 0 - if set, program the serial number, build date, part number, and hardware ID Bit 1 - if set, program the TCXO offset
xxxxxxxxxx	Serial number (10 digits)
yymmdd	Date of the board build (year/month/day)
hhmmss	Time of the board build (hour/min/sec)
a..a	Product part number; format: XXXXX-XX
a..a	Hardware ID (variable length character string)
x.x	Board's TCXO offset. Units: ppb.

Response to set format:

`$PTNLRVR,P,a*hh<CR><LF>`

Field	Description
a	Status (A - success; V - failure)