

Application Note

Antenna Integration: Resolution SMT™ GG & Resolution SMT™x

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For use with:

Resolution SMT™ GG Timing Module (P/N 89999-XX)

Resolution SMT™x Timing Module (P/N 99889-XX)

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Overview

This application note describes the recommended antenna feed circuit for Trimble's Resolution SMT™ GG multi-GNSS and Resolution SMT™x GPS Timing Modules.

The purpose of this application note is to help system developers to better understand the function of Trimble's recommended circuit and to provide guidance for successful integration of Trimble's embedded Timing modules into host-systems.

For more information about Resolution SMT™ GG and Resolution SMT™x and their derivatives on carrier cards, please consult the user guides of these products, which can be found on <http://www.trimble.com/timing/>.

1. Antenna requirements

Resolution SMT™ GG and Resolution SMT™x require an active GPS/GNSS antenna with built-in Low-Noise Amplifier (LNA) for optimal performance. The antenna LNA amplifies the received satellite signals for two purposes:

- a) Compensation of losses on the cable
- b) Lifting the signal amplitude in the suitable range for the receiver frontend.

Task b) requires an amplification of at least 20dB, while 22dB is the optimum for Resolution SMT™ timing modules. This would be the required LNA gain if the antenna was directly attached to the receiver without cable in-between.

Cable and connector between the antenna and the receiver cause loss. The overhead over the minimum required 22dB and the actual LNA gain of the antenna is available for task a). So in case of a 30dB LNA gain in the antenna, 8dB are available for compensating losses.

Or in other words, the attenuation of all elements (cables and connectors) between the antenna and the receiver can be up to a total of 8dB with a 30dB LNA. With a different antenna type, just take the difference between 22dB and the antennas LNA gain as the available compensation capability.

Now you can just subtract the insertion losses of all connectors from the 8dB (or whatever the number is) and the remainder is the maximum loss, which your cable must not exceed.

As the GPS signal is hidden in the thermal noise floor, it is very important that the antenna LNA doesn't add more noise than necessary to the system. Therefore, a low noise figure is even more important than the absolute amplification.

For system design verification, we recommend to compare the C/No values of your installation to those of Trimble's starter kit with Trimble antenna. The average C/No values should be at a similar level, within a few dB-Hz tolerances, if everything is fine.

We do not recommend having more than 35dB remaining gain (LNA gain minus all cable and connector losses) at the antenna input of the receiver module. The recommended range of remaining LNA-gain at the connector of the receiver module is 22dB to 30dB with a minimum of 20dB and a maximum of 35dB.

In steady state, 5V (3V) at the antenna connector causes a current through R1 and R2 into the base of Q2, thus causing a current through R4 and the base of Q1, which opens Q1 and powers the antenna.

In case of excessive current draw, the voltage drop across R3 and Q1 will increase, thus lowering the voltage at the connection between R1 and R3, which reduces the base current into Q2, which reduces the base current of Q1 which lowers (limits) the collector current of Q1.

At startup, or after a short-circuit condition at the antenna connector, there's no base current of Q1, so that it gets closed and no voltage is present at R1 which could open Q2 in order to switch on Q1. The SHORT pin of U1 is used as a 'starter' by configuring it as output with high-level in order to initially open Q2 and thereby Q1. This involves a software method to initialize the antenna power, before reconfiguring the SHORT pin as input for monitoring.

The SHORT pin is bidirectional. Following a short-circuit condition the SHORT pin is driven high for approximately 25 microseconds in every second to turn the antenna power circuit back on. It is always pulsed on startup in order to initialize the antenna supply.

Due to boot-up processes, there can be 5 to 10 seconds delay between power-on of the Resolution SMT module and the initialization of the antenna feed circuit. This delay is typically only seen if a load is connected to the antenna connector. Without load, V_{ANT} usually raises without delay due to parasitic currents.

Q3 and Q4 form a current mirror that detects the voltage drop across the current sensing resistor R3. Very low or no voltage drop across R3 indicates too low current through R3. In this condition, high-level will be present at the OPEN pin, indicating that no or not enough supply current is consumed by the antenna.

3. *Antenna supply current*

The antenna monitoring circuit for OPEN/SHORT detection causes a voltage drop between supply voltage input and antenna feed output. This circuit is basically a current monitor. Voltage drops occur on transistor Q1 (current limiter to protect against short circuit condition) and on the current sensing resistor R3.

If you are using antennas with high current consumption, the voltage drop across the sensing resistor will increase and the supply voltage at the RF-connector may drop too low to provide sufficient power to the antenna LNA. In that case, Trimble recommends using either antennas with lower operating current (preferred), or antennas with wider supply voltage range.

Antenna Voltage Feed Conditions:

+3.3V:

Open: Below the 4mA to 2mA range

Short Alarm: Approx. 80 mA

Current Limiting: Above 120mA

+5.0V:

Open: Below the 8mA to 4mA

Short: Above 150mA

Current Limiting: Above 190mA

The current limiting of Trimble timing modules may begin above 120mA up to approx. 190mA in a full short-circuit condition, but it's not a sharp cut-off. You will see an increasing drop of the supply voltage that goes up with the supply current. These values are dependent on the component tolerances and operating temperature and are therefore only rough numbers and not very precise.

The antenna power input is only specified up to 5.5V (55mA). The reason for the 55mA upper limit is basically the voltage drop. Exceeding 55mA will not damage the receiver, but the antenna supply might be insufficient. The 5.5V limit should, however, not be exceeded, because the open/short signals are routed to the processor, and higher voltage at those points may cause damage to the receiver due to electrical overstress.

4. Power-sequencing

Ideally, VCC_{ANT} and VCC are both switched On and Off at the same time. In most designs, they are tied together - special sequencing is not required.

Removing VCC_{ANT} while VCC is On doesn't pose a problem; it just un-powers an active antenna and will raise the SHORT indicator in the TSIP messages, but that doesn't affect the receiver's operation, except that no more satellites are being tracked with an unpowered antenna. As soon as VCC_{ANT} is applied again, the receiver will resume normal operation and tracking and the SHORT alarm will be removed.

VCC_{ANT} without VCC will not back-power Resolution SMT modules because the Open and Short signals have both a 10K inline resistor to the I/O-pins. However, that is an undefined condition and Trimble doesn't recommend powering VCC_{ANT} without VCC in order to avoid any latch-up condition or other unexpected effects.

5. Supply voltage control

Power cycling of the module requires the use of tri-state gates at all signal lines during power-down. No input should be driven during power-down. The board may not start up as expected if pins are driven before supply voltage is switched-on. If VCC is switched off, VCC_{ANT} shall also be switched off in order to prevent undefined conditions.

Ideally, you should use a separate low-noise linear voltage regulator for Resolution SMT supply (VCC and VCC_{ANT}). Current limiting is not required. VCC_{ANT} will be limited automatically by the antenna short protection circuit.

6. Advanced antenna feed circuits

Alternatively to Trimble's proven and recommended circuit, customers can also design their own antenna feed circuit if different antenna circuit limitations are desired.

In case of more advanced requirements on the current supply capability, lower dropout voltage, tighter threshold control, etc., refer to specialized, integrated circuits for active antenna supply, such as the

- Linear Technology LT3050 <http://www.linear.com/product/LT3050>
- Zetex ZX1030 www.diodes.com/_files/design_note_pdfs/zetex/dn88.pdf
- Maxim MAX16913 <http://www.maximintegrated.com/datasheet/index.mvp/id/6250>.

Trimble has not tested circuits with these components, nor do we prefer or recommend certain components or vendors. We are just providing the information as design ideas.

Note: *If the OPEN and SHORT pins are left floating, the unit reports an antenna open condition. To avoid this, pull SHORT high with a 10 K Ω resistor and pull OPEN low. Refer to the User Guide for more details on the function of these pins, especially regarding the 'Antenna Detect Truth Table'.*

7. Surge protection

The 19x19 mm SMT modules have built-in ESD protections on all pins, including the RF-input pin. However, additional surge protection may be required if rooftop antennas are being connected, in order to meet the regulations and standards for lightning protection in the countries where the end-product will be installed.

Lightning protection means actually a protection of people and buildings. If the antenna is hit by a direct lightning strike, your least worry should be damage of the GPS receiver. You should worry about the lightning energy, which can enter the building and directly strike a person or cause fire. A lightning protection shall be mounted at the place where the antenna cable enters the building. The primary lightning protection must be capable of conducting all potentially dangerous electrical energy to PE (Protective Earth). In case of a rooftop antenna, a coax-cable insert is needed. Trimble doesn't sell these, but there are many companies, which do. The antenna on the roof can't be protected against a direct lightning strike. It will just melt if hit by a direct lightning strike.

Rooftop antenna should be installed by experienced electricians, who are familiar with the local regulations and standards. Not following these regulations may lead to legal actions and rejection of insurance coverage in case of damage from lightning.

Without recommending or preferring a particular vendor of lightning protectors, we'd like to mention this website, as one example of a vendor:

<http://www.protectiongroup.com/Surge/RF-Lightning-Protection/Type/DC-Pass-Lightning-Protection>

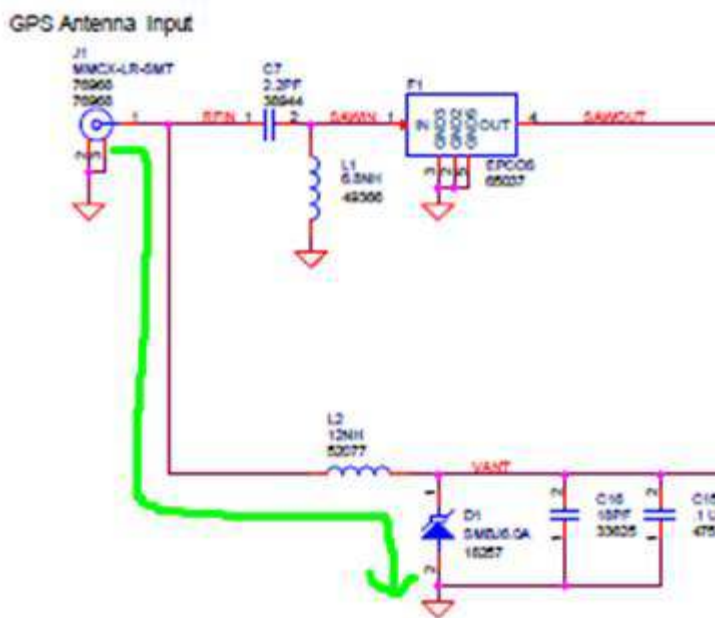
They have a wide variety of surge arrestors, including low-voltage types. Make sure to choose one with DC-pass and suitable for the GPS frequency range (1.575GHz) with low attenuation. Trimble customers have successfully used type DGXZ+06NFNF-A. Certainly, there are other vendors of such products in the market, therefore please understand this is just an example.

Trimble recommend using a first-level fast lightning protector that has 15V and 20V clamping voltage. We have seen RF front-end damage if our receivers were used with slow 90V surge arrestors. Damage will occur if the surge energy exceeds the power dissipation of the TVS diode on the board. Using the lower voltage surge arrestor with a faster response reduces the risk of damage after surges.

8. GND-System

There is a common ground plane on the Resolution SMT™ carrier board. RF-GND and ‘rest-of-the-board’-GND are connected, including the GND vias around the mounting holes and the coax-connector metal frame, which is also the GND return path and shield of the antenna cable.

The Resolution SMTx on Carrier Card is surge-protected with a TVS diode, as shown on the schematic diagram below. D1 is a 6.0V TVS diode with a peak pulse power dissipation of 600W (10/1000µs). The green line indicates the current path of a surge on the antenna center wire. A surge on the antenna shield will directly go to common GND at the coax connector of Resolution SMTx Carrier Card.



This circuit provides second-level surge protection, but it does not provide primary surge protection against lightning. In order to arrest higher energy from lightning, a coax surge arrester is required, and it has to be placed at the point where the antenna cable enters the building, according to local installation regulations for rooftop antennas in the country where the antenna is installed.

9. Antenna Placement

9.1 Sky-Visibility

GPS signals can only be received on a direct line of sight between antenna and satellite. The antenna should see as much as possible from the total sky. Seen from the northern hemisphere of the earth, more satellites will be visible in the southern direction rather than in northern direction. The antenna should therefore have open view to the southern sky. If there are obstacles at the place of installation, the antenna should be placed south of the obstacles, preferably, in order not to block sky-view to the south.

If the place of installation is in the southern hemisphere of the earth, then things are vice-versa – more satellites will be visible in the northern direction. Near to the equator, it doesn't matter.

Partial sky visibility causes often poor DOP values due to the geometry of the visible satellites in the sky. If the receiver can only see a small area of the sky, the DOP has a high degree of uncertainty and will be worse compared to a condition with better geometrical distribution. It may happen that a receiver is seeing 6 satellites, all close together, and still get a much worse DOP than a receiver which sees 4 satellites, but all in different corners of the sky. The receiver's DOP filter rejects fixes with high DOP (high uncertainty), therefore it can take long to get the first acceptable fix if sky visibility is partly obstructed.

9.2 Multipath-reflections

GPS signals can be reflected by objects, where metal, walls and shielded glass parts are pretty good reflectors. The antenna should not be placed near a wall, window or other large vertical objects.

9.3 Jamming

This is when the receiver function is disturbed by external RF sources that interfere with GPS or saturate the LNA or receiver front-end. A quite good indicator to detect jamming is switching off all other equipment except the GPS. Watch the satellite signal levels in this condition. Then switch on other equipment and see if the signal levels go down. A drop of signal levels indicates interference of GPS with other equipment. This method can, however, not detect all possible kinds of jamming. Spurious events are hard to catch. Low frequency fields, like 50Hz, are unlikely to jam the receiver. Broadband sparks are a potential source of spurious jamming. It is not possible to standardize a test scenario because the effect of jamming is highly depends on the nature of the jamming signal.

9.4 Ground-Plane

A big metal plate under the receiver can block signals (reflections) from below. This is a good method to improve the robustness against reflections, if the receiver is mounted on high masts or other elevated places.



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