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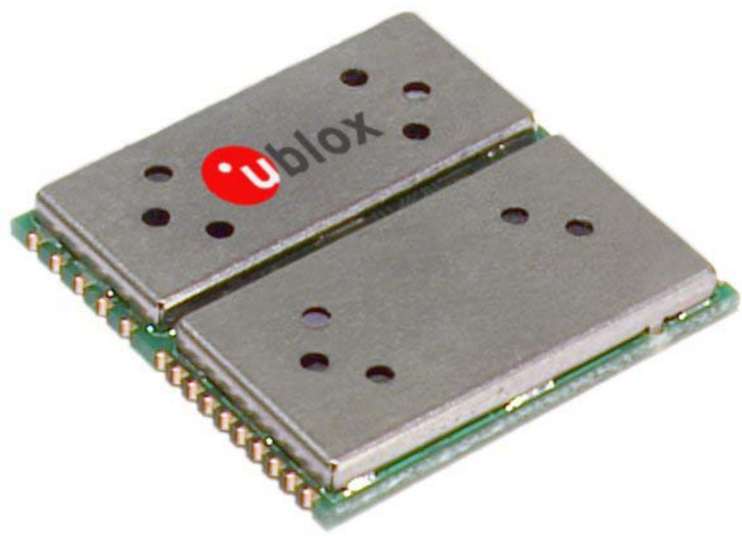
TIM-LC, TIM-LF, TIM-LP System Integration

Manual



Abstract

This document describes the features and specifications of the TIM-LC, TIM-LF and TIM-LP ultra-low power GPS receiver macro-components. It guides through a design in of TIM-LC, TIM-LF and TIM-LP and provides knowledge to get maximum GPS performance at very low power consumption.

This manual applies to ANTARIS® GPS receiver with Firmware Version 3.0 or higher.

your position is our focus

Manual

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A	21/01/2004	Thomas Christen	Update for FW Version 3.00
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Initial Version	17/06.2002	Thomas Christen	

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Contents

1 Preface

The TIM-LC, TIM-LF and TIM-LF System Integration Manual provides the necessary information to successfully design in and configure these ANTARIS® based GPS receivers. The chapter below shall help you to navigate this manual and to find the information you are looking for as quickly as possible.

1.1 How to use this Manual

This manual has a modular structure. It is not necessary to read from the beginning to the end. Skip section 2, if you are already familiar with GPS, but in any case read the Receiver Description in Section 4 carefully. It not only provides an overview about the features and benefits of the ANTARIS® GPS technology but also contains the necessary information required to fully exploit the benefits of this powerful GPS technology.

In order to help you finding the information you need, we provide a brief section overview. You will find the table of contents at the beginning and the index (page 150) as well as the list of figures (page 152) and the list of tables (page 154) at the end of this document.

1. Preface

   This chapter gives an overview over the document and some helpful contact information.

2. GPS Fundamentals

   This chapter provides an overview over the GPS system and functionality. There is very useful information about the different antenna types available on the market and how to reduce interference in your design containing a GPS receiver.

3. System Considerations

   This chapter tells what to consider when designing an application (e.g. antenna, power consumption, accuracy etc.) and which product would fit to your application.

4. Receiver Description

   This chapter describes the functionality of the ANTARIS® GPS Technology for navigation and positioning.

5. Schematic Overview

   This chapter describes how to connect and implement an ANTARIS® GPS receiver in a user application. It holds a minimal configuration schematic as well as one using optional functions.

6. Layout Considerations

   This chapter gives helpful information for the PCB Board design and RF-considerations including a reference layout.

7. Product Handling

   This chapter defines packaging, handling, shipment, storage and soldering.

8. Product Testing

   This chapter provides information about testing of OEM receivers in production.

9. PC Support Tools

   This chapter describes our very valuable PC support tools and how to install and use them.

10. Troubleshooting

    This chapter gives useful hints, when your system is not running as expected.

If you have any questions about the u-blox GPS system integration, please:

- Read this manual carefully.
- Refer to the Trouble-Shooting *Section 10 or Index* on page 150.
- Contact our information service on the homepage http://www.u-blox.com
- Read the questions and answers on our FAQ database on the homepage http://www.u-blox.com

u-blox Glossary and Abbreviations

Every technology has it's own language. To assure a precise terminology we provide a general GPS dictionary [7] on our website. Feel free to download this information for a better understanding of our documents.

1.2 Technical Support

Worldwide Web

Our website (http://www.u-blox.com) is a rich pool of information. Product information, technical documents and helpful FAQ can be accessed 24h a day.

By E-mail

If you have technical problems or cannot find the required information in the provided documents, contact the nearest of the Technical Support offices by email. Use our service pool email addresses rather than any personal email address of our staff. This makes sure that your request is processed as soon as possible. You will find the contact details at the end of the document.

By Phone

If an email contact is not the right choice to solve your problem or does not clearly answer your questions, call the nearest Technical Support office for assistance. You will find the contact details at the end of the document.

Helpful Information when Contacting Technical Support

If you contact Technical Support please prepare the following information. We may need some of this information to serve you:

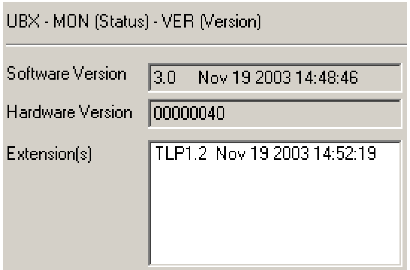
Information Type		Example Description	
GPS Receiver	Type	Macro component	Macro component, Receiver board, Smart antenna, antenna, evaluation box, development platform
	Product	TIM-LP	Or GPS-MS1E, TIM, TIM-CS, TIM-CL, TIM-CJ, TIM-LF, TIM-LC, SBR-LS
	Serial No of Product	1234567	
	Data Code	pppppv.hhff.xxx.nnnnnnn	231000.1000.00
PC	System	OS	Win98, W2k, XP, others
Software		Version	
Antenna	Type	Placement	Near, window, roof, N/S/E/W direction, available sky view
		Distribution	
Additional	Hardware	Description	
		Connection	
Failure	Type	Description	
		Picture	
Log	Files	Enable	All INF Messages
		Enable	All MON Messages
Screenshots	Files	Debugger	
		u-center	
		Others	
Other	Information	Description	
		Picture	
Contact	Information	Your E-mail	Name, address, telephone number

Table 1: Helpful information when contacting technical support

2 GPS Fundamentals

2.1 Theory of operation

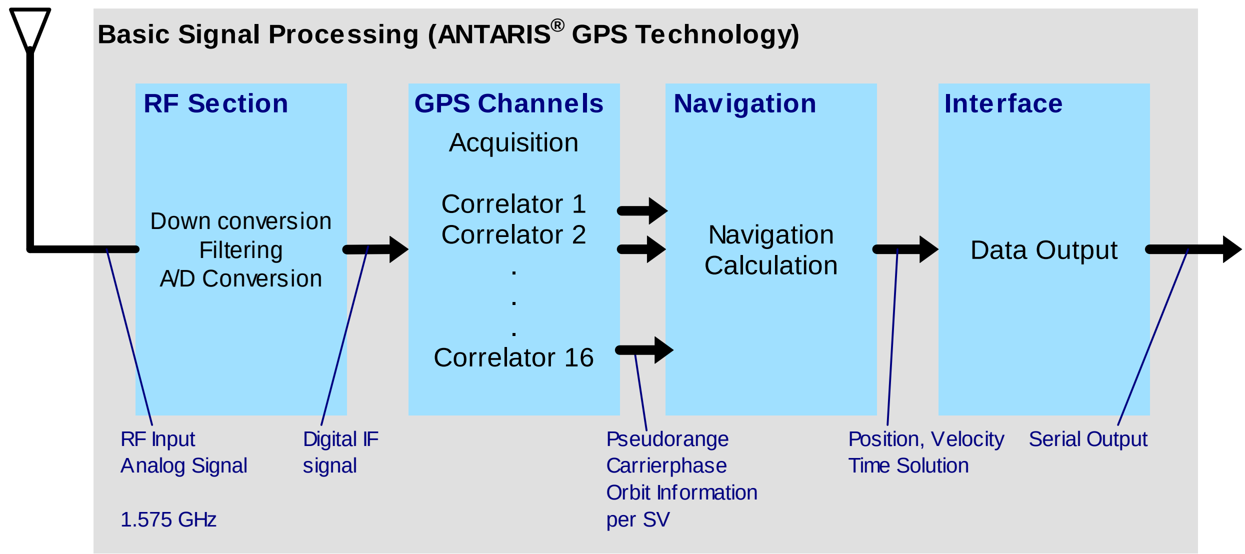


Figure 1: Basic Signal Processing

The ANTARIS® GPS macro component receiver is a L1 Frequency (C/A Code) GPS receiver and performs the entire GPS signal processing, from antenna input to serial position data output.

The processing steps involved are:

1. RF Section

   In the RF Section the GPS signal detected by the antenna is amplified, filtered and converted to an intermediate frequency (IF). An A/D converter changes the analog intermediate frequency into a digital IF signal.

2. GPS Channels

   The digital IF signal bit stream is passed to the baseband section, where it is fed into the correlators. It is the function of the correlators to acquire and track the satellite signals. There are 16 channels used in parallel, with each correlator looking for a characteristic PRN code sequence in the bit stream. Once the correlator has a valid signal, Pseudorange, Carrier Phase and Orbit Information can be extracted from the GPS signal.

3. Navigation

   The on-board processor is running an algorithm that calculates the position, velocity and time. This calculation is called the navigation solution. Once the navigation solution is calculated, it can be transformed into the desired coordinate system, e.g. Latitude/ Longitude/ Altitude.

4. Interface

   The data of the navigation solution is available at the serial RS232 interface.

2.2 Basic Operation Cycle

When the receiver is powered up, it steps trough a sequence of states until it can initially determine position, velocity and time. Afterwards, the satellite signals are tracked continuously and the position is calculated periodically.

This process is depicted below:

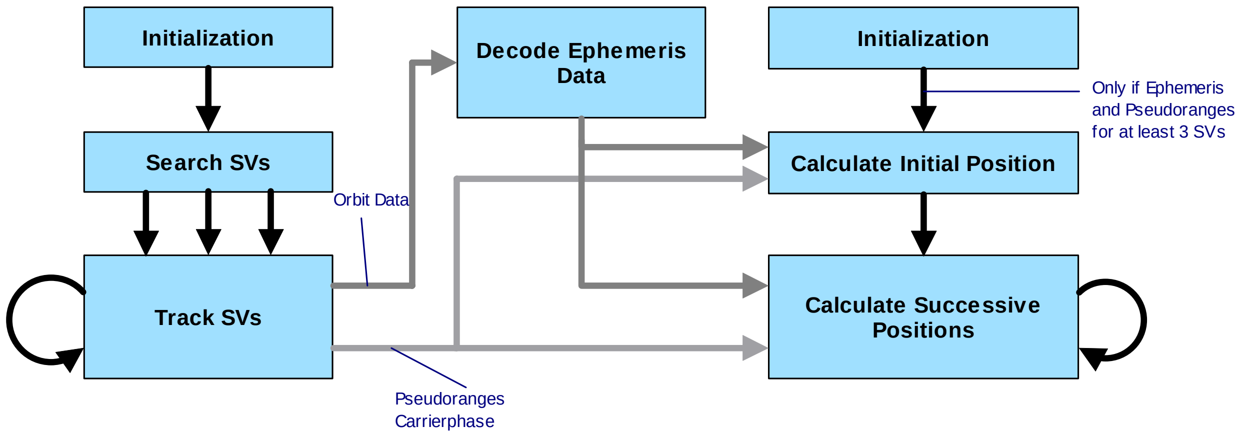


Figure 2: Basic Operation Cycle

In order to perform a navigation solution (3D solution), the receiver needs

- Distances (Pseudo Ranges) for at least 4 SVs (Space Vehicles)
- Ephemeris Data for the SVs it will use in the navigation solution.

! NOTE If almanac navigation is enabled, the receiver can calculate a position without downloading ephemeris data (with a significant position error compared to an ephemeris based solution).

The initial position calculation is made using a Least-Squares Algorithm. Successive position calculations are performed with a Kalman Filter. To generate a Position (3D solution) Calculation the receiver needs at least 4 measurements to different satellites, to calculate a position (Lat/Long/Height), for a 2D solution with an estimated altitude 3 different satellites are required.

Pseudo Range and Carrier Phase information is available to the Position Determination Algorithms if the receiver has found a SV (Acquisition) and can track the signal thereafter.

Ephemeris data for a SV can be decoded from Orbit Data once the GPS signal has been acquired. Each SV transmits its own ephemeris data, the broadcast lasts for 18 seconds, repeating every 30 seconds.

The receiver stores ephemeris data in battery-backed memory. This data is valid for 2 hours and can be used in future startup's to improve the time to first fix (TTFF). Ephemeris can also be supplied to the receiver via the serial port.

2.3 Start-Up

Depending on the receiver's knowledge of last position, current time and ephemeris Data, the receiver will apply different strategies to start-up, namely:

Coldstart

In Coldstart, the receiver has no knowledge of its last position or time. This is the case when the RTC has not been running; no valid ephemeris data or almanac data is available (This is the case if the receiver has never been navigating or the battery backup memory is lost).

Warmstart

Warmstart is performed whenever the receiver has only access to valid almanac data, and has not significantly moved since the last valid position calculation. This is typically the case, if the receiver has been shut off for more than 2 hours, but still has knowledge of last position, time and almanac. This allows it to predict the current visible SVs. However, since ephemeris data is not available or outdated, the receiver needs to wait for the ephemeris broadcast to complete.

Hotstart

Hotstart is performed whenever the receiver still has access to valid ephemeris data and precise time. This is typically the case if the receiver has been shut off for less than 2 hours and the RTC has been running during that time. Furthermore, during the previous session, the receiver must have been navigating (to allow it to decode and store ephemeris data).

In Hotstart, the receiver can predict the currently visible SVs, and is therefore able to quickly acquire and track the signal. Because ephemeris is already known, there is no need to wait for the ephemeris broadcast to complete.

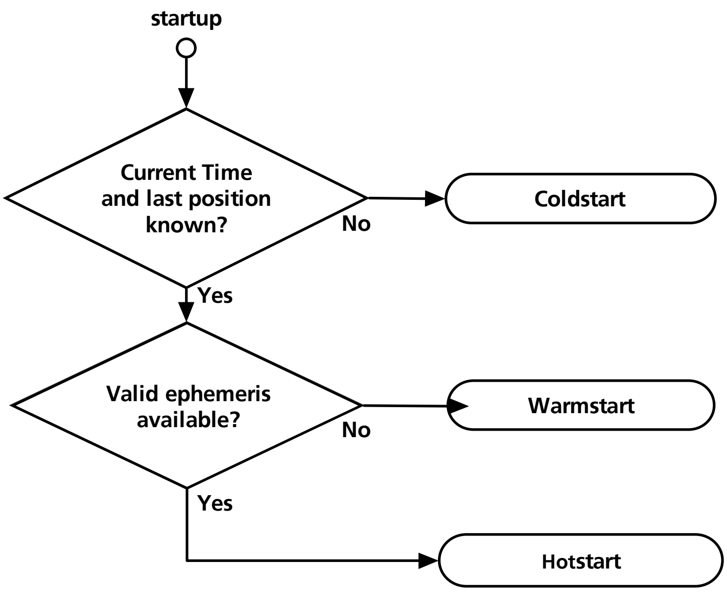


Figure 3: Decision Tree on Startup Mode

If external aiding information like ephemeris and/or precise position and time are provided to the receiver, the Time To First Fix may significantly be improved. Refer to *section 4.4.4* for further information.

2.4 Consideration on GPS Performance

GPS works with weak signals. The signal strength on earth is approximately 15dB below the thermal noise floor. In order to design a reliable GPS enabled system, the following parameters have to be considered carefully during the design phase as they may significantly degrade the GPS performance.

1. Antenna shortcomings
    - Poor gain of the GPS antenna
    - Poor directivity (radiation pattern) of the GPS antenna
    - Improper orientation of the antenna to the sky
    - Poor matching between antenna and cable impedance
    - Poor noise performance of the receivers input stage or the antenna amplifier

2. Electrical Environment
    - Jamming from external signals
    - Jamming from signals generated by the receiver itself
3. GPS related effects
    - Signal path obstruction by buildings, foliage, covers, snow, etc.
    - Multi-path effects
    - Satellite constellation and geometry

The antenna related issues from above list will be further discussed in *Section 2.5*. Jamming and interference issues will be extensively discussed in *Section 2.6*.

2.4.1 Dilution of Precision (DOP)

The Dilution of Precision (DOP) is a unitless value that indicates when the satellite geometry provides the most accurate results. It is the mathematical representation of the quality of the navigation solution, based on the geometry of the satellites used in the calculation. The number of visible satellites and their relative positions in the sky mainly control DOP. Satellites spread over the sky give better results (lower DOP).

The most commonly used DOP is position dilution of precision (PDOP), which is the combination of horizontal dilution of precision (HDOP) and vertical dilution of precision (VDOP). A PDOP value of 1 indicates an optimum satellite constellation and high-quality data. The quality of the data decreases as the PDOP value increases. PDOP values in excess of 8 are considered poor.

! **Note** A point calculated with a PDOP of 30.0 may be off by more than 150 m from its true location.

Examples of DOP values:

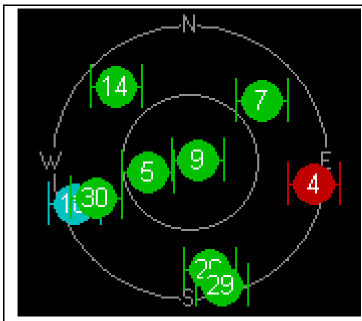
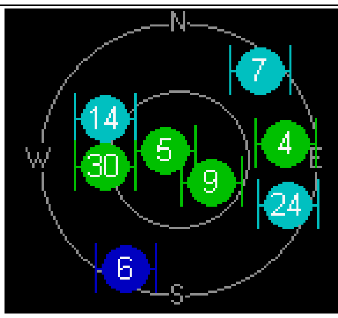
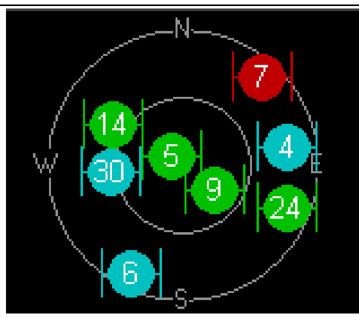
 PDOP: 1.7 DOP value is ok for good GPS performance	 PDOP: 4.3 DOP value is acceptable for a good GPS performance	 PDOP: 12.6 DOP too high (all the satellites are in a straight line), this will degrade the GPS performance

Figure 4: Examples of DOP values

2.4.2 Multipath

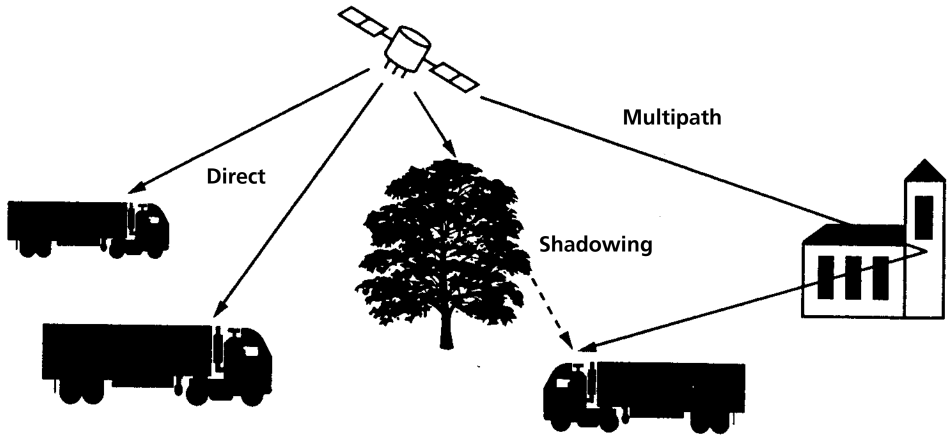


Figure 5: A multi-path environment

A multi-path environment exists if GPS signals arrive at the antenna directly from the satellite, (line of sight, LOS) and also from reflective surfaces, e.g. water or building walls. If there is a direct path in addition to the reflected path available, the receiver can usually detect the situation and compensate to some extent. If there is no direct line of sight, but only reflections, the receiver is not able to detect the situation. Under these multipath conditions the range measurement to the satellite will provide incorrect information to the navigation solution, resulting in less accurate position. If there are only few satellites in sight, the navigation solution might be wrong by several 100's m.

If there is a LOS available, the effect of multi-path is actually twofold. First, the correlation peak will be distorted which results in a less precise position. This effect can be compensated for by advanced receiver technology as the ANTARIS® technology patented multipath mitigation scheme. The second effect relates to the carrier phase relation of the direct and reflected signal, the received signal strength is subject to an interference effect. The two signals may cancel out each other (out of phase) or add onto each other (in phase). Even if the receiver remains stationary, the motion of the satellite will change the phase relation between direct and reflected signal, resulting in a periodic modulation of the C/N_0 measured by the receiver.

The receiver cannot compensate for the second effect, because the signals cancel out at the antenna, not inside the GPS unit. However, as the reflected signal is usually much weaker than the direct signal, the two signals will not cancel out completely. The reflected signal will also have an inverted polarity (left hand circular rather than right hand circular), further reducing the signal level, particularly if the antenna has good polarization selectivity.

Water is a very good reflector; so all sea borne applications require special attention to reflected signals arriving at the antenna from the underside, i.e. the water surface. Also, location of the antenna close to vertical metal surfaces can be very harmful since metal is an almost perfect reflector. When mounting an antenna on top of a reflective surface, the antenna should be mounted as close to the surface as possible. Then, the reflective surface will act as an extension of the antennas ground plane and not as a source of multi-path.

2.5 Antennas

Even the best receiver cannot bring back what has been lost at the antenna. The attention paid to this part of a GPS system cannot be stated highly enough.

2.5.1 Selecting the right Antenna

Several different antenna designs are available within the market of GPS applications. The GPS signal is right-hand circular polarized (RHCP). This results in a style of antenna that is different from the well-known whip antennas used for linear polarized signals. The most prominent antenna designs for GPS are the patch antenna as shown in *Figure 6*.

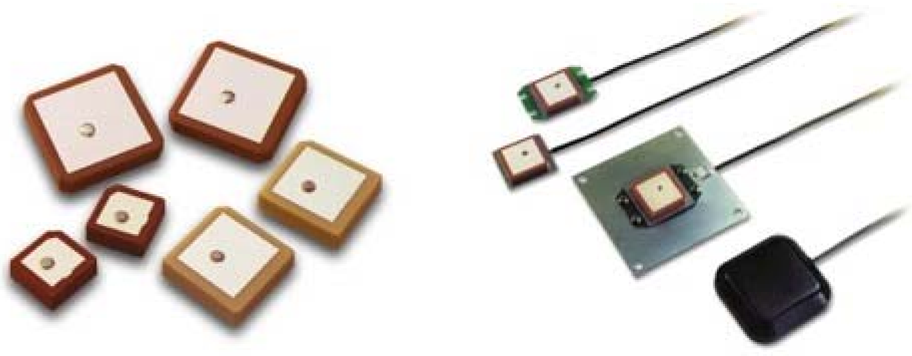


Figure 6: Patch Antennas, EMTAC Technology Corp.

Another style is the quadrifilar helix antenna shown in *Figure 7*. The actual geometric size of both antenna designs depends on the dielectric that fills the space between the active parts of the antenna. If the antenna is only loaded with air it will be comparatively large, high dielectric constant ceramics result in a much smaller form factor. The smaller the dimensions of the antenna, the more performance critical tight manufacturing tolerances become. Furthermore, a smaller antenna will present a smaller aperture to collect the signal energy from sky resulting in a lower overall gain of the antenna. This is the result of pure physics and there is no "magic" to get around this problem. Amplifying the signal after the antenna will not improve the signal to noise ratio.

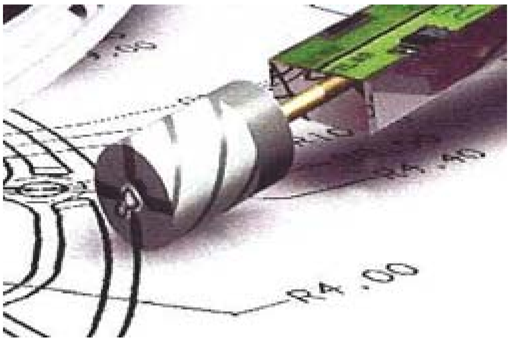


Figure 7: Quadrifilar Helix Antenna, Sarantel, Ltd.

In contrast to helix antennas, patch antennas require a ground plane for operation. Helix antennas can be designed for use with or without a ground plane.

For precision applications such as surveying or timing, some very high-end systems do exist. Common to these designs are large size, high power consumption and high price. These designs are highly optimized to suppress multi-path signals reflected from the ground (choke ring antennas, multi-path limiting antennas, MLA). Another area of optimization is accurate determination of the phase center of the antenna. For precision GPS applications with position resolution in the millimeter range it is important that signals from satellites at all elevations virtually meet at exactly the same point inside the antenna. For this type of application often receivers with multiple antenna inputs are required.

At the low end of the spectrum of possible antenna solutions - if the user is willing to accept significant signal losses - a simple linear polarized whip or strip antenna will work. Compared to a circular polarized antenna, a minimum of 3 dB of signal to noise ratio will be lost.

2.5.2 Active and Passive Antennas

Passive antennas contain only the radiating element, e.g. the ceramic patch or the helix structure. Sometimes they also contain a passive matching network to match the electrical connection to 50 Ohms impedance.

Active antennas have an integrated low-noise amplifier. This is beneficial in two respects. First, the losses of the cable do no longer affect the overall noise figure of the GPS receiver system. Secondly, even the receiver noise figure can be much higher without sacrificing performance. Therefore, some receivers will only work with active antennas. Active antennas need a power supply that will contribute to GPS system power consumption, typically in the region of 5 to 20 mA. Usually, the supply voltage is fed to the antenna through the coaxial RF cable. Inside the antenna, the DC component on the inner conductor will be separated from the RF signal and routed to the supply pin of the LNA.

The use of an active antenna is always advisable if the RF-cable length between receiver and antenna exceeds about 10 cm. Care should be taken that the gain of the LNA inside the antenna does not lead to an overload condition at the receiver. For receivers that also work with passive antennas an antenna LNA gain of 15 dB is usually sufficient, even for cable lengths up to 5 m. There's no need for the antenna LNA gain to exceed 26 dB for use with u-blox receivers. With shorter cables and a gain above 25 dB, an overload condition might occur on some receivers.

When comparing gain measures of active and passive antennas one has to keep in mind that the gain of an active antenna is composed of two components, the antenna gain of the passive radiator, given in dBic, and the LNA power gain given in dB. A low antenna gain cannot be compensated by high LNA gain. If a manufacturer provides one total gain figure, this is not sufficient to judge the quality of the antenna. One would need information on antenna gain (in dBic), amplifier gain, and amplifier noise figure.

2.5.3 Patch Antennas

Patch antennas are ideal for an application where the antenna sits on a flat surface, e.g. the roof of a car. Patch antennas can show a very high gain, especially if they are mounted on top of a large ground plane. Ceramic patch antennas are very popular because of the small size, typically measuring 25 x 25 mm^2 down to 12 x 12 mm^2. Very cheap construction might also use ordinary circuit board material like FR-4 or even air as dielectric, but this will result in a much larger size, typically in the order of some 10 x 10 cm^2. *Figure 8* shows a typical example of the radiation pattern of a 16 x 16 mm^2 ceramic patch antenna. This measurement only shows the upper sphere of the radiation pattern. Depending on ground plane size there will also be a prominent back lobe present.

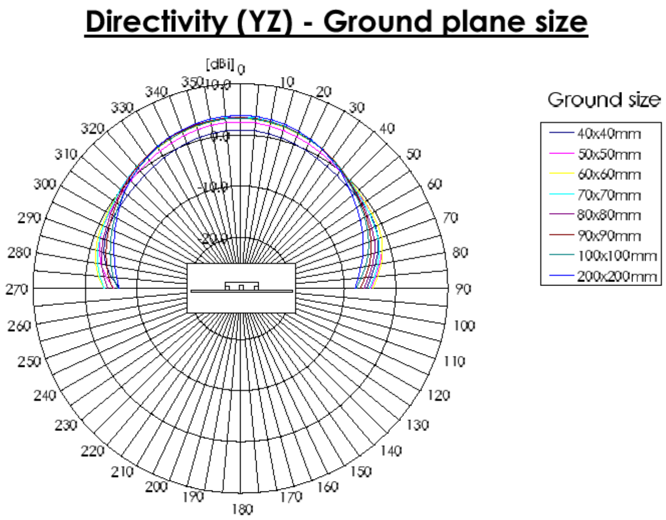


Figure 8: Typical Radiation Pattern of a Patch Antenna, MuRata, Inc.

One can easily see that the so-called axial ratio, i.e. the relation between maximum antenna gain at the zenith and gain at 90 degree can reach the order of 10 dB for large ground planes. Therefore, the correct dimensioning of the size of the ground plane is always a compromise between maximum gain at high elevations and reasonable gain even at low elevations.

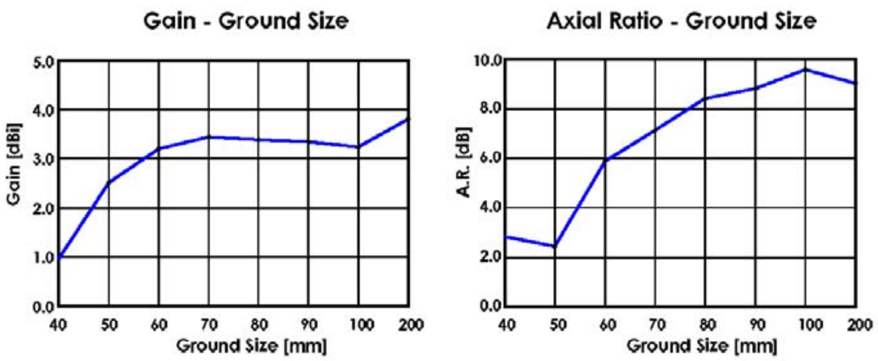


Figure 9: Typical Gain and Axial Ratio of a Patch antenna with respect to ground plane size, MuRata, Inc.

A good trade-off for the ground plane size is typically in the area of 50 to 70 mm square. This number is largely independent of the size of the patch itself (when considering ceramic patches). Patch antennas with small ground planes will also have a certain back-lobe in their radiation pattern, making them susceptible to radiation coming from the backside of the antenna, e.g. multi-path signals reflected off the ground. The larger the size of the ground plane, the less severe this effect becomes.

Smaller size patches will usually reach their maximum gain with a slightly smaller ground plane compared to a larger size patch. However, the maximum gain of a small sized patch with optimum ground plane may still be much lower than the gain of a large size patch on a less than optimal ground plane.

It is not only gain and axial ratio of the patch antenna that is affected by the size of the ground plane but also the matching of the antenna to the 50 Ohms impedance of the receiver. See *Section 2.5.6* for more information on matching.

2.5.4 Helix Antennas

Helix antennas can be designed for use with or without ground plane. For example, the radiating elements on board the GPS satellites do have a ground plane. Using an array of helix antennas, the GPS satellites can control the direction of the emitted beam. If a helix antenna is designed without ground plane it can be tuned such to show a more omni directional radiation pattern as shown in *Figure 10*.

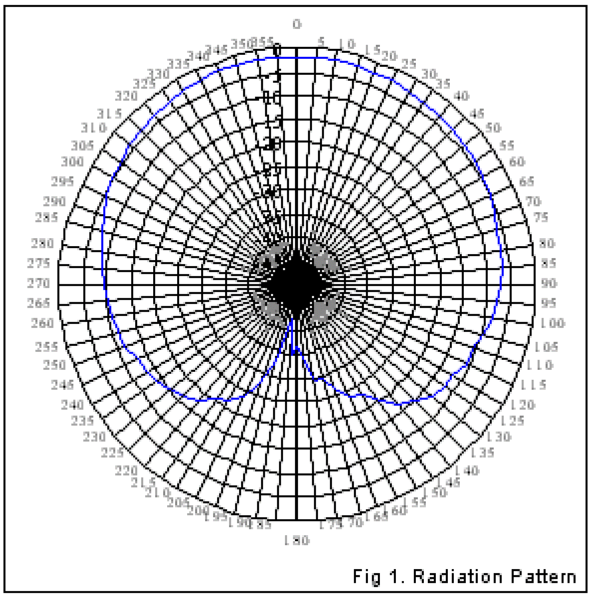


Figure 10: Radiation pattern of helix antenna without ground plane, Sarantel, Ltd.

Although we can determine an axial ratio close to 9 dB between zero degree and 90 degrees elevation, which compares to the patch antenna, the back lobe of the helix generally degrades much smoother and does not show any sensitivity at the –180 degree direction. In contrast, back lobe of the patch antenna depends very much on size and shape of the ground plane. As with patch antennas, filling the antenna with a high dielectric constant material can reduce the size of helix antennas. Sizes in the order of 18 mm length and 10 mm diameter are being offered to the market. Again, antenna gain will decrease with decreasing size of the antenna.

2.5.5 Helix or Patch, which selection is best?

For practical applications the possibilities of integrating a certain style of antenna into the actual device is of primary concern. Some designs naturally prefer the patch type of antenna, e.g. for rooftop applications. Others prefer the pole like style of the helix antenna, which is quite similar to the style of mobile phone antennas. Furthermore, it is important that the antennas main lobe points to the sky in order to receive as many satellites as possible with the maximum antenna gain. If the application is a hand held device, the antenna should be designed in a way that natural user operation results in optimum antenna orientation. The helix antenna seems to be more appropriate in this respect.

However, one has to keep in mind that comparable antenna gain requires comparable size of the antenna aperture, which will lead to a larger volume filled by a helix antenna in comparison to a patch antenna. Helix antennas with a "reasonable" size will therefore typically show a lower sensitivity compared to a "reasonably" sized patch antenna.

A helix antenna might result in a "more satellites on the screen" situation in difficult signal environments when directly compared with a patch antenna. This is due to the fact that the helix will more easily pick up reflected signals through its omni directional radiation pattern. However, the practical use of these signals is very limited because of the uncertain path of the reflected signals. Therefore, the receivers can see more satellites but the navigation solution will be degraded because of distorted range measurements in a multi-path environment.

If possible test the actual performance of different antenna types in a real life environment before starting the mechanical design of the GPS enabled product.

2.5.6 Antenna Matching

All common GPS antennas are designed for a 50 Ohms electrical load. Therefore, one should select a 50 Ohms cable to connect the antenna to the receiver. However, there are several circumstances under which the matching impedance of the antenna might shift considerably. Expressed in other words, this means that the antenna no longer presents a 50 Ohms source impedance. Typically what happens is that the center frequency of the antenna is shifted away from GPS frequency - usually towards lower frequencies – by some external influence. The reason for this effect are primarily disturbing objects in the near field of the antenna. This can either be a ground plane, which does not have the same size as the antenna was designed for, or it can be an enclosure with a different dielectric constant than air.

In order to analyze effects like this one would normally employ electrical field simulations, which will result in exact representation of the electric fields in the near field of the antenna. Furthermore, these distortions of the near field will also show their effect in the far field, changing the radiation pattern of the antenna. Unfortunately, there is no simple formula to calculate the frequency shift of a given antenna in a specified environment. So one has to go either for extensive simulation or do some experimental work. Usually, antenna manufacturers offer a selection of pre-tuned antennas, so the user can test and select the version that fits his environment best. However, equipment such as a scalar network analyzer is needed to verify the matching.

Again, it must be pointed out that the smaller the size of the antenna, the more sensitive it will be to distortions in the near field. Also the antenna bandwidth will decrease with decreasing antenna size, making it harder to achieve optimum tuning.

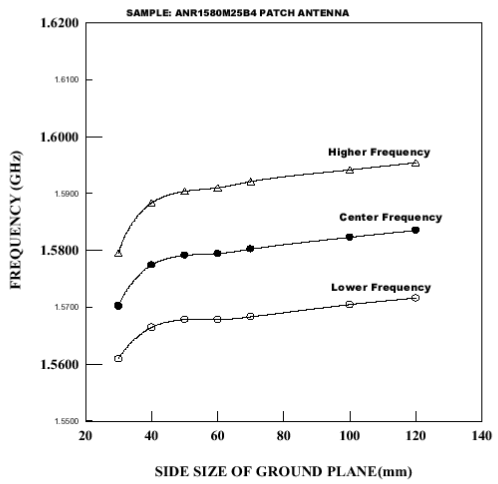


Figure 11: Dependency of center frequency on ground plane dimension for a 25 x 25 mm^2 patch, EMTAC

A LNA placed very close to the antenna can help to relax the matching requirements. If the interconnect length between antenna and LNA is much shorter than the wavelength (9.5 cm on FR-4), the matching losses become less important. Under these conditions the matching of the input to the LNA becomes more important. Within a reasonable mismatch range, integrated LNAs may show a decrease of their gain in the order of a few dBs versus an increase of noise figure in the order of some tenths of a dB. If your application requires a very small antenna, a LNA can help to match the hard to control impedance of the antenna to a 50 Ohms cable. This effect is even beneficial if the antenna cable between the antenna and the receiver is only short. In this case, there's no need for the gain of the LNA to exceed 10-15 dB. In this environment the sole purpose of the LNA is to provide impedance matching and not signal amplification.

2.5.7 Antenna Placement

The position of the antenna mounting is crucial for an optimal performance of the GPS receiver.

When using patch antennas, the antenna plane should be parallel to the geographic horizon. The antenna must have full view of the sky ensuring a direct line-of-sight with as many visible satellites as possible.

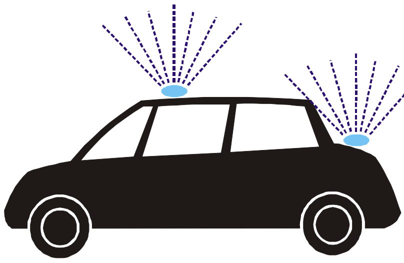
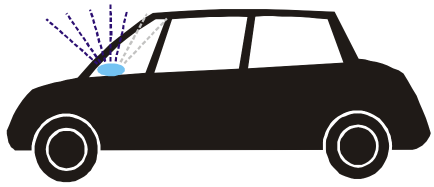
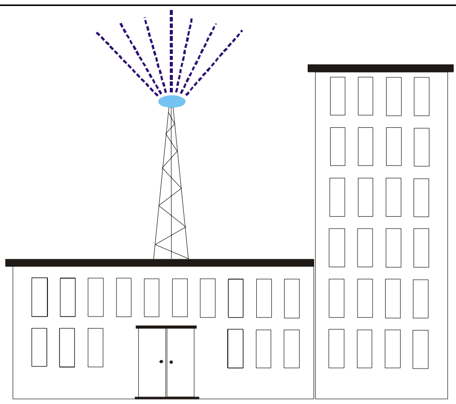
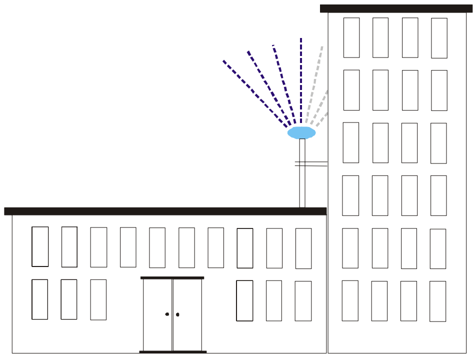
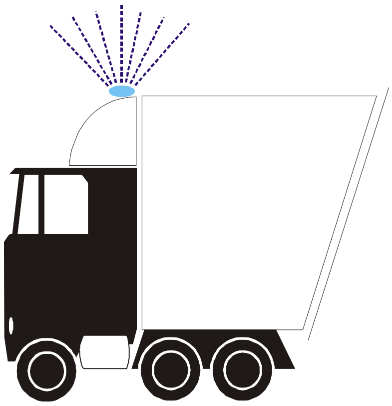
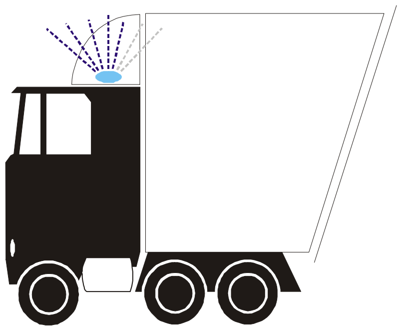
1st Choice Placement	**2nd Choice Placement**
Recommended Antenna positions	Performance may be degraded! If recommended placements are not available, these may also viable.
	 **Note:** Window and roof reduce GPS signal and obstruct sky view[1]
	 **Note:** There may be multipath signals and a obstructed sky view
	 **Note:** Fiberglass airfoil attenuates the GPS signal

Table 2: Optimal antenna placement

2.6 Interference Issues

A typical GPS receiver has a very low dynamic range. This is because the antenna should only see thermal noise in GPS frequency band, given that the peak power of the GPS signal is 15 dB below thermal noise floor. And, this thermal noise floor is usually very constant over time. Most receiver architectures use an automatic gain

[1] Some cars have a metallic coating on the windscreens. GPS reception may not be possible in such a car. There is usually a small section, typically behind the rear view mirror, spared for mobile phone and GPS antennas.

control (AGC) circuitry to automatically adjust to the input levels presented by different antenna and pre-amplifier combinations. The control range of these AGC's can be as large as 50 dB. However, the dynamic range for a jamming signal exceeding the thermal noise floor is typically only 6 to 12dB, due to the one or two bit quantization schemes commonly used in GPS receivers. If there are jamming signals present at the antenna and the levels of these signals exceed the thermal noise power, the AGC will regulate on the jamming signal, suppressing the GPS signal buried in thermal noise even further. Depending on the filter characteristics of the antenna and the front end of the GPS receiver, the sensitivity to such in-band jamming signals decreases more or less rapidly if the frequency of the jamming signal moves away from GPS signal frequency. We can conclude that a jamming signal exceeding thermal noise floor within a reasonable bandwidth, e.g. 100 MHz, around GPS signal frequency will degrade the performance significantly.

But, even out-of-band signals might affect GPS receiver performance. If these jamming signals are strong enough that even antenna and front-end filter attenuation are not sufficient, the AGC will still regulate on the jamming signal. Moreover, very high jamming signal levels can result in non-linear effects in the pre-amplifier stages of the receiver, resulting in desensitizing of the whole receiver. One such particular difficult scenario is the transmitting antenna of a DCS handset (max. 30 dBm at 1710 MHz) in close proximity to the GPS antenna. When integrating GPS with other RF transmitters special care is necessary.

If the particular application requires integration of the antenna with other digital systems, one should make sure that jamming signal levels are kept to an absolute minimum. Even harmonics of a CPU clock can reach as high as 1.5 GHz and still exceed thermal noise floor.

On the receiver side there's not much that can be done to relax the situation without significant effort. Of course, high price military receivers have integrated counter-measures against intentional jamming. But the methods employed are out of the scope of this note and might even conflict with export restrictions for dual-use goods.

This whole section contains a number of general recommendations and ideas. It is however totally dependent on the actual application if any of these concepts will apply.

In applications where an active antenna is used in a remote position, e.g. >1 m away from other electronics, interference should not be an issue.

! **Note** If antenna and electronics are to be integrated tightly, the following sections should be read very carefully.

2.6.1 Sources of Noise

Basically two sources of noise are responsible for most of the interference issues with GPS receivers:

1. Strong RF transmitters close to GPS frequency, e.g. DCS at 1710 MHz or radars at 1300 MHz.
2. Harmonics of the clock frequency emitted from digital circuitry.

The first problem can be very hard to solve, but if GPS and RF transmitter are to be integrated close to each other, there's also the engineer at hand who knows the specifications of the RF transmitter. In most cases, counter measures such as filters will be required on the transmitter side to limit its spurious emissions below noise floor in the vicinity of GPS frequency.

Even if the transmitter is quiet in the GPS band, a very strong emission close to GPS band can cause saturation in the front-end of the receiver. Typically, the receiver's front-end stage will reach its compression point, which will in turn increase the overall noise figure of the receiver. In that case, only special filtering between GPS antenna and receiver input will help to reduce signal levels to the region of linear operation of the front-end.

The second problem is more common but also proves to be hard to solve regularly. Here, the emitting source is not well specified and the emission can be of broadband nature, making specific countermeasures very difficult. Moreover, the GPS band is far beyond the 1 GHz limit that applies to almost all EMC regulations. So, even if a device is compliant with respect to EMC regulations it might disturb a GPS receiver severely.

If the GPS antenna is to be placed very close to some other electronics, e.g. the GPS receiver itself or a PDA-like appliance, the EMC issue has to be taken very seriously right from the concept phase of the design. It is one of the most demanding tasks in electrical engineering to design a system that is essentially free of measurable emissions in a certain frequency band.

2.6.2 Eliminating Digital Noise Sources

Digital noise is caused by short rise-times of digital signals. Data and address buses with rise-times in the nanosecond range will emit harmonics up to several GHz. The following sections contain some general hints on how to decrease the level of noise emitted from a digital circuit board that eventually sits close to the GPS receiver or the antenna.

2.6.2.1 Power and Ground Planes

Use solid planes for power and ground interconnect. This will typically result in a PCB with at least four layers but will also result in a much lower radiation. Solid ground planes ensure that there is a defined return path for the signals routed on the signal layer. This will reduce the "antenna" area of the radiating loop. Planes should be solid in a sense that there are no slots or large holes inside the plane.

The outer extent of the power plane should be within the extent of the ground plane. This avoids that the edges of the two planes form a slot antenna at the board edges. It's a good idea to have a ground frame on the circumference of every layer that is connected to the ground plane with as many vias as possible. If necessary, a shield can then be easily mounted on top of this frame (see *Figure 12*). Furthermore, free space on the outermost Layers can be filled with ground shapes connected to the ground plane to shield radiation from internal layers.

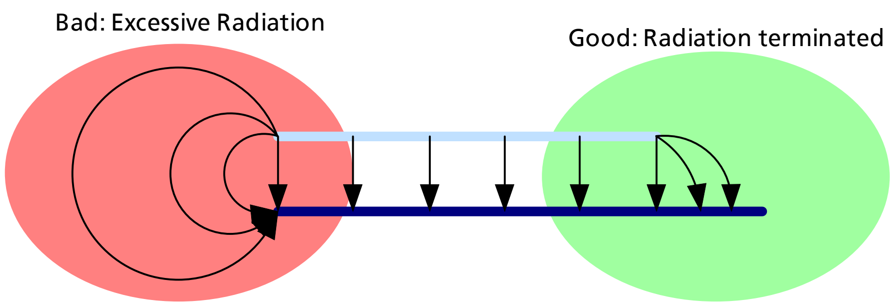


Figure 12: Signal and power plane extends should lie within ground plane extends

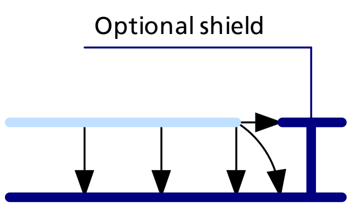


Figure 13: Further improvement of reduction of power plane radiation

2.6.2.2 High Speed Signal Lines

Keep high-speed lines as short as possible. This will reduce the area of the noise-emitting antenna, i.e. the conductor traces. Furthermore, the use of line drivers with controlled signal rise-time is suggested whenever it comes to driving large bus systems. Alternatively, high-speed signal lines can be terminated with resistors or even active terminations to reduce high frequency radiations originating from overshoot and ringing on these lines.

If dielectric layers are thick compared to the line width route ground traces between the signal lines to increase shielding. This is especially important if only two layer boards are used (see *Figure 14*).

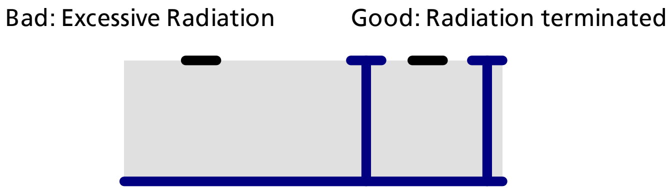


Figure 14: Terminating radiation of signal lines

2.6.2.3 Decoupling Capacitors

Use a sufficient number of decoupling capacitors in parallel between power and ground nets. Small size, small capacitance types reduce high-frequency emissions. Large size high capacitance types stabilize low frequency variations. It's preferred to have a large number of small value capacitors in parallel rather than having a small number of large value capacitors. Every capacitor has an internal inductance in series with the specified capacitance. Above resonance, the capacitor will behave like an inductor. If many capacitors are connected in parallel, total inductance will decrease while total capacitance will increase. *Figure 15* shows the impedance dependency of SMD capacitors.

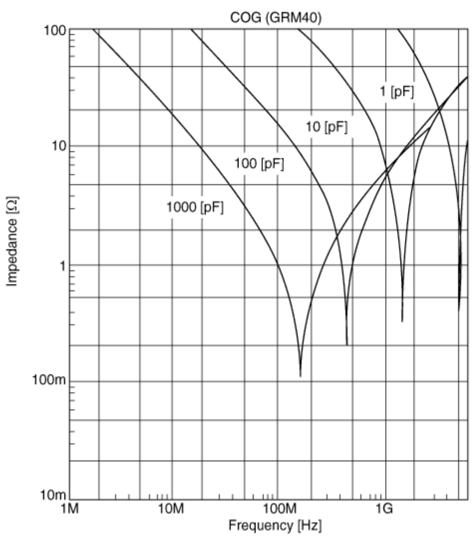


Figure 15: Impedance of 0805 size SMD capacitors vs. frequency, MuRata

If an efficient capacitor network not connect power and ground plane, the power plane may act as a radiating patch antenna with respect to ground.

Furthermore, ceramic capacitors come with different versions of dielectric material. These materials show different temperature behavior. For industrial temperature range applications, at least a X5R quality should be selected. Y5V or Z5U types may loose almost all of their capacitance at low and high temperatures, resulting in potential system failure at low temperatures because of excessive noise emissions from the digital part. Tantalum capacitors show good thermal stability, however, their high ESR (equivalent series resistance) limits the usable frequency range to some 100 kHz.

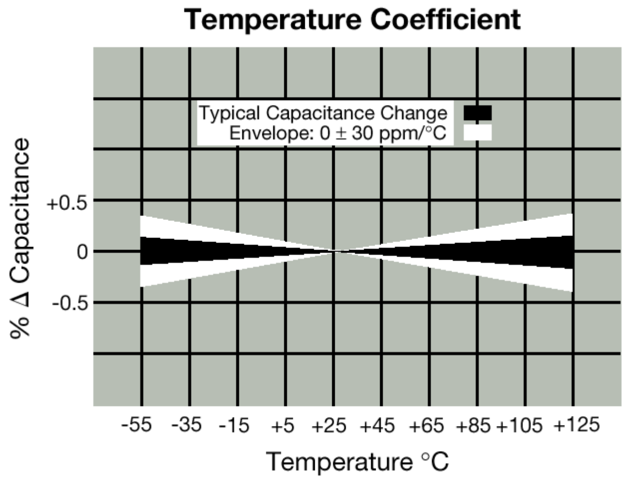


Figure 16: Temperature dependency of COG/NPO dielectric, AVX

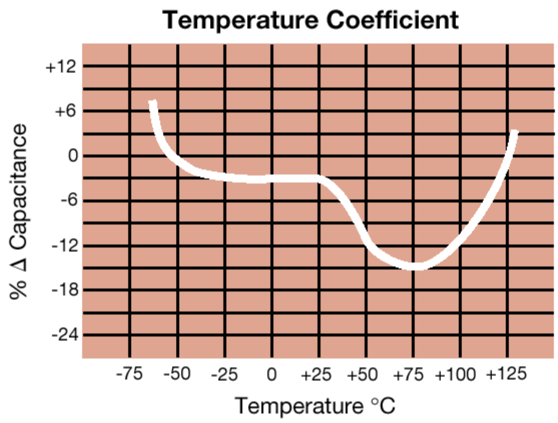


Figure 17: Temperature dependency of X7R dielectric, AVX

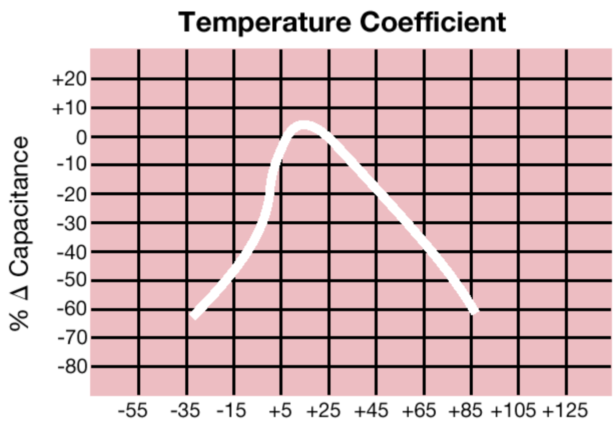


Figure 18: Temperature dependency of Y5V dielectric, AVX

2.6.3 Shielding

If employing the countermeasures listed in *Section 2.6.2* cannot solve EMI problems, the ultimate solution will be shielding of the noise source. But, a real-world shield is not perfect. The shielding effectiveness you can expect from a solid metal shield is somewhere in the order of 30-40 dB. If a thin PCB copper layer is used as a shield, these numbers might even be lower. Perforation of the shield will also lower its effectiveness.

Be aware of the negative effects that holes in the shield can have on shielding effectiveness. Lengthy slots might even turn a shield into a radiating slot antenna. Therefore, a proper shield has to be tightly closed and very well connected to the circuit board.

2.6.3.1 Feed through Capacitors

The basic concept of shielding is that a metal box will terminate all electrical fields on its surface. In practice we have the problem that we need to route some signals from inside to outside of this box.

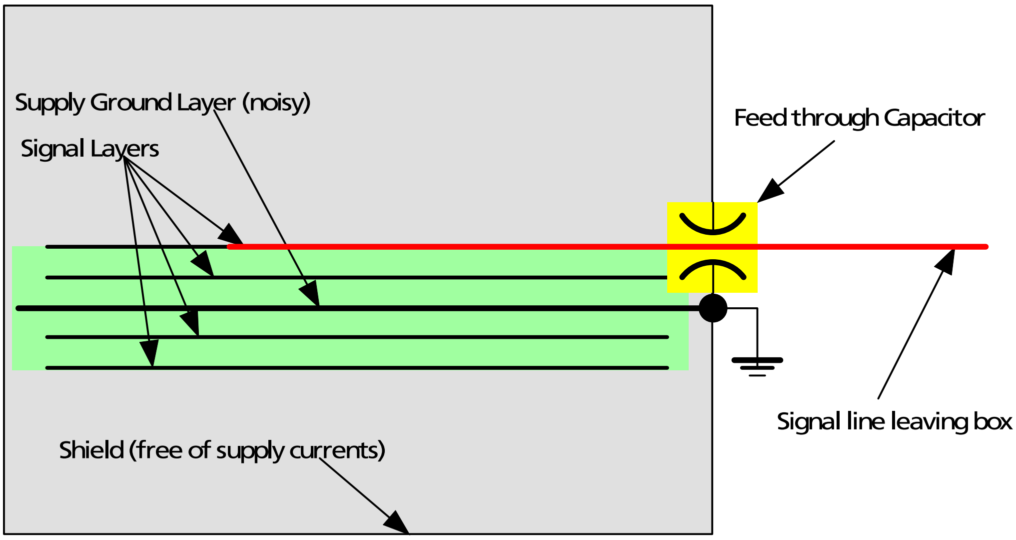


Figure 19: Ideal shielding

The proposed setup for such a system is shown in *Figure 19*. A feed through capacitor removes all high frequency content from the outgoing signal line. It's important to notice that any conductor traveling through the shielding box is subject to picking up noise inside and re-radiating it outside, regardless of the actual signal it is intended to carry. Therefore, also DC lines, e.g. the power supply should be filtered with feed through capacitors. When selecting feed through capacitors, it's important to choose components with appropriate frequency behavior. As with the ordinary capacitors, small value types will show better attenuation at high frequencies, see *Figure 20*. For the GPS frequency band the 470pF capacitor is the optimum choice of the Murata NFM21C series.

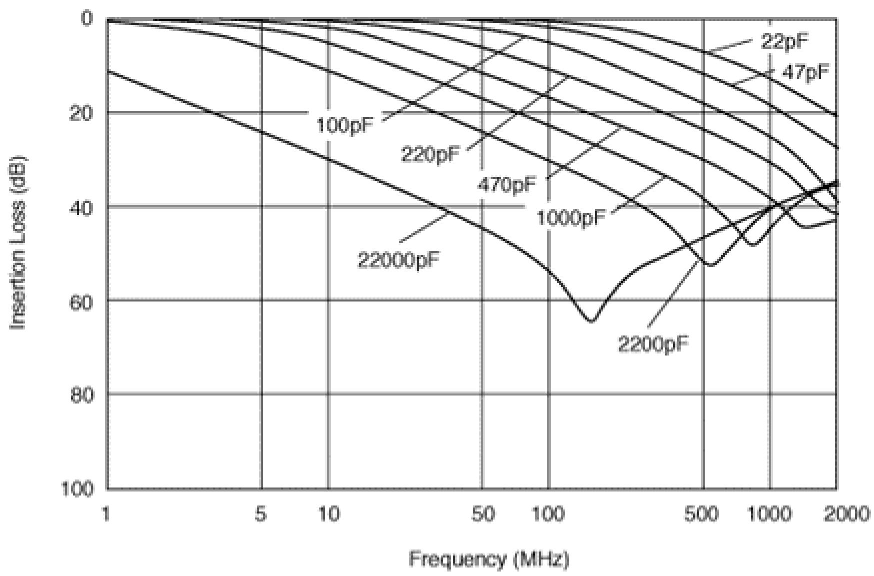


Figure 20: MuRata's NFM21C Feed Trough Capacitors

Any feed through capacitor will only achieve its specified performance if it has a proper ground connection.

If use of a special feed through capacitor is not feasible for a particular design, a simple capacitor between signal line and shielding ground placed very close to the feed through of the signal line will also help. It has been found that a 12 pF SMD capacitor works quite well at GPS frequency range. Larger capacitance values will be less efficient.

One should keep in mind that a feed-through capacitor is basically a high frequency "short" between signal line and ground. If the ground point that the capacitor is connected to is not ideal, meaning the ground connection or plane has a finite resistance, noise will be injected into the ground net. Therefore, one should try to place any feed trough capacitor far away from the most noise sensitive parts of the circuit. And, to stress this once again, one should ensure a very good ground connection for the feed through capacitor.

If there is no good ground connection available at the point of the feed through, or injection of noise into the non-ideal ground net must be avoided totally, inserting a component with a high resistance at high frequencies might be a good alternative. Ferrite beads are the components of choice if a high DC resistance cannot be accepted. Otherwise, for ordinary signal lines one could insert a 1 K series resistor, which would then form a low-pass filter together with the parasitic capacitance of the conductor trace.

See also MuRata web page for extensive discussion on EMC countermeasures.

2.6.3.2 Shielding Sets of Sub-System Assembly

Yet another problem arises if more than one building block are combined in a single system. *Figure 21* shows one possible scenario. In this case, the supply current traveling through the inductive ground connection between the two sub-systems will cause a voltage difference between the two shields of the sub-system. The shield of the other system will then act as a transmitting antenna, radiating with respect to the ground and shield of the GPS receiver and the attached antenna.

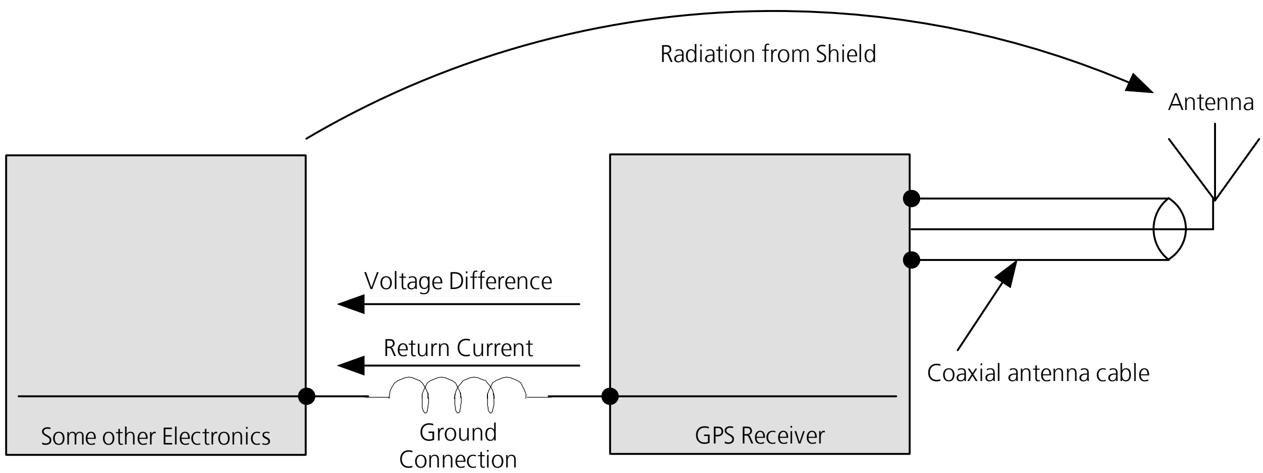


Figure 21: Two shielded sub-systems, connected by a "poor" ground

This situation can be avoided by ensuring a low inductivity ground connection between the two shields. But now, it might be difficult to control the path of the ground return currents to the power supply since the shield is probably connected to the supply ground at more than one location. The preferred solution is shown in *Figure 22*. Again, it is important to have a good, i.e. low inductance interconnection between the outer shield and the shielding ground of the GPS receiver.

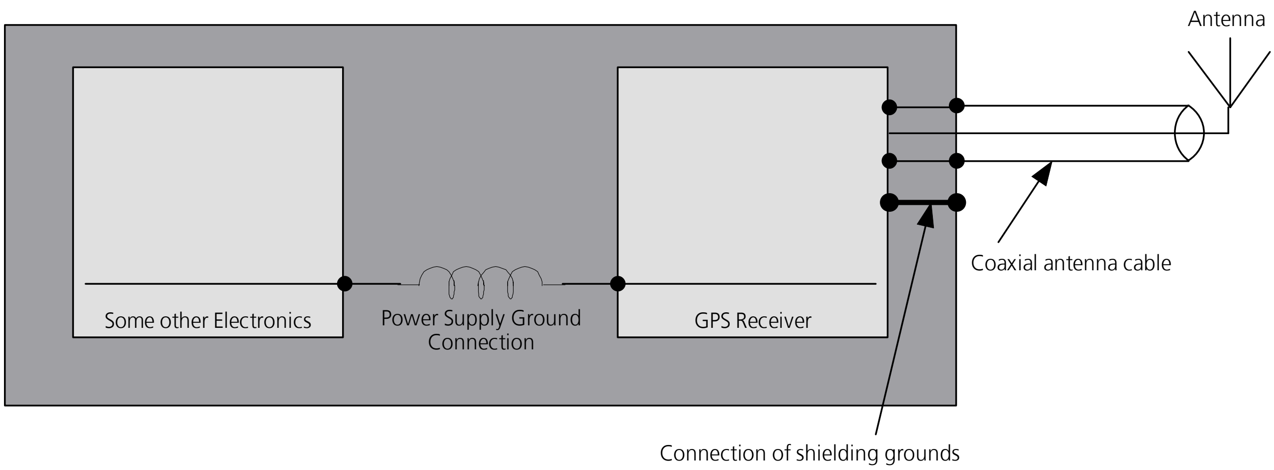


Figure 22: Proper shielding of a sub-system assembly

It is clear that the situation depicted in *Figure 22* might get arbitrarily complex if "Some other electronics" contains another wireless transmitter system, requiring a second antenna, which is referenced to the systems shielding ground. As already pointed out, in a setup like this it is important to keep the shield free from supply currents with high frequency spectral content. If there are to be additional connections to the shielding ground, these should be of high inductivity nature.

3 System Considerations

3.1 Considerations before you start

There is no easy recipe to define the requirements for a GPS based application! Defining the requirements for a user application means prioritizing different needs to get the best trade off. Certain settings can be excellent for avionics, but might not the best choice for a portable application and vice versa.

Understanding the application environment as well as the GPS fundamentals is a prerequisite in order to define the core requirements for a design.

In the following sections there is a comparison of different settings with their positive and negative aspects. It highlights the main trade-offs. This will help to get optimal settings for your application.

3.2 Macro Component vs. Receiver Board vs. Chipset

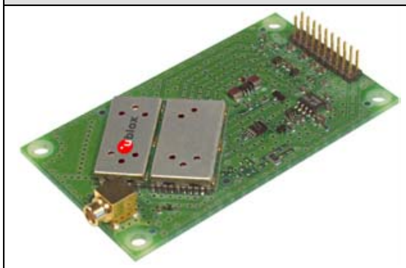
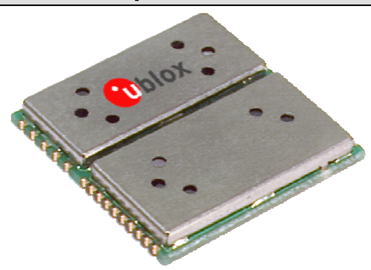
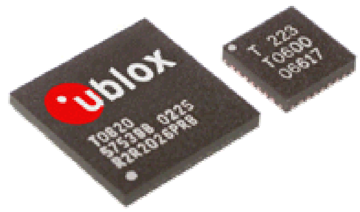
Receiver Board	Macro Components	Chipset
		
A Receiver Board contains the GPS receiver module inclusive active antenna connector and all needed elements to run a PVT sensor.	A macro component allows a customer specific design.	The ANTARIS® chipset, a true 2 chip solution allows a customer specific design on minimal board space. **For very high volumes only!**
• Ready to go PCB board for fast design-in and easy mounting • Industry standard form factors allow fast replacement of other GPS technologies to benefit from the ANTARIS® technology without a big design effort • Convenient connection of active antennas	• A GPS module allows a customer specific design with optimised PCB space • The module allows an automatic placement on the PCB boards • Suitable for reflow soldering machines. • Reduced requirement of connectors providing a more cost effective, robust design. • Low design effort and risk • Simple testing as 100% of the modules are tested at u-blox •	• Most flexible way to implement ANTARIS® Technology into customer specific design • Optimal use of the PCB board space • GPS Firmware runs from ROM integrated in the baseband chip. • Customer needs to setup a GPS Test Equipment in its production line • Sourcing of critical components is up to the customer's responsibility. **!** **Note:** Requires advanced skills in RF design

Table 3: Macro Component vs. Receiver Board vs. Chipset

3.3 Macro Component vs. Smart Antenna

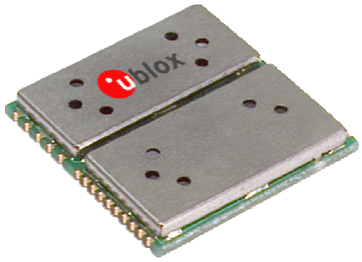
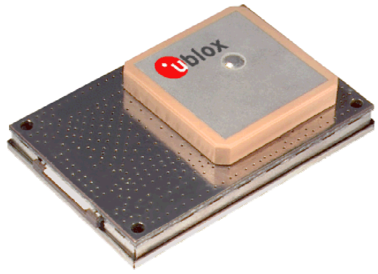
Macro Components	Smart Antenna
	
A macro component needs a design with a matching active or passive antenna to be connected.	A Smart Antenna Module combines the receiver and a passive antenna
• Receiver can be adapted to any application needs. • For TIM-LP macro-components, passive or active antenna can be connected, for TIM-LF or TIM-LC receiver boards only active antennas are supported. • Additional signals such as TIMEPULSE or receiver STATUS are available.	• No effort needed to connect an antenna or design a RF conform PCB. • Requires only minimal RF knowledge • Easy solution, if only a small, simple position sensor is needed. • Shorter time to market • Best trade-off for smaller number of devices

Table 4: Macro component vs. smart antenna

! **Note** Use the Smart Antenna Module to shorten your time to market or in a case of low or medium-size volume.

3.4 Use of Software Customization (ANTARIS® SCKit)

For further information about Software Customization (SCKit), please refer to *Section 4.8*.

3.5 Active vs. Passive Antenna

First some general issues:

- A GPS needs to receive signals from as many satellites as possible. A GPS receiver doesn't work properly in narrow streets and underground parking lots or if objects or human beings cover the antenna. Poor visibility may result in position drift or a prolonged Time-To-First-Fix (TTFF). **A good sky visibility is therefore a prerequisite.**
- A GPS receiver will only achieve the specified performance if the average Carrier-To-Noise-Ratio (C/No) of the strongest satellites reaches at least 44dBHz. In a well-designed system, the average of the C/No ratio of high elevation satellites should be in the range between 44 dBHz and about 50dBHz. With a standard off-the-shelf active antenna, 47 dBHz should easily be achieved. **Even the best receiver can't make up for signal loss due to a poor antenna, in-band jamming or a bad RF-board design.**

Active Antenna	Passive Antenna
Active antenna connected to the GPS receiver macro component.	Passive patch antennas or helical antennas connected with a micro strip or stripline to the GPS receiver macro component.
• A wide range of active patch or helical antennas is available in the market. They differ in size, sensitivity and power consumption • Less sensitive to jamming than a passive antenna, as the placement of the active antenna is usually some distance away of other noise or signal radiating devices. • Needs more power than a passive antenna	• Passive patch antennas or helical antennas are available in different form factors and sensitivity • Antenna must be connected with a carefully designed micro strip or stripline to the GPS receiver macro component to ensure a good GPS performance. • The PCB design with a passive antenna must consider the sensitivity of the GPS antenna to other radiating circuits or general signal jamming. • Due to the proximity of antenna, GPS and other electronic circuits, in-band jamming may become a critical issue. • Only suitable for RF experts!

Table 5: Active vs. Passive Antenna

! **Note** Take an active antenna setup, if you are not an expert in RF designs and place the antenna away from any emitting circuits.

3.6 Antenna Placement

External	Built-in
An external antenna usually has an LNA in the antenna, which means it's used as an active antenna, see Section *3.2*.	A built-in antenna may have an LNA (setup as a active antenna) or none (setup as passive antenna), see *Section 3.2*. It's typically near to other digital circuits, so additional considerations against jamming are needed.
• Easier and less sensitive to jamming • More freedom to place the antenna	• Needs more experience in RF design • Requires more effort to optimise the circuit design to minimize jamming into the antenna and the antenna signal routing.

Table 6: Antenna placement

Some cars have a metallic coating on the windshield. GPS reception may not be possible in such a car. There is usually a small section, typically behind the rear view mirror without the coating for mobile phone and GPS antennas.

! **Note** Place the antenna with optimal sky visibility.

! **Note** An external antenna (e.g. with a magnetic base) is easier to use and usually allows a better positioning.

3.7 NMEA vs. UBX Binary Protocol

NMEA	UBX
The NMEA-1083[2] protocol is an ASCII based industry-standard protocol	The UBX propriety protocol is optimized for the ANTARIS® GPS technology.
• Compatible to other GPS receiver using the same standard • ASCII protocol • Only limited information available • Only limited configuration options available	• Provides a wider range of parameters than the NMEA protocol • Binary protocol • Gives direct access to the GPS receiver configuration settings for an optimal GPS performance • Allows direct analysis of GPS data with the u-center with interesting graphic overviews to optimise the GPS performance • High data density

Table 7: NMEA vs. UBX propriety protocol

! **Note** UBX offers a better flexibility and more powerful messages than NMEA. It's optimized to communicate with u-center to get the best performance and optimal design-in support.

[2] For details, refer to www.nmea.org

4 Receiver Description

4.1 Overview

The ANTARIS® GPS Receiver Macro Component is a self-contained receiver for the Global Positioning System (GPS). The complete signal processing chain from antenna input to serial output is contained within a single component.

The height of 3mm (~120mil) at the size of 25.4mm x 25.4mm (1" x 1") makes it the ideal GPS solution for applications with stringent space requirements. Innovative packaging technology has opened the door for a thin and compact GPS receiver unique in the market.

This type of package makes expensive RF cabling obsolete. Because the RF input is available on a pin, the ANTARIS® GPS macro component is SMT solderable and can be handled by standard pick and place equipment.

The ANTARIS® GPS Receiver provides up to two serial ports, which can handle NMEA, UBX proprietary data format and accepts differential GPS correction data (RTCM).

There are tree different ANTARIS® GPS Receiver Modules available. Which to choose depends on the customer requirements:

	TIM-LP	TIM-LF	TIM-LC
RF Section			
Low Noise Amplification (LNA)	ATR0610	Not available	Not available
SAW Filter	Built in	Built in	Built in
RF IC	ATR600	ATR0600	ATR0600
GPS Crystal	23.104 MHz	23.104 MHz	23.104 MHz
Active Antenna Power Control	Built in	Built in	Built in
Digital Section			
Base Band Processor	ATR0620	ATR0620	ATR0620
Asynchronous Serial Ports	2 ports 3.0 V level	2 ports 3.0 V level /5 V compatible	1 port 3.0 V level /5 V compatible
RTC Crystal	32.768 kHz	32.768 kHz	32.768 kHz
FLASH	1 MB	1 MB	Not available
STATUS	3.3 V level	1.8 V level	Not available
TIMEPULSE	3.3 V level	1.8 V level	1.8 V level
Additional Functions			
Software Customization Kit (SCKit)	Available	Available	Not available as there is no internal FLASH
Synchronous USART/ SPI Interface	2 ports available (Only with SCKit)	2 ports available (Only with SCKit)	Not available
GPIO	Up to 8 3.3 level (only with SCKit)	Up to 8 1.8 V level (only with SCKit)	Not available

4.1.1 Hardware Block Schematic

The ANTARIS® GPS receiver is divided into two distinct, separately shielded sections. The smaller section is the RF-Section, the larger section contains the baseband. Specific hardware block schematics are shown in *Figure 23* for TIM-LP, *Figure 24* for TIM-LF and *Figure 25* for TIM-LC.

The upper RF section contains the low noise amplifier (LNA) ATR0610 (TIM-LP only), the SAW bandpass filter, the RF-IC ATR0600 and the GPS crystal. The ATR0600 uses a single IF sub-sampling scheme with an analogue IF of 98.764 MHz, a sampling frequency of 23.104 MHz, and a resulting digital IF of 4.348 MHz.

The baseband section contains the digital circuitry comprised of the ATR0620 baseband processor, the RTC crystal and additional elements as FLASH memory, level shifters where specified.

The two sections are connected by a number of digital signals: Control signals from the digital part switch between different power states of the RF section. The 23.104 MHz clock is supplied to the digital part as well as the 1.5 bit quantized IF signal. Another status signal reports the status of the antenna bias input to the baseband processor. Finally, after rigorous filtering, power is supplied from the digital part to the RF part.

4.1.1.1.1 The RF Section explained

The RF section fulfills four major tasks:

1. Low Noise Amplification of the antenna signal (TIM-LP only)

   The built-in Low noise amplifier, LNA (ATR0610) provides the initial amplification of the antenna signal. It has a very low noise figure and is the first pre-amplification stage. The performance of this part determines the noise performance of the whole receiver.

2. Filtering of the antenna signal

   Since the architecture of the ATR0600 does not use an image reject mixer for power saving reasons, a SAW filter at the RF input is needed to suppress the image frequency.

3. Frequency conversion of the input signal to a frequency suited for digital processing.

4. Sampling of the analog signal to obtain a digital bit stream

   An automatic gain control (AGC) loop is used in front of the A/D-converter to maintain an optimum load for the converter input and maximize the dynamic range of its 1.5 bit resolution. The A/D converter output signal is sampled using the sampling clock, yielding a synchronous time-discrete representation of the input signal.

5. Generation of the main clock frequency.

   An integrated crystal oscillator (XTO) generates the main clock frequency of 23.104 MHz, using only a simple crystal. A fully integrated voltage controlled oscillator (VCO) with PLL features as local oscillator for the mixer.

In order to ease connection of active antennas, a bias-T is integrated. It provides the ability to supply a DC current into the **V_ANT** pin, which is internally fed into the **RF_IN** pin.

4.1.1.2 The Digital Section explained

The core component of the digital section is the highly integrated baseband processor ATR0620. It contains an ARM7 CPU, the GPS correlator hardware, RAM and ROM, non-volatile RAM (using an external battery), RTC, reset generator and two voltage regulators. TIM-LP and TIM-LF contain an addition FLASH memory, which is used to store program updates and user-specific code.

LF contain an addition FLASH memory, which is used to store program updates and user-specific code.

Level-shifters translate the 1.8 V I/O levels of the ATR0620 to 3 V CMOS compatible levels (not 5 V tolerant), available at the external pins of TIM-LP. For TIM-LF and TIM-LC only the serial ports are level-shifted to 3 V CMOS compatible levels (5 V tolerant).

The crystal required for the RTC is also integrated into all the GPS modules.

Pin **EXTINT0** can be used to generate direct software interrupts from outside of the GPS module.

The **TIMEPULSE** pin provides a highly configurable time pulse signal, synchronized to UTC.

In standard software, the **STATUS** pin provides receiver status information (e.g. number of tracked satellites) periodically.

The **BOOT_INT** pin is used to start the GPS Receiver in Boot Mode (e.g. to recover in case of corrupt firmware images due to failed firmware updates).

The **RESET_N** pin can be used either as output to initialize external logic upon power up of the GPS module or to initiate a hardware reset of the GPS module from external hardware.

Standard applications will probably only use the asynchronous serial interfaces **RxD1**, **RxD2**, **TxD1**, and **TxD2,** or even only one of both.

For TIM-LP and TIM-LF, customer specific software might make use of the general purpose I/Os **P8**, **P9**, **P17**, and **P20** – **P26**. The SPI interface is available at pins **SCK**, **MISO**, **MOSI**, **PCS0_N/SS_N**, **PCS1_N**, and **PCS3_N**. The **SCK1** and **SCK2** pins can be used to enable synchronous operation of the serial interfaces. It is obvious that not all functionality can be used at the same time or even in the same application schematic. Please refer to the u-blox *SCKit Manual [4]* in the *ANTARIS® Software Customization Kit* for details on configuring and using these additional pins.

The **GPSMODE** pins of the TIM-LC are used to customize the startup configuration.

4.1.1.3 TIM-LP Block Diagram

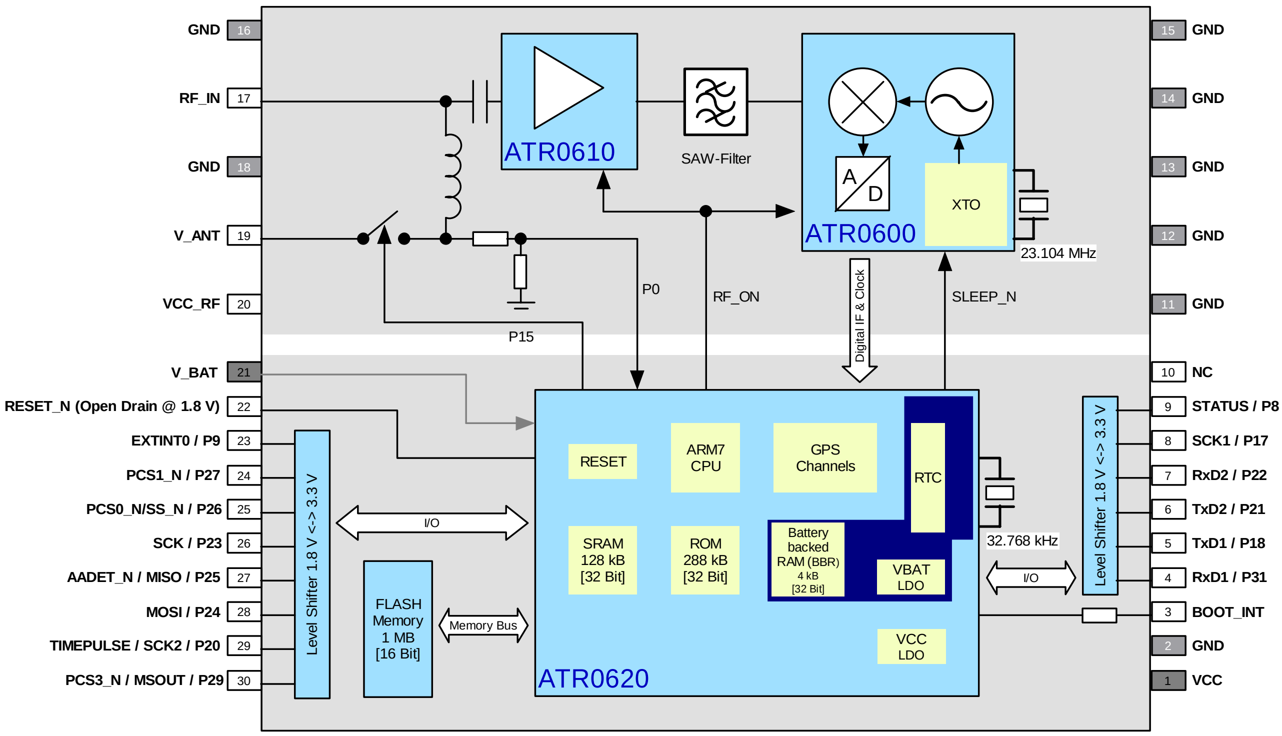


Figure 23: Hardware Block Schematic TIM-LP

4.1.1.4 TIM-LF Block Diagram

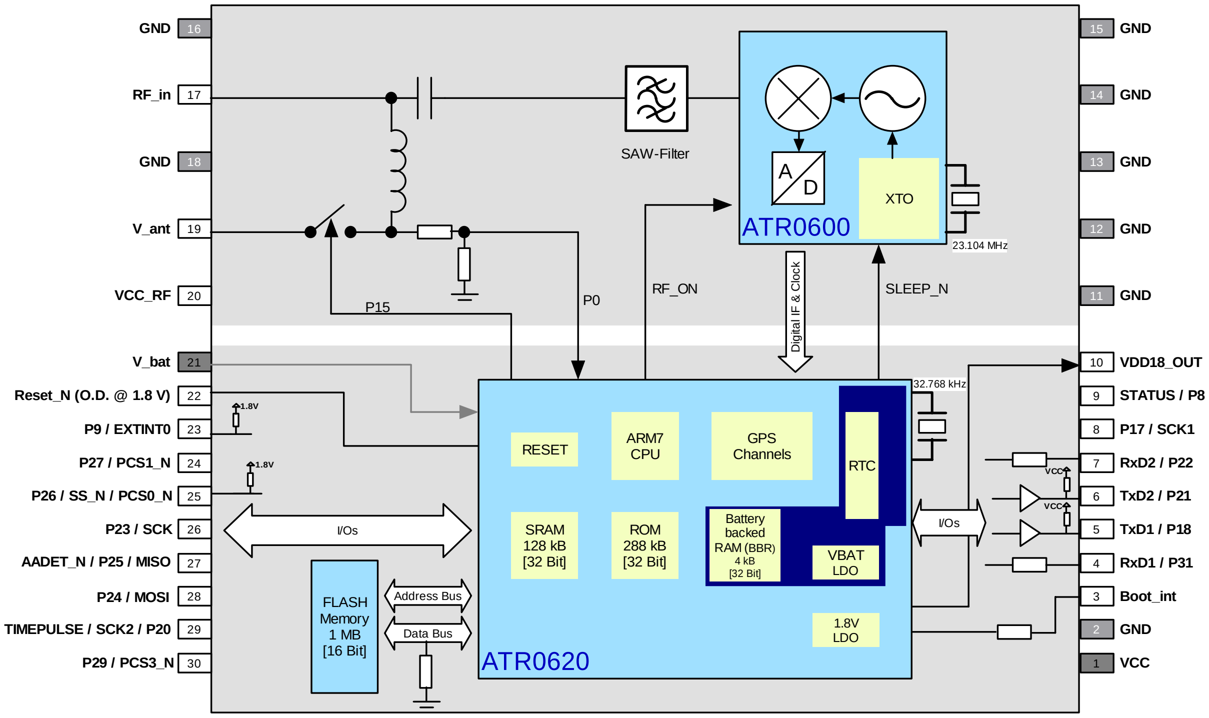


Figure 24: Hardware Block Schematic TIM-LF

4.1.1.5 TIM-LC Block Diagram

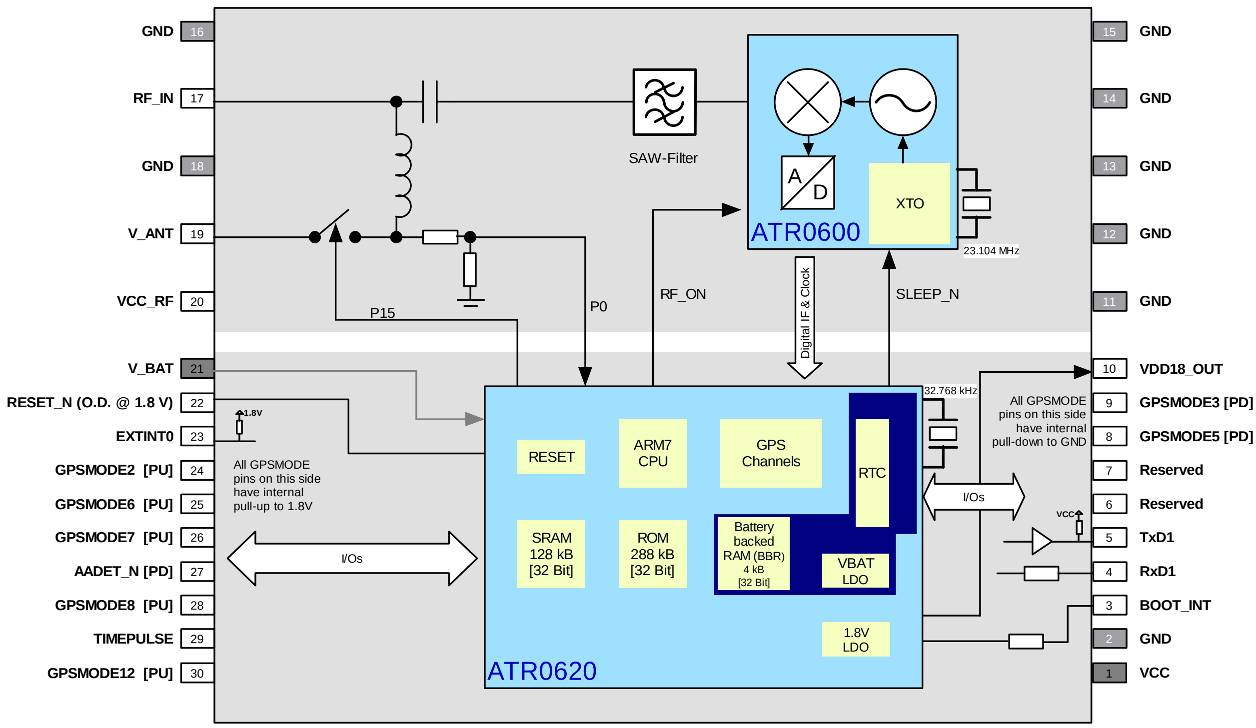


Figure 25: Hardware Block Schematic TIM-LC

4.1.2 Software Block Schematic

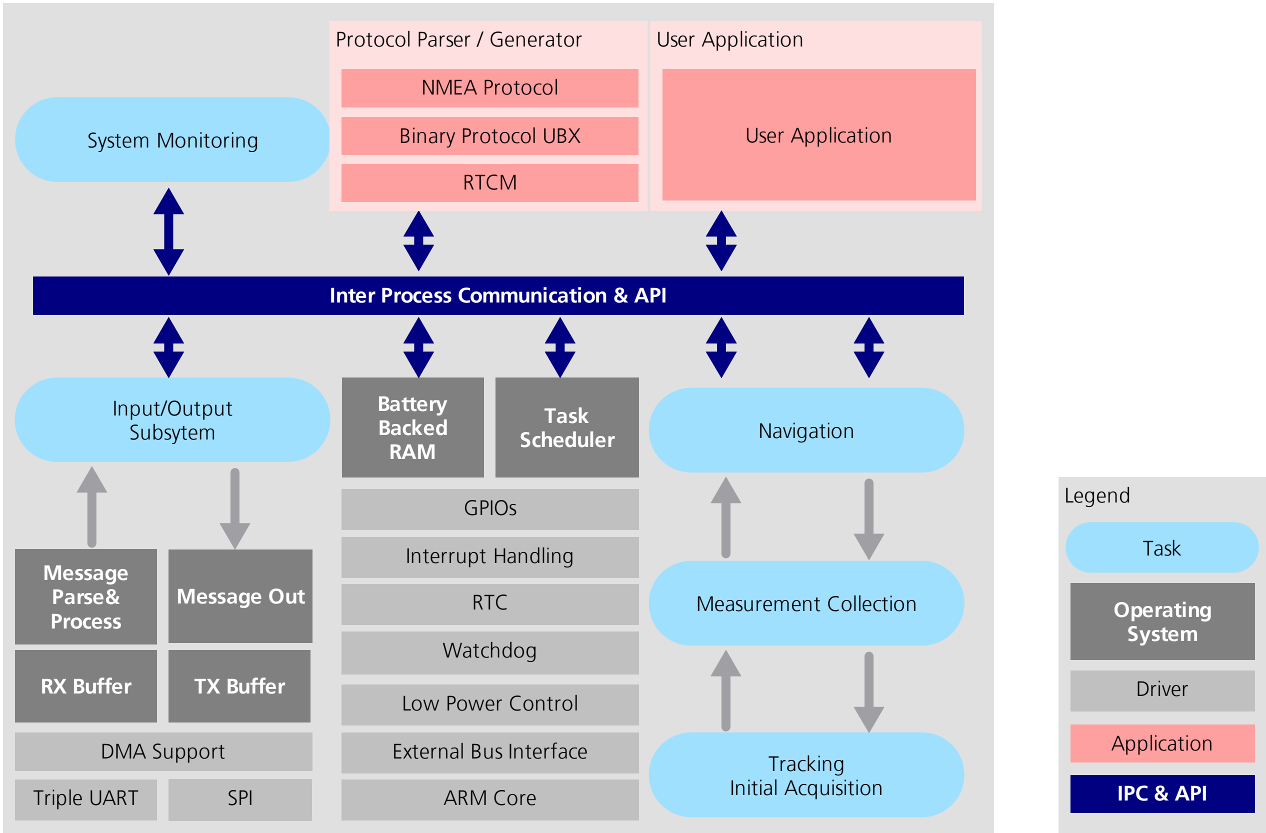


Figure 26: Software Block Schematic

Figure 26 shows an overview of the ANTARIS® firmware structure. The backbone is the Inter Process Communication & API Bus, which is used to communicate between the different tasks such as the Navigation, System Monitoring, Tracking & Acquisition Task etc. as well as any Hardware Modules such as GPIO, Interrupt Handling and RTC etc.

User Applications implemented with the *ANTARIS® Software Customization Kit (SCKit)* communicate via the API bus, they have a large library of class methods available to develop and enhance the GPS module functionality.

4.2 Power Management

4.2.1 Operating Modes

The ANTARIS® GPS technology offers ultra-low power architecture with built-in autonomous power save functions. The receiver uses the ANTARIS® Autonomous Power Management (APM) to minimize the power consumption at any given time. The CPU clock is geared down every time the full CPU performance is not needed. Even at very low clock speeds, the CPU can still respond to interrupts and gear up CPU clock quickly if demanded by the computing task. The software frequently makes use of this feature to reduce average power consumption. Furthermore, the clock supply to unused peripheral on-chip blocks is shut down by software.

The ANTARIS® GPS Technology defines the following Operating Modes:

Operating Modes	Description
Continuous Tracking Mode (CTM)	The Continuous Tracking Mode is optimized for position accuracy. This mode is optimized for minimal power consumption based on the ANTARIS® Autonomous Power Management (APM). The Continuous Tracking Mode is the default setting of the ANTARIS® GPS receiver. There is no specific configuration needed.
Power Save Mode	
FixNOW™ Mode (FXN)	FixNOW™ Mode allows an application to request a navigation solution as required. It includes additional power save functions and is the best mode for any mobile, tracking unit application where low power consumption is of primary consideration. This mode can be configured for different application requirements.

Table 8: Operating Modes

Choosing an Operation Strategy

The ANTARIS® GPS receivers offer different features to optimize the overall power consumption. The receiver always runs in the most economic power state and switches off internal modules that are not in use. (E.g. if no input and/or output protocol is selected for a serial port, the respective gates on the ASIC will not be clocked and the SPI is switched off by default).

! **Note** The update rate influences the power consumption and position accuracy.

! **Note** Initial acquisition and reacquisition needs maximum power as specified in the datasheet.

Requirements	Recommended Operation Mode
Maximum Accuracy	*Continuous Tracking Mode* (CTM)
Periodic position fixes (< 10s) Power consumption is of minor concern	*Continuous Tracking Mode* (CTM) It's possible to adjust the measurement period and the message rate of the serial output messages.
Periodic position fixes (>10s) Minimal power consumption	*FixNOW™ Mode* (FXN) Set the on- and off-time of the receiver as desired.
Position fix required on demand 'Time to first fix' as short as possible	*FixNOW™ Mode* (FXN) Set the on-time to 35s and off-time of to <1800s.
Position fix required on demand Minimal power consumption	*FixNOW™ Mode* (FXN) Set the on-time to 0s and off-time as required by the application.
Position fix required upon demand 'Time to first fix' may exceed 25 seconds. Minimal power consumption	*FixNOW™ Mode* (FXN) Set the on- and off-time of the receiver as desired.

Table 9: Choosing an operation strategy

4.2.2 Power States

In the Continuous Tracking Mode (CTM) the receiver is always in the Full Power State. In FixNOW™ Mode (FXN) the receiver may use different power states influencing the functionality and power consumption of the receiver.

	Modes		
Power States	**CTM**	**FXN**	**Description**
Full Power State	✓	✓	This is the state during satellite acquisition, reacquisition and tracking. All active sections are powered.
Sleep State	-	✓	Can be selected in FXN Mode when no navigation solution is required or possible.
CPU Only	-	-	Only available with ANTARIS® Software Customization Kit (SCKit).

Table 10: Overview Power States

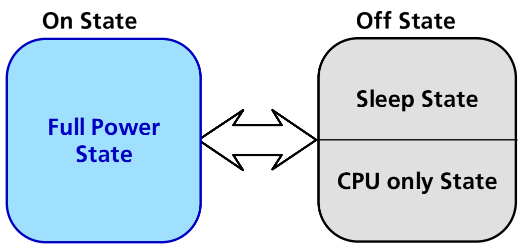


Figure 27: Overview On State - Off State

4.2.2.1 Full Power State (On State)

In Full Power State all parts of ANTARIS® chipset are powered through pin **VCC**. This is the standard operation mode. Depending on CPU load, activity of the peripheral hardware and external load on the I/Os, actual supply current requirement may vary significantly.

4.2.2.2 Sleep State (Off State)

Within this mode the CPU is powered and the receiver can be woken up with a request on the serial communication interface or an external interrupt.

If no computations need to be done, further power saving can be achieved by shutting down the clock. Nevertheless, the system can still respond to interrupt sources and wake up again.

If voltage supply is always present at pin **VCC**, no backup battery is needed. The sleep state is useful if the system is idle and waiting for user input or similar events. The real time clock – as it remains active and running – can also schedule the sleep state to wake up the receiver after a pre-defined period of time.

4.2.2.3 CPU Only State (Off State)

In a custom application where ARM7 processor of the GPS receiver is needed, but no GPS functionality is required, the entire GPS part of the system can be shut down while e.g. no position output and no satellite tracking is required and the CPU is executing the custom code. This way the customer has access to 100% of the CPU power. (The CPU clock is still supplied from the RF section to the baseband processor.)

! **Note** The SCKit is required for using the CPU Only State.

4.2.3 Continuous Tracking Mode (CTM)

The Continuous Tracking Mode (CTM) continuously tracks GPS signals and computes position fixes. Apart from the ANTARIS® Autonomous Power Management (APM), the receiver will not try to save power.

! **Note** CTM is the default operation mode.

4.2.4 FixNOW™ Mode (FXN)

In FixNOW™ Mode (FXN), the receiver will shut down automatically if there is no GPS signal and wake up at predefined intervals in order to acquire GPS PVT Data. FixNOW™ Mode also allows the GPS receiver to be set into Sleep State to further reduce the power consumption of the receiver.

4.2.4.1 Position upon Request

The receiver can be configured to calculate a PVT solution upon request during the off time by:

- The UBX - RXM (Receiver Manager) – POSREQ (Position Request) Message `(0x02, 0x40)`
- **EXTINT0** Pin

To configure the FixNOW™ Mode (FXN) use the UBX–CFG–FXN message. Use the UBX–CFG–RXM message to enable or disable FixNOW™ Mode.

The optimal settings of the receiver depend on the requirements of the application such as required update rate or maximum response time.

4.2.4.2 Waking up ANTARIS® GPS Receiver with external signals

If the ANTARIS® GPS Receiver has entered Sleep State and the power supply at pin **VCC** is present, various triggers can wake the receiver.

In order to wakeup the receiver from sleep state various pins may be used:

Wakeup conditions	
Pin	**Trigger**
EXTINT0	Rising (or falling)[3] edge
RxD1 or **RxD2**	Falling (or rising)[4] edge

Table 11: Possibilities to wakeup the receiver

! **Note** When waking up TIM-LP with RxD1, RxD2 from sleep- or backup state send a number (at least 8) of 0xFF characters to wake up the serial communication module otherwise the first bytes may get lost. To request a position fix a position request message must be sent via serial port after waking up the ANTARIS® GPS Receiver.

! **Note** When waking up the ANTARIS® GPS Receiver by **EXTINT0** or **SS_N** a position will be calculated.

During off state driving **RESET_N** low can wake the receiver up. If the receiver configuration has not been saved in BBR, the receiver will loose the actual configuration and load the last saved one.

4.2.4.3 Waking up the ANTARIS® GPS Receiver by RTC

The ANTARIS® GPS Receiver has an internal RTC, which is used to set a timeout to wake-up the receiver without any external signal. This is used in the FixNOW™ Mode (FXN) see *Section 4.2.4).*

! **Note** The timeout to wake up the ANTARIS® GPS receiver can't be set independently of the FXN functionality.

[3] Only available with the SCKit
[4] Only available with the SCKit

4.2.4.4 Active Antenna Power Control with FixNOW™

The FixNOW™ mode controls the Power Supply of any connected active antenna via the Antenna Bias Voltage (**V_ANT**). The voltage supply will be shut down when the receiver goes to Off State.

4.2.4.5 Functional Overview

The FXN mode has several parameters to optimize the GPS- and Power-Performance to meet specific user application requirements:

Parameter	Description
T_on [s]	Time the receiver stays on after achieving the first position fix with the flag 'position within limits' set. Note: If T_on is set to 0s, the receiver will shut down immediately after the first valid fix. If a new ephemeris is needed to achieve the defined accuracy, the receiver will automatically increase the "startup acquisition time T_acq" whenever necessary.
T_off [s]	Time the receiver stays in Off State
Base TOW [s]	Alignment of T_on (start-up) to GPS Time of Week.
T_acq [s]	Time the receiver tries to acquire SV before going to Off State, if SV acquisition is not successful.
T_acq_off [s]	Time the receiver stays in Off State, when SV acquisition was not successful.
T_reacq [s]	Time the receiver tries to reacquire as soon as a sky obstruction happens and no 2D or 3D fix is possible.
T_reacq_off [s]	Time the receiver stays in Off State, after reacquisition was not successful.
Search passes	If enabled, search pass defines how many times the receiver will search through the SV list attempting to find an SV, before switching to the Off State.

Table 12: FXN mode parameter description

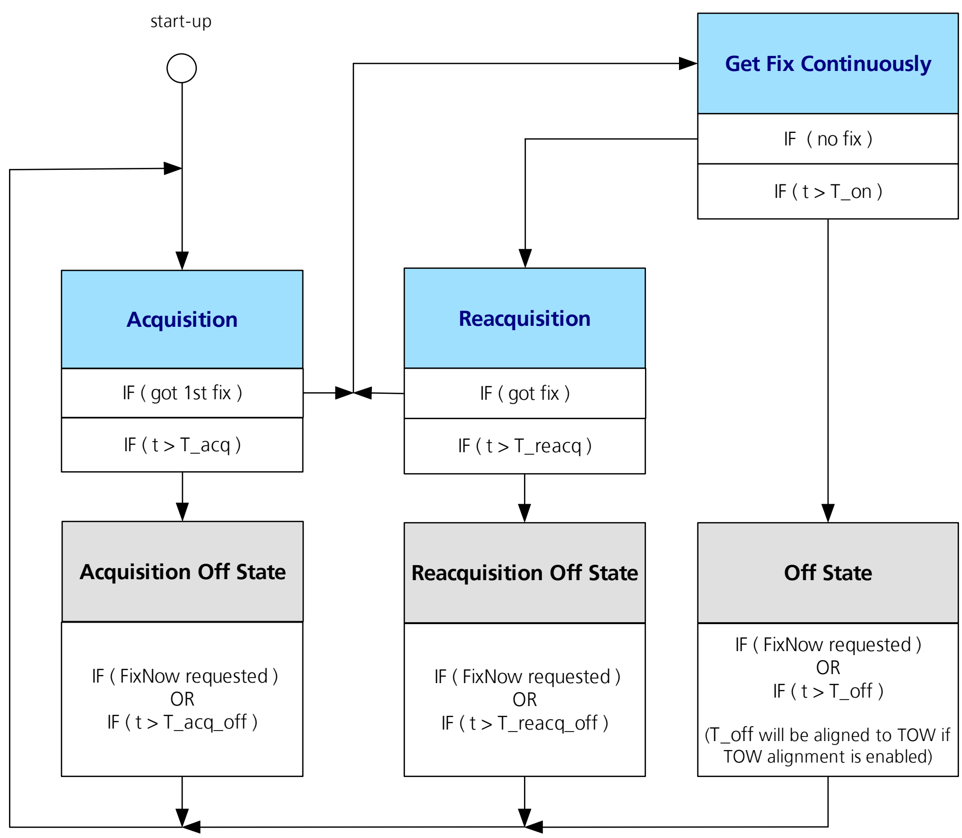


Figure 28: Simplified FXN state diagram

4.2.4.6 FXN without On/Off Time

In this mode, the receiver will – as long as there is good GPS coverage – never turn itself off. If there is loss of signal, or if there is no signal at power-up, the receiver will time out and go to an Off State for a predefined period.

T_acq (acquisition time) and **T_acq_off** (off time after an unsuccessful acquiring period) define the startup behavior after an off time. This can be an initial startup or a subsequent startup after an unsuccessful reacquisition procedure.

T_reacq (reacquisition time) and **T_reacq_off** configure the reacquisition procedure after a GPS signal loss. If the GPS signal is lost, the receiver tries during **T_reacq** to reacquire the signal. If this fails, the receiver goes to Off State for **T_reacq_off.** After this time the receiver will startup as defined above.

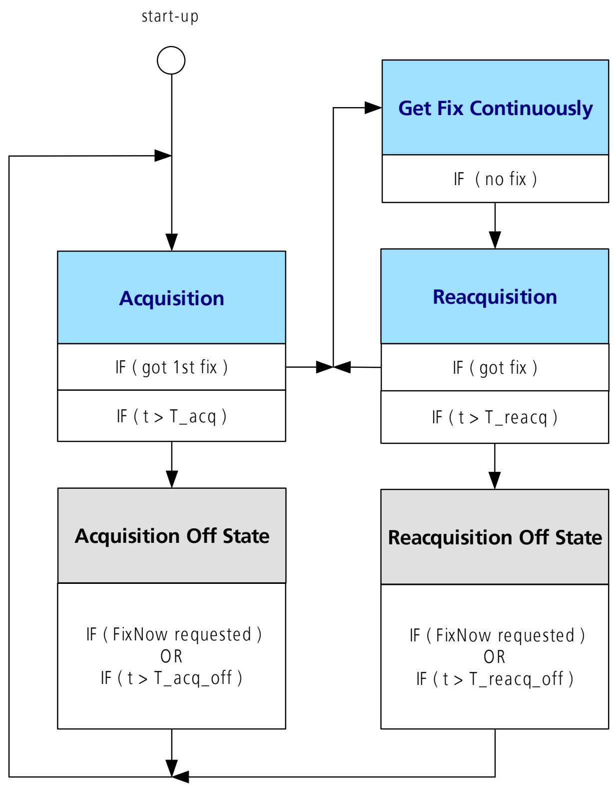


Figure 29: Simplified state diagram FXN Without On/Off Time

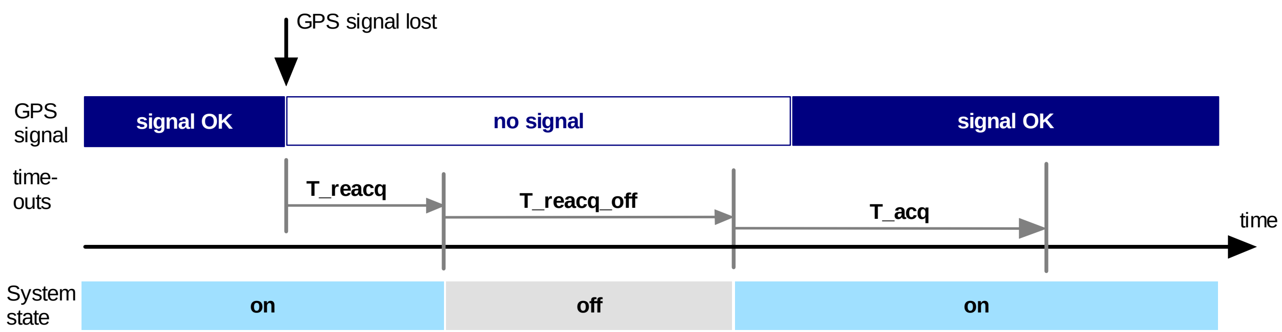


Figure 30: FXN without On/Off Time, GPS signal is lost in Full Power State

Example				
Use on/off time	Disabled			
T_on [s]	Not used		T_off [s]	Not used
Absolute align	Disabled		Base TOW [s]	Not used
T_acq [s]	60		**T_acq_off [s]**	120
T_reacq [s]	5		**T_reacq_off [s]**	60
Use search pass	Disabled		Search passes	Not used
Operation				
As long as there is good GPS coverage, the receiver will keep running. If there is loss of signal for at least 5 seconds, the receiver will shut down for 60 seconds. After that off time, the receiver will try to find the signal for 60 seconds. If that fails it will shut down for another 120 seconds.				

Table 13: Example settings FXN without On/Off Time

4.2.4.7 FXN with On/Off Time

In contrast to using FXN without On/Off Time the receiver will only stay on for **T_on** after an initial fix has been achieved and switch to Off State for **T_off** afterwards.

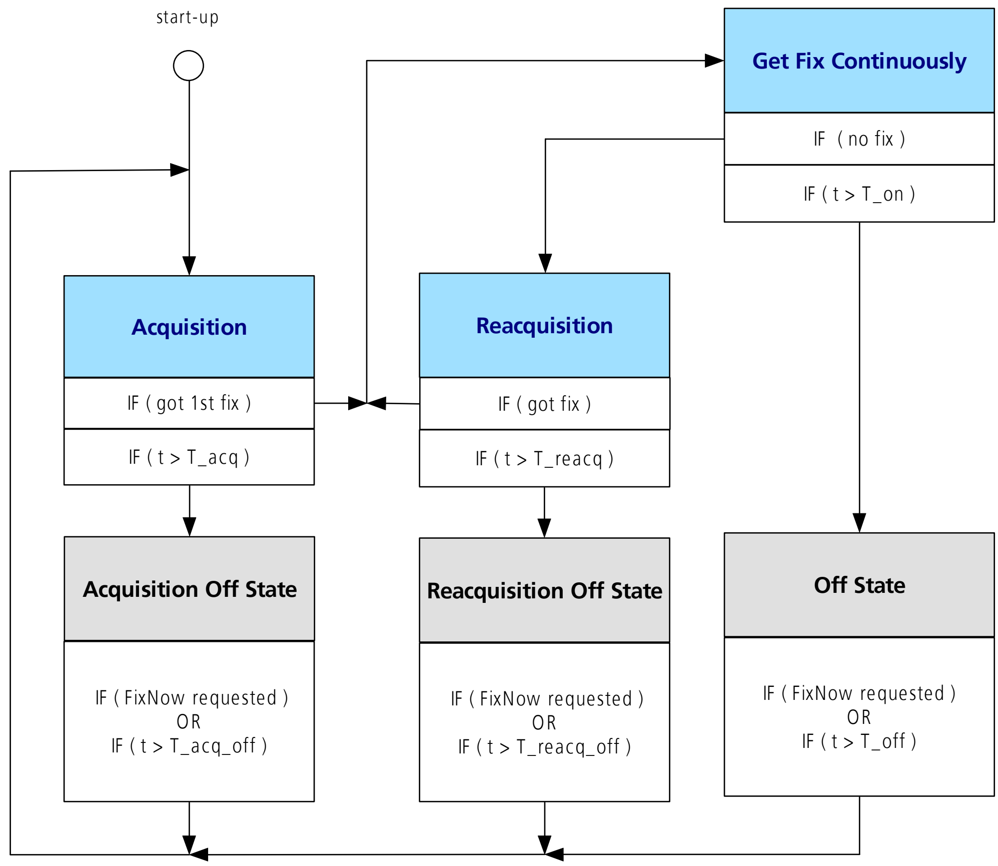


Figure 31: Simplified state diagram FXN With On/Off Time

If there is no GPS signal when the receiver wakes up, the receiver will try to acquire a fix as usual for **T_acq**. If this is not successful the receiver goes to Off State for **T_acq_off.**

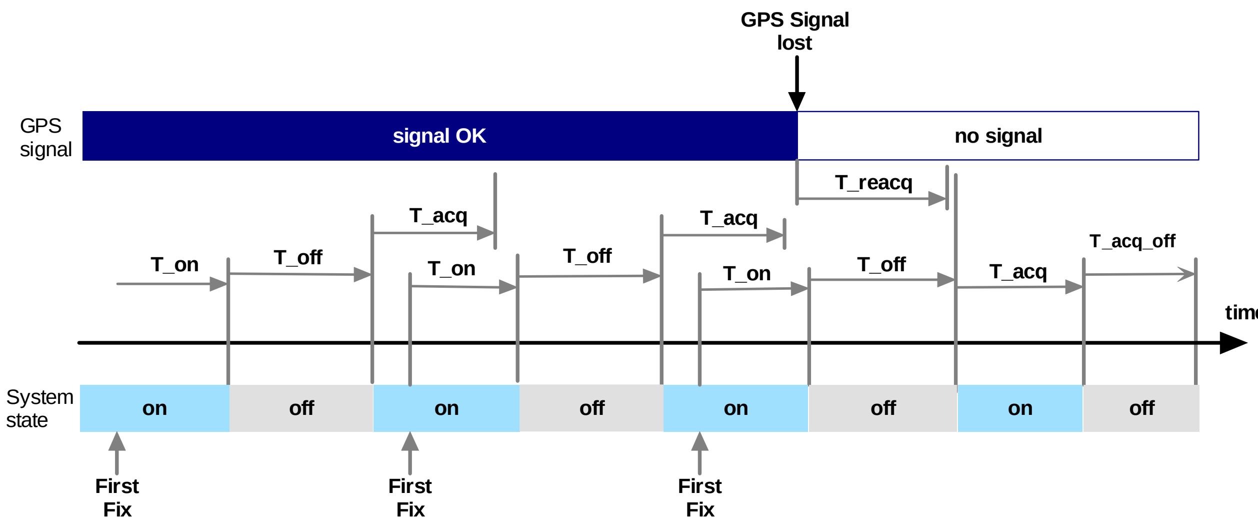


Figure 32: FXN with On/Off Time, GPS signal is lost in Full Power State

If the signal is lost during the on time, the receiver starts to reacquire the SV for **T_reacq**, if this is not successful the receiver goes to Off State for **T_reacq_off**. If T_on is reached before T_reacq is expired, the receiver goes to Off State for **T_off**. After this time the GPS will start to acquire SV as a normal start up.

! Note If **T_reacq** is longer than **T_on** a reacquisition timeout will never happen, because **T_on** overrules **T_reacq**.

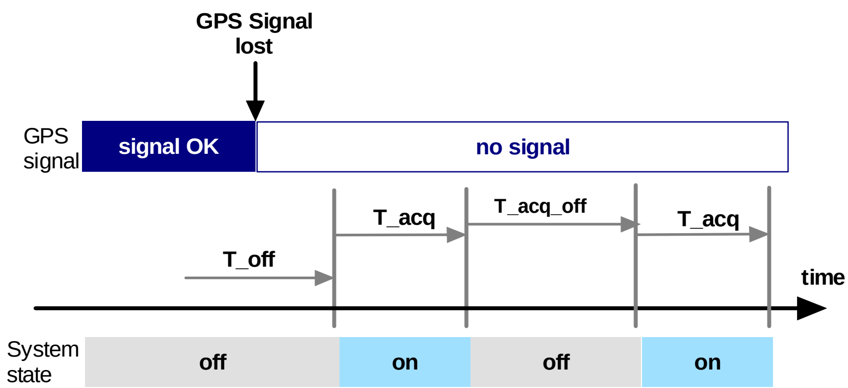


Figure 33: FXN with On/Off Time, GPS signal is lost in Full Power State

Example				
Use on/off time	Enabled			
T_on [s]	0 (= one valid fix)		**T_off [s]**	60
Absolute align	Disabled		Base TOW [s]	Not used
T_acq [s]	60		**T_acq_off [s]**	120
T_reacq [s]	5		**T_reacq_off [s]**	60
Use search pass	Disabled		Search passes	Not used
Operation				
As long as there is good GPS coverage, the receiver will perform PVT solutions for **T_on**, then switches to the sleep state for **T_off** (60 seconds). If – during the on time - there is loss of signal for **T_reacq** (5 seconds, before **T_on** expires), the receiver will shut down for **T_reacq_off** (60 seconds). After that off time, the receiver will try to find the signal for **T_acq** (60 seconds). If that fails it will shut down for another **T_acq_off** (2 minutes).				

Table 14: Example settings FXN with On/Off Time

! Note If **T_on** is set to 0s, the receiver will enter Off State as soon as the Position Accuracy is below the **P Accuracy Mask** (see also 4.5.8.1). For an improved accuracy, increase **T_on** by a few seconds.

4.2.4.8 FXN with On/Off Time and absolute Alignment

This mode's operation is equivalent to "**FXN With On/Off Time"**, but the receiver will align on- and off time to an absolute TOW-based (GPS time) time grid after the first successful fix.

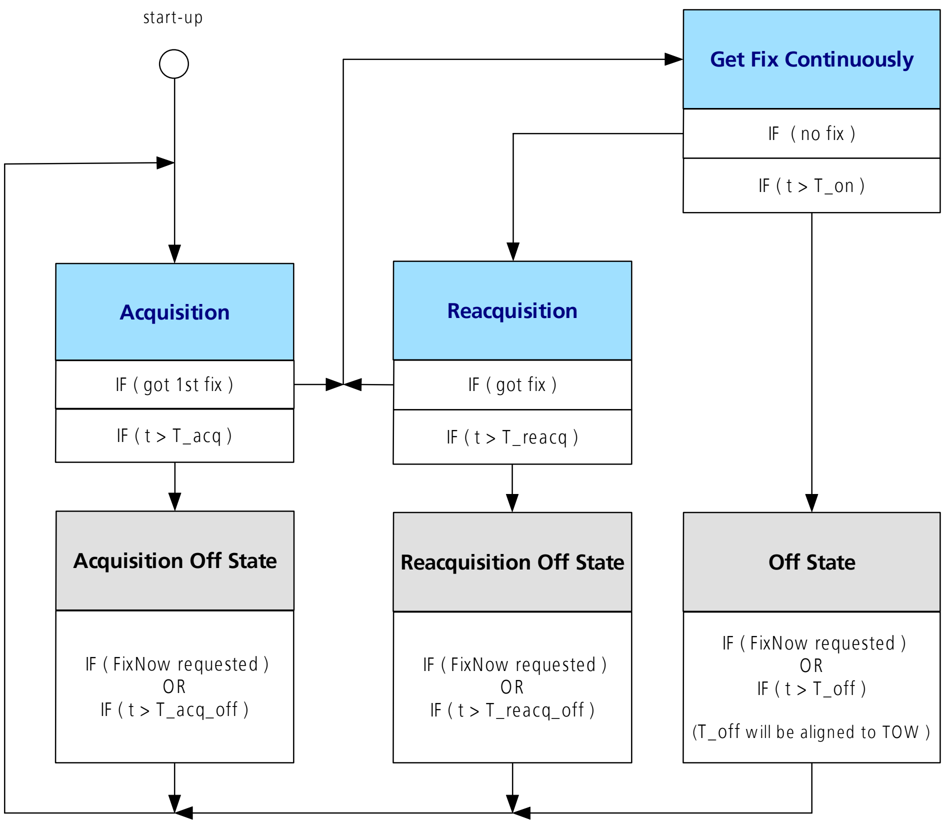


Figure 34: Simplified state diagram FXN With On/Off Time and absolute alignment

The parameter **T_off** has a slightly different meaning compared to the non-aligned FixNOW™ mode. It is the time grid unit rather than the off time. **T_on** is still the time the receiver operates in Full Power State and output valid position fixes. **Base TOW** is the parameter, which shifts the time grid relative to TOW 0.

The TOW count begins with the value 0 at the beginning of the GPS week (transition period from Saturday 23:59:59 hours to Sunday 00:00:00 hours).

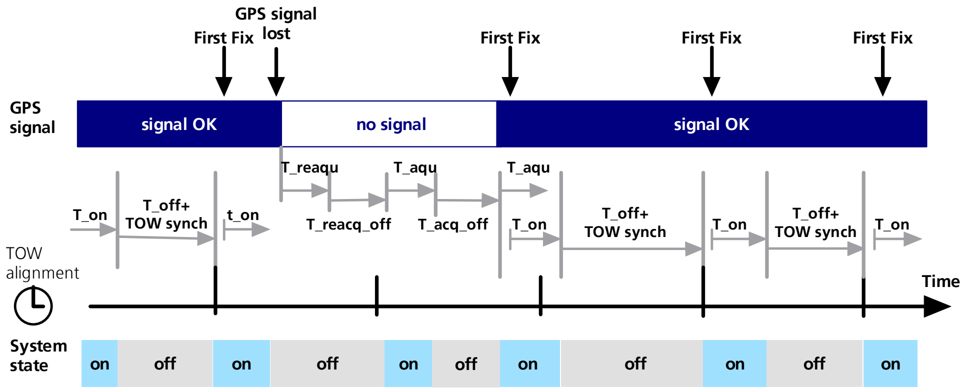


Figure 35: FXN With On/Off Time and absolute alignment after a first fix

! **Note:** If the division of number of seconds a week (604800) by **T_off** isn't an integer value, at the end of the week the Off Time be shorter than **T_off**. This is caused by the synchronisation of the wake up time to TOW.

Example				
Use on/off time	Enabled			
T_on [s]	0 (= one valid fix)		**T_off [s]**	86'400 (=24 hours)
Absolute align	Enabled		**Base TOW [s]**	43'200 (=12 hours)
T_acq [s]	60 (=1 minute)		**T_acq_off [s]**	120 (=2 minutes)
T_reacq [s]	5		**T_reacq_off [s]**	60
Use search pass	Disabled		Search passes	Not used
Operation				
The receiver will wake up once a day at 12:00 GPS and perform one position fix.				

Table 15: Example settings FXN With On/Off Time and absolute Alignment

! **Note** If **T_on** is set to 0s, the receiver will enter Off State as soon as the Position Accuracy is below the **P Accuracy Mask** (see also 4.5.8.1). For an improved accuracy, increase **T_on** by a few seconds.

4.2.5 FixNOW™, Application Examples

The FixNOW™ (FXN) screen in u-center AE holds three templates (example parameter sets) based on the FixNOW™ Mode (FXN), providing an insight to the power of this feature.

1. Mobile Device Set: Power optimized GPS usage
2. Asset Tracking Unit Set: Sleeping unit but allows position information on request
3. Schedule Fix Set: As Asset Tracking Unit but with position information aligned to a fix time
4. User Set: Is selected as soon as any of the predefined settings are changed

4.2.5.1 FXN, Mobile Unit Set

The Mobile Device Set is typical for any portable device that is carried around and moved sometimes into an obstructed view. For these applications power saving is critical. For pedestrian applications update rates are typically low and the user often stays in areas with obstructed view. In order to save power the device will sleep, if no satellites are visible and only wakeup after a predefined time for another acquisition attempt to acquire the SVs.

The device will check the satellite signal at startup and switch off if there are no satellites in view. When satellites are in view the device will get a fix and continuously deliver a fix. If the satellite signal disappears the device will try to reacquire them. After a predefined time, the receiver enters a sleep state to save energy. The receiver will exit the sleep state upon assertion of the FixNOW™ signal or after the predefined timeout has expired.

Default values				
use on/off time	Disabled			
T_on [s]	Not used		T_off [s]	Not used
absolute align	Disabled		Base TOW [s]	Not used
T_acq [s]	120		T_acq_off [s]	180
T_reacq [s]	120		T_reacq_off [s]	180
Use search pass	Disabled		search passes	Not used
Operation				
Whilst there is good GPS coverage, the receiver will keep running				
If there is loss of signal for **T_reacq** (120 seconds), the receiver will shut down for **T_reacq_off** (180 seconds). After that off time, the receiver will try to find the signal for **T_acq** (120 seconds). If that fails it will shut down for another **T_acq_off** (180 seconds).				
No GPS signal acquire-interval				
No GPS signal sleep-interval				

Table 16: Default settings for FXN, Mobile Unit Set

! Note The Mobile Unit Set is based on *FXN without On/Off Time.*

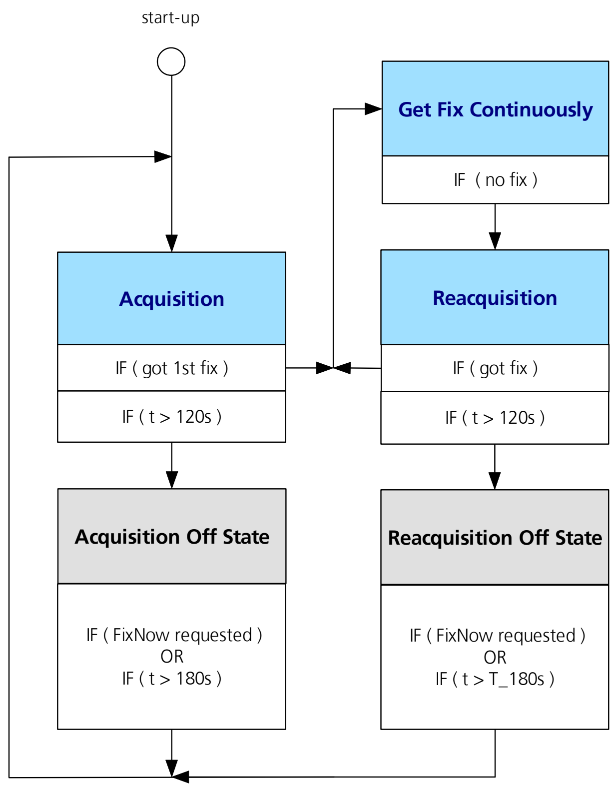


Figure 36: Simplified state diagram FXN, Mobile Unit Set

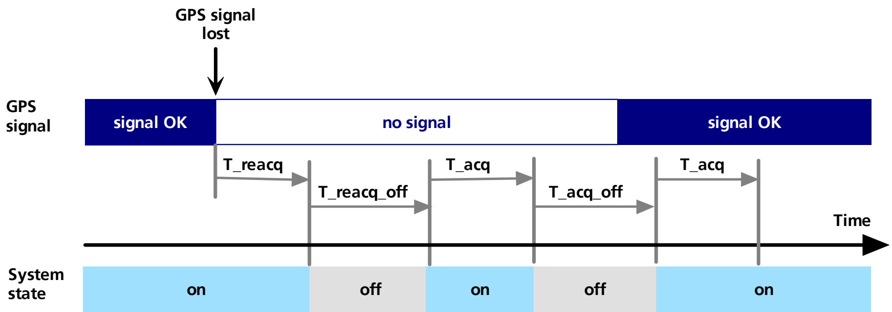


Figure 37: Time diagram FXN, Mobile Unit Set

4.2.5.2 FXN, Asset Tracking Unit Set

Asset Tracking Unit Set is used for a device that needs to deliver a position at a predefined interval rather than a continuous position. Compared to the FXN, Mobile Set, the Asset Tracking Unit Set offers additional functionality. When GPS signals are available, the receiver operates for a predefined duration providing a continuous fix, the unit then goes to the off state for a defined duration, then wakes up and starts acquiring the satellites again.

! **Note** The Asset Tracking Unit Set is based on *FXN with On/Off Time*.

Default values				
use on/off time	Enabled			
T_on [s]	0[5] (= one valid fix)		T_off [s]	1800
absolute align	Disabled		Base TOW [s]	Not used
T_acq [s]	120		T_acq_off [s]	600
T_reacq [s]	120		T_reacq_off [s]	600
Use search pass	Disabled		search passes	Not used

Operation

As long as there is good GPS coverage, the receiver will perform good PVT solutions for **T_on** (0 seconds = 1 position fix), then sleeps for **T_off** (1800 seconds).

Explanation for T_on > T_reacq (this example)**:**

As **T_on** (0 seconds) is always shorter than **T_reacq** (120 seconds), the reacquisition functionality is not used. The receiver always stays on for **T_on**.

Explanation for T_on > T_reacq:

If the GPS signal gets lost for **T_reacq** during an on time, the receiver will shut down for **T_reacq_off**. After this, the receiver will try to acquire the signal for **T_acq**. If this fails it will shut down for **T_acq_off**.

Table 17: Default settings for FXN, Asset Tracking Unit Set

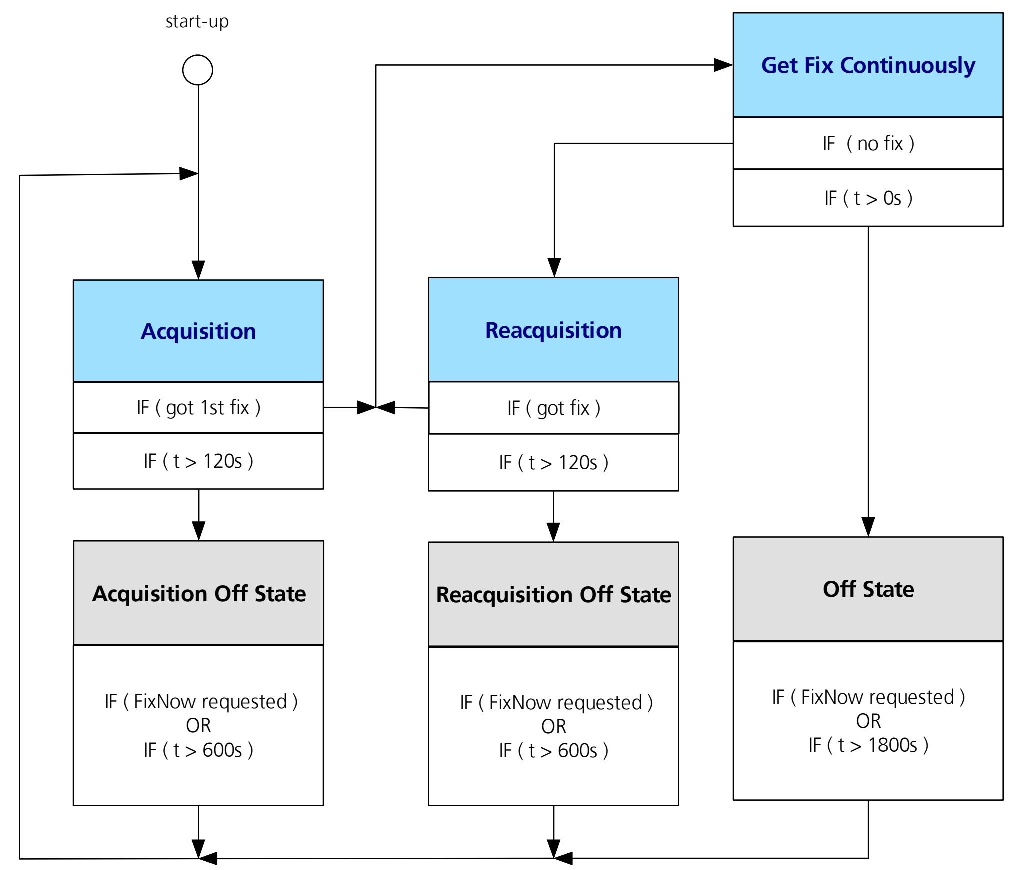


Figure 38: Simplified state diagram FXN, Asset Tracking Unit Set

5 Increasing T_on will improve the position accuracy.

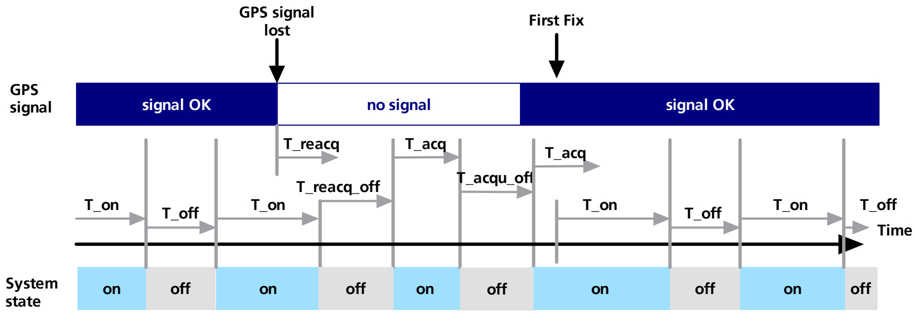


Figure 39: Time diagram FXN, Asset Tracking Unit Set

4.2.5.3 FXN, Scheduled Fix Set

Scheduled Fix Set allows the definition a specific time synchronized to time of week (TOW) time to wake up the receiver. The Startup of the receiver is aligned to GPS TOW.

! Note The Scheduled Fix Set is based on *FXN with On/Off Time and absolute Alignment.*

Default values				
use on/off time	Enabled			
T_on [s]	0[6] (= one valid fix)		**T_off [s]**	1800
absolute align	Enabled		**Base TOW [s]**	0
T_acq [s]	120		**T_acq_off [s]**	3600
T_reacq [s]	120		**T_reacq_off [s]**	3600
Use search pass	Disabled		**search passes**	Not used
Operation				
Works like the Asset tracking unit set with the following differences: The off-time is now aligned to TOW (GPS time), so the first scheduled wake-up time starts at: TOW alignment time: 0*1000ms = 0:00:00 h GPS time Next scheduled wake up time would be at: T_off + TOW alignment time: 1800*1000ms+0*1000ms = 0:30:00 h GPS time This would repeat every **T_off** (1800 seconds).				

Table 18: Default settings for FXN, Scheduled Fix Set

[6] Increasing T_on will improve the position accuracy.

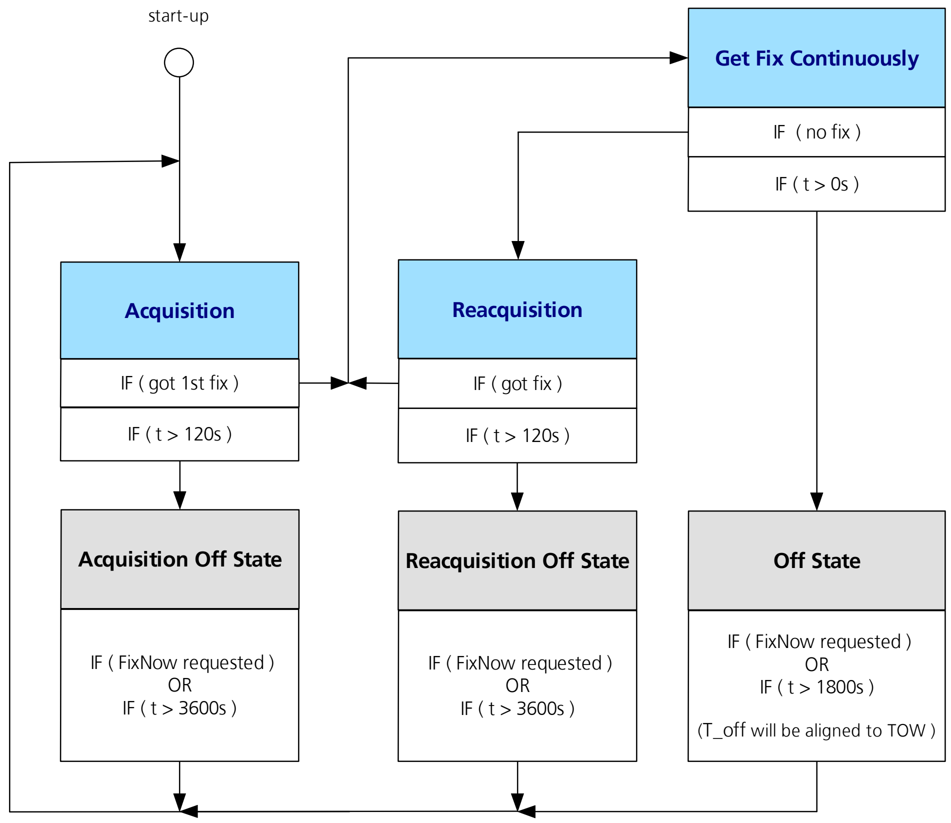


Figure 40: Simplified state diagram FXN, Scheduled Fix Set

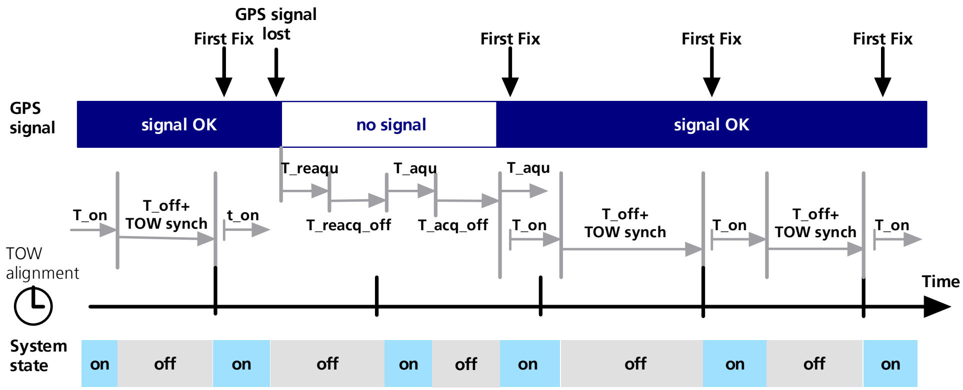


Figure 41: Time diagram FXN, Scheduled Fix Set

4.2.6 Externally Controlled Power Management

When controlling power of the GPS Receiver from externally, it's necessary to monitor the Real Time Clock Status in UBX – MON (Status) – HW (Hardware Status). The Real Time Clock Status indicates whether the internal RTC is calibrated or not. A calibrated RTC is required to achieve minimal startup time.

4.3 Serial Communication

The ANTARIS® GPS Technology comes with a highly flexible communication interface. It supports both the NMEA and the proprietary UBX protocol and is able to accept differential correction data (RTCM). It is truly multi-port and multi-protocol capable. Each protocol (UBX, NMEA, RTCM, custom protocol) can be assigned to several ports at the same time (multi-port capability) with individual settings (e.g. baudrate, messages enabled, etc.) for each port. It is even possible to assign more than one protocol (e.g. UBX protocol and NMEA) to a single port (multi-protocol capability), which is particularly useful for debugging purposes.

Use the UBX proprietary messages UBX – CFG (Config) – PRT (Port) to activate a protocol (UBX, NMEA, RTCM) on a port and UBX - CFG (Config) – MSG (Message) to activate a specific Message on a serial port and define the output rate (see *ANTARIS® GPS Technology Protocol Specifications [8])*. Every protocol can be activated on several ports if required.

4.3.1 USART Ports

TIM-LP and TIM-LF feature two universal synchronous/asynchronous receiver/transmitters (USART) ports (**RxD1/TxD1** and **RxD2/TxD2**) that can be used to transmit GPS measurements, monitor status information and configure the receiver. The TIM-LC only supports one serial port (**RxD1/TxD1**).

Using the following functionality of the serial port requires the *ANTARIS® Software Customization Kit:*

- Synchronous serial interfacing using the additional pins **SCK0 SCK1** and **SCK2** as synchronous serial clocks.
- SPI Interface

All serial interface signals (Port1: **TxD1**, **RxD1**; Port2: **TxD2**, **RxD2**) operate on 3V CMOS signal levels. External line transceivers (e.g. MAX3232) are necessary to provide RS 232 compatible signal levels.

The serial ports consist of a RX- and a TX line. No handshaking- or hardware flow control signals are available. These serial ports operate in asynchronous mode. Supported Baud Rates are:

Possible Asynchronous Serial Interface Configurations		Data bit	Parity bit	Stop bit
Baud rate	4'800 9'600 19'200 38'400 57'600 115'200	8	N	1

Table 19: USART configuration

The baud rates can be set individually for each Serial Port. Different baud rates for RX and TX or for different protocols on the same port are not supported.

A normal data transmission (with a configuration of 8 Data bits, No Parity, 1 Stop bit, usually short named '**8N1**') of a single byte looks as follows:

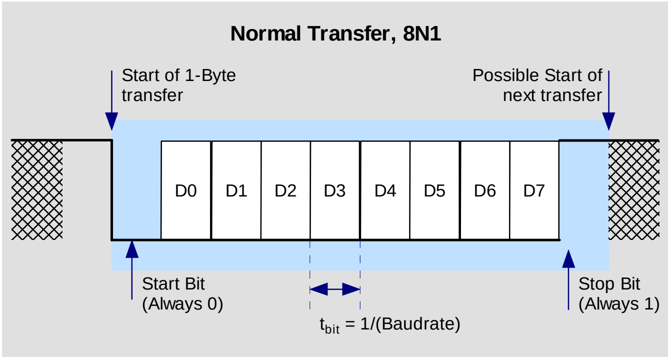


Figure 42: Definition USART data packets

4.3.1.1 Error Conditions on USART Ports

On the receiving side, the Serial Port can detect and report the following error conditions:

Framing Error

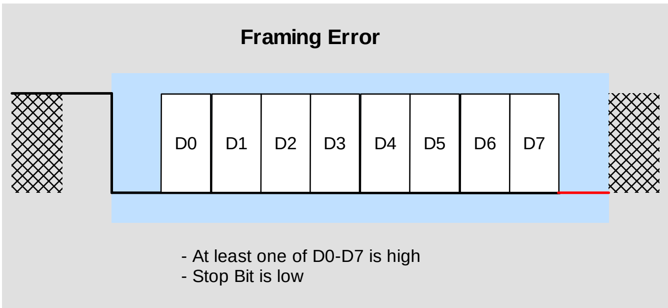


Figure 43: USART framing error

Break

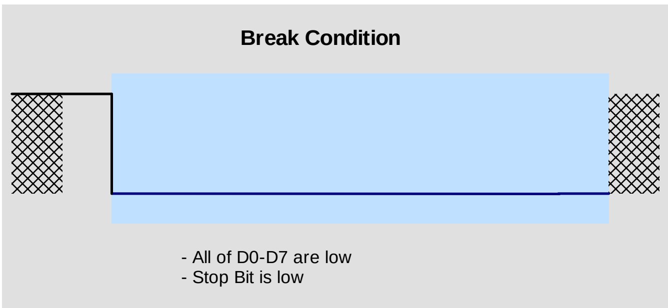


Figure 44: USART break condition

Please note that for protocols such as NMEA or UBX, it does not make sense to change the default values of Word Length or Bit Order, since these properties are defined by the protocol, not by the electrical interface.

! **Note** If the baudrate is insufficient to transmit all enabled messages, some messages may be discarded and not transmitted. The receiver does not check whether a message will be transmitted completely in the remaining time. Discarded messages won't be transmitted in the next sequence.

4.3.1.2 Autobauding

The user can individually configure each port to use an autobauding mechanism. This mechanism gets active if the receiver indicates an error when receiving data.

- If multiple break conditions are encountered, the baud rate of the serial port is reduced to the next lower standard baud rate
- If the receiver detects multiple framing errors, the baud rate is increased to the next higher standard baud rate.

! **Warning** Don't use the u-center AE autobauding feature if the GPS receiver autobauding is enabled.

! **Warning** Some serial port cards/adapters frequently generate errors. The u-center autobauding may not work reliably in this case. If you experience frequent errors, please set the baud rate manually.

4.3.1.3 Synchronous- and other Special-Purpose Operations of the USARTs.

The USART can also be operated in synchronous mode. In this mode, a clock signal (**SCK1** for Port1, **SCK2** for Port2), synchronous with the data bit timing, is output or input. This operation however is not supported by standard firmware. This function is only available with the *ANTARIS® Software Customization Kit (SCKit)*

4.3.1.4 SPI Interface

The standard software does not support this interface. The SPI port of the ANTARIS® GPS Receiver is an alternative function of the unit and can only be configured with the *ANTARIS® Software Customization Kit (SCKit).*

The Serial Peripheral Interface, SPI is basically a three-wire serial bus for eight or sixteen bit data transfer applications. The three wires carry information between devices connected to the bus. Each device on the bus acts simultaneously as transmitter and receiver. Two of the three lines (**MOSI** and **MISO**) transfer data (one line for each direction) and the third is a serial clock (**SCK**). Some devices may be only transmitters while others act as receivers only. In general, a device that transmits data is usually able to receive data as well. A SPI display is an example of a receive-only device while EEPROM is a receive-and-transmit device.

Find more information in the documentation of the *ANTARIS® Software Customization Kit (SCKit).*

4.3.2 UBX Binary Protocol

The u-blox GPS Receivers use a u-blox proprietary protocol to transmit GPS data to a host computer using asynchronous RS232 ports. This proprietary protocol has the following key features:

- Compact. 8 Bit binary data is used
- Checksum protected, using a low-overhead checksum algorithm
- Modular, using a 2-stage Message Identifier (Class- and Message ID)

! **Note** UBX protocol offers a greater flexibility and more powerful messages than NMEA protocol. It's optimized to communicate with u-center to get the best performance and optimal debugging.

4.3.2.1 UBX Packet Structure

A basic UBX packet looks as follows:

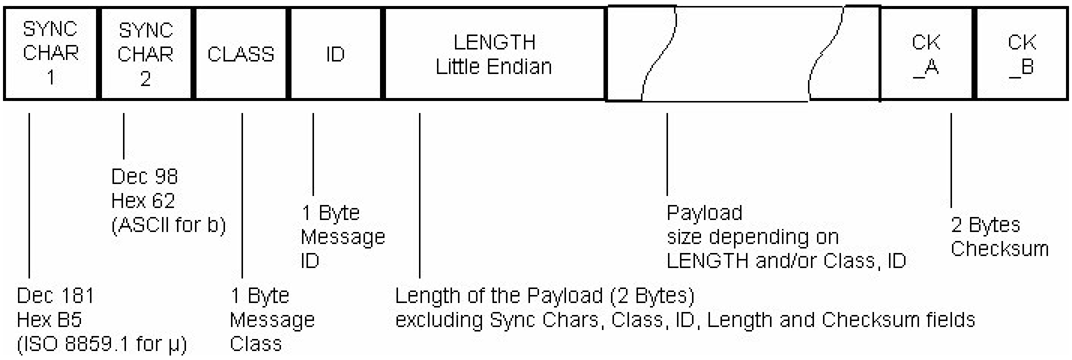


Figure 45: UBX Protocol Framing

- Every message starts with 2 Bytes: 0xB5 0x62
- A 1 Byte Class Field follows. The Class defines the basic subset of the message
- A 1 Byte ID Field defines the message that is to follow
- A 2 Byte Length Field is following. Length is defined as being the length of the payload, only. It does not include Sync Chars, Length Field, Class, ID or CRC fields. The number format of the length field is an unsigned 16-Bit integer in Little Endian Format.
- The Payload is a variable length field.
- CK_A and CK_B is a 16 Bit checksum whose calculation is defined below.

4.3.2.2 UBX Message Class

A Class is a grouping of messages, which are related to each other. The following table gives the short names, description and Class ID Definitions.

Class ID	Class Name	Class No	Description	Examples
NAV	Navigation	0x01	Navigation Results	Position, Speed, Time, Acc, Heading, DOP, SVs used
RXM	Receiver Manager	0x02	Receiver Manager Messages	Pseudo Ranges, avg. C/N0, Channel STATUS
INF	Informative	0x04	Printf-Style Messages	Error, Warning, Notice
ACK	Acknowledgement	0x05	Reply to CFG Input Messages	Ack / Nack
CFG	Configuration	0x06	Receiver Configuration Input	Set Dynamic Model, Set DOP Mask
UPD	Update	0x09	Firmware Update Messages	
MON	Monitor	0x0A	ANTARIS® Monitor	Stack Usage, CPU Load, Communication, IPC and task status
AID	Aiding	0x0B	Navigation Aiding	Position, Time, Ephemeris, Almanac feeds
USR	User	0x4x	SCK Customer Messages	SCK Customer Messages
TIM	Timing	0x0D	Timing	Timepulse data, Time mark data

Table 20: UBX Message Class

! **Note:** All remaining class IDs are reserved

4.3.2.3 UBX Payload

Structure Packing

Values are placed in an order that structure packing is not a problem. This means that 2-Byte values shall start on offsets, which are a multiple of 2, 4-byte values shall start at a multiple of 4, and so on. This can easily be achieved by placing the largest values first in the Message payload (e.g. R8), and ending with the smallest (i.e. one-byters such as U1) values.

Message Naming

Adding the class name and a dash in front of the message name does referring to messages. For example, the ECEF-Message is referred to as NAV-POSECEF. Adding a dash and the name, e.g. NAV-POSECEF-X, does referring to values.

Number Formats

All multi-byte values are ordered in Little Endian manner, unless mentioned otherwise. All floating-point values are transmitted in IEEE754 single or double precision. A technical description of the IEEE754 format can be found in the Answer Book from the ADS1.x (ARM Developers Suite) toolkit.

The following table gives information about the various values:

Number Formats					
Short	**Type**	**Size (Bytes)**	**Comment**	**Min/Max**	**Resolution**
U1	Unsigned Char	1		0..255	1
I1	Signed Char	1	2's complement	-128...127	1
U2	Unsigned Short	2		0..65535	1
I2	Signed Short	2	2's complement	-32768...32767	1
U4	Unsigned Long	4		0..4'294'967'295	1
I4	Signed Long	4	2's complement	-2'147'483'648... 2'147'483'647	1
R4	IEEE 754 Single Precision	4		-1*2^+127…2^+127	~Value * 2^-24
R8	IEEE 754 Double Precision	8		-1*2^+1023...2^+1023	~Value * 2^-53
CH	ASCII / ISO 8859.1 Encoding	1			

Table 21: Internal Field Number Formats

UBX Checksum

The checksum is calculated over the packet, starting and including the CLASS field, up until, but excluding, the Checksum Field:

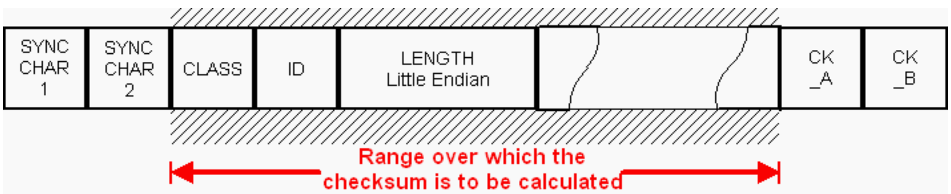


Figure 46: UBX Checksum range

The checksum algorithm used is the 8-Bit Fletcher Algorithm, which is being used in the TCP standard (RFC 1145). This algorithm works as follows:

Buffer[N] contains the data over which the checksum is to be calculated.

The two CK_ values are 8-Bit Unsigned Integers, only! If you implement it with larger-sized integer values, make sure to mask both **CK_A** and **CK_B** with **0xFF** after both operations in the loop.

```
CK_ A = 0, CK_B = 0;
For(i=0; i<N; i++)
{
   CK_A = CK_A + Buffer[i];
   CK_B = CK_B + CK_A;
}
```

After the loop, we end up having two UINT8 values, which are transmitted at the end of the packet.

4.3.2.4 UBX Message Flow

There are certain features associated with the messages being sent back and forth:

- Acknowledgement
  When messages from the Class CFG are sent to the receiver, the receiver will send an Acknowledge or a Not Acknowledge message back to the sender, depending on whether or not the message was processed correctly.
- Polling Mechanism
  All messages that can be output by the receiver can also be polled.

There is not a single specific message, which polls any other message. The UBX protocol was designed, that when sending a message with no payload (or just a single parameter which identifies the poll request) the message is polled.

To configure UBX output messages to a specific repetition rate use UBX-CFG-MSG.

4.3.2.5 UBX Valid Flag (Position Fix Indicator)

UBX protocol provides status information in abundance. Table 22 lists the position fix flags:

Status Field	Message	Enumeration	Description
GPSfix	NAV-STATUS	0x00	No Fix
	NAV-SOL	0x01	Dead Reckoning only
		0x02	2D-fix
		0x03	3D-fix
		0x04	GPS + Dead Reckoning combined[7]
Flags	NAV-STATUS	0x01	GPS fix OK (i.e. within PDOP & Position Accuracy Masks)
	NAV-SOL	0x02	DGPS used
		0x04	Week Number valid
		0x08	Time of Week valid

Table 22: UBX Valid Flags (Position Fix Indicator)

A position fix shall be treated as valid, if 'GPSfix' reports either a '2D-fix' or a '3D-fix' and 'Flags' indicates 'GPS fix OK' or 'DGPS used'.

For DR enabled receivers a position fix shall be treated as valid if 'GPSfix' reports either a 'GPS + Dead Reckoning combined' or 'Dead Reckoning only' and 'Flags' indicates 'GPS fix OK'.

[7] Requires TIM-LR or SBR-LS

4.3.2.6 UBX Status Information

For debugging purposes, additional status information is available in UBX protocol:

Status Field	Message	Enumeration / Unit	Description
Pacc	NAV-SOL NAV-POSECEF	cm	3D Position Accuracy Estimate
SAcc	NAV-SOL NAV-VELECEF NAV-VELNED	cm/s	Speed Accuracy Estimate
CAcc	NAV-VELNED		Course / Heading Accuracy Estimate
Hacc		cm	Horizontal Accuracy Estimate
Vacc		cm	Vertical Accuracy Estimate
TAcc	NAV-TIMEGPS NAV-TIMEUTC	ns	Time Accuracy Estimate
PDOP	NAV-SOL NAV-DOP	-	Position DOP
numSV	NAV-SOL	-	Number of SVs used in Nav Solution
DiffS	NAV-STATUS		Bits [1:0] - DGPS Input Status • 00: none • 01: PR+PRR Correction • 10: PR+PRR+CP Correction • 11: High accuracy PR+PRR+CP Correction
TTFF	NAV-STATUS	ms	Time to first fix (millisecond time tag)
MSSS	NAV-STATUS	ms	Milliseconds since Startup / Reset
Valid (Time)	NAV-TIMEGPS NAV-TIMEUTC	0x01 0x02 0x04	Valid Time of Week Valid Week Number Valid UTC (Leap Seconds known)

Table 23: Status Information in UBX Protocol

For further information about the UBX messages, refer to the *ANTARIS® GPS Technology Protocol Specifications* [8].

4.3.3 NMEA Protocol

The NMEA protocol is an industry-standard protocol that was developed for marine electronics and was originally designed to allow data exchange between various sensors and navigation equipment aboard ships. Nowadays, it is a de-facto standard for GPS receiver data output. For further information on the NMEA Standard please refer to "NMEA 0183 Standard For Interfacing Marine Electronic Devices", Version 2.300, March 1, 1998. The full specification of the protocol is available from the National Marine Electronics Association at http://www.nmea.org.

! Note UBX protocol offers a greater flexibility and more powerful messages than NMEA protocol. It's optimized to communicate with u-center to get the best performance and optimal debugging.

4.3.3.1 NMEA Protocol Overview

The NMEA protocol is an ASCII-based protocol. Records start with a `$` and end with carriage return/line feed. GPS specific messages all start with `$GPxxx` where xxx is a three-letter identifier of the message data that follows. NMEA messages have a checksum, which allows detection of corrupted data transfers. *Figure 47* shows the structure of a NMEA protocol message.

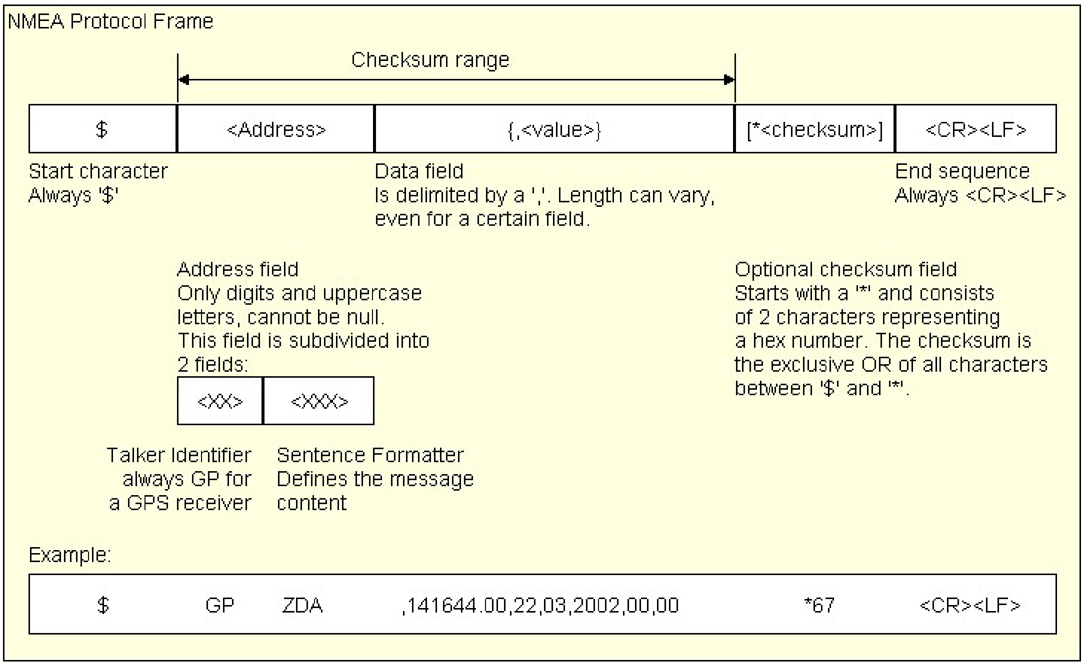


Figure 47: NMEA Protocol Framing

NMEA messages supported by the ANTARIS® GPS Technology

The ANTARIS® GPS Technology supports NMEA-0183, version 2.3. This is upward compatible with NMEA-0183 version 3.0. The NMEA protocol does not take advantage of all the features of the ANTARIS® GPS Technology, due to bandwidth limitations of the ASCII-protocol.

- Standard NMEA
  - GGA - Global positioning system fix data
  - GLL - Geographic position - latitude/longitude
  - GSA - GNSS DOP and active satellites
  - GSV - GNSS satellites in view
  - RMC - Recommended minimum specific GNSS data
  - VTG - Course over ground and ground speed
  - GRS - GNSS range residuals
  - GST - GNSS pseudo range error statistics
  - TXT – Text messages
  - ZDA - Time and date

The NMEA standard allows for proprietary, manufacturer-specific messages to be added. These shall be marked with a manufacturer mnemonic. The mnemonic assigned to u-blox is UBX and is used for all non-standard messages.

- Proprietary NMEA:
  - PUBX,00 - Navstar Position (Lat/Long)
  - PUBX,01 - Navstar Position (UTM)
  - PUBX,02 - Navstar Position (Local Grid)
  - PUBX,03 - Navstar Satellite Information
  - PUBX,04 - Navstar Time & Clock Information
  - PUBX,40 - Set NMEA message output rate
  - PUBX,41 - Set Protocols and Baudrate

- Queries
  - GPQ - Polls a standard message
  - PUBX - Polls a PUBX message

For further details, see ANTARIS® GPS Technology Protocol Specifications [8].

4.3.3.2 NMEA Valid Flag (Position Fix Indicator)

A position fix is declared as valid if all of the conditions below are met:

- Position fix with at least 3 satellites (2D or 3D fix). In order to ensure a good accuracy, the ANTARIS® GPS Technology does not support 1D fixes.
- The '3D Position Accuracy Estimate' needs to be below the 'Position Accuracy Mask'
- The PDOP value needs to be below the 'PDOP Accuracy Mask'.

! Note The 'Position Accuracy Mask' and the 'PDOP Mask' are configurable. This allows customizing the behaviour of the valid flag to application requirements (see *Section 4.5.8*)

Table 24 lists the status fields (valid flags) for the different NMEA message:

NMEA Message	Field	No Position Fix (after power-up, after losing Satellite lock)	Valid Position Fix but User Limits exceeded	EKF[8]	2D Position Fix	3D Position Fix	Combined GPS/EKF Position Fix[9]
GGA	Status	0	0	6	1/2	1/2	1/2
		0=Fix not available/invalid, 1=GPS SPS Mode, Fix valid, 2=Differential GPS, SPS Mode, Fix Valid, 6=Estimated/Dead Reckoning					
GLL	Status	V	V	A	A	A	A
		A=Data VALID, V=Data Invalid					
	Mode Indicator	N	N	E	A/D	A/D	A/D
		N=No Fix, A=Autonomous GNSS Fix, D=Differential GNSS Fix, E=Estimated/Dead Reckoning Fix					
GSA	Nav Mode	1	1	E	2	3	3
		1=Fix Not available, 2=2D Fix, 3=3D Fix, E=Estimated/Dead Reckoning Fix					
RMC	Status	V	V	A	A	A	A
		A=Data VALID, V=Data Invalid					
	Mode Indicator	N	N	E	A/D	A/D	A/D
		N=No Fix, A=Autonomous GNSS Fix, D=Differential GNSS Fix, E=Estimated/Dead Reckoning Fix					
VTG	Mode Indicator	N	N	E	A/D	A/D	A/D
		N=No Fix, A=Autonomous GNSS Fix, D=Differential GNSS Fix, E=Estimated/Dead Reckoning Fix					

Table 24: NMEA Valid Flag

[8] Dead Reckoning receivers only
[9] Dead Reckoning receivers only

NMEA Output in case of invalid position fixes

Starting with firmware release V3.00, the ANTARIS® GPS Technology will not output data in case of invalid position fixes. By default, it will output comma-separated fields for position, velocity and time as depicted in Table 25.

Data Validity	GGA Output
Invalid time and invalid position	`$GPGGA,,,,,,0,0,99.99,,,,,,0*48`
Valid time, invalid position fix	`$GPGGA,125749.00,,,,,0,0,99.99,,,,,,0*6A`
Valid time and position fix	`$GPGGA,125822.00,4717.11387,N,00833.91113,E,1,4,2.15,498.4,M,48.0,M,,0*57`

Table 25: NMEA Output in case of invalid position fixes (Firmware ≥V3.00)

Receivers running a firmware older than V3.00 (e.g. V2.00) will output data even in case of invalid position fixes. It's up to the user to filter invalid data based on the information in the valid flag (see Table 24). It is also possible to configure receivers with a firmware ≥V3.00 to comply to the old output philosophy with the UBX-CFG-NMEA message.

4.3.4 RTCM Protocol

The RTCM (Radio Technical Commission for Maritime Services) protocol is a unidirectional protocol (input to the receiver) supplying the GPS receiver with real-time differential correction data (DGPS). The RTCM protocol specification is available from http://www.rtcm.org/.

The ANTARIS® GPS Technology support RTCM Correction Type Messages 1,2, 3 and 9.

4.4 Acquisition

At system power up the ANTARIS® GPS Software executes the initial acquisition code. This part of the GPS Software defines three different strategies:

- Coldstart
- Warmstart
- Hotstart

Depending on the amount of valid orbital information available, the receiver chooses the fastest possible startup scenario.

During the calculation of a position fix, receivers based on the ANTARIS® GPS Technology must acquire and track GPS signals. Acquisition is the process of 'locking' onto the signal. Tracking is the process of maintaining a lock on a previously acquired signal.

Tracking and Acquisition Algorithms have an associated sensitivity level at which GPS signals can be detected with a sufficiently high confidence level.

4.4.1 Coldstart Strategy

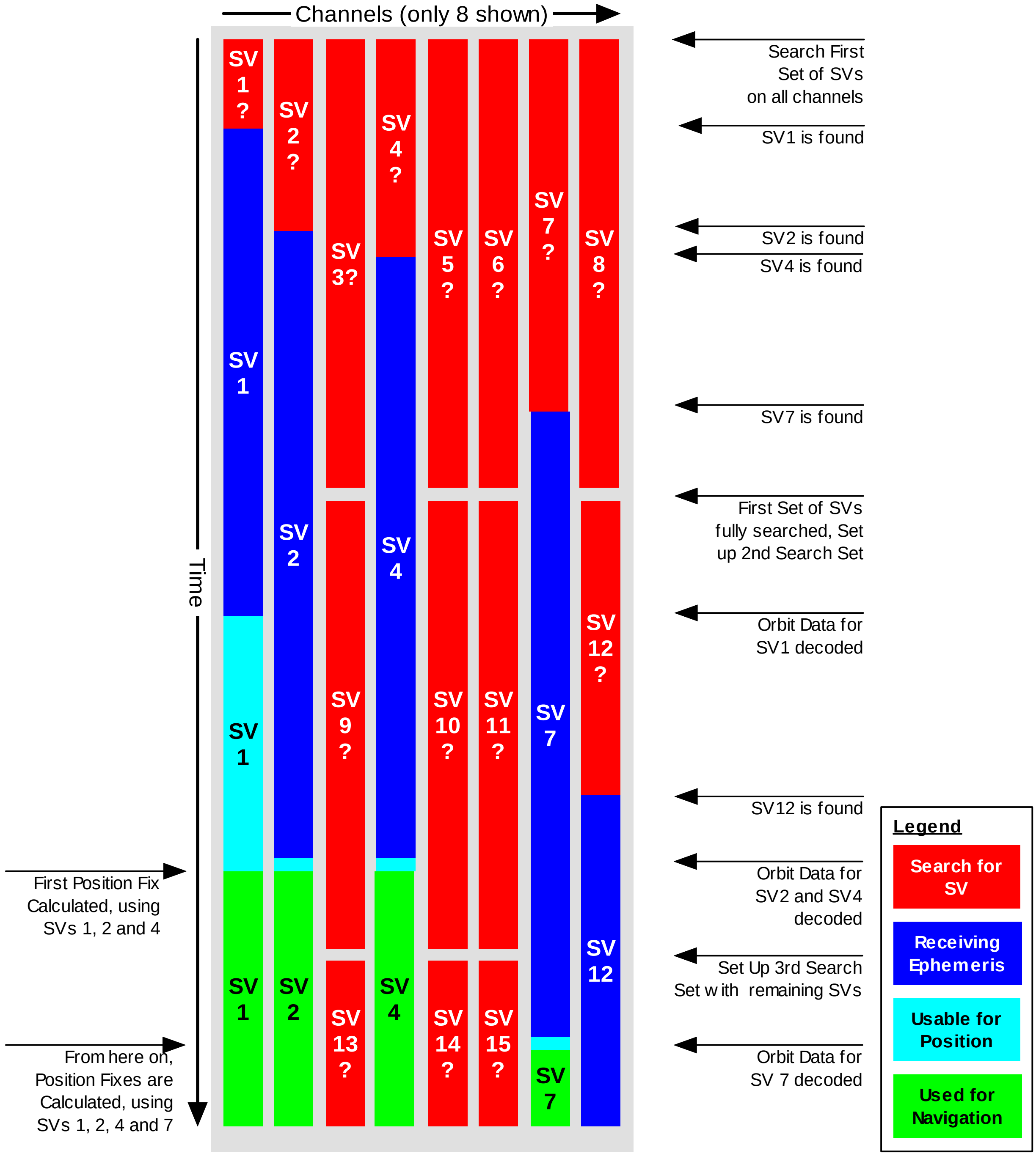


Figure 48: Typical Coldstart Scenario

In Coldstart, the receiver searches all valid SV numbers, from 1 to 32, in a predefined order. As the ANTARIS® GPS Technology has 16 channels, there are only 2 search passes needed to check all 32 satellites.

As soon as SVs are found, they are transferred to tracking and ephemeris decoding starts. Once there are sufficient SVs with valid ephemeris, position fixes are calculated and output.

4.4.2 Warmstart Strategy

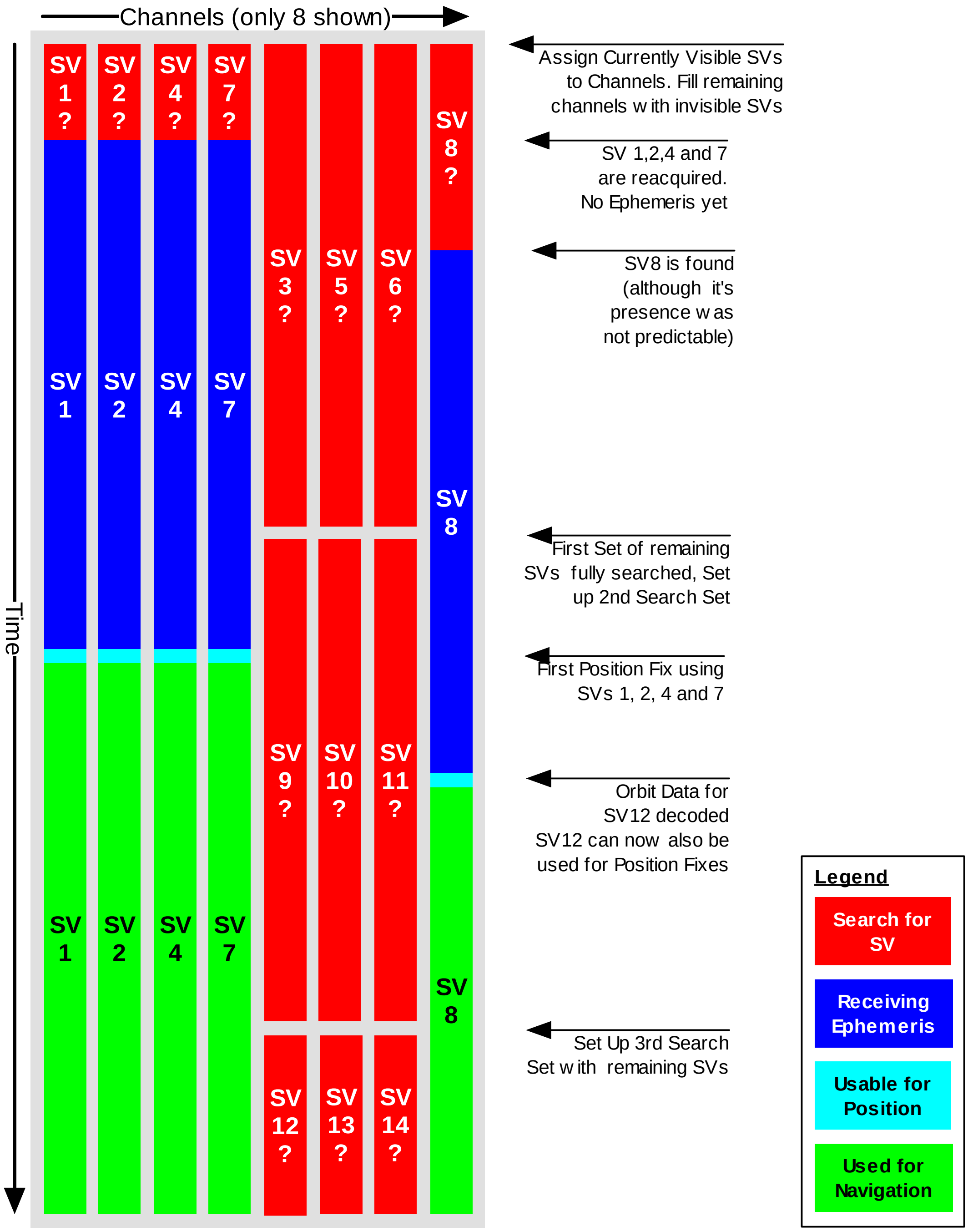


Figure 49: Typical Warmstart Scenario

In Warmstart, the receiver assigns up to 12 channels with currently visible SVs and tries to acquire them. The remaining channels will be assigned to non-visible SVs. Once sufficient SVs are found and ephemeris is decoded, the receiver starts to navigate.

4.4.3 Hotstart Strategy

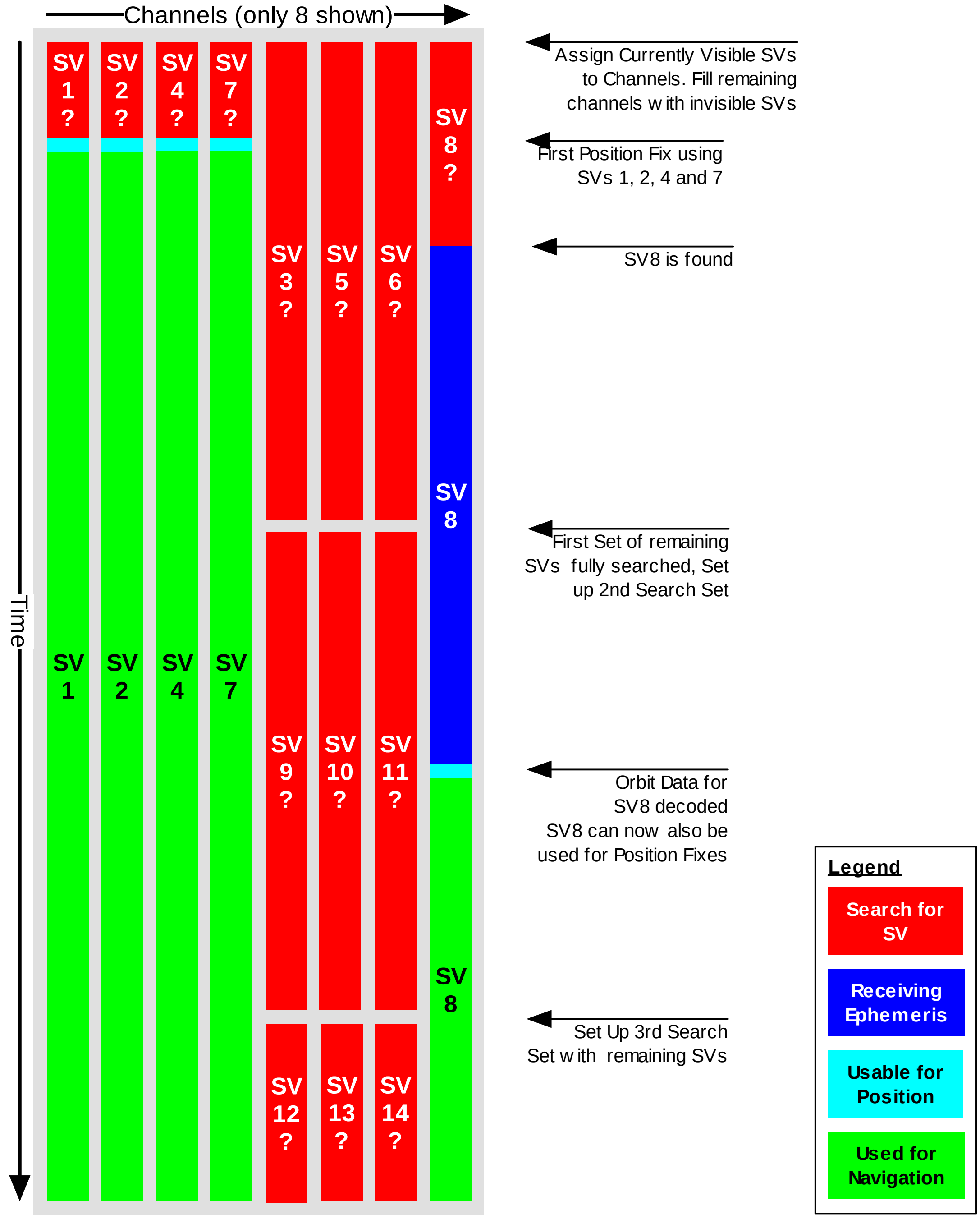


Figure 50: Typical Hotstart Scenario

In Hotstart, the receiver will assign up to 12 channels with currently visible SVs (according the available almanac data) and will try to acquire them. The remaining channels will be assigned with non-visible SVs. In Hotstart, the receiver doesn't need to download ephemeris and will start to navigate almost instantly.

4.4.4 Aiding

The ANTARIS® aiding feature allows supplying external information to improve Time To First Fix (TTFF). This is particularly useful if a receiver does not have a backup battery. Depending on the information provided the ANTARIS® GPS receiver will perform the best possible startup scenario.

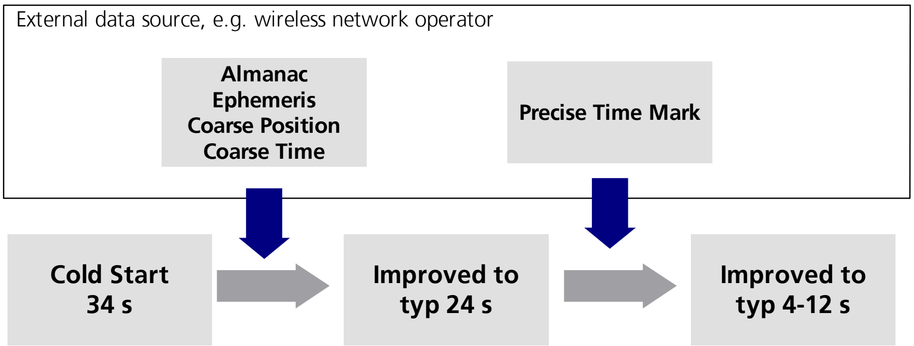


Figure 51: Aiding Principal

The startup performance depends on the accuracy and availability of the provided data:

TTFF	Required Aiding Data
Typ. **4 sec**	• Almanac or Ephemeris data • Position & Time (< 0.4 ms time-error [10]) • Hardware synchronization (i.e. with TIMEMARK)
Typ. **12 sec**	• Almanac or Ephemeris data • Position & Time (< 8 ms time-error) • Hardware synchronization (e.g. with TIMEMARK)
Typ. **24 sec**	• Almanac or Ephemeris data • Position & Time (< 2-3 s time-error)

Table 26: Aiding Startup performance

[10] The time-error for aiding is calculated with the following formula: $error_{time} = \Delta pos \bullet c + \Delta t$

4.4.4.1 Aiding - Topology

A receiver can be configured to automatically request aiding data if it detects that it has not enough information to perform a hotstart. A host system can reply to this request to speed up the startup process. If no data is received from the host, the receiver continues its normal startup strategy.

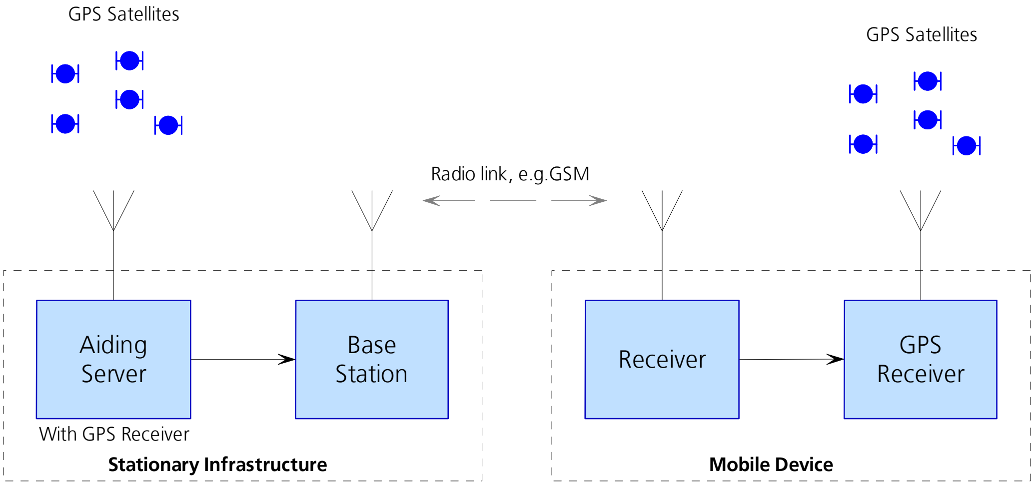


Figure 52: Aiding Topology

To configure the ANTARIS® GPS receiver to request aiding data, enable UBX - AID (Aiding) – REQ (Request) in UBX – CFG (Config) – MSG (Messages). It's a virtual message for aiding configuration purposes. If UBX-AID-REQ is activated, the receiver will request aiding data by sending a UBX - AID (Aiding) – DATA (Data) message; an aiding server will then provide the necessary aiding data.

The use of the virtual message UBX – AID – REQ is optional. The aiding data can be provided to the receiver on startup without getting a request.

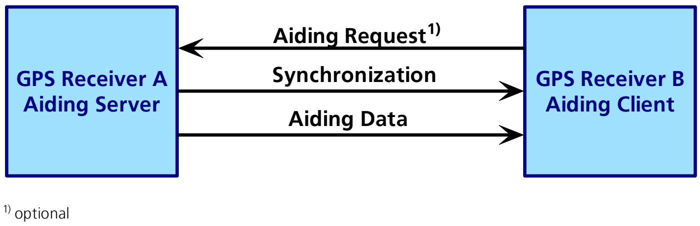


Figure 53: Aiding Setup

UBX Aiding messages

Message	Description
AID-REQ	Virtual Aiding configuration message to enable aiding request at startup.
AID-DATA	Polls all GPS Initial Aiding Data
AID-INI	Contains position, time, clock drift and validation parameters of the aiding data.
AID-HUI	Contains health bit mask, UTC time and Klobuchar parameters.
AID-ALM	Contains the almanac data of one SV.
AID-EPH	Contains the ephemeris data of one SV.

Table 27: Aiding messages

For further information about the UBX aiding messages, refer to the *ANTARIS® GPS Technology Protocol Specifications* [8].

4.4.4.2 GPS Health-, UTC and Ionosphere Parameter Aiding

The UBX – AID (Aiding) – HUI (GPS Health, UTC and Ionosphere Parameters) message is not required to achieve a good TTFF, but it helps to achieve a good position accuracy and to correct the UTC offset.

4.4.5 Sensitivity Settings (Tracking and Acquisition Modes)

For a given hardware setup (antenna and receiver), higher sensitivity can be reached by extending the integration time of the GPS signal. This means that higher sensitivity is a trade-off versus the time it takes to detect a GPS signal. Therefore, both the hardware setup and the user application determine which sensitivity mode will provide the best performance.

The ANTARIS® GPS Technology allows the sensitivity of the receiver to be modified in three steps. Namely, they are:

- **Normal** (trade off between sensitivity and time to acquire, the default setting)
- **Fast Acquisition** (optimized for fast acquisition, at the cost of 3dB less sensitivity than with the 'normal' setting)
- **High Sensitivity** (optimized for higher sensitivity, i.e. 3dB more sensitive than the 'normal' setting, at the cost of longer startup times.). This mode is primarily intended for applications with passive antennas.

The Sensitivity Setting can be changed using UBX – CFG (Config) – RXM (Receiver Manager) proprietary messages.

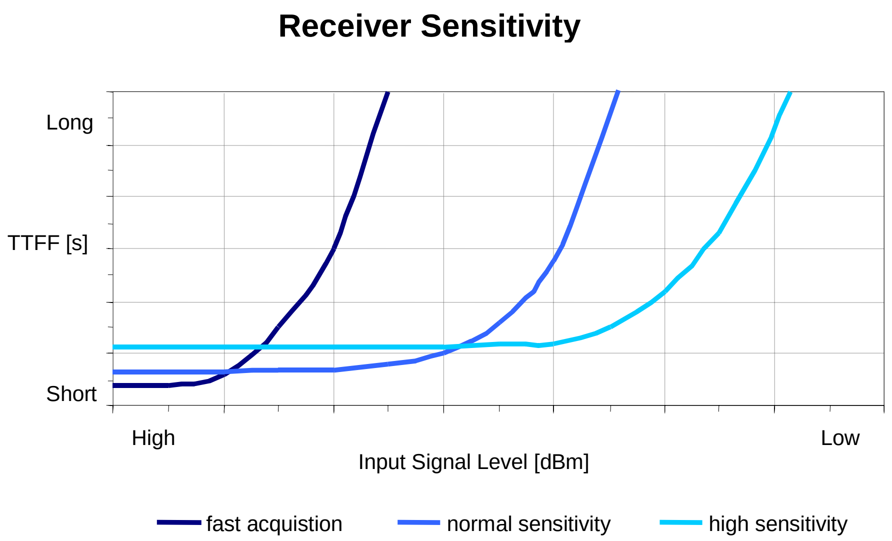


Figure 54: Receiver Sensitivity (Acquisition)

! Note Use 'Fast Acquisition' mode if the C/No ratio of the strongest SV exceeds 48dBHz. In case the C/No value of the strongest SV is below 45dBHz, use 'High Sensitivity' mode.

! Note It's not recommended to configure an ANTARIS® GPS receiver to 'High Sensitivity Mode' in designs with a built-in LNA and a high gain (25dB) active antenna.

4.5 Navigation

Once the GPS receiver is tracking enough satellites, it uses the measurements to calculate the current position. This part of the code is called Navigation Solution.

The following section discusses mainly the usage of the UBX proprietary messages UBX - CFG (Config) - RATE (Rates), UBX - CFG (Config) - DAT (Datums) and UBX - CFG (Config) - NAV (Navigation) to configure the Navigation Engine of the ANTARIS® GPS receiver. To get an optimal setting the application environment must be considered.

4.5.1 Overview

Parameter	Description
Navigation Output	The ANTARIS® GPS Technology outputs the navigation data in LLA (Latitude, Longitude and Altitude), ECEF coordinate frame or Universal Transverse Mercator (UTM) format. The LLA output can be configured to one out of more than 200 pre-defined datums, or to a user datum.
Map Datum	The ANTARIS® GPS Technology supports more than 200 different map datums (including one user specific datum) and Universal Transverse Locator (UTM)
Navigation Update Rate	The ANTARIS® GPS Technology supports navigation update rates higher than 1 update per second.
Dynamic Platform Model	Dynamic models adjust the navigation engine, tuning the GPS performance to the application environment.
Allow Almanac Navigation	Enable Almanac Navigation (without ephemeris data) as a degraded mode of the GPS receiver to realize fast fixes with reduced position accuracy.
Navigation Input Filters	Applies a mask to the input parameters of the navigation engine to filter the data input. It screens potentially poor quality data preventing its use in the navigation engine.
Navigation Output Filters	Applies a mask to the solution of the navigation engine to prevent poor quality from being output. Internally, the positions are still calculated to further track the SVs.
RAIM	Receiver Autonomous Integrity Monitoring
DGPS	Specific Differential GPS parameters

Table 28: Overview GPS Navigation Parameter

4.5.1.1 Navigation Output

The ANTARIS® GPS Technology outputs the navigation data in LLA (Latitude, Longitude and Altitude), ECEF (Earth Centered Earth Fixed) or UTM (Universal Transverse Mercator) format.

The LLA output can be configured to one out of more than 200 predefined datums or to a user datum. The default datum is WGS84. The altitude is available as height above ellipsoid (HAE). The height above mean sea level (MSL) is available if the default datum WGS84 is selected.

! **Note:** Refer to *Appendix C* for a list of all predefined datums

4.5.2 Navigation Update Rate

The ANTARIS® GPS Technology supports raw data and navigation update rates higher or lower than 1 update per second.

Parameter	Description
Measurement Period	Defines the time between two raw data (pseudo range) measurements.
Navigation Rate	Defines the navigation update rate (see formula below).
Time Source[11]	Defines whether the navigation update is aligned to GPS time or UTC.

Table 29: Navigation rate parameters

$$NavigationUpdateRate[1/s] = \frac{1000}{NavigationRate * MeasurementPeriod[ms]}$$

! **Note:** The update rate has a direct influence on the power consumption. The more fixes that are required, the more CPU power and communication resources are required.

! **Note:** The higher the dynamics of the device holding a GPS system, the faster the position update shall be.

4.5.3 Dynamic Platform Model

The ANTARIS® GPS Technology supports different dynamic platforms models to adjust the navigation engine to the expected environment. This platform settings can be changed dynamically without doing a power cycle or reset. It allows a better interpretation of the measurements and hence provides a more accurate position output. Setting the GPS receiver to an unsuitable platform model for the application environment may reduce the receiver performance and position accuracy significantly.

[11] This parameter has only an effect if the navigation update rate is less than 1 update per second (e.g. 1 update per 10s).

Platform	Description
Stationary	Timing applications (antenna must be stationary) or other stationary applications • Velocity is constrained to 0 m/s • No process noise (assuming zero dynamics)
Pedestrian	Applications with low accelerations and low speed, as any portable devices carried and moved by manpower. • Assuming low accelerations
Automotive	Used for applications that can be compared with the dynamics of a passenger car. • Assuming low process noise • Assuming low vertical acceleration
At sea	Recommended for applications at sea, with zero vertical velocity. • Assuming zero vertical velocity • Assuming low process noise
Airborne <1g	Used for applications that have to handle a higher dynamic range than a car and higher vertical accelerations. • Assuming intermediate process noise
Airborne <2g	Recommended for a typical airplane environment. • Assuming high process noise
Airborne <4g	Only recommended for an extreme dynamic environment. • Assuming high process noise

Table 30: Dynamic Platform Model

! **Note:** Dynamic platforms designed for high acceleration systems (e.g. AIRBORNE < 2G) may result in a greater standard deviation in the reported position.

4.5.4 Static Hold Mode

Starting with firmware revision V3.00, the ANTARIS® GPS Technology features a Static Hold mode. The Static Hold mode allows the navigation algorithms to decrease the noise in the position output when the velocity is below a pre-defined 'Static Hold Threshold'. This reduces the position wander caused by environmental issues such as multipath and improves position accuracy especially in stationary applications. By default, static hold mode is disabled.

Functionality

If the speed goes below the defined 'Static Hold Threshold', the position is kept constant. As soon as the rises above twice the value of the 'Static Hold Threshold', the position solution is released again.

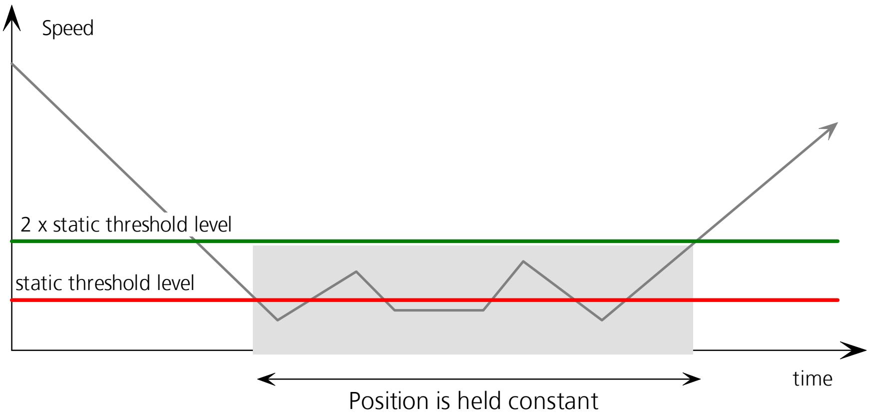


Figure 55: Static Hold Mode

! **Note:** Do not set the parameter of the Static Hold Mode too aggressive, as it may degrade the performance of the GPS receiver, when e.g. a Vehicle equipped with a ANTARIS® Receiver starts moving after a longer stop. A threshold in a range of 0.25 to 0.5 m/s will suit most of the requirements.

4.5.5 Degraded Navigation

Degraded navigation describes all navigation modes, which use less than 4 satellites.

4.5.5.1 2D Navigation

If the GPS receiver only has 3 satellites to calculate a position, the navigation algorithm uses a constant altitude to make up for the missing fourth satellite. When losing a satellite after a successful 3D fix (min. 4 SV available), the altitude is kept constant to the last known altitude. This is called a 2D fix.

! **Note** The ANTARIS® GPS Technology does not calculate any solution with a number of SVs less than 3 SV.

! **Note** If the receiver makes initial 2D LSQ fixes during acquisition, the initial altitude is set to 500m. This default setup cannot be changed.

4.5.5.2 Dead Reckoning

The implemented Dead Reckoning algorithm gets active as soon as the receiver looses all signals from the previously tracked SV's. It keeps a fix track (heading is equal to the last calculated heading) until the Dead Reckoning Timeout is reached. The position is extrapolated but it's indicated with "NoFix".

! **Note** For real Dead Reckoning GPS solutions, u-blox offers a Sensor Based GPS Receiver Technology. It allows high accuracy position solutions for automotive applications at places with poor or no GPS coverage. This technology relies on additional inputs from a gyroscope and wheel tick signals.

4.5.6 Almanac Navigation

The satellite orbit information retrieved from an almanac is much less accurate than the information retrieved from the ephemeris. If during a startup period, only almanac information is available, (e.g. while the ephemeris still is being downloaded) the receiver still is able to navigate based on almanac orbits.

With almanac navigation enabled, when a new satellite rises and its reception just has started, the receiver might use an almanac to use this satellite in the navigation solution until the ephemeris is fully retrieved. By disabling almanac navigation, the receiver does not use the almanac for navigation, but will always wait to collect the entire ephemeris information before including a satellite in the navigation solution.

With an almanac only solution the position will only have an accuracy of a few kilometers. Normal GPS performance requires at least 4 satellites included in the navigation solution, which have ephemeris information available.

Almanac navigation allows much faster start up, as there is no need to wait for the completion of the ephemeris download (>18s). This is useful whenever an inaccurate position is better than no position (e.g. emergency or security devices).

! **Note** The almanac information is NOT used for calculating a position, if valid ephemeris information is present, regardless of the setting of this flag. But the almanac information is needed to acquire the SV when there is no ephemeris data available.

! **Note** Refer to *Section 4.5.8* for information on how to filter any position solutions with high deviation caused by enabling almanac navigation.

4.5.7 Navigation Input Filters

Parameter	Description
Min SVs	Restricts the navigation solution to be calculated with at least n satellites. This could be used to inhibit a solution with only 3 satellites.
Max SVs	Uses at most 'n' satellites for a navigation solution.
Min C/No	Conditional lower limit for C/N0: This threshold is only applied if the number of satellites (e.g. 5) with a C/No ratio above it is sufficient to calculate a position solution. This ensures that the satellites with the highest C/No ratio are used for navigation.
Abs Min C/No	Absolute lower limit for C/N0: A satellite with a C/N0 below this limit is not used for navigation.
Min CLT	Conditional lower limit for carrier lock time (CLT): Carrier Lock Time (CLT) is the amount of time during which the receiver was able to track the carrier signal without loosing lock. This limit is applied, if and only if there are enough (e.g. 5) satellites above this limit to be able to calculate a solution.
Abs Min CLT	Absolute lower limit for carrier lock time (CLT): Carrier Lock Time (CLT) is the amount of time during which the receiver was able to track the carrier signal without loosing lock. A satellite with a CLT below this limit is not used for navigation.
Min SV Elevation	Minimum elevation of a satellite above the horizon in order to be used in the navigation solution. Low elevation satellites may provide degraded accuracy, because of the long signal path through the atmosphere.
DR (Dead Reckoning) Timeout	The time during which the receiver provides a dead reckoning solution. After the DR timeout has expired no GPS solution is provided at all.

Table 31: Navigation Input Filter parameters

The navigation input filters mask the input data of the navigation engine. These settings are optimized already. It is not recommended that changes to any parameters are made unless advised by u-blox support engineers.

4.5.8 Navigation Output Filters

Parameter	Description
PDOP Mask **P Accuracy Mask**	The PDOP and Position Accuracy Mask are used to determine, if a position solution is marked valid in the NMEA sentences or the UBX PosLimit Flag is set. A solution is considered valid, when both PDOP and Accuracy lie below the respective limits.
TDOP Mask **T Accuracy Mask**	The TDOP and Time Accuracy Mask are used to determine, when a Time Pulse should be allowed. The TIMEPULSE is disabled if either TDOP or the time accuracy exceeds its respective limit.

Table 32: Navigation Output Filter parameter

4.5.8.1 PDOP and P Accuracy Mask

These navigation output filters adjust the valid flag of the NMEA and UBX- message. Users of the UBX protocol have additional access to messages containing an accuracy indicator, along with the position.

4.5.8.2 TDOP and T Accuracy Mask

The **TDOP** and **T accuracy mask** control the **TIMEPULSE** output. They define when the **TIMPULSE** is available and within the requested accuracy range. Only when these conditions are met the **TIMEPULSE** is available on the **TIMEPULSE** pin.

4.5.9 DGPS (Differential GPS)

Differential GPS (DGPS) provides slightly better accuracy than a stand-alone GPS receiver. The correction data from a reference station is transmitted to the GPS receiver in order to eliminate pseudorange errors. Additional hardware is required to receive these data.

Parameter	Description
Timeout	Indicates how long the received DGPS data can be used, before suspending the DGPS mode.
Max PRC Age	The maximum age of a pseudo range correction data (DGPS time tag) that will be used in the navigation solution.
Timetag Rounding	Allow the Timetag of the differential corrections to be rounded to the top of second.

Table 33: DGPS parameters

The DGPS parameters are based on good experience with common DGPS systems. Do not change them if you don't have very specific requirements.

! **Note** DGPS lost significance when the Selective Availability (SA) was discontinued in May 2000. These days, the applications of DGPS are typically limited to surveying.

4.5.10 SBAS (Satellite Based Augmentation Systems)

SBAS (Satellite Based Augmentation System) is an augmentation technology to GPS, which calculates GPS integrity and correction data with RIMS (Ranging and Integrity Monitoring Stations) on the ground and uses geostationary satellites (GEOs) to broadcast GPS integrity and correction data to GPS users. The correction data is transmitted on the GPS L1 frequency (1575.42 MHz) therefore there is no additional receiver required to make use of the correction- and integrity data.

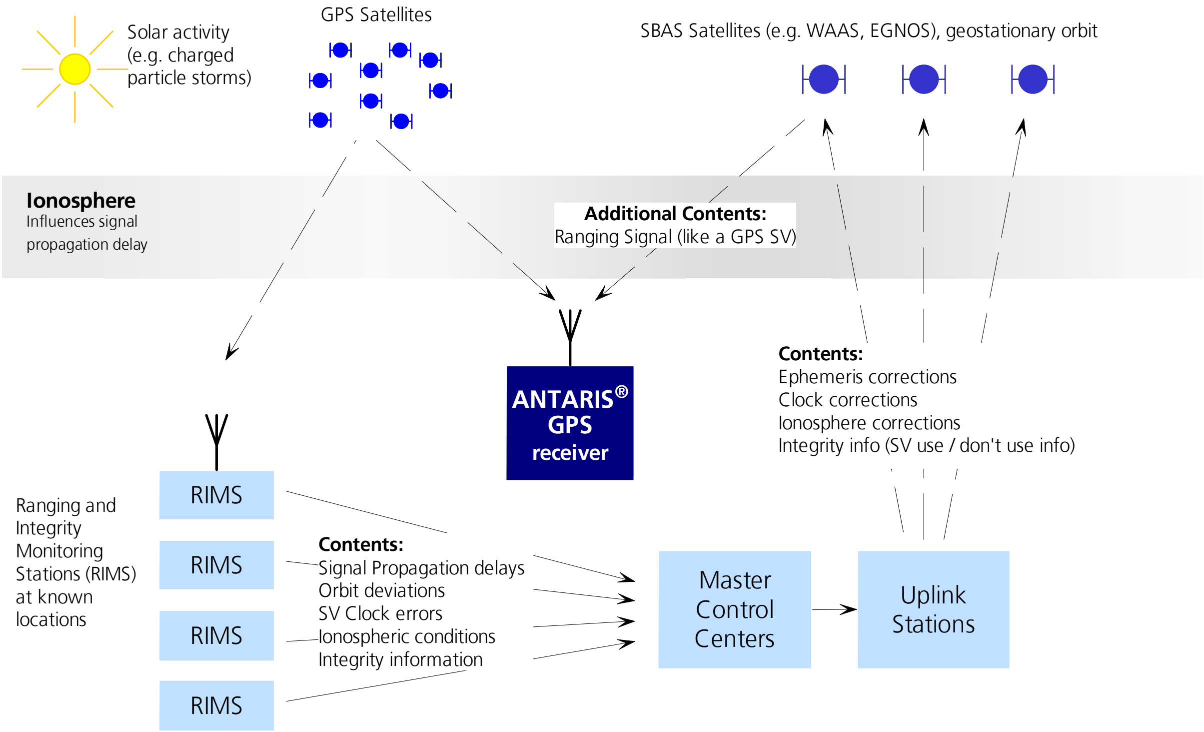


Figure 56: SBAS-Principal

There are several compatible SBAS systems available or in development all around the world:

- WAAS (Wide Area Augmentation System) for Northern America is in operation since 2003.
- EGNOS (European Geostationary Navigation Overlay Service) is in test mode ESTB (EGNOS satellite test bed). Full operation of EGNOS is planned for 2006.
- MSAS (Multi-Functional Satellite Augmentation System) for Asia is in development stage. This system is yet available, not even in test mode.

Other systems are planned for Canada (CSAS), India (GAGAN), Africa (EGNOS) and South America.

SBAS is primarily used to meet the requirements of onboard aircraft navigation. SBAS Support allows the ANTARIS® Technology to take full benefit of the augmentation systems that are available (WAAS, EGNOS), the test beds (NSTB, ESTB) and future systems that are planned (such as MSAS) for non-avionics applications.

! **Note** This ANTARIS® SBAS implementation is – in accordance with standard RTCA/DO-229C – a class Beta-1 equipment. All timeouts etc. are chosen for the En Route Case. Do not use this equipment for safety of live applications!

With SBAS enabled the user benefits of additional satellites for ranging (navigation). The ANTARIS® Technology uses the available SBAS Satellites for navigation just like GPS satellites, if the SBAS satellites offer this service.

To improve position accuracy SBAS uses different types of correction data:

- **Fast Corrections** account for short-term disturbances in GPS signals (due to clock problems, etc)
- **Long term corrections** cancel effects due to slow GPS clock problems, broadcast orbit errors etc.
- **Ionosphere corrections** cancel effects due to Ionosphere activity

Another benefit is the use of GPS integrity information. In that way SBAS Control stations can 'disable' usage of GPS satellites in case of major GPS satellite problems within 6 seconds time to alarm.

For more information on SBAS and associated services please refer to

- RTCA/DO-229C (MOPS). Available from www.rtca.org
- gps.faa.gov for information on WAAS and the NSTB
- www.esa.int for information on EGNOS and the ESTB
- www.essp.be for information about European Satellite Services Provider EEIG is the EGNOS operations manager.

4.5.10.1 SBAS Features

ANTARIS ® is capable to receive multiple SBAS satellites in parallel, even from different SBAS systems (WAAS, EGNOS, etc.). They can be tracked and used for navigation simultaneously. Up to three SBAS satellites can be searched in parallel and every SBAS satellite tracked utilizes one vacant GPS receiver channel. Only the number of receiver channels limits the total number of satellites used, which is 16 for ANTARIS® based products. Each SBAS satellite, which broadcasts ephemeris or almanac information, can be used for navigation, just like a normal GPS satellite.

For receiving correction data, the ANTARIS® GPS receiver automatically chooses the best SBAS satellite as its primary source. It will select only one since the information received from other SBAS GEOs is redundant and/or could be inconsistent. The selection strategy is determined by the proximity of the GEOs, the services offered by the GEO, the configuration of the receiver (Testmode allowed/disallowed, Integrity enabled/disabled) and the signal link quality to the GEO.

In case corrections are available from the chosen GEO and used in the navigation calculation, the DGPS flag is set in the receiver's output protocol messages.

The most important SBAS feature for accuracy improvement is Ionosphere correction. The measured data from RIMS stations of a region are combined to a TEC (Total Electron Content) Map. This map is transferred to the GPS devices via the GEOs to allow a correction of the ionosphere error on each received satellite.

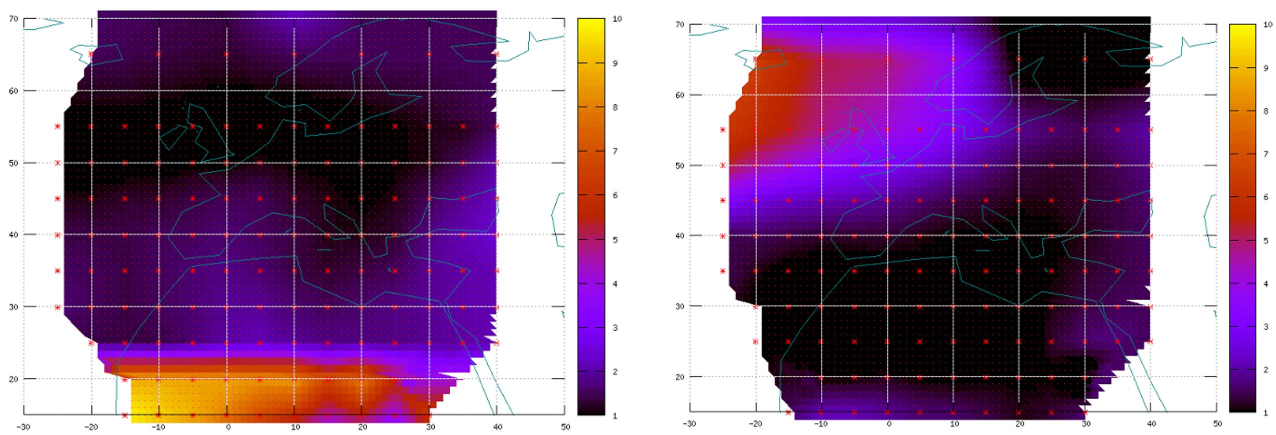


Figure 57: Examples of a TEC-Map over Europe

The following SBAS messages are supported, in accordance to standard DO-229C:

Message Type	Message Content	Used from
0(0/2)	Test Mode	All
1	PRN Mask Assignment	Primary
2, 3, 4, 5	Fast Corrections	Primary
6	Integrity	Primary
7	Fast Correction Degradation	Primary
9	GEO Navigation (Ephemeris)	All
10	Degradation	Primary
12	Time Offset	Primary
17	GEO Almanachs	All
18	Ionosphere Grid Point Assignment	Primary
24	Mixed Fast / Long term Corrections	Primary
25	Long term Corrections	Primary
26	Ionosphere Delays	Primary

Table 34: Supported SBAS messages

4.5.10.2 SBAS GEO PRN Numbers

The PRN of the GEO's used for SBAS are in a range from 120 to 150. Table 35 shows the SBAS GEO's in operation.

GEO identification		Stationed over	GPS PRN	SBAS Provider
INMARSAT AOR-E	(Atlantic Ocean Region East)	Eastern Africa	120	EGNOS
INMARSAT AOR-W	(Atlantic Ocean Region West)	Western Africa	122	WAAS
INMARSAT IOR	(Indian Ocean Region)	Indian Ocean	131	EGNOS
INMARSAT POR	(Pacific Ocean Region)	Pacific	134	WAAS
INMARSAT IOR-W (III-F5)	(Indian Ocean Region West)	Africa (Congo)	126	EGNOS
Artemis		Africa (Congo)	124	EGNOS
MTSAT-1R		Start anticipated in 2004	129	MSAS
MTSAT-2		Start anticipated in 2005	137	MSAS

Table 35: PRN of GEO's used for SBAS

As each GEO services a specific region, the correction signal is only useful within that region. Therefore, mission planning is crucial to determine the best possible configuration. The different stages (Testmode vs. Operational) of the various SBAS systems further complicate this task. The following examples show possible scenarios:

Example 1: SBAS Receiver in North America

At the time of writing, the WAAS system is in operational stage, whereas the EGNOS system is still in test mode (ESTB). Therefore, and especially in the eastern parts of the US, care must be taken in order not to have EGNOS satellites taking preference over WAAS satellites. This can be achieved by Disallowing Test Mode use (this inhibits EGNOS satellites from being used as a correction data source), but keeping the PRN Mask to have all SBAS GEOs enabled (which allows EGNOS GEOs to be used for navigation).

Example 2: SBAS Receiver in Europe

At the time of writing, the EGNOS system is still in test mode. To try out EGNOS operation, Testmode usage must be enabled. Since the WAAS GEO #122 can be received in the western parts of Europe, but since this GEO does not carry correction data for the European continent, the GEOs from all but the EGNOS system should be disallowed, using the PRN Mask. It is important to understand that while EGNOS is in test mode, anything can happen to the EGNOS signals, such as sudden interruption of service or broadcast of invalid or inconsistent data.

! **Note** The ANTARIS® GPS receiver makes always use of the best available SBAS correction data.

4.5.10.3 SBAS Configuration

To configure the SBAS functionalities use the UBX proprietary message UBX – CFG (Config) – SBAS (SBAS Configuration) message.

Parameter		Description
Mode	**SBAS Subsystem**	Enables or disables the SBAS subsystem
	Allow test mode usage (Msg0)	Allow / Disallow SBAS usage from satellites in Test Mode (Message 0)
Services/ Usage	**Ranging**	Use the SBAS satellites for navigation
	Apply SBAS correction data	Combined enable/disable switch for Fast-, Long-Term and Ionosphere Corrections
	Apply integrity information	Use integrity data
Number of search channels		Sets on how many channels SBAS satellites are searched in parallel. SBAS satellites, which are already received, do not count for the maximum.
PRN Mask		Allows to selectively enable/disable SBAS satellite. With this parameter, for example, one can restrict SBAS usage to WAAS-only

Table 36: SBAS parameters

By default SBAS is enabled with one SBAS search channel and it will use any received SBAS satellites for navigation.

4.5.10.4 SBAS Status Information

Parameter	Description
GEO/ ID	SBAS GEO which is used for receiving correction data is shown (this GEO is automatically chosen and can change depending on signal conditions and distance from the receiver's location)
System	SBAS System, which is being used for correction data (WAAS, EGNOS, etc.)
Mode	Indicates the mode of the tracked SBAS satellite (Disable, Testmode, Operational)
For each received GNSS signal (GPS and SBAS)	• The SV Number • UDRE; monitoring status as defined in DO-229C • Whether or not fast corrections are used for this SV. The PRC value in meters is given • Whether or not Ionosphere corrections are used for this SV. The slant PRC delay is given in meters. • Whether or not Long term corrections are used for this SV • Whether or not Integrity Data is used for this SV • The GNSS system for this SV (currently limited to GPS or SBAS) • The Services and Status provided by this SV. Can be a combination of 'Ranging', 'Correction Data', 'Integrity Information' and 'Testmode'.

! Note The Message UBX-NAV-DGPS does not monitor SBAS correction data. That message is used for monitoring RTCM-input, only!

! **Warning** The ANTARIS® SBAS implementation is **not certified**, nor is it planned to get certifications **for avionics**. ANTARIS® GPS receivers shall not – under any circumstances – be used for safety-of-life applications or avionics navigation.

4.5.11 RAIM (Receiver Autonomous Integrity Monitoring)

RAIM is a process where the GPS unit itself uses various techniques to monitor the signals it is receiving from the satellites, ensuring that the information used in the navigation solution is valid. Four SVs are required for a 3D navigation solution. The presence of one bad SV could be detected if five SVs were available. A bad SV could be identified and eliminated from the solution if six or more SVs are available (Fault Detection and Exclusion (FDE)).

The ANTARIS® Technology supports RAIM and has the ability to enable/disable this feature using software commands.

RAIM can only work with sufficient SV visibility and acceptable DOP geometry. It is our recommendation that RAIM is enabled all the time.

4.6 Timing

4.6.1 TIMEPULSE

ANTARIS® GPS receivers provide a hardware-synchronized **TIMEPULSE** (Pin 29) with a Time **Pulse Period** of 1 ms to 60 s. The polarity (rising or falling edge) and the pulse duration can be configured. Use the UBX proprietary message UBX - CFG (Config) - TP (Time Pulse) to change the TIMEPULSE settings. The UBX - TIM (Time) - TP (Timepulse) message provides the time information for the next TIMEPULSE, time source and a quantization error.

Parameter	Description	
Pulse Mode	'falling edge'	**TIMEPULSE** synchronization on the falling edge
	'disabled'	**TIMEPULSE** disabled (output signal low)
	'rising edge'	**TIMEPULSE** synchronization on the rising edge
Pulse Period	Period of the **TIMEPULSE**	
Pulse Length	Duration of the **TIMEPULSE**	
Pulse Frequency	The pulse frequency is calculated from the pulse period (u-center output only)	
Time Source	Selection whether the Time Pulse is GPS time or UTC time synchronized	
Cable Delay	Signal delay in the cable from the antenna to the ANTARIS® GPS Receiver	
User Delay	The cable delay from ANTARIS® GPS Receiver to the user device plus signal delay of any user application	
RF Group Delay	Delay of the signal in the ANTARIS® GPS Receiver RF module (hard coded)	

Table 37: TIMEPULSE Parameter description

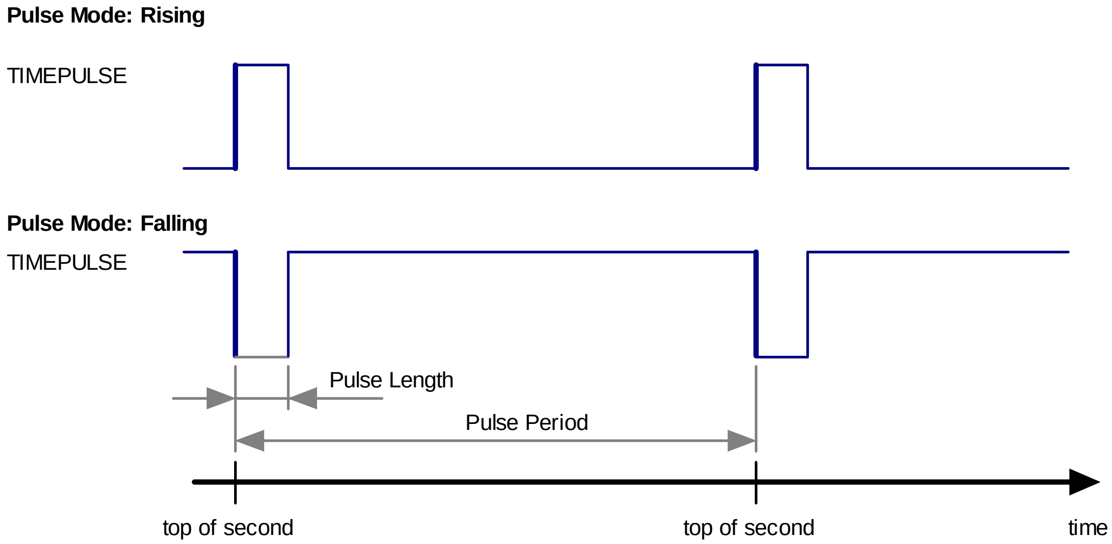


Figure 58: Example of a 1PPS Signal designed with TIMEPULSE

As a pulse reference **GPS** or **UTC time** can be selected. This makes a difference if the Pulse Period exceeds 1s. As the TIMEPULSE is synchronized with GPS- or UTC-time the Pulse Period must fulfill the following condition:

$$n \cdot PulsePeriod = 60s$$

n must be a integer value!

! Note The Maximum Pulse Length can't exceed the Pulse Period minus 1ms.

Figure 59 shows the sequential order of the signal present at pin **TIMEPULSE** and the respective output message for the simple case of 1 pulse per second and a one second navigation update rate.

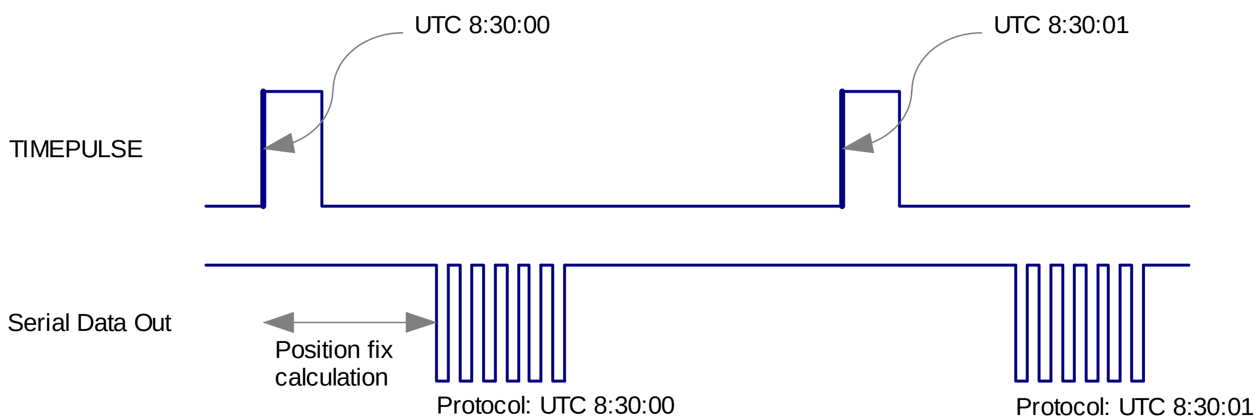


Figure 59: TIMPULSE output signal and protocol time message, example for 1 s period and rising edge configuration

The navigation update rate and TIMEPULSE period should be configured to result in a meaningful pattern. E.g. having four navigation updates per second and 3 **TIMEPULSE's** per second would make correlation of **TIMEPULSE** output and output message difficult.

The **TIMEPULSE** signal is aligned to the sampling clock of 23.104 MHz. This results in a timing resolution of 43 ns. This quantization error has to be added to the time accuracy estimation delivered through the timing message UBX – TIM (Timing)- TP (Timepulse).

The rise time of the **TIMEPULSE** signal affects the absolute accuracy of the TIMEPULSE signal and needs to be considered. At 15 pF load capacitance the output driver is able to deliver a typical rise time of 7 ns, but the maximum rise time may also reach 25 ns. Low load on this pin is therefore mandatory.

The GPS receiver always calculates time and position at the phase center of the GPS antenna. As the application using the time signal is not directly at the antenna, any delays caused by cables, filters and any other processes have to be considered. The Cable Delay (5.5 ns / m for PTFE isolated coaxial cable) is the delay in the antenna cable from the GPS antenna phase center to the Antenna Pin, the RF Group Delay is the delay from the Antenna Pin to the TIMEPULSE Pin (which is defined as a constant) and the User Delay are any other delays in the user application.

! **Note** When using the **TIMEPULSE** for a Timing Application it is recommended that the RF signal delay is calibrated against a reference timing source.

! **Note** To get the best timing accuracy with the GPS antenna, a fixed position is needed and the receiver must be configured to the static platform (refer to *Section 4.5.3*).

4.6.1.1 TIMEPULSE, Application Examples

The default setting for the TIMEPULSE defines a 1PPS signal, with a defined accuracy if the **TDOP** and **T accuracy masks** are used. Parameter changes can be made according to specific application requirements.

! **Note** If there is 'No Fix' or **TDOP** or **T accuracy mask** are exceeded no TIMEPULSE is being output.

4.6.1.2 1PPS TIMEPULSE

The following example shows a 1PPS rising edge triggered TIMEPULSE aligned to GPS time:

Parameter values				
Pulse Mode	+ 1 – rising			
Pulse Period [ms]	1000		**Pulse Length [ms]**	100
Time Source	1 – GPS			
Cable Delay [ns]	50		**User Delay [ns]**	0

Table 38: 1PPS TIMEPULSE Parameter settings

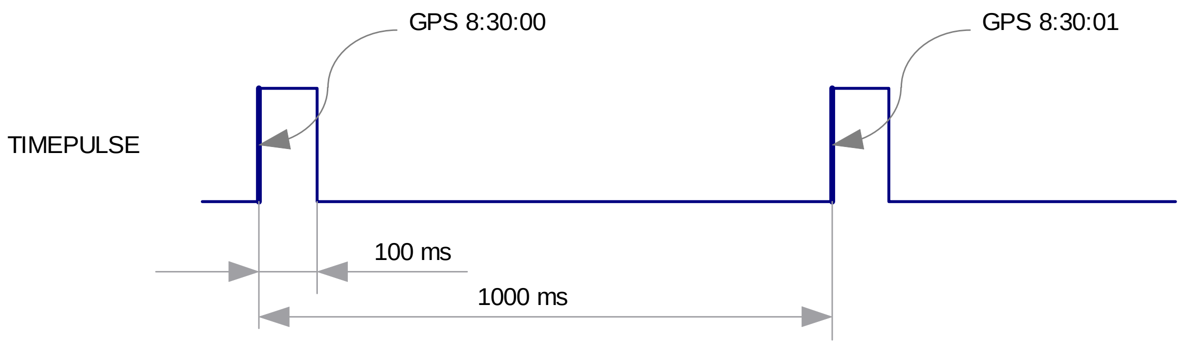


Figure 60: 1PPS TIMEPULSE Output Signal

4.6.1.3 1kHz TIMEPULSE

The following example shows a 1kHz, rising edge triggered TIMEPULSE aligned to GPS time:

Parameter values			
Pulse Mode	+ 1 – rising		
Pulse Period [ms]	1	**Pulse Length [ms]**	0.1
Time Source	1 – GPS		
Cable Delay [ns]	50	**User Delay [ns]**	0

Table 39: 1kHz TIMEPULSE Parameter settings

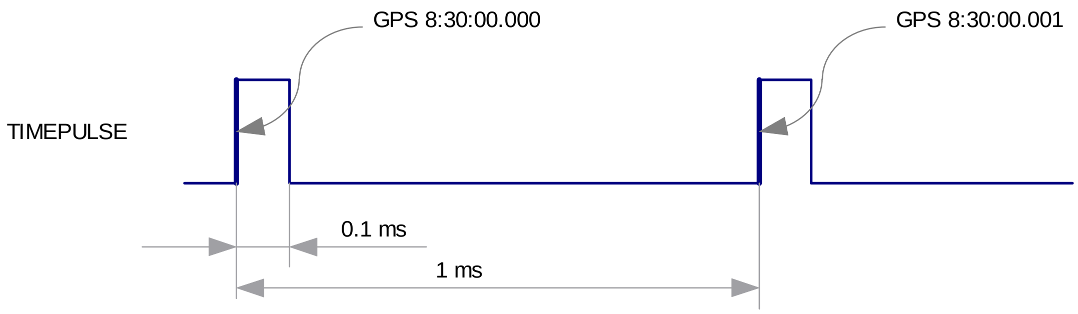


Figure 61: 1kHz TIMEPULSE Output Signal

4.6.1.4 60s UTC aligned TIMEPULSE

The following example shows a 60s, falling edge triggered TIMEPULSE aligned to UTC time:

Parameter values			
Pulse Mode	- 1 – falling		
Pulse Period [ms]	60000	**Pulse Length [ms]**	1
Time Source	0 – UTC		
Cable Delay [ns]	50	**User Delay [ns]**	0

Table 40: 60s UTC aligned Timepulse settings

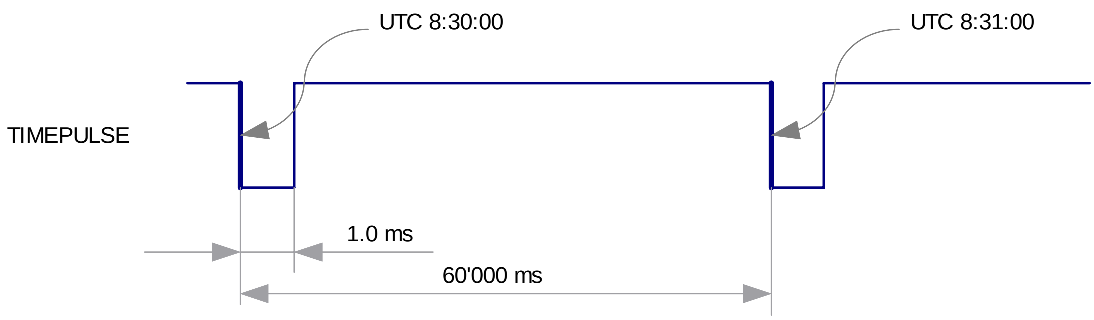


Figure 62: 60s TIMEPULSE Output Signal

4.6.2 Timemark

ANTARIS® GPS Receiver can be used for time measurements with a sub millisecond resolution using the external interrupt (EXTINT0). The Timemark functionality can be enabled with UBX – CFG – TM.

The results are transmitted via serial port with the UBX – TIM – TM messages including time of the last Timemark time source, validity, number of marks, delta time and a quantization error.

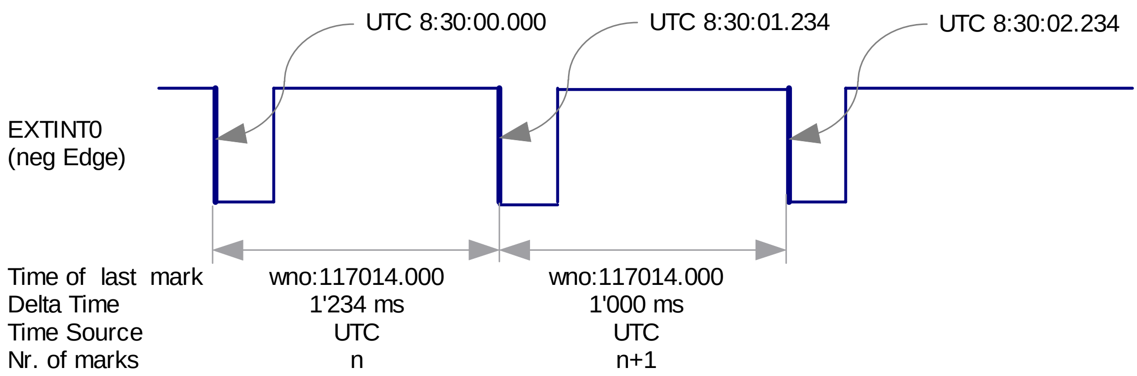


Figure 63: Timemark example

4.7 Receiver Configuration

4.7.1 Configuration Concept

The ANTARIS® GPS Technology is fully configurable with UBX protocol configuration messages (message class UBX-CFG). The configuration of the receiver can be changed during normal operation mode. The configuration data is automatically stored to the current configuration section and becomes immediately active (see Figure 64). The ANTARIS® GPS core always uses the current configuration.

The settings from the current section will only become permanent settings if they are saved to the permanent configuration section with a 'SAVE' command. The permanent settings are copied to the current section after a start-up or whenever a 'LOAD' command is received. The 'CLEAR' command erases the settings in the permanent section but not the current section.

! **Note** The 'SAVE', 'LOAD' and 'CLEAR' commands can be sent to the receiver with an UBX-CFG-CFG message.

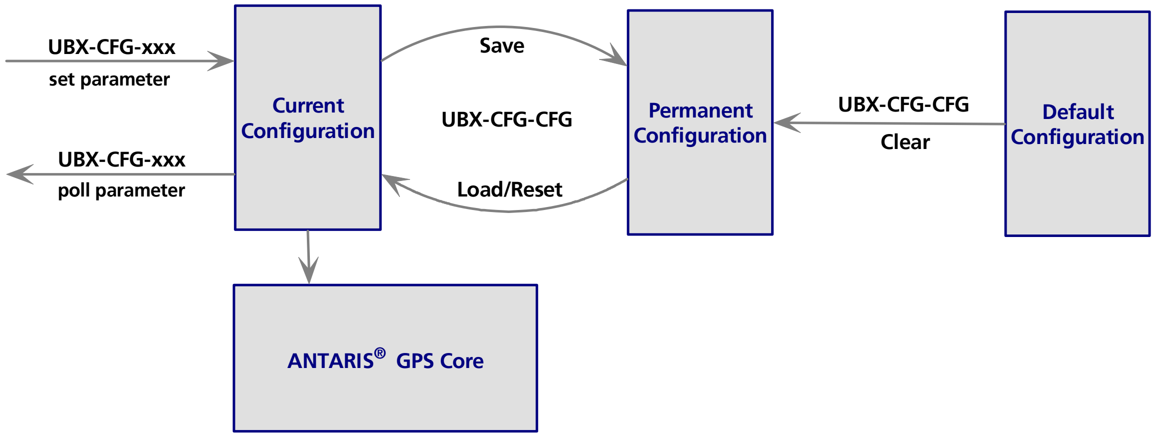


Figure 64: Configuration concept

An alternative approach is to hard-code user settings but this requires software customization. TIM-LC also offers the possibility to choose a configuration with pin settings (GPSMODE pins). For further information refer to *Section 4.7.7*.

4.7.2 Configuration Storage Media

The configuration may be stored in the on-chip battery backed-up RAM (TIM-LC) or the FLASH memory of the receiver (TIM-LP and TIM-LC). The stored configuration will be loaded on every restart. The firmware of the GPS receiver defines which media is used based on the available resources.

An overview of the memory/storage media

Memory/Storage Media	Specifics
SRAM (Static RAM)	Volatile RAM, stored data gets lost on a power down.
On-chip BBR (battery backed-up RAM) (TIM-LC)	Volatile RAM, stored data remain only if a Backup Battery is applied. Also used to store receiver configuration.
FLASH (TIM-LP and TIM-LF only)	Non Volatile RAM, used to store data, receiver configuration and user specific firmware code (only with SCKit).
ROM (Read Only Memory)	ROM holds the firmware of the GPS receiver

Table 41: Memory/ Storage Media on

4.7.2.1 Organization of the Configuration Sections

The configuration is divided into several sub-sections. Each of these sub-sections corresponds to one or several UBX-CFG messages.

Sub-Section		CFG - Messages	Description
0	PRT	UBX–CFG–PRT	Port settings
1	MSG	UBX–CFG–MSG UBX–CFG–NMEA	Message settings (enable/disable, update rate)
2	INF	UBX–CFG–INF	Information output settings (Errors, Warnings, Notice, Test etc.)
3	NAV DAT RATE TP TM	UBX–CFG–NAV UBX–CFG–DAT UBX–CFG–RATE UBX–CFG–TP UBX–CFG–TM	Navigation Parameter Receiver Datum Measurement and Navigation Rate setting Timepulse Settings Timemark Settings
4	RXM SBAS	UBX–CFG–RXM UBX–CFG–SBAS	RXM SBAS
5	FXN	UBX–CFG–FXN	Parameters of FixNOW™ mode
6-9	EKF Configuration	UBX–CFG–EKF	EKF Configuration
10	ANT	UBX–CFG–ANT	Antenna Configuration
11	Reserved	N/A	Reserved
12-15	User0 – User3	N/A	User settings, only available with the SCKit
10	ANT	UBX–CFG–ANT	Antenna Configuration
12-15	User0 – User3	N/A	User settings, only available with the SCKit

Table 42: Configuration messages

! **Note** The sub-sections can be saved, loaded and cleared individually. If a sub-section is cleared, saved or loaded with one single UBX-CFG-CFG message, the ‚CLEAR' command will be executed first, then the ‚SAVE' and finally the ‚LOAD' command.

! **Note** The user sections (User0 – User3) are only usable in conjunction with the SCKit.

4.7.3 Change Configuration temporarily

To change the configuration temporarily, any of the UBX configuration messages can be sent over the Serial Communication Port. The receiver will change its configuration immediately after receiving the message. However it will not be stored in non-volatile memory.

4.7.4 Change Configuration permanently

To change a configuration permanently on the receiver, the configuration parameters must have been previously stored in order to be available at startup. Therefore any permanent change of configuration must be saved in the battery backed-up RAM (TIM-LC) or FLASH (TIM-LP and TIM-LF).

To store a configuration select the section to be saved in the UBX – CFG (Config) – CFG (Configuration) in u-center AE and send the message to the receiver by pressing the send button (Send).

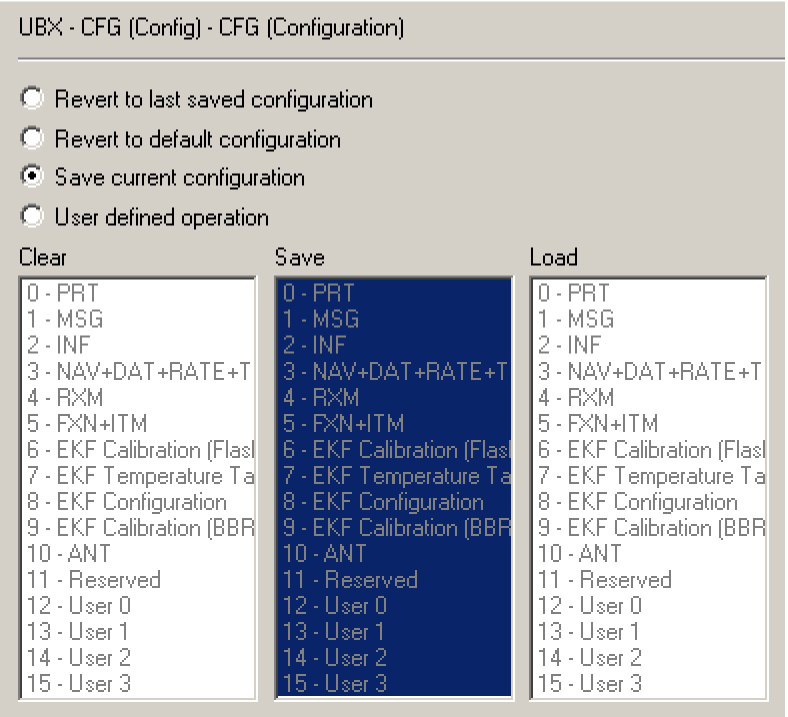


Figure 65: Saving a configuration section

! **Note:** Use the <ctrl> + <left click> to deselect the last selection, if you choose "user defined".

4.7.5 Loading a Configuration

Generally there is no need to manually load configuration settings since they are automatically loaded at startup. The ability to force a load of the settings can be useful if you changed some settings (without saving them) and want to reset the configuration to the last saved configuration. To do this select the requested sections in the load box and send the message to the receiver.

4.7.6 Clear a Configuration permanently

Clearing a configuration can be useful if you want to reset to the factory default state. You have to load them afterwards to become effective.

! **NOTE:** This operation only clears the configuration Memory. It doesn't reapply defaults. You need to do a „Load" or restart the system in order to load the defaults.

! **NOTE:** When selecting sections in the Clear, Save and Load box Configuration is first cleared then saved and finally reloaded.

4.7.7 Start-Up Pin Configuration (GPSMODE Pins) – (TIM-LC only)

The start-up configuration of ROM based receivers like TIM-LC is defined by the status of the GPSMODE pins after system reset. The default configuration can by altered by pulling up or down a number of so-called GPSMODE pins (see *Figure 25 and* Table 43). Alternatively, the system can be configured through message commands passed through the serial interface after start-up. Figure 66 depicts the start-up procedure of ANTARIS® GPS receivers.

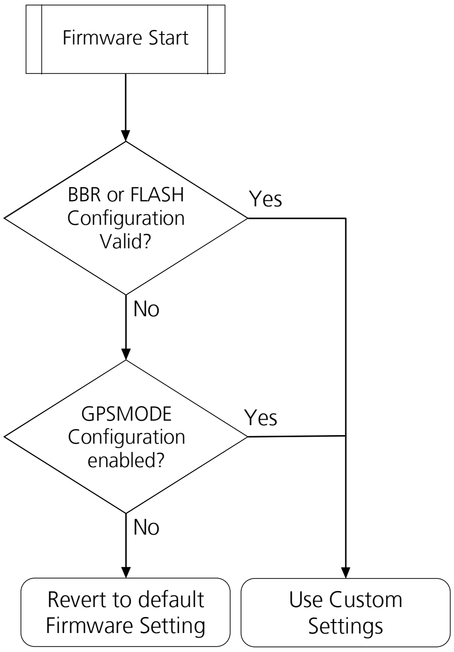


Figure 66: ANTARIS® GPS Technology Start-Up Procedure

TIM-LC supports only a subset of all GPSMODE configurations of the ANTARIS® Chipset due to limited pin available on the receiver board.

Pin	Function
GPSMODE2	GPS sensitivity settings
GPSMODE3	
GPSMODE5	Serial I/O configuration
GPSMODE6	
GPSMODE7	Navigation rate settings
GPSMODE8	
GPSMODE12	Serial I/O configuration

Table 43: GPSMODE functions on TIM-LC

4.7.7.1 Sensitivity Settings

GPSMODE3 [PD]	GPSMODE2 [PU]	Description
0	0	Reserved
0	1	**Fast Mode (Default)**
1	0	Normal sensitivity mode
1	1	High sensitivity mode

Table 44: Sensitivity Settings with GPSMODE pins

4.7.7.2 Serial I/O Configuration

The ANTARIS® receiver features a two-stage I/O message and protocol selection procedure for the available serial ports.

1. The RTCM, NMEA or UBX protocol can be enabled or disabled for a given USART port.
2. Messages can be enabled or disabled for each enabled protocol on each port.

To handle the serial I/O configuration with GPSMODE pins, there are message sets defined and **all protocols are enabled on all ports** (for input and output).

GPSMODE			USART1	Messages	Information Messages	Information Messages
12 PU	6 PU	5 PD	Output Protocol / Baudrate (kBaud)		(UBX INF)	(NMEA TXT)
0	0	0	UBX / 57.6	High	User, Notice, Warning, Error	
0	0	1	UBX / 38.4	Med	User, Notice, Warning, Error	
0	1	0	UBX / 19.2	Low	User, Notice, Warning, Error	
0	1	1	- / Auto	Off	None	None
1	0	0	NMEA / 19.2 (default)	High		User, Notice, Warning, Error
1	0	1	NMEA / 4.8	Low		User, Notice, Warning, Error
1	1	0	**NMEA / 9.6 (default)**	**Med**		**User, Notice, Warning, Error**
1	1	1	UBX / 115.2	Debug	All	

Table 45: Serial I/O configuration with GPSMODE pins

All available USART ports accept input messages in all three supported protocols (NMEA, RTCM, and UBX) at the configured baud rate. Input messages of all three protocols can be arbitrarily mixed. Response to a query input message will always use the same protocol as the query input message.

In Auto mode, no output message is sent out by default, but all input messages are accepted at any supported baud rate. Response to query input commands will be given using the same protocol and baud rate as it was used for the query command. Using the respective configuration commands, periodic output messages can be enabled.

The following message settings are used in the *Table 45* above:

NMEA Port	Standard	GGA, RMC
UBX Port	NAV	SOL, SVINFO

Table 46: Supported messages in setting "Low"

NMEA Port	Standard	GGA, RMC, GSA, GSV, GLL, VTG, ZDA
UBX Port	NAV	SOL, SVINFO, POSECEF, POSLLH, STATUS, DOP, VELECEF, VELNED, TIMEGPS, TIMEUTC, CLOCK

Table 47: Supported messages in setting "Med"

NMEA Port	Standard	GGA, RMC, GSA, GSV, GLL, VTG, ZDA, GRS, GST
	Proprietary	PUBX00, PUBX03, PUBX04
UBX Port	NAV	SOL, SVINFO, POSECEF, POSLLH, STATUS, DOP,VELECEF, VELNED,TIMEGPS, TIMEUTC, CLOCK
	MON	SCHD, IO, IPC

Table 48: Supported messages in setting "High"

NMEA Port	Standard	GGA, RMC, GSA, GSV, GLL, VTG, ZDA, GRS, GST
	Proprietary	PUBX00, PUBX03, PUBX04
UBX Port	NAV	SOL, SVINFO, POSECEF, POSLLH, STATUS, DOP,VELECEF, VELNED,TIMEGPS, TIMEUTC, CLOCK
	MON	SCHD, IO, IPC
	RXM	RAW

Table 49: Supported messages in setting "Debug" [12]

4.7.7.3 Navigation Rate Settings

GPSMODE		(NMEA TXT)
8 PU	7 PU	
0	0	2 Hz Navigation rate
0	1	0.5 Hz Navigation rate
1	0	4 Hz Navigation rate
1	1	**1 Hz Navigation rate (Default)**

Table 50: Navigation rate settings

4.8 Software Customization

The spare resources of the ARM7DTMI™ of the ATR0620 can be used to run user applications. Table 51 outlines the option as well as the pros and cons of each approach.

ANTARIS® SW Customization (User code resides in Flash)	External processor
All custom specific applications run on the processor of the ANTARIS® chipset. The user code resides in a Flash connected to the ATR0620 via EBI.	An external processor is combined with the ANTARIS® GPS receiver. It communicates with the GPS receiver via the serial ports and does post-processing of GPS data or any other control tasks.
• TIM-LF or TIM-LP but no additional processor required • Board space and cost reduction as external CPU is substituted. • Direct access to GPS resources via API functions.	• An external processor is only needed if the available resources (CPU power, GPIO, Memory) are not sufficient or any critical real time task needs to be executed during acquisition.
Optimal solution if external hardware needs to be controlled or when major additions to the ROM firmware is required.	Optimal solution whenever an external CPU with spare resources is available.

Table 51: Software customization vs. external processor

4.8.1 Custom Protocols

The receiver software can be modified in order to support any binary or ASCII protocol over any of its serial ports. For this purpose, an *ANTARIS® Software Customization Kit (SCKit)* is available, which allows the extension of existing protocols by adding custom messages, or the ability to implement new, uni- or bi-directional protocols. For more information, refer to the *ANTARIS® GPS Software Customization Kit Datasheet [12]*.

[12] Additional undocumented messages may be part of output data

4.8.2 EXTINT0 External Interrupt pin

EXTINT0 is an external interrupt pin. In standard configuration **EXTINT0** to initiate a position fix in the FixNOW Mode, pulling **EXTINT0** high wakes up the module and initiates a position fix calculation.

4.8.3 Programmable I/Os (GPIO) - (For TIM-LP and TIM-LF only)

The ANTARIS® GPS Receiver offers alternate functions of its pins, up to 8 pins can be configured as GPIO. **P9, P17, P23** – **27** and **P30** are available as general purpose I/Os (see *Appendix A* for detailed information). If **P23** is used as GPIO pin, FixNow™ and Timemark functionalities are not available and must be disabled. If **P27** is used as a GPIO, the Active Antenna Detection is not available and must be disabled.

4.9 System Functions

4.9.1 Reset Options

The ANTARIS® GPS Technology distinguishes between four types of reset. An external hardware reset (by pulling open drain **RESET_N** pin low), two resets are controlled software resets and one is an asynchronous software reset, which are used to shut down and restart parts or the whole receiver.

The controlled software resets are broadcasting events when shutting down. This may help when running user specific software with the *ANTARIS® Software Customization Kit (SCKit)* to execute some code before resetting.

The forced reset performs an immediate hardware reset similar to the external hardware reset.

Upon every software reset, it’s possible to define the type of start-up scenario (hotstart, warmstart, coldstart). This start-up scenario defines which GPS data is reused and which is cleared (e.g. the ephemeris data is cleared for a warmstart).

4.9.1.1 Controlled Reset

The Controlled Reset waits until the system is in the background task (all tasks are idle). It then broadcasts a GPS Stop Event and a System Stop Event. After that the software is started again. This means that the configuration from BBR (battery backed-up RAM) or Flash (depending on the firmware used) is reloaded.

4.9.1.2 Controlled GPS only Reset

The Controlled GPS only Reset waits until all GPS Tasks are idle (not running or pending). It then resets the Navigation and Tracking Engine and starts them again. The system is not fully restarted from scratch.

4.9.1.3 Forced Reset (Watchdog)

The Forced Reset is an asynchronous reset that immediately stops all tasks that are running and resets the hardware. No System Stop or GPS Stop Event is sent. This reset is equivalent to an externally supplied reset signal.

4.9.2 STATUS Signal - (For TIM-LP and TIM-LF only)

The ANTARIS® GPS Receiver provide a **STATUS** signal on pin 9**.** It is a software specific feature of the receiver. It can be used to monitor the STATUS of the receiver e.g. with a LED. The pattern indicates the number of visible satellites that are actually used for the navigation solution. The pattern always starts with a 1 s start bit followed by one pulse for each satellite used in the calculation. The pattern is repeated every 5 s

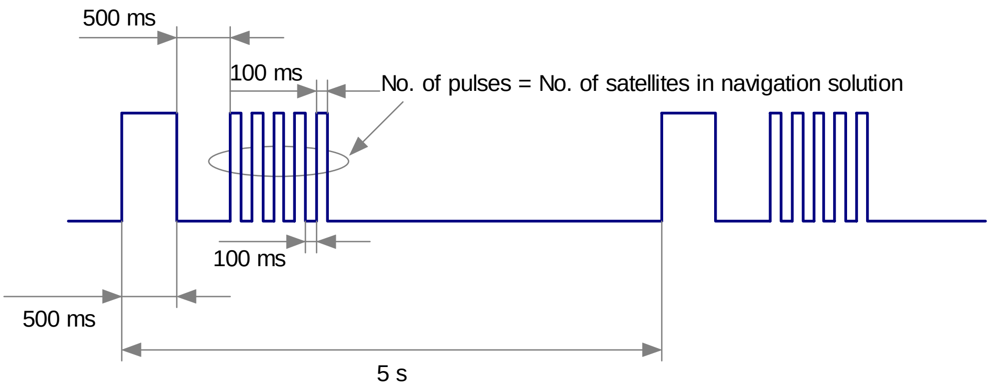


Figure 67: Output pattern at pin P8

4.9.3 System Monitoring

The ANTARIS® GPS Receiver provides System Monitoring functions that allow the operation of the embedded processor and associated peripherals to be supervised. These System Monitoring functions are being output as part of the UBX protocol, class 'MON'. The information available from the system monitoring functions is:

1. Software Version
2. Hardware Version
3. Current system CPU load
4. Maximum stack usage since last reset
5. Last exception (type/registers/ stack dump)
6. Target (USART/SPI) specific values:
   - Number of bytes received
   - Number of bytes transmitted
   - Number of parity errors
   - Number of framing errors
   - Number of overrun errors
   - Number of break conditions
   - Number of bytes received, that were not part of any of the supported protocols
   - Current transmission buffer usage
   - Maximum transmission buffer usage since last reset
   - Number of bytes pending for transmission
   - Current reception buffer usage
   - Maximum reception buffer usage since last reset
   - Number of received and correctly decoded messages for each supported protocol

Please refer to the *ANTARIS® GPS Technology Protocol Specifications [8]* for more information on individual system monitoring functions.

5 Schematic Overview

This chapter discusses different schematics integrating the ANTARIS® GPS Receiver into a customer's system.

5.1 Connecting Power

The ANTARIS® GPS Receiver basically has two power supply pins, **VCC** and **V_BAT**. *Figure 68* shows the internal connections of the power supply network.

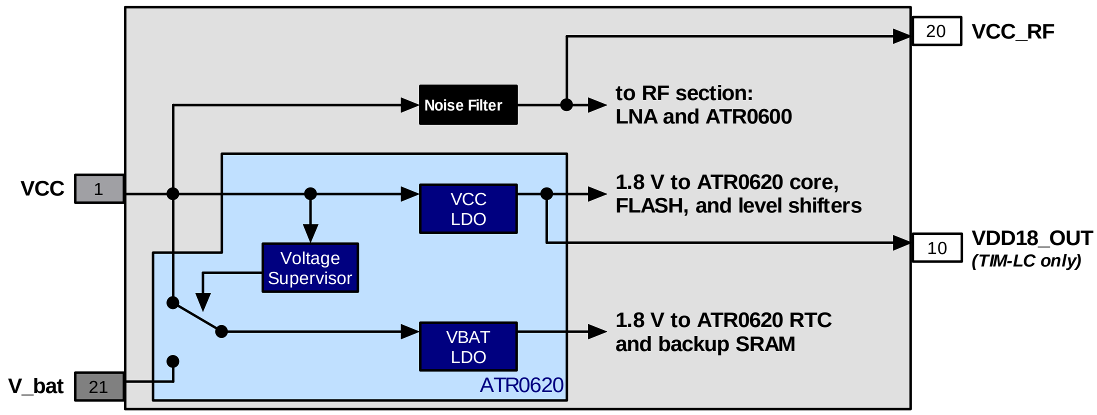


Figure 68: Power supply concept

5.1.1 VCC - Main Power

Main power supply is fed through the **VCC** pin. During operation, the current drawn by the ANTARIS® GPS Receiver can vary by some orders of magnitude, especially, if low-power operation modes are enabled. It is important that the system power supply circuitry should be able to support the peak power (see datasheet for specification) for a short time. In order to dimension your power supply, you may use the sustained power figure.

5.1.2 V_bat - Backup battery Power

In case of a power failure on pin **VCC**, real-time clock and backed-up SRAM are supplied through pin **V_bat**. This enables the ANTARIS® GPS Receiver to recover from power failure with either a hotstart or a warmstart (depending on the duration of **VCC** outage). Please see *section 2.3* for more information on coldstart, warmstart and hotstart scenarios.

! Note It's recommended to connect a backup battery to the ANTARIS® GPS Receiver. The configuration of the receiver, last time, last position, almanac and ephemeris are stored in the BBR (battery backed-up RAM). A backup battery must power the BBR to keep configuration and navigation data. If there is not a Backup Battery connected the receiver performs a coldstart when powered up.

! Note If no backup battery is available connect V_bat to GND.

! Warning The battery backup current will be at an undefined level if the backup voltage is applied to the GPS receiver without having the GPS receiver turned on once to put the real-time-clock (RTC) into a known state. If you are using the GPS receiver with backup battery connected, turn the GPS receiver on for the first time to bring it into a known state.

5.2 Antenna

Any ANTARIS® GPS Receiver receives of the L1 band signals from GPS satellites at a nominal frequency of 1575.42 MHz. The RF signal is connected to the **RF_IN** pin.

The TIM-LP GPS receiver macro component can be connected to an on-board passive patch antenna or an antenna connector without using RF cables.

As TIM-LF and TIM-LC don't have a built-in Low Noise Amplifier (LNA) any passive patch antenna signal must be amplified externally before connecting it to the receiver. Active antennas can be connected to the receiver directly without using any LNA.

! **Note** For TIM-LF and TIM-LC a minimal antenna gain of 25 dB is recommended for an antenna cable length up to 5 m (after subtraction of cable and connector losses, a minimum total gain of 20 dB should be observed at TIM-Lx RF input).

! **Note** For TIM-LF and TIM-LC total preamplifier gain (minus cable and interconnect losses) must not exceed 65 dB. Total noise figure should be below 3 dB. For TIM-LP total preamplifier gain (minus cable and interconnect losses) must not exceed 50 dB. Total noise figure should be below 3 dB.

The ANTARIS® Technology supports either a short circuit protection of the active antenna or an active antenna supervisor circuit (open and short circuit detection). For further information refer to *Section 5.2.4.*

5.2.1 Passive Antenna (TIM-LP only)

A design using a passive antenna requires more attention regarding the layout of the RF section. Typically a passive antenna is located near electronic components; therefore care should be taken to reduce electrical 'noise' that may interfere with the antenna performance. For further information about passive Antenna design refer to *Section 6.3.*

Passive antennas do not require a DC bias voltage and can be directly connected to the RF input pin **RF_IN**. Sometimes, they may also need a passive matching network to match the impedance to 50 Ohms.

! **Note** Some passive antenna designs present a DC short to the RF input, when connected. If a system is designed with antenna bias supply AND there is a risk of a passive antenna being connected to the design, consider a short circuit protection.

5.2.2 Active Antenna

Active antennas have an integrated low-noise amplifier. They can be directly connected to **RF_IN**. If an active antenna is connected to **RF_IN**, the integrated low-noise amplifier of the antenna needs to be supplied with the correct voltage through pin **V_ANT**. Usually, the supply voltage is fed to the antenna through the coaxial RF cable. Active antennas require a power supply that will contribute to the total GPS system power consumption budget with additional 5 to 20 mA typically. Inside the antenna, the DC component on the inner conductor will be separated from the RF signal and routed to the supply pin of the LNA (*see Figure 69*).

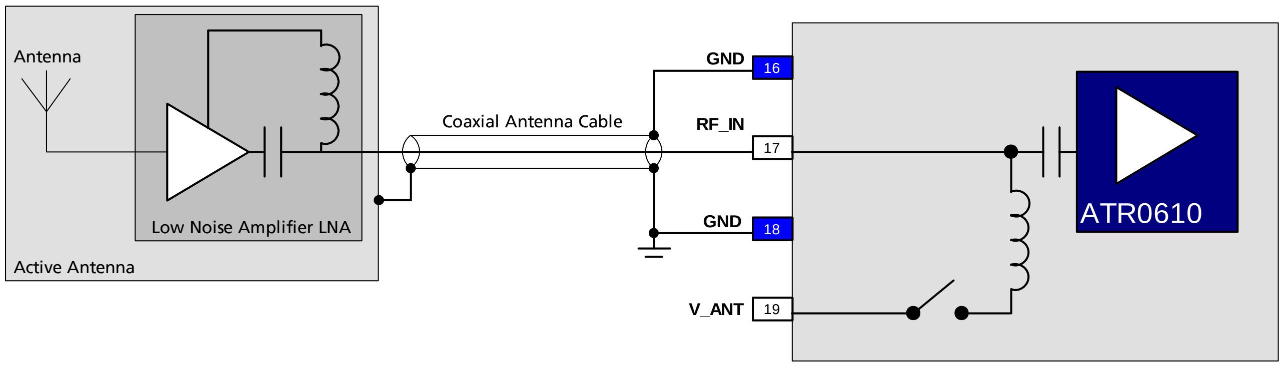


Figure 69: Active antenna biasing

Generally an active antenna is easier to integrate into a system design, as it is less sensitive to jamming compared to a passive Antenna. But an active Antenna must also be placed far from any noise sources to have a good performance.

! Warning Antennas should only be connected to the receiver when the receiver is not powered. Do not connect or disconnect the Antenna when the ANTARIS® GPS receiver is running. The receiver calibrates the noise floor on power-up, connecting the antenna after power-up can result in prolonged acquisition time.

! Warning Never feed supply voltage into RF_IN. Always feed V_ANT into RF_IN.

! Note To test GPS signal reacquisition, we recommend physically blocking the signal to the antenna, rather than disconnecting and reconnecting the receiver.

5.2.3 Active Antenna Bias Power

Two possibilities to supply the bias voltage to pin **V_ANT** do exist. One can either use an external supply, according to the specifications provided in the datasheet, or, the **VCC_RF** output can be connected to **V_ANT** to supply the antenna with a filtered supply voltage. However, the voltage specification of the antenna has to match the actual supply voltage of the ANTARIS® GPS Receiver (e.g. 3.0 V).

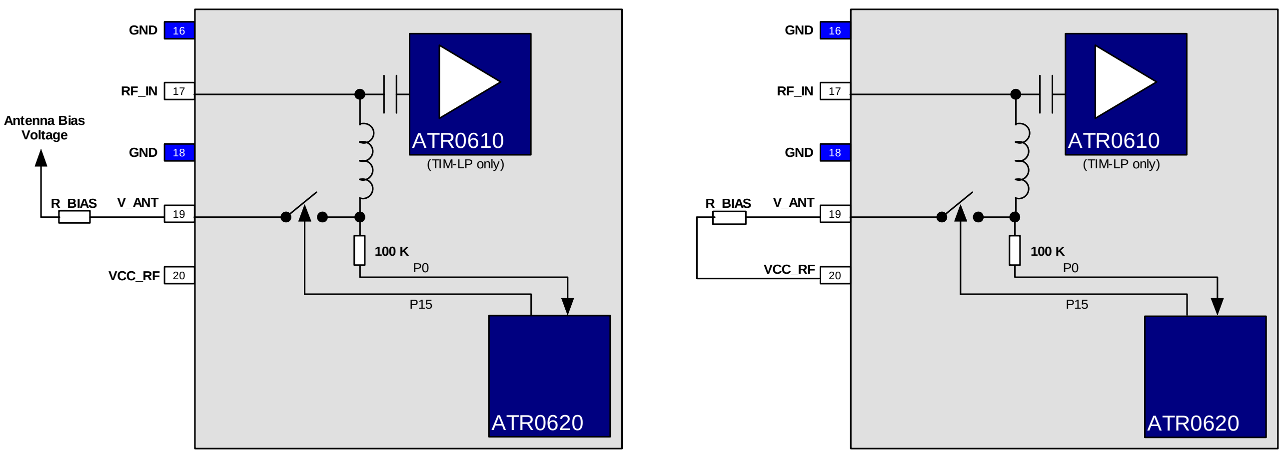


Figure 70: Supplying Antenna bias voltage

Since the bias voltage is fed into the most sensitive part of the receiver, i.e. the RF input, this supply should be virtually free of noise. Usually, low frequency noise is less critical than digital noise with spurious frequencies with harmonics up to the GPS band of 1.57542 GHz. Therefore, it is not recommended to use digital supply nets to feed pin **V_ANT**.

An internal switch (under control of the ANTARIS® GPS software) can shutdown the supply to the external antenna whenever it is not needed. This feature helps to reduce power consumption when the GPS receiver is sleeping or not receiving.

5.2.4 Active Antenna Supervisor

The ANTARIS® GPS Technology provides the means to implement an active antenna supervisor with a minimal number of parts. The antenna supervisor is highly configurable to suit various different applications.

5.2.4.1 Short Circuit Protection

If a reasonably dimensioned series resistor **R_BIAS** is placed in front of pin **V_ANT**, a short circuit situation can be detected by the baseband processor (ATR0620). If such a situation is detected, the baseband processor will shut down supply to the antenna. Voltage supply to the antenna will only be re-established after a hardware reset of the receiver, e.g. after power cycling.

References	Value	Tolerance	Description	Manufacturer
R_BIAS	10 Ω	± 10%	Resistor, min 0.250 W	

Table 52: Short circuit protection, bill of material

! **Warning** Short circuits without current limitation will result in a permanent damage of the receiver!

! **Note** An additional R_BIAS is not required, when using a short and open active antenna supervisor circuitry as defined in *Section 5.2.4.2*, as the R_BIAS is equal to R2.

! **Note** Max voltage for the short circuit protection circuitry is V_ANT_MAX specified in the datasheet of the ANTARIS® GPS receiver.

Please see also *Section 5.9* for specific information on proper layout of the external RF circuit.

5.2.4.2 Short and Open Circuit Active Antenna Supervisor

The Antenna Supervisor can be configured by a serial port message (only UBX binary).

When enabled the active antenna supervisor produces serial port messages (status reporting in NMEA and/or UBX binary protocol) which indicates all changes of the antenna circuitry (**disabled** antenna supervisor, antenna circuitry **ok**, **short** circuit, **open** circuit) and shuts the antenna supply down if required.

Following state diagram shall apply. Initial state after power-up is "Active Antenna OK".

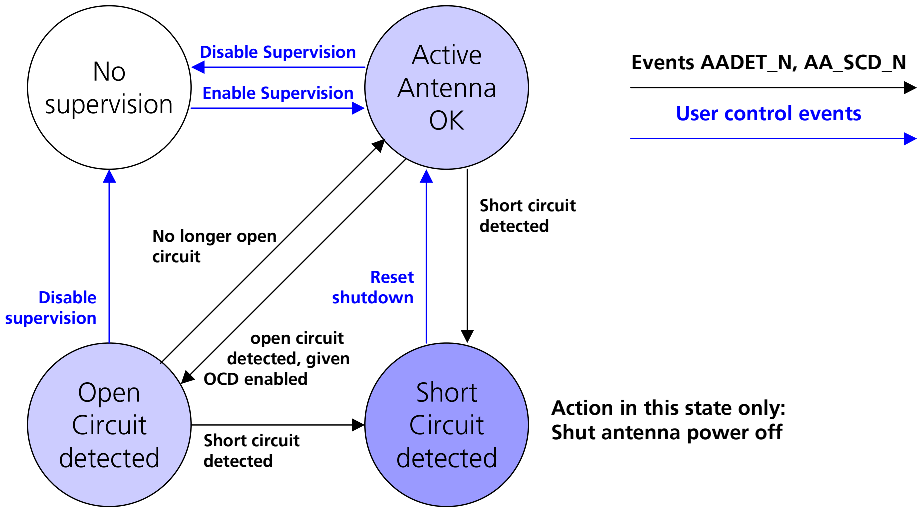


Figure 71: State Diagram of Active Antenna Supervisor

The active antenna supervisor provides the means to check the active antenna for open and short circuits and to shut the antenna supply off, if a short circuit is detected.

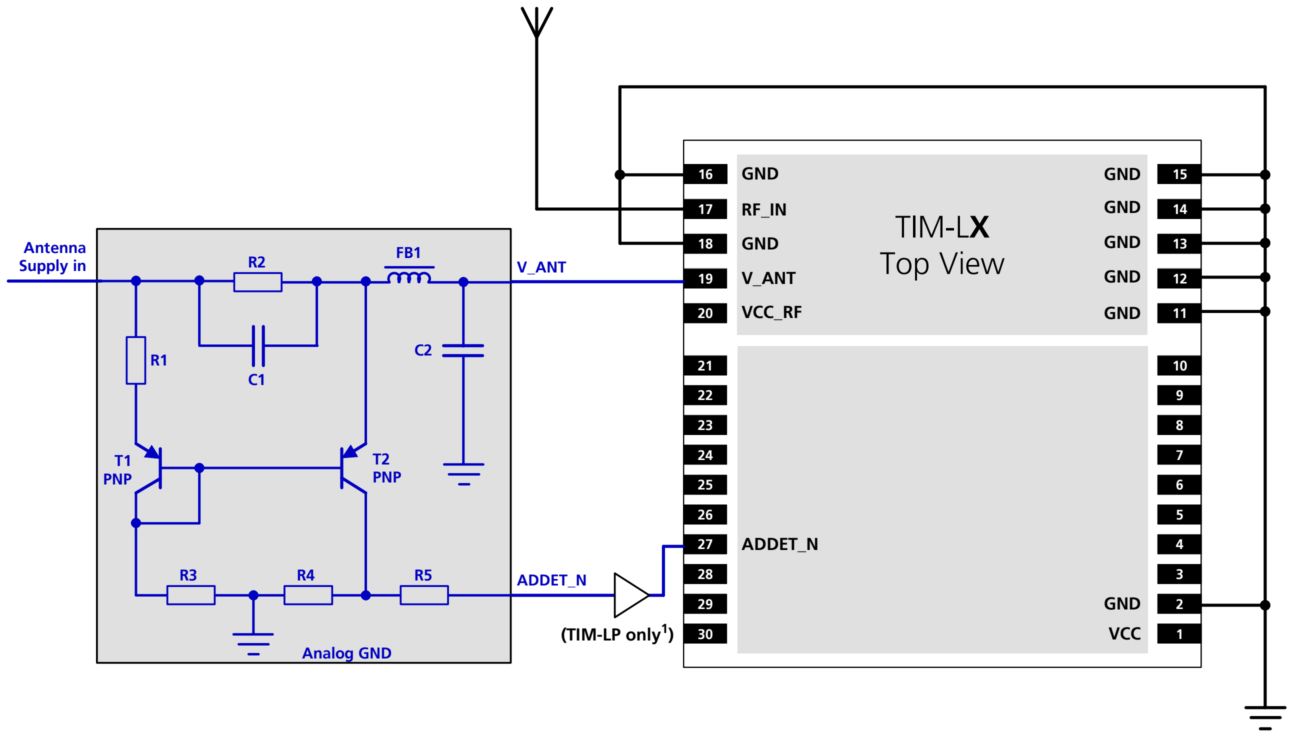


Figure 72: Schematic of open circuit detection

! Note A buffer (e.g. Fairchild NC7SZ125, powered to Vcc) is required in front of the ADDET_N input, if the Antenna Supervisor Circuitry shall be used in a TIM-LP design. This buffer is not needed for TIM-LF, TIM-LC receiver modules.

References	Value	Tolerance	Description	Manufacturer
C1	2.2 µF	± 10%	Capacitor, X7R, min 10 V	
C2	100 nF	± 10%	Capacitor, X7R, min 10 V	
FB1	600 Ω		Ferrite Bead	e.g. Murata BLM18HD601SN1
R1	56 Ω	± 10%	Resistor, min 0.063 W	
R2	10 Ω	± 10%	Resistor, min 0.250 W	
R3, R4	5.6 kΩ	± 10%	Resistor, min 0.063 W	
R5	100 kΩ	± 10%	Resistor, min 0.063 W	
T1, T2			PNP Transistor BC856B	Philips Semiconductors[13]

Table 53: Active Antenna Supervisor, bill of material

! Note Max. voltage for the short circuit protection circuitry is V_ANT_MAX as specified in the datasheet of the ANTARIS® GPS receivers.

[13] Transistors from other suppliers with comparable electrical characteristics may be used.

Short Circuit Detection (SCD)

A short circuit in the active antenna pulls **V_ANT** to ground. This is detected inside the ANTARIS® GPS macro component and the antenna will be shunt down.

! **Note:** Antenna short detection (SCD) and control is enabled by default.

Open Circuit Detection (OCD)

The open circuit detection circuit uses the current flow to detect an open circuit in the antenna. The threshold current is at 3-5mA. A current below 3mA will definitely indicate an open circuit. A current above 5mA will definitely indicate no open circuit (values apply for R2=10 Ω).

If the current through T2 is large, the voltage drop through R4 and therefore ADDET_N will be high, indicating an open connection. On the other hand, if the current is small, ADDET_N will be low.

! **Note:** The antenna open circuitry detection (OCD) is disabled by default.

Message Reporting

At startup and on every change of the antenna supervisor configuration the ANTARIS® GPS macro component will output a NMEA ($GPTXT) or UBX (INF-NOTICE) message with the internal status of the antenna supervisor (disabled, short detection only, enabled).

None, one or several of the strings below are part of this message to inform about the status of the active antenna supervisor circuitry (e.g. "ANTSUPERV= AC SC OD PdoS").

Abbreviation	Description
AC	Antenna Control (e.g. the antenna will be switched on/ off controlled by the GPS receiver)
SC	Short Circuit Detection Enabled
OD	Open Circuit Detection Enabled
PDoS	Power Down on shortage

Table 54: Active Antenna Supervisor Message on startup

! **Note** To activate the antenna supervisor use the UBX-CFG-ANT message. For further information refer to the *ANTARIS® GPS Technology Protocol Specifications [8].*

Similar to the antenna supervisor configuration the status of the antenna supervisor will be reported in a NMEA ($GPTXT) or UBX (INF-NOTICE) message at start-up and on every change.

Message	Description
ANTSTATUS=DONTKNOW	Active antenna supervisor is not configured and deactivated.
ANTSTATUS=OK	Active antenna connected and powered
ANTSTATUS=SHORT	Antenna short
ANTSTATUS=OPEN	Antenna not connected or antenna defective

Table 55: Active Antenna Supervisor Message on startup

! **Note** The open circuit supervisor circuitry has a quiescent current of approximately 2mA. This current may be reduced with an advanced circuitry, which fulfils the same functionality as the u-blox suggested circuitry.

5.3 Level-Shifting

5.3.1 Level-Shifting TIM-LP

TIM-LP is based on a 1.8V core technology, using internal bi-directional Level Shifters to make all Inputs/Outputs compatible with standard 3.0V logics. These Level Shifters have a low current driving capability. Please refer to the *TIM-LP datasheet* when connecting to devices not 3.0V compliant.

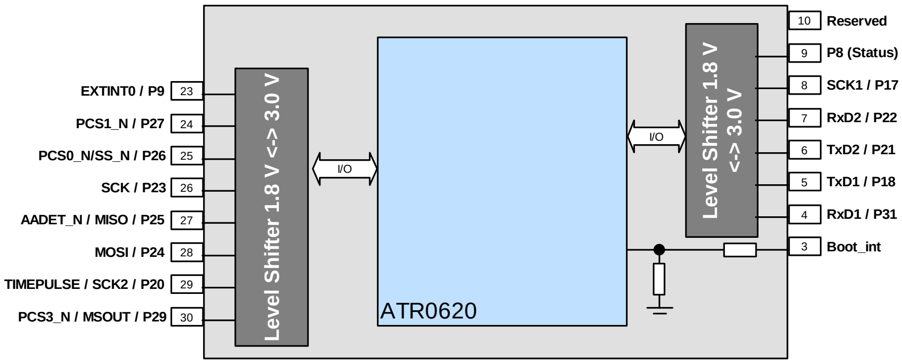


Figure 73: Internal level shifters on TIM-LP

! **Warning** Do not drive high loads directly with the TIM-LP output. Use appropriate drivers!

5.3.2 Level-Shifting TIM-LF

TIM-LF is based on a 1.8V core technology. Only the two Serial Port Interfaces are unidirectional level shifted to 3.0V. VDD18_OUT is the reference voltage for any external level shifter.

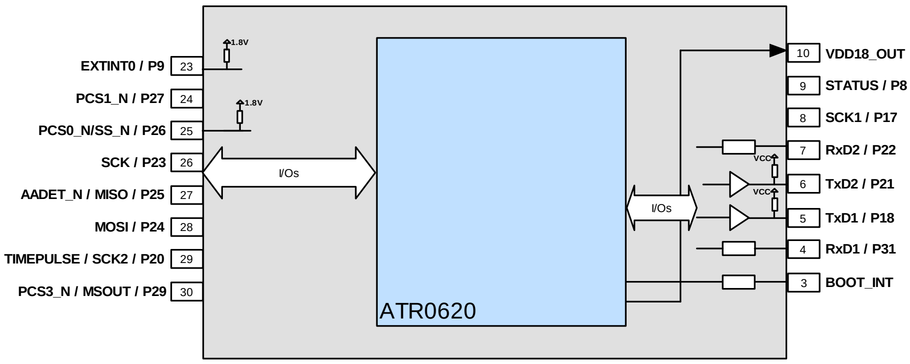


Figure 74: Internal level shifters on TIM-LF

5.3.3 Level-Shifting TIM-LC

TIM-LC is based on a 1.8V core technology. The Serial Port Interface is unidirectional level shifted to 3.3V (3V CMOS compatible level). VDD18_OUT is the reference voltage for any external level shifter.

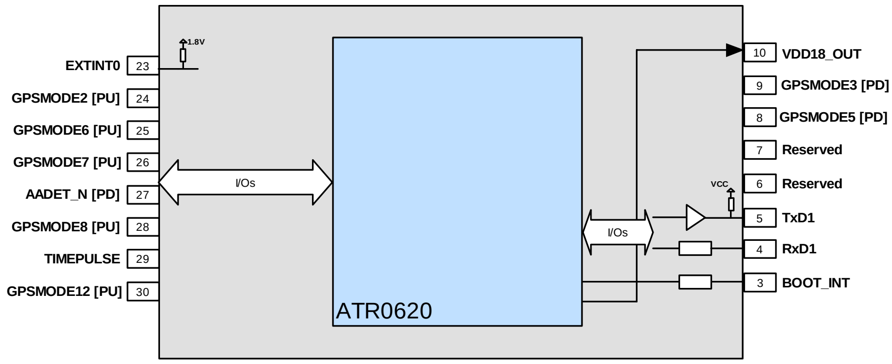


Figure 75: Internal level on TIM-LC

5.3.4 Recommended 1.8V Level Shifters

In some applications, it might be necessary to convert the 1.8V interface to 3.0V or 5.0V. There are various ways of converting voltage levels. *Table 56* lists the most commonly used methods.

Unidirectional Level Translators	NC7WZ07 MAX3374E, MAX3375E MAX3376E, MAX3379E MAX3390E–MAX3393E	FAIRCHILD MAXIM MAXIM MAXIM	There are a variety of unidirectional level translators. The selection in this table is by no means complete.
Bidirectional Level Translators	MAX3370, MAX3371 MAX3372E, MAX3373E MAX3377E, MAX3378E	MAXIM MAXIM MAXIM	There are a variety of bidirectional level translators. The selection in this table is by no means complete.
Open Drain Transistors	Various transistors		Open drain transistors invert the logic!
Current Limiting Resistors	It's recommended to use a 47 K resistor		Only feasible for input pins. At an input voltage of 5.5V, a current of 75µA will flow into the pin. It is not recommended to use current limiting resistors if the maximum frequency of the input exceeds 100kHz.
Bus Transceiver	ALVC164245	Texas Instruments	

Table 56: 1.8V Level Translators

5.4 RESET- Reset signal generation and use

ATR06020 contains an internal RESET signal generator.

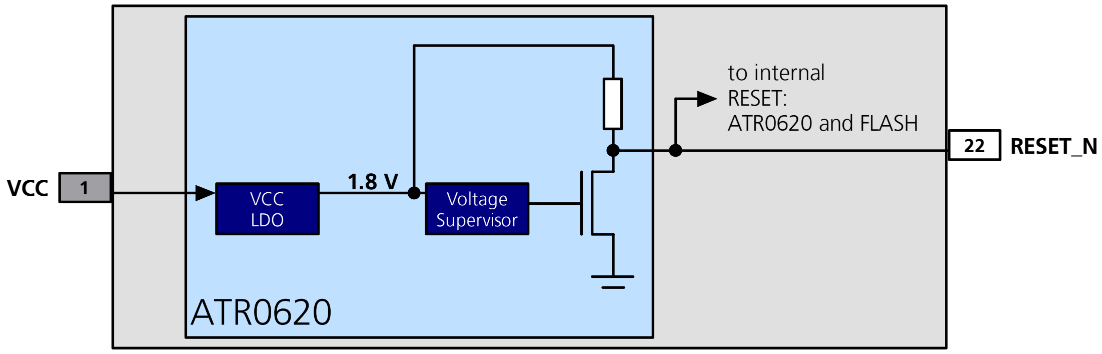


Figure 76: RESET generation

The circuit shown in *Figure 76* illustrates that pin **RESET_N** is normally an output pin, but one can also apply open drain external logic to drive the **RESET_N** signal low to activate a hardware reset of the system.

! **Note** The maximum output voltage at RESET_N is limited to the core voltage of ATR0620, i.e. 1.8 V.

! **Note** Leave RESET_N unconnected if not used.

! **Note** RESET_N is sensitive even to short voltage spikes. Keep this signal clean if routed outside TIM-Lx.

! **Warning** Do not drive **RESET_N** high.

For further reset options see *Section 4.9.1*.

5.5 BOOT_INT – Boot Mode Selection

BOOT_INT is used to set the boot mode of the ANTARIS® GPS Receiver. By default the receiver will boot in normal GPS mode. If there are corrupted data in FLASH, it may be necessary to boot the receiver in test mode by pulling **BOOT_INT** high during a power cycle or hardware reset to update the firmware.

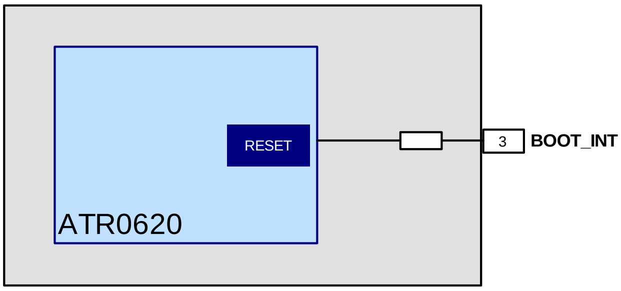


Figure 77: BOOT_INT, Internal connection

! Note This Pin is only needed if a firmware upgrade failed and therefore the firmware image is corrupt. Leave **BOOT_INT** unconnected if not used.

! Note Connect to a jumper with Vcc to be able to start TIM-LP / TIM-LF in boot mode. For TIM-LC this signal is only used for production tests at u-blox.

5.6 EXTINT0 - External Interrupt Pin

EXTINT0 is an external interrupt pin. This pin is used in standard configuration to initiate a position fix in the FixNOW™ Mode. Pulling **EXTINT0** low wakes up the module and initiates a position fix calculation. Using the *ANTARIS® Software Customization Kit*, **EXTINT0** can initiate external interrupts to custom functions.

! Note Leave **EXTINT0** unconnected if not used.

5.7 Generic Wirings

5.7.1 Generic Minimal Wiring for TIM-LC, TIM-LF and TIM-LP

Functional Block	Remark
Active Antenna	The connection to the antenna has to be routed on the PCB. Use a controlled impedance line (Micro strip) to connect RF_IN to the antenna or antenna connector.
Antenna Short Circuit Protection	R_BIAS can be omitted if the short circuit detection feature is not required. For details refer to *Section 5.2.4*
Backup Battery	No hotstart or warmstart possible, if no Backup Battery connected
Serial Interface	The Serial Interfaces have built-in level shifters to 3.0V. If you need different voltage levels, use appropriate level shifters, e.g. MAX 3232 from Maxim or equivalent in order to obtain RS-232 compatible levels. **! Note** Connect unused Rx-inputs to Vcc.

Table 57: Generic minimal configuration for TIM-LC, TIM-LF and TIM-LP

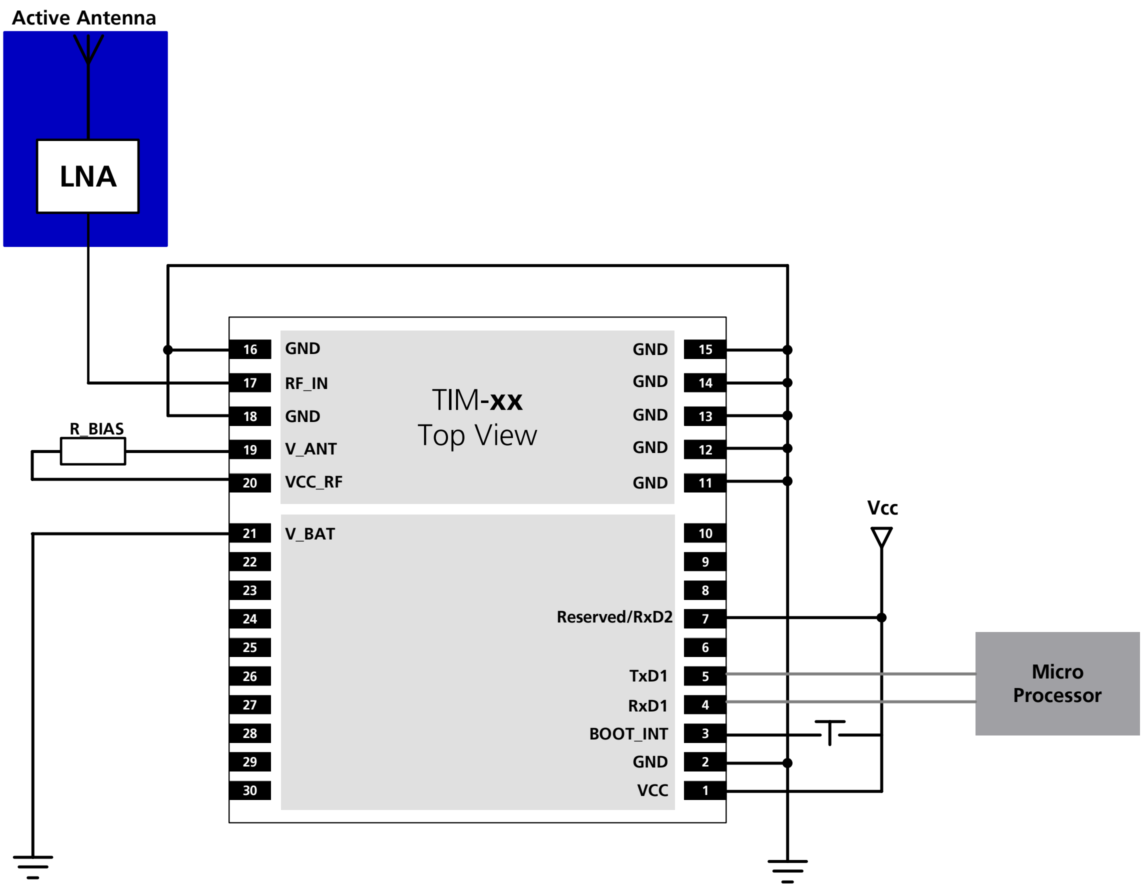


Figure 78: Generic minimal wiring for TIM-LC, TIM-LF, TIM-LP

! Note: This configuration allows a one-to-one replacement of TIM-LC, TIM-LF, TIM-LP and TIM.

! Note: To be able to upgrade a firmware in TIM-LF or TIM-LP designs it is recommended to design in accessible pads in RxD1/TxD1 or RxD2/TxD2.

5.7.2 Generic Maximum Wiring TIM-LC, TIM-LF and TIM-LP

Functional Block	Remark
Active Antenna	The connection to the antenna has to be routed on the PCB. Use a controlled impedance line (Micro strip) to connect RF_IN to the antenna or antenna connector.
Active Antenna Supervisor	To get more details of the Active Antenna Supervisor Circuit refer to *Section 5.2.4.2.*
Serial Interface	The Serial Interfaces have built-in level shifters to 3.0V. If you need different voltage levels, use appropriate level shifters, e.g. MAX 3232 from Maxim or equivalent in order to obtain RS-232 compatible levels. **! Note** Connect unused Rx-inputs to Vcc.

Table 58: Generic maximum configuration for TIM-LC, TIM-LF, TIM-LP

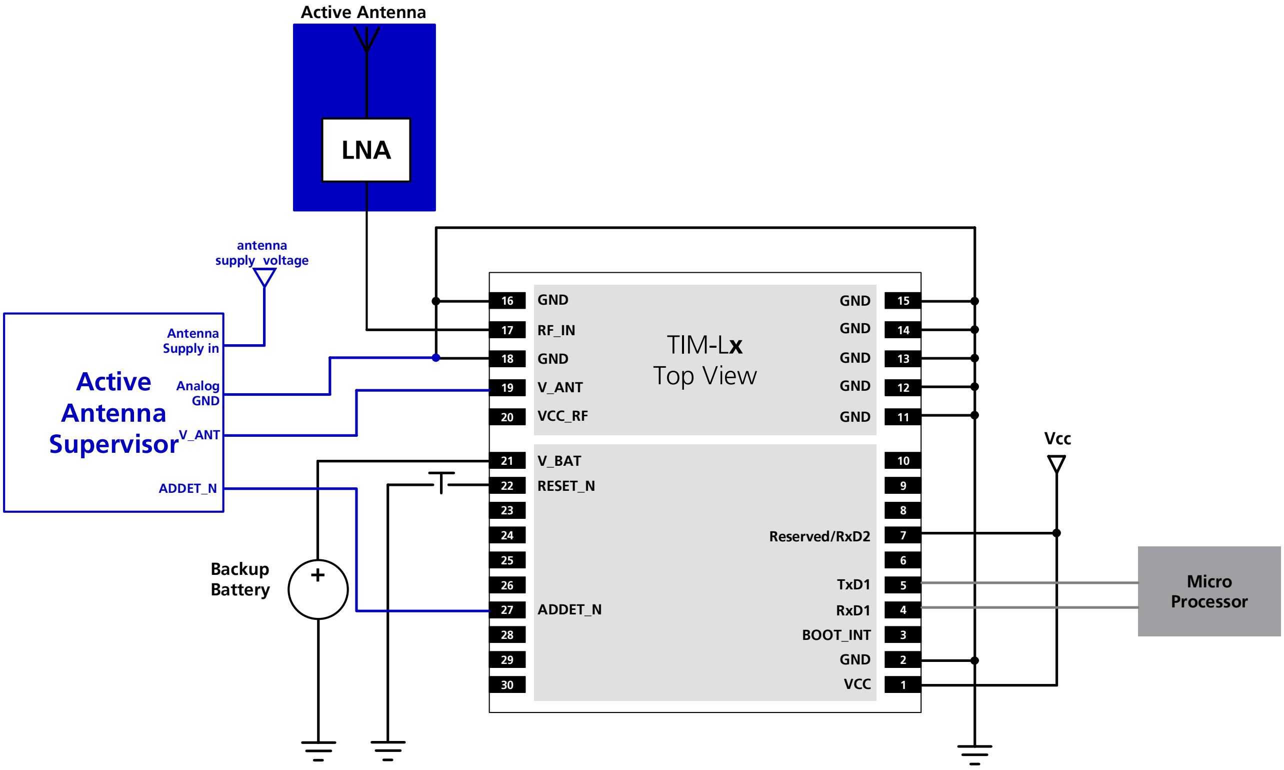


Figure 79: Generic maximum wiring for TIM-LC, TIM-LF, TIM-LP

! Note: This configuration allows a one to one replacement of TIM-LC, TIM-LF and TIM-LP

5.8 Specific Wiring TIM-LP

For the minimal wiring of TIM-LP with an active antenna refer to the generic configurations in *Section 5.7.*

5.8.1 Minimal Passive Antenna Wiring

Figure 80 shows an absolute minimal configuration schematic.

Functional Block	Remark
Passive Antenna	The connection to the antenna has to be routed on the PCB. Use a controlled impedance line (Micro strip) to connect RF_IN to the antenna or antenna connector.
Backup Battery	No hotstart or warmstart possible, if no Backup Battery connected
Serial Interface	The Serial Interfaces have built-in level shifters to 3.0V. If you need different voltage levels, use appropriate level shifters, e.g. MAX 3232 from Maxim or equivalent in order to obtain RS-232 compatible levels. **! Note** Connect unused Rx-inputs to Vcc.

Table 59: Minimal passive antenna system setup TIM-LP

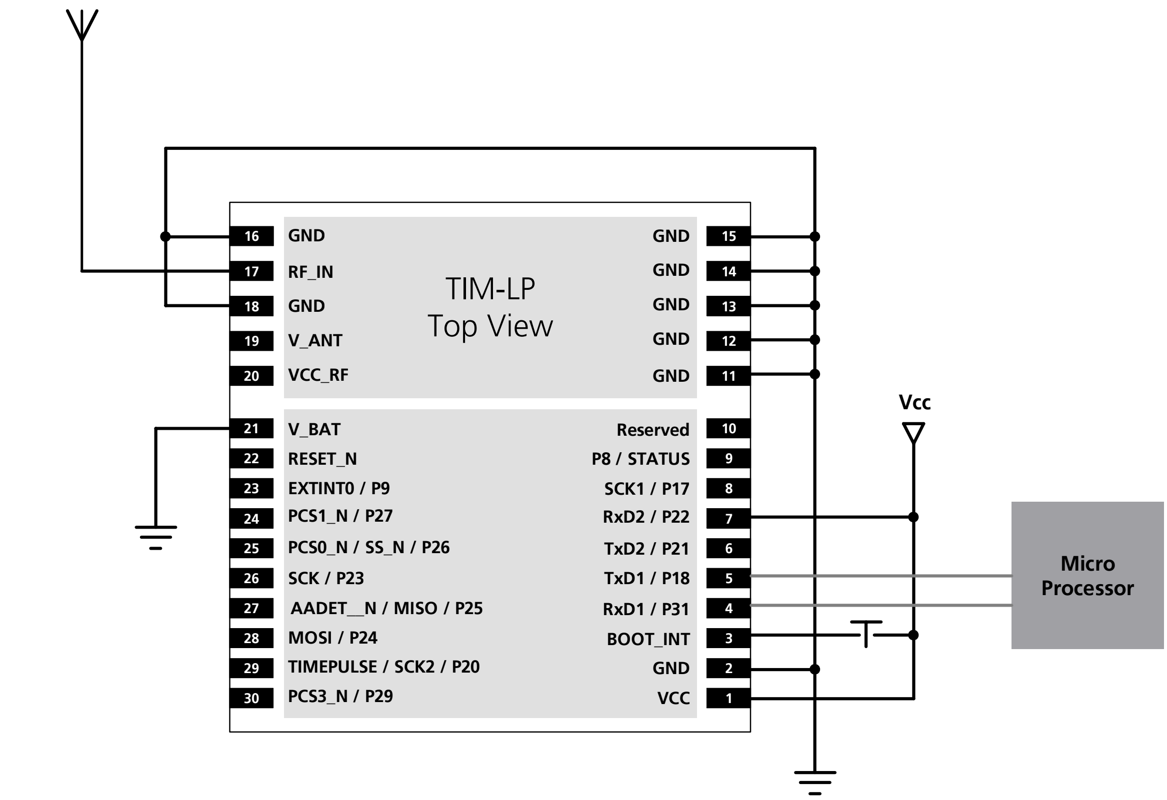


Figure 80: Example Schematic of a minimal passive antenna wiring TIM-LP

5.8.2 Maximal Active Antenna Wiring (using GPIOs or SPI)

Functional Block	Remark
Active Antenna	The connection to the antenna has to be routed on the PCB. Use a controlled impedance line (Micro strip) to connect RF_IN to the antenna or antenna connector.
Backup Battery	No hotstart or warmstart possible, if no Backup Battery connected
Serial Interface	The Serial Interfaces have built-in level shifters to 3.0V. If you need different voltage levels, use appropriate level shifters, e.g. MAX 3232 from Maxim or equivalent in order to obtain RS-232 compatible levels. **! Note** Connect unused Rx-inputs to Vcc.
STATUS LED	Connected to LED via a driver.

Table 60: Maximal active antenna wiring (using GPIOs or SPI) TIM-LP

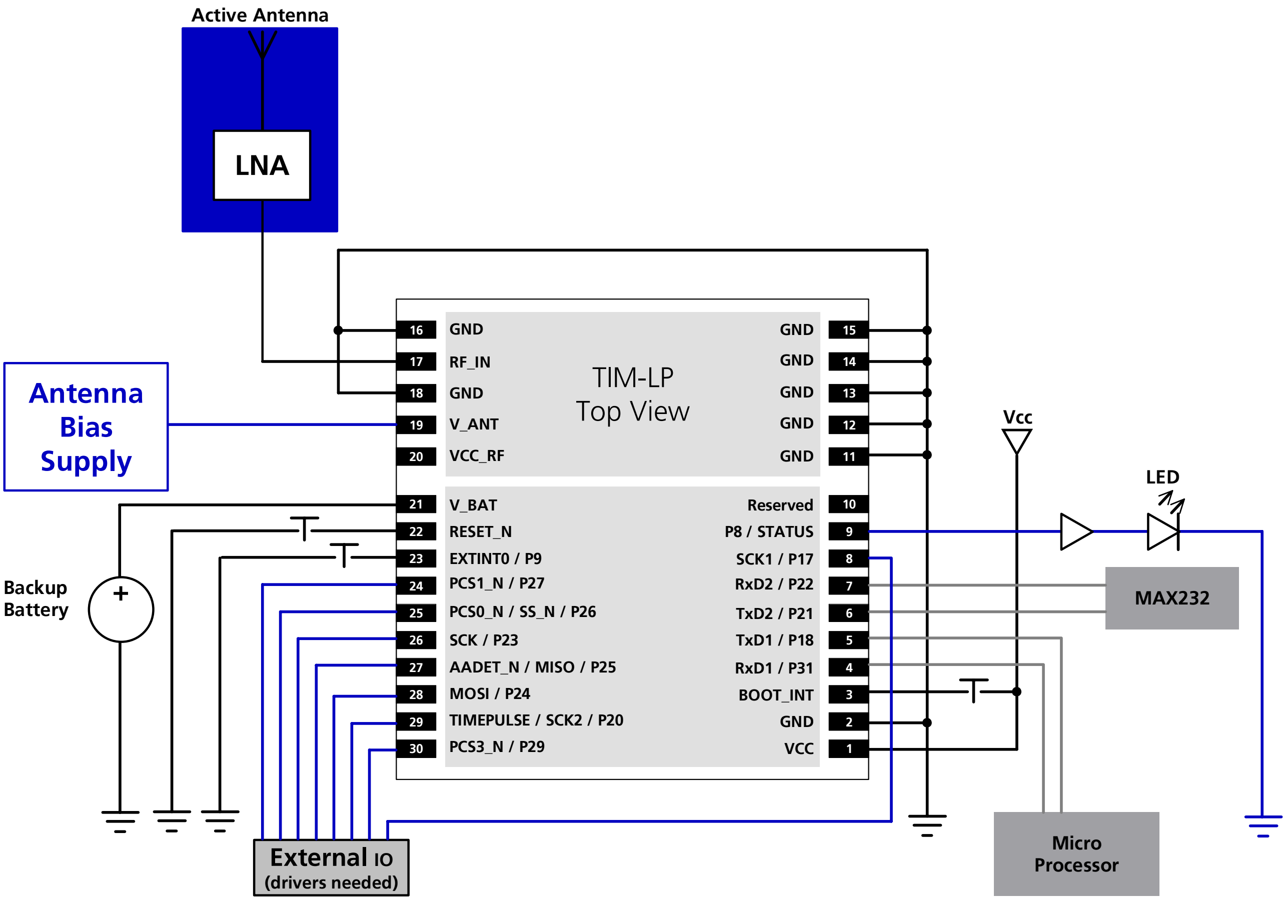


Figure 81: Maximal active antenna wiring TIM-LP

5.9 Specific Wiring TIM-LF

For the minimal wiring of TIM-LF refer to the generic configurations in *Section 5.7.*

5.9.1 Maximal Active Antenna Wiring (using GPIOs or SPI)

Functional Block	Remark
Active Antenna	The connection to the antenna has to be routed on the PCB. Use a controlled impedance line (Micro strip) to connect RF_IN to the antenna or antenna connector.
Backup Battery	No hotstart or warmstart possible, if no Backup Battery connected
Serial Interface	The Serial Interfaces have built-in level shifters to 3.0V. If you need different voltage levels, use appropriate level shifters, e.g. MAX 3232 from Maxim or equivalent in order to obtain RS-232 compatible levels. **! Note** Connect unused Rx-inputs to Vcc.
STATUS LED	Connected STATUS signal to LED. Note that the STATUS voltage level is 1.8V only.

Table 61: Maximal active antenna wiring TIM-LF

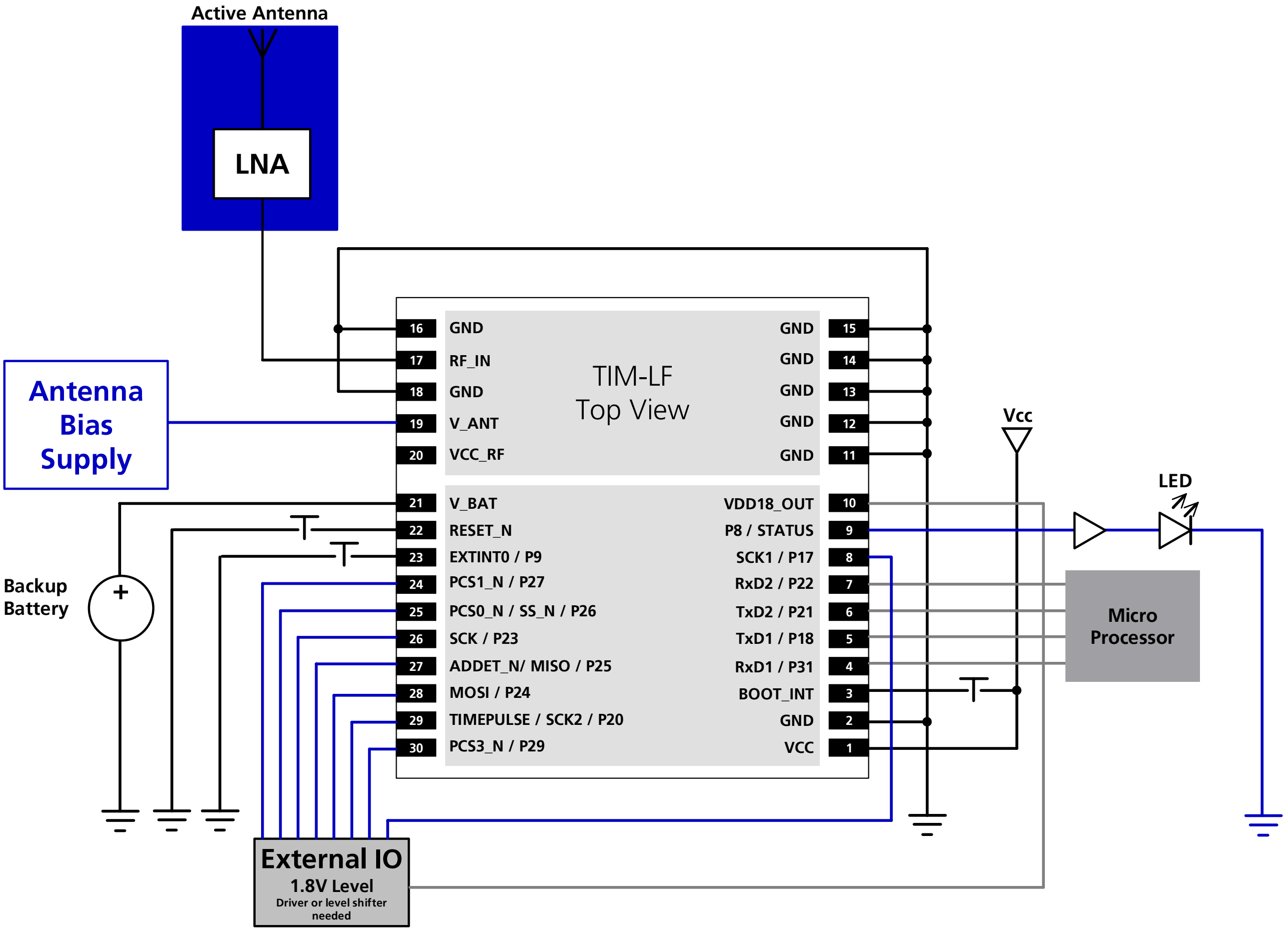


Figure 82: Maximal active antenna wiring TIM-LF

5.10 Specific Wiring TIM-LC

For the wiring of TIM-LC refer to the generic configurations in *Section 5.7.*

! **Note** TIM-LC is configured with the GPSMODE pins (*see 4.7.7*), which are checked at the start-up of the receiver. To be able to change the receiver configuration (e.g. sensitivity settings) it's recommended to consider assembly options at the design-in of the receiver.

5.10.1 GPSMODES Wiring

There are two different GPSMODE pin types, some with internal pull up resistor (marked as GPSMODEx[PU]), some with internal pull down resistor (marked as GPSMODEx[PD]). This internal wiring defines the default startup, if no GPSMODE pin is connected. If this default configuration suits the customer requirements, leave the GPSMODE pins unconnected. To change the default startup configuration of TIM-LC use the following wiring:

For GPSMODES with internal pull down resistor:

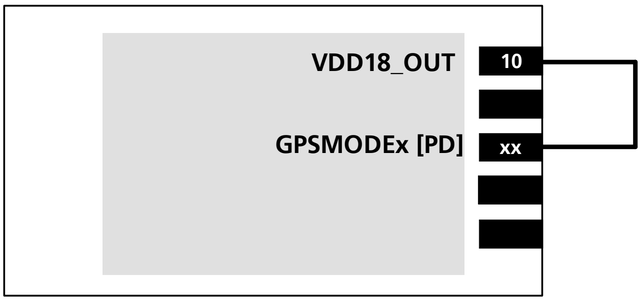


Figure 83: Wiring for GPSMODE's with internal pull down resistor

For GPSMODES with internal pull up resistor:

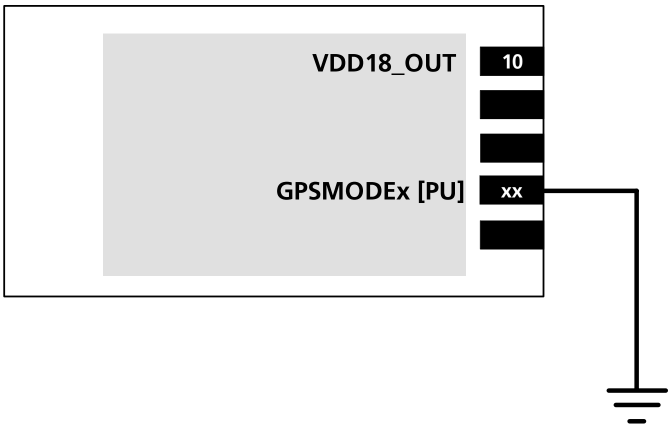


Figure 84: Wiring for GPSMODES with internal pull up resistor

The GPSMODE pins have to be set according to the configuration the GPS receiver has to startup with. GPSMODE [PU] pins have an internal pull-up resistor, GPSMODE [PO] have an internal pull-down resistor. Please refer to *Section 4.7.7* for further information.

6 Layout Considerations

The GPS signal on earth surface is about 15dB below the thermal noise floor. Signal loss of the antenna or the RF connection should be minimized as much as possible. When defining a layout including a GPS receiver the placement of the antenna vs. the receiver, grounding, shielding and jamming of other digital devices are the most important topics to be considered very carefully.

This section provides important information enabling the design of a reliable and sensitive GPS system.

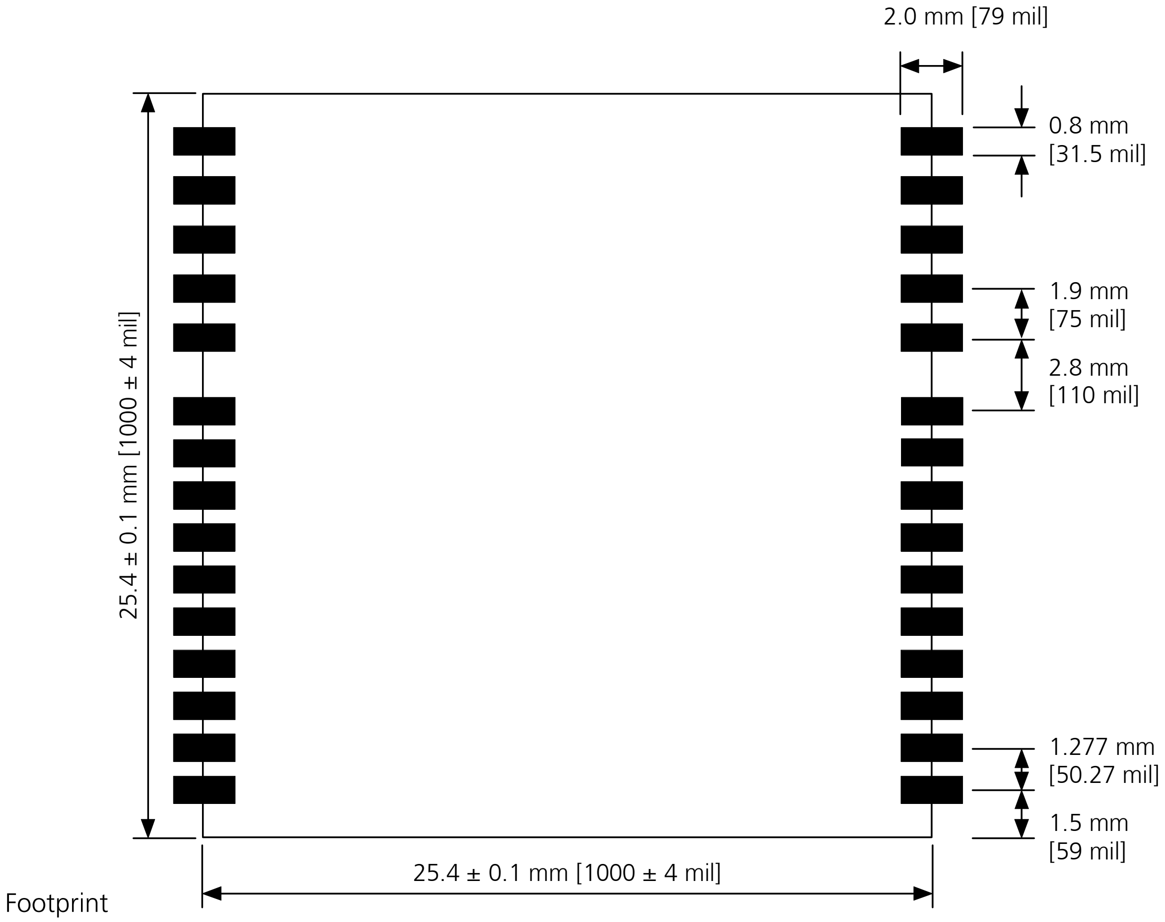


Figure 85: Recommended footprint

6.1 Paste Mask

To improve the quality of the soldering, define length of the paste-mask 0.4mm [16mil] longer than the pad length of the copper mask. The recommended thickness of the paste-mask should be 150µm [6mil].

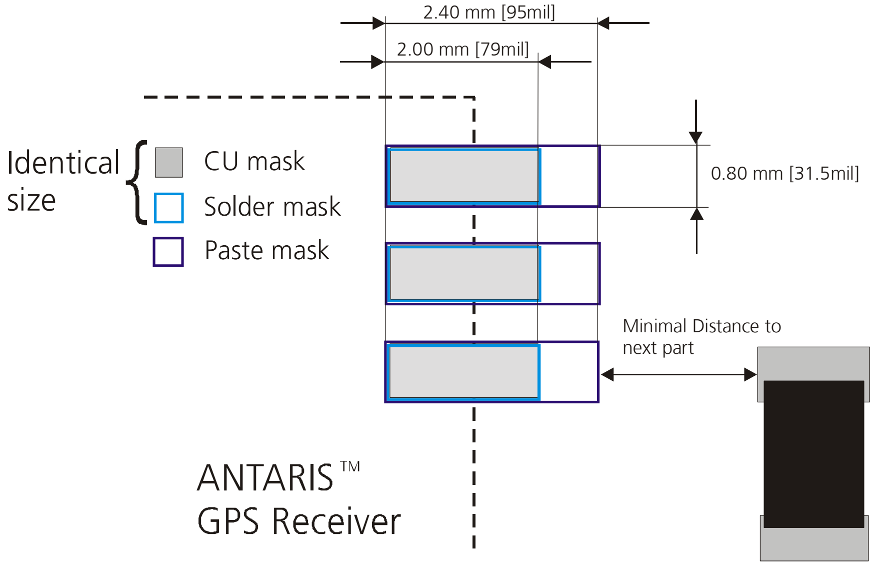


Figure 86: Recommendations for solder and paste mask

! **Note** Consider the paste mask outline when defining the minimal distance to the next part**.**

6.2 Placement

The placement of the ANTARIS® GPS Receiver on the PCB is very important to achieve maximum GPS performance. The connection to the antenna must be as short as possible to avoid jamming into the very sensitive RF section.

Make sure that RF critical circuits are clearly separated from any other digital circuits on the system board. To achieve this, position the receiver digital part towards your digital section of the system PCB.

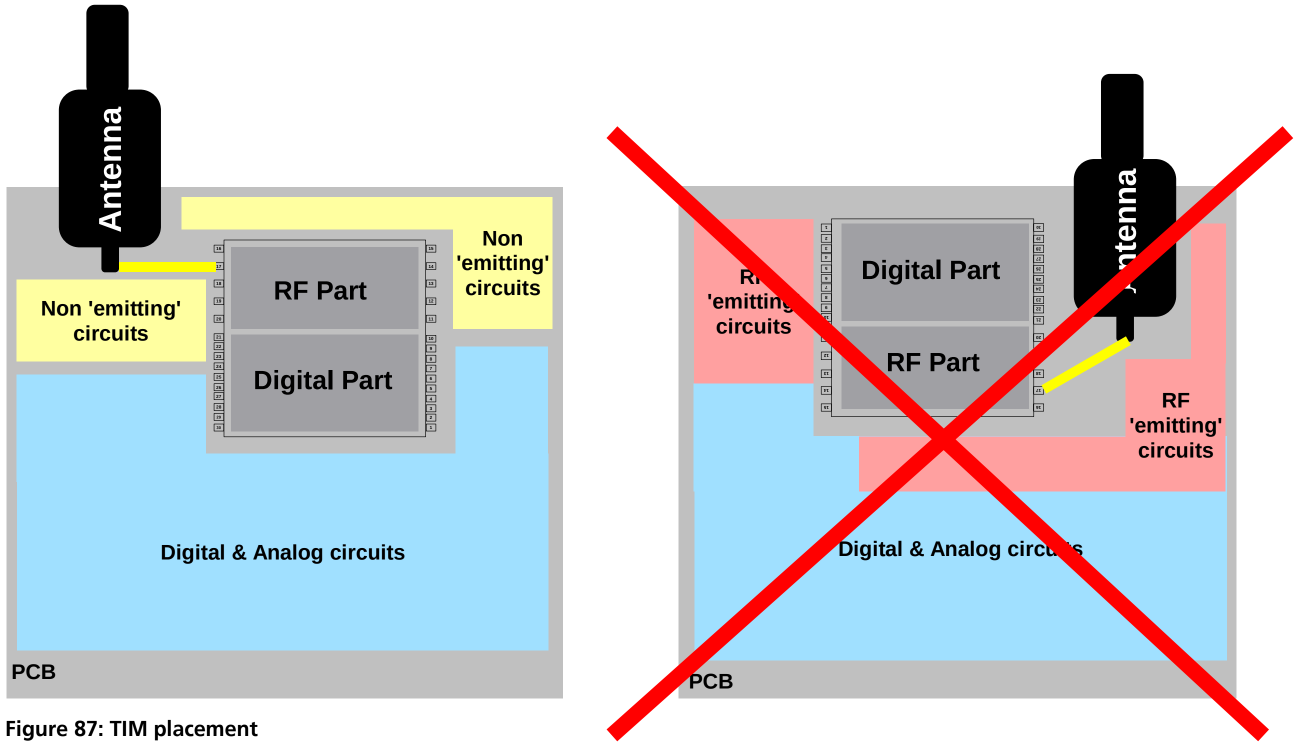


Figure 87: TIM placement

6.3 Layout

6.3.1 Antenna Connection and Grounding Plane Design

The TIM-LP GPS Receiver module can be connected to a passive patch antenna or an active antenna, the TIM-LF and TIM-LC to an active antenna connector without expensive RF cables. The antenna RF connection is on the PCB and connects the **RF_IN** pin with the antenna feed point or the signal pin of the connector, respectively. *Figure 88* illustrates connection to a typical five-pin RF connector. One can also see the improved shielding for digital lines according to the discussion in *Section 2.6.3*. Depending on the actual size of the ground area, additional vias should be placed in the outer region. In particular, the edges of the ground area should be terminated with a dense line of vias.

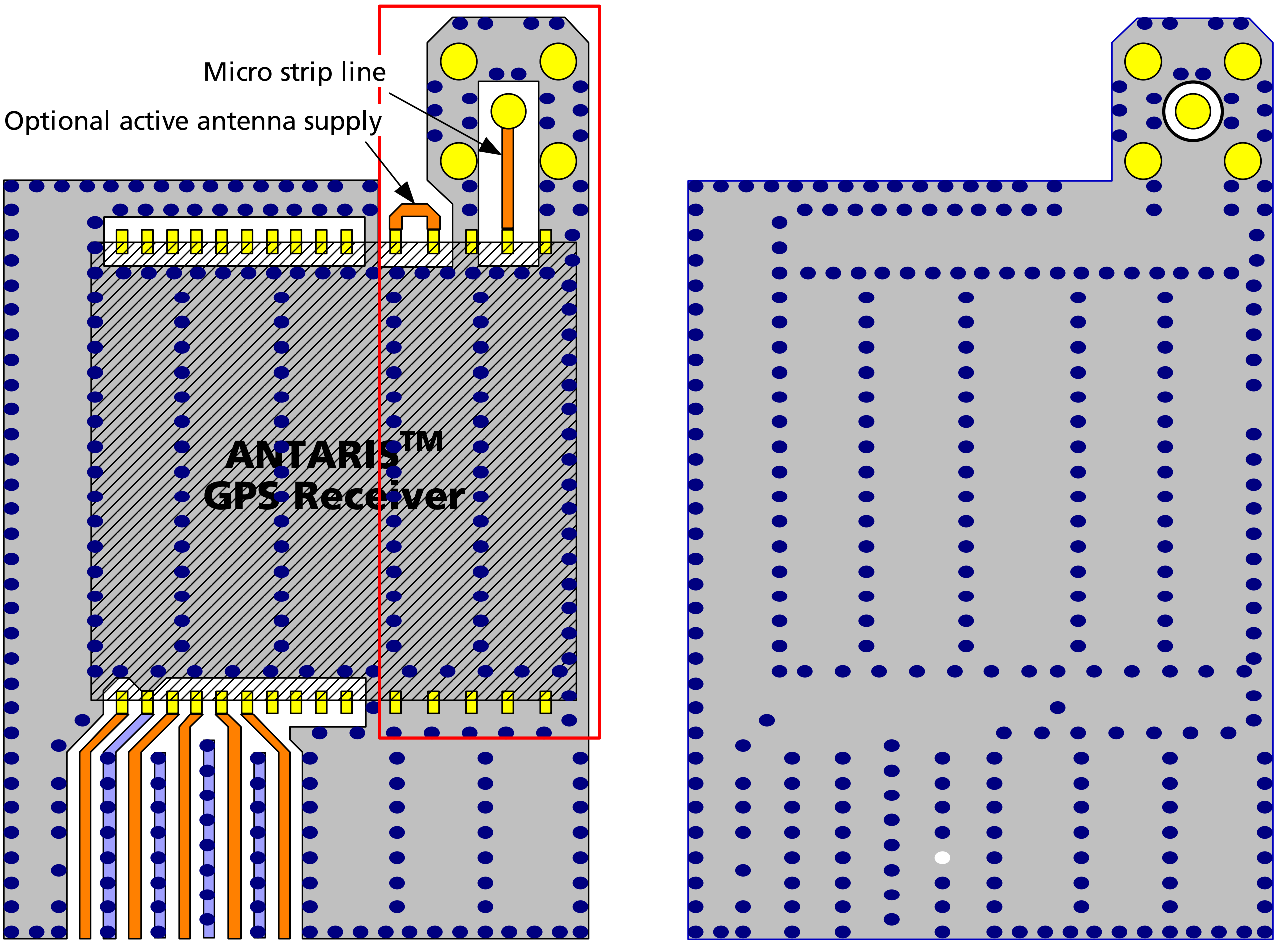


Figure 88: Recommended layout

As visible in *Figure 88,* an isolated ground area is created around and below the RF connection. This part of the circuit has to be kept as far away from potential noise sources as possible. Make sure that no signal lines cross or vias of signal traces show up at the PCB surface underneath the area surrounded by the red rectangle. Also, the ground plane should be free from digital supply return currents in this area. On a multi layer board, the whole layer stack below the RF connection should be free of digital lines. This is because even a solid ground plane provides only limited isolation.

The impedance of the antenna connection has to match the 50 Ohm impedance of the receiver. To achieve an impedance of 50 Ohms, the width W of the micro strip has to be chosen depending on the dielectric thickness H, the dielectric constant ε_r of the dielectric material of the PCB and on the built-up of the PCB (see *Section 6.3.2*). *Figure 89* shows two different builds: A 2 Layer PCB and a 4 Layer PCB. The reference ground plane is in both designs on layer 2 (red). Therefore the effective thickness of the dielectric is different.

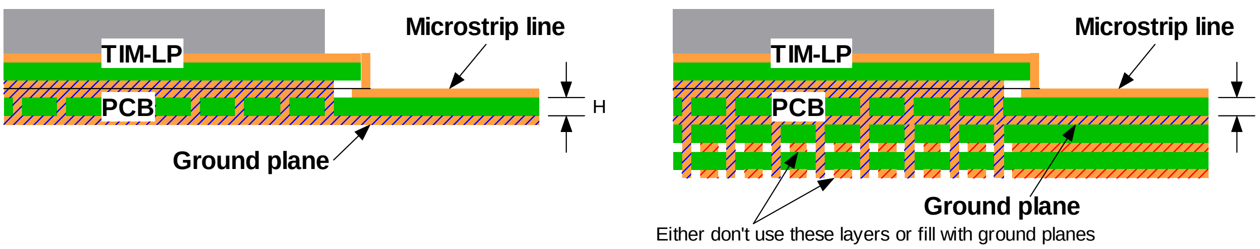
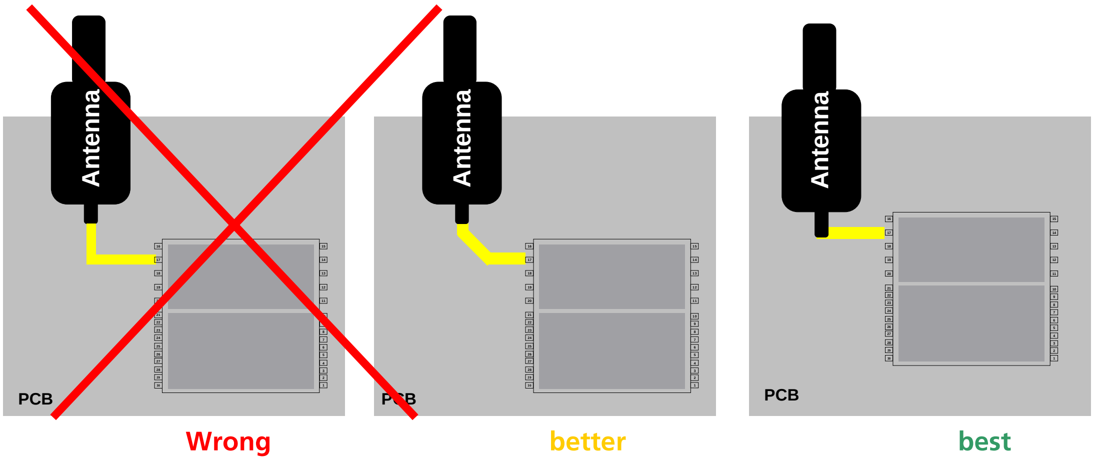


Figure 89: PCB build-up for Micro strip line. Left: 2-layer PCB, right: 4-layer PCB

General design recommendations:

- The length of the micro strip line should be kept as short as possible. Lengths over 2.5 cm (1 inch) should be avoided on standard PCB material and without additional shielding.
- Distance between micro strip line and ground area on the top layer should at least be as large as the dielectric thickness.
- Routing the RF connection close to digital sections of the design should be avoided.
- To reduce signal reflections, sharp angles in the routing of the micro strip line should be avoided. Chamfers or fillets are preferred for rectangular routing; 45-degree routing is preferred over Manhattan style 90-degree routing.



- Routing of the RF-connection underneath the receiver should be avoided. The distance of the micro strip line to the ground plane on the bottom side of the receiver is very small (some 100 µm) and has huge tolerances (up to 100%). Therefore, the impedance of this part of the trace cannot be controlled.
- Use as many vias as possible to connect the ground planes.
- In order to avoid reliability hazards, the area on the PCB under the receiver should be entirely covered with solder mask. Vias should not be open.

6.3.2 Antenna Micro Strip

There are many ways to design wave-guides on printed circuit boards. Common to all is that calculation of the electrical parameters is not straightforward. Freeware tools like AppCAD from Agilent or TXLine from Applied Wave Research, Inc. are of great help. They can be downloaded from www.agilent.com and www.mwoffice.com.

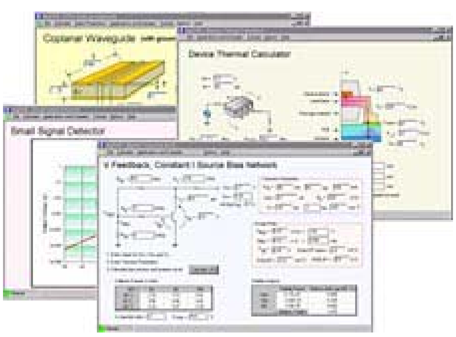


Figure 90: Screenshots from AppCAD, Agilent

The micro strip is the most common configuration for printed circuit boards. The basic configuration is shown in *Figure 91*. As a rule of thumb, for a FR-4 material the width of the conductor is roughly double the thickness of the dielectric to achieve 50 Ohms line impedance.

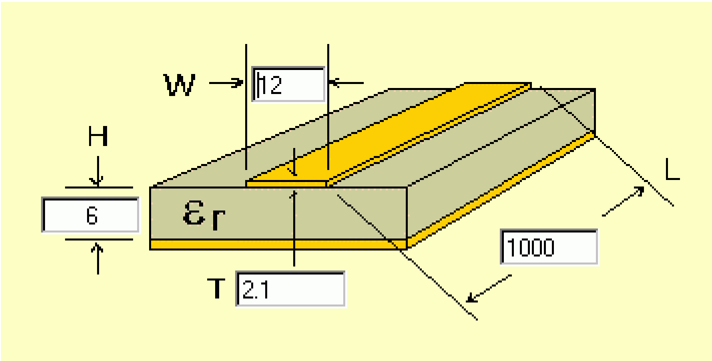


Figure 91: Micro strip, Agilent AppCAD

Table 62 shows some example results, which should fit most common designs on FR-4.

H [mm]	W ε_r = 4.1 T = 35 µm [mm]	W ε_r = 4.1 T = 18 µm [mm]	W ε_r = 4.6 T = 35 µm [mm]	W ε_r = 4.6 T = 18 µm [mm]
0.25	0.47	0.49	0.43	0.44
0.50	0.97	0.99	0.89	0.90
0.75	1.47	1.49	1.35	1.36
1.00	1.97	1.99	1.81	1.83
1.25	2.47	2.49	2.27	2.29
1.50	2.98	3.00	2.73	2.75
1.75	3.48	3.50	3.19	3.21
2.00	3.98	4.00	3.65	3.67

Table 62: AppCAD results for standard FR-4 based micro strip designs

6.4 Reference Layout

Figure 92 and *Figure 93* show examples of an application board. One can easily identify the large number of vias and the ground areas on the top layer. Since the dielectric is rather thick (1.6 mm) also the micro strip gets quite wide. Unfortunately, the mounting hole in the upper left corner required a trench in the micro strip line. Measurements show that this has no significant effect. The small slot in the ground plane on the bottom layer at the left end helps to isolate the noisy digital part from the RF input. This was necessary in this design because the RF connector sits quite close to the digital I/Os of the receiver. If in a different design, the connector could be moved further up, the slot would likely not be necessary and a layout similar to Figure 88 will work fine. Increasing the length of this slot is not recommended and will not further improve performance.

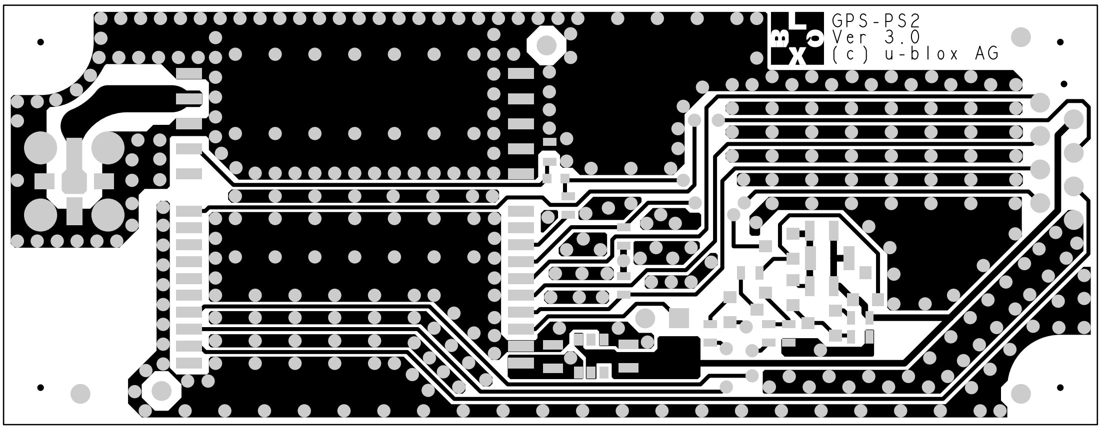


Figure 92: Reference layout: Top layer on 2-layer 1.6 mm FR-4 material

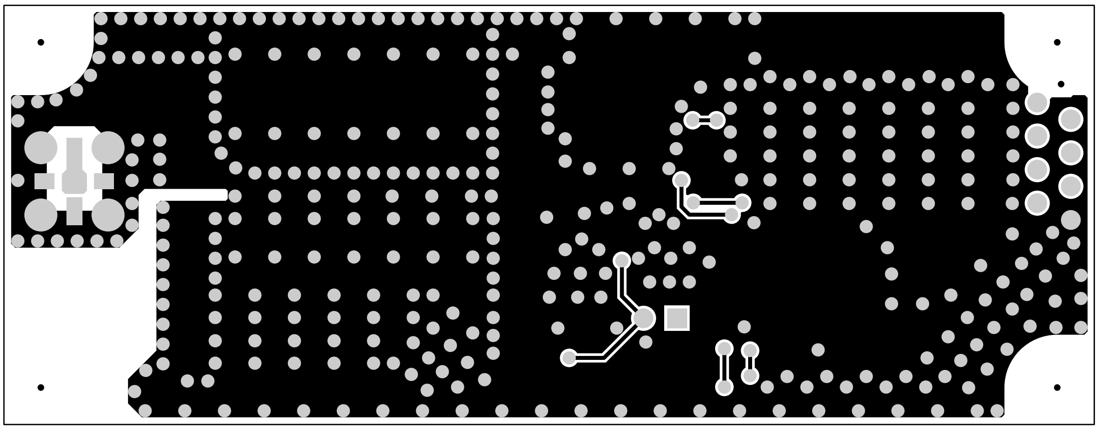


Figure 93: Reference layout: Bottom layer on 2-layer 1.6 mm FR-4 material

! **Note** u-blox offers a PCB review support for your design to assure a good GPS performance. Please contact your local u-blox office already in an early stage of your design process for optimal guidance.

7 Product Handling

7.1 Packaging

The ANTARIS® GPS Receiver Macro Components are delivered as hermitically sealed reeled tapes in order to enable efficient production, production lot set-up and tear-down.

Figure 94: Reeled ANTARIS® GPS Receiver macro components

7.1.1 Reels

The ANTARIS® GPS Receiver Macro Components are available in two reel sizes. A 100pcs reel and a 500pcs reel. The dimensions of both reels are identical:

Diameter: 330mm

Width: 44mm

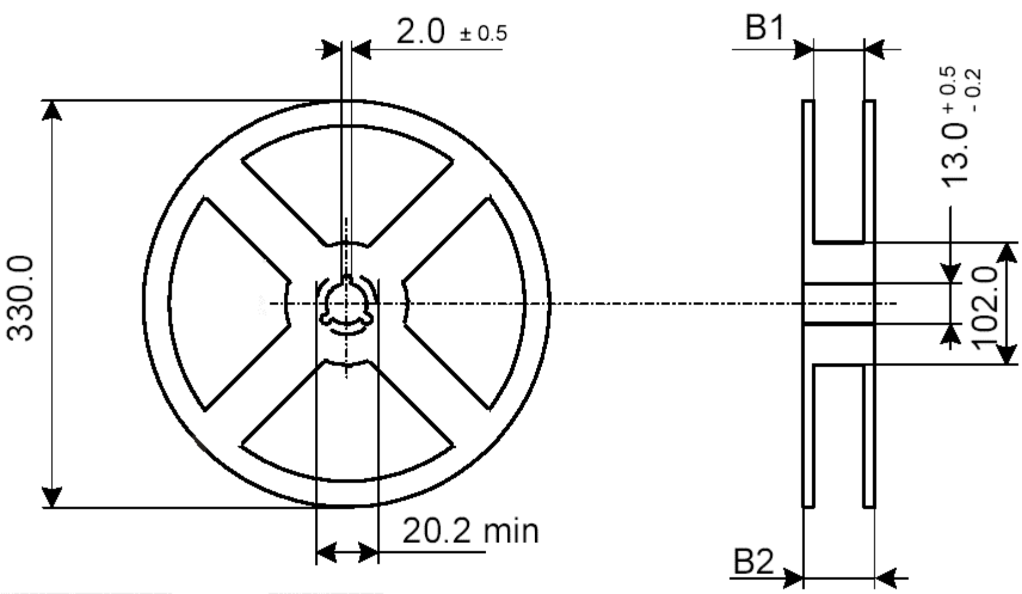


Figure 95: Reel - dimensions

7.1.2 Tapes

The tape is specified in *Figure 96*. Units are in mm.

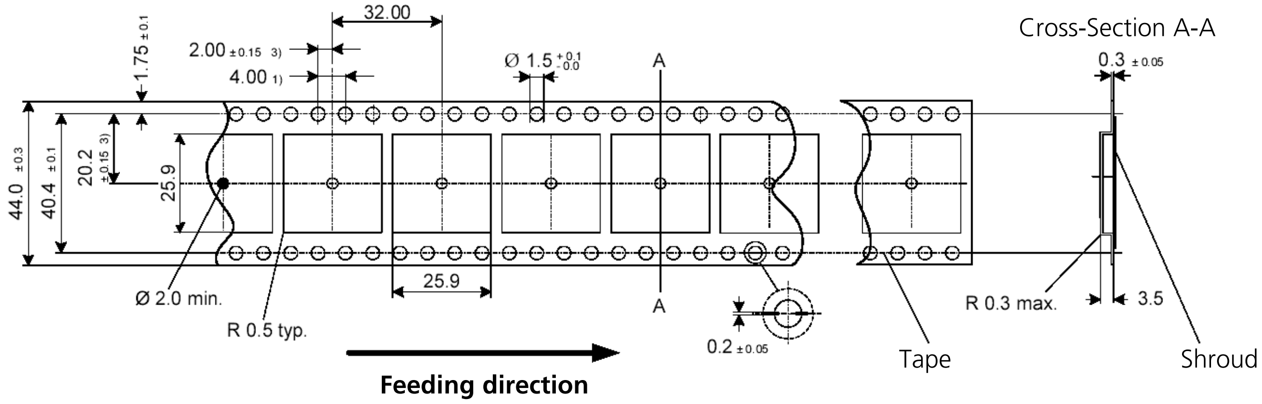


Figure 96: Tape - dimensions

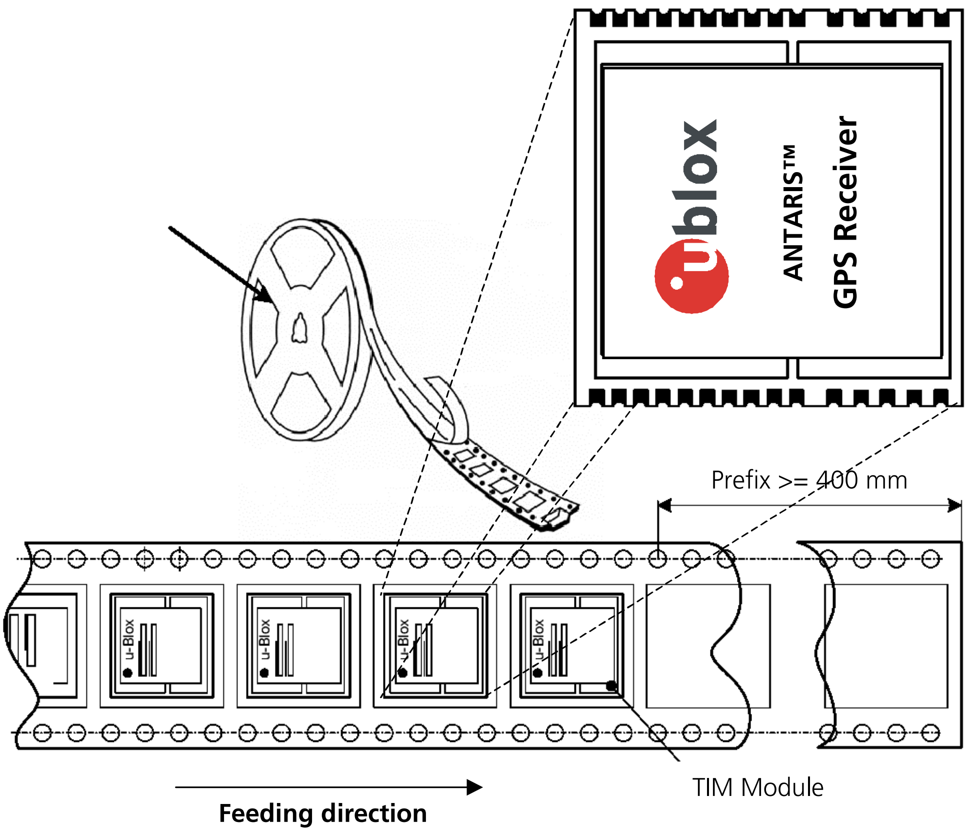


Figure 97: Reel - orientation of the ANTARIS® GPS Receiver Macro Components in relation to feed direction

7.2 Shipment, Storage and Handling

7.2.1 Handling

The ANTARIS® GPS Receiver Macro Component is designed and packaged to be processed in an automatic assembly line. The receiver macro component is shipped in Tape-and-Reel.

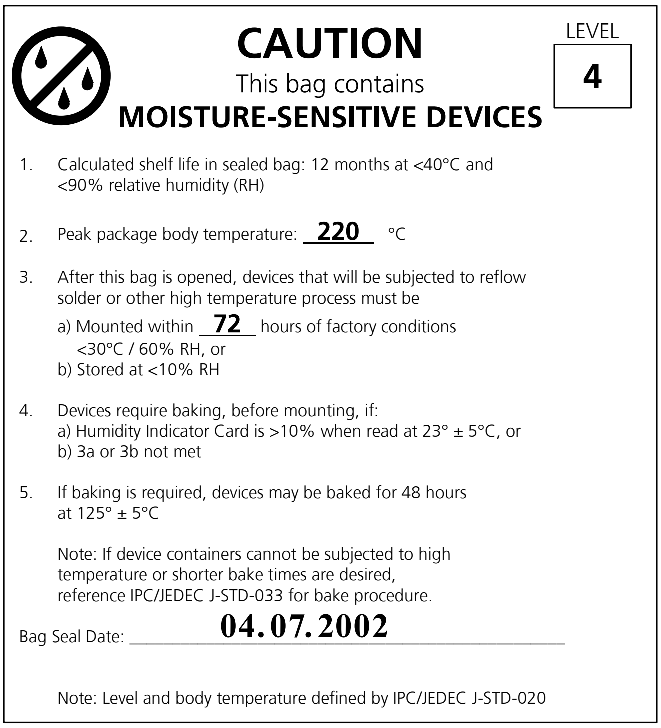
! Warning The component contains highly sensitive electronic circuitry. Handling the ANTARIS® GPS Receiver without proper ESD protection may destroy or damage the GPS macro components permanently.

! Warning According to JEDEC ISP, the ANTARIS® GPS Receiver Macro Components are moisture sensitive devices. Appropriate handling instructions and precautions are summarized in Sections 7.2.2 to 7.2.5. Read them carefully to prevent permanent damages due to moisture intake.

7.2.2 Shipment

The ANTARIS® GPS Receiver Macro Components are delivered on Tape-and-Reels in a hermetically sealed package ("dry bag") to prevent moisture intake and protection against electrostatic discharge. To prevent physical damages, the reels are individually packed in carton boxes.

The dry bag provides a JEDEC compliant MSD label (Moisture Sensitive Devices) describing the handling requirements to prevent humidity intake.


CAUTION
This bag contains
MOISTURE-SENSITIVE DEVICES

LEVEL 4

1. Calculated shelf life in sealed bag: 12 months at <40°C and <90% relative humidity (RH)
2. Peak package body temperature: 220 °C
3. After this bag is opened, devices that will be subjected to reflow solder or other high temperature process must be
   a) Mounted within 72 hours of factory conditions <30°C / 60% RH, or
   b) Stored at <10% RH
4. Devices require baking, before mounting, if:
   a) Humidity Indicator Card is >10% when read at 23° ± 5°C, or
   b) 3a or 3b not met
5. If baking is required, devices may be baked for 48 hours at 125° ± 5°C

   Note: If device containers cannot be subjected to high temperature or shorter bake times are desired, reference IPC/JEDEC J-STD-033 for bake procedure.

Bag Seal Date: 04.07.2002

Note: Level and body temperature defined by IPC/JEDEC J-STD-020

Figure 98: Applicable MSD Label (See section 3.1 for baking instructions)

7.2.3 Storage

Shelf life in sealed bag is 12 months at <40°C and <90% relative humidity.

7.2.4 Handling

A humidity indicator card and a desiccant bag to absorb humidity are enclosed in the sealed package. The parts are shipped on tape-and-reel in a hermetically sealed package. If no humidity has been drawn, the three fields in the humidity indicator card indicate blue color.

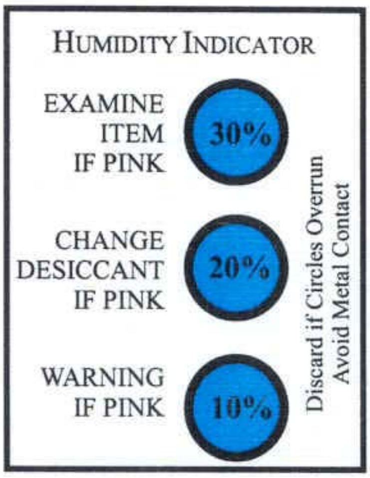


Figure 99: Humidity Indicator Card, good condition

7.2.5 Floor Life

For products with moisture sensitivity level 4, the floor life is 72 hours, or precisely three days. Under factory floor temperature and humidity conditions (<30°C, <60° relative humidity), the parts must be processed and soldered within this specified period of time.

Once the sealed package of the reel is opened and the parts exposed to humidity, they need to be processed within 72 hours (precisely three days) in a reflow soldering process. If this time is exceeded, or the sticker in the sealed package indicates that the goods have been exposed to moisture, the devices need to be pre-baked before used in the flow solder process. Please refer to chapter 7.3 for instructions on how to pre-bake the components.

7.3 Processing

7.3.1 Moisture Preconditioning

Both encapsulant and substrate materials absorb moisture. JEDEC specification J-STD-020 must be observed to prevent cracking and delamination associated with the "popcorn" effect during solder reflow. The popcorn effect can be described as miniature explosions of evaporating moisture. Baking before processing is required in following cases:

- Humidity indicator card: At least one circular indicator is no longer blue
- Floor life or environmental requirements after opening the seal is opened has been exceeded, e.g. exposure to excessive seasonal humidity.

Recommended baking procedure:

Duration:	48 hours
Temperature:	125°C
Humidity:	Below 5%. Desiccant must be placed into the oven to keep humidity low.
Oven:	Convection flow oven. Also put desiccant pack into the oven for dehydration.
After work:	Put the baked components with desiccant and moisture indicator into a humidity proof bag and use a vacuum hot barrier sealing machine for sealing if not processed within specified floor time. Storage in a nitrogen cabinet or dry box is also a possible approach to prevent moisture intake.

! **Warning** Do not attempt to bake the ANTARIS® GPS Receiver Macro Components contained in tape and rolled up in reels. If you need to bake the ANTARIS® GPS Receiver Macro Components quickly at 125°C for 48 hours, remove them from the belt and place them individually onto the oven tray.

! **Note** A repeated baking process will reduce the wetting effectiveness of the pad contacts. This advice applies to all SMT devices.

7.3.2 Soldering Paste

Use of "No Clean" soldering paste is strongly recommended, as it does not require cleaning after the soldering process has taken place. The paste listed in the example below meets these criteria.

Soldering Paste:	Ecorel 802 http://www.promosol.com/english/cremes01a.html
Alloy specification:	Sn62Pb36Ag2 (62% Zinc / 36% Lead / 2% Silver) Paste without Silver (63% Zinc / 37% Lead) also works.
Liquidus Temperature:	183°C or lower
Stencil Thickness:	≥ 150 µm for base boards

The final choice of the soldering paste depends on the approved manufacturing procedures.

The paste-mask geometry for applying soldering paste should meet the recommendations in *Figure 86*.

! **Note** The quality of the solder joints on the connectors ('half vias') should meet the appropriate IPC specification.

7.3.3 Reflow Soldering

A convection type-soldering oven is strongly recommended over the infrared type radiation oven. Convection heated ovens allow precise control of the temperature and all parts will be heated up evenly, regardless of material properties, thickness of components and surface color.

Consider the "IPC-7530 Guidelines for temperature profiling for mass soldering (reflow and wave) processes, published 2001" [2].

Preheat Phase

Initial heating of component leads and balls. Residual humidity will be dried out. Please note that this preheat phase will not replace prior baking procedures.

- Temperature rise time: 1 - 3°C/s
- Reach 100 - 125°C

Activation Phase

The solder paste dries out and the flux activates. The activation phase is normally dependent on your chosen soldering paste and is therefore subject to variations.

- Ramp up from 100-125°C range up to 150-175°C range
- Limit to 120 seconds (known as wetting time)

Reflow Phase

The temperature rises above the liquidus temperature of 183°C.

- Limit time above 183°C liquidus temperature: 60 - 120s
- Peak reflow temperature: max. 220°C (± 5°C)

Cooling Phase

A controlled cooling avoids negative metallurgical effects (solder becomes more brittle) of the solder and possible mechanical tensions in the products. Controlled cooling helps to achieve bright solder fillets with a good shape and low contact angle.

- Temperature fall rate: max 3°C / s

! **Note** To avoid falling off, the ANTARIS® GPS Receiver Macro Component shall be placed on the topside of the motherboard during soldering.

The final soldering temperature chosen at the factory depends on additional external factors like choice of soldering paste, size, thickness and properties of the base board, etc. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the macro component.

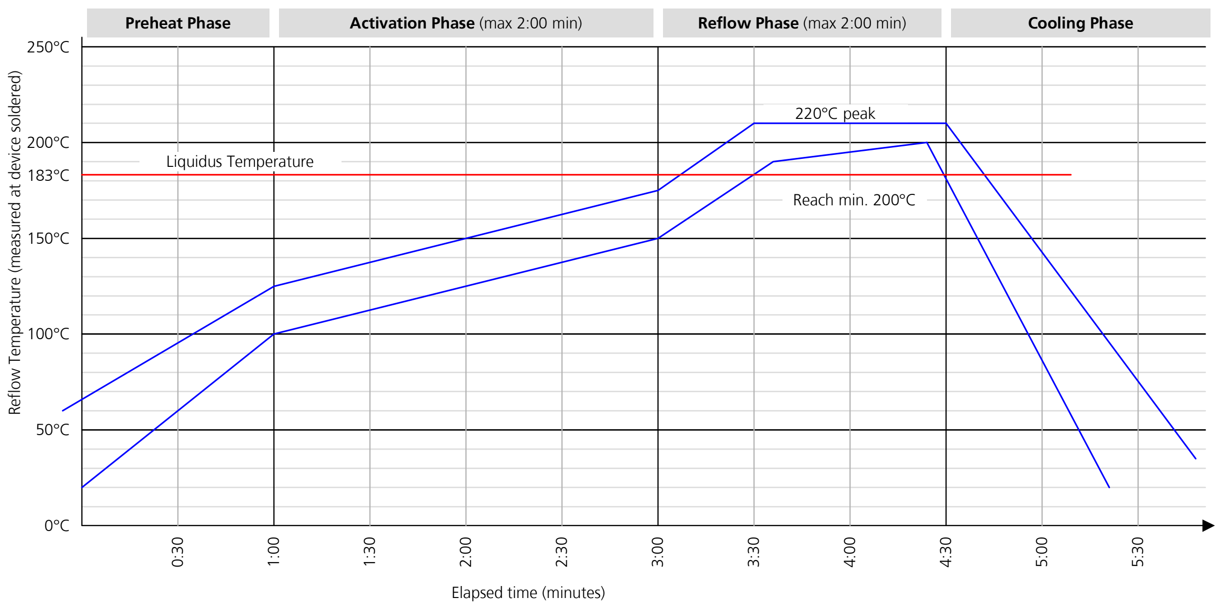


Figure 100: Recommended soldering profile

7.3.4 Optical Inspection

After soldering the ANTARIS® GPS Receiver Macro Component, consider an optical inspection step to check whether:

- ANTARIS® GPS Receiver Macro Component is properly aligned and centered over the pads
- All pads are properly soldered
- No excess solder has created contacts to neighboring pads, or possibly to pad stacks and vias nearby.

7.3.5 Cleaning

In general, cleaning the populated macro components is strongly discouraged. Residuals, which are underneath the ANTARIS® GPS Receiver Macro Components, cannot be removed easily with a washing process.

- Cleaning with water will lead to capillary effects where water is absorbed in the gap between the baseboard and the ANTARIS® GPS Receiver Macro Component. The combination of residuals of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pads. Water will also damage the sticker and the ink-jet printed text.
- Cleaning with alcohol or a similar organic solvent will likely flood soldering flux residuals into the two housings, which is a place not accessible for post-washing inspection. The solvent will also damage the sticker and the ink-jet printed text.
- Ultrasonic cleaning will damage an ANTARIS® GPS Receiver permanently, in particular the quartz oscillators.

The best approach is to consider using a "no clean" soldering paste and eliminate the cleaning step past the soldering.

7.3.6 Repeated Reflow Soldering

Only a single reflow soldering process is encouraged for boards with an ANTARIS® GPS Receiver Macro Component populated on it. Reason: Risk of falling off due to high weight in relation to the adhesive properties of the solder.

7.3.7 Wave Soldering

Base boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices require a wave soldering to solder the THT components. Only a single wave soldering process is encouraged for boards with an ANTARIS® GPS Receiver Macro Component populated on it.

7.3.8 Hand Soldering

Hand soldering is allowed. Use a Soldering iron temperature setting "7" which is equivalent to 350°C and carry out the hand soldering according to the IPC recommendations / reference documents IPC7711.

Place the ANTARIS® GPS Receiver Macro Component precisely on the pads. Start with a cross-diagonal fixture soldering (e.g. pins 1 and 16), and then continue from left to right.

7.3.9 Rework

The ANTARIS® GPS Receiver Macro Component can be unsoldered from the baseboard. Use desoldering braid made of copper. Avoid overheating the ANTARIS® GPS Receiver Macro Components.

A vacuum solder sucker is not recommended as solder residuals may remain in the gap below the macro component.

After all solder has been removed from all pads, lift the component carefully. Continue unsoldering carefully if the ANTARIS® GPS Receiver Macro Component does still stick. After the macro component is removed, clean the pads before placing and hand-soldering a new macro component.

! **Warning** Never attempt a rework on the macro component itself, e.g. replacing individual components. Such actions will terminate warranty coverage immediately.

7.3.10 Conformal Coating

Conformal coating with Humiseal or a similar coating product may be necessary in dedicated applications. Please note that the metal covers and the sticker prevent optimum inflow of such liquids or aerosols.

! **Note** Conformal Coating will void the warranty.

7.3.11 Casting

If casting is required, use viscose or another type of silicon pottant. The OEM is strongly advised to qualify such processes in combination with the ANTARIS® GPS Receiver Macro Component before implementing this in the production.

! **Note** Casting will void the warranty.

7.3.12 Grounding Metal Covers

Attempts to improve grounding by soldering ground cables, wick or other forms of metal strips directly onto the EMI covers is done on customer's own risk. The numerous ground pins should be sufficient to provide optimum immunity to interferences and noise.

! **Note** u-blox takes no warranty for damages on the ANTARIS® GPS Receiver Macro Component caused by soldering metal cables or any other forms of metal strips directly onto the EMI covers.

7.3.13 Use of any Ultrasonic Processes

Some components on the ANTARIS® GPS Receiver Macro Component are sensitive to Ultrasonic Waves. Use of any Ultrasonic Processes (cleaning, welding etc.) may cause damage to the GPS Receiver.

! **Note** u-blox takes no warranty for damages on the ANTARIS® GPS Receiver Macro Component caused of any Ultrasonic Processes.

8 Product Testing

8.1 u-blox In-Series Production Test

u-blox focuses on a high quality of their products. To achieve a high standard it's our philosophy to supply fully tested units. Therefore at the end of the production process every unit will be tested and any failed unit will be analyzed in detail to improve the production quality.

This is achieved with automatic test equipment, which delivers a detailed test report for each unit. The following measurements are done:

- Digital self-test (Software Download and verification of FLASH firmware)
- Measurement of voltage and currents
- Measurement of RF characteristics (e.g. C/No)

Figure 101: Automatic Test Equipment for Module Tests

8.2 Test Parameters for OEM Manufacturer

Based on the test done by u-blox (with 100% coverage), it is obvious that an OEM manufacturer doesn't need to repeat any firmware tests or measurements of the GPS parameters/characteristics (e.g. TTFF) in his production test.

An OEM Manufacturer should focus on

- Overall sensitivity of the device
- Communication to a host controller (if required)

8.3 System Sensitivity Test

The best approach to test the sensitivity of a GPS device is the use of a 1-channel GPS simulator. It assures reliable and constant signals at every measurement.

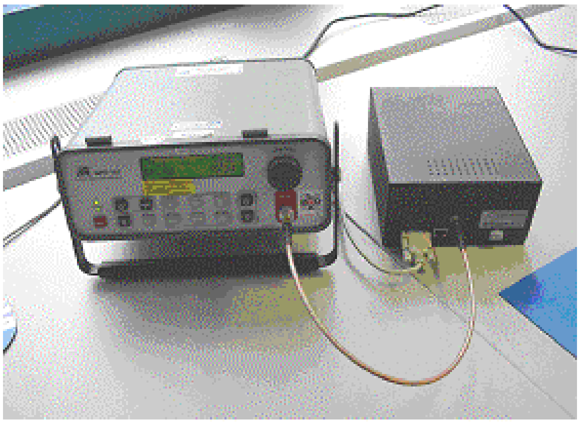


Figure 102: 1-channel GPS simulator

Here's a list of companies producing Single-Channel GPS Simulators:

- Spirent Communications Positioning Technology (previously GSS Global Simulation Systems) — www.positioningtechnology.co.uk
- Welnavigate — www.welnav.com
- JcAIR Test Systems — www.jcair.com
- Aeroflex (previously IFR) — www.aeroflex.com
- Rohde&Schwarz — www.rohde-schwarz.com

8.3.1 Guidelines for Sensitivity Tests

1. Connect a 1-channel GPS simulator to the OEM product
2. Choose the power level in a way that the "Golden Device" would report a C/No ratio of 45 dBHz
3. Power up the DUT (Device Under Test) and allow enough time for the acquisition
4. Read the C/No value from the NMEA GSV or the UBX-NAV-SVINFO message (e.g. with u-center AE)
5. Reduce the power level by 10dB and read the C/No value again
6. Compare the results to a "Golden Device" or an ANTARIS® GPS EvalKit.

8.3.2 'Go/No go' tests for integrated devices

The best test is to bring the device to an outdoor position **with excellent visibility** (HDOP < 3.0). Let the receiver acquire satellites and compare the signal strength with a "Golden Device".

! Note As the electro-magnetic field of a redistribution antenna is not homogenous, indoor tests are in most cases not reliable. This kind of tests may be useful as a 'go/no go' test but not for sensitivity measurements.

9 PC Support Tools

9.1 Firmware Update

There are two ways to upgrade the firmware

1. Download with the u-center (refer to *section 9.2.1*). This is the preferred way during product evaluation and development since it offers a graphical interface.

2. The ATR0620l.exe command line tool (refer to *section 9.2.2*) is perfectly suited for automatic firmware download if run on Microsoft Windows® based platforms.

9.1.1 ATR0620l.exe

The ATR0620l.exe is a command-line tool. It's possible to write customized batch files to run the firmware upgrade automatically. To run the ATR0620l.exe with a batch file, add a file e.g. udwld.bat to your project directory with the following content according to your PC and GPS receiver setup:

```
Atr0620l.exe –f ANTARIS_Fw_3.00_TIM-LP.bin –p com1
```

There are arguments of the command line tool:

```
-p <portname> serial port name
-f <filename> [<address>] firmware image and
    optional address in hex format   (def: 0x0100000)

optional arguments:
-m <mode> enter production boot mode (def: UBX 57600)
   UBX <baudrate> use UBX protocol
   CTL            use RTS / DTR control lines
   PS             manual
-b <baudrate> transfer baud rate       (def: 115200)
-i <filename> flash definition         (def: flash.txt)
-l <filename> loader image             (def: ATR0620.ldr)
-a <address>  flash address            (def: 0x01000000)
-e erase the complete flash memory even without firmware upgrade
-k erase only the space required for the firmware, keep the rest
-v <n> Set Verbosity Level (range 0 to 5, default 4)
```

9.2 Using u-center ANTARIS® Edition

u-center ANTARIS® Edition (u-center AE) is a very valuable PC support tool. It's provided with every *ANTARIS® EvalKit and ANTARIS® Software Customization Kit.* New continuously improved releases can be downloaded for free from our website: http://www.u-blox.com.

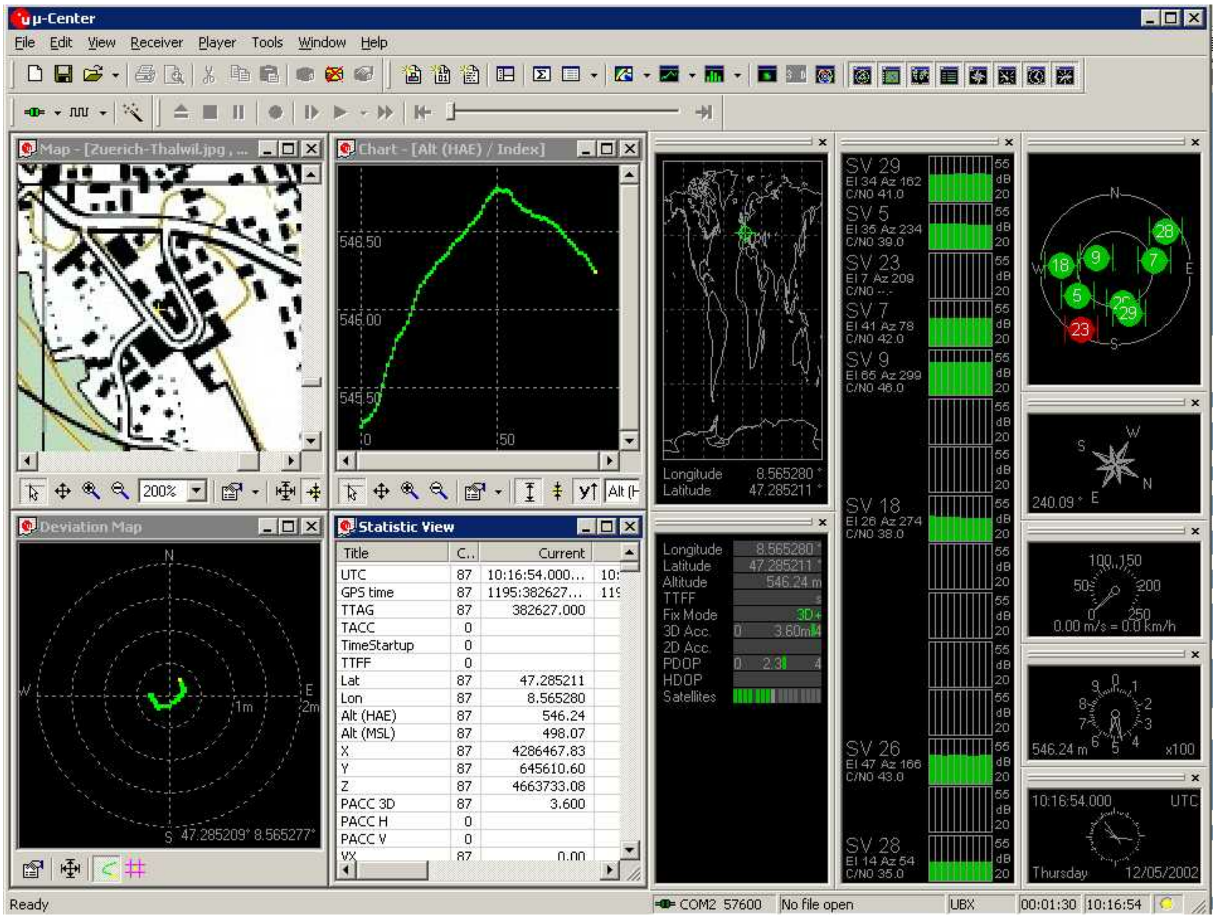


Figure 103: Screenshot, u-center ANTARIS® Edition (u-center AE)

9.2.1 Firmware update with u-center AE

The receiver firmware can be updated with the firmware update function in the Tools Menu of u-center AE.

Follow these steps to upgrade the firmware on ANTARIS® GPS Receiver:

1. Establish the serial communication between u- center AE and the Receiver.
2. Start the firmware update tool

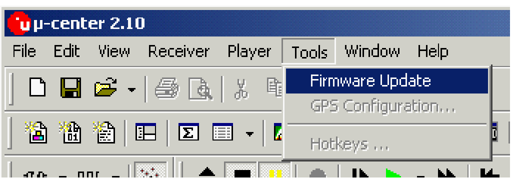


Figure 104: Screenshot, u-center ANTARIS® Edition, Tools Menu

3. Select the path of the ‘prodstub’ (ATR0620l.exe) and the firmware image.
4. Select the ‘Production Mode’. ANTARIS® based GPS receivers can be put into boot mode by sending a UBX protocol command. If the GPS receiver connected to u-center is configured for UBX protocol input, choose the ‘use serial port’ option. Otherwise, select ‘use bootmode pin’ and put the receiver manually into Boot Mode by setting pin **BOOT_INT** to high.
5. Check the COM port (automatically initialized with the current COM port in use).
6. Select the download baudrate. This is the baudrate used during the firmware download. The default value is 115200 baud. The lower this baudrate, the longer a firmware update takes.
7. If ‘Production Mode’ is set to ‘serial port with UBX protocol’, check the UBX protocol baudrate (automatically initialized with the current baudrate in use). The UBX protocol baudrate is only used to enter the download process.
8. Press ‘Update’ Button to start download.

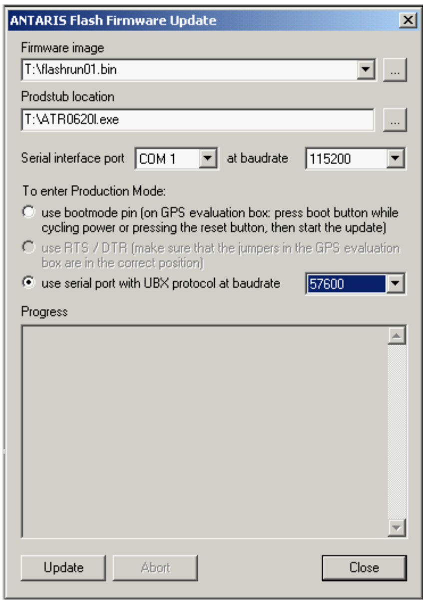


Figure 105: Screenshot, u-center Firmware; Update Tool

9.2.2 Configuration of ANTARIS® based GPS Receivers

u-center AE is capable to get the actual configuration of an ANTARIS® based GPS receiver and store it to an ASCII text file containing hexadecimal records. Such a file can be edited and stored to an ANTARIS® based GPS receiver again. By clicking the menu "`Tools->GPS Configuration…`" of u-center AE, the GPS Configuration dialog opens. The following functions are available:

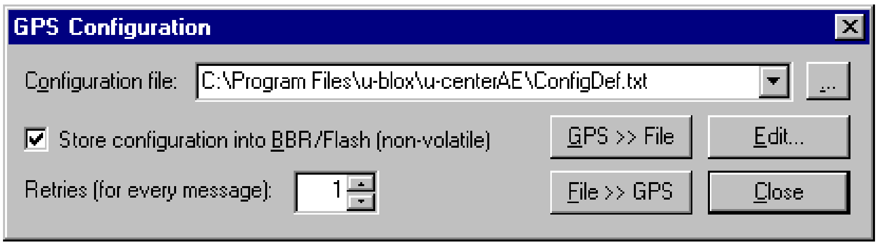
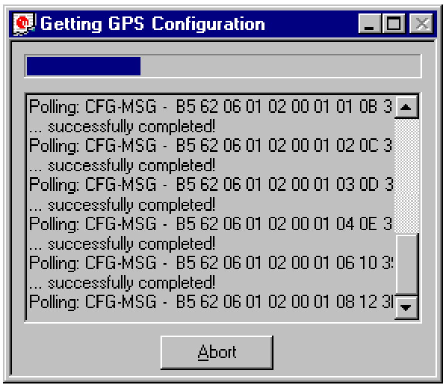


Figure 106: Screenshot, u-center GPS configuration

- Specify the name of a new configuration file to store current configuration from the ANTARIS® GPS receiver
- Specify the name of an existing configuration file and load this configuration into the ANTARIS® GPS receiver
- A flag can be set to force storing the configuration into the battery backed-up RAM (BBR) or Flash EPROM.

If reading or writing configuration data fails too frequently, try to increase the number of retries u-center AE should do on a single message if one fails.

! **NOTE:** Sending a configuration to an ANTARIS® GPS receiver may fail due to a baud rate change on the current serial port of the receiver where sending this configuration to. If this happens, simply change the u-center AE's baud rate and send the configuration again.



There is a window for showing the progress of data transfer to/from ANTARIS® based GPS receivers. Clicking "`GPS >> File`" closes this dialog box and opens the progress window showing configurations being polled and stored into a local file. Clicking "`File >> GPS`" opens the same progress window showing the configurations that are sent to the ANTARIS® based GPS receiver. This progress window closes after having finished transfer without any error.

Figure 107: Screenshot, u-center getting configuration

The user can abort the transfer by clicking the "`Abort`" button. It's not possible to close the window unless transfer has completed or the user aborted it.

! **Note:** It's not recommended to read/write configuration while the ANTARIS® based GPS receiver is in sleep mode.

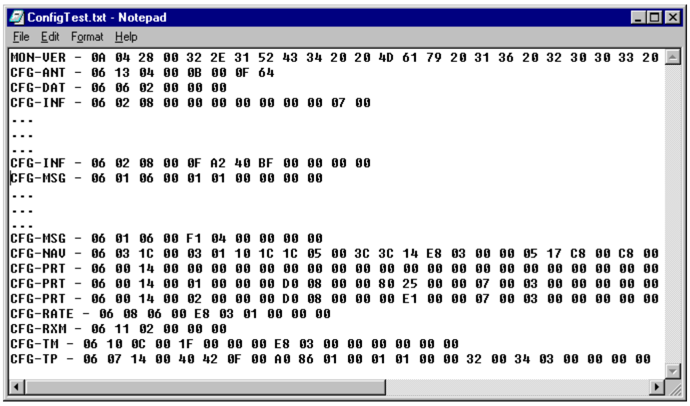


Figure 108: Content Configuration File

When clicking the "`Edit`" button in the GPS Configuration dialog, the Notepad editor opens (standard Windows software). Configurations are stored the following way:

- 1st line: it contains the version of the ANTARIS® based GPS receiver where the configuration is from. **Never change this line!**
- For the 2nd line and following each line contains the same: <class ID>-<message ID> - <hexadecimal byte code of the message>. The byte code consists of class and message IDs (2 bytes), payload length (2 bytes), payload (payload length bytes). The sync characters and the checksum are not included. They will be calculated automatically.

Please refer to ANTARIS® *Protocol Specification [8]* for detailed information.

10 Troubleshooting

My application (e.g. u-center AE) does not receive anything

Check if the evaluation box is powered and make sure the serial cable is properly connected to the evaluation box and the PC. By default, the evaluation box will output UBX protocol on port 1 at 57600 baud.

My application (e.g. u-center AE) does not receive all messages

Make sure the baudrate is sufficient. If the baudrate is insufficient, GPS receivers based on the ANTARIS® GPS Technology will skip excessive messages.

Some serial port cards/adapters (i.e. USB to RS232 converter) frequently generate errors. If a communication error occurs while u-center receives a message, the message will be discarded.

My application (e.g. u-center AE) looses the connection to the GPS receiver

The ANTARIS® GPS Technology and u-center have an autobauding feature. If frequent communication errors occur (i.e. due to problems with the serial port), the connection may be lost since u-center AE and the GPS receiver will autonomously try to adjust the baudrate. Do not enable the u-center AE autobauding feature if the GPS receiver has the autobauding flag enabled.

Some COM ports are not shown in the port list of my application (e.g. u-center AE)

Only the COM ports, that are available on your computer, will show up in the COM port drop down list. If a COM Port is gray, another application running on this computer is using it.

The ANTARIS® GPS receiver does not meet the TTFF specification

Make sure your antenna has a good sky view. Obstructed view leads to prolonged startup times.

In a well-designed system, the average of the C/No ratio of high elevation satellites should be in the range of 44 dBHz to about 50 dBHz. With a standard off-the-shelf active antenna, 47 dBHz should easily be achieved. Low C/No values lead to a prolonged startup time.

The position drifts heavily

Make sure your antenna has a good sky view. Obstructed view leads to position drift. Check the current satellite constellation before starting static tests in order to make sure it matches the test specifications (typically HDOP<2.0). Check every test drive for critical positions (minimal number of SV in view) and monitor the DOP (e.g. HDOP). If using UBX protocol, don't forget to check the position accuracy estimation.

The position is off by a few dozen meters

The ANTARIS® GPS Technology supports different datums. By default, it starts up with the WGS84 standard GPS datum. If your application expects a different datum, you'll most likely find the positions to be off by a few dozen meters. Find out what kind of datum your application requires and configure the EvalKit accordingly. And do not forget to check the calibration of u-center AE map files.

The position is off by hundreds of meters

Position drift may also occur when almanac navigation is enabled. The satellite orbit information retrieved from an almanac is much less accurate than the information retrieved from the ephemeris. With an almanac only solution the position will only have an accuracy of a few kilometers but it may startup faster or still navigate in areas with obscured visibility when the ephemeris from one or several satellites have not yet been received. The almanac information is NOT used for calculating a position, if valid ephemeris information is present, regardless of the setting of this flag.

In NMEA protocol, position solutions with high deviation (e.g. due to enabling almanac navigation) can be filtered with the Position Accuracy Mask. UBX protocol does not directly support this since it provides a position accuracy estimation, which allows the user to filter the position according to his requirements. However, the 'Position within Limits' flag of the UBX-NAV-STATUS message indicate whether the configured thresholds (i.e. P Accuracy Mask and PDOP) are exceeded.

The ANTARIS® GPS does not preserve the configuration in case of a reset

The ANTARIS® GPS technology uses a slightly different concept than most of the other GPS receivers do. Settings are initially stored to volatile memory. In order to save them permanently, sending a second command is required. This allows testing the new settings and reverting to the old settings by resetting the receiver if the new settings are no good. This is some kind of a safety procedure as it's no longer possible to accidentally program a bad configuration (e.g. disabling the main communication port). See *section 4.9.3* for the details.

On my GPS receiver with external power management, the TTFF times are much longer than specified

On startup (after the first position fix) the GPS receiver performs a RTC calibration to have an accurate internal time source. A calibrated RTC is required to achieve minimal startup time.

Before shutting down the receiver externally, check the status in MON-HW in field 'Real Time Clock Status'. Don't shut down the receiver if the RTC is not calibrated.

The Battery Backup Current is much higher than specified in the datasheet.

The battery backup current will be at an undefined level if the backup voltage is applied to the GPS receiver without having the GPS receiver turned on once to put the real-time-clock (RTC) into a known state.

If you are using the GPS receiver with backup battery connected, turn the GPS receiver on for the first time to bring it into a known state.

NMEA GGA Messages shows 'SV used'=0, but the receiver receives more than 12 satellites

The NMEA protocol only defines the behavior up to 12 satellites. The ANTARIS FW 3.00 outputs 0 'SV used' if the number of used satellites is higher than 12 ('NMEA flag' = valid). Three workarounds are possible:

1. Use NMEA GSA message to calculate the number of satellites by counting the number of reported SV IDs. Max Number of Satellites will be 12 as the 12 strongest satellites are displayed in the list.
2. Check for the Nav Ok flag and if the Navigation solution is valid and 'SV used' = 0, then set 'SV used to 12.
3. Set UBX-CFG-NAV MaxSV=12 to force the receiver to use only the best 12 SV for the navigation solution.

u-center doesn't behave as expected

Please refer to the *u-center user's guide* for more information.

The GPS receiver EvalKit doesn't behave as expected

Please refer to the *ANTARIS® EvalKit - Users Guide* for more information.

The ANTARIS® GPS receiver does not work after a firmware update

There are different firmware images for TIM-LF and TIM-LP, which are both available from the u-blox website. If an incorrect firmware image has accidentally be downloaded, one will need to pull the BOOT_INT pin to high, then power cycle or reset the receiver before attempting to download the correct firmware image again (refer *section 5.5* to for further details).

A Pin Description

Some pins of ANTARIS® GPS Technology offer alternate functions. Using the *ANTARIS® Software Customization Kit (SCKit)* the alternate functions can be configured such as the SPI interface and General Purpose IOs.

A.1 Pin Description TIM-LP

Standard Function				Alternate Functions[14]			Remarks
No	Name	I/O	Description	Name	I/O	Description	
1	VCC	I	Supply voltage				
2	GND	I	Ground				
3	BOOT_INT	I	Boot mode				Leave open if not used (normal operation)
4	RxD1	I	Serial Port 1				Pull up if not used
5	TxD1	O	Serial Port 1				Leave open if not used
6	TxD2	O	Serial Port 2				Leave open if not used
7	RxD2	I	Serial Port 2				Pull up if not used
8	P17	I/O	GPIO	SCK1	I/O	synch. serial port 1 clock	Default config. to input with internal pull-up, leave open if not used
9	STATUS	O	GPS Status				Default config. to output, leave open if not used
10	Reserved		Not connected				Leave open
11 – 16	GND	I	Ground				
17	RF_IN	I	GPS signal input				Apply no DC through this pin
18	GND	I	Ground				
19	V_ANT	I	Antenna Bias voltage				Connect to GND if not used
20	VCC_RF	O	Output Voltage RF section				May be connected to V_ANT
21	V_BAT	I	Backup voltage supply				Connect to GND if not used
22	RESET_N	I/O	Reset (Active low)				Leave open if not used
23	EXTINT0	I	External Interrupt Pin	P9	I/O	GPIO	Default config. to input with internal pull-up, leave open if not used
24	P27	I/O	GPIO	PCS1_N	O	SPI Chip Select 1	Default config. to input with internal pull
25	P26	I/O	GPIO	SS_N PCS0_N	I O	SPI Slave Select SPI Chip Select 0	Default config. to input with internal pull
26	P23	I/O	GPIO	SCK	I/O	SPI clock	Default config. to input with internal pull
27	AADET_N	I	Active Antenna Detect	P25 MISO	I/O I/O	GPIO SPI MISO	Default config. to input with internal pull
28	P24	I/O	GPIO	MOSI	I/O	SPI MOSI	Default config. to input with internal pull
29	TIMEPULSE	O	Timepulse signal				Leave open if not used
30	P29	I/O	GPIO[15]	PCS3_N	O	SPI Chip Select 3	Default config. to input with internal pull

Table 63: Signals and Module Interface TIM-LP

[14] ANTARIS® Software Customization Kit needed to explore alternate functions
[15] Standard software allows this pin to be connected to GND externally

A.2 Pin Description TIM-LF

Standard Function				Alternate Functions[16]			Remarks
Pin	Name	I/O	Description	Name	I/O	Description	
1	VCC	I	Supply voltage				
2	GND	I	Ground				
3	BOOT_INT	I	Boot mode				Leave open if not used (normal operation)
4	RxD1	I	Serial Port 1				Pull up if not used
5	TxD1	O	Serial Port 1				Leave open if not used
6	TxD2	O	Serial Port 2				Leave open if not used
7	RxD2	I	Serial Port 2				Pull up if not used
8	P17	I/O	GPIO	SCK1	I/O	synch. serial port 1 clock	Default config. to output, leave open if not used
9	STATUS	O	GPS Status				Default config. to output, leave open if not used
10	VDD18_Out	O	1.8V supply output				Suitable as reference for external level shifter
11 – 16	GND	I	Ground				
17	RF_IN	I	GPS signal input				Apply no DC through this pin
18	GND	I	Ground				
19	V_ANT	I	Antenna Bias voltage				Connect to GND if not used
20	VCC_RF	O	Output Voltage RF section				May be connected to V_ANT
21	V_BAT	I	Backup voltage supply				Connect to GND if not used
22	RESET_N	I/O	Reset (Active low)				Leave open if not used
23	EXTINT0	I	External Interrupt Pin				Internal pull-up, Leave open if not used
24	P27	I/O	GPIO	PCS1_N	O	SPI Chip Select 1	Default config. to output, leave open if not used
25	P26	I/O	GPIO	SS_N PCS0_N	I O	SPI Slave Select SPI Chip Select 0	Internal pull-up, Leave open if not used
26	P23	I/O	GPIO	SCK	I/O	SPI clock	Default config. to output, leave open if not used
27	AADET_N[17]	I	Active Antenna Detect	P25 MISO	I/O I/O	GPIO SPI MISO	Default config. to output (!), leave open if not used
28	P24	I/O	GPIO	MOSI	I/O	SPI MOSI	Default config. to output, leave open if not used
29	TIMEPULSE	O	Timepulse signal				Default config. to output, leave open if not used
30	P29	I/O	GPIO[18]	PCS3_N	O	SPI Chip Select 3	Default config. to output, leave open if not used

Shaded pins use 1.8V signal levels

Table 64: Signals and Module Interface TIM-LF

[16] ANTARIS® Software Customization Kit needed to explore alternate functions
[17] AADET_N will only be operated as input pin if "Open Circuit Detection" for active antennas is activated or configured. Otherwise, it will operate as an output pin unless custom software configures this pin otherwise.
[18] Standard software allows this pin to be connected to GND externally

A.3 Pin Description TIM-LC

Standard Function				Remarks
Pin	Name	I/O	Description	
1	VCC	I	Supply voltage	
2	GND	I	Ground	
3	BOOT_INT	I	Boot mode	Leave open if not used (normal operation)
4	RxD1	I	Serial Port 1	Pull up if not used
5	TxD1	O	Serial Port 1	Leave open if not used
6	Reserved	O		Leave open
7	Reserved	I		Connect to VCC
8	GPSMODE5	I	Boot time configuration pin	Internal pull-down, leave open if not used
9	GPSMODE3	I	Boot time configuration pin	Internal pull-down, leave open if not used
10	VDD18_Out	O	1.8V supply output	Suitable for setting GPSMODE pins high and as reference for external level shifter
11 – 16	GND	I	Ground	
17	RF_IN	I	GPS signal input	Apply no DC through this pin
18	GND	I	Ground	
19	V_ANT	I	Antenna Bias voltage	Connect to GND if not used
20	VCC_RF	O	Output Voltage RF section	May be connected to V_ANT
21	V_BAT	I	Backup voltage supply	Connect to GND if not used
22	RESET_N	I/O	Reset (Active low)	Leave open if not used
23	EXTINT0	I	External Interrupt Pin	Internal pull-up, leave open if not used
24	GPSMODE2	I	Boot time configuration pin	Internal pull-up, leave open if not used
25	GPSMODE6	I	Boot time configuration pin	Internal pull-up, leave open if not used
26	GPSMODE7	I	Boot time configuration pin	Internal pull-up, leave open if not used
27	AADET_N	I	Active Antenna Detect	Internal pull-down, leave open if not used
28	GPSMODE8	I	Boot time configuration pin	Internal pull-up, leave open if not used
29	TIMEPULSE	O	Timepulse signal	Leave open if not used
30	GPSMODE12	I	Boot time configuration pin	Internal pull-up, leave open if not used

Shaded pins use 1.8V signal levels

Table 65: Signals and Module Interface TIM-LC

A.4 Comparison of Typical Pin Assignments

Pin No	TIM		TIM-LP		TIM-LF		TIM-LC	
	Pin Name	Typical Assignement	Pin Name	Typical Assignement	Pin Name	Typical Assignement	Pin Name	Typical Assignement
1	**VCC**	2.75 – 3.45V	**VCC**	2.70 – 3.30V	**VCC**	2.70 – 3.30V	**VCC**	2.70 – 3.30V
2	**GND**	GND	**GND**	GND	**GND**	GND	**GND**	GND
3	**BOOT_INT**	NC	**BOOT_INT**	NC	**BOOT_INT**	NC	**NC**	NC
4	**RXA**	3.0V in	**RXD1**	3.0V in	**RXD1**	3.0V in	**RXD1**	3.0V in
5	**TXA**	3.0V out	**TXD1**	3.0V out	**TXD1**	3.0V out	**TXD1**	3.0V out
6	**TXB**	3.0V out	**TXD2**	3.0V out	**TXD2**	3.0V out	**Reserved**	NC
7	**RXB**	3.0V in	**RXD2**	3.0V in	**RXD2**	3.0V in	**Reserved**	VCC
8	**AA_SCD_N**	NC[19]	**SCK1**	NC	**SCK1**	NC	**GPSMODE5**	NC
9	**RF_ON**	NC	**P17**	NC	**P17**	NC	**GPSMODE3**	NC
10	**GND**	NC	**RESERVED**	NC	**1.8V SUPPLY**	NC	**1.8V SUPPLY**	NC
11 to 16	**GND_A**	GND	**GND**	GND	**GND**	GND	**GND**	GND
17	**RF_IN**	RF_IN	**RF_IN**	RF_IN	**RF_IN**	RF_IN	**RF_IN**	RF_IN
18	**GND_A**	GND	**GND**	GND	**GND**	GND	**GND**	GND
19	**V_ANT**	3.0V -5.0V	**V_ANT**	3.0V -5.0V	**V_ANT**	3.0V -5.0V	**V_ANT**	3.0V -5.0V
20	**VCC_RF**	VCC - 0.1V	**VCC_RF**	VCC - 0.1V	**VCC_RF**	VCC - 0.1V	**VCC_RF**	VCC - 0.1V
21	**V_BAT**	1.85 – 3.6V	**V_BAT**	1.95 – 3.6V	**V_BAT**	1.95 – 3.6V	**V_BAT**	1.95 – 3.6V
22	**RESET_N**	ACTIVE LOW	**RESET_N**	ACTIVE LOW	**RESET_N**	ACTIVE LOW	**RESET_N**	ACTIVE LOW
23	**GPIO [10]**	NC	**EXTINT0**	NC	**EXTINT0**	NC	**EXTINT0**	NC
24	**GPIO [6]**	NC	**P27**	NC	**P27**	NC	**GPSMODE2**	NC
25	**GPIO [5]**	NC	**P26**	NC	**P26**	NC	**GPSMODE6**	NC
26	**GPIO [7]**	NC	**P23**	NC	**P23**	NC	**GPSMODE7**	NC
27	**AA_OCD**	NC[1)]	**AADET_N**	NC	**AADET_N**	NC	**AADET_N**	NC
28	**AA_CTRL**	NC[1)]	**P24**	NC	**P24**	NC	**GPSMODE8**	NC
29	**PPS**	3.0V out	**TIMEPULSE**	3.0V out	**TIMEPULSE**	1.8V out	**TIMEPULSE**	1.8V out
30	**GND**	NC	**P29**	NC	**P29**	NC	**GPSMODE12**	NC

[19] Antenna Supervisory circuit is disabled in factory firmware

B Default Settings

! **Note** For the default settings for the TIM-LC GPS receiver please refer as well to *section 4.7.7* as the configuration settings are defined by the status of the GPSMODE Pins at the start up.

B.1 Hardware

Antenna Configuration (UBX – CFG – ANT)

TIM-LP, TIM-LF

Parameter	Default setting	Unit	Range/Remark
Enable Control Signal	Enabled		Enabled - Disabled
Enable Short Circuit Detection	Enabled		Enabled - Disabled
Enable Short Circuit Power Down logic	Enabled		Enabled - Disabled
Enable Open circuit detection	Disabled		Enabled - Disabled

Table 66: Antenna settings

TIM-LC

Parameter	Default setting	Unit	Range/Remark
Enable Control Signal	Enabled		Enabled - Disabled
Enable Short Circuit Detection	Enabled		Enabled - Disabled
Enable Short Circuit Power Down logic	Enabled		Enabled - Disabled
Enable Open circuit detection	Enabled		Enabled - Disabled

Table 67: Antenna settings TIM-LC

B.2 Navigation

Datum (UBX – CFG – DAT)

Parameter	Default setting	Unit	Range/Remark
Datum	0 – WGS84		Refer to *Appendix C*

Table 68: Datum default settings

Navigation (UBX – CFG – NAV)

Parameter	Default setting	Unit	Range/Remark
Dynamic Platform Model	3-Automotive		1-Stationary; 2- Pedestrian; 3-Automotive; 4-Sea; 5-Airborne <1g; 6-Airborne <2g; 7-Airborne <4g
Allow Almanac Navigation	Enabled		Enabled - Disabled
Static Hold Threshold	0.00	m/s	
Navigation Input Filters			
Min SV's	3	#	1..16
Max SV's	16	#	1..16
Min C/NO	24	dBHz	
AbsMin C/NO	20	dBHz	
Min CLT	1000	ms	
AbsMin CLT	0	ms	
Min SV Elevation	5	deg	
DR Timeout	0	s	DR Timeout setting is not used anymore in TIM-Lx Firmware
Navigation Output Filters			
PDOP Mask	25	-	
TDOP Mask	25	-	
P Accuracy	100	m	
T Accuracy	300	m	
F Accuracy	1.5	m/s	
RAIM			
Range Check	Enabled		Enabled - Disabled; do not disable!
Doppler Check	Enabled		Enabled - Disabled; do not disable!
Delta Check	Enabled		Enabled - Disabled; do not disable!
ALM-EPH Check	Disabled		Enabled - Disabled
DGPS			
Timeout	60	s	
Max PRC Age	60	s	
Max CPC Age	20	s	
Timetag Rounding	Disabled		Enabled - Disabled

Table 69: Navigation default settings

NMEA Protocol (UBX – CFG – NMEA)

Parameter	Default setting	Unit	Range/Remark
Enable position output even for invalid fixes	Disabled		Enabled - Disabled
Enable position even for masked fixes	Disabled		Enabled - Disabled
Enable time output even for invalid times	Disabled		Enabled - Disabled
Enable time output even for invalid dates	Disabled		Enabled - Disabled
Version	2.3		

Table 70: NMEA Protocol default settings

Output Rates (UBX – CFG – RATE)

Parameter	Default setting	Unit	Range/Remark
Time Source	0 – UTC		0 – UTC1 - GPS
Measurement Period	1000	ms	
Measurement Rate	1	Cycles	

Table 71: Output Rates default settings

Receiver Manager (UBX - CFG – RXM)

Parameter	Default setting	Unit	Range/Remark
GPS Mode	Normal		Normal; Fast Acquisition; High Sensitivity
Low Power Mode	0 – CTM		0 - CTM; 1 - FXN

Table 72: Receiver Configuration default settings

B.3 Power Saving Modes

FixNOW™ Mode (UBX - CFG – FXN)

Parameter	Default setting	Unit	Range/Remark
On/ off time – Timeout			
Use on/off time	Enabled		Enabled - Disabled
T_on	36	s	
T_off	1800	s	
Absolute align	Disabled		Enabled - Disabled
Base TOW	0	s	
Startup – Timeout			
T_acq	120	s	
T_acq_off	600	s	
Use searchpass	Disabled		Enabled - Disabled
Num searchpasses	3	s	
Last Fix – Timeout			
T_reacq	120	s	
T_reacq_off	600	s	
System Mode	Sleep		On; Sleep

Table 73: FixNOW™ default settings

B.4 SBAS Configuration

SBAS Configuration

Parameter	Default setting	Unit	Range/Remark
SBAS Subsystem	Enabled		Enabled – Disabled
Allow test mode usage	Disabled		Enabled – Disabled
Services			
Ranging (Use SBAS for navigation)	Enabled		Enabled – Disabled
Apply SBAS Correction Data	Disabled		Enabled – Disabled
Apply integrity information	Disabled		Enabled – Disabled
Number of search channels	1		1..3
PRN Codes	Auto-Scan		Auto-Scan; WAAS; EGNOS; Other

Table 74: SBAS Configuration default settings

B.5 Communications Interface

Port Setting (UBX – CFG – PRT)

Parameter	Default setting	Unit	Range/Remark
USART1			
Protocol in	0+1+2 – UBX+NMEA+RTCM		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Protocol out	0+1 – NMEA + UBX		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Baudrate	9600	baud	8 bits, no parity bit 1 stop bit, autobauding disabled
Autobauding	Disabled		Enabled - Disabled
USART2 (TIM-LP and TIM-LF only)			
Protocol in	0+1+2 – UBX+NMEA+RTCM		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Protocol out	0+1 – UBX+NMEA		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Baudrate	57600	baud	8 bits, no parity bit 1 stop bit, autobauding disabled
Autobauding	Disabled		Enabled - Disabled

Table 75: Port default settings

B.6 Messages (UBX – CFG – MSG)

UBX

Message	Type	Target1[20]/ USART1	Target2[21]/ USART2	Range/Remark
NAV-POSECEF	Out			
NAV-POSLLH	Out		1	
NAV-STATUS	Out		1	
NAV-DOP	Out			
NAV-SOL	Out		1	
NAV-POSUTM	Out			
NAV-VELECEF	Out			
NAV-VELNED	Out			
NAV-TIMEGPS	Out			
NAV-TIMEUTC	Out			
NAV-CLOCK	Out			
NAV-SVINFO	Out		1	
NAV-DGPS	Out			
NAV-SBAS	Out			
NAV-EKFSTATUS	Out			
RXM-RAW	Out			
RXM-SFRB	Out			
RXM-SVSI	Out			
RXM-RTC	Out			
RXM-ALM	Out			
RXM-EPH	Out			
MON-SCHD	Out		1	
MON-IO	Out		1	
MON-IPC	Out			
MON-MSGPP	Out			

[20] The Number entered under Target1 – Target2 defines the output cycle: 1 means every measurement cycle, 2 every 2nd measurement etc.
[21] TARGET2 is not available on TIM-LC

MON-RXBUF	Out			
MON-TXBUF	Out		1	
MON-HW	Out			
MON-EXCEPT	Out			
MON-VER	Out			
AID-ALM	In/Out			
AID-EPH	In/Out			
AID-HUI	In/Out			
AID-INI	In/Out			
TIM-TP	Out			
TIM-TM	Out			
INF-Error	Out		1	
INF-Warning	Out		1	
INF-Notice	Out		1	
INF-Test	Out			
INF-Debug	Out			
INF-User	Out			Only available with ANTARIS® SCKit

Table 76: UBX output rate default settings

NMEA

Message	Type	Target1[22]/ USART1	Target2[23]/ USART2	Range/Remark
NMEA - GGA	Out	1		
NMEA - GLL	Out	1		
NMEA - GSA	Out	1		
NMEA - GSV	Out	1		
NMEA - RMC	Out	1		
NMEA - VTG	Out	1		
NMEA - GRS	Out			
NMEA - GST	Out			
NMEA - ZDA	Out	1		
NMEA – PUBX,00	Out			
NMEA – PUBX,01	Out			
NMEA – PUBX,02	Out			
NMEA – PUBX,03	Out			

Table 77: NMEA enabled output msg

B.7 Messages (UBX – CFG – INF)

UBX

Message	Type	Target1[20]/ USART1	Target2[21]/ USART2	Range/Remark
INF-Error	Out		1	
INF-Warning	Out		1	
INF-Notice	Out		1	
INF-Test	Out		1	
INF-Debug	Out		1	
INF-User	Out		1	Only available with ANTARIS® SCKit

Table 78: UBX default enabled INF msg

[22] The Number entered under Target1 – Target2 defines the output cycle: 1 means every measurement cycle, 2 every 2nd measurement etc.
[23] TARGET2 is not available on TIM-LC

NMEA

Message	Type	Target1[20]/ USART1	Target2[21]/ USART2	Range/Remark
INF-Error	Out	1		
INF-Warning	Out	1		
INF-Notice	Out	1		
INF-Test	Out			
INF-Debug	Out			
INF-User	Out	1		Only available with ANTARIS® SCKit

Table 79: NMEA default enabled INF msg

B.8 Timing Settings

Timemark (UBX – CFG – TM)

Parameter	Default setting	unit	Range/Remark
Enable Timemark	Disabled		Enable; disable
Time Source	0-GPS		0 – GPS; 1 – UTC
Input Line	31 – ExtInt0		29 – ExtInt 2; 30 – Extint 1; 31 – ExtInt0
Trigger Edge	0 – rising		0 – rising; 1 – falling
Poll Rate	1000	ms	

Table 80: Timemark default settings

Timepulse (UBX – CFG – TP)

Parameter	Default setting	unit	Range/Remark
Pulse Mode	+1 - rising		+1 – rising; 0 – disabled; -1 - falling
Pulse Period	1000	ms	1 ... 60’000
Pulse Length	100	ms	1us ... (Pulse Period – 0.250 us)
Time Source	1 – GPS time		0 – UTC time; 1 – GPS time
Cable Delay	50	ns	± $2x10^9$ us
User Delay	0	ns	± $2x10^9$ us

Table 81: Timepulse default settings

C Map Datums

C.1 Predefined Datums

Please refer to the booklet *GPS Basics, Introduction to the system* [6] for a detailed introduction to coordinate systems, datums and datum conversion.

Index	Name	Acronym	Ellipsoid index (see Table 83)	Rotation and scale index (see Table 84)	dX [m]	dY [m]	dZ [m]
0	World Geodetic System - 84	WGS84	0	0	0.0	0.0	0.0
1	World Geodetic System - 72	WGS72	23	1	0.0	0.0	4.5
2	Earth-90 - GLONASS Coordinate system	ETH90	8	0	0.0	0.0	4.0
3	Adindan - Mean Solution (Ethiopia & Sudan)	ADI-M	7	0	-166.0	-15.0	204.0
4	Adindan - Burkina Faso	ADI-E	7	0	-118.0	-14.0	218.0
5	Adindan - Cameroon	ADI-F	7	0	-134.0	-2.0	210.0
6	Adindan - Ethiopia	ADI-A	7	0	-165.0	-11.0	206.0
7	Adindan - Mali	ADI-C	7	0	-123.0	-20.0	220.0
8	Adindan - Senegal	ADI-D	7	0	-128.0	-18.0	224.0
9	Adindan - Sudan	ADI-B	7	0	-161.0	-14.0	205.0
10	Afgooye - Somalia	AFG	21	0	-43.0	-163.0	45.0
11	ARC 1950 - Mean (Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe)	ARF-M	7	0	-143.0	-90.0	-294.0
12	ARC 1950 - Botswana	ARF-A	7	0	-138.0	-105.0	-289.0
13	ARC 1950 - Burundi	ARF-H	7	0	-153.0	-5.0	-292.0
14	ARC 1950 - Lesotho	ARF-B	7	0	-125.0	-108.0	-295.0
15	ARC 1950 - Malawi	ARF-C	7	0	-161.0	-73.0	-317.0
16	ARC 1950 - Swaziland	ARF-D	7	0	-134.0	-105.0	-295.0
17	ARC 1950 - Zaire	ARF-E	7	0	-169.0	-19.0	-278.0
18	ARC 1950 - Zambia	ARF-F	7	0	-147.0	-74.0	-283.0
19	ARC 1950 - Zimbabwe	ARF-G	7	0	-142.0	-96.0	-293.0
20	ARC 1960 - Mean (Kenya, Tanzania)	ARS	7	0	-160.0	-6.0	-302.0
21	Ayabelle Lighthouse - Djibouti	PHA	7	0	-79.0	-129.0	145.0
22	Bissau - Guinea-Bissau	BID	20	0	-173.0	253.0	27.0
23	Cape - South Africa	CAP	7	0	-136.0	-108.0	-292.0
24	Carthage - Tunisia	CGE	7	0	-263.0	6.0	431.0
25	Dabola - Guinea	DAL	7	0	-83.0	37.0	124.0
26	Leigon - Ghana	LEH	7	0	-130.0	29.0	364.0
27	Liberia 1964	LIB	7	0	-90.0	40.0	88.0
28	Massawa - Eritrea (Ethiopia)	MAS	5	0	639.0	405.0	60.0
29	Merchich - Morocco	MER	7	0	31.0	146.0	47.0
30	Minna - Cameroon	MIN-A	7	0	-81.0	-84.0	115.0
31	Minna - Nigeria	MIN-B	7	0	-92.0	-93.0	122.0

Index	Name	Acronym	Ellipsoid index (see Table 83)	Rotation and scale index (see Table 84)	dX [m]	dY [m]	dZ [m]
32	M'Poraloko - Gabon	MPO	7	0	-74.0	-130.0	42.0
33	North Sahara 1959 - Algeria	NSD	7	0	-186.0	-93.0	310.0
34	Old Egyptian 1907 - Egypt	OEG	17	0	-130.0	110.0	-13.0
35	Point 58 - Mean Solution (Burkina Faso & Niger)	PTB	7	0	-106.0	-129.0	165.0
36	Pointe Noire 1948 - Congo	PTN	7	0	-148.0	51.0	-291.0
37	Schwarzeck - Namibia	SCK	5	0	616.0	97.0	-251.0
38	Voirol 1960 - Algeria	VOR	7	0	-123.0	-206.0	219.0
39	Ain El Abd 1970 - Bahrain Island	AIN-A	20	0	-150.0	-250.0	-1.0
40	Ain El Abd 1970 - Saudi Arabia	AIN-B	20	0	-143.0	-236.0	7.0
41	Djakarta (Batavia)- Sumatra (Indonesia)	BAT	5	0	-377.0	681.0	-50.0
42	Hong Kong 1963 - Hong Kong	HKD	20	0	-156.0	-271.0	-189.0
43	Hu-Tzu-Shan - Taiwan	HTN	20	0	-637.0	-549.0	-203.0
44	Indian - Bangladesh	IND-B	9	0	282.0	726.0	254.0
45	Indian - India & Nepal	IND-I	11	0	295.0	736.0	257.0
46	Indian 1954 - Thailand	INF-A	9	0	217.0	823.0	299.0
47	Indian 1960 - Vietnam (near 16N)	ING-A	9	0	198.0	881.0	317.0
48	Indian 1960 - Con Son Island (Vietnam)	ING-B	9	0	182.0	915.0	344.0
49	Indian 1975 - Thailand	INH-A	9	0	209.0	818.0	290.0
50	Indonesian 1974	IDN	19	0	-24.0	-15.0	5.0
51	Kandawala - Sri Lanka	KAN	9	0	-97.0	787.0	86.0
52	Kertau 1948 - West Malaysia & Singapore	KEA	13	0	-11.0	851.0	5.0
53	Nahrwan - Masirah Island (Oman)	NAH-A	7	0	-247.0	-148.0	369.0
54	Nahrwan - United Arab Emirates	NAH-B	7	0	-249.0	-156.0	381.0
55	Nahrwan - Saudi Arabia	NAH-C	7	0	-243.0	-192.0	477.0
56	Oman	FAH	7	0	-346.0	-1.0	224.0
57	Qatar National - Qatar	QAT	20	0	-128.0	-283.0	22.0
58	South Asia - Singapore	SOA	15	0	7.0	-10.0	-26.0
59	Timbalai 1948 - Brunei & East Malaysia (Sarawak & Sabah)	TIL	10	0	-679.0	669.0	-48.0
60	Tokyo - Mean Solution (Japan,Okinawa & South Korea)	TOY-M	5	0	-148.0	507.0	685.0
61	Tokyo - Japan	TOY-A	5	0	-148.0	507.0	685.0
62	Tokyo - Okinawa	TOY-C	5	0	-158.0	507.0	676.0
63	Tokyo - South Korea	TOY-B	5	0	-146.0	507.0	687.0
64	Australian Geodetic 1966 - Australia & Tasmania	AUA	3	0	-133.0	-48.0	148.0
65	Australian Geodetic 1984 - Australia & Tasmania	AUG	3	0	-134.0	-48.0	149.0
66	European 1950 - Mean (AU, B, DK, FN, F, G, GER, I, LUX, NL, N, P, E, S, CH)	EUR-M	20	0	-87.0	-98.0	-121.0
67	European 1950 - Western Europe (AU, DK, FR, GER, NL, CH)	EUR-A	20	0	-87.0	-96.0	-120.0

Index	Name	Acronym	Ellipsoid index (see Table 83)	Rotation and scale index (see Table 84)	dX [m]	dY [m]	dZ [m]
68	European 1950 - Cyprus	EUR-E	20	0	-104.0	-101.0	-140.0
69	European 1950 - Egypt	EUR-F	20	0	-130.0	-117.0	-151.0
70	European 1950 - England, Wales, Scotland & Channel Islands	EUR-G	20	0	-86.0	- 96.0	-120.0
71	European 1950 - England, Wales, Scotland & Ireland	EUR-K	20	0	-86.0	- 96.0	-120.0
72	European 1950 - Greece	EUR-B	20	0	-84.0	-95.0	-130.0
73	European 1950 - Iran	EUR-H	20	0	-117.0	-132.0	-164.0
74	European 1950 - Italy - Sardinia	EUR-I	20	0	-97.0	-103.0	-120.0
75	European 1950 - Italy - Sicily	EUR-J	20	0	-97.0	-88.0	-135.0
76	European 1950 - Malta	EUR-L	20	0	-107.0	-88.0	-149.0
77	European 1950 - Norway & Finland	EUR-C	20	0	-87.0	-95.0	-120.0
78	European 1950 - Portugal & Spain	EUR-D	20	0	-84.0	-107.0	-120.0
79	European 1950 - Tunisia	EUR-T	20	0	-112.0	-77.0	-145.0
80	European 1979 - Mean Solution (AU, FN, NL, N, E, S, CH)	EUS	20	0	-86.0	-98.0	-119.0
81	Hjorsey 1955 - Iceland	HJO	20	0	-73.0	46.0	-86.0
82	Ireland 1965	IRL	2	0	506.0	-122.0	611.0
83	Ordnance Survey of GB 1936 - Mean (E, IoM, S, ShI, W)	OGB-M	1	0	375.0	-111.0	431.0
84	Ordnance Survey of GB 1936 - England	OGB-A	1	0	371.0	-112.0	434.0
85	Ordnance Survey of GB 1936 - England, Isle of Man & Wales	OGB-B	1	0	371.0	-111.0	434.0
86	Ordnance Survey of GB 1936 - Scotland & Shetland Isles	OGB-C	1	0	384.0	-111.0	425.0
87	Ordnance Survey of GB 1936 - Wales	OGB-D	1	0	370.0	-108.0	434.0
88	Rome 1940 - Sardinia Island	MOD	20	0	-225.0	-65.0	9.0
89	S-42 (Pulkovo 1942) - Hungary	SPK	21	0	28.0	-121.0	-77.0
90	S-JTSK Czechoslavakia (prior to 1 Jan 1993)	CCD	5	0	589.0	76.0	480.0
91	Cape Canaveral - Mean Solution (Florida & Bahamas)	CAC	6	0	-2.0	151.0	181.0
92	N. American 1927 - Mean Solution (CONUS)	NAS-C	6	0	-8.0	160.0	176.0
93	N. American 1927 - Western US	NAS-B	6	0	-8.0	159.0	175.0
94	N. American 1927 - Eastern US	NAS-A	6	0	-9.0	161.0	179.0
95	N. American 1927 - Alaska (excluding Aleutian Islands)	NAS-D	6	0	-5.0	135.0	172.0
96	N. American 1927 - Aleutian Islands, East of 180W	NAS-V	6	0	-2.0	152.0	149.0
97	N. American 1927 - Aleutian Islands, West of 180W	NAS-W	6	0	2.0	204.0	105.0
98	N. American 1927 - Bahamas (excluding San Salvador Island)	NAS-Q	6	0	-4.0	154.0	178.0
99	N. American 1927 - San Salvador Island	NAS-R	6	0	1.0	140.0	165.0

Index	Name	Acronym	Ellipsoid index (see Table 83)	Rotation and scale index (see Table 84)	dX [m]	dY [m]	dZ [m]
100	N. American 1927 - Canada Mean Solution (including Newfoundland)	NAS-E	6	0	-10.0	158.0	187.0
101	N. American 1927 - Alberta & British Columbia	NAS-F	6	0	-7.0	162.0	188.0
102	N. American 1927 - Eastern Canada (Newfoundland, New Brunswick, Nova Scotia & Quebec)	NAS-G	6	0	-22.0	160.0	190.0
103	N. American 1927 - Manitoba & Ontario	NAS-H	6	0	-9.0	157.0	184.0
104	N. American 1927 - Northwest Territories & Saskatchewan	NAS-I	6	0	4.0	159.0	188.0
105	N. American 1927 - Yukon	NAS-J	6	0	-7.0	139.0	181.0
106	N. American 1927 - Canal Zone	NAS-O	6	0	0.0	125.0	201.0
107	N. American 1927 - Caribbean	NAS-P	6	0	-3.0	142.0	183.0
108	N. American 1927 - Central America	NAS-N	6	0	0.0	125.0	194.0
109	N. American 1927 - Cuba	NAS-T	6	0	-9.0	152.0	178.0
110	N. American 1927 - Greenland (Hayes Peninsula)	NAS-U	6	0	11.0	114.0	195.0
111	N. American 1927 - Mexico	NAS-L	6	0	-12.0	130.0	190.0
112	N. American 1983 - Alaska (excluding Aleutian Islands)	NAR-A	16	0	0.0	0.0	0.0
113	N. American 1983 - Aleutian Islands	NAR-E	16	0	-2.0	0.0	4.0
114	N. American 1983 - Canada	NAR-B	16	0	0.0	0.0	0.0
115	N. American 1983 - Mean Solution (CONUS)	NAR-C	16	0	0.0	0.0	0.0
116	N. American 1983 - Hawaii	NAR-H	16	0	1.0	1.0	-1.0
117	N. American 1983 - Mexico & Central America	NAR-D	16	0	0.0	0.0	0.0
118	Bogota Observatory - Colombia	BOO	20	0	307.0	304.0	-318.0
119	Campo Inchauspe 1969 - Argentina	CAI	20	0	-148.0	136.0	90.0
120	Chua Astro - Paraguay	CHU	20	0	-134.0	229.0	-29.0
121	Corrego Alegre - Brazil	COA	20	0	-206.0	172.0	-6.0
122	Prov S. American 1956 - Mean Solution (Bol, Col, Ecu, Guy, Per & Ven)	PRP-M	20	0	-288.0	175.0	-376.0
123	Prov S. American 1956 - Bolivia	PRP-A	20	0	-270.0	188.0	-388.0
124	Prov S. American 1956 - Northern Chile (near 19S)	PRP-B	20	0	-270.0	183.0	-390.0
125	Prov S. American 1956 - Southern Chile (near 43S)	PRP-C	20	0	-305.0	243.0	-442.0
126	Prov S. American 1956 - Colombia	PRP-D	20	0	-282.0	169.0	-371.0
127	Prov S. American 1956 - Ecuador	PRP-E	20	0	-278.0	171.0	-367.0
128	Prov S. American 1956 - Guyana	PRP-F	20	0	-298.0	159.0	-369.0
129	Prov S. American 1956 - Peru	PRP-G	20	0	-279.0	175.0	-379.0
130	Prov S. American 1956 - Venezuela	PRP-H	20	0	-295.0	173.0	-371.0
131	Prov South Chilean 1963	HIT	20	0	16.0	196.0	93.0
132	South American 1969 - Mean Solution (Arg, Bol, Bra, Chi, Col, Ecu, Guy, Par, Per, Tri & Tob, Ven)	SAN-M	22	0	-57.0	1.0	-41.0

Index	Name	Acronym	Ellipsoid index (see Table 83)	Rotation and scale index (see Table 84)	dX [m]	dY [m]	dZ [m]
133	South American 1969 - Argentina	SAN-A	22	0	-62.0	-1.0	-37.0
134	South American 1969 - Bolivia	SAN-B	22	0	-61.0	2.0	-48.0
135	South American 1969 - Brazil	SAN-C	22	0	-60.0	-2.0	-41.0
136	South American 1969 - Chile	SAN-D	22	0	-75.0	-1.0	-44.0
137	South American 1969 - Colombia	SAN-E	22	0	-44.0	6.0	-36.0
138	South American 1969 - Ecuador (excluding Galapagos Islands)	SAN-F	22	0	-48.0	3.0	-44.0
139	South American 1969 - Baltra, Galapagos Islands	SAN-J	22	0	-47.0	26.0	-42.0
140	South American 1969 - Guyana	SAN-G	22	0	-53.0	3.0	-47.0
141	South American 1969 - Paraguay	SAN-H	22	0	-61.0	2.0	-33.0
142	South American 1969 - Peru	SAN-I	22	0	-58.0	0.0	-44.0
143	South American 1969 - Trinidad & Tobago	SAN-K	22	0	-45.0	12.0	-33.0
144	South American 1969 - Venezuela	SAN-L	22	0	-45.0	8.0	-33.0
145	Zanderij - Suriname	ZAN	20	0	-265.0	120.0	-358.0
146	Antigua Island Astro 1943 - Antigua, Leeward Islands	AIA	7	0	-270.0	13.0	62.0
147	Ascension Island 1958	ASC	20	0	-205.0	107.0	53.0
148	Astro Dos 71/4 - St Helena Island	SHB	20	0	-320.0	550.0	-494.0
149	Bermuda 1957 - Bermuda Islands	BER	6	0	-73.0	213.0	296.0
150	Deception Island, Antarctica	DID	7	0	260.0	12.0	-147.0
151	Fort Thomas 1955 - Nevis, St Kitts, Leeward Islands	FOT	7	0	-7.0	215.0	225.0
152	Graciosa Base SW 1948 - Faial, Graciosa, Pico, Sao Jorge, Terceira Islands (Azores)	GRA	20	0	-104.0	167.0	-38.0
153	ISTS 061 Astro 1968 - South Georgia Islands	ISG	20	0	-794.0	119.0	-298.0
154	L.C. 5 Astro 1961 - Cayman Brac Island	LCF	6	0	42.0	124.0	147.0
155	Montserrat Island Astro 1958 - Montserrat Leeward Islands	ASM	7	0	174.0	359.0	365.0
156	Naparima, BWI - Trinidad & Tobago	NAP	20	0	-10.0	375.0	165.0
157	Observatorio Meteorologico 1939 - Corvo and Flores Islands (Azores)	FLO	20	0	-425.0	-169.0	81.0
158	Pico De Las Nieves - Canary Islands	PLN	20	0	-307.0	-92.0	127.0
159	Porto Santo 1936 - Porto Santo and Madeira Islands	POS	20	0	-499.0	-249.0	314.0
160	Puerto Rico - Puerto Rico & Virgin Islands	PUR	6	0	11.0	72.0	-101.0
161	Qornoq - South Greenland	QUO	20	0	164.0	138.0	-189.0
162	Sao Braz - Soa Miguel, Santa Maria Islands (Azores)	SAO	20	0	-203.0	141.0	53.0
163	Sapper Hill 1943 - East Falkland Island	SAP	20	0	-355.0	21.0	72.0
164	Selvagem Grande 1938 - Salvage Islands	SGM	20	0	-289.0	-124.0	60.0
165	Tristan Astro 1968 - Tristan du Cunha	TDC	20	0	-632.0	438.0	-609.0
166	Anna 1 Astro 1965 - Cocos Islands	ANO	3	0	-491.0	-22.0	435.0

Index	Name	Acronym	Ellipsoid index (see Table 83)	Rotation and scale index (see Table 84)	dX [m]	dY [m]	dZ [m]
167	Gandajika Base 1970 - Republic of Maldives	GAA	20	0	-133.0	-321.0	50.0
168	ISTS 073 Astro 1969 - Diego Garcia	IST	20	0	208.0	-435.0	-229.0
169	Kerguelen Island 1949 - Kerguelen Island	KEG	20	0	145.0	-187.0	103.0
170	Mahe 1971 - Mahe Island	MIK	7	0	41.0	-220.0	-134.0
171	Reunion - Mascarene Islands	RUE	20	0	94.0	-948.0	-1262.0
172	American Samoa 1962 - American Samoa Islands	AMA	6	0	-115.0	118.0	426.0
173	Astro Beacon E 1945 - Iwo Jima	ATF	20	0	145.0	75.0	-272.0
174	Astro Tern Island (Frig) 1961 - Tern Island	TRN	20	0	114.0	-116.0	-333.0
175	Astronomical Station 1952 - Marcus Island	ASQ	20	0	124.0	-234.0	-25.0
176	Bellevue (IGN) - Efate and Erromango Islands	IBE	20	0	-127.0	-769.0	472.0
177	Canton Astro 1966 - Phoenix Islands	CAO	20	0	298.0	-304.0	-375.0
178	Chatham Island Astro 1971 - Chatham Island (New Zeland)	CHI	20	0	175.0	-38.0	113.0
179	DOS 1968 - Gizo Island (New Georgia Islands)	GIZ	20	0	230.0	-199.0	-752.0
180	Easter Island 1967 - Easter Island	EAS	20	0	211.0	147.0	111.0
181	Geodetic Datum 1949 - New Zealand	GEO	20	0	84.0	-22.0	209.0
182	Guam 1963 - Guam Island	GUA	6	0	-100.0	-248.0	259.0
183	GUX 1 Astro - Guadalcanal Island	DOB	20	0	252.0	-209.0	-751.0
184	Indonesian 1974 - Indonesia	IDN	19	0	-24.0	-15.0	5.0
185	Johnston Island 1961 - Johnston Island	JOH	20	0	189.0	-79.0	-202.0
186	Kusaie Astro 1951 - Caroline Islands, Fed. States of Micronesia	KUS	20	0	647.0	1777.0	-1124.0
187	Luzon - Philippines (excluding Mindanao Island)	LUZ-A	6	0	-133.0	-77.0	-51.0
188	Luzon - Mindanao Island (Philippines)	LUZ-B	6	0	-133.0	-79.0	-72.0
189	Midway Astro 1961 - Midway Islands	MID	20	0	912.0	-58.0	1227.0
190	Old Hawaiian - Mean Solution	OHA-M	6	0	61.0	-285.0	-181.0
191	Old Hawaiian - Hawaii	OHA-A	6	0	89.0	-279.0	-183.0
192	Old Hawaiian - Kauai	OHA-B	6	0	45.0	-290.0	-172.0
193	Old Hawaiian - Maui	OHA-C	6	0	65.0	-290.0	-190.0
194	Old Hawaiian - Oahu	OHA-D	6	0	58.0	-283.0	-182.0
195	Pitcairn Astro 1967 - Pitcairn Island	PIT	20	0	185.0	165.0	42.0
196	Santo (Dos) 1965 - Espirito Santo Island	SAE	20	0	170.0	42.0	84.0
197	Viti Levu 1916 - Viti Levu Island (Fiji Islands)	MVS	7	0	51.0	391.0	-36.0
198	Wake-Eniwetok 1960 - Marshall Islands	ENW	18	0	102.0	52.0	-38.0
199	Wake Island Astro 1952 - Wake Atoll	WAK	20	0	276.0	-57.0	149.0
200	Bukit Rimpah - Bangka and Belitung Islands (Indonesia)	BUR	5	0	-384.0	664.0	-48.0
201	Camp Area Astro - Camp McMurdo Area, Antarctica	CAZ	20	0	-104.0	-129.0	239.0
202	European 1950 - Iraq, Israel, Jordan, Kuwait, Lebanon, Saudi Arabia & Syria	EUR-S	20	0	-103.0	-106.0	-141.0

Index	Name	Acronym	Ellipsoid index (see Table 83)	Rotation and scale index (see Table 84)	dX [m]	dY [m]	dZ [m]
203	Gunung Segara - Kalimantan (Indonesia)	GSE	5	0	-403.0	684.0	41.0
204	Herat North - Afghanistan	HEN	20	0	-333.0	-222.0	114.0
205	Indian - Pakistan	IND-P	9	0	283.0	682.0	231.0
206	Pulkovo 1942 - Russia	PUK	21	0	28.0	-130.0	-95.0
207	Tananarive Observatory 1925 - Madagascar	TAN	20	0	-189.0	-242.0	-91.0
208	Yacare - Uruguay	YAC	20	0	-155.0	171.0	37.0
209	Krassovsky 1942 - Russia	KRA42	21	0	26.0	-139.0	-80.0
210	Lommel Datum 1950 - Belgium & Luxembourg	BLG50	20	0	-55.0	49.0	-158.0
211	Reseau National Belge 1972 - Belgium	RNB72	20	0	-104.0	80.0	-75.0
212	NTF - Nouvelle Triangulation de la France	NTF	7	0	-168.0	-60.0	320.0
213	Netherlands 1921 - Netherlands	NL21	5	0	719.0	47.0	640.0
214	European Datum 1987, IAG RETrig Subcommision.	ED87	20	2	-82.5	-91.7	-117.7
215	Swiss Datum 1903+ (LV95)	CH95	5	0	674.374	15.056	405.346

Table 82: Datum

Index	Ellipsoid	Semi Major Axis [m]	1/Flattening
0	WGS 84	6378137.000	298.257223563
1	Airy 1830	6377563.396	299.3249646
2	Modified Airy	6377340.189	299.3249646
3	Australian National	6378160.000	298.25
4	Bessel 1841 (Namibia)	6377483.865	299.1528128
5	Bessel 1841	6377397.155	299.1528128
6	Clarke 1866	6378206.400	294.9786982
7	Clarke 1880	6378249.145	293.465
8	Earth-90	6378136.000	298.257839303
9	Everest (India 1830)	6377276.345	300.8017
10	Everest (Sabah Sarawak)	6377298.556	300.8017
11	Everest (India 1956)	6377301.243	300.8017
12	Everest (Malaysia 1969)	6377295.664	300.8017
13	Everest (Malay. & Singapore 1948)	6377304.063	300.8017
14	Everest (Pakistan)	6377309.613	300.8017
15	Modified Fischer 1960	6378155.000	298.3
16	GRS 80	6378137.000	298.257222101
17	Helmert 1906	6378200.000	298.3
18	Hough 1960	6378270.000	297.0
19	Indonesian 1974	6378160.000	298.247
20	International 1924	6378388.000	297.0
21	Krassovsky 1940	6378245.000	298.3
22	South American 1969	6378160.000	298.25
23	WGS 72	6378135.000	298.26

Table 83: Ellipsoids

Index	Description	Rot X [seconds]	Rot Y [seconds]	Rot Z [seconds]	Scale [-]
0		+0.0000	+0.0000	+0.0000	0.000
1		0.0000	0.0000	-0.5540	0.220
2	European Datum 1987 IAG RETrig Subcommision	0.1338	-0.0625	-0.0470	0.045

Table 84: Rotation and scale

D Index

2

A

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E Lists

E.1 List of Figures

E.2 List of Tables

F Glossary

API	Application Programming Interface
APM	Autonomous Power Management
BBR	Battery backed-up RAM
CTM	Continuous Tracking Mode, operation Mode of the u-blox GPS receiver technology
ECEF	Earth Centered Earth Fixed
ESD	Electro Static Discharge
FixNOW™	Operation Mode of the u-blox GPS receiver technology, initiates fix.
FXN	FixNOW™, operation Mode of the u-blox GPS receiver technology, initiates PVT fix.
HAE	Height Above WGS84-Ellipsoid
LLA	Latitude, Longitude and Altitude
LNA	Low Noise Amplifier
LOS	Line of sight,
MSL	Height above Mean Sea Level or Orthometric Height
NMEA 0183	ASCII based standard data communication protocol used by GPS receivers.
PUBX	u-blox proprietary extension to the NMEA protocol
PVT	Position, Velocity, Time
SA	Selective Availability
SBAS	Satellite Based Augmentation Systems
UBX	File extension for u-center log file or short form for the UBX protocol
UBX Protocol	A proprietary binary protocol used by the ANTARIS™ GPS technology
UTM	Universal Transverse Mercator
u-center AE	u-center ANTARIS® Edition

Related Documents

[1] TIM-LP Datasheet, Doc No GPS.G3-MS3-02010

[2] ANTARIS® EvalKit – Users Guide, Doc No GPS.G3-EK-02001

[3] u-center ANTARIS™ Edition – Users Guide, Doc No GPS.SW-02001

[4] SCKit Manual, CHM, online help file

[5] RF Design for GPS Receivers – Application Note, Doc No GPS-X-02015

[6] GPS Basics, Introduction to the system – Application overview - Doc No GPS-X-02007

[7] u-blox' GPS Dictionary - Doc No GPS-X-00001

[8] ANTARIS® GPS Technology Protocol Specifications – CHM, online help file

[9] TIM-LF Datasheet, Doc No GPS.G3-MS3-03017

[10] TIM-LC Datasheet, Doc No GPS.G3-MS3-03019

[11] ANTARIS® Technology Software Development Manual, Doc No GPS.G3-DK-03021

[12] ANTARIS® GPS Software Customization Kit Datasheet, Doc No GPS.G3-DK-03017

All these documents are available on our homepage (http://www.u-blox.com).

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