MN8010
Design Guidelines

1. Introduction

This document contains important technical information, design notes and helpful hints to assist the designer in achieving first time success in bringing up a design using the MN8010 GPS Receiver module. It contains design examples and suggestions on a wide variety of topics, including power supply connections and bypassing, RF interface design, shielding and filtering requirements, antenna considerations and other important subjects.

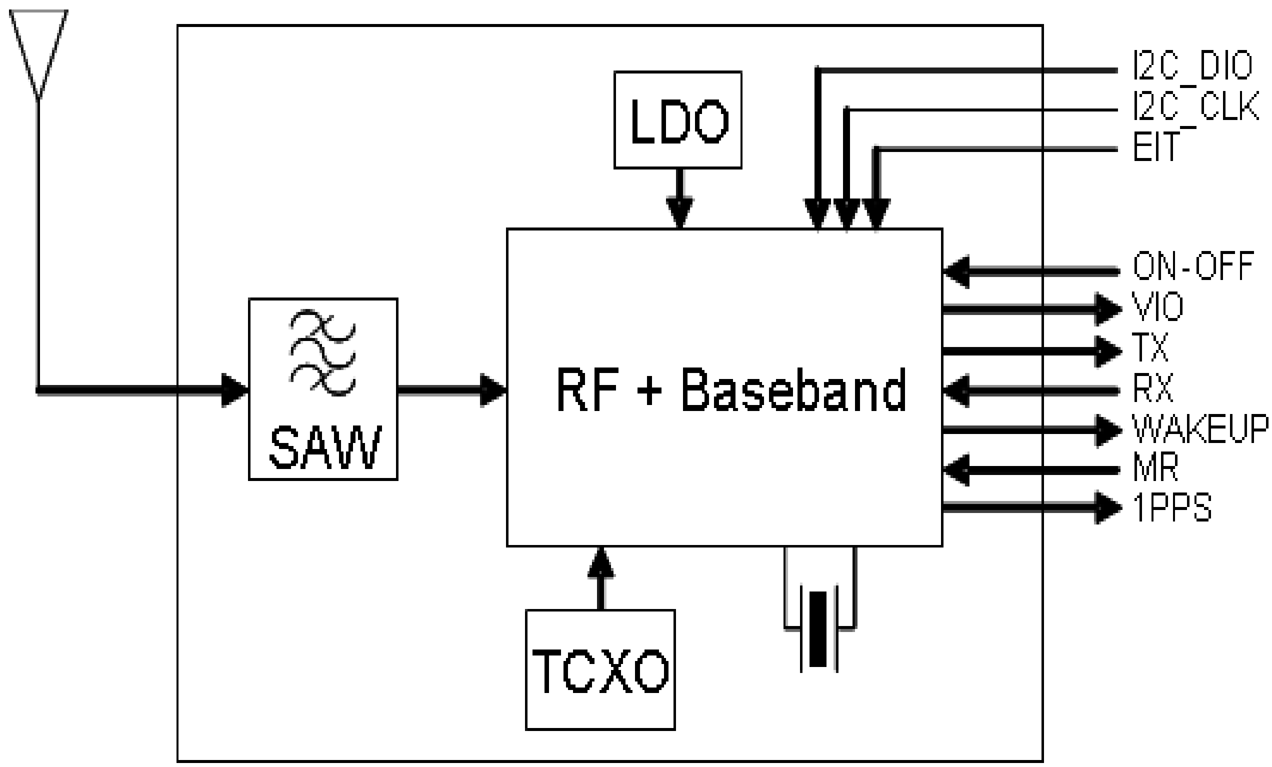

Figure 1 - MN8010 Block Diagram

Micro Modular Technologies Pte. Ltd.
No. 3, Ubi Avenue 3, #03-02 Crocodile House 408857 Singapore
Tel: 65-6745-8832 Fax: 65-6293-0661 Email: sales@micro-modular.com

2. Power Supply & Power Management

The MN8010 GPS Receiver Module is designed to operate directly from a battery with a supply range of 2.5 volts DC minimum to 5.0 volts DC maximum, such as a standard Lithium Ion battery pack or a three-pack of Nickel Metal Hydride batteries. The battery voltage should always present in order to keep the internal RTC clock and SRAM alive, even when the receiver is in hibernate mode.

2.1. On–Off Control

Power is controlled via the ON-OFF signal pin (pin 22) of the MN8010. The receiver always powers up in hibernate state. To put the receiver into active operation, host should generate and input a pulse to this pin as shown below in Figure 2 - ON-OFF Signal Timing and in Figure 3 - Module Activation. After that, the receiver will power up and run continuously while GPS_3.3V is applied. Although GPS_3.3V could be switched off to completely power down the receiver, all data stored in the receiver's RAM will be lost, with the following results:

- Internal TCXO calibration data is lost, lengthening the time for a cold start.
- The current time is lost, eliminating the possibility of a hot start or warm start.
- The current location is lost, eliminating the possibility of a warm start.
- Current ephemeris data is lost, requiring download of the latest ephemeris data.
- Current almanac data is lost so the receiver will revert to the factory almanac.
- Patch RAM contents (if any) are lost and will require a new download.

To place the receiver into hibernate state (all internal power supplies off except RTC and SRAM) from the full power operating (On) state, pulse the On-Off control high for a minimum of 100 milliseconds. To return the receiver to full power operating state from hibernate state, pulse the On-Off control high for a minimum of 100 milliseconds. The Power On–Off pulse must not occur more than once per second.

If the receiver is operating in one of the power management modes (Adaptive Trickle Power or Push-To-Fix mode), use the software commands to return the receiver to full power operating mode before sending the On-Off pulse. Sending an On-Off pulse during ATP or PTF mode could result in an undetermined power state.

The current power state of the receiver (On vs. Hibernate) can be determined by the level of the WAKEUP pin: when logic high (1.8V), the receiver is in full power operating state, when logic low (0V), the receiver is in hibernate state.

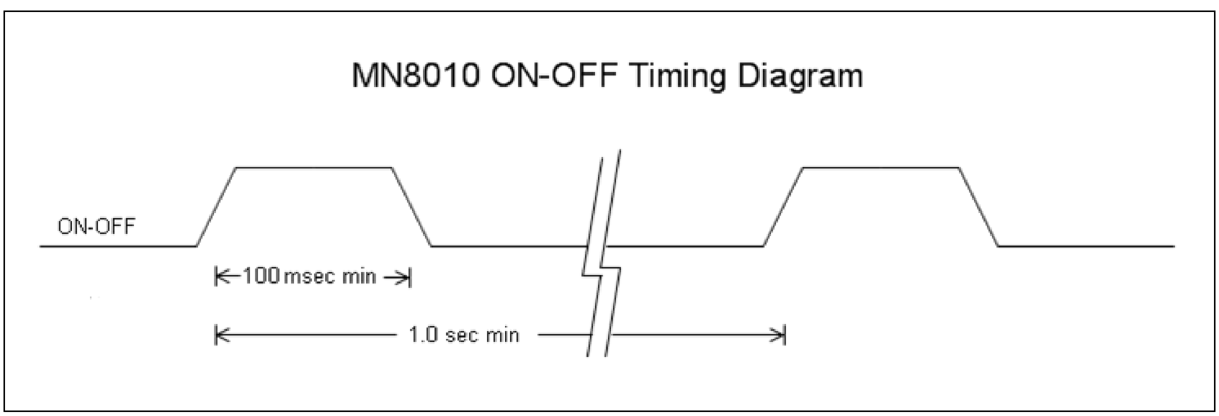

Figure 2 - ON-OFF Signal Timing

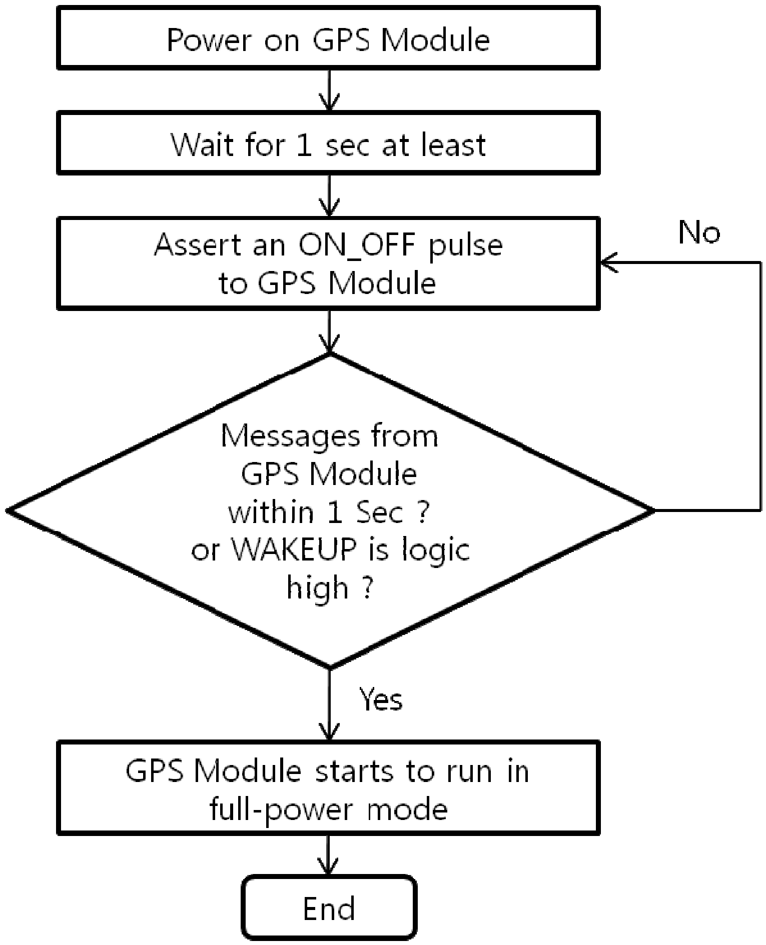

Figure 3 - Module Activation

2.2. VIO Pin

VIO (pin 12) is the output of the internal 1.8 volt I/O regulator. VIO can be used to provide power to an external buffer which would drive the MN8010 RX line. Select a buffer that powers down with high impedance inputs and outputs thereby eliminating the possibility of back-driving the MN8010 through the host side signal output (TX).

VIO can supply no more than 20mA.

3. Digital Signal Interface

3.1. Serial Interface

One full-duplex asynchronous serial data port provides data communications to and from the MN8010 GPS Receiver Module. The default bit rate is standard 4800 baud and the default data format is 8 data bits, no parity, 1 stop bit and no flow control.

RX (pin 7): This signal is the input for the UART and is normally used to input commands or other information to the receiver in either NMEA-0183 or SiRF binary protocol, depending upon the current configuration of the receiver. This signal is a 3.6 volt tolerant CMOS I/O logic level. In the idle condition, this pin should be driven at logic 1. During hibernation and when primary power (VCC) is not present, take care not to drive this line high (the normal default idle state of this signal) to prevent partially powering the MN8010 by back driving the ESD diode protection circuitry. Use the WAKEUP signal to determine whether or not it is safe to drive this line.

Do not hold this line low (BREAK state) while the receiver is active. Its idle state should be HIGH.

If command/data input is not needed, this pin should be open.

TX (pin 8): This signal is the output of the UART and is normally used to output position, time and velocity information from the receiver. This signal is a 1.8 volt CMOS I/O logic level with the idle condition being logic high. The protocol may be either NMEA-0183 or SiRF binary, depending upon the current configuration of the receiver. During hibernation, the TX data line will be at 0 volts. The user is cautioned to ensure that any downstream processing of this signal can tolerate a 0 volt condition (BREAK condition) whenever the MN8010 is in hibernate state. If necessary, the WAKEUP pin can be monitored to determine if the receiver is in hibernate state.

3.2. I2C-DIO

I2C-DIO (pin 3) is dead reckoning I2C bus data (SDA) which supports 400Kbps maximum date rate. It provides connectivity to optional Dead Reckoning sensors (e.g. 3-D Accelerometer). The bus supports also optional connectivity to EEPROM for Client Generated Extended Ephemeris (CGEE) data storage and ROM patch code upload during power up boot and after waking up from Hibernate state of the MN8010. This signal requires an external 2.2K ohm pull up resistor and can be left not connected when not used.

3.3. I2C-CLK

I2C-CLK (pin 4) is dead reckoning I2C bus clock (SCL) which supports 400Kbps maximum date rate. It provides connectivity to optional Dead Reckoning sensors (e.g. 3-D Accelerometer). The bus supports also optional connectivity to EEPROM for Client Generated Extended Ephemeris (CGEE) data storage and ROM patch code upload during power up boot and after waking up from Hibernate state of the MN8010. This signal requires an external 2.2K ohm pull up resistor and can be left not connected when not used.

3.4. EIT

This EIT (pin 6) can be used as a source of a level sensitive interrupt to wake up the MN8010 from hibernate state. It allows external sensors, e.g. Accelerometer, to provide an interrupt when a change of state is detected. The input can be left not connected when not used.

3.5. 1PPS

The 1PPS signal is a one-pulse-per-second (1PPS) signal. Whenever the receiver provides a valid navigation solution, the rising edge of each 1PPS pulse is synchronized with the UTC one-second epoch. Pulse length (high state) is 200ms about +/-1us accuracy synchronized at rising to full UTC second.

3.6. WAKEUP

This WAKEUP (pin 32) signal output is used to enable an external power management IC. A low on this output indicates that the MN8010 is in low-power state and a high on this output indicates that the MN8010 is in full-power state. It can be used externally to switch off the Active Antenna Bias supply voltage during Hibernate state.

4. RF Interface

4.1. RF Input

The MN8010 GPS Receiver Module accepts a GPS L1 C/A signal from an industry-standard GPS antenna (which may be passive or active). If a passive antenna is used, no other circuitry is required. However, if an active antenna is required, refer to Section 4.5

The RF input is isolated from DC levels to a maximum of +/- 25 VDC.

4.2. General RF Layout

Maintain a characteristic impedance of 50 ohm throughout the entire RF signal path. Keep the RF signal path as short as possible, and do not route near noise sources such as digital signals, oscillators, switching power supplies, or other RF transmitters, such as Bluetooth.

Do not route the RF signal under or over any other components including the module or other signal path.

Avoid vias whenever possible, Every via adds inductive impedance to the signal path. Vias are acceptable for coupling the RF grounds between layers.

Avoid sharp bends, if a bend is necessary make two 45-angle bends or a radius bend instead of a single 90-angle bend.

Do not route the RF signal path on an inner layer of a multi-layer PCB if possible to minimize signal loss and the need of interlayer vias.

4.3. 50-Ohm RF Trace

The goal is to provide a perfectly matched 50-ohm transmission line environment between a 50-ohm antenna and the module RF-input to ensure maximum power transfer to the RF front-end. Any discontinuities due to unmatched impedance in the RF trace, excessive vias, poor layout design, or energy coupling because of poor grounding can reduce the GPS performance significantly or even render it non-functional. To reiterate, this signal path is the most critical part of the GPS system design. Consult with us or a PCB vendor for more detail design guidelines.

4.4. Passive Antenna

A passive antenna can be directly connected to the ANT input of the MN8010. Assuming the antenna is well tuned for the ground plane it would sit on and any plastics that would enclose it, matching of the antenna to the MN8010 would not be required. However, good practice suggests that footprints for a PI matching network would be prudent if space permits.

The ANT input to the MN8010 directly feeds an LNA. If high levels of RF interference are expected in the end product, the addition of a pre-select SAW or ceramic filter may be required to provide good performance.

The rejection characteristics of the pre-select filter can be determined by measuring the out of band signal levels.

4.5. Active Antenna

MN8010 receiver was set to High Gain mode for a passive antenna use via the High/Low LNA gain configuration bit inside the receiver by default, so it need to be set to Low Gain mode thru a software command in SiRF Open Socket Protocol (OSP, a super set of SiRF binary) message format to support an active antenna. In this case, output gain of the active antenna should be 20dB +/- 2 dB including cable loss. For the details about the command, refer to SiRF OSP document. Note that the receiver is unable to keep the changed (Low Gain mode) setting. It goes back to the default setting (High Gain mode) when the power of the receiver is switched off. To make this up, there are two options

1. Sending a command from host side to the receiver whenever the power cycling happens.
2. Adding an EEPROM to the I2C bus of the receiver to store a patch which will be a customized code having Low Gain mode by default. For implementing this, contact us.

There is another method to support an active antenna without setting the receiver to Low Gain mode. As shown in Figure 4, depending upon the amplifier gain of the active antenna (not to be confused with antenna gain) and cable loss, a PI pad can be inserted in front of the MN8010 to attenuate the gain of the active antenna. A total signal gain (LNA gain – Cable loss) greater than 12 dB should be attenuated to bring the total gain in front of the MN8010 down to 12 dB. Operating with higher gain is not allowed and may result in damaged device. If it needs to be supported to set the R1 and R2 values of the Pi PAD, contact us with the active antenna specification.

Suitable means for powering the active antenna should be provided external to the MN8010 GPS Receiver Module as shown in Figure 4. “L” in Figure 4 is replacing for a quarter wave stub which will have 27mm trace length on FR4 PCB material.

If high levels of RF interference are presented in the end product, the active antenna can be selected to have both a pre-select and post-select filter to attenuate the unwanted interference.

No. 3, Ubi Avenue 3, #03-02 Crocodile House 408857 Singapore
Tel: 65-6745-8832 Fax: 65-6293-0661 Email: sales@micro-modular.com www.micro-modular.com

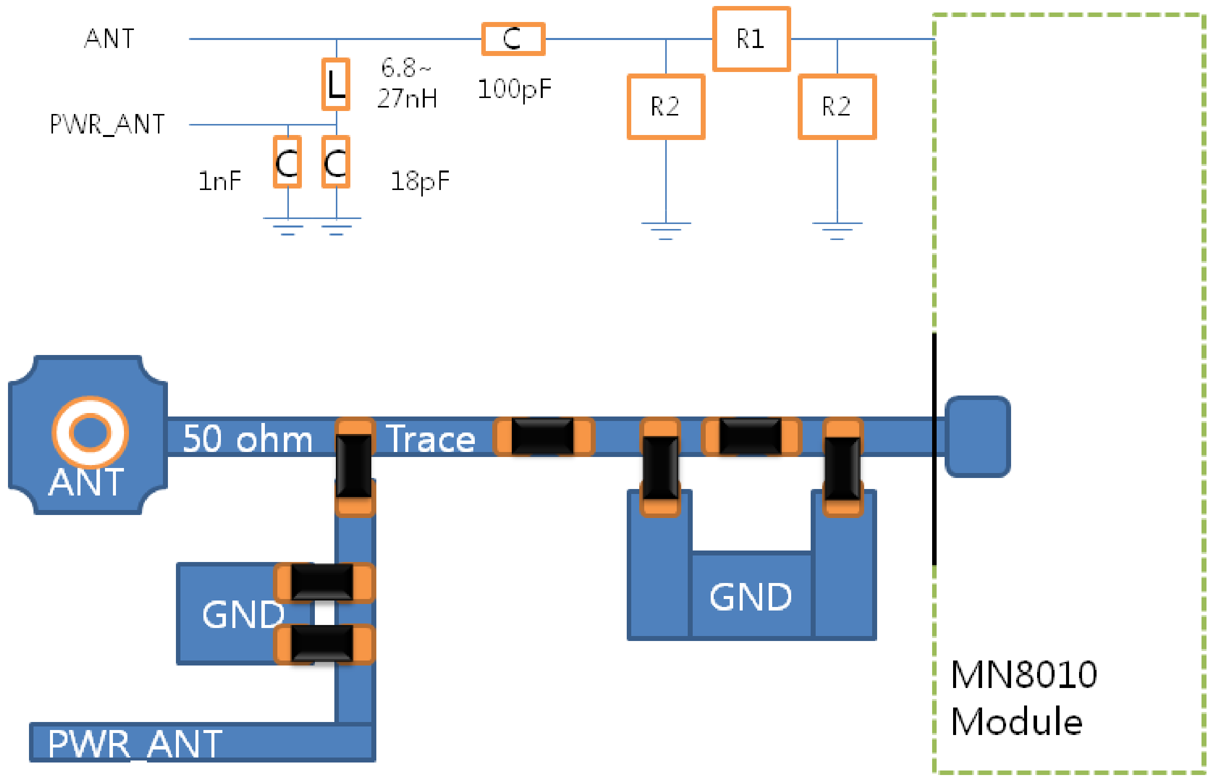

Figure 4 - Antenna Power and Pi PAD

4.6. LO Leakage

The MN8010 has an internal LO at 1571.424MHz that can appear at the ANT pad of the device. While this level is quite low (approximately -90 dBm), it is high enough that it could interfere with another GPS receiver in the vicinity. Normally, this is not a problem in normal operation, but during test and evaluation, several receivers could be operating simultaneously off of a common antenna or other signal source. In this case, care must be taken to provide proper isolation between the receivers.

4.7. Spurious Signals

Due to the small size of the MN8010 module and the tight IC geometries used internally, the MN8010 does generate a fair amount of digital noise. Since this is all based upon the internal reference frequency of 16.369 MHz, it is synchronous within the receiver and does not impact receiver operation. However, some signals may interfere with external circuitry. Therefore, it may be necessary to shield the GPS module and related circuitry from other receivers in the end product.

4.8. Burnout Protection

The MN8010 GPS Receiver Module can accept signal levels up to +10 dBm with a DC voltage of +/- 25 V on the RF input pin without permanent damage to the module.

5. Shielding and Filtering Requirements

The MN8010 is designed to use a GPS signal that can be as low as -163 dBm. Any source of interference near in frequency to the GPS signal could potentially jam the MN8010 and disrupt reception of the signal.

5.1. Digital Emissions

For proper system design, the GPS antenna needs to be shielded from any potential jamming source. For that reason, in most designs not containing a transmitter, it makes more sense to shield the digital portion of the product rather than the RF portion. This keeps the digital noise from radiating into the antenna and/or antenna feed lines. Generally, it is not necessary to provide additional shielding around the MN8010 and associated circuitry.

It is important to note the GPS signal level is well below any regulatory emissions requirement for EMI and EMC. Thus while a product meets FCC class B or CISPR 22, it is possible the emissions from the product will still seriously impact the MN8010 performance.

Excessive interference into the MN8010 via the antenna can result is low to very low reported C/Nos of the satellite signals and subsequent excessive TTFF times. Assuming an 18mm square patch antenna with good LNA, the reported C/Nos should be in the high 40s and low 50s. If the values are below this, then interference needs to be considered as a problem and resolved. This can also be checked by substituting an external active antenna and moving it closer to and away from the device and noting the change in reported C/Nos. If any improvement in signal is noted as the external antenna is moved away from the device, then additional shielding is required.

5.2. RF Emissions

MN8010 features a jammer remover that can track up to eight jammers to help filter out interference, but nevertheless, if the product contains an RF transmitter or a second heterodyne receiver, then care must be taken to prevent overloading the front end of the MN8010 if simultaneous operation is required. This overloading can come from several sources.

First, the input LNA of the MN8010 does not have a preselect filter and is fairly broad band. If for example a GSM transmitter (1.8 GHz) was close by, then the GSM signal could overload the LNA. The output of the LNA is going to be proportional to its input, and if the GSM signal so dominates, the GPS signal would be attenuated and sensitivity of the receiver would be reduced. The OEM designer would need to design suitable input filtering to the MN8010 to protect in this case.

A second case occurs in the collocated transmitter. The power amplifier has both a gain and a noise figure. If we take an example of a power amp noise figure of 15 dB and 30 dB of gain, this would mean that the power amp radiates broadband noise approximately 45 dB above thermal noise. This means the power amp alone could present a noise source in the GPS band of -129 dBm. While this would easily meet any regulatory emissions requirements, it would render the GPS receiver inoperative. In this case, a suitable filter must be placed on the output of the power amplifier of the collocated transmitter, not the GPS receiver, to avoid this case.

6. GPS Antenna Selection

Currently there are several types of GPS antennas available for the user to choose from. Each type of antenna has both advantages and disadvantages which need to be carefully weighed in making a selection. In addition, most antenna types are available in both an active (includes built in LNA) and passive versions.

No. 3, Ubi Avenue 3, #03-02 Crocodile House 408857 Singapore
Tel: 65-6745-8832 Fax: 65-6293-0661 Email: sales@micro-modular.com www.micro-modular.com

When selecting the antenna it is important both to consider the characteristics of the GPS signal itself along with the characteristics of the antenna. The GPS signal is broadcast at 1.57542GHz and comes from any of the GPS satellites from the sky. The receiver needs a minimum of four signals to compute a 3D position. Ideally, the antenna should have an unrestricted view of the sky. Certain locations may limit the visibility of the sky such as being close to a building, etc, so it is important that the product in which the antenna is installed does not further limitation to satellite visibility.

The GPS signal is also right hand circularly polarized (RHCP) so best results are achieved under most conditions with a right hand circularly polarized antenna. Under severed obscuration where multipath signal reflections are present, a linearly polarized antenna my give better results under the assumption that a reflected signal is better than no signal.

Antennas are specified by antenna type, antenna gain, antenna pattern, polarization and axial ratio. Antenna gain is typically considered to be the ratio of the signal level received by the antenna under consideration at zenith as compared to a theoretical isotropic radiator (equal signal level in all directions). The gain is measure in dBi (for a linearly polarized antenna) or dBic (for a circularly polarized antenna). The gain of an antenna is going to very depending upon elevation and azimuth of the signal source with respect to the antenna. Graphically plotting this variation results in an antenna pattern. The axial ratio of an antenna is a measure of the quality of its polarization. An axial ratio of 1 is perfect circular polarization, an infinite axial ratio in perfectly linear polarization.

6.1. Patch Antennas

Patch antenna are typically square or round ceramic elements with metallic plating on both sides, the top being the metallic antenna element and the bottom being the ground plane.

Figure 5 – Typical patch antenna

If a patch antenna is selected, it is important that it be oriented such that the top surface of the antenna is horizontal with respect to the surface of the earth. Tilting the antenna away from the horizontal will result in an artificial obscuration of potentially visible satellites.

No. 3, Ubi Avenue 3, #03-02 Crocodile House 408857 Singapore
Tel: 65-6745-8832 Fax: 65-6293-0661 Email: sales@micro-modular.com www.micro-modular.com

While patch antenna are low cost and can provide good gain, it is important that the patch antenna be used with a proper ground plane. The antenna vendor can provide assistance in this area. In addition, patch antennas are detuned by the present of anything within its near field, such as a plastic cover. The antenna vendor can tune the antenna to compensate for this detuning.

6.2. Helix Antennas

Helix antennas are usually spirally wound onto a tubular ceramic piece (see Figure 6). For best performance, the helix antenna needs to be vertical with respect to the surface of the earth. Helix antennas do not require a ground plane, but may work better with one.

Figure 6 – Sarantel helix antenna (cover removed)

6.3. Chip Antennas

Chip antennas (Figure 7) are the smallest antenna available for GPS and are quite popular in small handhelds. However, chip antennas are linearly polarized making them more receptive to multipath signals which would degrade the computed position in some cases. Chip antennas also have very specific ground plane requirements. The antenna vendor can provide assistance in this area and can possibly tune the chip for a specific application.

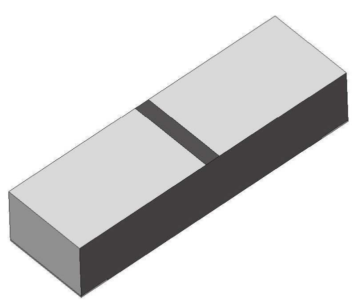

Figure 7 – Chip Antenna

7. Notices

All reference and informational documents (including marketing information, specifications, reference designs, etc.) are provided for information only and are subject to change without notice. Reasonable efforts have been made in the preparation of these documents to assure their accuracy, however Micro Modular Technologies Pte. Ltd. assumes no liability resulting from errors or omissions in this, or any document, or from the use of the information contained herein. Micro Modular Technologies Pte. Ltd. reserves the right to make changes in the product design and specifications as needed and without notification to its users. Please check our website for the most current documentation. All information contained herein is the property of Micro Modular Technologies Pte Ltd. and may not be copied or reproduced, other than for your information, without prior written consent.

8. Contact Information

Email: sales@micro-modular.com

www.micro-modular.com

Asia & Corporate Headquarters
Tel: (65) 6745-8832

Americas and Europe
Tel: (1) 949-336-7850