General RF & Antenna Guidelines

1 Introduction

This document contains information about general RF design guidelines and commonly used GPS antennas. The products it refers to are the MN5515HS and MN5310HS, henceforth referred to as “MMT receivers.”

2 Shielding and Filtering Requirements

MMT receivers are designed to use a GPS signal that can be as low as -159 dBm. Any source of interference near in frequency to the GPS signal could potentially jam the MMT receiver and disrupt reception of the signal.

2.1 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 line. Generally, it is not necessary to provide additional shielding around the MMT receiver 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 MMT receiver’s performance.

Excessive interference into the MMT receiver via the antenna can result in low to very low reported C/Nos of the satellite signals and consequent lengthened TTFF times. Assuming an 18mm square patch antenna with good LNA and a clear view of the sky, the reported C/Nos should be in the high 40s. If the values are below this, then interference needs to be considered as a problem and resolved. This can also be checked by connecting an external active antenna and moving it closer to and further away from the device while 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.

2.2 RF Emissions

If the product contains an RF transmitter or another heterodyne receiver, then care must be taken to prevent overloading the front end of the MMT receiver if simultaneous operation is required. This overloading can come from several sources.

First, the input LNA on an active antenna may not have a preselect filter and is fairly broad band. If, for example a GSM transmitter (1.8 GHz) were 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 include suitable input filtering to the MMT receiver to avoid this situation.

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 situation.

3 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 version (which includes a built in LNA) and passive version. The MN5515HS is designed to use an active antenna; if a passive antenna is used, an external LNA must be added. The MN5310HS can use either active or passive antenna.

When selecting the antenna, it is important to consider the characteristics of the GPS signal itself as well as the characteristics of the antenna. The GPS signal is broadcast at 1.57542GHz and comes from each of the visible GPS satellites. 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 proximity to a building, etc, so it is important that the product in which the antenna is installed does not further obscure satellite visibility.

The GPS signal is right hand circularly polarized (RHCP), so best results are achieved (under most conditions) with a right hand circularly polarized antenna. Under severe 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. Three common antenna types are covered in the next sections. Antenna gain is the ratio of the signal level received by the antenna under consideration at zenith as compared to a theoretical isotropic radiator (one with equal signal levels in all directions). The gain is measured in dBi for a linearly polarized antenna or dBic for a circularly polarized antenna. The gain of an antenna will vary depending upon the direction (elevation and azimuth) of the signal source with respect to the antenna and an antenna pattern is a graphical plot of this variation. The axial ratio of an antenna is a measure of the quality of its polarization. An axial ratio of 1 is perfect circular polarization, and an infinite axial ratio is perfectly linear polarization.

3.1 Patch Antennas

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

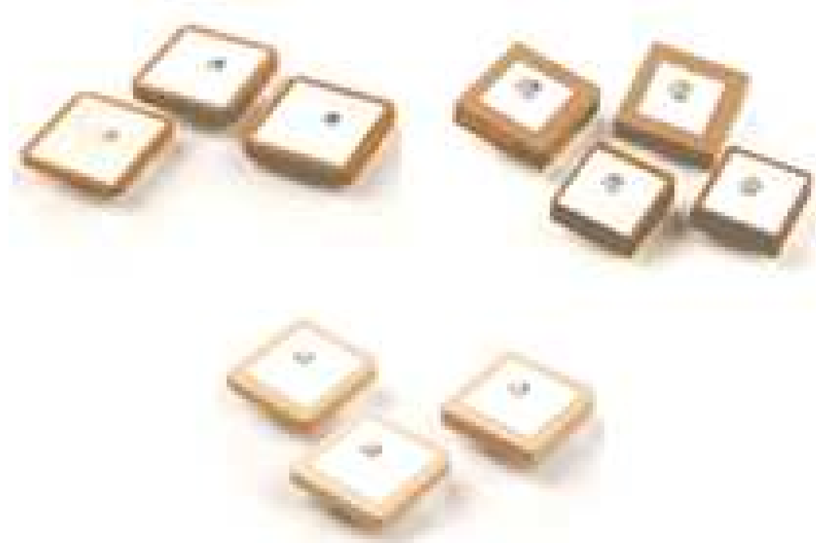

Figure 1 – Typical patch antennas

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.

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

Helix Antennas

Helix antennas consist of spirally wound elements on a tubular substrate of ceramic or other material (see Figure 2). For best performance, the helix antenna should be oriented vertically with respect to the surface of the earth. Helix antennas do not require a ground plane, but may work better with one.

Figure 2 – Sarantel helix antenna (cover removed)

3.2 Chip Antennas

Chip antennas are the smallest type available for GPS and are quite popular in small handheld devices. However, chip antennas are linearly polarized, giving them a 3 dB disadvantage and making them more receptive to multipath signals (which could degrade the accuracy of 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.

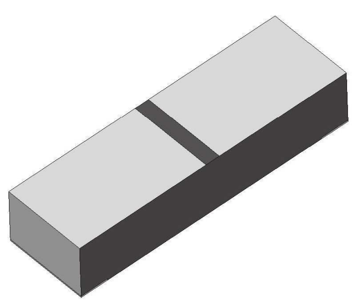

Figure 3 – Chip Antenna

4 Notices

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