Application Note:

Ground Plane Considerations for GNSS Ceramic Patch Antennas

Introduction

It is well understood that an antenna is a key component in a GNSS system, much the same way a lens is key to a quality camera system. However, it is less well known that the performance of a GNSS ceramic antenna is very dependent upon the ground plane used in the installation. To better understand the importance of the ground plane let's first define it. A ceramic patch antenna consists of a metallic patch placed on top of a grounded ceramic substrate forming a resonant antenna (Fig. 1 a). The ceramic antenna is optimally mounted in a horizontal plane since its peak gain occurs perpendicular to its surface. The performance of the ceramic antenna, including gain, can be optimized by placing it on an RF reflective surface. This surface is what is commonly referred to as the antenna ground plane (Fig. 1 b). Note, this ground plane is not required to be connected to the electrical ground of the receiver system and only acts to reflect the RF signal incident on the antenna. In a proper installation, this reflected wave has such a phase that it adds to the incident signal, thereby increasing the antenna gain. In an improper installation the reflected wave can actually subtract from the incident signal decreasing the gain! The ground plane therefore has a large impact on the antenna's radiation pattern. The purpose of this application note is to provide guidance on the proper use of ground planes for GNSS ceramic patch antennas.

Figure 1. a) Antenna without ground plane. Figure 1. b) Antenna with ground plane.

The following graph (Figure 2) illustrates the ability of a good ground plane to increase the gain of a patch antenna:

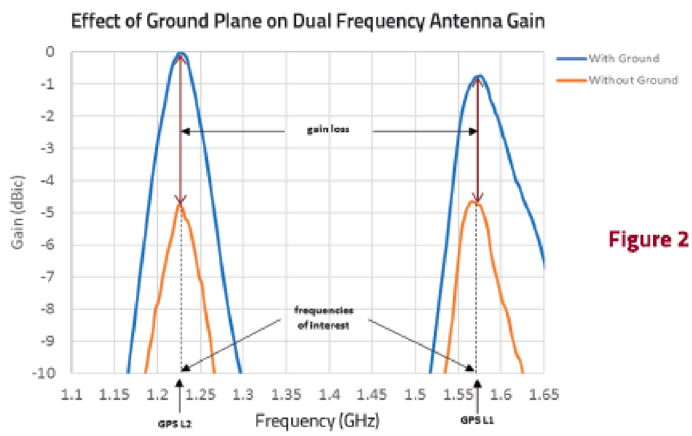

Figure 2

Ground Plane Shape

The shape of the ground plane is important because GNSS systems use right hand circularly polarized (RHCP) signals. This means that ideally the gain of the antenna should be the same at any angle of azimuth. To ensure this, the ground plane should be as symmetric as possible; a circular ground plane (Fig. 3) is optimal for the axial ratio of the antenna, which improves the rejection of cross-polarized (LHCP) signals and mitigates multi-path effects, which can reduce the positioning precision of the antenna.

It should also ideally be a continuous shape, without breaks, as this will not interrupt the ground currents induced by the incident EM fields.

Figure 3. Housed antenna mounted on a 120mm circular aluminum ground plane.

Ground Plane Size

The size of the ground plane is important and for GNSS applications and this should ideally be between 100mm to 120mm across. As the ground plane size increases, the gain of the antenna can be reduced due to surface wave diffraction at the ground plane edges.

A non-planar ground plane, such as the metallized top surface of an aircraft wing, has also been demonstrated to provide satisfactory performance.

Mounting Method

Non-housed Antennas - For mounting non-housed ceramic patch antennas in a customer application, one common method of installation is for the customer to include a cut-out in their PCB that the Tallysman antenna can be inserted through from below (Fig. 4). The ground plane can be implemented as an area of circular copper pour (ideally with a diameter of 100mm to 120mm as mentioned above) on the top side of the customers PCB. The antenna can be mounted with screws (the embedded antenna PCB has screw holes for this purpose) or two-sided adhesive tape.

Housed Antennas - Options for mounting Tallysman housed antennas include magnetic mount, adhesive tape, screw-hole and through-hole mounting. It is again highly recommended to include a ground plane (following the shape and size recommendations given above) directly under the antenna which can be implemented by any RF reflective material such as metallic tape, metal discs (such as aluminum), metallic paint, etc.

Cable Routing

The antenna coaxial cable can act as a reflector and affect the radiation pattern of the antenna. It is recommended to route the antenna cable underneath the antenna ground plane (Fig. 4) where it will be shielded from the antenna.

Figure 4. Antenna with cable routed below the ground plane.

Co-location with other Antennas

Installation of GNSS antennas in close proximity to other antennas can result in coupling and detuning of the GNSS antenna as well as the potential for RF interference. A general guideline is to ensure separate, isolated ground planes for the antennas to ensure the ground plane currents of each antenna do not interact. A pre-filtered antenna should be considered to mitigate RF interference. In any installation requiring the co-location of the GNSS antenna with other antennas it is highly recommended to contact our applications engineering team to review the installation as early in the design cycle as possible.

Summary

Ground planes play a large role in GNSS ceramic patch antenna performance, particularly on gain, radiation pattern, and axial ratio. A properly shaped and sized ground plane is paramount for optimal GNSS antenna performance to ensure good reception of GNSS signals and mitigation of multipath interference. GNSS antennas are frequently mounted on metallic surfaces that serve as a ground plane. These surfaces can vary in shape and size depending on the user application and may negatively impact antenna performance. The method of installation, cable routing and co-location with other antennas also play a role in the antenna's performance. In any GNSS antenna application it is recommended to contact our applications engineering team to review the installation as early in the design cycle as possible.