GPS Patch Integration Application Note

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1. PATCH BASICS

A GPS ceramic patch antenna is preferred over other antenna typologies because it can be made into small format compact applications while maintaining its advantages of high gain towards zenith, a key requirement for satellite based navigation systems. The other key advantage is it can be made to be circularly polarized, and this matches more efficiently with the circularly polarized radiation transmitted from the GPS satellites.

2. POSITIONING

Theoretically the best position for the GPS antenna is on top of the GPS receiver in the centre of the PCB. There are both electrical and physical reasons for this. The electrical reasons are that by placing the antenna directly above the GPS receiver removes the necessity for a transmission line on the PCB between the feed point on the antenna and the input to the GPS receiver. The physical reason is that if the antenna is placed in the centre of the PCB then the radiation plots won't be skewed due to the effects of placing it close to the edge of the PCB.

3. GROUND PLANE SIZE

The larger the ground-plane, the higher the antenna gain in general. Also the centre frequency of the antenna will change in proportion to the size of the ground-plane.

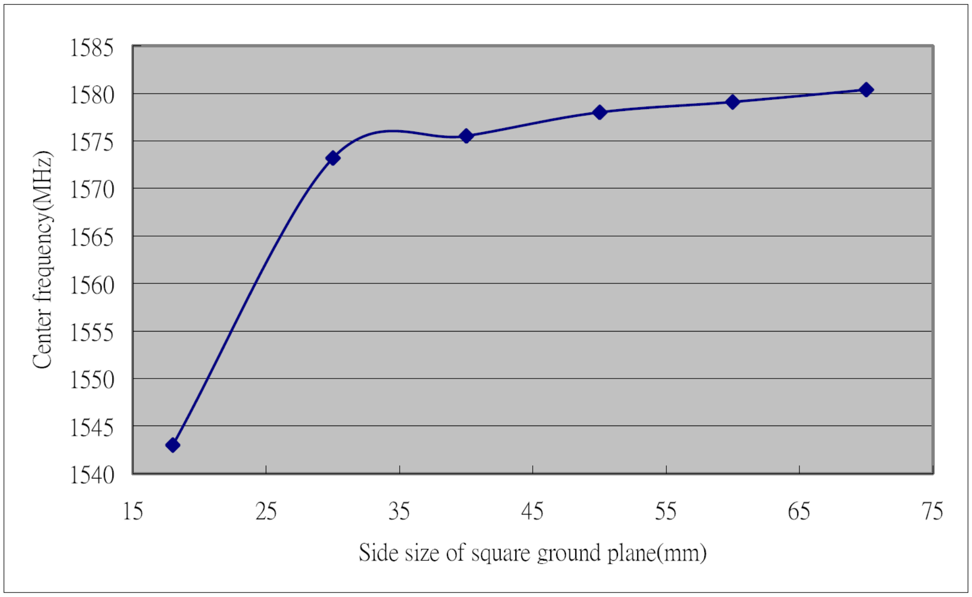


Fig. 1 Centre Frequency shift with Ground-plane size

4. BANDWIDTH

The effective bandwidth of a GPS antenna is usually measured by the frequency band, below -10dB return loss. The bandwidth of a GPS ceramic patch narrows with size of the patch.

Typical bandwidths for GPS patches are as follows

25*25*4 mm	20 MHz
18*18*4 mm	10 Mhz
15*15*4 mm	8 Mhz
12*12*4 mm	7 MHz
10*10*4 mm	5 MHz

Therefore the smaller the antenna, the higher the chance that it will experience frequency shifts in the device, this will cause it to perform very poorly, thus necessitating the antenna bandwidth to be retuned to have the effective bandwidth at the GPS 1.5754 GHz frequency.

5. GAIN

Gain of the antenna is chiefly determined by the directionality of the antenna and the surface area.

A GPS patch antenna has high gain towards the zenith (highest point in the sky), and gradually decreasing gain towards the horizon.
Typical peak gain for GPS patch antennas on standardized ground planes are following.

25mm Patch	5 dBi
18mm Patch	2dBi
15mm Patch	1dBi
12mm Patch	0.5 dBi
10mm Patch	-2 dBi

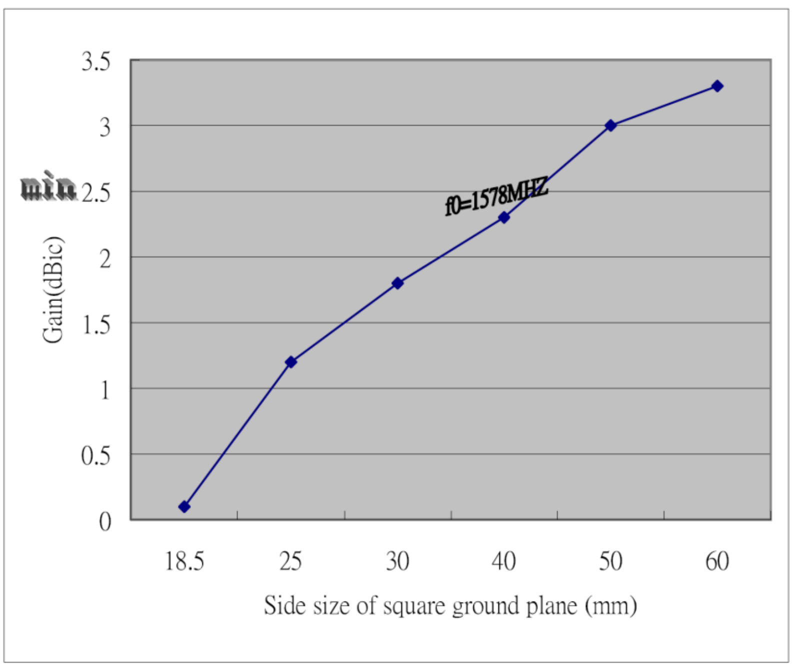


Fig. 2 Gain vs Size of Ground-plane

A larger ground plane will increase the gain of the antenna

6. ADVANTAGES of the GPS Patch

- Maximum gain towards sky – critical for high performance applications
- Suitable for high volume mass production
- Economical
- Small form factor
- Can be optimized by tuning to environment

7. MOUNTING

There are two GPS patch mounting types available.

7.1 PATCH WITH PIN

The standard patch is mounted using double sided tape to the cleared area on the device board. The pin goes through to the bottom side of the board where it is soldered to the feed line.

Fig. 3 Patch with Pin

7.2 SMT MOUNT PATCH

Taoglas also has unique patches that can be surface mounted using reflow soldering directly to pads on the board using normal reflow temperature profiles The patches come in tape and reel for easy pick and place. They have been automotive quality approved at up to 20G vibrations and also pass peak temperatures in reflow process up to 261 degrees Celsius at 41 seconds.

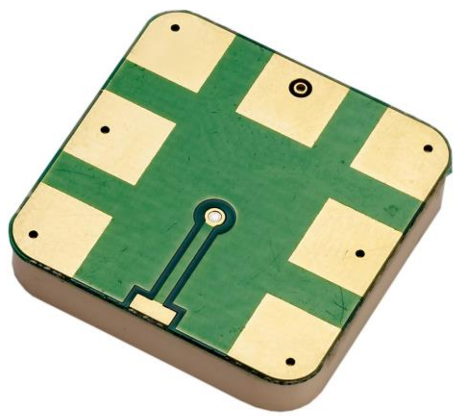


Fig. 4 Patch with Solder Pads for SMT Mount

8. ENVIRONMENTAL CONSIDERATIONS

Close proximity to components or housing affects the electrical performance of all antennas. The centre frequency will shift, and the radiation pattern will be skewed. We call the process by which we try to realign the centre frequency and impedance “tuning”.

When placed on a non-conductive area of the board, ideally there should be clearance of 4~10mm in all directions from the board/housing for maximum efficiency.

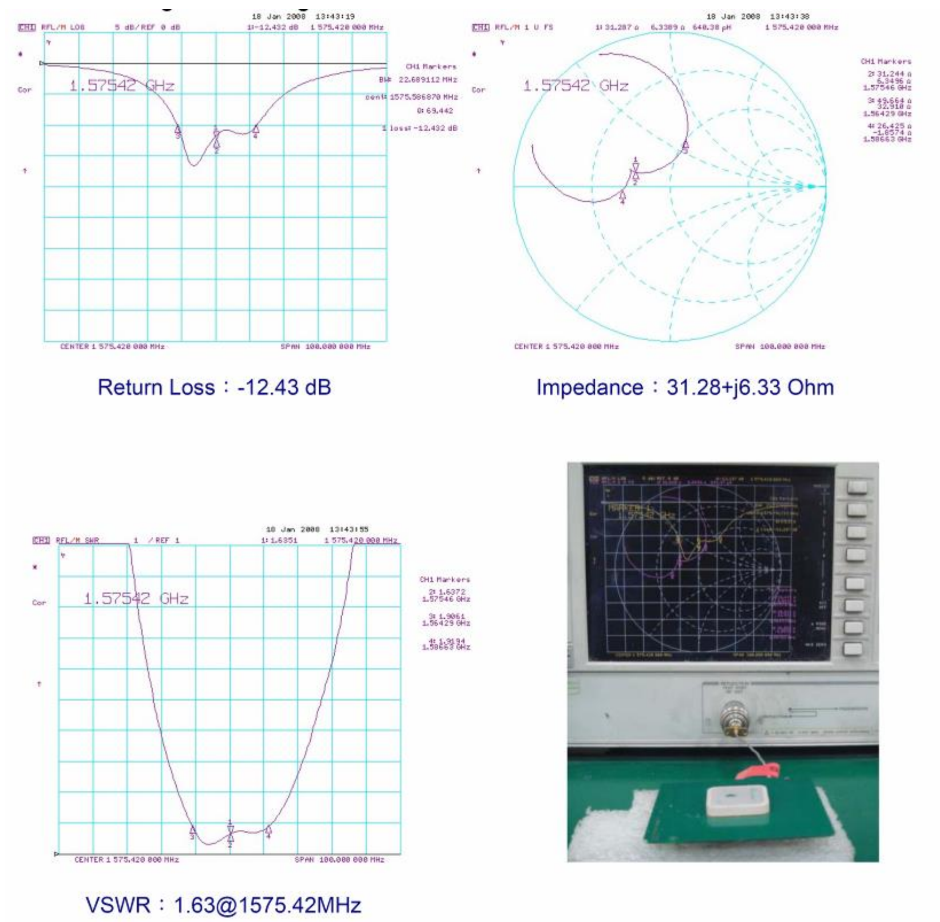
9. TUNING

GPS Patch antennas should be tuned to their ground-plane that they are mounted on and taking into account the frequency shifts due to the specific device environment the antenna finds itself in. This is done with real-life trial and error testing, which is much faster and more accurate than trying to use simulation tools.

9.1 IMPEDENCE MATCHING

The antenna will be tuned to get close to a 50 Ohm match on the Smith Chart when in the device. The S11 return loss magnitude is also looked at and the industry standard is <10dB across the bandwidth.

But it can be more important to check the radiation pattern and gain at in-bandwidth frequencies to understand the real performance of the antenna in the device



The antenna is physically tuned a number of ways, the shape of the top silver electrode can be changed, or the feed-point can be moved.

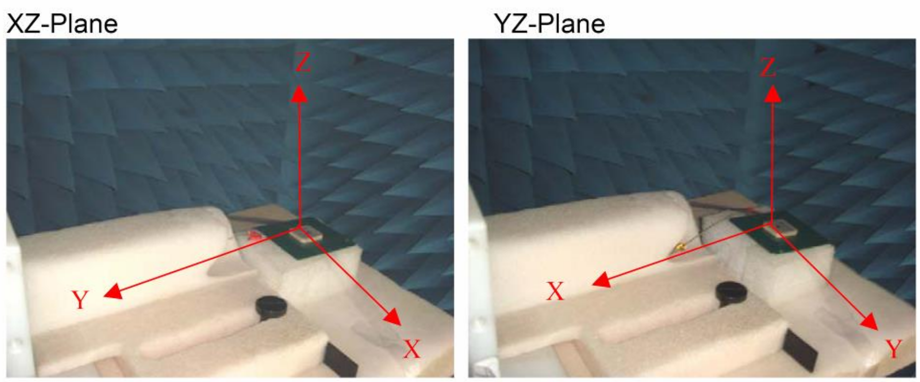
Fig. 6 Example of Tuning change to a GPS Patch

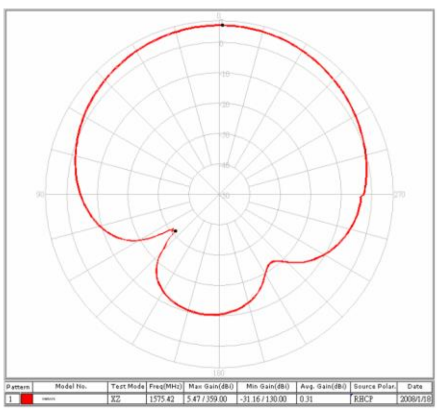
9.2 RADIATION PATTERN AND GAIN TESTING

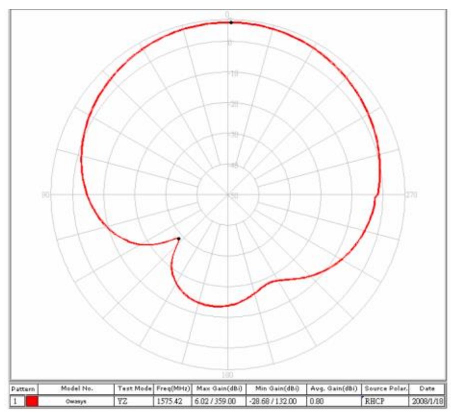
Radiation patterns of the antennas X-Y and Y-Z planes are taken in the device.

This corresponds to two vertical cuts of an “apple” type pattern which is the typical pattern of a GPS patch antenna at cross angles to each other. Where they intersect we can then take their point readings at 0deg/180 deg horizontal to have four points of reference for the horizontal radiation pattern and drawing a line through them we can now produce the horizontal radiation pattern of the radiation thereby giving us a 3D view of the radiation pattern.

These radiation patterns tell us the most important information about the real-life antenna performance in the field such as the antenna’s ability to receive signals from satellites at low altitudes, or to be able to compare relative performance of one antenna against another. The below patterns are taken from scans of a 25mm*25mm*2mm patch on an extended 35mm ground-plane.







XZ Plane1575.42 MHz

YZ Plane 1575.42 MHz