ISSN: 2321-8169
3143 – 3148

# Microstrip Inverted F Antenna for GPS Application

Ms. S.Sridurga Devi, Ms. M. Pradeepa
Assistant Professor/ECE,
V.R.S College of Engineering and Technology, Arasur, Villupuram.
*smartsri84@gmail.com, prathipamohan@gmail.com*

***Abstract -*** A design of compact micro strip inverted F antenna for GPS application is presented. Proposed model is an Inverted-F antenna which receives all the operating frequencies of GPS receiver ranging from 1.176 GHz to 1.575 GHz placed in automobiles. The antenna structure is fabricated, to maintain the axial ratio of 2dB to 3dB and also to achieve circular polarization. FR4- Fiber Glass (Epoxy) is used as Substrate with a Dielectric Constant of 4.4. Copper is used as Radiating Element. The parameters such as Frequency, Return loss, VSWR, Impedance, Radiation pattern and Directivity of the proposed model is simulated by HFSS (High Frequency Structure Simulator) software of Version 13.

*****

## I. INTRODUCTION

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. While originally a military project, GPS is considered a *dual-use* technology, meaning it has significant military and civilian applications.

GPS has become a widely deployed and useful tool for commerce, scientific uses, tracking, and surveillance. GPS's accurate time facilitates everyday activities such as banking, mobile phone operations, and even the control of power grids by allowing well synchronized hand-off switching. A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. In general, GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock .So in total there will be a trade-off between height over ground, Omni-directional reception and reducing spurious emissions influences. Sometimes the polarization of the antenna is of some importance, as some signals are transmitted specially polarized, e.g. SDARS is left hand circular polarized. There are many positions possible to place antennas on a vehicle, but not all are good for each type of car. Some antenna structures are easier to handle even in tight environment and some antenna. Technologies are very fragile in terms of antenna characteristics in tight metallic surroundings.

## II. VARIOUS ANTENNA TECHNOLOGIES

Selecting the appropriate antenna structures helps finding a compromise between antenna position and performance. Antennas can be placed on the vehicle on many places, but only a few positions are ideal. To define which position is ideal, this must be considered for the service and frequency band as well as in conjunction with selected antenna technology. As each transmitter requires a separate frequency in order not to interfere with each other, the dedicated frequency spectrum is quickly used up. Clever frequency allocation and frequency reuse is needed. For VHF and UHF a number of antenna techniques can be used. The cheapest version is using a monopole, but on-glass slot antenna structures offer a very efficient way as well. If the vehicle has a plastic spoiler or a plastic fender/bumper, it can inherit VHF/UHF antennas.

A short overview about the most popular antenna technologies was given.

### *A. Monopole antenna*

Monopole antennas are the most popular antenna type, as they are very easy to handle, easy to manufacture, easy to implement to the vehicle and very cheap. The rod antenna on a roof or fender does not satisfy modern design emotions, so car designers try to avoid simple rod antennas on their cars. Especially for premium car manufacturers, rod antennas are meant to be avoided in modern Car antenna system concepts.

### *B. Patch antenna*

A patch antenna is a flatted monopole. This antenna type is becoming more and more popular in the automotive industry. As this antenna type is unobtrusively flat and can be implemented into the vehicles structure, e.g. behind a fender or bumper or in a plastic trunk cover. Patch Antennas require a large metallic ground structure, preferably flat of minimum 1*λ around the antenna. If the vehicle cannot fulfill this requirement at the position with its surrounding metallic structure, then the patch antenna shall provide its own ground plane in the antenna structure.

### *C. On-glass antenna*

With on-glass antennas it becomes possible to hide a number of antennas for the regular user's eye. As most vehicles have glass windows, an antenna structure can be implemented there. The most straight forward antenna technique for on-glass follows a slot antenna principle. The development of such on-glass antennas can take some time, as car structure and glass window holes in the metallic structure are both parts of the antenna jointly, which influence each other. So changing the shape of the car will change the on-glass antenna characteristics. But once a suitable structure is found, the manufacturing process is very cheap.

### *D. Glued foil antenna*

Similar to slot antennas and patch antennas, these structures can be placed on metallic foil, which is glued to a plastic element. However there are some disadvantages to be mentioned, which are the very narrow usable bandwidth and

 ISSN: 2321-8169
3143 – 3148

the problem to connect coaxial cables to the flat foil antenna. In addition, Moisture and spray water shall be avoided. The connection problem with coaxial cable is often solved by coupling the signal to the structure, but losses must be taken into account.

*E. Fractal antenna*

A very modern field of antenna technology is summarized as fractal antennas. It has been found that not only some structures repeat their resonance with n*λ, but also when repeating the structure in itself. This fractal breakdown of a wire structure or a patch antenna structure leads to multiple resonances of the antenna. When tuning the structure that many frequency ranges can be used, only one antenna could be used to serve most of the required services.

Various models were used with Dipole antenna, folded dipole antenna, H-shaped patch antenna, and annular ring patch antenna to receive frequencies corresponding to GPS application. As the benefit is that only a few antennas need to be placed, which is good for small cars, the disadvantage is the very limited usable bandwidth where the structure resonates.

## III. INVERTED-F ANTENNA FOR AUTOMOBILES

Inverted-F Antennas (IFA) are widely used in a variety of communication systems especially in mobile phone handsets and automobiles due to low profile, light weight, easy integration and easy to manufacture. In recent years, there have been a number of IFA designs describing different configurations to achieve single and multiple bands operation. These are generally designed to operate to include one or more wireless communications bands which may include Global System. Surface mounted antennas in cars, trains, aircrafts, satellite etc., needs to be smaller in size, light weight so that it consumes less fuel. Here substrate used in antenna design plays a vital role in the miniaturization of antennas. This property is exploited using FR-4 substrate.

The Global positioning system (GPS) is the most popular member of global satellite navigation systems (GNSS).The integration of L5 1.176.45 GHz frequency band with L1 (1.575 GHz), L2 (1.227 GHz), L3 (1.381.05 GHz) and L4 (1.379.913 GHz) frequency bands has introduced the multi band GPS operation that will improve the robustness of this service and techniques for high accuracy positioning.

Availability of limited space on GPS receivers is a major challenge for the antenna design. Moreover, embedding multiple antennas in a GNSS receiver to cover all five frequency bands give rise to the problem of mutual coupling that degrades the overall system performance. Design of a single antenna that can cover multiple GNSS bands effectively, efficiently, and simultaneously can ameliorate this problem. Circular polarized (CP) micro strip patch antennas are a popular choice for the GNSS receivers.

The ground plane of IFA is an important factor and can play an important role to enhance the performance of the antenna.

## IV. INVERTERD F ANTENNA PERFORMANCE

The inverted-F antenna appears to be a wire antenna, after some analysis of how this antenna radiates, it is more accurately classified as an aperture antenna. The geometry of inverted-F antenna is shown in Figure 1.

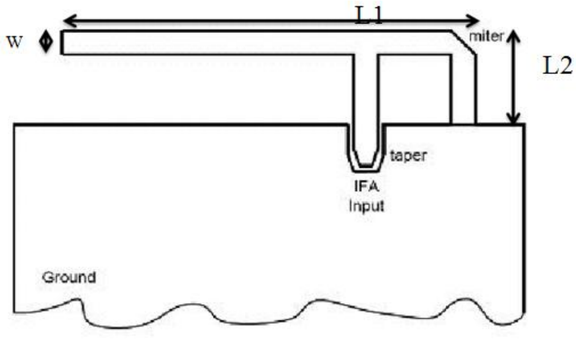


*Figure.1. Geometry of Inverted F Antenna (IFA).*

*A. Analysis of IFA*

The feed is placed from the ground plane to the upper arm of the IFA. The upper arm of the IFA has a length that is roughly a quarter of a wavelength. To the left of the feed (as shown in Figure 1), the upper arm is shorted to the ground plane. The feed is closer to the shorting pin than to the open end of the upper arm. The polarization of this antenna is vertical, and the radiation pattern is roughly donut shaped, with the axis of the donut in the vertical direction. The ground plane should be at least as wide as the IFA length (L), and the ground plane should be at least lambda/4 in height. If the height of the ground plane is smaller, the bandwidth and efficiency will decrease. The height of the IFA (H) should be a small fraction of a wavelength. The radiation properties and impedance are not a strong function of this parameter (H).

In the real part of the impedance for an IFA or slot antenna, note that if the slot antenna was fed at the center of the slot, the impedance would be practically infinite, so that the antenna would not radiate. By moving the feed away from the center for a slot, this also allows the current to decrease from zero, which allows the impedance to drop to a more desirable value. The same is true on the IFA antenna. Hence, the feed location is a critical factor in designing an IFA or slot. A good location for the feed can easily be obtained experimentally during an antenna design.

*B. Antenna Design and Layout*

The structure of proposed single inverted F antenna is depicted in figure 2.This single IFA is designed to achieve the linear polarization with the following parameters

- ,L1 = 33mm
- L2 = 11.24mm
- W = 2.11mm

The total length L1+L2+W of the antenna is equal to the quarter wavelength of IFA which has been used to achieve the circular polarization. The figure 2 shows the designed singleIFA layout.

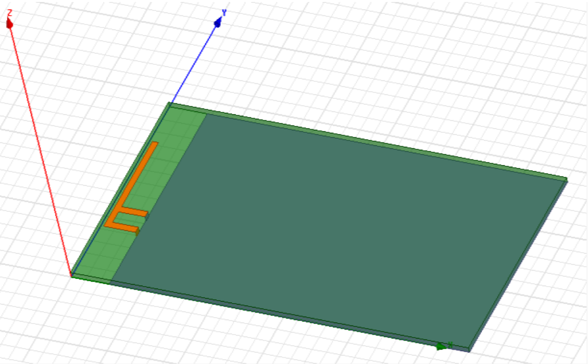

*Figure.2. Designed single IFA Antenna Layout*

To achieve circular polarization in order to receive all the GPS frequencies, an array of inverted F antenna is designed. Hence, another inverted F antenna is placed on the other end of the substrate. Antenna 1 and antenna 2 are placed at each end to avoid mutual coupling between the successive antennas. Antenna is resonated by giving Inserted feed. Crossed dipole antenna is fabricated at the edge of this model so as to achieve circular polarization (RHCP and LHCP) easily. This array antenna is designed using HFSS software package which is shown in figure 3.

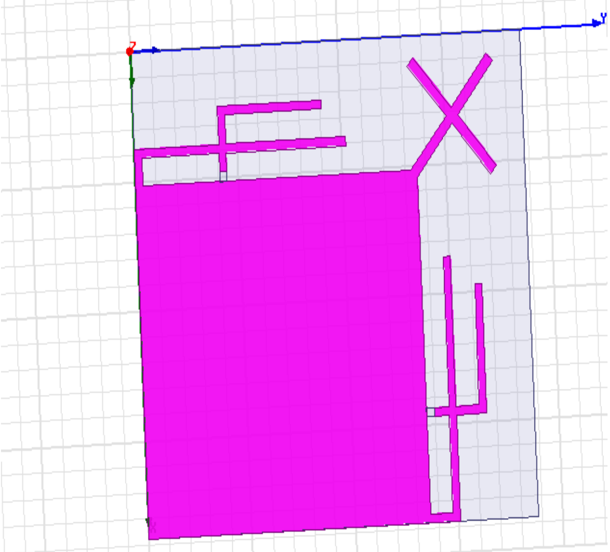

*Figure.3. Designed Antenna array Layout*

## V. RESULTS AND DISCUSSION

The performance of the proposed antenna configuration in terms of good bore sight axial-ratio, VSWR, Directivity and return-loss the HFSS (High Frequency Structure Simulator) is used for simulations in the design. The simulated results for single IFA is shown from the figures 4 to7. The figure 4 shows, that the return loss to be less than -10dB and figure 5 depicts that the antenna maintains the impedance value of 50ohm and further the simulation plot shown in figure 6 results the VSWR value of 1.2dB at the frequency of 1.572 GHz

Since the antenna is placed over the ground plane, the radiation pattern is viewed in the elevation angle such that phi is at 0 degree which is given in figure 7.The figures from 8 to 17 shows the simulated results for the antenna array. The radiation plots shown in figures from 8 to 13 reveals the radiation pattern for all the GPS frequencies ranging from 1.2GHz to 1.& GHz and in these radiation pattern plots, the difference between LHCP and RHCP is more than -20dB at 0 degree. Hence, these plots prove that the designed antenna is capable of achieving circular polarization. From the figure 14, VSWR value antenna 1 and 2 is from 1.2dB to 1.8dB. Impedance plots for antenna1 and antenna 2 are shown in figures 15 and 16 respectively, in which the impedance of 50 ohm is maintained. Axial ratio for all the frequencies are maintained to be 2dB to 3 dB and is shown in figure 17 and so, this plot proves the reception of GPS frequencies by achieving circular polarization.

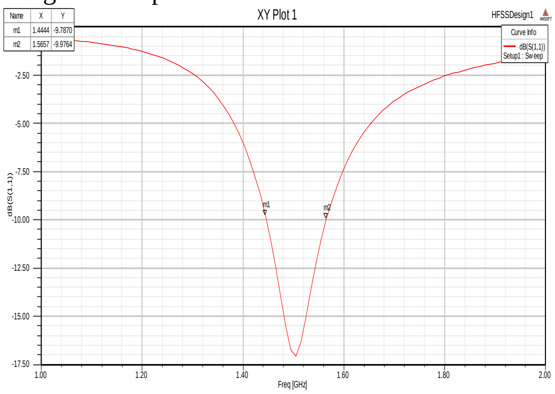


*Figure.4. Frequency Vs return loss*

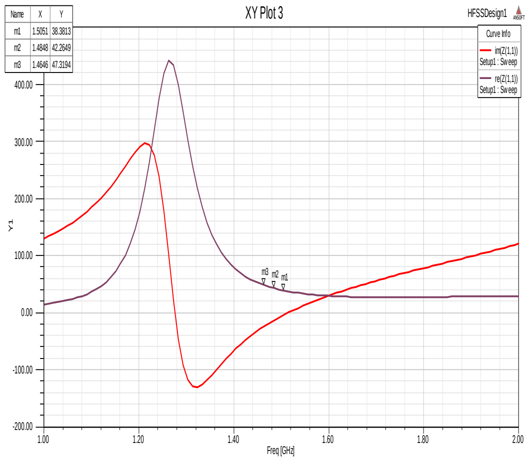


*Figure.5. Impedance Plot*

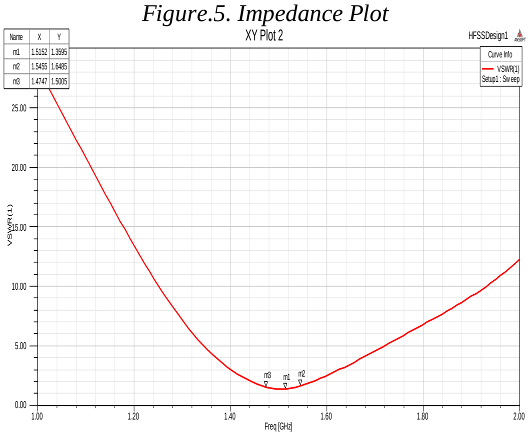


*Figure.6. Frequency Vs VSWR*

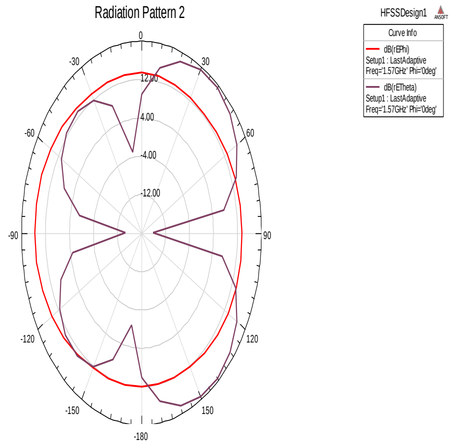


*Figure.7. Radiation pattern in terms of phi and theta angles*

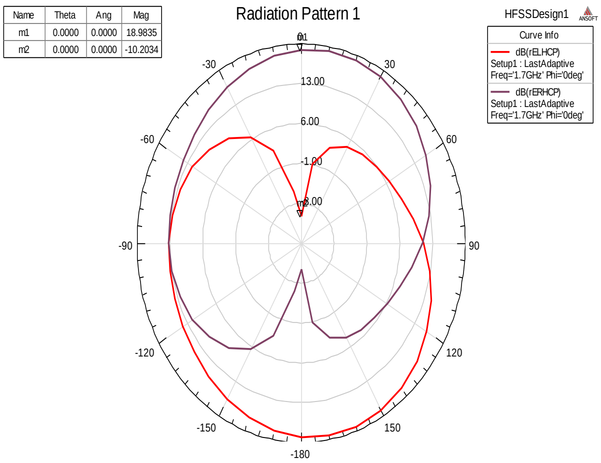


*Figure.8. Radiation pattern at 1.7GHz*

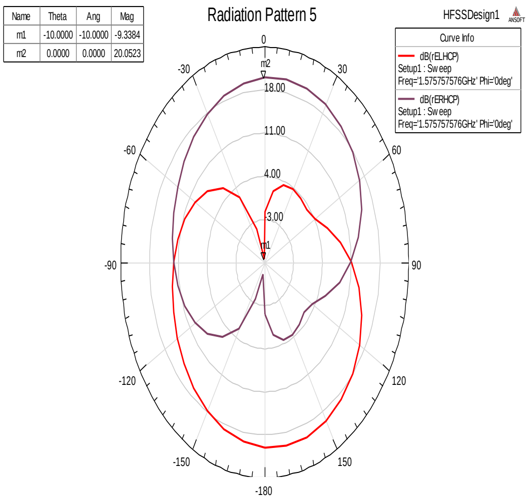


*Figure.9. Radiation pattern at 1.57GHz*

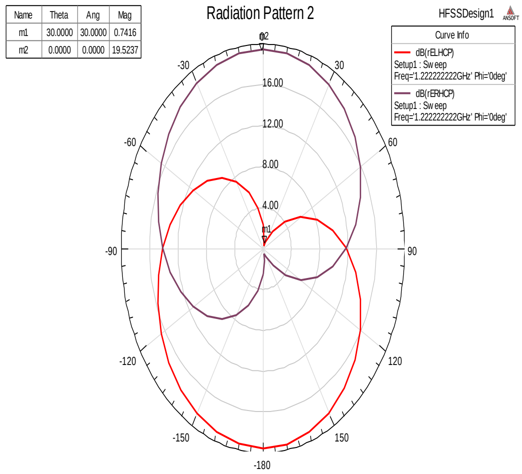


*Figure.10. Radiation pattern at 1.57GHz*

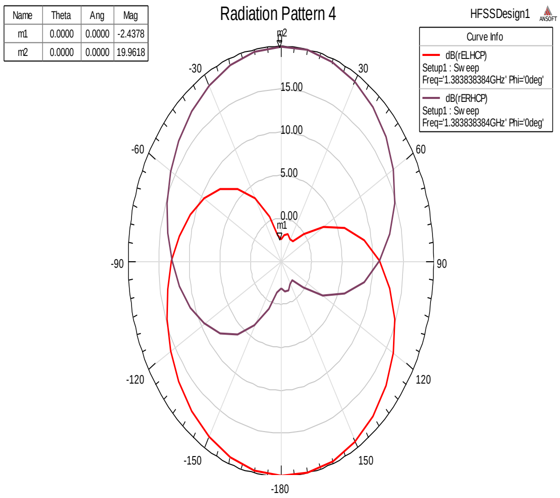


*Figure.11. Radiation pattern at 1.38GHz*

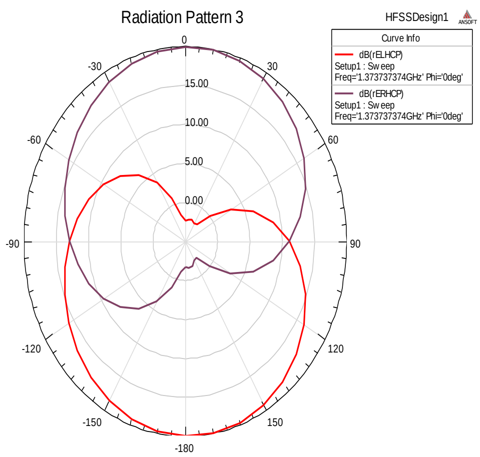


*Figure.12. Radiation pattern at 1.37GHz*

ISSN: 2321-8169
3143 – 3148

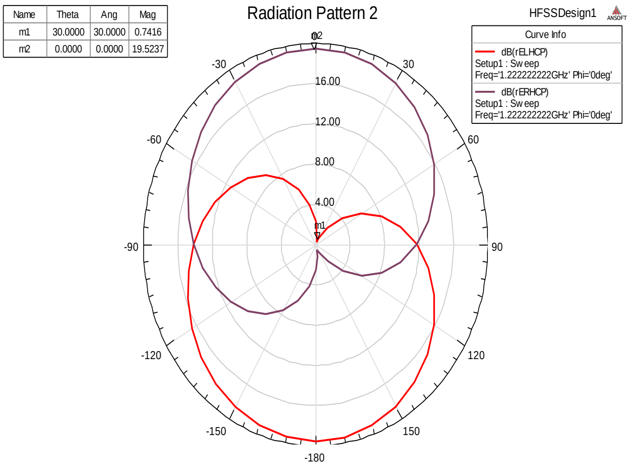


*Figure.13. Radiation pattern at 1.22GHz*

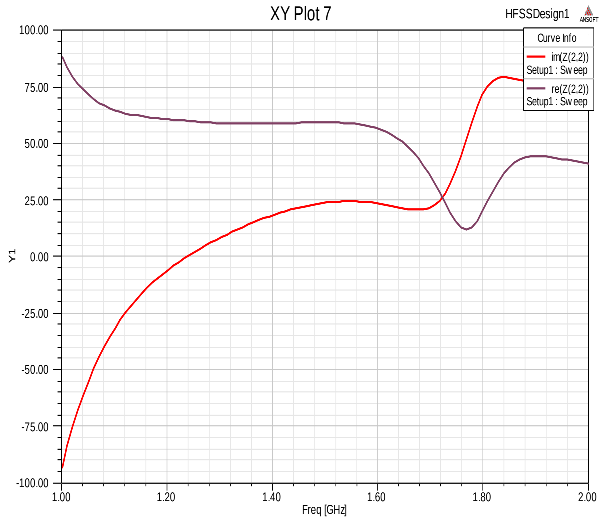


*Figure.16. Impedance plot for Antenna 2*

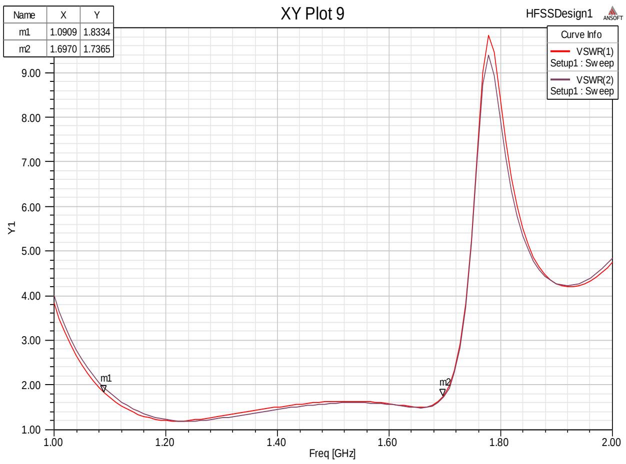


*Figure.14. VSWR plot for Antenna 1 and Antenna 2*

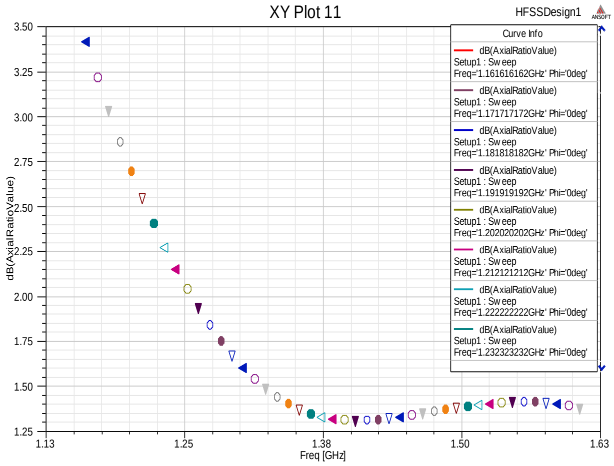


*Figure.17. Axial ratio plot for all frequencies*

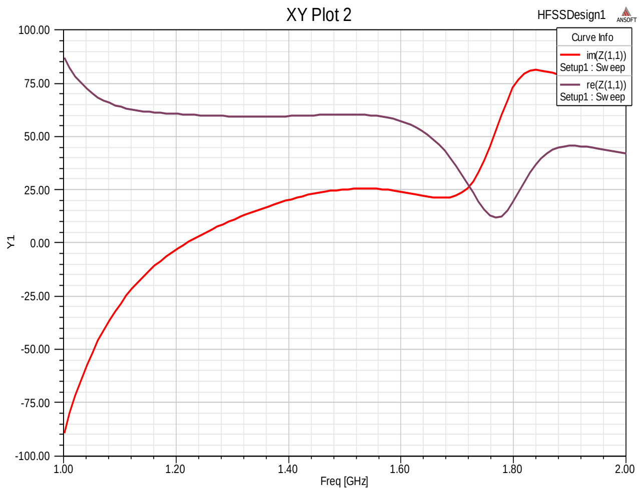


*Figure.15. Impedance plot for Antenna 1*

## VI. CONCLUSION

The array of Micro strip inverted F antenna to achieve circular polarization is designed by the software package HFSS of version 13 for GPS reception has been presented. The simulated data of Frequency, Return loss, VSWR, Radiation pattern Impedance, Directivity and axial ratio for single Inverted F antenna and also for antenna array are shown. The simulated results depicts that the antenna array is suitable for the reception of all the frequency levels in GHz for GPS application.

## REFERENCES

[1] Amaut Dierck, Hendrik Rogier and Frederick Declercq, “A Wearable Active Antenna for Global Positioning System and Satellite Phone,” IEEE Transactions on antennas and propagation, vol.61, no. 2, pp532-538, 2013.

[2] G.Z.Rafi, M.Mohajer, A.Mlarjy, P. Mousavi and Safavi-Naeini “Low-profile integrated micro strip Antenna for GPS-DSRC application,” IEEE Antennas Wireless Propag, Lett., vol. 8, pp.44- 48, 2009

ISSN: 2321-8169
3143 – 3148

[3] Shun-Lai Ma and Jeen-Sheen Row, "Design of Single-Feed Dual-Frequency Patch Antenna for GPS and WLAN applications", IEEE Transactions on antennas and propagation, vol. 59, no. 29, pp. 3433-3436, 2011.
[4] [4] Francesco Mariottini, Matteo Albani, Enrico Toniolo, Davide Amatori and Stefano Maci, "Design of a Compact GPS and SDARS Integrated Antenna for Automotive Applications," IEEETransactions on antennas And propagation, vol. 9, no. 29, pp 405-408, 2010.
[5] C. L. Mak, K. M. Luk, K. F. Lee, and Y. L. Chow, "Experimental studyof a microstrip patch antenna with an L-shaped probe," IEEE Transactions on Antennas and Propagation., vol. 48, pp. 777–783, May 2000.
[6] K.P. Yang and K. L. Wong, "Dual-band circularly-polarized square microstrip antenna," IEEE Trans. A Antennas Propag., vol. 49, no. 3, pp. 377–382, 2001
[7] J. James and P. Hall, "Handbook of microstrip antennas," IEE Electron.Waves Series, vol. 28, 1988
[8] www.antennatheory.com