CIRCULARLY POLARIZED MONOPOLE MOBILE PHONE ANTENNA FOR GNSS APPLICATIONS

R.Meenakshi[1], G.Premalatha[2]

[1]*M.E Student, Department of Communication Systems*
[2]*Associate Professor, Department of Electronics and Communication Engineering*
Prathyusha Engineering College

Abstract - *Circular Polarization is a method in which the electric field of the passing wave does not change the strength but only changes direction in a rotary manner. Circular polarization may be referred to as right-handed or left-handed, and clockwise or anti-clockwise, depending on the direction in which the electric field vector rotates. Circular polarization is often used erroneously to describe mixed polarity signals used mostly in where a vertical and a horizontal component are propagated simultaneously by a single or a combined array. This has the effect of producing greater penetration into buildings and difficult reception areas than a signal with just one plane of polarization. A Mobile Phone Antenna and Wireless Modem Antennas also known as cellular antenna has higher dB rating and produces more signal strength. These categories contain GSM antennas, 2G antennas, 3G antennas, 4G antennas and wireless modem antennas (wireless internet antennas or mobile broadband antennas for most applications. The third category contains a range of MIMO antennas which are designed specifically for 4G devices with two antenna ports and suit all carriers that offer a 4G service. MIMO antennas should be used where optimum 4G performance is required.*

The proposed Antenna generates a resonant frequency which provides a wide band. It also includes a strip with a tuning stub is matched in order to provide bandwidth which covers several applications such as GNSS, GLONASS, COMPASS etc

Key Words: Circular Polarization, Monopole Antenna, GNSS, GLONASS, COMPASS

1. INTRODUCTION

A mobile phone is a telephone that can make and receive calls over a radio frequency carrier while the user is moving within a telephone service area. The radio frequency link establishes a connection to the switching systems of a mobile phone operator, which provides access to the public switched telephone network (PSTN). Modern mobile telephone service uses a cellular network architecture, and therefore mobile telephones are often also called cellular telephones, or cell phones. In addition to telephony, modern mobile phones support a variety of other services, such as text messaging, MMS, email, Internet access, short-range wireless communications (infrared, Bluetooth), business applications, gaming, and photography. Mobile phones which offer these and more general computing capabilities are referred to as smart phones. Mobile phones are commonly used to collect location data. While the phone is turned on, the geographical location of a mobile phone can be determined easily (whether it is being used or not) using a technique known as multi lateration to calculate the differences in time for a signal to travel from the mobile phone to each of several cell towers near the owner of the phone. The movements of a mobile phone user can be tracked by their service provider and, if desired, by law enforcement agencies and their governments. Both the SIM card and the handset can be tracked. A major goal of personal communications networks and services is to provide seamless, ubiquitous wireless communications to the user. For the last several years, several providers have pushed to develop and deploy low-earth orbit satellite constellations which are intended to play a major role in providing this desired world-wide coverage [2].

1.1 MICROSTRIP PATCH ANTENNA

The patch antenna consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. The two metal sheets together form a resonant piece of Microstrip transmission line with a length of approximately one-half wavelength of the radio waves. The radiation mechanism arises from discontinuities at each truncated edge of the Microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of Microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used. One of the most important steps toward the realization of antennas is the determination of amplitude and phase of excitated current on patch antenna. In comparison with other antenna designs the Microstrip antenna analysis is complicated due to the presence of the dielectric in homogeneity, narrow band electrical characteristics and a wide variety of patch and substrate configurations. Microstrip models which account for the dielectric substrate in a rigorous manner are referred to as full wave solutions.

1.2 PATCH ANTENNA

A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common micro strip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. The patch area of the corner truncated driven patch is marginally smaller than that of a parasitic patch to achieve improved performance [3]. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency. A single patch antenna provides a maximum directive gain of around 6-9 dBi. It is relatively easy to print an array of patches on a single (large) substrate using lithographic techniques. Patch arrays can provide much higher gains than a single patch at little additional cost; matching and phase adjustment can be performed with printed micro strip feed structures, again in the same operations that form the radiating patches. The ability to create high gain arrays in a low-profile antenna is one reason that patch arrays are common on airplanes and in other military applications.

Such an array of patch antennas is an easy way to make a phased array of antennas with dynamic beam forming ability. An advantage inherent to patch antennas is the ability to have polarization diversity. Patch antennas can easily be designed to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations, using multiple feed points, or a single feed point with asymmetric patch structures. Wideband CP is obtained by truncating one of the corners of the antenna element. This arrangement introduces orthogonal components with quadrature phase difference to excite circularly polarized wave [4]. This unique property allows patch antennas to be used in many types of communications links that may have varied requirements.

The most commonly employed micro strip antenna is a rectangular patch which looks like a truncated micro strip transmission line. It is approximately of one-half wavelength long. When air is used as the dielectric substrate, the length of the rectangular micro strip antenna is approximately one-half of a free-space wavelength. The CP bandwidth can be significantly enhanced by implanting a pair of inverted-L grounded strips into the slot and adjusting the dimensions of the lightening-shaped feed line, whereas the impedance bandwidth can be greatly enlarged through tuning embedded vertical and horizontal stubs [1]. As the antenna is loaded with a dielectric as its substrate, the length of the antenna decreases as the relative dielectric constant of the substrate increases. The resonant length of the antenna is slightly shorter because of the extended electric "fringing fields" which increase the electrical length of the antenna slightly. An early model of the micro strip antenna is a section of micro strip transmission line with equivalent loads on either end to represent the radiation loss.

2. ADVANCED DESIGN SYSTEM

Advanced Design System (ADS) is an electronic design automation software system produced by Agilent EEs of EDA, a unit of Agilent Technologies. It provides an integrated design environment to designers of RF electronic products such as mobile phones, pagers, wireless networks, satellite communications, radar systems and high speed data links. Agilent ADS supports every step of the design process-Schematic capture, layout, frequency-domain and time-domain circuit simulation and electromagnetic field simulation allowing the engineer to fully characterize and optimize an RF design without changing tools. Agilent EEs of has donated copies of the ADS software to the electrical engineering departments at many universities and a large percentage of new graduates are experienced in its use. As a result the system has found wide acceptance in industry.

An ADS is a sophisticated circuit simulator and can take a significant amount of time to learn all the complex features. ADS can run on a variety of operating systems. The current version runs on a UNIX machine and Windows XP.

Momentum is a part of Advanced Design System and gives us the simulation tools. We need to evaluate and design modern communication system products. Momentum is an electromagnetic simulator that computes S-parameters for general planar circuits including Microstrip, slot line, strip line, coplanar waveguide and other topologies. Vias and air bridges connect topologies between layers, so we can simulate Multi layer RF/Microwave printed circuit boards, hybrids, Multichip modules and integrated circuits. Momentum gives us a complete tool to predict the performance of high frequency circuit boards, antennas and ICs. Momentum optimization extends Momentum capability to a true design automation tool. The momentum optimization process varies geometry automatically to help us achieve the optimal structure that meets the circuit or device performance goals. Momentum visualization is an option that gives users a 3D perspective of simulation results, enabling to view and animate current flow in conductors and slots, and view both 2D and 3D representations of far-field radiation patterns. It also includes a electromagnetic simulator based on the method of moments. Adaptive frequency sampling for fast, accurate, simulation results. Comprehensive data display tools for viewing results. Equation and Expression Capability for performing calculations on simulated data. Full integration in ADS circuit simulation environment allowing EM/circuit simulation.

All satellites broadcast at the same two frequencies, 1.57542 GHz (L1 signal) and 1.2276 GHz (L2 signal). The satellite network uses a CDMA spread-spectrum technique where the low-bit rate message data is encoded with a high-rate pseudo-random (PRN) sequence that is different for each satellite. The receiver must be aware of the PRN codes for each satellite to reconstruct the actual message data. The C/A code, for civilian use, transmits data at 1.023 million chips per second, whereas the P code, for U.S. military use, transmits at 10.23 million chips per second. The actual internal reference of the satellites is 10.22999999543 MHz to compensate for relativistic effects that make observers on the Earth perceive a different time reference with respect to the transmitters in orbit. The L1 carrier is modulated by both the C/A and P codes, while the L2 carrier is only modulated by the P code. The P code can be encrypted as a so-called P(Y) code that is only available to military equipment with a proper decryption key. Both the C/A and P(Y) codes impart the precise time-of-day to the user.

The L3 signal at a frequency of 1.38105 GHz is used to transmit data from the satellites to ground stations. This data is used by the United States Nuclear Detonation (NUDET) Detection System (USNDS) to detect, locate, and report nuclear detonations (NUDETs) in the Earth's atmosphere and near space. One usage is the enforcement of nuclear test ban treaties.

The L4 band at 1.379913 GHz is being studied for additional ionosphere correction. The L5 frequency band at 1.17645 GHz was added in the process of GPS modernization. This frequency falls into an internationally protected range for aeronautical navigation, promising little or no interference under all circumstances. The first Block IIF satellite that provides this signal was launched in 2010. The L5 consists of two carrier components that are in phase quadrature with each other. Each carrier component is bi-phase shift key (BPSK) modulated by a separate bit train. "L5, the third civil GPS signal, will eventually support safety-of-life applications for aviation and provide improved availability and accuracy." Slot antenna for GPS receiver is designed to operate in both the L1 and L2 bands of the Global Positioning System (GPS)[5].

A conditional waiver has recently been granted to Light Squared to operate a terrestrial broadband service near the L1 band. Although Light Squared had applied for a license to operate in the 1525 to 1559 band as early as 2003 and it was put out for public comment, the FCC asked Light Squared to form a study group with the GPS community to test GPS receivers and identify issue that might arise due to the larger signal power from the Light Squared terrestrial network.

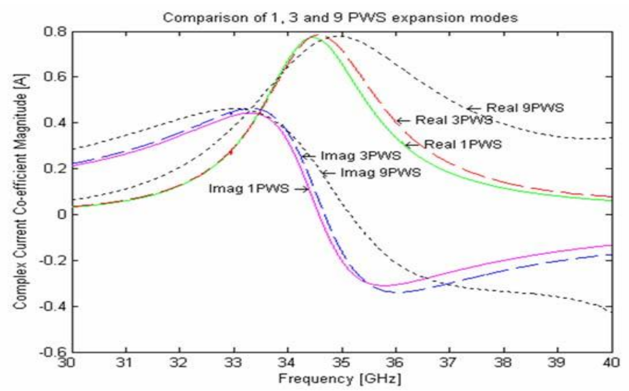
Band	Frequency	Description
L1	1575.42 MHz	Coarse-acquisition (C/A) and encrypted precision (P(Y)) codes, plus the L1 civilian (L1C) and military (M) codes on future Block III satellites.
L2	1227.60 MHz	P(Y) code, plus the L2C and military codes on the Block IIR-M and newer satellites.
L3	1381.05 MHz	Used for nuclear detonation (NUDET) detection.
L4	1379.913 MHz	Being studied for additional ionospheric correction
L5	1176.45 MHz	Proposed for use as a civilian safety-of-life (SoL) signal.

Table -1: Detailed Frequency Parameter Ranges

One of the most important steps toward the realization of antennas is the determination of amplitude and phase of excitated current on patch antenna. In comparison with other antenna designs the Microstrip antenna analysis is complicated due to the presence of the dielectric in homogeneity, narrow band electrical characteristics and a wide variety of patch and substrate configurations. Microstrip models which account for the dielectric substrate in a rigorous manner are referred to as full wave solutions. These models use exact Green's function in a Moment Of Method (MoM) solution for the dielectric substrate, which allows including in the mathematical model space wave radiations, surface wave modes, dielectric loss and coupling to external elements. MoM analysis is a very well known technique for accurate calculations of antenna parameters. It can be used to calculate all the necessary antenna parameters under consideration.

The MOM analysis for single patch antenna is carried out at Ka-band (35 GHz) for PWS expansion modes. Figure shows the comparison of 1, 3 and 9 PWS modes. The resonance frequency was found to be f_r = 34.583 GHz, 34.683 GHz and 35.155 GHz. The length of the patch was varied in order to see the phase shift created at the resonance frequency by changing the width of the rectangular patch.

Chart -1: Variance of complex current co-efficient



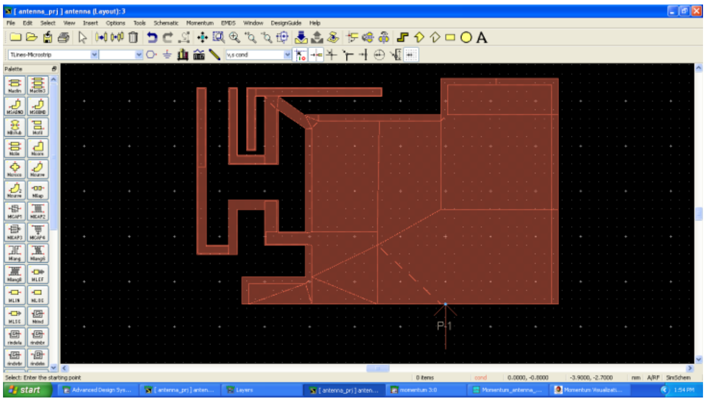


Fig -1: **Patch Shape**

The simulation process combines the green function that were calculated for the substrate of a circuit, plus Mesh information that was calculated for the circuit, and solves the currents in circuit. Using these calculations, S-parameters are then calculated for the circuit. A substrate definition must be specified for the circuit. The circuit must include at least one port. A Mesh must be defined for the circuit. A Simulation frequency plan must be specified. The Momentum Planar solver uses information from the substrate database and the Mesh generator to perform the circuit simulation. The substrate calculations and Mesh may be computed prior to running the simulation to ensure they are valid. This will reduce simulation time. The steps include Specifying and editing frequency plans, selecting a process mode, Specifying solution files, electing to view data.

3. CONCLUSIONS

Cell phone antennas are often linearly polarized, so rotating the phone can often match the polarization of the phone and thus increase reception. Circular polarization is a desirable characteristic for many antennas. Two antennas that are both circularly polarized do not suffer signal loss due to polarization mismatch. Antennas used in GPS systems are Right Hand Circularly Polarized. Circular polarization is really two orthongal linear polarized waves 90 degrees out of phase. Hence, a linearly polarized (LP) antenna will simply pick up the in-phase component of the circularly polarized (CP) wave.

REFERENCES

[1] J. Y. Sze, C. I. Hsu, Z. W. Chen, and C. C. Chang, “Broadband CPW-fed circularly polarized square slot antenna with lightening- shaped feed line and inverted-L grounded strips,” IEEE Trans. Antennas Propag., vol. 58, no. 3, pp. 973–977, Mar. 2010.

[2] M. A. Jensen, “Alternative antenna polarization schemes for satellite handset links include operator tissue,” in Proc. Antennas Propag.Soc. Int. Sym. Digest, Jul. 13–18, 1997, vol. 2, pp. 1336–1339.

[3] S. Shekhawat, P. Sekra, D. Bhatnagar, V. K. Saxena, and J. Saini, “Stacked arrangement of rectangular Microstrip patches for circularly polarized broadband performance,” IEEE Antennas Wireless Propag. Lett, vol. 9, pp. 910–913, Sep. 2010.

[4] S. L. S. Yang, A. A. Kishk, and K. F. Lee, “Wideband circularly polarized antenna with L-shaped slot,” IEEE Trans. Antennas Propag., vol. 56, no. 6, pp. 1780–1783, Jun. 2008.

[5] Wang-Ta Hsieh, Tze-Hsuan Chang, and Jean-Fu Kiang, “Dual-Band Circularly Polarized Cavity-Backed Annular Slot Antenna for GPS Receiver,”IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 60, NO. 4, APRIL 2012.