Design of a ME Dipole Antenna in Planar Configuration using CRLH-TL implementation

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Abstract - **In recent years, dual polarized antenna plays a crucial role in antenna designs. Its attractive features such as high gain, wider bandwidth is responsible for creating a ME dipole antenna. Thus, the objective is to design a planar Magneto-Electric (ME) dipole antenna which is the combination of magnetic and electric dipoles, based on the composite right/left handed transmission lines (CRLH). The magneto-electric dipole antenna is excited by single differential feed and therefore it acts as a travelling wave antenna that enables the formation of Omni directional radiation pattern. This merged structure of dipole antenna has attracted considerable attention due to increased demand for multi functionality and switchable characteristics including wide bandwidth, low cross polarization and reduced side lobes and back lobes radiation, nearly the same E-plane and H-plane patterns, constant radiation pattern and steady antenna gain over the operating frequency range. The proposed ME dipole antenna based on CRLH-TL gain is analyzed at different frequencies using FEKO simulator.**

Keywords: **Magneto-Electric (ME) dipole, Composite right/left handed (CRLH) transmission line, Antenna radiation pattern, Theta gain and Phi gain.**

I. INTRODUCTION

An antenna is as an electrical device that converts electric currents into radio waves and vice versa and therefore antenna performs as a transducer. It is required by any radio receiver or transmitter to combine its electrical connection to the electromagnetic field. Radio waves are EM waves which carry signals through the air (or through space) at the instant of light with almost absence of transmission loss. An antenna consists of metallic conductor which is electrically connected to the radio source or receiver. It is employed in wide variety of application such as Wireless Fidelity (Wi-Fi), satellite and communication link and other remote controlled appliance such as garage door openers, remote sensors etc. Antennas are characterized by a number of performance measures which a user would be concerned with in selecting or designing an antenna for a particular application. Antenna are characterized by basic fundamental properties such as radiation pattern, gain, directivity, bandwidth, beam width, polarization etc. The radiation pattern is the graphical representation of radiation properties of antenna. Gain is defined as the ratio of radiation intensity in the direction to the average radiated power where the radiation intensity is average power radiated per unit solid angle. Bandwidth is the range of frequencies over which the antenna maintains required characteristics to the specified value and beam width is the measure of directivity of antenna. Directivity is defined as the ratio of maximum radiation intensity to average radiation intensity. The Polarization is the curve traced by instantaneous electric field radiated by antenna in a plane perpendicular to the radial direction.

There are many types of antenna such as wire antenna, patch antenna, travelling wave antenna etc, which is used in wide variety of applications. A wire antenna is a radio antenna consisting of a long wire suspended above the ground, whose length does not tolerate a relation to the wavelength of the radio waves used. The wire may be straight or it may be strung back and forth between trees or walls just to get enough wire into the air. The wire antennas are the dipole and monopole antenna. A dipole antenna is a radio antenna that can be made of a simple wire, consists of two metal conductors of rod or wire placed linearly with a small space between them. The voltage is applied to the antenna at the center, between the two conductors. The dipole antennas are the simplest and widely used practical antenna. The dipole antennas are the resonating antenna in which the radio waves bounce back and forth between their ends. There are two types of dipole antenna. Magnetic dipole antenna is a type of dipole antenna which is capable of radiating an electromagnetic wave in response to a circulation of electric current in the loop. It acts as a loop antenna. Electric dipole antenna is a pair of opposite electric charges which is separated by a small magnitude. The Magneto-Electric (ME) dipole antenna is a combination of two radiators (Magnetic and Electric dipole) which attracted considerable attention due to its versatility.

A monopole antenna is a class of radio antenna consisting of a straight rod shaped conductor, often mounted perpendicularly over some type of conductive surface called a ground plane. The driving signal from the transmitter is applied, or for receiving antennas, the output voltage is taken, between the lower ends of the monopole antenna the ground plane. One side of the antenna feed line is attached to the lower end of the monopole and the other side is attached to the ground plane, which is often the earth. Another type of antenna is a micro strip patch antenna. A patch antenna is a narrowband, wire-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. Some patch antennas do not use a dielectric substrate and instead made of a metal patch mounted above a ground plane using insulating spacers. The resulting structure is less rugged but has a wider bandwidth.

II. DESIGN OF ME DIPOLE ANTENNA

This paper presents the objective to design a dual polarized antenna that exhibits stable gain and wider bandwidth. The Magneto-Electric dipole antenna is a dual polarized antenna which possesses high gain, directivity and stabilized radiation. The combination of the two elementary types of radiators, namely, magnetic and electric dipoles, into a Magneto Electric (ME) antenna is called Magneto Electric dipole antenna. This may offer enhanced performance and functionalities. The concept of collocated magnetic and electric dipole radiators has recently attracted considerable attention due to the increased demand for multi functionality and switchable characteristics in modern communication systems. Applications include anti collisions systems for vehicular transport; multiple input multiple output systems for high speed communications and enhanced polarization diversity MIMO systems. The ME antenna produce an identical E-plane and H- plane radiation patterns which are obtained by exciting simultaneously electric dipole and a magnetic dipole.

The Proposed Magneto-Electric dipole antenna based on CRLH-TL is analyzed at different frequencies using FEKO simulator. FEKO is an electromagnetic tool is used for various applications to solve all electromagnetic related problems. This can be used for antenna analysis, waveguide, micro strip, aerospace, automotive, naval, antenna placement, antenna synthesis, bio-electromagnetic etc. The FEKO solution employs the Method of Moments (MoM) which makes FEKO ideally suited to the analysis of typical Electromagnetic Compatibility antennas. The ME dipole antenna is designed by setting a ground plane of dielectric substrate and is obtained by creating two ellipse of different radius (say, 7mm and 6.5mm) and subtract the two ellipse to obtain the loop, excited by using a current source that acts as a magnetic dipole and electric dipole is obtained by creating a normal dipole which is placed within the loop in same radial direction as that of magnetic dipole, excited using voltage source.

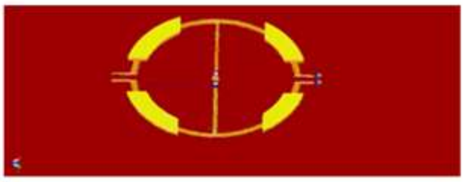

Fig 1 Planar ME dipole antenna based on CRLH-TL implementation

Fig 1 shows a planar ME dipole antenna based on the CRLH-TL implementation. If a second differential port, of impedance $Z_0 \neq 0$ is placed at the other side of the loop, the structure transforms from a resonant type to a travelling wave type antenna. The proposed antenna based on the CRLH-TL is obtained same as the collocated ME dipoles with separate feed but the rectangles are added at four quarters of the loop and subtract the region from the rectangle. Again the rectangle is then added to the subtracted loop and union the region which forms the bottom signal layer. The top signal layer is then created same as that of bottom layer at a height of about 0.127mm. Thus the proposed structure acts as a parallel plate capacitor.

III. SIMULATION PERFORMANCE

The Magneto-Electric dipole antenna based on the CRLH-TL radiation pattern is shown Figure 2. It is designed by using substrate FR-4. The Composite right/left handed implementation of the ME dipole operating in the balanced condition and radiating into the half space above the ground plane. The implementation of CRLH-TL is the metal-insulator-metal (MIM). It is designed in the form of parallel plate capacitor which consists of two metals with dielectric space in middle.

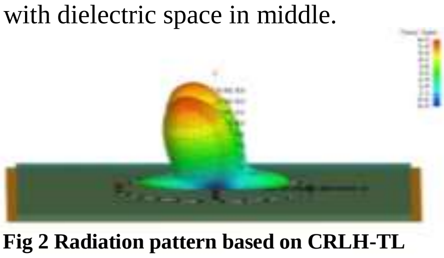

Fig 2 Radiation pattern based on CRLH-TL

The radiation pattern for the composite right/left handed implementation of the ME dipole operating in the balanced condition and radiating into the half space above the ground plane is shown in Figure 2 with the gain of about 6dB and it acts as parallel plate capacitor with dielectric space in the middle. The gain of the magnetic loop dipole is small but it can be theoretically improved by increasing the size of the loop while maintaining the current along the loop constant. It consists of ground plane and two layers (top signal and bottom signal layer) with dielectric air space in between. This prototype consists of substrate with ε_r = 2.42 and tan δ=0.02 as thickness.

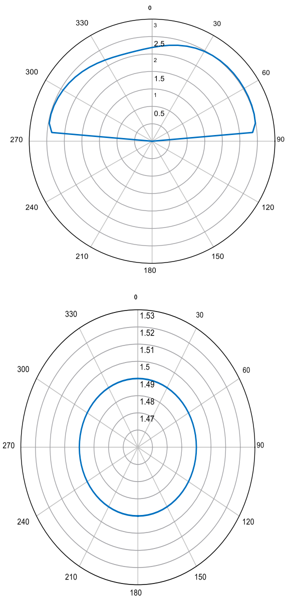

Fig 2.a Theta gain and Phi gain at the frequency of 14GHz

The theta gain for CRLH-TL implementation is shown in the Fig 6.a at the frequency of about 14GHz with the gain is about 2.5dB. Fig 2.a shows the Phi gain of about 1.48dB for CRLH-TL implementation at the frequency of about 14GHz.

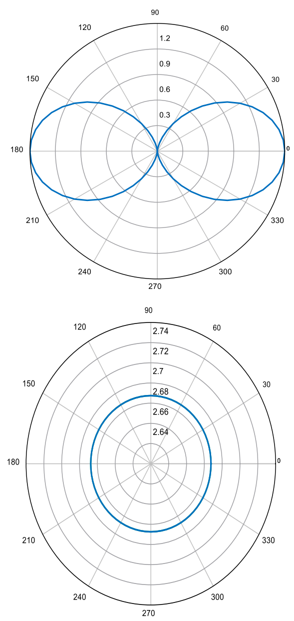

Fig 2.b Theta gain and Phi gain at the frequency of 14.25GHz

The theta gain for ME dipole antenna based on the CRLH-TL implementation at the frequency of about 14.25GHz with the gain of about 1.5dB is shown in the Figure 6.b. The phi gain for ME dipole antenna based on the CRLH-TL implementation at the frequency of about 14.25GHz with the gain of about 2.5dB is shown in the Figure 2.b.

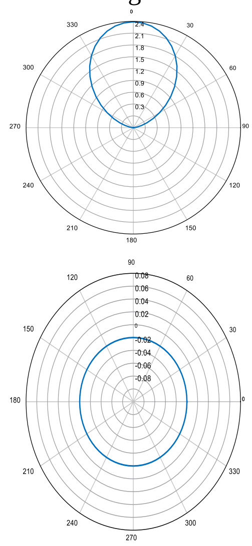

Fig 2.c Theta gain and Phi gain at the frequency of 15GHz

The theta gain for ME dipole antenna based on the CRLH-TL implementation at the frequency of about 15GHz with the gain of about 2.5dB is shown in the Figure 6.c. The phi gain for ME dipole antenna based on the CRLH-TL implementation at the frequency of about 15GHz with the gain of about -0.5dB is shown in the Figure 2.c.

IV. CONCLUSION

The planar ME-dipole antenna based on the CRLH-TL transmission line has been proposed. The series elements of the CRLH transmission lines form the M-dipoles and shunt elements form the E-dipoles. The CRLH transmission line is in the balanced condition which has been exploited in order to form high gain magnetic radiators in conjunction with conventional electric radiators which are excited simultaneously using a single differential feed. The Magneto-Electric dipole antenna is twin polarized antenna which is used to achieve high peak M-dipole gain without side lobes. The CRLH-TL balancing requirements causes the series and shunt elements cannot be tuned to control the E- and M-dipole gains independently. However, by controlling the size of the ring, the E-dipole and M-dipole gains may be equalized. It is used in the wide varieties of applications such as MIMO system for high speed communication and enhanced polarization diversity MIMO systems, anti collisions systems for vehicular transport etc. These collocated magnetic and electric dipoles has attracted considerable attention due to increased demand for multi functionality and switchable characteristics in modern communications and this may offer enhanced performance functionalities. The proposed antenna therefore exhibits great flexibility and versatility in its radiation characteristics and may lead to innovative design which is used in high speed wireless applications.

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