DESIGN OF THE DUAL BAND DIPOLE ANTENNA SERVE WLAN AND DSRC FOR ITS APPLICATION

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1. Abstract

In this design, the dual band dipole antenna feed network with wide bandwidth tapered microstrip balun is studied. The design and experimental results of low profile embedded microstrip dipole antenna with tapered microstrip balun shows fairly good performances. The feed network of the design with wider bandwidth and lower power loss tapered microstrip line to overlap coplanar stripline (CPS) transition that provided unbalanced to balanced line with balanced equal power output of 180° phase difference. The achieved planar embedded ITS dual band dipole antenna exhibits 19.5% and 13.7% of 10dB bandwidths at 2.45GHz and 5.85GHz center frequency, respectively. Apply full wave EM analyses and shows good agreement with those experimental data.

2. Introduction

Intelligent transportation systems (ITS) encompass a broad range of wireless and wireless communications based information, control and electronics technologies [1]. When integrated into the transportation system infrastructure, and in vehicles themselves, these technologies help monitor and manage traffic flow, reduce congestion, provide alternate routes to travelers, enhance productivity, and save lives, time and money. Intelligent transportation systems provide the tools for skilled transportation professionals to collect, analyze, and archive data about the performance of the system during the hours of peak use. Having this data enhances traffic operators' ability to respond to incidents, adverse weather or other capacity constricting events. The traffic congestion and transportation security have become serious problems to most governments. Dedicated Short Range Communications (DSRC) is a block of spectrum in the 5.85~5.925 GHz band allocated by US FCC to enhance the safety and the productivity of the transportation system. DSRC is a medium range communication service intended to support both public safety and licensed private operations over roadside-to-vehicle and vehicle-to-vehicle communication channels. DSRC complements cellular communications by providing very high data transfer rates in circumstances where minimizing latency in the communication link and isolating relatively small communication zones are important. Modern in the living time, IEEE 802.11 wireless local area network (WLAN), Home RF, HIPER LAN and Bluetooth providing limited RF connectivity range for voice and high data transmissions between information appliances with fast and secure transmissions to procure wireless connect without cable are widely operated in ISM (Industrial Scientific Medicine) band of the wireless communication system. Integrating advanced transportation technology and intelligent transportation system is the main transportation future policy in Taiwan. This design will devise and fabricate a dual band embedded antenna sub-system integration using Wireless LAN IEEE 802.11b (0.24~0.2485GHz), IEEE 802.11a (5.47~5.725GHz) and IEEE 802.11p (5.85~5.925GHz) for short range ITS communication system. Balanced antennas are an important class of radiation structures; however, interface and shielding considerations usually restrict the designs to using balanced transmission lines at

ISBN: 89-86522-77-2 94460©KEES

microwave frequencies. In this design, dipole like antenna is suitable used as a radiation element in an ITS wireless communication system. Feeding a balanced antenna with unbalanced transmission line has been always an important issue for antenna designers.

3. Antenna and Balun Integration Design

Balanced network feed for dipole antenna not only exhibits equal power magnitude with 180° phase difference but also improves matching capability. Balanced to unbalanced (Balun) transformers is commonly applied in many applications such as balanced mixer, push-pull amplifier, balanced frequency multipliers, phase shifters, matching structures, etc. Double Y balun, Marchand balun, etc. [2-8] as the antenna feed networks are hard to implement with complex transition problem to solve. A simple and quick method of balun network is proposed as a feeding network for low profile planar dipole antenna. The simple tapered balun for the designed dipole antenna exhibits fairly good performances and compact size. The balanced transmission line with an embedded balun for a half wavelength dipole antenna is shown in Fig.1. The top metal line and bottom tapered ground plane with an overlapped coplanar stripline (CPS) are as a balun transition, which provides balanced equal power output and 180° phase difference as the dipole antenna feeder.The bottom tapered ground transition is designed for impedance matching tuner of balanced output. The designed feeding network of the dipole antenna with the tapered balun transition is tuned by the angle of tapered ground plane for impedance matching and balanced output. From back-to-back measurement, the insertion loss of the tapered balun in Fig.2 is about 0.28dB on a FR4 substrate. The designed tapered balun with power loss of $1\text{-}|s_{11}|^2\text{-}|s_{21}|^2$ in dipole antenna is quite low as showed.

4. Result

The task we'll achieve in this project is to contrive lower power loss tapered microstrip line to feed dual band dipole antennas with 2.45GHz and 5.85GHz center frequency, respectively and antenna bandwidth can cover ITS design specification. These embedded antennas utilizing planar PCB as substrate could be concealed in any parts of vehicle body easily such as car's rear-view mirrors, car's windscreen and car's case. These antennas are popular for their well-known attractive features, such as a low profile, lightweight and compatibility with radio frequency and mobile communication integrated circuits. Full-wave Galerkin method [9,10] for the simulation and analysis was applied for the microstrip dipole antenna. Unbalanced currents compensated by balun transition to provide the equal same direction currents at dipole driver introduce the maximum antenna radiation and efficiency. FR4 substrate (dielectric constant 4.5, loss $\tan\delta$ =0.02 and height 1.6mm) was applied in this design. A compact and low profile microstrip dipole antenna (Fig.1) was designed with L1=17mm and L2=8mm for pure dipole antenna and addition ground plane (10 cm*10 cm) to simulate car's case. EM simulations and measured return loss shown in Fig.3 and Fig.4 by HP8720C network analyzer exhibit dual wide bandwidth for design band ITS applications. About antenna bandwidth for VSWR 2:1 (about 10dB return loss) is shown in Fig.3. The measured antenna dual bandwidth (2.22~3.05GHz) and (5.37~6.1GHz) of the dual band dipole antenna cover the ITS wanted design band. Another integrated ground plane as car's case, about antenna bandwidth for VSWR 2:1 (about 10dB return loss) is shown in Fig.4. The measured antenna dual bandwidth (2.39~3.86GHz) and (5.35~6.3GHz) of the dual band dipole antenna cover the ITS wanted design band. It is found the good matching around 2.45/5.85GHz center frequencies, respectively. Measured results based on antenna anechoic chamber using an HP-8720C network analyzer and NSI-800F-10 far field antenna measurement system shows that the dual band dipole antenna possesses an operating bandwidth. Table 1 and Table 2 show radiation patterns of co-polarization antenna gain for horizontal pattern and vertical pattern radiation at 2.4~2.5GHz and 5.4~6GHz with far field measurement system, respectively.

5. Conclusion

In this ITS dual wide band dipole design, low profile tapered microstrip line balun feed dual band dipole antennas with center frequencies at 2.45GHz and 5.85GHz are study. The measured results show fairly good performances and fine agreements with those simulated data from full wave EM analyses. The embedded dipole antenna with matching tapered ground plane exhibits an available bandwidth as well as good impedance matching with a feeding balun. The achieved planar embedded ITS dual band dipole antenna exhibits 19.5% and 13.7% of 10dB bandwidths at 2.45GHz and 5.85GHz center frequency, respectively. The radiation efficiency and return loss of the dipole antenna fill the bill and anticipation of the design.

6. References

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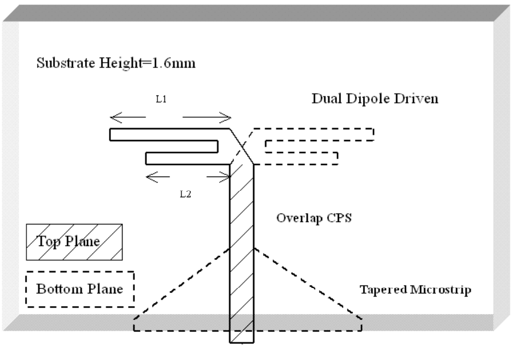

Fig. 1 Low profile dual band dipole antenna

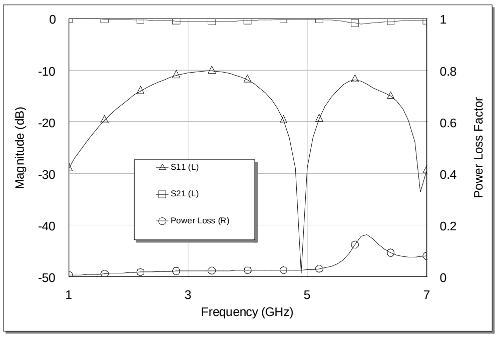

Fig. 2 Measurement result of back to back balun feed network

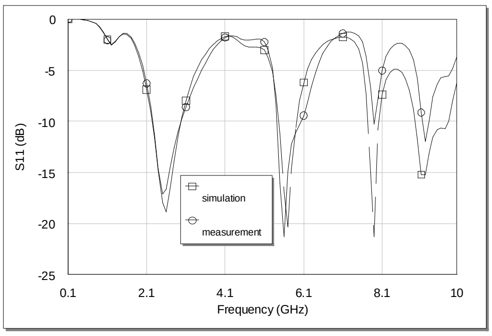

Fig. 3 Simulation and measurement data with dipole antenna without ground plane

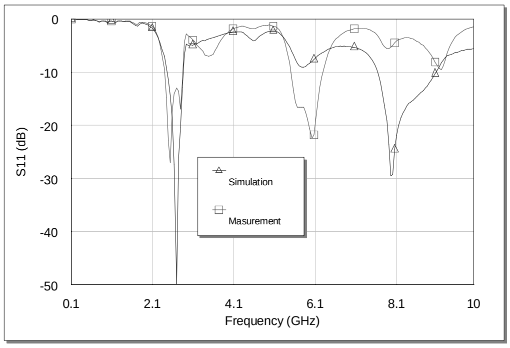

Fig. 4 Simulation and measurement data with dipole antenna integrated with ground plan as car's case

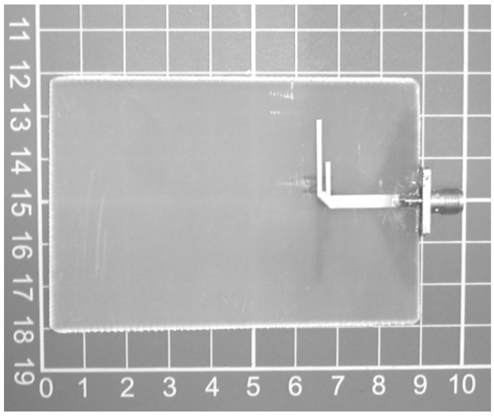

Fig.5 The practical low profile dual band ITS antenna implement on a FR4 substrate.

Table 1. No ground plane

Frequency	2.4 GHz	2.45 GHz	2.5 GHz	5.4 GHz	5.7 GHz	6 GHz
E-Plane	2.8	3.33	4.24	4.47	4.21	3.45
H-Plane	2.62	3.5	4.57	3.6	3.49	3.05

Table 2. Integrated ground plane (10cm*10cm) as to simulate on a car's case

Frequency	2.4 GHz	2.45 GHz	2.5 GHz	5.4 GHz	5.7 GHz	6 GHz
E-Plane	6.32	6.88	7.29	6	5.89	5.12
H-Plane	5.85	6.61	6.12	5.57	6.68	4.82