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Design And Implementation Of UWB UHF Antenna Array For Radar Application

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Abstract: This paper reviews various antenna design for achieving Ultra Wide Band (UWB) performance at Ultra High Frequency (UHF) range. The paper discusses the dipole antenna with varying feeding arrangement that can provide UWB performance. Tightly Coupled Dipole Array (TCDA) which utilizes coupling between the elements to enhance the bandwidth is reviewed. Balun is an integral component of a dipole antenna. Various balun topologies that can provide UWB performance are also discussed and reviewed.

Keywords: TCDA, UWB, UHF, Balun, Dipoles, Antenna Array, CPW, CPS, TCPAs.

I. INTRODUCTION

The trend of Ultra Wideband Technology in communication sector is prevalent and quite matured. UWB technology in radar application such as Ground Penetrating Radar, Through Wall Imaging and Foliage penetration is crucial and the functionality of these radars cannot be met using conventional narrow band radar technology. The UWB signal in radar improves the target range measurement and accuracy. It improves stability of the target at the low elevation angles. It also provides immunity to external narrow band electromagnetic radiation effect and noise. UWB signals also have the ability to share frequency spectrum, have large channel capacity, Low probability of intercept and detection, resistance to jamming, high performance multipath channels and superior penetration properties. For high resolution images of various shaped targets tomographic radar imaging is emerging as a powerful imaging technique. Low frequency in the VHF and lower UHF are generally preferred for foliage penetration while frequencies from 500MHz to 4GHz are typically used for ground penetration and through wall imaging radars. Antenna system meeting the UWB requirement is challenging. This paper reviews the different dipole antenna topologies that can provide UWB requirement in the UHF range. It also provides an insight on the various design reported and the feeding technique implemented in an array. Basically dipoles are narrowband and a balanced antenna, however connecting an unbalanced coaxial line requires a balun. The paper also describes the balun design reported for integrating a coaxial line with the dipole.

II. TECHNICAL REVIEW

In this paper [1] the Tightly Coupled Phased Array (TCPAs) concept is used to achieve Ultra Wide Band (UWB) performance due to the strong inter-element coupling. To mitigate finite array edge effect and improve the bandwidth various edge element termination techniques (resistive, short and open-circuit) techniques are investigated. A strategy that employs uniform excitation of the central array element and short circuit the periphery elements is reported is this paper. At least for the medium size arrays, this approach provides upto 3dB more gain and 50% higher efficiency. In this paper 7 x 7 linearly polarized dipole array of 60.96cm x 60.96cm (2’ x 2’) size, for 200 MHz to 600MHz operating frequency is simulated. This array is fed with a compact UWB Balun providing 10:1 bandwidth for VSWR < 2. MA-COM part TP-103 balun providing 1: 4 impedance transformation from 50-Ω CPW 50 Ohm to 200 Ohm CPS line feeding the dipole is implemented in the design. The array covered 200MHz-600MHz measured realized gain greater than 5dBi.The cross-pol. Gain is measured is below -10dBi.For 30° H-plane scan has the realized gain is greater than>3dBi.

In this paper [2] a Tightly Coupled Dipole Array (TCDA) concept is explained. The antenna consists of 3 overlapping dipoles which are fed at 3 different locations to ensure uniform current flow. The 3 dipoles are printed on 0.3mm thick polymer substrate (ε_r=3), which are sandwiched between two flexible polymer sheet (ε_r=3) each of 2cm thick. The size of the array is 1.4m x 0.09m.The antenna is reported to achieve 67:1 bandwidth over 30MHz to 2GHz operating frequency. The feed transforms a 50-Ω unbalance coaxial line to 100-Ω balance optimal transition. The 2:1 impedance transformer is added to transform the 50-Ω impedance to 100-Ω impedance, a balun is used to transform unbalance coplanar to balance twin lead line .The antenna is intended for integration along the arms of a human subject. VSWR<3 for desired frequency bands is exhibited.

In this paper [3] the miniature L-Band cross bowtie antenna operating at 770 to 1700MHz is described. The Bowtie edge is curved to reduce the antenna footprint and also to maintain nearly constant input impedance. This bow tie antenna is integrated with microstrip matching network and balun. The antenna exhibits dual linear polarization with greater than 5dBi gain. It also exhibits return loss greater than 10 dB when placed at $\lambda/10$ at 770MHz above the ground plane. Each bow tie is 110mm long, the antenna is placed between two sheet of Rogers R04003.Each printed circuit board is 32mil thick and antenna is placed 68mm above the ground plane. The microstrip line is excited using 50-Ω SMA connecters. $S_{11} < -10$ dB from 0.77 to 1.7GHz is simulated with the bow tie shape and integrated with a Balun.

In this paper[4] a broadband printed dipole and a printed array for base station application is presented with adjustable integrated balun and offers bandwidth of more than 40%.It has almost constant gain of 16dBi over the frequency range from 1.7 to 2.5GHz and has application for the 2G,3G and 4G application. The impedance matching can be achieved by adjusting position of the feed point of the integrated balun. It shows the linear 8-element array concept which is compatible design for wireless application.

In this paper [5] the construction and design, measurement of low profile VHF/UHF ultra-wideband array for airborne ice sounding is described. The thickness of the array for the lowest operating frequency(f_{low}) is only $0.08\lambda_{low}$.It is shown that the array over 150-550MHz exhibits gain of 6-8dBi for the Vertical polarization and 8-14dBi for the horizontal polarization array over 150-300MHz.A polarization reconfigurable design of antenna based on the resistive loaded planar dipole antenna element is explained. The frequency of operation is 150 - 550MHz.The dimension of the array is 3.6m x 0.8m with a ground plane of 16cm.The antenna pair is fed with a 50Ω coaxial feed. The 50Ohm line is spliced into two 100Ω micro-strip-line, which is connected to the coplanar waveguide transition balun. Measured Return loss better than 18dB and insertion loss less than 0.32dB from 150 to 600MHz is reported for the back to back printed balun configuration.

In this paper [6] a CPW to slot-line transition for UHF application Decade-Bandwidth Planar Balun is presented. The balun exhibits return-loss less than -10dB over the frequency range of 200MHz to 2GHz.The antenna is fed with a 50Ω coaxial feed. The balun is modeled with air bridge technique to obtain the impedance transformation from 50Ohm to 25Ohm. The balun exhibits good bandwidth and high isolation between CPW input ground and CPW output ground, and the transition is improved between CPW and 50Ω coaxial connector.

In this paper [7] a printed compensated balun with defected ground structure (DGS) design in 3-layered FR4 PCB structure is explained. This compensated balun achieves bandwidth ratio of 15:1.Here the 50Ω SMA connectors are used for the testing purposed. Return-loss than -10dB bandwidth is achieved from 0.45 to 6.85 GHz. The magnitude and phase imbalance are less than 0.5dB and 10° over entire operation band from 0.45 to 6.85 GHz.

In this paper [8] a very compact balun for CPW-to-CPS for ultra-wide band (UWB) antenna in the frequency range 6 to 8.5GHz is provided. Uniplanar balun was miniaturized by adding second layer of metallization. This balun exhibits low insertion losses and distortion. The design is realized on Rogers RO4003C with relative permittivity ε_r=3.38.The balun provides the transition from unbalanced coplanar waveguide (CPW) to balanced coplanar strip-line.

In this paper [9] design of CPW to CPS printed balun for the wideband application is introduced. The impedance for CPW is 50Ω and for the CPS is 100Ω for the matching impedance the design is realized using asymmetric design. The substrate is used RT DURIOD 5880 with dielectric constant 2.2.They are using a technique of symmetric CPW to CPS balun, and achieves the return loss less than -10 dB which gives the bandwidth of 3.4GHz. The Symmetric design is reported to achieve a bandwidth of 2.7GHz and Asymmetric Design achieves 2.2 to 8GHz of frequency range.

In this paper [10] a compact printed dipole antenna for wideband wireless application with beveled offset feeding structure placed with the dipole arm to achieve a wideband impedance bandwidth. It is integrated with a printed balun which has a micro strip-to-slot line transition and achieves the return loss <-10 dB for the frequency range of 2.65 to 17.5GHz The coupling due to the beveled structure is reported to improve the bandwidth.

CONCLUSION

In this literature survey, the design and analysis of printed dipole antenna elements which can provide UWB performance at UHF is reviewed. The construction detail of the antenna element and the balun details for dipole antennas are also reviewed. This survey also indicates the integration of the balun with the antenna element and the performance of the integrated antenna. The TCDA technique of obtaining UWB using dipoles is reviewed and the element performance in array environment is also reviewed.

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BIOGRAPHIES

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