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Performance Analysis of Electromechanical Tuner for Broadband Application

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Abstract: ***The greatest challenges to RF power devices are to match impedance for coupled network. Many causes for improper impedance results in cable loss, reflection losses and hence reduce the performance of existing system. An Impedance tuner is designed for testing prior to final set up to get satisfactory output with saving time. In modern communication systems many technologies are adding relay coils and other compensating passive components. In this paper, an impedance matching tuner is designed for multiband application with compact and cost effective structure. The characteristics of fabricated tuner is designed for 50 ohm matching two port network .The designed Electro mechanical tuner is manually characterised on the basis of experimental results to validate the system. The results suggest that it works for multiband sub GHz, Bluetooth sensor application.***

Keywords: ***Impedance tuner, VSWR, Insertion loss, Electromagnetic Interference***

I. INTRODUCTION

This is an International reputed journal that published research for electromagnetic tuner with a purpose to optimize impedance matching for accurate data transmission. The tuner is used to select defined band of frequency with proper resonances and low reflective losses. Various types of tuners are designed as per the application for operational frequency and power handling capabilities. They are of different types: Manual Impedance Tuners, Automated Impedance Tuners, Multi-Harmonic Impedance Tuners, Sensor and Automated Sliding Shorts. According to requirement of RF device tuners are selected. This electro mechanical tuner is tuned for different distance on characterised transmission line .Each line distance offers different impedance based on passive component R and C selection. The wide range frequency is covered by using single stage matching network [1]. In 2006 Whatley et al, designed a π type matching network with complex load and source impedance to get low pass characteristics. The designed low pass networks is characterised using one fixed inductor and two variable capacitors .

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The switching mechanism is excited using varactor diode [2].

In 2007 Hoarau, C. et al, have developed the RF tuner for broadband applications. Varactor diodes are used in tuner design as which works as a tuning elements in the RF frequency range. The prototype is designed to validate the relative tuner characteristics. They used loaded-line topology used for a phase shifter applications [3].

In 2011 Impedance Matching was originally developed for electrical power circuits. Than after it will be applied for all other forms of energy transferred between a source and a load. Schottky diode frequency multipliers and Schottky mixer diodes used in the waveguide environment for High frequency power transform [5].

In early 21st century the Wireless Power Technology is used for development of embedded devices. For this embedded applications minor change in load impedance results to power sensitivity. Normally, Ultra capacitor is used for changing impedances. As ultra-capacitor is being charged, the load will be increasing in instantaneous manner [6]. The key objective is to design a compact and cost effective tuner as per current era requirement.

The tuner device is a Basic coaxial line design is as shown in figure 1. To make proper impedance matching device and operate single device for various band of tuning brass material tuner is designed using basic characteristic impedance equation shown in equation (1) & (2).

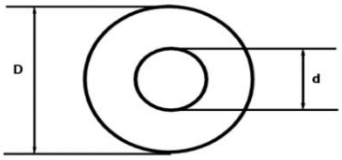

Figure: 1 Outer and Inner diameter for coaxial transmission line

$$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 377 ohm \qquad (1)$$

$$Z_0 = \frac{1}{2\pi}\sqrt{\frac{\mu_0}{\varepsilon_0}} \ln\frac{D}{d} = 60 \ln\frac{D}{d} \qquad (2)$$

Where , D is the outer most diameter of the coaxial conductor, d is the inner diameter of coaxial conductor. The tuner is designed for air dielectric medium with selecting ratio D/d = 2.3.

II. TUNER PARAMETER STATISTICS

Tuner Parameters are calculated and designed for various Low pass, High Pass or Band pass characteristics. As per the required frequency band various parameters like capacitance and inductance are measured.

The coaxial cable offers a capacitance between the gap of conductor and outer conductor. With proper arrangement of spacing and dielectric material result in variance capacitance used for tuning frequency. The Inductance of a coaxial cable varies directly along the line length of a coaxial cable .It is independent of the dielectric constant of the material. Using equation (1) and (2); Tuner is designed for 1.25 wavelength with inner and outer diameter ratio for 50 ohm characteristic impedance as shown in figure 2.Tuner assembly is prepared for 1.5 wavelength length with two hollow cylinder inner and outer with a diameter ratio 2/3.Tuning assembly is moved for different frequency with sliding screw arrangement at the top of tuner.

Tuner is connected with N-type connector at both the side for measurement with VNA or Signal generator or Spectrum analyzer.

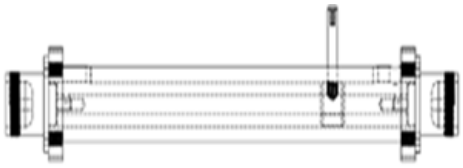

Figure 2: Brass tuner design for fabrication

Impedance tuner with different size runner with different material is fabricated as shown in figure 3.Impedance tuner is calibrated with SOLT (Shot, Open, Load, through) technique using Pocket VNA for desired frequency range.

Figure : 3 Fabricated 50 ohm Impedance tuner with derlin runners

Two port brass tuner calibrated output from VNA for 100 MHz to 3 GHz is obtained as shown in figure 4.

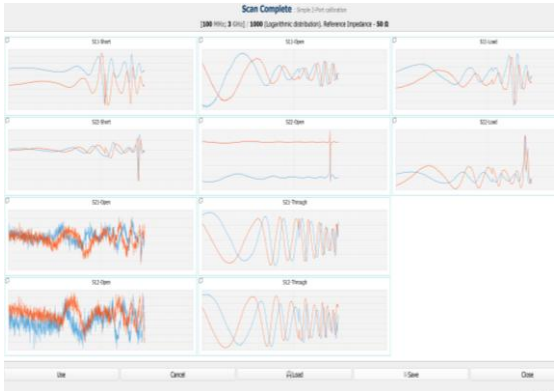

Figure 4: Two port Calibration using VNA

Calibrated tuner without runners of brass material with different size are tested. Line length represents inductive component while spacing between inner and outer varies capacitance. Thus with change in runners size and spacing results in proper impedance matching for desired band frequency.

III. FABRICATED TUNER TEST RESULT

Impedance tuner assembly is used to locate various tuning band with fixing different runner position. One of the familiar application is Bluetooth: which operates at frequencies between 2402 and 2480 MHz, or 2400 and 2483.5 MHz including guard bands 2 MHz .The brass tuner is used for Bluetooth application as results show in Figure 5.

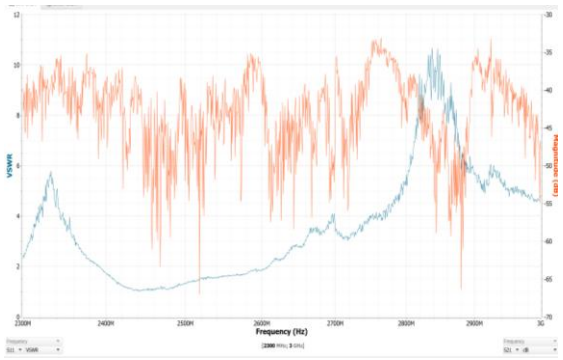

Figure 5: Bluetooth sensor tuning range

Advanced automotive car technology sensors are used at the 2.4 GHz frequency for various car monitoring applications. These devices required signal strength of 500 mW. Figure 6 shows good tuning impedance for this application. Many Wireless networks operate on 2.4–2.4835 GHz band and are used to remove interference from other devices.

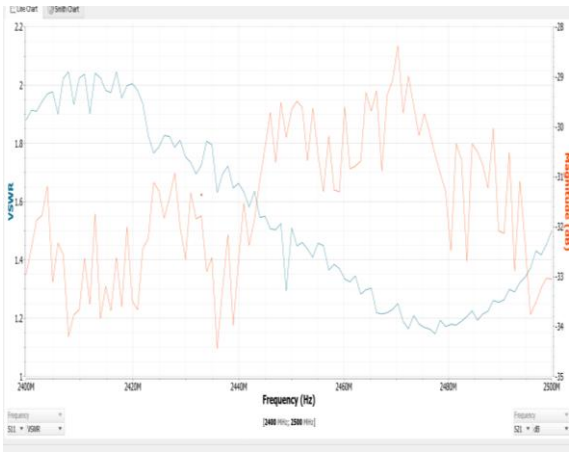

Figure 6 : VSWR for sub 1GHz frequency

In modern Wireless technology transmission, each channel can be time-shared by multiple networks. Fabricated tuner is provide good tuning range for different networks in crowded environments.

IV. CONCLUSION

In modern digital era many of Bluetooth sensors operates at frequencies between 2402 and 2480 MHz, or 2400 and 2483.5 MHz .

Advanced car manufacturing technology uses automotive sensor systems operates at 2.4 GHz frequency for vehicle tacking, remote shutdown and health monitoring Giga-promo applications.

Wireless data networks operate in the 2.4–2.4835 GHz band are used to avoid interference from other RF devices. It is cleared from above observations that the Tuner may use for various broadband applications.

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Hetal Pathak is from Vadodara Gujarat, India. She has completed her B.E. Electronics in 1996 from The M S University and M.E (Communication systems Engineering) 2009 from Gujarat University. She was posted as Associate professor in BIT, Vadodara since 2009. She is having 18 years of teaching experience. Her area of interest is RF,Microwave ,Antenna Engineering Design ,Digital and Analog communications. The author is life member of IETE. She is awarded with best paper award in National Women's Conference on "Exploring Potentialities Of Women In Engineering **",** CIT, Changa in 2009.She got appreciated for fetching Funds from various agencies for several research projects.

Shweta Shah is from Surat, Gujarat, India. She has completed her B.E. Electronics in 2003 and M.Tech (Communication system) 2008. She was posted as Assistant professor in NIT, Surat since March 2009. Before that she worked as Adhoc lecturer in the same institute. She is having 12 years of teaching experience. Her area of interest is wireless communication, mobile communication, and mobile networks. She completed her Ph.D. in Dec. 2015. The second author is life member of IETE and ISTE. She is awarded with "Rashtriya Vidya Gaurav Purskar" and "National Mahila Rattan Gold Medal Award" in 2016.