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Bluetooth and WiMAX Applications Verification using Compact Klopfenstein BALUN

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Abstract: This paper covers design of compact BALUN transformer using Klopfenstein transformer. The verification of BALUN is done through three different approaches. First approach is to connect 100 Ω SMD resistor and then using two different dipole antennas covering Bluetooth and WiMax applications. All the measurements are satisfactory and confirms the successful design of compact Klopfenstein BALUN transformer.

Keywords: Coplanar stripline, Bluetooth, WiMAX, BALUN, taper transformer, Klopfenstein transformer.

I. INTRODUCTION

A compact BALUN transformer can have different forms to have a compact size. There are enough literatures available covering different approaches to achieve this compactness in the structure. Each structure has its own advantages and disadvantages w.r.t. size of the BALUN and bandwidth of the BALUN [1-7].

A compact structure is always advantageous to design handy electronic product. Another advantage is low power and low cost. In this paper a BALUN is designed using simple technique covered in [9]. The proposed steps are used to design a very compact size BALUN to cover Bluetooth and WiMAX bands. The same BALUN is interfaced with two dipole antennas to verify the viability of BALUN transformer. Figure 1 shows the impedance behaviour of tapered line. Initial impedance is Z0 and final impedance is ZL.

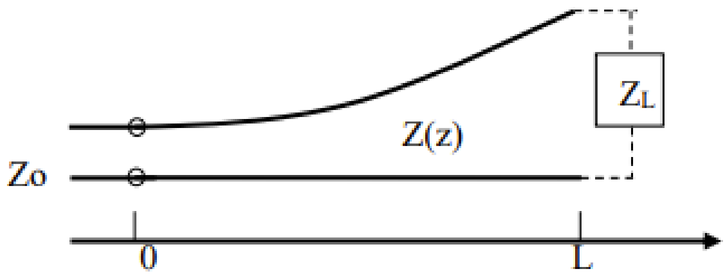

Figure 1. Taper transmission line loaded with load Z_L and driven by reference impedance Zo.

In order to design a taper line following design equations can be used [9]:

$$A = \cosh^{-1}\frac{\Gamma_0}{\Gamma_m} \quad (1)$$

$$\Gamma_0 = \frac{Z_L - Z_0}{Z_L + Z_0} \quad (2)$$

$$\Gamma_m = \frac{\Gamma_0}{\cosh A} \quad (3)$$

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$$|\Gamma| = \frac{1}{2} ln \left[\frac{Z_L}{Z_0}\right] \left[\frac{sin\left(\frac{\beta L}{2}\right)}{\frac{\beta L}{2}}\right]^2 \quad 4$$

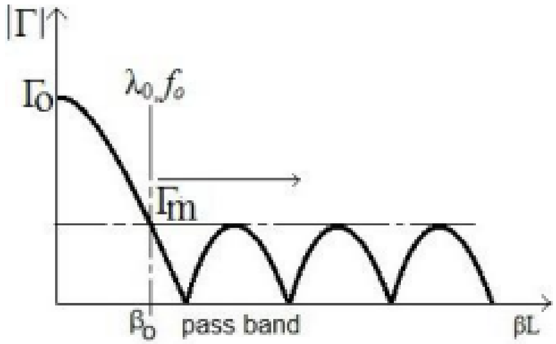

Figure 2. Reflection coefficient as a function of β L for an n section Tchebycheff transformer.

When Γ_m is minimum reflection coefficient and chosen as 0.02 and Γ_0 is maximum reflection coefficient and is chosen as 0.35 then the for a cut-off frequency of 1.5 GHz, the transformer length comes to be of 3 cm. In order to have compact size of BALUN, design approach given in [9] is used and BALUN length of 3 cm is considered as circumference of circular BALUN. The radius of the circular BALUN comes as 5 mm. Dimension of the 3 cm straight Klopfenstein transformer is given in table 1. BALUN length of 3 cm is divided into 21 sections and last two sections are of 98.56 **Ω** and 100 **Ω**. Width of these two sections on Fr-4 substrate with thickness 0.8 mm are 0.34 mm and 0.32 mm respectively. The width of the first section is 1.44 mm which has 52 Ω impedance. In order to design a curved BALUN, remaining 18 sections are converted into circular structure with radius 5 mm. CST-Studio simulation tool is used to simulate this structure.

TABLE I DISTRIBUTION OF IMPEDANCE OF EACH SECTION OF TAPER LINE.

Sr. No.	**Length(cm)**	**Line impedance (Z)**
1	-1.5	52.04054
2	-1.35	52.78966
3	-1.2	53.796
4	-1.05	55.06953
5	-0.9	56.63037
6	-0.75	58.49205
7	-0.6	60.65981
8	-0.45	63.12875
9	-0.3	65.88202
10	-0.15	68.88934
11	0	72.13913
12	0.15	75.54222
13	0.3	78.9905
14	0.45	82.43556
15	0.6	85.7908
16	0.75	88.97028
17	0.9	91.89511
18	1.05	94.4997
19	1.2	96.71637
20	1.35	98.56446
21	1.5	100.0166

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Figure 3 shows structure of compact BALUN. It comprises of feed line of 50 Ω, circular section transforming impedance to 98.56 Ω. The last two sections are 98.56 Ω and 100 Ω line. The final microstrip line is connect with a coplanar strip line of 100 Ω. Thus, the transformer converts 50 Ω impedance to 100 Ω.

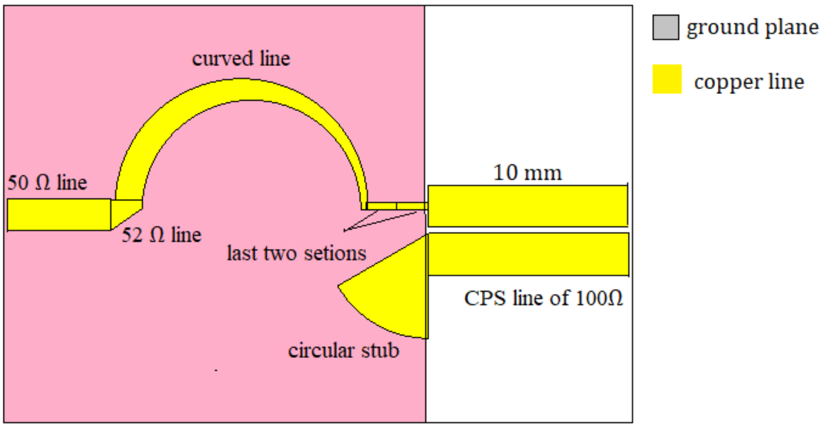

Figure 3. BALUN structure.

II. VALIDATION OF WORKING OF BALUN USING DIPOLE

The BALUN structure shown in figure is simulated for a load of 100 Ω. The simulated result is shown in Figure 5 and shows that the BALUN works for a frequency of 1.5 GHz to more than 12 GHz. The same BALUN is manufactured on a dielectric substrate Fr-4 of thickness 0.8 mm. The same is connected to a load of 100 Ω and is measured using VNA. The BALUN is loaded with smd component to support higher frequency.

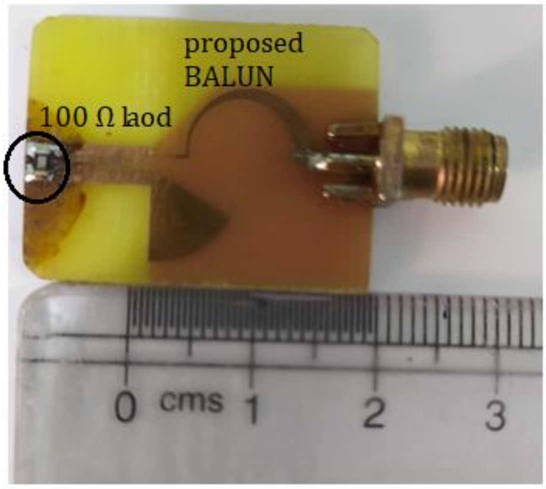

Figure 4. Photograph of proposed BALUN with SMD 100 Ω load.

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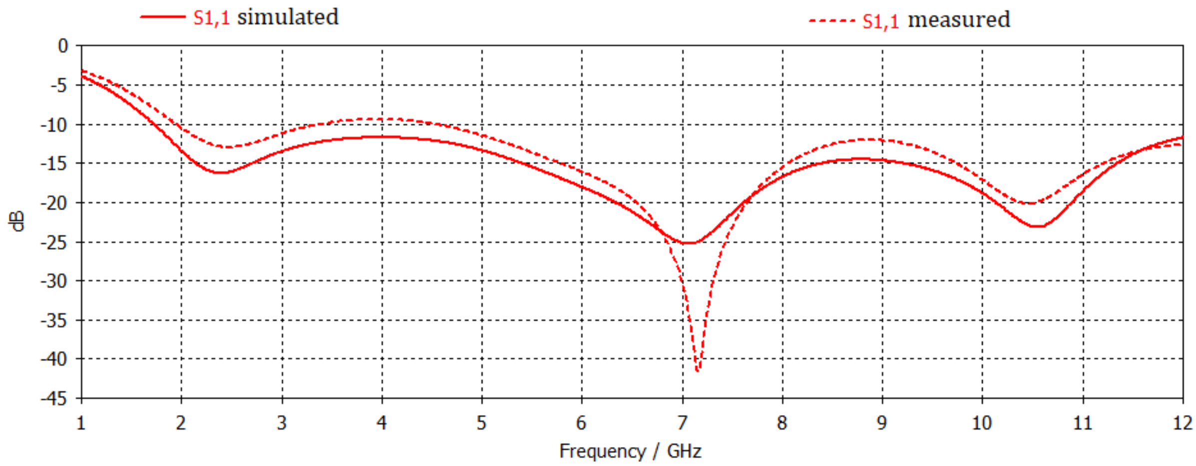
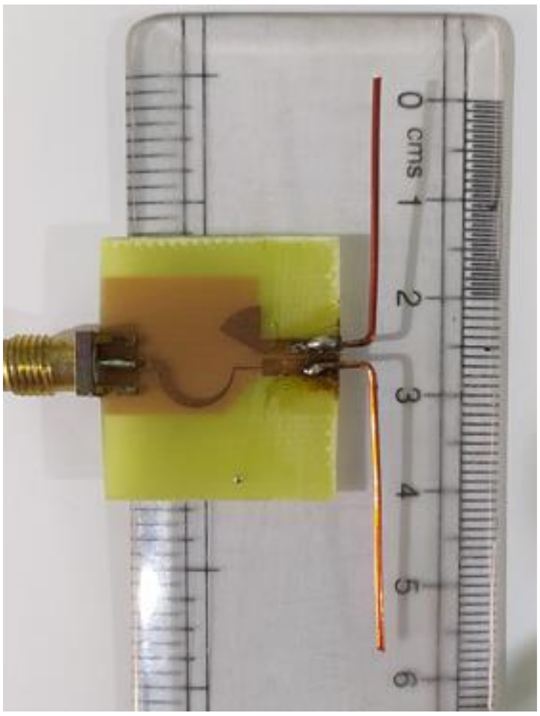
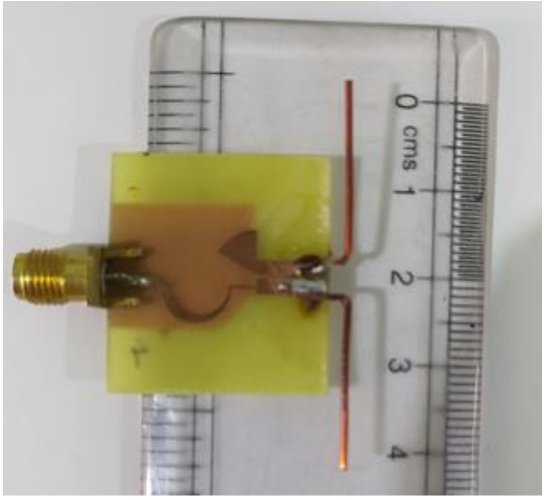


Figure 5. Frequency v/s reflection coefficient of BALUN for 100 Ω load.

Further verification of BALUN is done with the help of two dipole antennas which are balanced in nature and are compatible with CPS line. Photograph of the proposed BLAUN with dipole antennas are shown in figure 6. Figure 6(a) shows the dipole antenna of length about 6 cm and supports BLUETOOTH frequency 2.4 GHz. Figure 6(b) shows the dipole antenna of length about 4.5 cm and supports WiMAX frequency of 3.4 GHz.



(a)



(b)
Figure 6. (a) Dipole for 2.4 GHz and (b) 3.4 GHz applications.

The two dipoles are connected with BALUNs and response of each is measured with VNA. Figure 7 shows the measured result for the two cases. It can be seen that BALUN when interfaced with 2.4 GHz dipole, it resonates at 2.4 GHz and also covers 4 GHz frequency. This can be due to second resonance of the dipole and since BALUN covers a larger band second band also gets covered. WiMAX result is verified with second antenna.

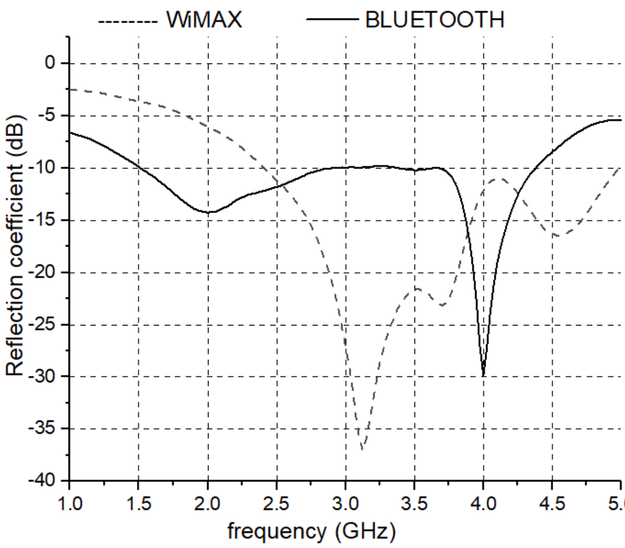


Figure 7. Measured result of two BALUNs with tow dipoles.

II. CONCLUSION

The proposed approach to design compact size Klopfenstein transformer is valid technique to design compact size of the antenna. The compact BALUN is suitable to feed balanced antenna such as dipole and loop antenna.

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