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Simulation of Double Stub Impedance Matching using LabVIEW

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Abstract - **This paper introduces useful concept of impedance matching with double stub technique using graphical programming language - LabVIEW. Impedance matching is very essential for transferring maximum power from source to load. Scope of impedance matching using single stub is restricted when load impedance or frequency is varying, double stub matching can be used for varying load and frequency. Solving double stub matching problem on Smith Chart is very manual and time consuming. With the use of LabVIEW program, parameters of this technique can be easily found.**

Keywords – Impedance Matching, Double Stub, LabVIEW Program

I. INTRODUCTION.

There are many methods for impedance matching like quarter wave transform, single stub matching and double matching etc. But double stub matching using LabVIEW is better method for impedance matching. In the single stub matching stub length and position of the stub on transmission line need to be changed as load impedance changes, in practice it is difficult to implement. Double stub matching can resolve this problem of single stub matching [1]. In the double stub position of the stub can be fixed on transmission line, so no need to change the position of stub. The techniques for solving impedance matching problems on a smith chart are well known [2]-[4]. It involves four parameters namely, the lengths of the two stubs ,distance between two stubs, and the distance between first stub and the load. In that case, a distance must be allowed between the first stub and the load. The minimum value of this distance is not easily found on a Smith chart, nor is analytical formulas available for the determination of this minimum distance .In our case study the distance between load and first stub is not zero. Once the load impedance and frequency is taken into consideration with the use of it all the parameters of the double stub matching can be determined [1].

II. PROCEDURE OF THE SYSTEM

Fig.1 shows the entire procedure of the system. Once the load impedance and the distance between two stubs are known all the parameters of the double stub matching can be determined. Parameters such as lengths of two stubs and minimum length required between first stub and load can be computed by known parameters. With the use of the ABCD-matrix (the chain- parameter) representation for a transmission-line network an analytical solution for the general double-stub impedance-matching problem can be obtained.

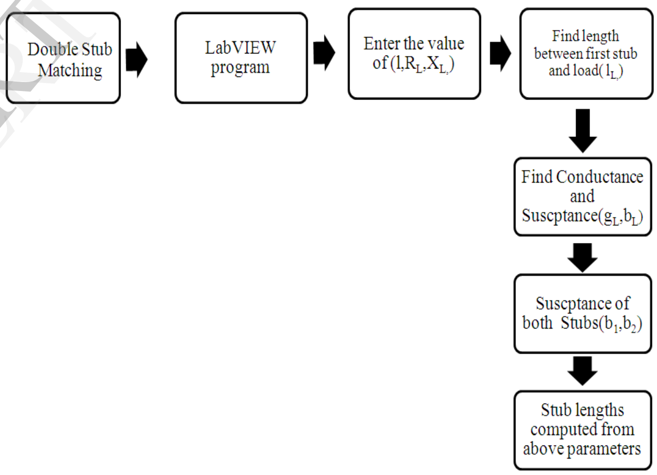

Fig 1. Block Diagram of Entire procedure

III. MATHEMATICAL COMPUTATION

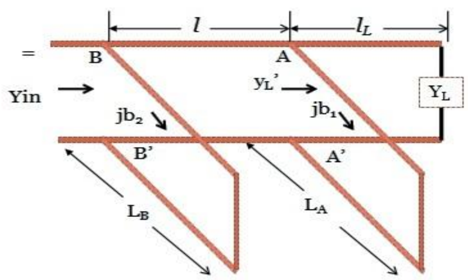

Fig 2 Double Stub Arrangement

From the fig, 2 load admittance Y_L is to be matched to a main line with characteristics admittance Y_O. Four parameter of this system, are,

L_A = length of first stub
L_B = length of second stub
L = distance between the stubs
L_1 = distance between first stub and load

ABCD parameters can be used for transmission line network representation, because they can be used easily in cascade connection.

ABCD matrices for a shunt stub having a normalized input susceptance b and for a section 1 of a lossless transmission line are respectively

$$\begin{bmatrix} 1 & 0 \\ jb & 1 \end{bmatrix} \text{ And}$$

$$\begin{bmatrix} \cos\beta l & j\sin\beta l \\ j\sin\beta l & \cos\beta l \end{bmatrix}$$

ABCD matrix for the combination of transmission line of length L and the shunt stubs at ports AA' and BB'.

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cos\beta l - b_1\sin\beta l & j\sin\beta l \\ j[(b_1+b_2)\cos\beta l + (1-b_1b_2)\sin\beta l] & \cos\beta l - b_2\sin\beta l \end{bmatrix} \quad (1)$$

Then the equation for the normalized admittance at terminal AA' looking towards Load is

$$y_L' = g_L' + jb_L' \quad (2)$$

The normalized input admittance at terminals BB' is [1]

$$y_{in} = \frac{Y_{in}}{Y} = \frac{Dy_L' + C}{By_L' + A} \quad (3)$$

$$y_{in} = \frac{(\cos\beta l - b_2\sin\beta l)(g_L' + jb_L') + j[(b_1+b_2)\cos\beta l + (1-b_1b_2)\sin\beta l]}{(j\sin\beta l)(g_L' + jb_L') + \cos\beta l - b_1\sin\beta l} \quad (4)$$

And for perfect match,

$$y_{in} = 1 + j0. \quad (5)$$

From eq 1,2,3,4 we get

$$g_L' = \frac{1}{\left[(\cos\beta l - b_2\sin\beta l)^2 + (\sin\beta l)^2\right]} \quad (6)$$

$$\therefore b_L' = \frac{-b_1(1 - 2b_2\sin\beta l\cos\beta l) + b_2^2(\cos\beta l - b_1\sin\beta l)\sin\beta l - b_2(\cos^2\beta l - \sin^2\beta l)}{\left[(\cos\beta l - b_2\sin\beta l)^2 + (\sin\beta l)^2\right]} \quad (7)$$

From eq. 6 and 7 value of b_1 and b_2 can be calculated .

$$b_1 = \frac{b_2^2\sin\beta l\cos\beta l - b_2(\cos^2\beta l - \sin^2\beta l) - \frac{b_L}{g_L}}{1 - 2b_2\sin\beta l\cos\beta l + b_2^2\sin^2\beta l} \quad (8)$$

$$b_2 = \frac{\cos\beta l}{\sin\beta l} \pm \sqrt{\frac{1}{g_L\sin^2\beta l}} - 1 \quad (9)$$

Impedance of short circuited stub is

$$z_s = jz_0\tan\beta l \quad (10)$$

From the above equation the final lengths of both the stubs can be written as

$$\frac{l_A}{\lambda} = \begin{cases} \frac{1}{2\pi}\tan^{-1}\left(-\frac{1}{b_1}\right), & b_1 \le 0 \\ \frac{1}{2\pi}\left[\pi + \tan^{-1}\left(-\frac{1}{b_1}\right)\right], & b_1 > 0 \end{cases} \quad (11)$$

$$\frac{l_B}{\lambda} = \begin{cases} \frac{1}{2\pi}\tan^{-1}\left(-\frac{1}{b_2}\right), & b_2 \le 0 \\ \frac{1}{2\pi}\left[\pi + \tan^{-1}\left(-\frac{1}{b_2}\right)\right], & b_2 > 0 \end{cases} \quad (12)$$

IV. IMPLIMENTATION ON LABVIEW

A. Following system tools of LabVIEW are being utilized in the present study:

Case Structure

Have one or more sub diagrams, or cases, exactly one of which executes when the structure executes as shown in fig.3. The value wired to the selector terminal determines which case to execute and can be Boolean, string, integer, or enumerated type. Right-click the structure border to add or delete cases. Use the labeling tool to enter value(s) in the case selector label and configure the value(s) handled by each case[5].

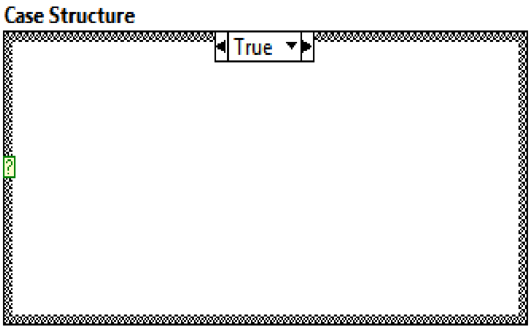

Fig 3 LabVIEW screen shot of case structure [5]

Formula Express VI

It uses a calculator interface to create mathematical formulas as shown in the fig.4. You can use this Express VI to perform most math functions that a basic scientific calculator can compute.

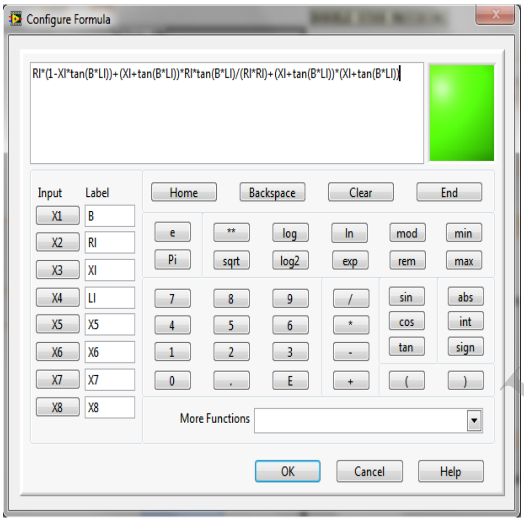

Fig 4 LabVIEW screen shot of formula express VI

V. RESULTS

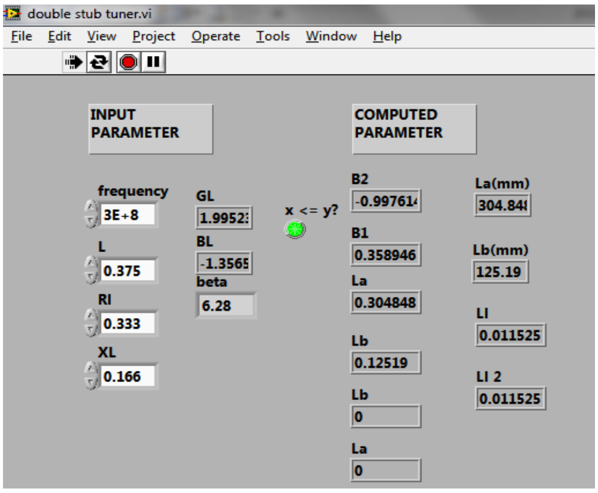

Fig 5 LabVIEW screen shot of Front Panel

Fig.5 shows the front panel of the entire program. With the use of LabVIEW all the parameters of the system can be easily determined.

Sr. No.	r_L (Ω)	x_L (Ω)	l/λ	Program Result	
				$\frac{l_A}{\lambda}$	$\frac{l_B}{\lambda}$
1	1.46	-1.6	3/8	0.125	0.344
2	0.5	0.4	1/8	0.375	0.44
3	0.333	0.167	3/8	0.304	0.125
4	1.2	-1.6	1/8	0.445	0.375

Table-1 Observation table

Table-1 Shows that with the use of known parameters all the double stub parameters can be determined.

VI. CONCLUTION

Impedance matching is very essential to transfer maximum power from source to load. With the use of double stub matching stub positions can be fixed on transmission line and required stub lengths can be calculated. LabVIEW is very useful tool to develop basic GUI of the system and the algorithm of the double stub matching technique can be easily implemented with the use of LabVIEW. Results show that with the use of the load impedance and distance between two stubs required lengths of two stubs can be calculated and impedance matching can be achieved.

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