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State-of the-Art Design for Microwave Frequency (Simpson's Integrator)

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Abstract: Due to advantage of stability and saturation in both analog and digital systems, Integrators are preferred over differentiators. Various types of integrators can be to designed like Trapezoidal integrator, Rectangular Integrator, Simpson's Integrator, Tick integrator, Ngo integrator. Among above mentioned integrators, Rectangular and Trapezoidal Integrators are commonly used but accurate result cannot be determined at high frequencies. So, an approach to get more accurate results is Simpson's integrator. The approach is to make a more precise design of low pass Simpson Integrator that gives accurate result at microwave frequencies.

Keywords: Digital integrators, Simpson's integrator, Quasi-Newton algorithm, open circuit stub, transmission line, z- Domain filter.

I. INTRODUCTION

Integrator is an electronic integration circuit. Integrators ate the basic building blocks for analog and digital signal processing and the output voltage is proportional to the input voltage integrated over time. The transfer function of integrator is

$$H(jw) = \frac{1}{jw} \qquad (1)$$

And the gain of the ideal integrator is given y equation Gain of Ideal Integrator (Time domain)

$$Vo(t) = -\frac{1}{RC}\int V(t)\,dt \qquad (2)$$

Gain of integrator (Frequency domain)

$$Vo(s) = -\frac{1}{RCS}Vin\ (s) \qquad (3)$$

$$\frac{Vo(s)}{in(s)} = -\frac{1}{RCS}$$

on putting s = jω

$$\frac{Vo(j\omega)}{Vin(j\omega)} = -\frac{1}{j\omega\, RCS}$$

$$\left|\frac{Vo(j\omega)}{Vin(j\omega)}\right| = \frac{1}{RC\omega} \quad (4)$$

Where $j = \sqrt{-1}$ and ω denotes angular frequency in radians.

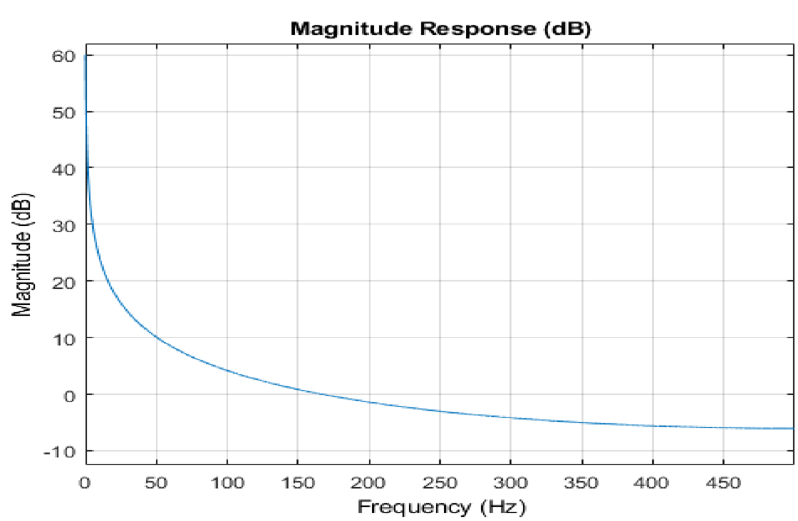

Fig.1 Magnitude Response of Integrator

Pulse shaping, image blurring and microwave integrator are some of the applications of integrator. Some of the fields where integrators are widely used are instrumentation, Digital image processing, Digital systems, Control System and in many other fields of engineering.

II. STATEOF INTEGRATORIN Z- DOMAIN

The design of the digital integrators in Z- domain are given by the following functions-

A. *Rectangular Integrator*

$$H(z) = \frac{zT}{z-1} \qquad (1)$$

B. *Trapezoidal Integrator*

$$H(z) = \frac{T}{2}\left(\frac{z+1}{z-1}\right) \qquad (2)$$

C. *Simpson's Integrator*

$$H(z) = \frac{T}{3}\left(\frac{z^2+4z+1}{z^2-1}\right) \qquad (3)$$

Here T denotes the sampling time.

High frequency integrator con be realized by the various combination of open circuit stub, short circuit stub and transmission line sections. The open circuit stub can be defined by the following matrix

$$\begin{bmatrix} TF_{11} & TF_{12} \\ TF_{21} & TF_{12} \end{bmatrix}$$

$$= \frac{1}{1+D^{-2}}\begin{bmatrix} (1+c)+(1-c)D^{-2} & c-cD^{-2} \\ -c+cD^{-2} & (1-c)+(1+c)D^{-2} \end{bmatrix} (4)$$

Similarly, short circuit stub can be defined by the matrix

$$\begin{bmatrix} TF_{11} & TF_{12} \\ TF_{21} & TF_{12} \end{bmatrix}$$

$$= \frac{1}{1-D^{-2}}\begin{bmatrix} (1+c)-(1-c)D^{-2} & c+cD^{-2} \\ -c-cD^{-2} & (1-c)-(1+c)D^{-2} \end{bmatrix} (5)$$

For Transmission line

$$\begin{bmatrix} TF_{11} & TF_{12} \\ TF_{21} & TF_{12} \end{bmatrix}$$

$$= \frac{1}{D^{-1}(1-\Gamma^{-2})}\begin{bmatrix} 1-\Gamma^{-2}D^{-2} & -(\Gamma-\Gamma D^{-2}) \\ \Gamma-\Gamma D^{-2} & -\Gamma+\Gamma D^{-2} \end{bmatrix}\Gamma \qquad (6)$$

The chain components of all these components is calculated by the product of the above equations of open circuit stub, short circuit stub and the transmission line section that is given by

$$\begin{bmatrix} TF_{11} & TF_{12} \\ TF_{21} & TF_{12} \end{bmatrix} = \prod_{i=1}^{N} \begin{bmatrix} TF_{11}^{i} & TF_{12}^{i} \\ TF_{21}^{i} & TF_{22}^{i} \end{bmatrix} \qquad (7)$$

And in Z- domain the transfer function is described by

$$T_{11}(D) = \frac{\prod_{K=1}^{K}(1+D^{-2})\prod_{l=1}^{L}(1-D^{-2})\prod_{m=1}^{M}(D^{-1}(1+\Gamma^{-2}))}{\sum_{i=0}^{N} a_i D^{-2i}} \qquad (8)$$

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D. Steps For Design

The initial approach is to propose the structure of microwave integrator (combination of open circuit and short circuit stub and transmission line section) on the ADS software. The Advance Design System(ADS) is an automation tool.

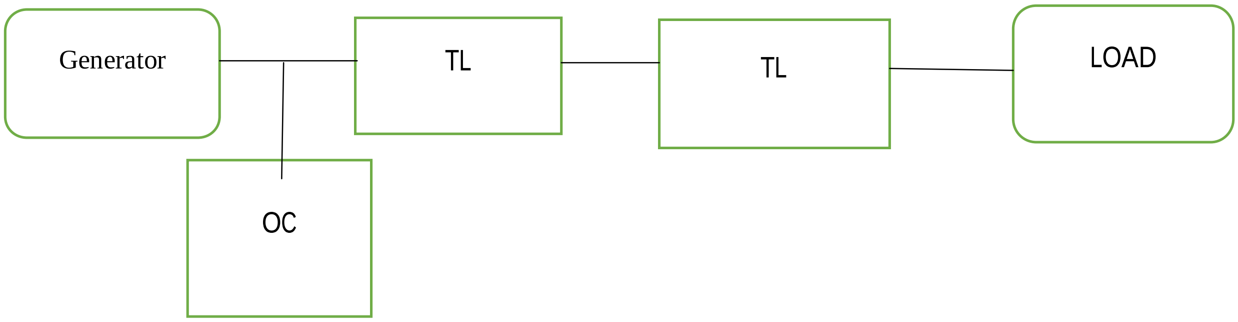

Fig.2 Block Diagram for Proposed Design

Here TL indicates transmission line section and OC is the open circuit stub. The source and load end impedance are 50ohm.

III. SIMULATION

In this proposed paper the designed formed by the combination of stubs and transmission sections is given in figure below.

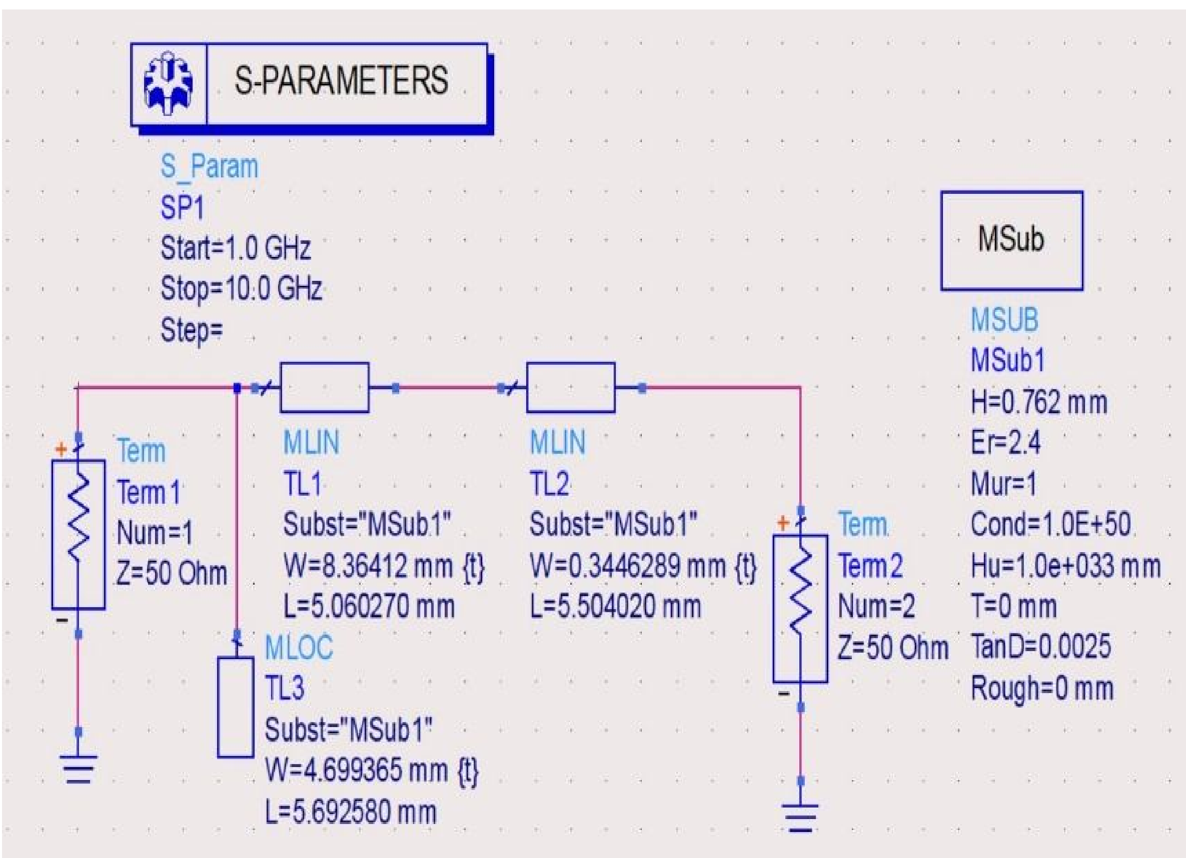

Fig.3 Proposed Design for Integrator on ADS

In this proposed design, the source and load end impedance are 50Ω. There can be more solution of integrator depending upon the dimensions like width and length of the stubs and transmission line sections.The following is the result of the simulation on ADS that behaves well till the frequency up to 8Ghz and for frequencies above 8Ghz, the result is not well controlled.

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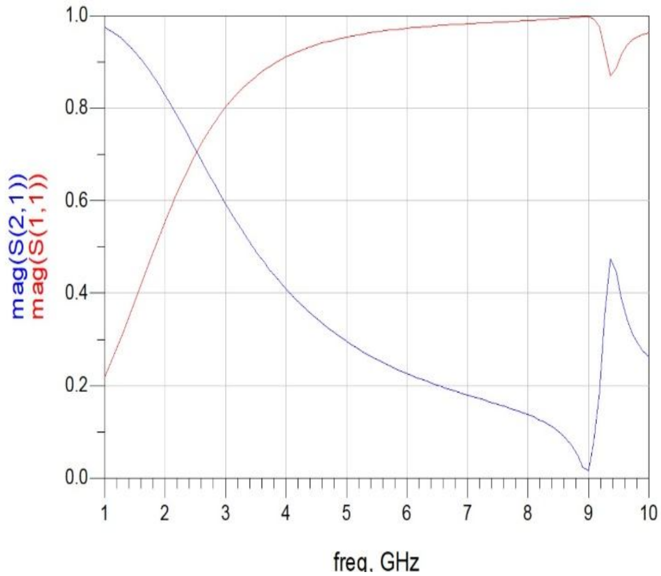

Fig.4 Resultant for magnitude response on ADS Simulation tool

IV. RESULT AND DISCUSSION

The proposed result of microwave integrator is good up to 8Ghz and for above 8Ghz it is not well controlled. These results can be further tuned and made modified by adjusting the dimensions of the open and short circuit stub and the transmission line sections.

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