*IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)*
*e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 11, Issue 6 Ver. IV (Nov. – Dec. 2016), PP 19-22*
*www.iosrjournals.org*

# Virtual Instrumentation Based Simulation of Frequency Response of a First order System

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***Abstract:*** *The frequency response of a system is the major way of characterizing how a system behaves in the frequency domain. It is important to understand the frequency characteristics of a given system rather than frequency domain characteristics alone for many practical applications like filter design. In present work a modeling and simulation process of the first order system frequency response control model is implemented on the LabVIEW platform for the Resistor-Capacitor (filter) network.*

***Keywords:*** *First order system, Resistor-Capacitor network, Frequency Response, LabVIEW*

## I. Introduction

The frequency response and time response of a system can derive from a mathematical model of a system. The mathematical model describes a physical system and analyzing their dynamic characteristics [2]. Mathematical models of processes are the foundation of control theory. The existing analysis and synthesis tools are all based on certain types of mathematical description of the system to be controlled; also called plant. Presently the linear differential equations and transfer function are used to build the mathematical model of system.

The mathematical model of system involves the developing and analyzing a model to describe a plant or a system, designing and analyzing, simulating the dynamic system. LabVIEW provides solutions for each of these phases designing and analyzing, simulating the dynamic system. It has different tools which are built on this platform with different approaches at each phase in the mathematical model based on design and quickly identify the optimal design for a control system. Present a Resistor-Capacitor (filter) network taken as a plant or system.

## II. Mathematical Modeling of Resistor-Capacitor Network

The mathematical model of a control system constitutes a set of differential equations. The response or output of system can be studied by solving the differential equations for various input conditions [3]. The present model is obtained by using Resistor-Capacitor network is formed by a voltage source.

The differential equations governing of resistor–capacitor system by applying of kirchoff law,

$$V(t) \quad = R(i) + \frac{1}{C}\int i(t)$$

In this equation describes system has constant coefficients, so the mathematical model is linear and input, output are functions of time then the system called the linear time invariant. The differential equation of a liner time invariant system can be reshaped into different form for the convenience of analysis. One such model for single input and single output system analysis is transfer function of the system. The transfer function of a system is defined as the ratio of Laplace transform of output to the Laplace transform of input with zero initial conditions [2].

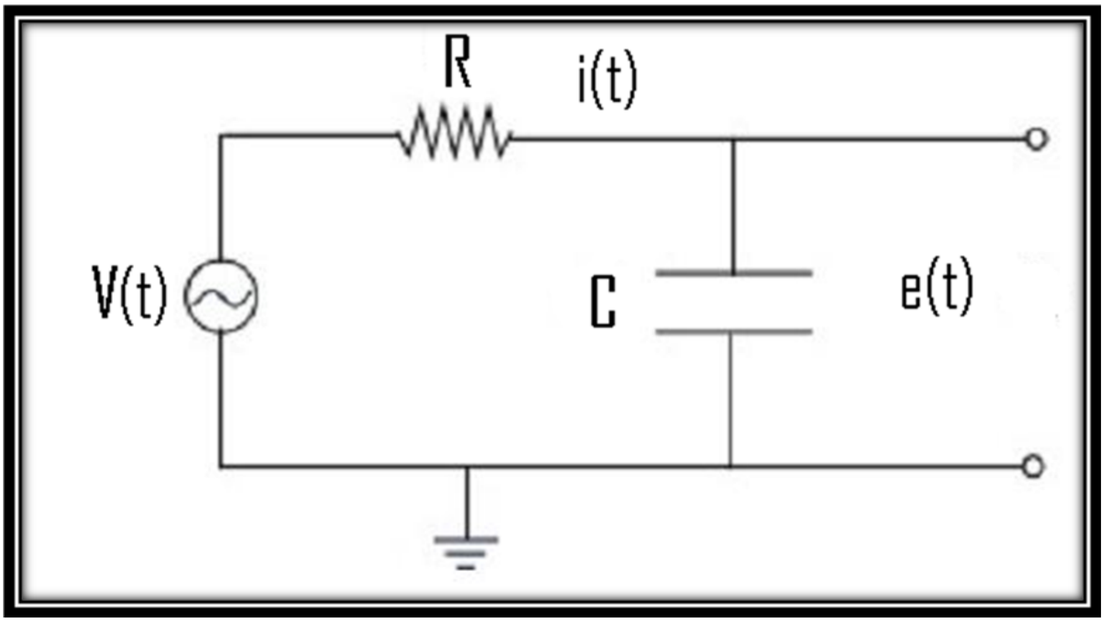


**Fig.1** The series R-C circuit

Assuming zero initial conditions and taking Laplace transform [4] on both sides

$$V(S) \quad = R\,I(S) + \frac{1}{CS} I(S)$$

$$V(S) \quad = \left(R + \frac{1}{CS}\right) I(S)$$

$$I(S) \quad = \frac{V(S)}{\left(R + \frac{1}{CS}\right)}$$

Finally

$$\frac{I(S)}{V(S)} = \frac{KS}{1+TS}$$

Where T=RC and K=C

According to Black Diagram Algebra diagram is shows fig 2.

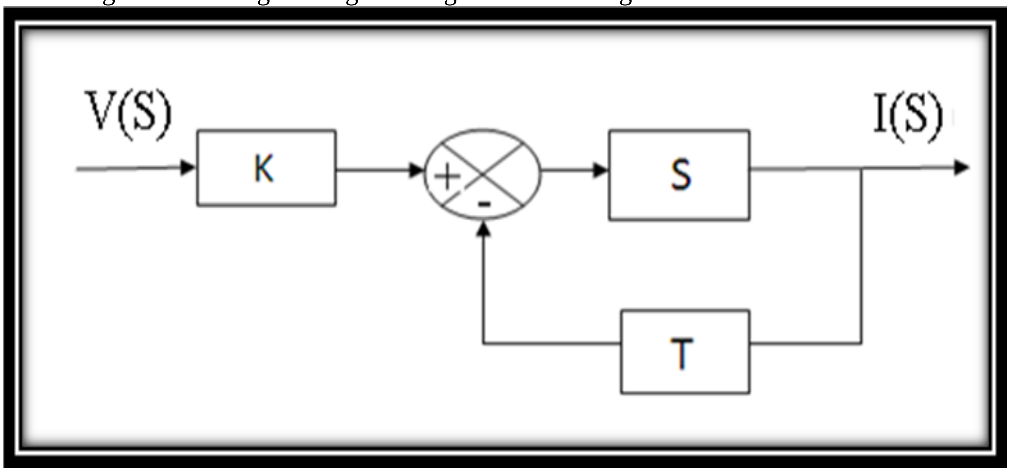


**Fig.2** The Block diagram Algebra diagram of Resistor-Capacitor

The transfer function above block diagram is

$$T(S) \quad = \frac{I(S)}{V(S)} = \frac{KS}{1+TS}$$

In transfer function has two polynomials are numerator and denominator polynomials, the denominator polynomial of transfer function is called the characteristic equation. The characteristic equation of Resistor-Capacitor network has maximum power of “S” is 1; hence system is called the first order system. In control systems time response is very important to analysis the desired characteristics. The time response of a control system is usually divided in two parts is the transient response and steady state response [5, 1]. This paper describes the steady state response of the Resistor-Capacitor network [8].

The frequency response is the steady state response (output) of a system. In frequency response analysis transfer function T(s), if **s** is replaced by **j**□ then the resulting transfer function T(**j**ω) is called sinusoidal transfer function [7]. The frequency response of the R-C network (system) can be directly obtained from the sinusoidal system transfer function T(**j**□) of the system.

The sinusoidal transfer function of Resistor-Capacitor is

$$T(\mathbf{j}\omega) = \frac{I(\mathbf{j}\omega)}{V(\mathbf{j}\omega)} = \frac{\mathrm{K}(\mathbf{j}\omega)}{1+\mathrm{T}(\mathbf{j}\omega)}$$

The transfer function T(**j**ω) Is a complex function of frequency. The magnitude and phase T(**j**ω) are function of frequency and can be evaluated for various values of frequency. Different techniques are available for frequency response analysis. In present work the frequency response done by the Bode plot. A Bode plot has two graphs; one is a plot of the magnitude of sinusoidal transfer function versus log □ **.** The other is plot of the phase angle of a sinusoidal transfer function versus log ω**.**

## III. Frequency response in virtual instrumentation

Obtaining the Frequency response of a system involves numerically integrating the system mathematical model. The LabVIEW Control Design and Simulation Modules provide contraction and control models transfer function in s-domain. The R-C net work transfer function in S-domain to simulated in LabVIEW [6], it has inbuilt conversion of S-domain transfer function to sinusoidal transfer function.

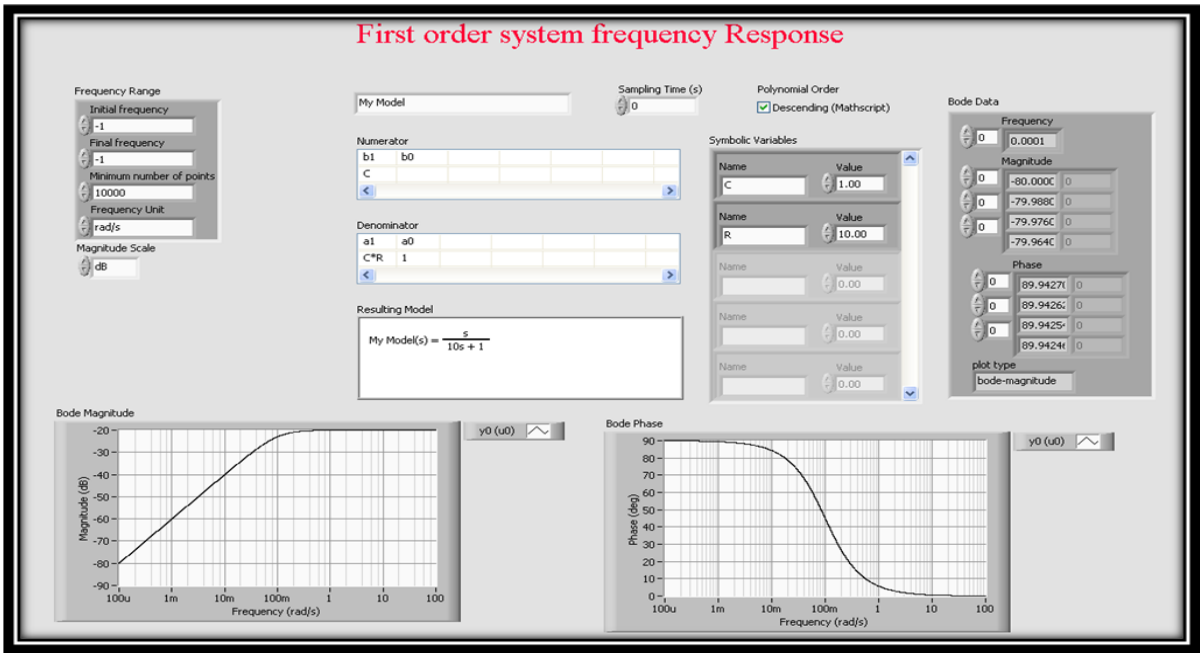


**Fig. 3** The front panel of R-C network in Lab VIEW

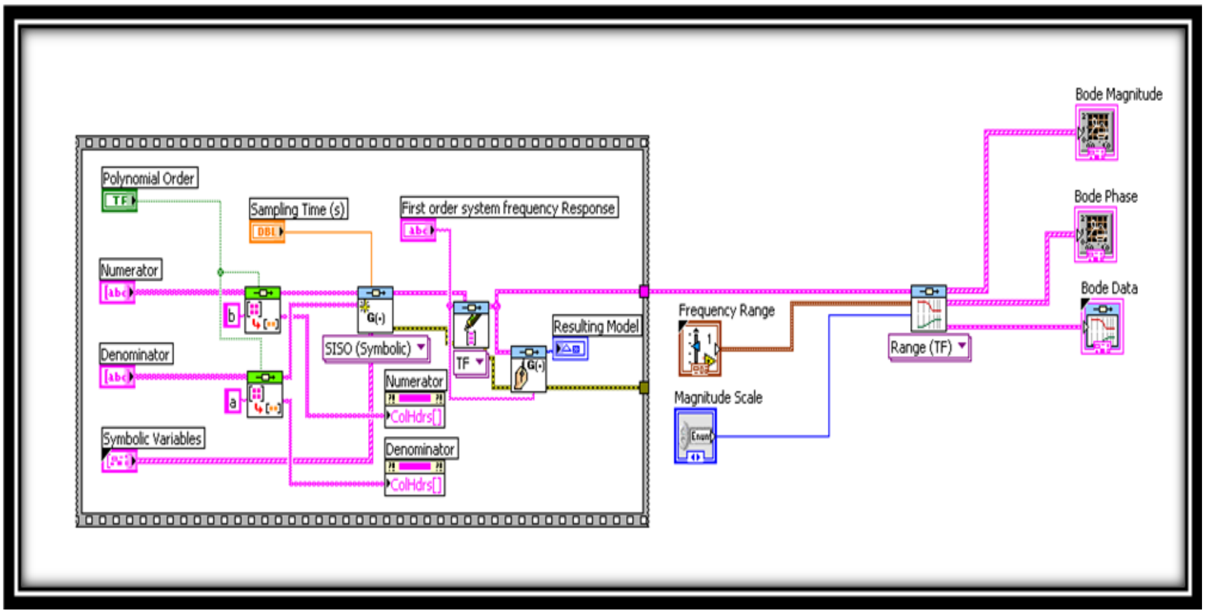


**Fig. 4** The block diagram of R-C network in LabVIEW

## IV. Results and Discussions

Resistor-Capacitor Time Response control model and simulator is constructed with virtual instruments under the LabVIEW environment. In Bode magnitude plot the gain margin is to be added by 20db.The correct magnitude plot is obtained by shifting the plot k=1 by 20 db upwards and in Bode phase plot the phase plot crosses – 180 only at infinity. The magnitude at infinity is –α db .Hence the gain margin is +α.

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