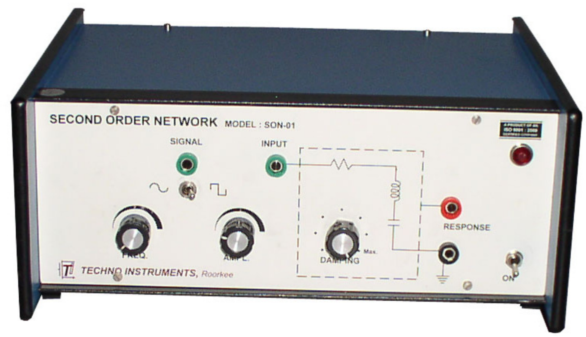
STUDY OF SECOND ORDER NETWORK — SON-01

- **Active second order network**
- **Damping control – over-, critical, and under-damping**
- **Built-in square wave signal**
- **Built-in sine wave signal**
- **Needs an external CRO for response study**
- **Operates with 220V/50 Hz**
- **Detailed technical literature and experiment results supplied**



INTRODUCTION

Second order networks are important because of the fact that these are the simplest networks that produce the complete range of transient response – from over damping to near oscillations. Although theoretical discussions are normally confined to passive RLC networks, such networks are limited in their performance due to the rather large resistance of any reasonable value inductance that might be constructed to operate at frequencies of few kHz. In the present unit active RC-network has been designed which span the complete behaviour of an equivalent passive RLC network. The user thus has the experience of studying a near ideal passive second order network complete with all theoretical computations and their experimental verifications.

THEORY

A second order RLC series circuit, Fig. 1, has the dynamic equation as,

$$e(t) = Ri + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$$

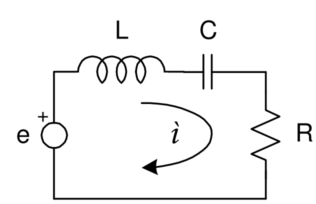


Fig.1

Taking Laplace Transform and rearranging the terms, for an unit step input, the current is given by,

$$I(s) = \frac{\frac{1}{L}}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

The above may be put in the standard, normalized form as,

$$I(s) = \frac{C\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

where,

$$\zeta = \frac{R}{2}\sqrt{\frac{C}{L}} \quad \text{is the damping ratio, and } \omega_n = \frac{1}{\sqrt{LC}} \text{ is the natural frequency.}$$

Various operating conditions, denominator roots and the resulting response may be summarized as,

$\zeta > 1$, two real distinct roots $\Rightarrow$ overdamped
$\zeta = 1$, two repeated roots $\Rightarrow$ critically damped
$\zeta < 1$, complex conjugate roots $\Rightarrow$ underdamped
$\zeta = 0$, two roots on the $j\omega$ - axis $\Rightarrow$ oscillatory

The figure shown next depicts a typical current plot, i(t), for four different values of ζ,. The experiment enables the student to vary the value of damping ratio through a marked dial and observe the nature of response. The experiment suggests methods to compute approximate values of equivalent components using the data obtained from the CRO trace.

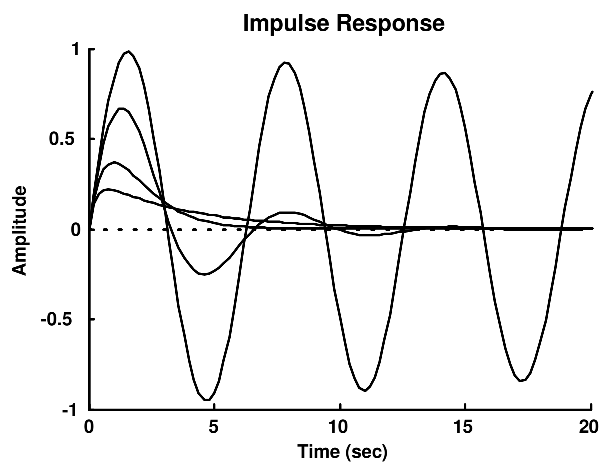


Fig.: **Step Response of Series RLC Network**

A sinusoidal excitation of the network may also be used to obtain its frequency response and observe the phenomenon of resonance for different values of damping ratio.

SUGGESTED EXPERIMENTS

(a) Observe and trace from the CRO screen the step response for different values of ζ.

(b) Compute approximate values of equivalent network parameters.

(c) Plot the frequency response for various values of ζ and observe resonance.