**EXPERIMENT - 1**

**TIME RESPONSE OS SECOND ORDER SYSTEM**

**AIM:** To study the time response of second order system with step input and square input

**APPARATUS:**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No.** | **Nane of the Equipment** | **Rage** | **Qauntity** |
| 1 | Second order system study unit |  | 1 |
| 2 | CRO |  | 1 |
| 3 | CRO Probes |  | 2 |
| 4 | Multimeter |  | 1 |
| 5 | Cables |  | Required |

**Circuit diagram:** L

R



10

Square wave

2H

C 0.32 𝜇𝐹

Signal

**THEORY:**

This unit consists of two parts:-

1. Signal source for second order system.
2. A second order system.

## Signal Source:

The Signal source generates the necessary input excitation supply for the second order system under different damping factor and time constant. This part generates a square wave of 15 Hz approximately. A switch is provided to select square wave or step (DC) source. ON/OFF switch is provided for signal source. Amplitude of the signal source can be varied from 0V to 15 V approximately for square wave and 0 V to 10 V approximately for DC source.

1. **Second order source:**

This part consists of a second order system built using Op-amp.

In order to study the behavior of a second order system with varies damping factors, facility has been provide to select the damping factor -0.3,0.7,1 and2.

In order to study the behavior of a second order system with different time Constants, facility has been provide to choose the constant at 3m sec or 5 sec.

The input & output terminals of the second order system are brought out on the front panel independently, So we can also use external signal source to study the frequency response if the system.

# SECOND ORDER SYSTEM USING R L C

## PROCEDURE:

* 1. Switch ON the mains supply to the unit, observe the signal source output by selecting square wave or step input and by varying amplitude potentiometer.
  2. Make sure signal source is correct before connecting the input of the second order system.

3 ) Now Select square wave signal. Draw the input square wave signal.

1. Connect the output of square wave signal source to second order system using RLC.
2. Draw the second order system o/p for different values of damping factor 0 to 2 in steps of 0.1 by varying Potentiometer R provided.
3. Compare this with the theoretical wave forms.
4. Measure the R value using Digital DC voltmeter or multimeter between the I/P terminals with main switch in OFF position.

**SECOND ORDER SYSTEM STUDY UNIT**



0.7

1

SIGNAL SOURCE

2

0.3

Time constant

3 m Sec

Damping factor

𝑅(𝛼)

AMPLITUDE

R

5 Sec

USING RLC

SQ

ON

**I N P U T**

USING OP-

OUTPUT

OUTPUT TO

CRO

STE

OFF

POWE

Second order

system

**Connection diagram for SECOND ORDER SYSTEM using RLC**

**SECOND ORDER SYSTEM STUDY UNIT**



SIGNAL SOURCE

0.7

1

Time constant

3 m Sec

2

0.3

Damping factor

5 Sec

AMPLITUDE

USING RLC

SQ

ON

OUTPUT

STE

OFF

**I N P U T**

USING OP-AMP

OUTPUT TO

CRO

POWE

Second order

system

**Connection diagram for SECOND ORDER SYSTEM using op amp for square input**

**SECOND ORDER SYSTEM STUDY UNIT**



SIGNAL SOURCE

0.7

1

Time constant

3 m Sec

2

0.3

Damping factor

5 Sec

AMPLITUDE

USING RLC

SQ

ON

OUTPUT

**I N P U**

USING OP-AMP

STE

OFF

**T**

TO MULTIMETER OR DSO

TO

POWER

Second order

system

**Connection diagram for SECOND ORDER SYSTEM using op amp for STEP input**

**Front Panel Details:-**

1. **Power** : Mains ON/OFF Switch to the unit with built in indicator.
2. **Amplitude** : Potentiometer to vary the amplitude of signal source.
3. **Sq./Step** : Switch to select square wave or step (DC) input.
4. **ON/OFF** : ON/OFF Switch for signal.
5. **OUTPUT** : Signal output points.
6. **Damping factor** : Switch to select damping factor 0.3/0.7/i&2.

**7 .INPUT** : Second order system input points to connect signal source.

1. **OUTPUT** : Second order system input points
2. **Time constant** : 3m sec/5 sec : Switch to select time constant.
3. **R (α)** : Potentiometer to vary damping factor of second order system using RLC varying R.
4. **R** : Terminals to measure R (Resistance) of second order system using RLC

**PROCEDURE:-**

* 1. Switch ON the mains supply to the unit observe the signal source output by selecting square wave or step input and by varying amplitude potentiometer.

2 ) Make sure that the signal source is correct before connecting the input of the second order system.

* + 1. Now select square wave signal and 3 m sec time constant. Draw the input square wav signal
    2. Connect signal output to second order system input
    3. Draw the second order system o/p for different values of damping factor 0.3, 0.7, 1 and 2. Compare this with the theoretical wave forms.
    4. Select step input, adjust the amplitude potentiometer to get 5 Volts DC and select 5sec time constant .Switch off the signal.
    5. Now Switch ON the signal, monitors the second order system o/p using a multimeter .Note down the o/p voltage for every second.
    6. Draw the graph of time v/s voltage.
    7. Repeat the same for different damping factor.
    8. When testing a second order system with large time constant -5 sec, it is essential to supply a DC as a step voltage. This source provides a DC step input to the system by selecting sep signal and by switch ON the signal source from OFF to ON.
    9. When testing a second order system with low time constant – 3 m sec ,the response of the system for a step input stabilizers to its final value within about 50-75m sec .In such case, the system response for a step can be studied by giving a repeated step, which is effectively, a square wave.
    10. Input level to the system should be chosen so as to obtain the output response within the saturable voltage of op-amp +nor -15 V
    11. The amplitude should be within 5 to 8 V. If a much lower input voltage is selected the other interference’s such as mains picks up can be become relatively higher & the response obtained may not be satisfactory.
    12. The parameter of a second order system such as delay time, rise time, peak time, settling time and peak overshoot are important parameter to be understood.
    13. For zeta less than I, the system is under damped and the system response shows overshoot for very low damping factor the step response is DC superimposed with an exponentially dying cosine waveform.
    14. For zeta greater than 1, the system said to have over damped response. In practical system, the damping factor is set between 0.7 and 1.

Note: Use 3 pin grounded mains supply to the unit avoids line interference. Use proper CRO probe to see the output wave forms.

**TABULAR COLUMN:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.No.** | **R**  **in (Ώ)** | **L**  **in (Henry)** | **C**  **in (Farad)** | **Damping Factor**  𝜹 | **Delay Time**  𝒕𝒅  **(sec)** | **Rise Time**  𝒕𝒓  **(sec)** | **Max. power over shoot**  𝑴𝒑  **(volts)** | **Peak Time**  𝒕𝒑  **(sec)** | **Setting Time**  𝒕𝒔  **(sec)** | 𝒆𝒔𝒔 |
| 1 |  |  |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |  |  |  |

**Calculation:**

Undamped Natural frequency, wn  

1

LC

Damping factor, ζ  

R C

2 L

Delay time, td 

ω 1 ζ2

n

1 0.7 ζ 

Rise time, tr  

π Tan 1( 1 ζ2 /ζ )

ω 1 ζ2

n

Peak time, tp  

π

ω 1 ζ2

n

Settling

time, ts

ts

(for 2% tolerance) 

(for 5% tolerance) 

4 

ζωn

3 

ζωn

1ζ2

p

% Peak overshoot,

% M  eπζ/ 

Transfer function,

ω 2

T(s)  n 

s2  2 ζω s ω 2

n n

**Model Graph:**

Vc (t)



Mp

O td tr tp t

**Result :**