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| **Course Name:** | **Automation & Control Systems** | **Semester:** | **V** |
| **Date of Performance:** | **07 / 08 / 2024** | **Batch No:** | **B - 1** |
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| **Faculty Sign & Date:** |  | **Grade / Marks:** | **\_\_\_ / 25** |

**Experiment No.: 3**

**Title: To determine response of first order and second order systems.**

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| **Aim and Objective of the Experiment:** |
| To determine response of first order and second order systems for step input for several of constant `K’ using linear simulator unit and compare theoretical and practical results. |

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| **COs to be achieved:** |
| **CO2:** Describe and design control systems. |

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| **Theory:** |
| A thorough understanding of transient response analysis is a pre-requisite for this experiment. Although the topic is covered in great detail in all the text books on automatic control, a brief description of the portions relevant to the experiment is presented below.    **Fig1. Linear System Simulator**   1. **First Order System:** These are characterized by one pole and/or zero. A pure integrator and a single time constant, having transfer function of the form K/s and K/ (sT+1), are the two commonly studies representatives of this class of system. Many thermal systems thermal systems and electrical systems with R-C/R-L element are the examples of first order systems.   Unit step response of the systems is computed as follows and are shown in fig 2(a),    If C(s)/R(s)=G(s)= K/s then for R(s) = 1/s  C(s) = K/S2, and c(t) = K\*t (1)  Again, if G(s)=K/(sT+1) then with R(s) = 1/s  C(s) = K/s(sT+1), and c(t) = K(1-e-t/T).……………………………………………………..…. (2)  Time constant of the system is defined from eq (2) at t = T which gives  C(T) = K(1-e-1) = 0.632K  This is an important characteristic of the system which is also defined in terms of the slope of the response curve at t = 0.  For proper viewing in CRO, the step input needs to be replaced by a square wave of sufficiently low frequency (to allow c(t) in equation 2 to reach up to 99% of its final value). This is shown in the second sketch of fig 2(b). However, in the first sketch of fig 2b a triangular wave output results since frequency is not sufficiently low. If may further be seen that if the square wave is of frequency f and peak-to-peak input amplitude is 1V, the peak-to-peak amplitude of the triangular wave at the output of the pure integrator is given as K/4f.    **Fig 2(a). Unit Step Response of First Order Transfer Functions**    **Fig 2(b). Unit Step Response of First Order Transfer Functions**   1. **Second Order System:** These systems are characterized by two poles and up to two zeros. For the purpose of transient response studies, zeros are usually not considered primarily because of simplicity in calculations and also because the zeros do not affect the internal modes of the system. A great deal of analytical results regarding second order systems is available in the text books. This forms the basis of studying higher order systems many of which can be approximated to second order.   A second order systems is represented in the standard form as,        **Closed Loop Systems:**  Closed loop or feedback systems involve a measurement of the output of the system and generation of the control signals, which are based on decision making under the influence of a command or reference and the measured values of the output (Fig.3). Such system is of great interest to control engineers due to features like automatic correction, disturbance rejection, immunity to noise and parameter variation etc. A study of the performance of closed loop system is the basics objective of this experiment. It may be easily appreciated that although the mathematically description of a closed loop system is no different form that discussed earlier, the fact that variation of forward path gain shifts the pole location, changes the situation drastically and makes direct computation of little value. Referring to  Fig3., the closed loop transfer function for different open loop functions is shown below:    Thus, the response of the closed loop system can be altered by varying the open gain K and as a consequence it should be possible to choose K to obtain a suitable performance.  This leads to the concept of performance characteristics as defined on the step response of an underdamped second order system in Fig. 4. It must be noted that these specifications are not restricted to second order system, although the mathematical expression/definitions given below are valid and computationally practicable for second order systems only. |

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| **Procedure:** |
| **Open Loop Response:**  As a first step, the open loop transfer function of all the books viz. integrator, time constant, uncommitted amplifier and error detector/adders are to be determined experimentally. All measurement is done with the help of a measuring oscilloscope and the signal source is the built -in –square wave generates in each case. Further, to get a properly synchronized waveform, especially for small values of signals, it will be convenient to use the built – in trigger source keeping the CRO in external triggering mode. A double beam CRO for the simultaneous viewing of input output is recommended. Note that the value of 𝑘1,2, 𝐾3 and 𝑇1, 𝑇2 obtained experimentally may differ somewhat from their nominal value indicated.   1. **Error Detector Cum Variable Gain**    * Apply a 100mV square wave signal to any of the three inputs.    * Set the gain setting potentiometer to 10.0    * Measure the P-P output voltage notes its sign. Calculate the gain. This is the maximum value of gain possible for this block.    * Repeat for the other two inputs one by one.    * Write the equation of this block and verify by connecting the signal to all three inputs. 2. **Disturbance Adder**    * This section may be tested exactly in the same manner as (a) except that three are only two inputs and there is no gain setting potentiometer. 3. **Uncommitted Amplifier**    * Apply a 1 volt p-p square wave input.    * Measure the p-p output voltage and note its sign.    * Record the equation of this block for later use. 4. **Integrator**    * Apply a 1 volt p-p square wave input of known frequency (frequency measured by CRO)    * Measure the p-p output voltage of the triangular wave and also note its phase.    * Calculate the gain constant K of integrator as discussed, and write the transfer function of this block. 5. **Time Constant**    * Apply a 100 mV square wave of known frequency (measured by the CRO). For this experiment, the frequency should be selected towards the lower and to ensure that steady state is nearly reached.    * Find on the track the time t=T at which the response reaches 63.2%. this is the time constant.    * Find on the track the steady state value of the response. The value of K is given by the ratio of p-p stead state output to the p-p input amplitude.    * Write transfer function of the block as discussed.    * The wave form in the CRO may be traced on the tracing paper for analysis   **Closed Loop Response:**   * Two forms of first order closed loop system, as shown in Fig.5 are possible. Make proper connections for the configuration chosen. * Apply a 1 volt square wave input and trace the output waveform on a tracing paper for K = 0.5. 1.0, * 1.5 …. Calculate the time constant in each case and compare with theoretical result. |

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| **MATLAB Simulation Result:** |
| **First Order System Block Diagram:**     |  |  | | --- | --- | | **Step** |  | | **Ramp** |  | | **Impulse** |  |   First Order System using MATLAB code –    **Second Order System Block Diagram:**     |  |  | | --- | --- | | **Step** |  | | **Ramp** |  | | **Impulse** |  |   Second Order System using MATLAB code –    **Varying ζ values:**  **ζ = 0, ζ = 1, ζ > 1, 0 < ζ < 1**  Block Diagram for varying ζ –     |  |  | | --- | --- | | **ζ** | **Graphs** | | **ζ = 0** |  | | **ζ = 1** |  | | **ζ > 1, ζ = 5** |  | | **0 < ζ < 1, ζ = 0.5** |  |   **Varying ωn while keeping ζ constant:**  **ζ = 1**  Block Diagram for varying ωn –     |  |  | | --- | --- | | **ωn** | **Graphs** | | **ωn = 1** |  | | **ωn = 3** |  | | **ωn = 5** |  | | **ωn = 10** |  | |
| **Conclusion:** |
| The experiment demonstrated that first-order systems exhibit a single exponential response, while second-order systems show oscillatory behavior whose damping and frequency depend on ζ and ω. By varying ζ, we observed the transition from underdamped to overdamped responses, highlighting the critical role of damping in system stability and response time. |

**Signature of faculty in-charge with Date:**