SEHS4653 Control System Analysis

Experiment 2 : Application of PID Controller

Objective : Tuning PID controller parameters and then apply it to the DC servo motor speed control

Equipment : PC computer, Matlab with Simulink, ACS-1000 Analog Control System, ACS-18001 DC servo motor & control unit

Procedure :

<u>Tunning of PID Controller Parameters by Trial-and-Error Method</u>

1. Figure 1 shows the block diagram of closed-loop control system with a plant plus PID controller.

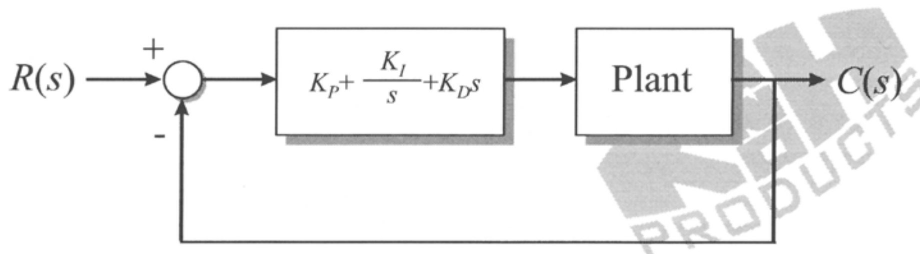


Figure 1. Block diagram of the closed-loop system.

2. The plant is the DC servo motor speed control system which has the following transfer function,

$$\frac{10}{s+10}$$

Then, the combined transfer function of PID controller plus plant becomes,

$$\left(K_p + \frac{K_I}{s} + K_D s\right)\left(\frac{10}{s+10}\right) = \frac{K_D s^2 + K_p s + K_I}{\frac{1}{10}s^2 + s}$$

3. Draw the block diagram in Simulink as shown below.

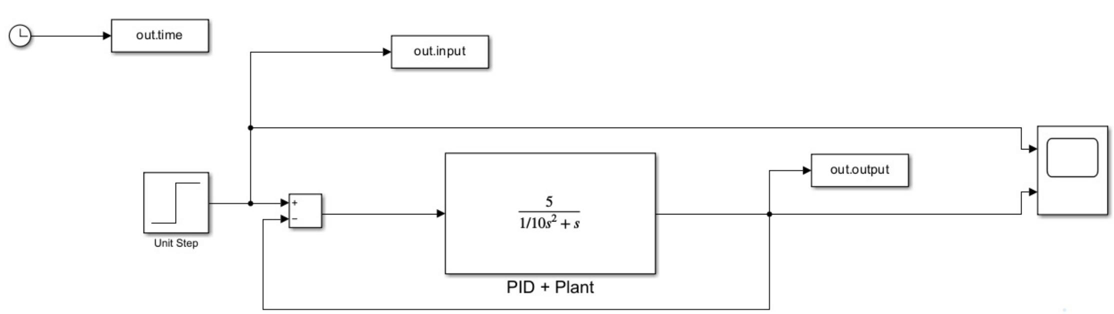


Figure 2. Block diagram in Simulink.

4. Set the “Final value” to 1 and “Step time” to 0 in the **Step** block. Adjust the simulation stop time to 0.2 in the menu bar.

5. Save the block diagram as Lab3.slx (or Lab3.mdl).

6. Modify the coefficient of s^0 term of numerator of “PID + Plant” transfer function K_I to make 15% ~ 20% overshoot by setting K_P and $K_D = 0$. Record the value K_I.

7. Modify the coefficient of s term of numerator of “PID + Plant” transfer function K_P to make overshoot disappeared. Record the value of K_P.

8. Modify the coefficient of s^2 term of numerator of “PID + Plant” transfer function K_D to make the system response quick. Record the value K_D.

9. Repeat Steps 6 to 8 until satisfactory.
Note: Due to the hardware limitation. Take note on the operating range of K_P and K_I : 0 ~ 500, and K_D : 0 ~ 1.

<u>PID Controller Used in DC Servo Motor Speed Control</u>

10. Complete the connections by referring to the block diagram and wiring diagram shown in Figures 3 and 4.

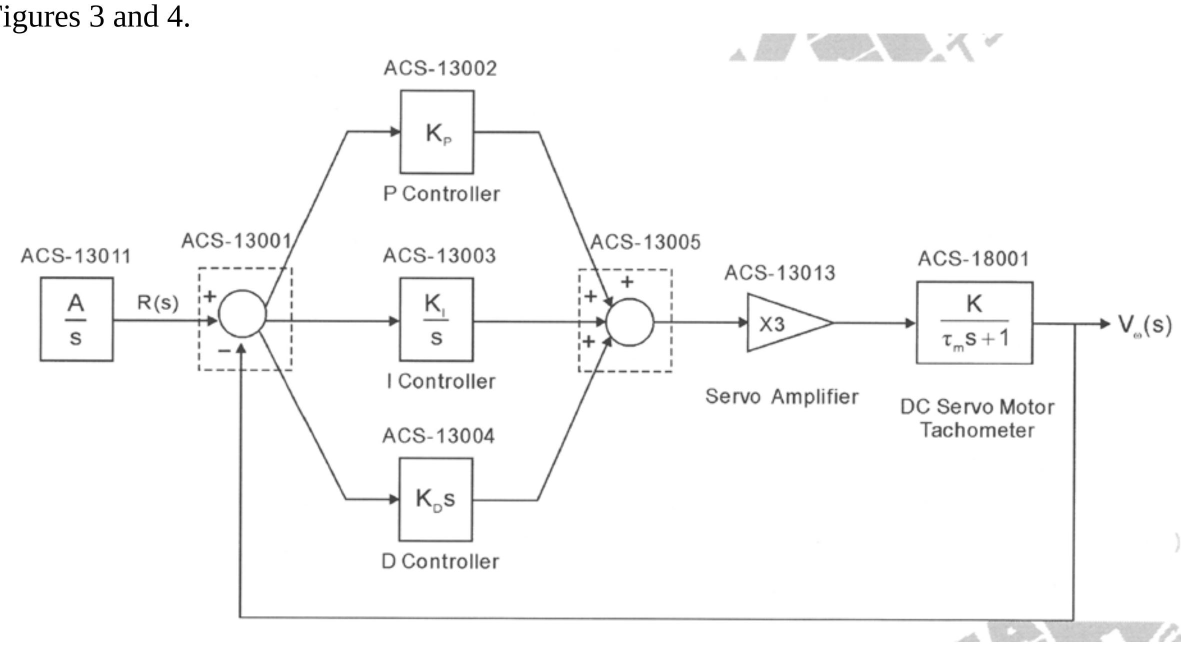


Figure 3. Block diagram.

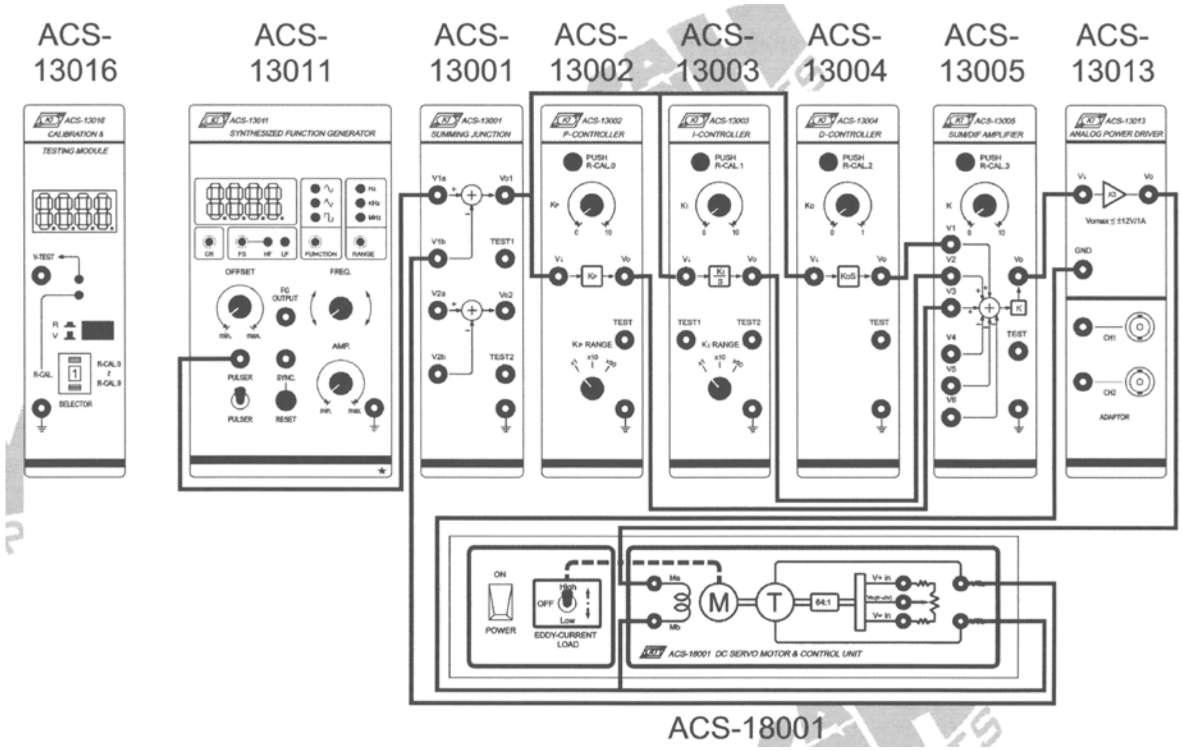


Figure 4. Wiring diagram.

11. On ACS-13011, pull **OFFSET** control knob, adjust **OFFSET** and **AMP** control knobs to generate a 4 Vpp pulse (low level = 0 V) at **PULSER** output terminal.

12. Set K = 1 by turning the K control knob on ACS-13005 until the ACS-13016 R-CAL.3 displays 10.

13. Input your K_P (ACS-13002), K_I (ACS-13003) and K_D (ACS-13004) values obtained in Step 9 to control the DC servo motor speed.
Note: Before pressing the R-CAL push button switch to set parameters in ACS-13016, disconnect the connecting wire to motor coil terminal Ma.

14. You may require to re-tune your PID controller for obtaining a satisfactory response.

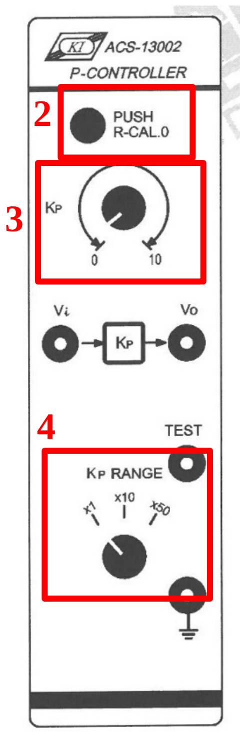
15. Record the system response and **store in your USB**.

16. Compare the system responses between your PID controller and other controller(s) as given by lecturer(s) after all the lab sessions ended.

17. State the limitations of the experiment.

Appendix A: Analog Control System (ACS-1000) Manual

ACS-13002 P-Controller



To set **K_P = 1**

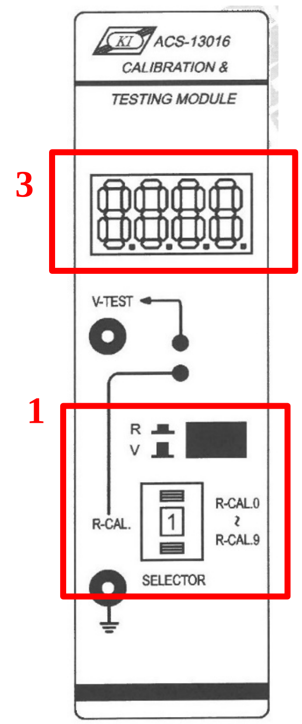
1. On ACS-13016 (right hand side), set "**SELECTOR**" switch to **0** (R-CAL.0) and set the R/ V selector switch to **R** position.

2. On ACS-13002 (left hand side), press "R-CAL.0" pushbutton switch.

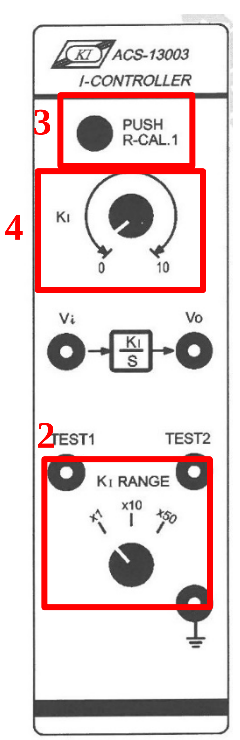
3. Turn the K_P control knob until the ACS-13016 R-CAL.0 **displays 10**.

4. Set K_P "**RANGE**" selector switch to **x1** position.

Conclusion: **Display = 10 × K_P**



ACS-13003 I-Controller



To set **K_I = 10**

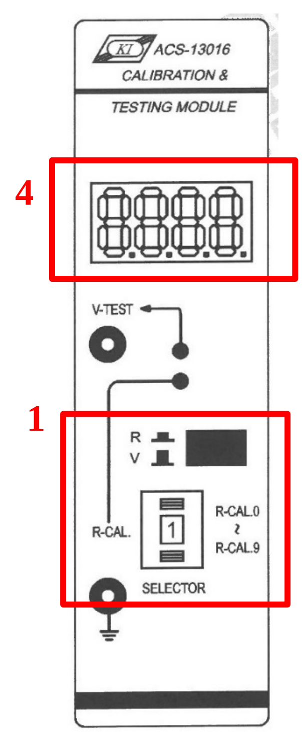
1. On ACS-13016 (right hand side), set "**SELECTOR**" switch to **1** (R-CAL.1) and set the R/ V selector switch to **R** position.

2. Set K_I "**RANGE**" selector switch to **x10** position.

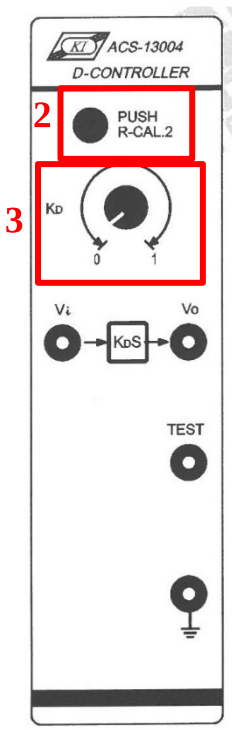
3. On ACS-13003 (left hand side), press "R-CAL.1" pushbutton switch.

4. Turn the K_I control knob until the ACS-13016 R-CAL.1 **displays 100**.

Conclusion: **Display = 10 × K_I**



ACS-13004 D-Controller



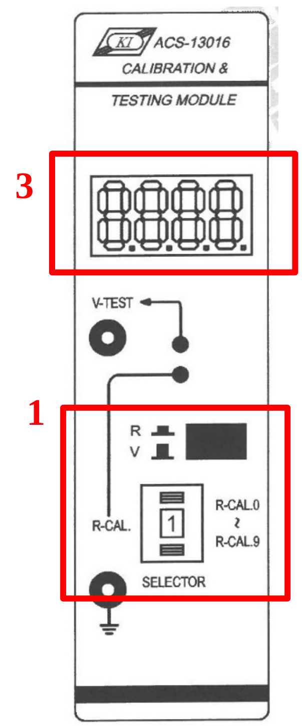
To set **K_D = 0.1**

1. On ACS-13016 (right hand side), set "**SELECTOR**" switch to **2** (R-CAL.2) and set the R/ V selector switch to **R** position.

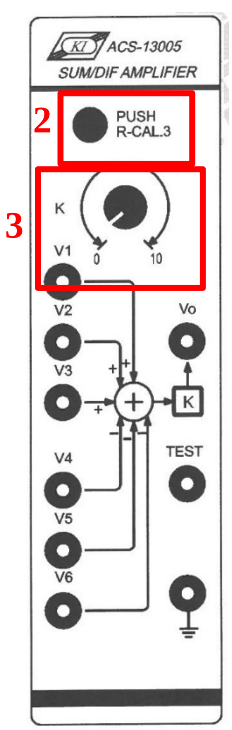
2. On ACS-13004 (left hand side), press "R-CAL.2" pushbutton switch.

3. Turn the K_D control knob until the ACS-13016 R-CAL.2 **displays 10**.

Conclusion: **Display = K_D / 0.01**



ACS-13005 SUM/DIF Amplifier



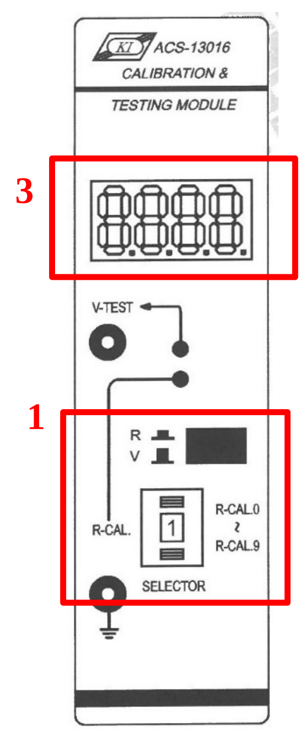
To set **K = 1**

4. On ACS-13016 (right hand side), set "**SELECTOR**" switch to **3** (R-CAL.3) and set the R/ V selector switch to **R** position.

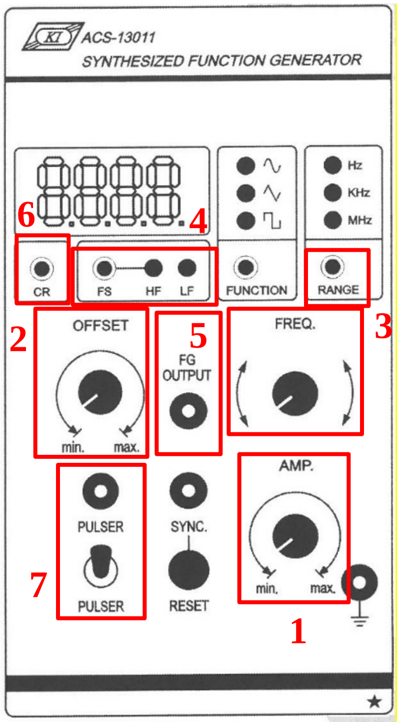
5. On ACS-13005 (left hand side), press "R-CAL.3" pushbutton switch.

6. Turn the K control knob until the ACS-13016 R-CAL.3 **displays 10**.

Conclusion: **Display = 10 × K**



ACS-13011 Synthesized Function Generator



Output Wave: (a) Sine, (b) Triangle, (c) Square and (d) Step

1. Amplitude (100 mVpp – 18 Vpp): **AMP** control knob

2. DC Offset (-10 V – +10 V): **OFFSET** control knob
   0 V Offset: Depress **OFFSET**
   Adjust offset: Pull **OFFSET** control knob then turning

3. Frequency (6 ranges): **FREQ** control knob and **RANGE** selector
   (a) 0.01–10 Hz, (b) 0.1–100 Hz, (c) 1–1000 Hz, (d) 10 Hz – 10 KHz, (e) 100 Hz – 100 KHz, and (f) 1 KHz – 1 MHz

4. Push **FS** button to makes **FREQ** control knob alternate between coarse to fine modes.
   HF ON: Coarse tuning mode
   LF ON: Fine tuning mode

5. Use an oscilloscope to measure and observe the output waveform at **FG OUTPUT** terminal.

6. Default value (100 Hz sine in 100 Hz frequency range): **CR** button

7. Step function: **PULSER** output terminal and push **PULSER** button and use **AMP** and **OFFSET** for adjustment.

End of Experiment 2

Updated on 13 Feb 2023