# ME 360: FUNDAMENTALS OF SIGNAL PROCESSING, INSTRUMENTATION, AND CONTROL

## Experiment No. 5
## Speed Control of a DC Electric Motor
## Data Sheet

### Simulation of Motor-generator System (15 pts.)

| Test Case | $V_{in}$ [V] | $\omega$ [rpm] | $V_{gen}$ [V] |
|---|---|---|---|
| 1 | 3 | | |
| 2 | 4 | | |
| 3 | 5 | | |

$V_{in}$ = input to motor    $\omega$ = steady-state motor speed

### Simulation of Motor-generator System with PI Speed Control (20 pts.)

| | Test Case | $\omega_{ref}$ [rpm] | $K_P$ | $K_I$ | $T_{dist}$ [N-m] | $\omega_{out}$ [rpm] | $V_{gen}$ [V] | $t_{rise}$ (5 – 95%) [ms] | $\omega_{err}$ [rpm] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Open-loop | 1000 | 1 | 0 | 0 | | | | |
| 2 | Closed-loop | 1000 | 2 | 0 | 0 | | | | |
| 3 | Closed-loop | 1000 | 2 | 0 | 0.02 | | | | |
| 4 | Closed-loop | 1000 | 2 | 0 | 0.04 | | | | |
| 5 | Closed-loop | 1000 | 4 | 0 | 0.04 | | | | |
| 6 | Closed-loop | 1000 | 8 | 20 | 0.04 | | | | |
| 7 | Closed-loop | 1000 | 8 | 50 | 0.04 | | | | |
| 8 | Closed-loop | 1000 | 8 | 100 | 0.04 | | | | |

$\omega_{ref}$ = set-point motor speed    $\omega_{out}$ = steady-state motor speed    $\omega_{err}$ = steady-state error = $\omega_{out} - \omega_{ref}$
$K_P$ = Proportional gain    $K_I$ = Integral gain    $t_{rise}$ = rise time    $T_{dist}$ = Disturbance torque

**Observations / Conclusions**

**Sketch the typical motor response with and without integral control. (5 pts.)**

## Testing the Motor-generator System with PI Speed Control (15 pts.)

| Test Case | | $\omega_{ref}$ [rpm] | $K_P$ | $K_I$ | $\omega_{out}$ [rpm] | $V_{gen}$ [V] | $\omega_{err}$ [rpm] |
|---|---|---|---|---|---|---|---|
| 1 | Closed-loop | 1000 | 4 | 0 | | | |
| 2 | Closed-loop | 1000 | 4 | 10 | | | |
| 3 | Closed-loop | 1000 | 4 | 20 | | | |
| 4 | Closed-loop | 1000 | 4 | 50 | | | |
| 5 | Closed-loop | 1000 | 8 | 10 | | | |

**Sketch the motor response for Cases 2, 3 and 5 to show the effects of varying $K_P$ and $K_I$ (5 pts.)**

## <u>Disturbance rejection</u> (5 pts.)

**Ask your TA to help you add a disturbance to the motor's shaft when the controller is running. Comment on how the motor reacts without and with integral control.**

## <u>Integral Windup</u> (5 pts.)

**Sketch motor response with the integral windup problem. Why does this large overshoot occur?**