EGR 431 Control Systems

Lab 4: QET DCMCT Speed Control with a PI Controller

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Introduction

This lab teaches students several topics regarding the QET DCMCT. Students will learn about the properties of proportional and integral action as well as practice the Ziegler-Nochols tuning procedure. Students will also modify and deign a PI controller based on given specifications. The last topic students will gain experience in is the technique of set-point weighting.

Development

Equipment/Part List

1. QET DCMCT

Implementation

Step 3.1: Start-Up Procedure

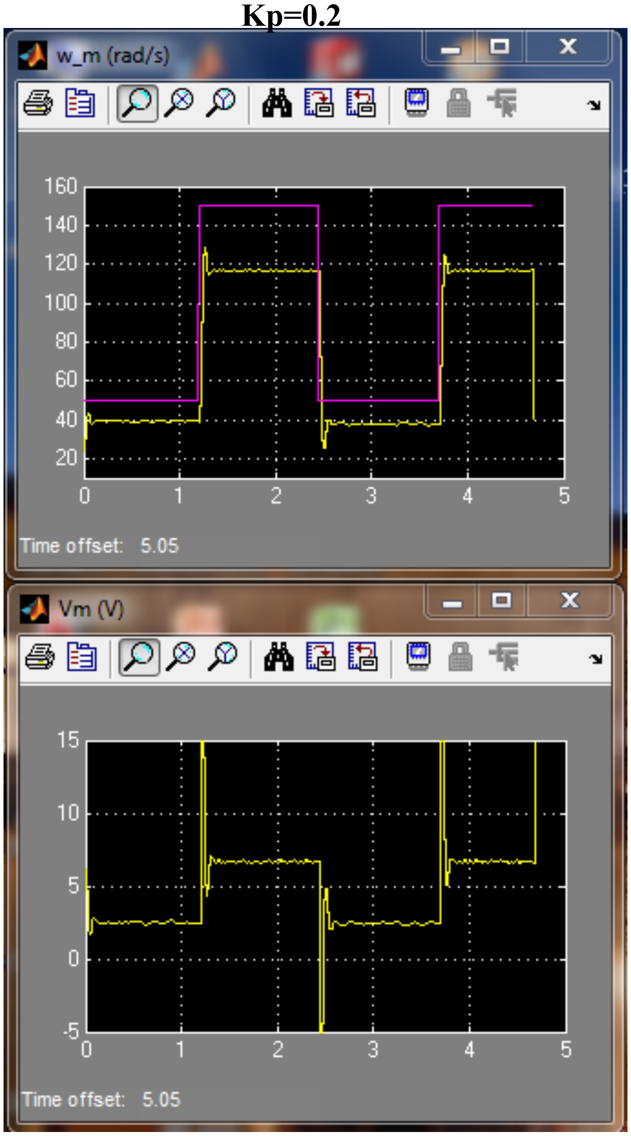
We began by setting up the QET DCMCT based on the connections given in Lab 1. We then ran the “setup_spd_cntrl.m” file and build the model “q_qet_spd_cntrl.mdl”.

Step 3.2: Pure Proportional Control

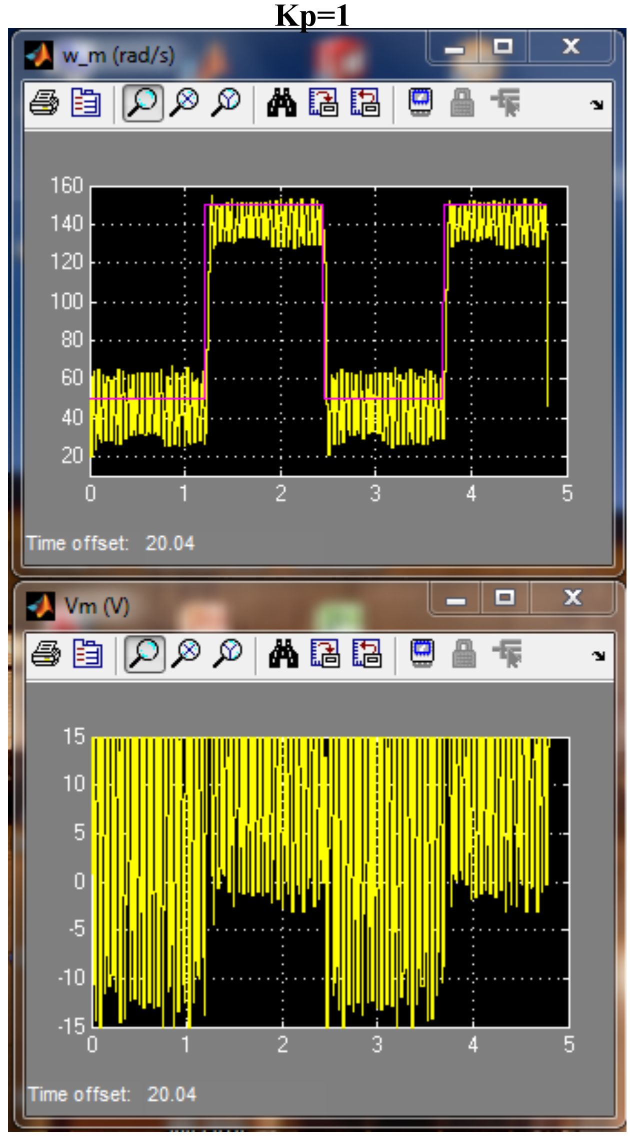
After setting up the QET DCMCT, we changed the parameters specified in the lab manual.

a) We changed the gain by steps of 0.04 (Vs/rad). Our screen shots are shown below.

Kp=0.2

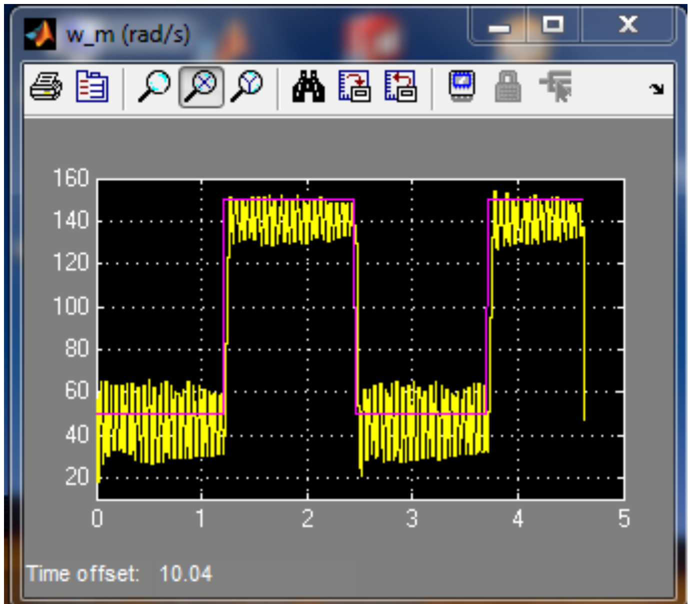


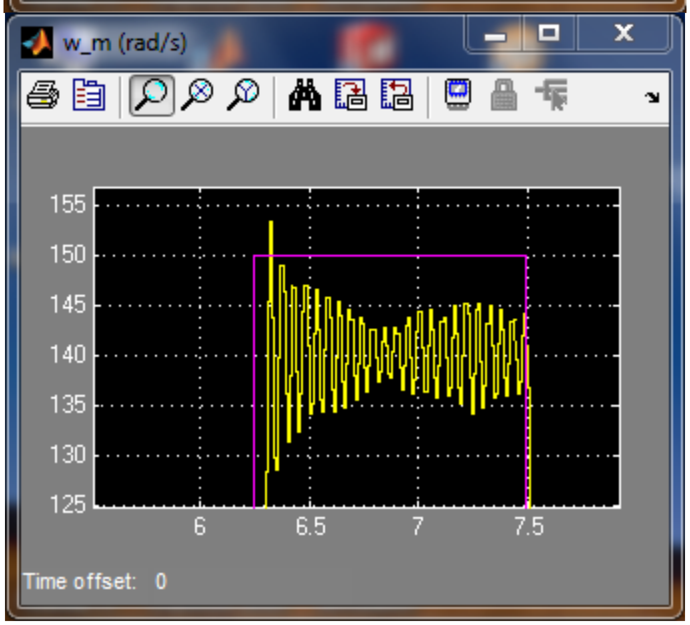
Kp=1



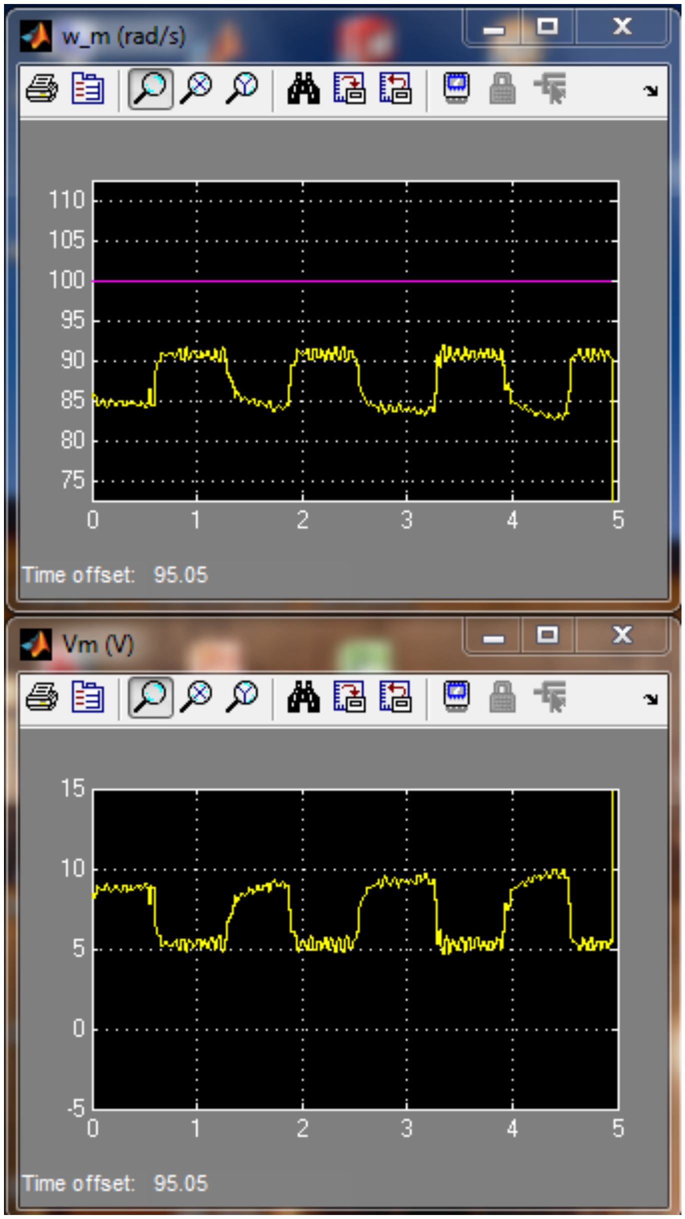
b) We then adjusted the K value until we found the system to be marginally stable. From this, we determined K_{pc} and T_{pc}. Our results and screen shots are shown below.

$K_{pc} = 1.07$
$T_{pc} = 6.6\text{ms}$





c) We then set the amplitude of the square wave to 0 to make the reference signal 100rad/s. We then ran the model and gently touched the load wheel to give the system a disturbance. Our screen shot is shown below.

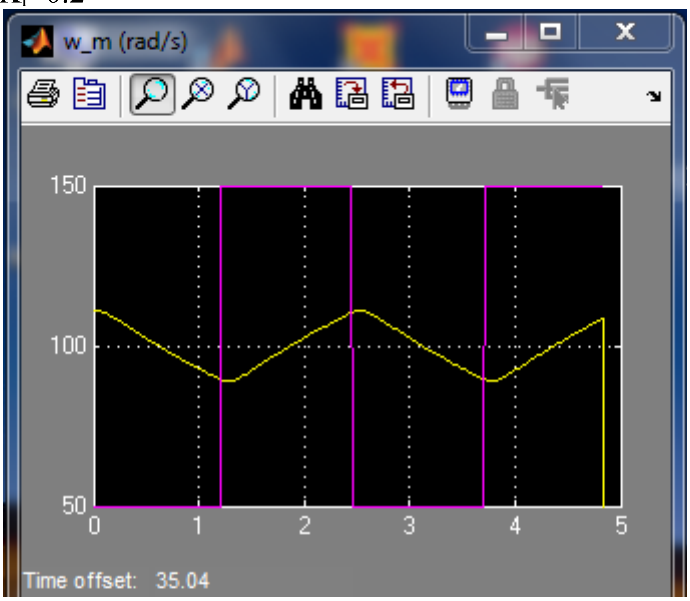


Step 3.3: Pure Integral Control

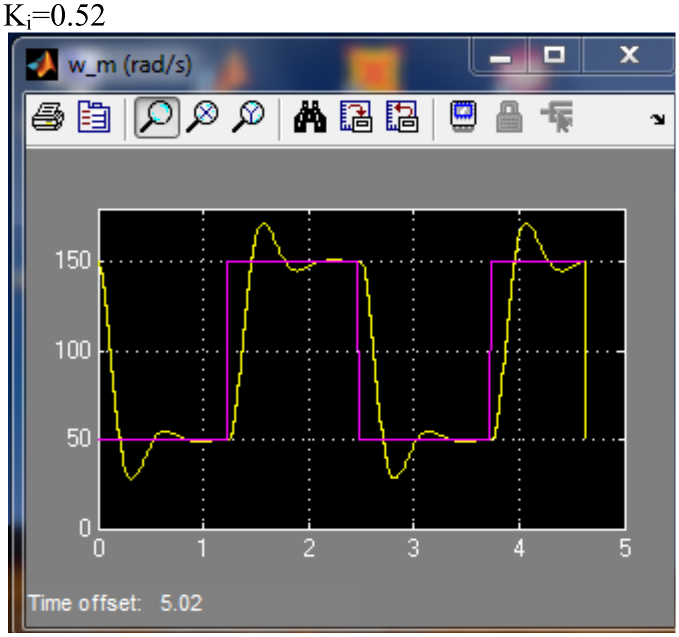
We were then instructed to set the reference signal to a square wave with an amplitude of 50rad/s, a frequency of 0.4Hz, and offset value of 100rad/s. We also set $K_p = 0$ and $K_i = 0.02$ (V/rad).

d) We changed the integral gain by steps of 0.5 (Vs/rad). Our screen shots are shown below.

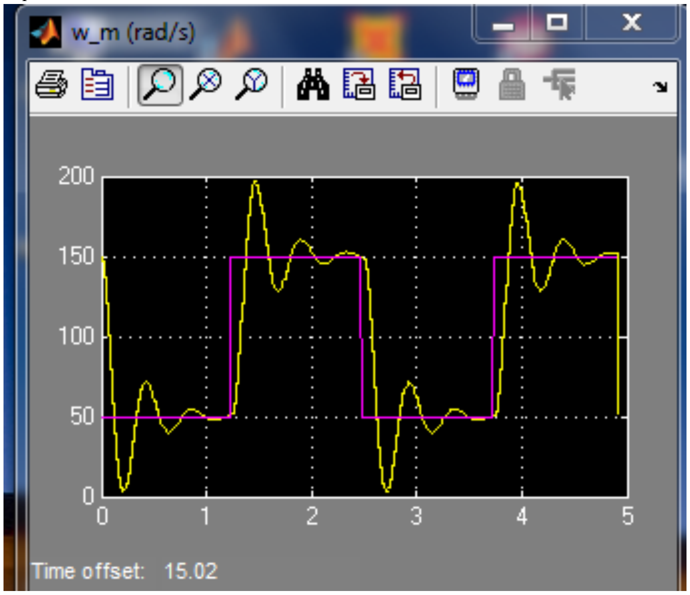
K_i=0.2



K_i=0.52

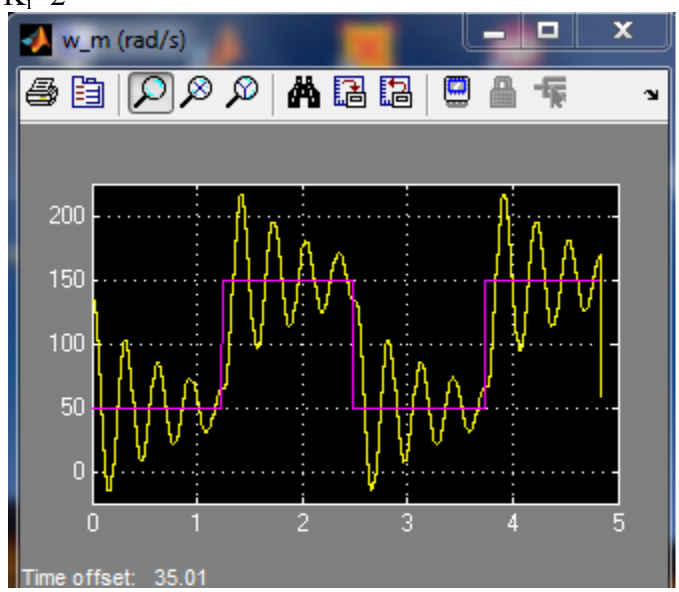


K_i=1.02



w_m (rad/s)
200
150
100
50
0
0
1
2
3
4
5
Time offset: 15.02

K_i=2

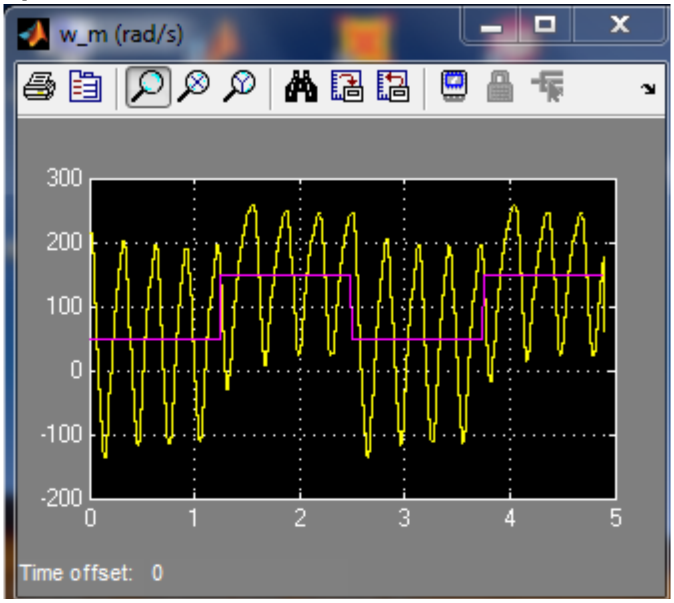


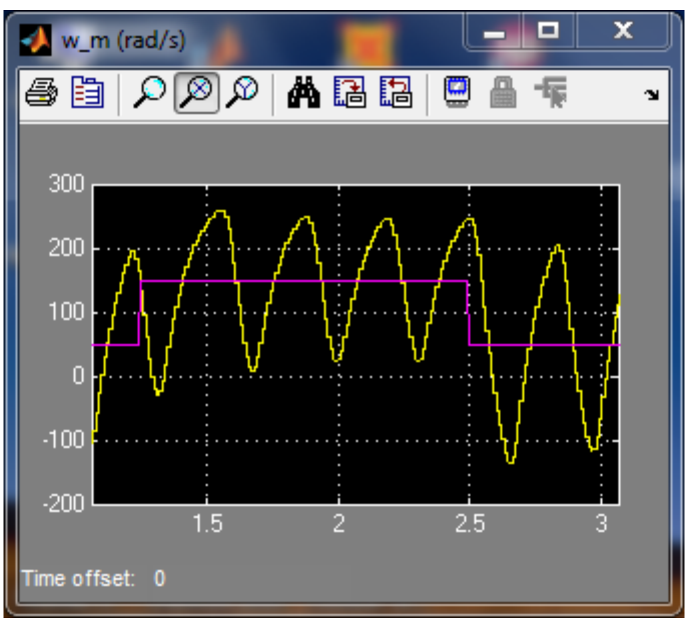
w_m (rad/s)
200
150
100
50
0
0
1
2
3
4
5
Time offset: 35.01

e) We then proceeded to find the value of K which causes the sytem to be marginally stable. From this, we determined K_{ic} and T_{ic}. Our results and screen shots are shown below.

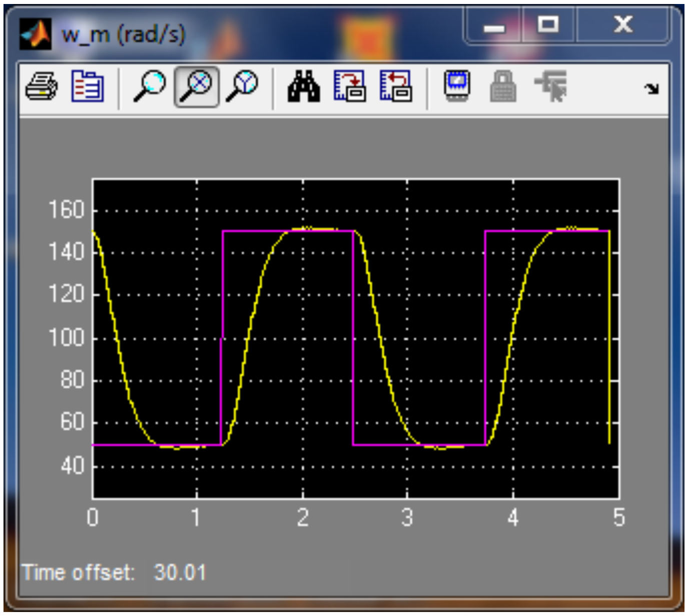
$K_{ix} = 0.2$
$T_{ic} = 0.25s$

$K_i = 3.9631$

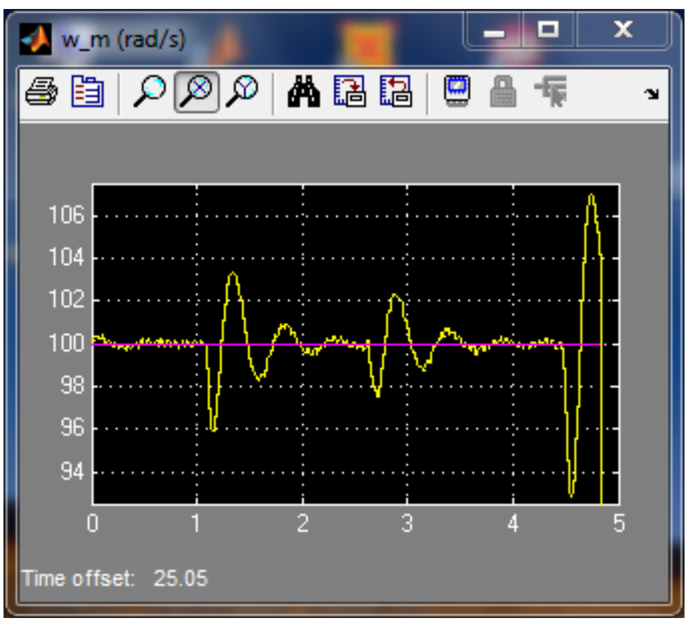




f) We then found the value of the integral gain for which the response does not have overshoot. Our result and screen shot are shown below.



g) We again set the reference signal to 100rad/s and gave the system a disturbance by tapping the load wheel. Our screen shot it shown below.



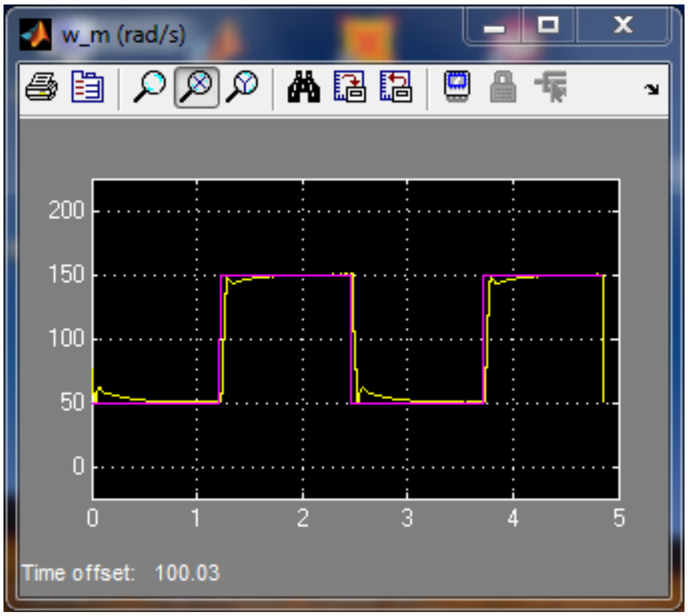
Step 3.4: Ziegler-Nichols Tuning of PI Controller

a) We calculated the values of K_p and K_i using the formulas $K_p=0.45K_{pc}$ and $K_i=0.54K_{pc}/T_{pc}$
We then used these values and the given parameters to set the model. We then ran the model and observed the response. Our calculation results and screen shot are shown below.

$K_p = 0.4815$
$K_i = 11.556$

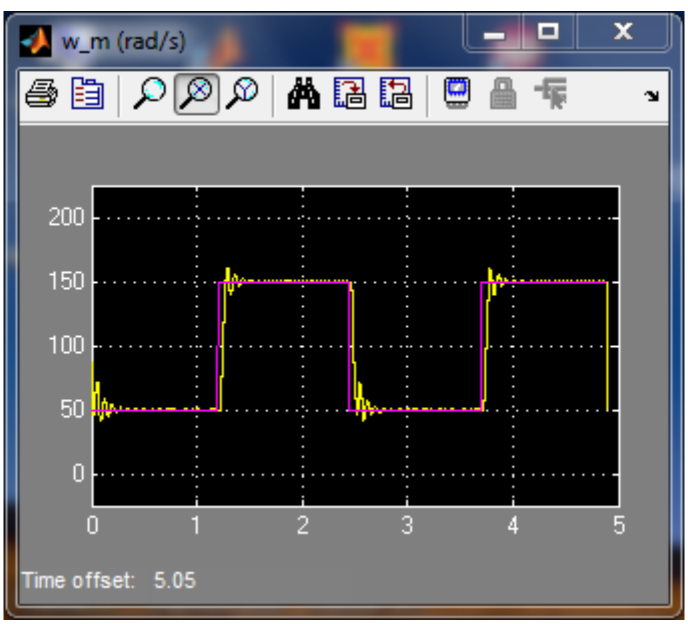
b) We then manually adjusted the gain until there was no overshoot. The gain we found and screen shot we obtained are shown below.

$K_p = 0.2015$
$K_i = 0.92448$

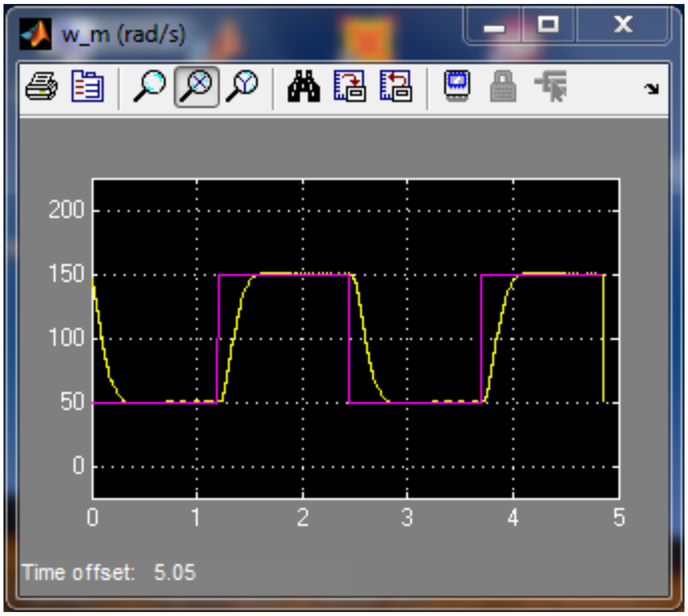


Step 3.5: Design PI Controller to Given Specification

a) We then took the gains we found using the Ziegler-Nochols formula and used them in our model and observed the response. Our screen shot is shown below.

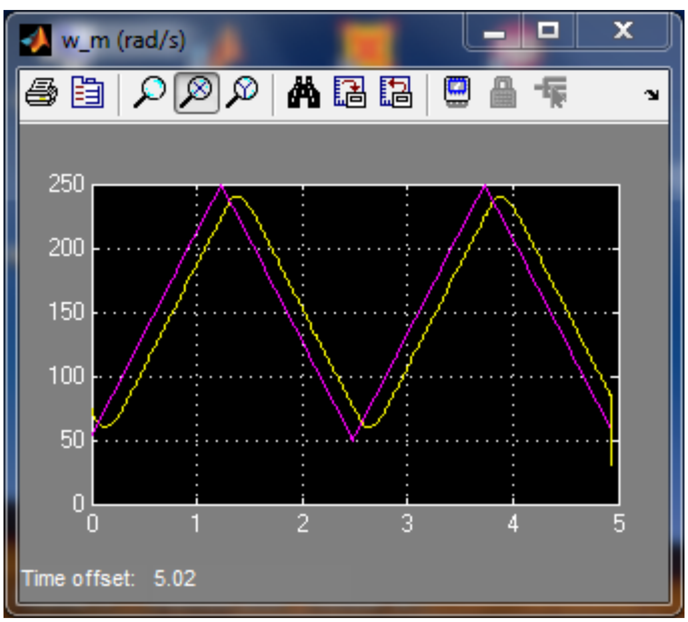


b) We then used the gain calculated in the pro-lab from section 2.3c. We set the parameters and observed the response. Our screen shot is shown below.

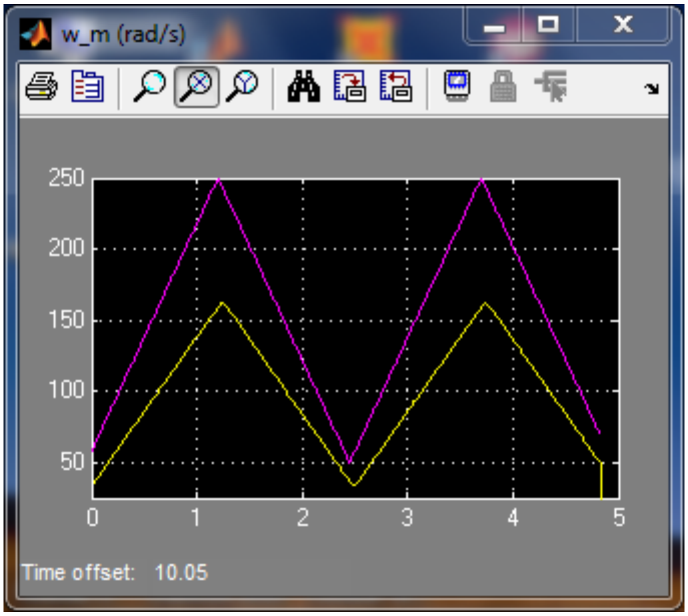


Step 3.6: Tracking Triangular Signals

a) After obtaining our results with a square wave, we repeated similar steps using a triangular signal as an input. We set the appropriate parameters and observed the response. Our screen shot is shown below.



b) We then changed K_i=0, b_{sp}=1, and K_{p}=0.1(Vs/rad) and observed the response. The error becomes much larger with these values. Our screen shot is shown below.



Discussion

We did not encounter many problems during this lab. We did however have difficulty understanding what some of the questions were asking for. After we learned what they meant, the lab went smoothly.

Conclusions

This lab has taught us more about the QET DCMCT and how to control its speed using a PI Controller. We have also learned how to apply the Ziegler-Nichols tuning procedure and also learned about the set-point weighting technique.