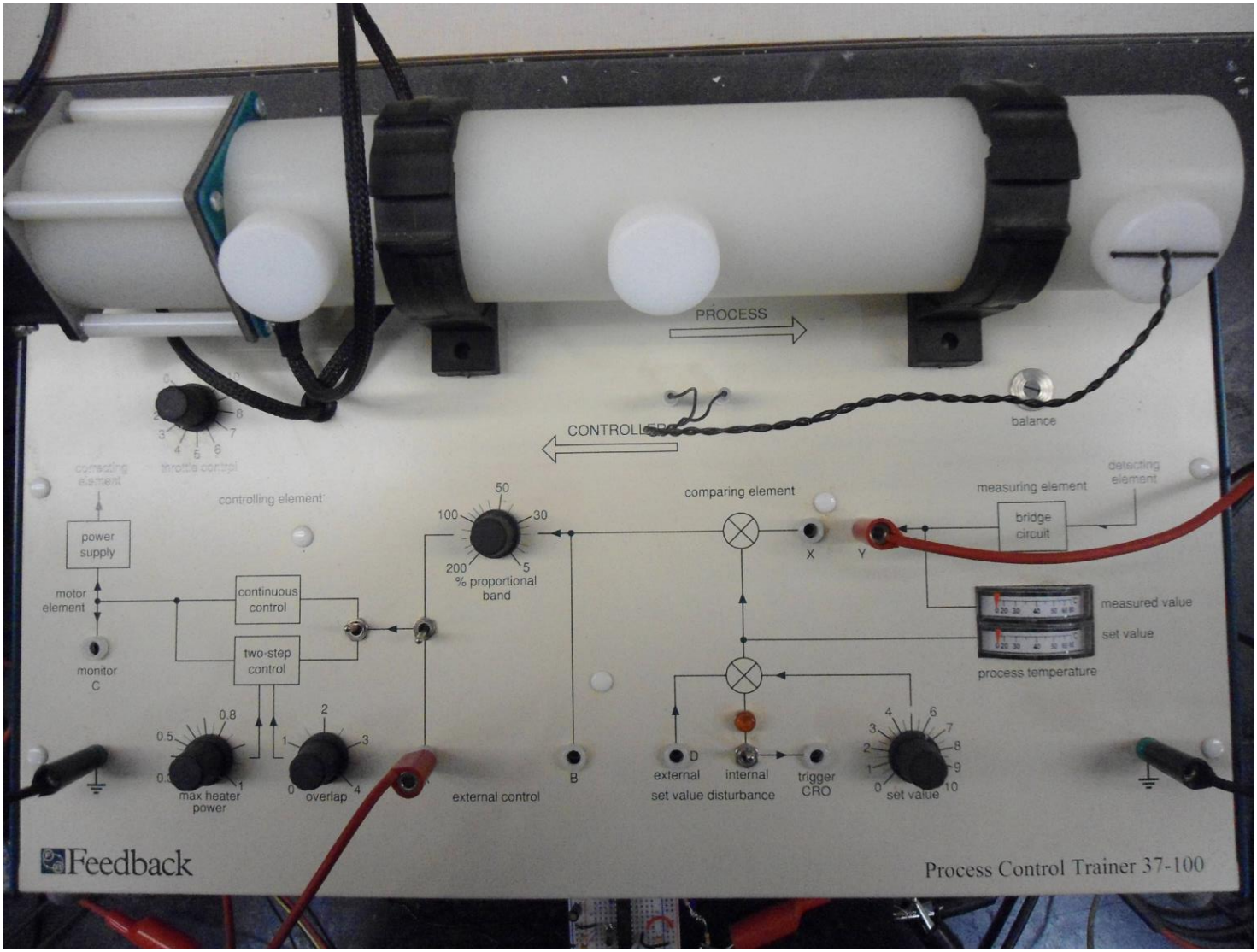
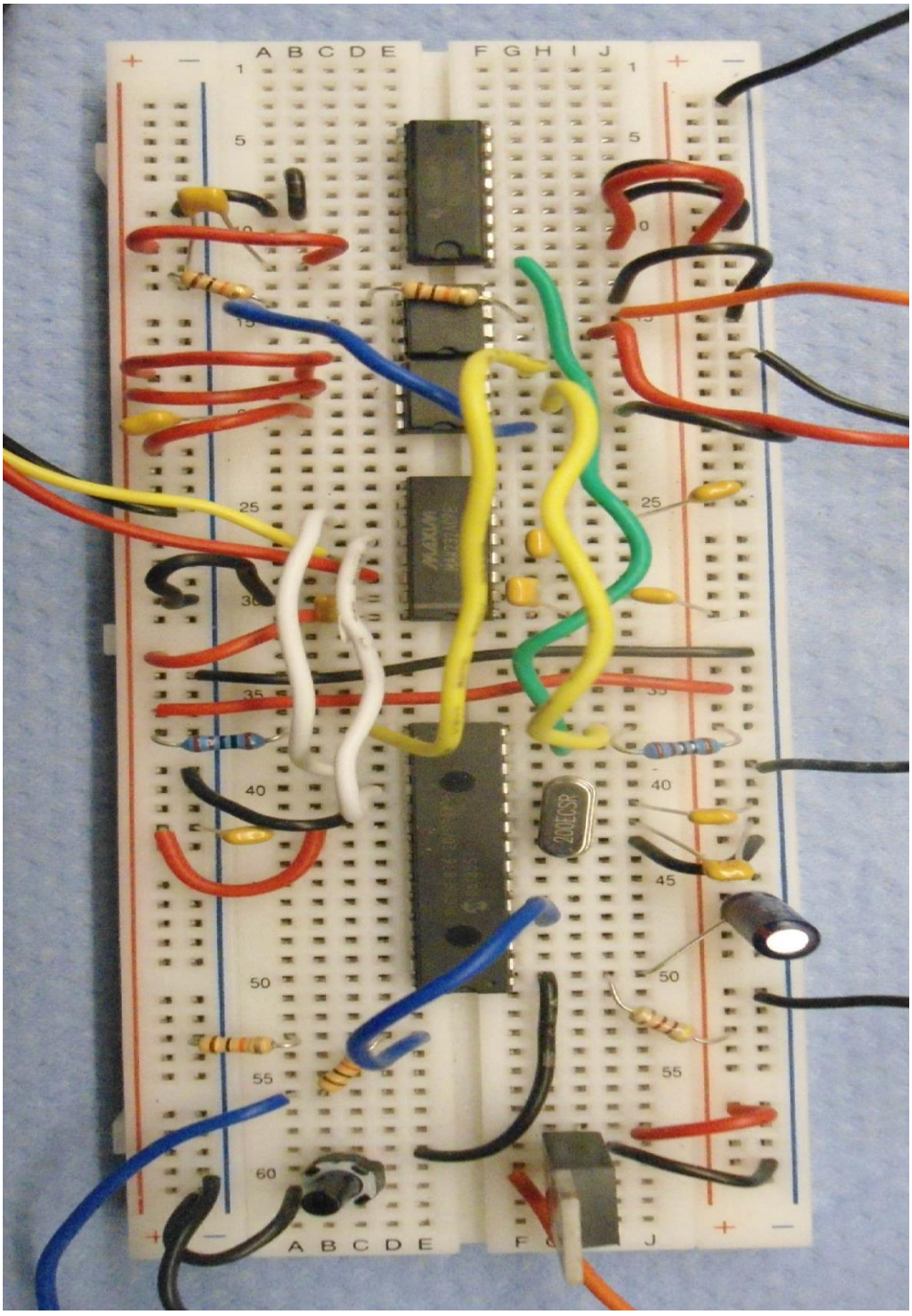
AUTOMATIC CONTROL ENGINEERING

PIPE FLOW NYQUIST LAB

PURPOSE: The main purpose of this lab is to give you some experience getting the GH or Nyquist plot of a system from an experiment.

PROCEDURE: The PIC code gh.c operates the pipe flow setup open loop. Using gh.c, send a sinusoidal signal into the heater. Display the heater and sensor signals on an oscilloscope. From the oscilloscope traces estimate the open loop magnitude ratio and phase shift for different heater frequencies. Use these data to construct a GH Plot. Use the GH Plot to estimate the borderline $\mathbf{K_P}$ and $\mathbf{T_P}$. Compare these $\mathbf{K_P}$ and $\mathbf{T_P}$ with those obtained in the Ziegler Nichols gains lab.


PROCESS
CONTROLLED
balance
throttle control
correcting element
controlling element
comparing element
measuring element
detecting element
power supply
motor element
monitor C
continuous control
two-step control
50
100
30
200
5
% proportional band
bridge circuit
X
Y
measured value
set value
process temperature
0.5
0.8
1
max heater power
2
1
3
0
4
overlap
external control
B
D
external set value
internal disturbance
trigger CRO
4
6
3
7
2
8
1
9
0
10
set value
Feedback
Process Control Trainer 37-100


A B C D E
F G H I J
MAXIM
200ECSP

```
/************************************************

           PIPE FLOW SETUP   NYQUIST LAB

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/* header files */
#include<16f876.h>
#include<math.h>
#fuses HS,NOWDT,NOPROTECT
#fuses NOBROWNOUT,NOPUT,NOLVP
#use delay(clock=20000000)
#use i2c(master,sda=PIN_C4,scl=PIN_C3,slow)
#org 0x1F00,0x1FFF{}


/* declare variables */
   float a,b,p,o;
   float t,dt,c;
   float wave,s;
   int power;

void chip(int data);


/*  main code */

    void main()
{
    c=3.14159;
    s=254.0/10.0;
    a=6.0*s; b=2.0*s;
    p=10.0; o=2*c/p;
    dt=0.0129; t=0.0;

    delay_ms(7000);

/*  control loop */

    while(TRUE)
{
    t=t+dt;
    delay_ms(10);
    wave=a+b*sin(o*t);
    power=wave;
    chip(power);
}
}


void chip(int data)
{
 i2c_start();
 i2c_write(0x5e);
 i2c_write(0);
 i2c_write(data);
 i2c_stop();
}
```
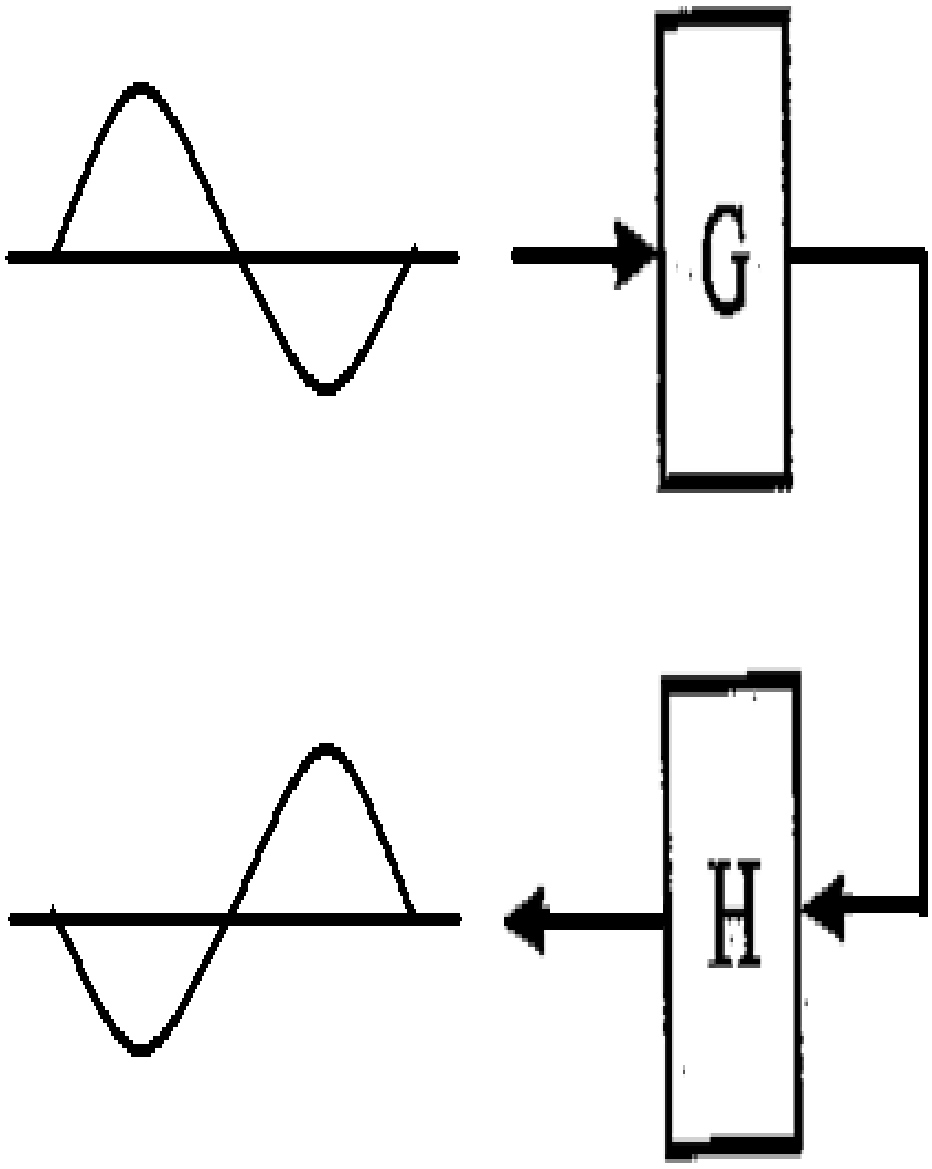


G
H

NYQUIST LAB DATA SHEET

GAIN = COMMAND = $[2I_o]$ =

MR = $[2O_o]/[2I_o]$ $\phi = \Delta T/T\ 360$

T	ΔT	$2O_o$	MR	ϕ

PIPE FLOW SETUP

A simple model of the pipe flow setup is

$$X\ dR/dt + Y\ R = Q$$

$$Q = K_P\ E \qquad E = C - \mathbf{R}$$

$$\mathbf{R}(t) = R(t-T)$$

Laplace Transformation gives

$$(X\ S + Y)\ R = Q$$

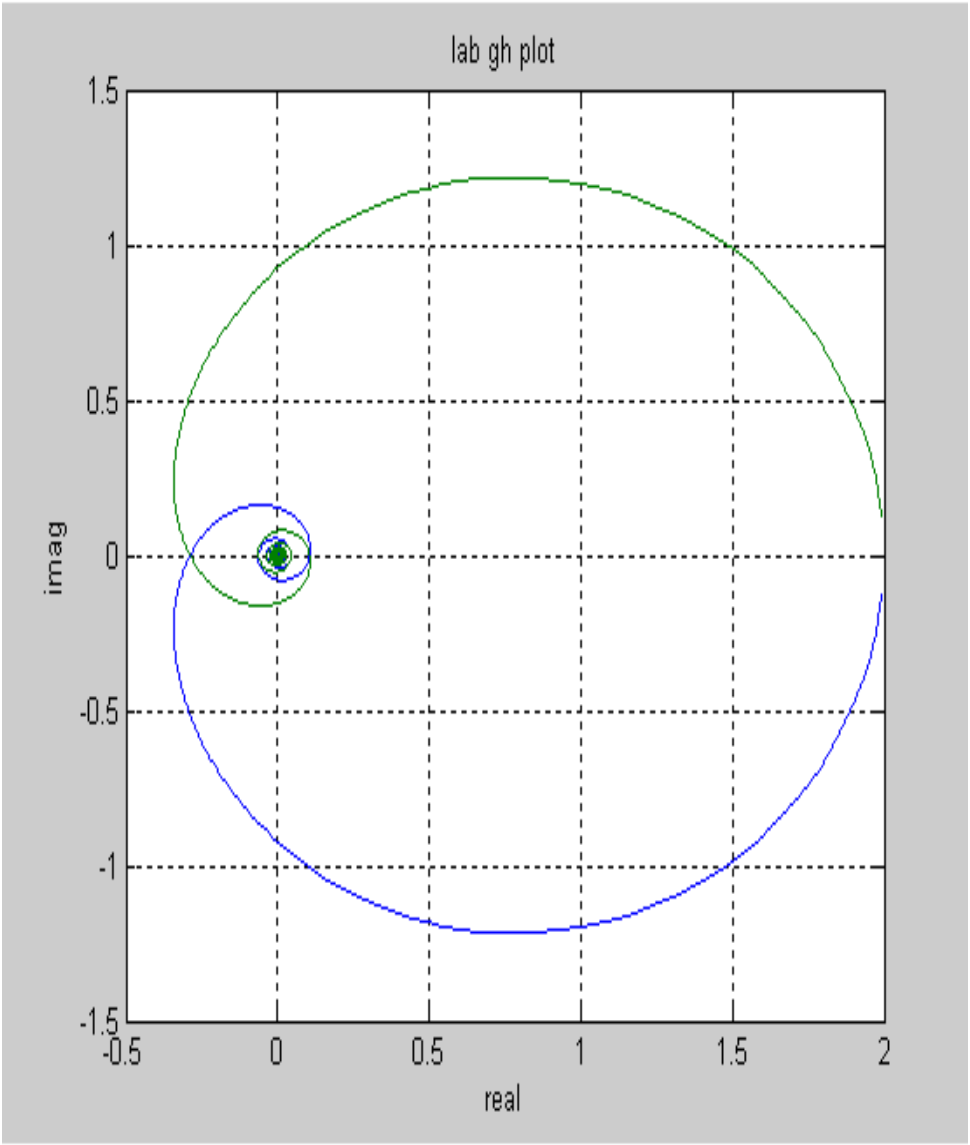
$$Q = K_P\ E \qquad E = C - \mathbf{R}$$

$$\mathbf{R} = e^{-TS}\ R$$

The GH function for the setup is:

$$K_P\ e^{[-TS]} \ / \ (X\ S + Y)$$

```
% PIPE FLOW SETUP
% OPEN LOOP PLOT

X=0.5;Y=0.5;
W=0.05;DW=0.05;
GP=1.0;T=0.25;
NIT=5000;
for K=1:NIT
S=complex(0.0,W);
num=GP*exp(-T*S);
den=X*S+Y;
p(K)=real(num/den);
q(K)=imag(num/den);
W=W+DW;
end
plot(p,q,p,-q);
title('lab gh plot')
xlabel('real')
ylabel('imag')
grid
```


lab gh plot
1.5
1
0.5
0
-0.5
-1
-1.5
imag
-0.5
0
0.5
1
1.5
2
real