Educational Control Products

Manual For Model 205/205a

Torsional Control System

(Instructor's Edition)

Important Notice

Section 2.3 of this manual contains important safety information that must be read by all users prior to operating the ECP system.

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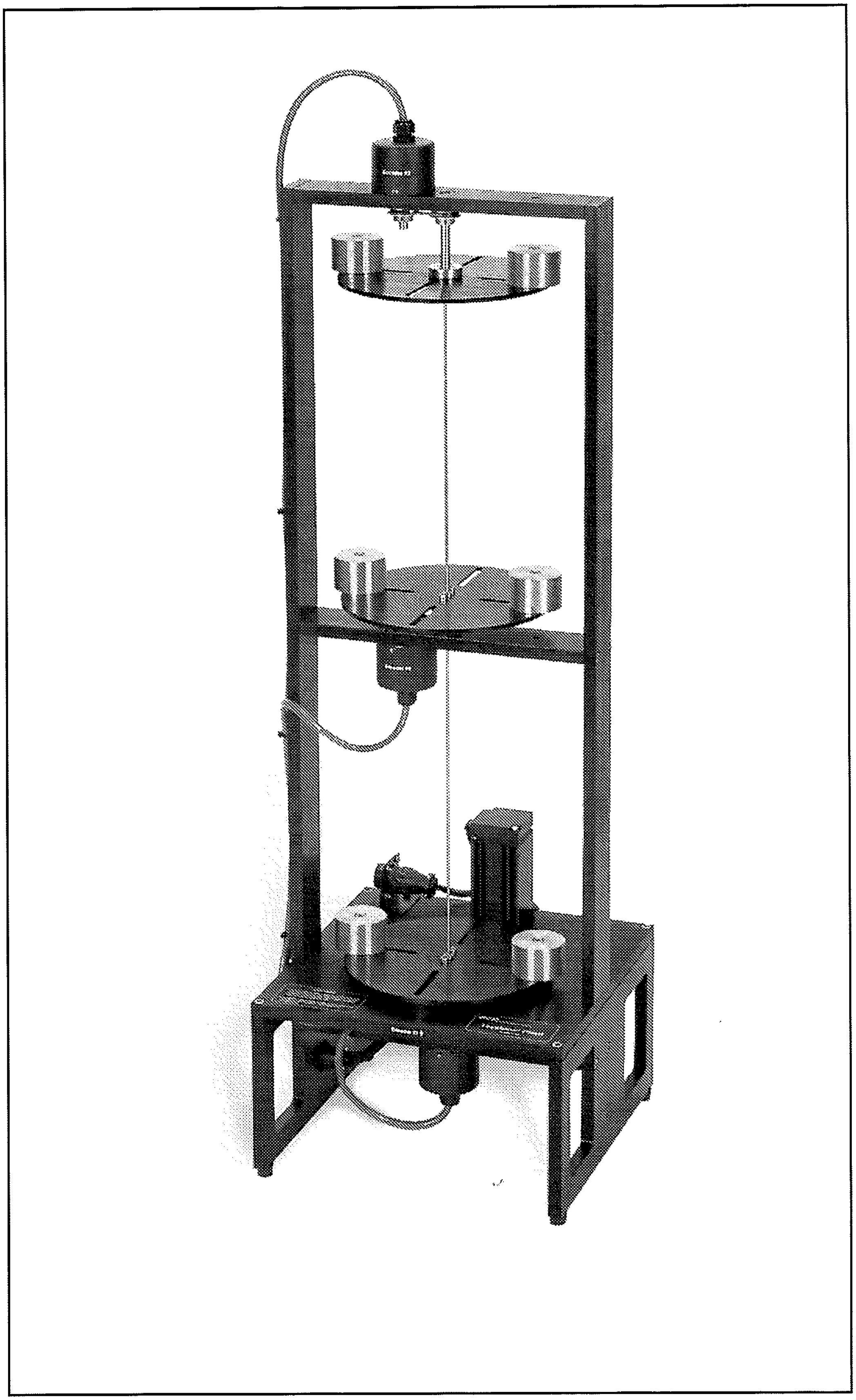

The Model 205a Torsion Spring / Inertia Apparatus

Appendix Ai. Useful Scripts

Listed in this appendix are Matlab® scripts for building the numerical plant models, and some LQR related design work from Section 6.7. These are not represented as being numerically or methodologically optimal, but may be useful to some users.

A.1i Plant Model Builder

The following script builds models of configurations 1, 2, and 3 of Section 6.1i (see Figure 6.1-2i). Parameter values used here are for a specific measured plant. For more precise results, use the identified values for your plant. Use only the script portion for one configuration at a time (i.e. Plant #1, #2, or #3).

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%% Hardware Gain, khw %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
kc=10/32768;
kaktkp=0.70;
ke= 16000/2/pi;
ks=32;
khw=kc*kaktkp*ke*ks


% Use any the following to build Plant #1,2,or3.

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  Plant #1  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
J=.0109;
cstr=.948;
N=khw/J;
D=[1 cstr 0];
% State Space model:
A1=[0 1];
A2=[0 -cstr];
Aol=[A1;A2];
B=[0 khw/J]';
C=[1 0];%For theta output


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  Plant #2  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% By J,c,k identification:
J1=.0108;J2=.0103;
c1=0.007;c2=0.001;
k1=1.37;
N1=khw/J1*[1 c2/J2 k1/J2];
N2=khw*k1/(J1*J2);
D=[J1*J2 (c1*J2+c2*J1) (k1*(J1+J2)+c1*c2) (k1*(c1+c2)) 0]/(J1*J2);

% By Frequency based identification:
wp=15.71;zp=0.024;
```

```
wz=11.15;zz=.017; %Use zz≈abs(imag(zero(N1))/abs(zero(N1))), where N1 is as
above
cstr=0.69;
N1=khw/J1*[1 2*zz*wz wz^2];
N2=khw*k1/J1/J2;
D=conv(conv([1 0],[1 cstr]),[1 2*zp*wp wp^2]);

% State Space model:
A1=[0 1 0 0];
A2=[-k1/J1 -c1/J1 k1/J1 0];
A3=[0 0 0 1];
A4=[k1/J2 0 -k1/J2 -c2/J2];
Aol=[A1;A2;A3;A4];
B=[0 khw/J1 0 0]';
C=[0 0 1 0];%For theta2 output


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  Plant #3  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% By J,c,k identification:
J1=.0025;J2=.0018;J3=J2;
c1=0.007;c2=0.001;c3=c2;
k1=2.7;k2=2.6;
N1=khw*[J2*J3  (J2*c3+J3*c2)  (J2*k2+J3*k1+J3*k2+c2*c3)  (c2*k2+c3*k1+c3*k2)
k1*k2]/J1/J2/J3;
N2=khw*k1*[J3 c3 k2]/J1/J2/J3;
N3=khw*k1*k2/J1/J2/J3;
D=[J1*J2*J3,(J1*J2*c3+J1*J3*c2+J2*J3*c1),(J1*(J2*k2+J3*k1+J3*k2+c2*c3)+J2*(J3*k
1+c1*c3)+J3*c1*c2),(J1*(c2*k2+c3*k1+c3*k2)+J2*(c1*k2+c3*k1)+J3*(c1*k1+c1*k2+c2
*k1)+c1*c2*c3),(J1+J2+J3)*k1*k2+c1*(c2*k2+c3*k1+c3*k2)+c2*c3*k1,(c1+c2+c3)*k1*
k2,0]/J1/J2/J3;

% By Frequency based identification:
wp1=35.18;zp1=0.032;
wp2=63.9;zp2=0.012;
wz1=23.1;zz1=.023;
wz2=60.1;zz2=.009;
wz=37.3;zz=.015;
cstr=1.6;
N1=khw/J1*conv([1 2*zz1*wz1 wz1^2],[1 2*zz2*wz2 wz2^2]);
N2=khw*k1/J1/J2*[1 2*zz*wz wz^2];
N3=khw*k1*k2/J1/J2/J3;
D=conv(conv(conv([1 0],[1 cstr]),[1 2*zp1*wp1 wp1^2]),[1 2*zp2*wp2 wp2^2]);

% State Space model:
A1=[0 1 0 0 0 0];
A2=[-k1/J1 -c1/J1 k1/J1 0 0 0];
A3=[0 0 0 1 0 0];
A4=[k1/J2 0 -(k1+k2)/J2 -c2/J2 k2/J2 0];
A5=[0 0 0 0 0  1];
A6=[0 0 k2/J3 0 -k2/J3 -c3/J3];
Aol=[A1;A2;A3;A4;A5;A6];
B=[0 khw/J1 0 0 0 0]';
C=[0 0 0 0 1 0];%For theta3 output
```