LAMPIRAN A

Kolom_loopterbuka.m

```
% Menentukan hubungan sistem loop terbuka
%
kolom_model
%
% nilai singular dari G
omega = logspace(-4,2,100);
olp_g = frsp(G,omega);
olp_g82 = frsp(G82,omega);
figure(1)
vplot('liv,lm',vsvd(olp_g),'y-',vsvd(olp_g82),'r--'),grid
title('Plot Nilai Singular dari G dan G_4')
xlabel('Frekuensi (rad/menit)')
ylabel('Magnituda')
%
% Membentuk Fungsi Pembobotan
kolom_bobot
%
omega = logspace(-4,2,100);
Wm_g = frsp(Wm1,omega);
figure(2)
vplot('liv,lm',Wm_g,'r-'), grid
title('Respon Frekuensi Model M')
xlabel('Frekuensi (rad/menit)')
ylabel('Magnituda')
%
omega = logspace(-4,2,100);
wn_g = frsp(wn,omega);
figure(3)
vplot('liv,lm',wn_g,'m-'), grid
title('Pembobotan Noise')
xlabel('Frekuensi (rad/menit)')
ylabel('Magnituda')
omega = logspace(-6,2,100);
wp_g = frsp(wp,omega);
wpi_g = minv(wp_g);
figure(4)
vplot('liv,lm',wpi_g,'r-'), grid
title('Invers Fungsi Pembobotan Kinerja')
xlabel('Frekuensi (rad/menit)')
ylabel('Magnituda')
omega = logspace(-4,4,100);
wu_g = frsp(wu,omega);
figure(5)
vplot('liv,lm',wu_g,'r-'), grid
title('Fungsi Pembobotan Aksi Kontrol')
```

```
xlabel('Frekuensi (rad/menit)')
ylabel('Magnituda')
%
% koneksi loop terbuka dengan fungsi pembobotan
systemnames = ' G W_Delta Wm Wn Wp Wu ';
inputvar = '[ pert{2}; ref{2}; noise{2}; control{2} ]';
outputvar = '[ W_Delta; Wp; Wu; -G-Wn; ref ]';
input_to_G = '[ pert+control ]';
input_to_W_Delta = '[ control ]';
input_to_Wm =  '[ ref ]';
input_to_Wn = '[ noise ]';
input_to_Wp = '[ G-Wm ]';
input_to_Wu = '[ control ]';
sysoutname = 'sys_ic';
cleanupsysic = 'yes';
sysic
```

kolom_model.m

```
% Membentuk Model Distilasi Kolom Orde 6 dengan konfigurasi
LV
% Variabel yang didapat adalah
% A         C         G4       Si      Uinit
% B         D         G        So      Xinit
% dimana:
% G4 - Model distilasi kolom orde 82 yang telah diskalakan
% G  - Model distilasi kolom orde 6
% A,B,C,D - Matriks dari G
% Si and So - Penskalaan Input dan output
% Uinit - nilai nominal (steady state) untuk input
% Xinit - nilai nominal (steady state) untuk state
%
%--------------
% Mencari Model
%--------------
% Mensimulasikan model LV selama 5000 menit
[t,x] = ode15s(@cola_lv,[0 5000],0.5*ones(1,82)');
Xinit = x(sel(size(x),1,1),:)';
%
%-----------------------
% Linierisasi Model, G4u
%-----------------------
Ls = 2.70629; Vs = 3.20629; Fs = 1.0; zFs = 0.5;
Uinit = [Ls Vs Fs zFs]';
[A,B,C,D] = cola_lin(@cola_lv_lin,Xinit',Uinit');
G4u =  pck(A,B,C,D);
%
%-------------------------------
% Model yang telah diskalakan, G4
%-------------------------------
% Skala
Du = diag([1 1]);                % input max
```

```
Dd = diag([0.2 0.1]);            % gangguan max
De = diag([0.01 0.01]);          % error output max
% Model yang telah diskalakan, G4
Si = daug(Du,Dd); So = minv(De); % matriks penskalaan
G4 = mmult(So, G4u, Si);
[A82,B82,C82,D82] = unpck(G4);
A = A82; B = B82(:,1:2); C = C82; D = D82(:,1:2);
G82 = pck(A,B,C,D);
%
%-----------------
% Reduksi Model, G
%-----------------
[syssb,hsig] = sysbal(G4);
G4_6 = hankmr(syssb,hsig,6,'d');
[A6,B6,C6,D6] = unpck(G4_6);
A = A6; B = B6(:,1:2); C = C6; D = D6(:,1:2);
G = pck(A,B,C,D);
%
clear t;clear x;
clear Ls; clear Vs; clear Fs; clear zFs;
clear Dd, clear De; clear Du;
clear hsig; clear sys1; clear syss; clear syssb; clear sysu;
```

kolom_bobot.m

```
% Fungsi Pembobotan untuk Sistem Kolom Distilasi
%
% Bobot Ketidakpastian
nuW_Delta1 = [2.2138 15.9537 27.6702  4.9050];
dnW_Delta1 = [1.      8.3412 21.2393 22.6705];
gainW_Delta1 = 1;
w_Delta1 = nd2sys(nuW_Delta1,dnW_Delta1,gainW_Delta1);
%
nuW_Delta2 = [2.2138 15.9537 27.6702  4.9050];
dnW_Delta2 = [1.      8.3412 21.2393 22.6705];
gainW_Delta2 = 1;
w_Delta2 = nd2sys(nuW_Delta2,dnW_Delta2,gainW_Delta2);
%
W_Delta = daug(w_Delta1,w_Delta2);
%
% Model
nuWm1 = 1;
dnWm1 = [6.0^2  2*0.8*6.0  1];
gainWm1 = 1.0;
wm1 = nd2sys(nuWm1,dnWm1,gainWm1);
nuWm2 = 1;
dnWm2 = [6.0^2  2*0.8*6.0  1];
gainWm2 = 1.0;
wm2 = nd2sys(nuWm2,dnWm2,gainWm2);
wm12 = 0.;
wm21 = 0.;
Wm1 = sbs(wm1,wm12);
```

```
Wm2 = sbs(wm21,wm2);
Wm = abv(Wm1,Wm2);
%
% Bobot Kinerja
tol = 10^(-4);
nuWp = [9.5 3];
dnWp = [9.5 tol];
gainWp = 0.55;
wp = nd2sys(nuWp,dnWp,gainWp);
wp12 = 0.3;
wp21 = 0.3;
Wp1 = sbs(wp,wp12);
Wp2 = sbs(wp21,wp);
Wp = abv(Wp1,Wp2);
%
% Bobot Aksi Kontrol
nuWu = [1  1];
dnWu = [0.01   1];
gainWu = 8.7*10^(-1);
wu = nd2sys(nuWu,dnWu,gainWu);
Wu = daug(wu,wu);
%
% Shaping Filter untuk Noise
nuWn = [1 0];
dnWn = [1 1];
gainWn = 10^(-2);
wn = nd2sys(nuWn,dnWn,gainWn);
Wn = daug(wn,wn);
```

kolom_timedelay.m

```
% Pendekatan dari ketidakpastian time delay dengan Pertubasi
Multiplicative tidak terstruktur
%
hold off
omega = logspace(-2,2,200);
% pendekatan orde 3
W_Delta = nd2sys([2.2138 15.9537 27.6702  4.9050], ...
                 [1.      8.3412 21.2393 22.6705]);
W_Delta_g = frsp(W_Delta,omega);
%
for k = 0.8:0.05:1.2;
    for tau = 0:0.1:1.0;
        for i = 1:200
            om = omega(i);
            pert(i) = sqrt((k*cos(om*tau)-1)^2 +
(k*sin(om*tau))^2);
        end
        magg = vpck(pert',omega');
        vplot('liv,m',W_Delta_g,'r-',magg,'b--'), grid on
        hold on
```

```
    end
end
xlabel('Frequensi (rad/menit)')
ylabel('Magnituda')
title('Pendekatan dari ketidakpastian time delay dengan
pertubasi multiplicative')
```

kolom_hinfcon.m

```
% Mencari solusi H_infinity untuk sistem kolom distilasi
%
nmeas = 4;
ncon = 2;
gmin = 0.1;
gmax = 10;
tol = 0.001;
[K_hin,clp] = hinfsyn(sys_ic,nmeas,ncon,gmin,gmax,tol);
K = K_hin;
```

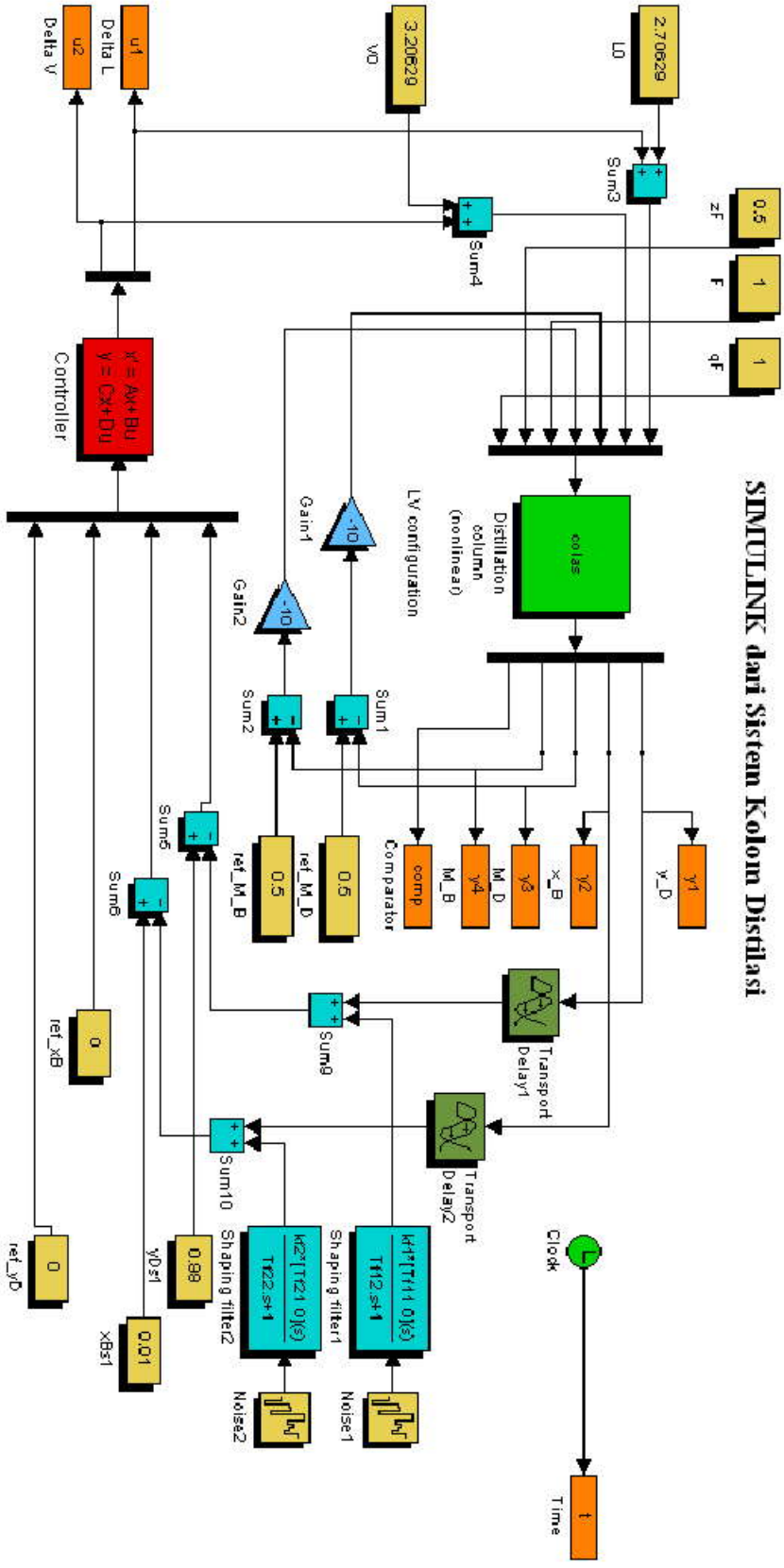
kolom_parasimulink.m

```
% Parameter untuk simulasi dengan simulink
%
% Mensimulasikan model LV selama 20000 menit
[t,x] = ode15s(@cola_lv,[0 20000],0.5*ones(1,82)');
lengthx = size(x); Xinit = x(lengthx(1),:)';
%
% Input
LT = 2.70629;                          % Reflux
VB = 3.20629;                          % Boilup
D = 0.5;                               % Distillate
B = 0.5;                               % Bottom products
F = 1.0;                               % Feedrate
zF = 0.5;                              % Feed composition
qF = 1.0;                              % Feed liquid
fraction
Uinit = [ LT VB D B F zF qF]';

clear x; clear t; clear LT; clear VB; clear D; clear B;
clear F; clear zF; clear qF;
%
% Menskalakan pengontrol
S = daug(So,So);
K_u = mmult(K,S);
[Ak,Bk,Ck,Dk] = unpck(K_u);
%
% parameter untuk noise shaping filter
kf1 = 0.01/So(1,1); Tf11 = 1;   Tf12 = 1;
kf2 = 0.01/So(2,2); Tf21 = 1;   Tf22 = 1;

save kolom_parasimulink
```

LAMPIRAN B


SIMULINK dari Sistem Kolom Distilasi
Delta V
Delta L
V0
L0
Sum3
Sum4
zF
F
qF
Controller
Distillation column (nonlinear)
LV configuration
Gain1
Gain2
Sum1
Sum2
Comparator
ref_M_B
ref_M_D
M_B
M_D
x_B
y_D
Sum5
Sum6
Sum9
Transport Delay1
Transport Delay2
Sum10
ref_xB
ref_yD
yDs1
xBs1
Shaping filter2
Shaping filter1
Noise2
Noise1
Clock
Time

LAMPIRAN C

Matriks Plant Sistem Kolom Distilasi Orde 6

A6 =

-1.7881	-2.1712	-0.1774	0.9759	0.0028	0.0035
0	-1.0520	1.7046	0.7553	0.0002	-0.1367
0	-1.6702	-0.2762	-0.0324	0.0040	0.0538
0	0	0	-0.2536	-0.0013	0.0100
0	0	0	0	-0.0052	0.0024
0	0	0	0	0	-0.0754

B6 =

-0.8898	-0.3328	-0.1469	-0.0587
-0.6293	-0.0371	0.0723	0.0360
0.6764	0.1243	-0.0093	0.0702
0.3317	-0.1544	0.1155	-0.2455
-0.7111	0.6993	-0.0626	-0.0723
-0.0655	0.2971	-0.2419	-0.0828

C6 =

0.1933	0.1635	-0.0586	0.0273	-0.6331	0.2664
1.2511	-0.0392	-0.1505	-0.3080	-0.7827	-0.2328

D6 =

0.0124	0.0138	0.0122	-0.0038
0.0790	0.0055	0.0338	-0.0122

Matriks Pengontrol orde 22

Ak =

1.0e+004 *

Columns 1 through 9

0.0014	0.0007	-0.0029	0.0032	-0.0164	0.0023	0.0019	0.0005	-0.0000
0.0016	0.0005	-0.0022	0.0025	-0.0134	0.0016	0.0016	0.0004	-0.0000
-0.0020	-0.0012	0.0033	-0.0035	0.0192	-0.0026	-0.0023	-0.0006	0.0000
-0.0015	-0.0004	0.0019	-0.0018	0.0106	-0.0012	-0.0013	-0.0003	0.0000
0.0041	0.0010	-0.0047	0.0044	-0.0262	0.0027	0.0031	0.0008	-0.0000
0.0010	0.0001	-0.0008	0.0007	-0.0045	0.0003	0.0005	0.0001	-0.0000
-0.0023	-0.0002	0.0034	-0.0033	0.0181	-0.0013	-0.0025	-0.0005	-0.0000
-0.0009	-0.0001	0.0014	-0.0013	0.0073	-0.0005	-0.0011	-0.0004	0.0001
-0.0004	-0.0000	0.0006	-0.0006	0.0030	-0.0002	-0.0004	-0.0002	-0.0005
0.0040	0.0004	-0.0059	0.0057	-0.0311	0.0022	0.0041	0.0011	-0.0000
0.0016	0.0002	-0.0024	0.0023	-0.0125	0.0009	0.0017	0.0004	-0.0000
0.0007	0.0001	-0.0010	0.0010	-0.0052	0.0004	0.0007	0.0002	-0.0000
0.0000	0.0000	-0.0000	0.0000	-0.0000	0.0000	0.0000	0.0000	-0.0000
-0.0000	-0.0000	0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000
-0.0000	-0.0000	0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000
0.0000	0.0000	-0.0000	0.0000	-0.0000	0.0000	0.0000	0.0000	-0.0000
-0.0000	-0.0000	0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000
0.0000	0.0000	-0.0000	0.0000	-0.0000	0.0000	0.0000	0.0000	-0.0000
0.0000	0.0000	-0.0000	0.0000	-0.0000	0.0000	0.0000	0.0000	-0.0000
-0.0000	-0.0000	0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000
-0.1280	-0.0130	0.1864	-0.1821	0.9892	-0.0694	-0.1311	-0.0335	0.0007
0.2196	0.0223	-0.3199	0.3125	-1.6970	0.1188	0.2251	0.0574	-0.0012

Columns 10 through 18

-0.0036	-0.0011	-0.0000	0.0035	0.0010	0.0023	0.0014	-0.0004	0.0001
-0.0029	-0.0009	-0.0000	0.0028	0.0009	0.0019	0.0011	-0.0003	0.0000
0.0041	0.0012	0.0000	-0.0040	-0.0012	-0.0027	-0.0016	0.0005	-0.0001
0.0023	0.0007	0.0000	-0.0022	-0.0007	-0.0015	-0.0009	0.0002	-0.0000
-0.0057	-0.0017	-0.0000	0.0056	0.0017	0.0037	0.0022	-0.0004	-0.0000
-0.0010	-0.0003	-0.0000	0.0010	0.0003	0.0006	0.0004	-0.0000	-0.0000
0.0044	0.0013	0.0000	-0.0043	-0.0013	-0.0029	-0.0017	-0.0000	-0.0000
0.0018	0.0005	0.0000	-0.0017	-0.0005	-0.0012	-0.0007	-0.0000	-0.0000
0.0007	0.0002	0.0000	-0.0007	-0.0002	-0.0005	-0.0003	-0.0000	-0.0000
-0.0077	-0.0021	-0.0001	0.0074	0.0022	0.0049	0.0030	-0.0000	-0.0000
-0.0032	-0.0011	0.0001	0.0030	0.0009	0.0020	0.0012	-0.0000	-0.0000
-0.0013	-0.0005	-0.0005	0.0012	0.0004	0.0008	0.0005	-0.0000	-0.0000
-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0001	-0.0000
-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0001
-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000
0.2416	0.0714	0.0010	-0.2347	-0.0703	-0.1565	-0.0939	-0.0000	-0.0000
-0.4145	-0.1224	-0.0018	0.4025	0.1207	0.2686	0.1611	-0.0000	-0.0000

Columns 19 through 22

0.0038	0.0033	0.0044	-0.0077
0.0031	0.0027	0.0036	-0.0063
-0.0044	-0.0038	-0.0052	0.0090
-0.0025	-0.0021	-0.0029	0.0050
0.0061	0.0053	0.0072	-0.0123
0.0011	0.0009	0.0013	-0.0021
-0.0047	-0.0041	-0.0054	0.0096
-0.0019	-0.0016	-0.0022	0.0039
-0.0008	-0.0007	-0.0009	0.0016
0.0081	0.0070	0.0096	-0.0163
0.0033	0.0028	0.0039	-0.0066
0.0014	0.0012	0.0016	-0.0027
0.0000	0.0000	0.0000	-0.0000
-0.0000	-0.0000	-0.0000	0.0000
-0.0000	-0.0000	-0.0000	0.0000
0.0000	0.0000	0.0000	-0.0000
-0.0000	-0.0000	-0.0000	0.0000
0.0000	0.0000	0.0000	-0.0000
0.0000	0.0000	0.0000	-0.0000
-0.0000	-0.0000	-0.0000	0.0000
-0.2586	-0.2220	-0.3057	0.5250
0.4435	0.3809	0.5240	-0.9009

Bk =

1.0e+004 *

3.0296	-0.6768	0	0
2.0397	-0.2907	0	0
-3.4954	0.6873	0	0
-1.4835	0.0814	0	0
3.1524	0.1858	0	0
0.2323	0.2492	0	0
0.0000	0.0000	0	0
0.0000	0.0000	0	0
0.0000	0.0000	0	0
0.0000	0.0000	0	0
0.0000	0.0000	0	0
0.0000	0.0000	0	0
-0.0000	-0.0000	-0.0196	0
0.0000	0.0000	0.0196	0
0.0000	0.0000	0	-0.0196
-0.0000	-0.0000	0	0.0196
-0.0063	0.0011	0	0
0.0032	-0.0011	0	0
-0.0318	-0.0000	0	0
-0.0001	-0.0320	0	0
0.0000	0.0000	0	0
0.0000	0.0000	0	0

Ck =

Columns 1 through 9

-1.7937	-0.1821	2.6129	-2.5526	13.8642	-0.9723	-1.8379	-0.4693	0.0099
3.0776	0.3124	-4.4833	4.3793	-23.7835	1.6653	3.1545	0.8042	-0.0170

Columns 10 through 18

3.3868	1.0002	0.0145	-3.2892	-0.9858	-2.1937	-1.3164	-0.0000	-0.0000
-5.8089	-1.7162	-0.0248	5.6406	1.6912	3.7647	2.2584	-0.0000	-0.0000

Columns 19 through 22

-3.6246	-3.1107	-4.1446	7.3578
6.2161	5.3380	7.3442	-12.4855

Dk =

1.0e-003 *

0.2852	0.4769	0	0
0.0653	0.0922	0	0