ANEXOS

Las simulaciones se realizaron de 2 maneras: la primera parte en código Matlab y la segunda utilizando Simulink con Carsim.

1.- El código Matlab también fue adjuntado en la carpeta "CodigoMatlab", además de los datos obtenidos de simulación se almaceno como "conductor", como los datos del entrenamiento de la red neuronal "ULTIMO_13FALLAS_JULIO_ULTIMODELOS ULTIMOS_2capa_16dot2_100n_cont=1256435".

1.- CODIGO EN MATLAB

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% DiagnosticoEPS.m %%%%%%%%%%%%%%%%%%%%
clear all
close all
clc
load
ULTIMO_13FALLAS_JULIO_ULTIMODELOSULTIMOS_2capa_16dot2_100n_cont=1256
435
load conductor %Cargamos Torque del conductor que se utilizo con
Carsim-Simulink
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%--------------------- DiagnosticoEPS.m  ------------------------%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%% GENERA VECTOR RANDOM PARA LA VARIACION DE PARAMETROS-PLANTA%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
nn = 25;
fmin = 1;   fmax = 1;
z = rand(nn,1);
zmin = min(z);
zmax = max(z);
ff = (fmax-fmin)/(zmax-zmin)*(z-zmin)+fmin;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%% PARAMETROS PLANTA REAL EPS %%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Jsw10 = 0.03444*1;%ff(1,1);     %momento inercial volante
Jsc10 = 0.03444*1;%ff(2,1);     %momento inercial de la columna
Jfw10 = 0.61463*ff(3,1);      %momento inercial de la rueda
Jm10 =  3.5*1e-4*1;%ff(4,1);    %momento inercial del motor
Mr10 = 2*ff(5,1);             %masa de la cremallera
Bsw10 = 0.36042*1;%ff(6,1);     %friccion viscosa volante
Bfw10 = 88.128*ff(7,1);       %friccion viscosa rueda
Bsc10 = 0.36042*1;%ff(8,1);     %friccion viscosa columna
Br10 = 88.128*ff(9,1);        %friccion viscosa cremallera
Bm10 = 0.8*ff(10,1);          %friccion viscosa motor
Mf10 = Bm10;
Ksw10 = 42057*ff(11,1);       %rigidez rotacional volante
Ksc10 = 42057*ff(12,1);       %rigidez rotacional columna
Ktr10 = 42057*ff(13,1);       %barra de torsión rigidez rotacional
Ksl10 = 14878*ff(14,1);       % direccion rigidez rotacional
La10 = 0.0001*1;%ff(23,1);      %inductancia motor
Ra10 = 0.1*1;%ff(22,1);         %resistencia motor
Kt10 = 0.0533*1;%ff(15,1);      %constante motor torque
Kb10 = 0.0533*1;%ff(16,1);      %Fuerza contra electromotriz motor
N110= 49/3*ff(24,1);          %relación de transmisión
```

```
Rp10 = 0.007367*1;%ff(17,1);     %radio del piñon
NI10 = 0.11816*1;%ff(18,1);      %tasa de dirección de vinculación
nf10 = 0.985*ff(19,1);%Relación de transmisión hacia adelante
nB10 = 0.985*ff(20,1);        %Relación de transmisión hacia atrás
B110 =Bsc10;
Jeq10 =Jsc10*ff(21,1);
Cfr = 0.4;          %friccion coulomb en cremallera
Cfw = 0.04;         %La fricción de Coulomb fuerza de arranque
Fcoulomb1=0*1e2*Cfr; %Friccion seca
Fcoulomb2=0*1e2*Cfw; %Friccion seca

%%% modelo de espacio de estados
%       Tsw'                              Tsw
Tsc'
  A=[ -Bsw10/Jsw10                         -Ksc10/Jsw10
Bsw10/Jsw10                            Ksc10/Jsw10
0                        0
0                  0              0                0
         1                                        0
0                                      0                            0
0                                               0                  0
0                0
       B110/Jeq10                                 Ksc10/Jeq10
-B110/Jeq10                       -(Ktr10/Jeq10+Ksc10/Jeq10)
0                Ktr10/(Jeq10*Rp10)
0                  0              0           Kt10*N110/Jeq10
         0                                        0
1                                      0                            0
0                                               0                  0
0                0
         0                                        0
0                               nf10*Ktr10/(Rp10*Mr10)            -
Br10/Mr10     -(nf10*Ktr10/(Rp10^2*Mr10)+2*nB10*Ksl10/(NI10^2*Mr10))
0      2*nB10*Ksl10/(NI10*Mr10)    0                0
         0                                        0
0                                      0                            1
0                                               0                  0
0                0
         0                                        0
0                                      0                            0
Ksl10/(NI10*Jfw10)                                  -Bfw10/Jfw10
-Ksl10/Jfw10         0                0
         0                                        0
0                                      0                            0
0                                               1                  0
0                0
         0                                        0
0                                   0*Ksc10                         0
0                                               0                  0
-Bm10/Jm10        Kt10*N110/Jm10
         0                                        0
0                                      0                            0
0                                               0                  0
-Kb10*N110/La10     -Ra10/La10     ];
%%%%%
  B=[    0
         0
         0
         0
         0
         0
```

```
        0
        0
        0
        1/La10];% entrada de control voltaje
%%%%%%
    F = [  1/Jsw10   0
             0     0
             0     0
             0     0
             0     0
             0     0
             0   1/Jfw10
             0     0
             0     0
             0     0 ]; % ENTRADAS DESCONOCIDAS
  B2 = F;
%%%%%%
  C =  [0  Ksc10  0   -Ksc10  0  0  0  0  0   0 % Sensor de torque
        0   0   0     1   0  0  0  0  0   0 % Sensor angulo columns
        0   0   0     0   0  0  0  0  1   0 % velocidad angular
        0   0   0     0   0  0  0  0  0   1 % corriente
        0   0   0     0   0  1  0  0  0   0 ]; % Yr
%%% friccion seca
   Fric1 = [ 0
             0
             0
             0
         -Fcoulomb1/Mr10
             0
             0
             0
             0
             0  ];
%%%
   Fric2 = [ 0
             0
             0
             0
             0
             0
         -Fcoulomb2/Jfw10
             0
             0
             0  ];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%% PARAMATROS MODELO EPS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Jsw = 0.03444;      %momento inercial volante
Jsc = 0.03444;      %momento inercial columna
Jfw = 0.61463;      %momento inercial rueda
Jm =  3.5*1e-4;     %momento inercial motor
Mr = 2;             %masa de la cremallera
Bsw = 0.36042;      %friccion viscosa volante
Bfw = 88.128;       %friccion viscosa rueda
Bsc = 0.36042;      %friccion viscosa columna
Br = 88.128;        %friccion viscosa cremallera
Bm = 0.8;           %friccion viscosa motor
Mf = Bm;
Ksw = 42057;        %rigidez rotacional volante
Ksc = 42057;        %rigidez rotacional columna
Ktr = 42057;        %barra de torsión rigidez rotacional
```

```
Ksl = 14878;        % direccion rigidez rotacional
La = 0.0001;        %inductancia motor
Ra = 0.1;           %resistencia motor
Kt = 0.0533;        %constante motor torque
Kb = 0.0533;        %Fuerza contra electromotriz motor
N1= 49/3;           %relación de transmisión
Rp = 0.007367;      %radio del piñon
NI = 0.11816;       %tasa de dirección de vinculación
nf = 0.985;         %Relación de transmisión del par hacia adelante
nB = 0.985;         %Relación de transmisión de par hacia atrás
Kd=300;             %constante derivativo
Kp=20000;           %constante proporcional
B1=Bsc;
Jeq=Jsc;
phi = Kb*N1;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%  VECTOR DE TIEMPO %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
val=9.4730;
tff=val;     ti=0;    dt=0.0001;
t=ti:dt:tff;
t=t';
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%   MODELO DISCRETO DEL SISTEMA EPS %%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
[Ak,Bk]=c2d(A,B,dt);
[Ak,B2k]=c2d(A,B2,dt);
[Ak,Fric1k]=c2d(A,Fric1,dt);
[Ak,Fric2k]=c2d(A,Fric2,dt);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%% PERTURBACION DE TORQUE DE VOLANTE Y CARRETERA %%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Fd=zeros(1,length(t))';   % perturbacion de las ruedas
Td=5/2*Torque_driver.signals.values;% Torque de condcutor
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%% CONDICIONES INICIALES %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
x  = [ 0 0 0 0 0 0 0 0 0 0 ]';
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%% CONDICIONES PARA Ra %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Raest(2,1)=Ra;
p(1,1) = 1e6;
par(1,1)=0;
r(1,1)=0;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%% CONDICIONES PARA  Jm %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Mfest(2,1)=Mf;
pJm(1,1) = 1e6;
parJm(1,1)=0;
rJm(1,1)=0;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%% CONDICIONES PARA  phi %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fiest(2,1)=Kb*N1;
pfi(1,1) = 1e6;
parfi(1,1)=0;
rfi(1,1)=0;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%  condiciones paramétricas %%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
lamda = 0.98; % factor de olvido
ra=Ra;
mf=Mf;
Jm1=Jm;
La1=La;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%  FILTROS PASA BAJOS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
pp=400; %frecuencia de corte filtro 1
gg= 0.00001; %frecuencia corte filtro 2
Fr1=0;
Fr2=0;
Fr3=0;
Fr4=0;
Frcc=0;
Fry=0;
F_vel1 = 0;
F_vel2 = 0;
F_vel3 = 0;
F_corr1 = 0;
F_corr2 = 0;
F_tsc1 = 0;
F_t2sc1 = 0;
F_t3sc1 = 0;
F_t4sc1 = 0;
F_yr1 = 0;
F_yr2 = 0;
F_sen1 = 0;
F_sen2 = 0;
F_sen3 = 0;
Tsen1 = 0;
Fsc1 = 0;
Fyr1 = 0;
Fsen1 = 0;
Tact1 = 0;
Fvel = 0;
Fcorr = 0;
F_volt1 = 0;
Fder = 0;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
ruido=randn(1,length(t)); % ruido
contt=0; % constanten para deteccion de torque
disp(' Solo ingresar 12 clases de fallas 8 simple y 4 dobles ');
faultCorr = input('falla corriente [-90 100%] = ');
faultVel = input('falla velocidad [-90 100%] = ');
faultTorq = input('falla Torque [-90 100%] = ');
faultCrem = input('falla Cremallera [-90 100%] = ');
faultR = input('falla R [-50 50%] = ');
faultMf = input('falla Mf [-50 50%] = ');
faultPhi = input('falla Phi [-50 50%] = ');
tiem1 = input('inicio de falla [0 9.4seg] = ');
tiem2 = input('fin de falla [0 9.4seg] = ');
k = 2; % Inicio de bucle
% para validar matriz de confusion
cont = 1;
typeF = 0;
% bucle
for tt=ti:dt:tff-dt
```

```
vel_wheel(k)=x(1); ang_wheel(k)=x(2); vel_col(k)=x(3);
ang_col(k)=x(4);vel_rack(k)=x(5); rack(k)=x(6); vel_road(k)=x(7);
road(k)=x(8); vel_motor(k)=x(9); corr(k)=x(10);
y = C*x ; % sensores
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%% SENSORES MEDIDOS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Tsen(k,1)=y(1,1);% + 0.1*ruido(k);% Sensor Torque
                       %  Tsen_filted(k,1)=Tsen1;
                       %  Tsen1 = (1-50*dt)*Tsen1 + 50*Tsen(k,1)*dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
thetha_sc(k,1)=y(2,1);% Sensor angulo columna
                        thetha_sc1(k,1)=Fsc1;
                        Fsc1 = (1-gg*dt)*Fsc1 + gg*thetha_sc(k,1)*dt;
Yr_sen(k,1) = y(5,1)/1; % sensor posicion cremallera
                        Yr_sen1(k,1)=Fyr1;
                        Fyr1 = (1-gg*dt)*Fyr1 + gg*Yr_sen(k,1)*dt;
%%%%%%%%%%%%% SENSORES DE MOTOR %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
vel_motor_sen(k,1) = y(3,1)/1;% + 0.1*ruido(k); % velocidad angular
                       vel_motor_sen1(k,1)=Fvel;
                  Fvel = (1-gg*dt)*Fvel + gg*vel_motor_sen(k,1)*dt;
corr_sen(k,1) = y(4,1)/1;% + 0.1*ruido(k);  % sensor de corriente
                       corr_sen1(k,1)=Fcorr;
                       Fcorr = (1-gg*dt)*Fcorr + gg*corr_sen(k,1)*dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%  FALLOS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
if ((tt>=tiem1)&(tt<=tiem2))
Yr_sen(k,1) = Yr_sen(k,1) + 0.1*(faultCrem/100);% + 0.005 +
0.001*ruido(k);
Tsen(k,1) = Tsen(k,1) + 60*(faultTorq/100);% + 0.1*ruido(k);
corr_sen(k,1) = corr_sen(k,1) + 30*(faultCorr/100);% + 1*ruido(k);
vel_motor_sen(k,1)  = (vel_motor_sen(k,1) +
                       1500*2*pi/60*(faultVel/100));%
Ra10=0.1*(1+(faultR)/100);   Bm10 = 0.8*ff(10,1)*(1-faultMf/100);
Kb10=0.0533*(1+faultPhi/100); Kt10=Kb10; Jm10 = 3.5e-04;La10=1e-4;
%Ra=0.15;   Bm =1.2;    Kb=0.0107;   Kt=Kb; Jm = 3.5e-04; La=1e-4;
%Ra=0.8;   Bm =1.8;    Kb=0.0833;   Kt=Kb; Jm = 3.5e-04; La=1e-4;
  A=[ -Bsw10/Jsw10                          -Ksc10/Jsw10
Bsw10/Jsw10                            Ksc10/Jsw10
0                       0
0                 0              0               0
         1                                      0
0                                        0                            0
0                                                 0                 0
0               0
       B110/Jeq10                                 Ksc10/Jeq10
-B110/Jeq10                       -(Ktr10/Jeq10+Ksc10/Jeq10)
0                Ktr10/(Jeq10*Rp10)
0                 0              0         Kt10*N110/Jeq10
         0                                      0
1                                        0                            0
0                                                 0                 0
0               0
         0                                      0
0                             nf10*Ktr10/(Rp10*Mr10)            -
Br10/Mr10    -(nf10*Ktr10/(Rp10^2*Mr10)+2*nB10*Ksl10/(NI10^2*Mr10))
0      2*nB10*Ksl10/(NI10*Mr10)    0               0
         0                                      0
0                                        0                            1
```

```
0                                                0                  0
0                0
         0                                       0
0                                       0                            0
Ksl10/(NI10*Jfw10)                                  -Bfw10/Jfw10
-Ksl10/Jfw10        0                0
         0                                       0
0                                       0                            0
0                                                1                  0
0                0
         0                                       0
0                                    0*Ksc10                         0
0                                                0                  0
-Bm10/Jm10       Kt10*N110/Jm10
         0                                       0
0                                       0                            0
0                                                0                  0
-Kb10*N110/La10     -Ra10/La10     ];
%%%
[Ak,Bk]=c2d(A,B,dt);
[Ak,B2k]=c2d(A,B2,dt);
elseif ((tt>tiem2)&(tt<=tiem2+2*dt))
Ra10=0.1*(1+0/100);    Bm10 = 0.8*ff(10,1)*(1+0/100);
Kb10=0.0533*(1-0/100); Kt10=Kb10; Jm10 = 3.5e-04; La10=1e-4;
%Ra=0.15;    Bm =1.2;     Kb=0.0107;    Kt=Kb; Jm = 3.5e-04; La=1e-4;
%Ra=0.8;    Bm =1.8;     Kb=0.0833;    Kt=Kb; Jm = 3.5e-04; La=1e-4;
  A=[ -Bsw10/Jsw10                         -Ksc10/Jsw10
Bsw10/Jsw10                            Ksc10/Jsw10
0                        0
0                  0               0                0
         1                                       0
0                                       0                            0
0                                                0                  0
0                0
       B110/Jeq10                                Ksc10/Jeq10
-B110/Jeq10                        -(Ktr10/Jeq10+Ksc10/Jeq10)
0                 Ktr10/(Jeq10*Rp10)
0                  0               0          Kt10*N110/Jeq10
         0                                       0
1                                       0                            0
0                                                0                  0
0                0
         0                                       0
0                                nf10*Ktr10/(Rp10*Mr10)          -
Br10/Mr10     -(nf10*Ktr10/(Rp10^2*Mr10)+2*nB10*Ksl10/(NI10^2*Mr10))
0      2*nB10*Ksl10/(NI10*Mr10)    0                0
         0                                       0
0                                       0                            1
0                                                0                  0
0                0
         0                                       0
0                                       0                            0
Ksl10/(NI10*Jfw10)                                  -Bfw10/Jfw10
-Ksl10/Jfw10        0                0
         0                                       0
0                                       0                            0
0                                                1                  0
0                0
         0                                       0
0                                    0*Ksc10                         0
```

```
0                                                    0                    0
-Bm10/Jm10       Kt10*N110/Jm10
         0                                           0
0                                                0                        0
0                                                    0                    0
-Kb10*N110/La10    -Ra10/La10    ];
%%%%
[Ak,Bk]=c2d(A,B,dt);
[Ak,B2k]=c2d(A,B2,dt);
end
    Tsen_filted(k,1)=Tsen1;
    Tsen1 = (1-50*dt)*Tsen1 + 50*Tsen(k,1)*dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Tp_sen(k,1) = (Tsen(k,1) - Tsen(k-1,1))/dt; % derivada sensor torque
                        Tp_sen1(k,1)=Fsen1;
                        Fsen1 = (1-gg*dt)*Fsen1 + gg*Tp_sen(k,1)*dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%% CURVA BOOSTER VELOCIDAD - TORQUE %%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
yh =5;
   if (Td(k) == 5)
      io = -1*yh;
   elseif (Td(k) == -5 )
               io = 1*yh;
   else
               io = 0*yh;
   end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%% LEY DE CONTROL DE SISTEMA EPS %%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
der(k,1) = Kd*(Tp_sen(k,1)/Ksc);
                    der_filted(k,1)=Fder;
                        Fder = (1-30*dt)*Fder + 30*der(k,1)*dt;
volt(k,1)=Kp*((Tsen_filted(k,1)-io)/Ksc) + 0*der_filted(k,1);
u = volt(k,1);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
volt_p(k,1) = (volt(k,1) - volt(k-1,1))/dt;
                    volt_p1(k,1)=F_volt1;
                    F_volt1 = (1-(50)*dt)*F_volt1 +
(50)*volt_p(k,1)*dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%friccion de coulomb %%%%%%%%%%%%%%%%%%%%%%%%%%%%
   if (x(5)>=0)
       Yp = 1;
   elseif (x(5)<0)
       Yp = -1;
   end
   if (x(7)>=0)
       Fwp = 1;
   elseif (x(7)<0)
       Fwp = -1;
   end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%% MODELO DEL SISTEMA EPS x=Ax+Bu+Fd %%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
x = Ak*x + Bk*u + B2k*[Td(k) Fd(k)]' + Fric1k*Yp + Fric2k*Fwp;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%  CALCULOS DERIVADAS %%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%% velocidad
vel_p(k,1) = (vel_motor_sen(k,1)-vel_motor_sen(k-1,1))/dt;
```

```
                    vel_p1(k,1)=F_vel1;
                    F_vel1 = (1-(gg)*dt)*F_vel1 + (gg)*vel_p(k,1)*dt;
              vel_2p(k,1) = (vel_p(k,1) - vel_p(k-1,1))/dt;
                    vel_2p1(k,1)=F_vel2;
                    F_vel2 = (1-(gg)*dt)*F_vel2 + (gg)*vel_2p(k,1)*dt;
              vel_3p(k,1) = (vel_2p(k,1) - vel_2p(k-1,1))/dt;
                    vel_3p1(k,1)=F_vel3;
                    F_vel3 = (1-(gg)*dt)*F_vel3 + (gg)*vel_3p(k,1)*dt;
%%%%%% corriente
corr_p(k,1) = (corr_sen(k,1)-corr_sen(k-1,1))/dt;
                    corr_p1(k,1)=F_corr1;
                    F_corr1 = (1-(gg)*dt)*F_corr1 +
                              (gg)*corr_p(k,1)*dt;
          corr_2p(k,1) = (corr_p(k,1) - corr_p(k-1,1))/dt;
                    corr_2p1(k,1)=F_corr2;
                    F_corr2 = (1-(gg)*dt)*F_corr2 +
                              (gg)*corr_2p(k,1)*dt;
%%%%% columna
thetha_p_sc(k,1) = (thetha_sc(k,1) - thetha_sc(k-1,1))/dt;
                    thetha_p_sc1(k,1)=F_tsc1;
                    F_tsc1 = (1-(gg)*dt)*F_tsc1 +
                             (gg)*thetha_p_sc(k,1)*dt;
       thetha_2p_sc(k,1) = (thetha_p_sc(k,1) - thetha_p_sc(k-
                            1,1))/dt;
                    thetha_2p_sc1(k,1)=F_t2sc1;
                    F_t2sc1 = (1-(gg)*dt)*F_t2sc1 +
                              (gg)*thetha_2p_sc(k,1)*dt;
       thetha_3p_sc(k,1) = (thetha_2p_sc(k,1) - thetha_2p_sc(k-
                            1,1))/dt;
                    thetha_3p_sc1(k,1)=F_t3sc1;
                    F_t3sc1 = (1-(gg)*dt)*F_t3sc1 +
                              (gg)*thetha_3p_sc(k,1)*dt;
       thetha_4p_sc(k,1) = (thetha_3p_sc(k,1) - thetha_3p_sc(k-
                            1,1))/dt;
                    thetha_4p_sc1(k,1)=F_t4sc1;
                    F_t4sc1 = (1-(gg)*dt)*F_t4sc1 +
                              (gg)*thetha_4p_sc(k,1)*dt;
%%%%%% cremallera
Yr_p(k,1) = (Yr_sen(k,1) - Yr_sen(k-1,1))/dt;
                    Yr_p1(k,1)=F_yr1;
                    F_yr1 = (1-(gg)*dt)*F_yr1 + (gg)*Yr_p(k,1)*dt;
          Yr_2p(k,1) = (Yr_p(k,1) - Yr_p(k-1,1))/dt;
                    Yr_2p1(k,1)=F_yr2;
                    F_yr2 = (1-(gg)*dt)*F_yr2 + (gg)*Yr_2p(k,1)*dt;
%%%%%% torque
Tsen_p(k,1) = (Tsen(k,1)-Tsen(k-1,1))/dt;
                    Tsen_p1(k,1)=F_sen1;
                    F_sen1 = (1-(gg)*dt)*F_sen1 + (gg)*Tsen_p(k,1)*dt;
          Tsen_2p(k,1) = (Tsen_p(k,1)-Tsen_p(k-1,1))/dt;
                     Tsen_2p1(k,1)=F_sen2;
                    F_sen2 = (1-(gg)*dt)*F_sen2 +
                             (gg)*Tsen_2p(k,1)*dt;
          Tsen_3p(k,1) = (Tsen_2p(k,1)-Tsen_2p(k-1,1))/dt;
                    Tsen_3p1(k,1)=F_sen3;
                    F_sen3 = (1-(gg)*dt)*F_sen3 +
                             (gg)*Tsen_3p(k,1)*dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%% RESIDUALES %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
r1(k,1) = ((phi*corr_sen(k,1) - Jm1*vel_p(k,1) -
             mf*vel_motor_sen(k,1)))/1;%+ML;
```

```
            r1_filted(k,1)=Fr1;
               Fr1 = (1-pp*dt)*Fr1 + pp*r1(k,1)*dt;
%%%%%%
r2(k,1) = (phi*volt(k,1) - (phi^2+ra*mf)*vel_motor_sen(k,1) -
(ra*Jm1 + La1*mf)*vel_p(k,1) - La1*Jm1*vel_2p(k,1))/1;% -Ra*ML -
La*ML_p;
            r2_filted(k,1)=Fr2;
               Fr2 = (1-pp*dt)*Fr2 + pp*r2(k,1)*dt;
%%%%%%%
r3(k,1) = (mf*volt(k,1) - (ra*mf + phi^2)*corr_sen(k,1) - (mf*La1 +
Jm1*ra)*corr_p(k,1) - La1*Jm1*corr_2p(k,1) +Jm1*volt_p(k,1))/1;%
+phi*ML;
            r3_filted(k,1)=Fr3;
               Fr3 = (1-pp*dt)*Fr3 + pp*r3(k,1)*dt;
%%%%%%%
r4(k,1) = (volt(k,1) - La1*corr_p(k,1) - ra*corr_sen(k,1) -
          phi*vel_motor_sen(k,1))/1;
           r4_filted(k,1)=Fr4;
               Fr4 = (1-pp*dt)*Fr4 + pp*r4(k,1)*dt;
%%%%%%%
rcross_check1(k,1) = (Jm1*vel_p(k,1) + mf*vel_motor_sen(k,1) -
Ktr*(thetha_sc(k,1) - Yr_sen(k,1)/Rp) + Tsen(k,1) +
Bsc/Ksc*Tsen_p(k,1)-Jeq*thetha_2p_sc(k,1))/(5*1e8);
%%
con = (nf*Ktr/Rp^2+ 2*nB*Ksl/NI^2);
%%
rcross_check(k,1) =
((Jm1*(Mr*vel_3p(k,1)+Br*vel_2p(k,1)+con*vel_p(k,1)) +
mf*(Mr*vel_2p(k,1)+Br*vel_p(k,1)+con*vel_motor_sen(k,1)) -
Ktr*(Mr*thetha_2p_sc(k,1)+Br*thetha_p_sc(k,1)+con*thetha_sc(k,1)) +
(Mr*Tsen_2p(k,1)+Br*Tsen_p(k,1)+con*Tsen(k,1)) +
Bsc/Ksc*(Mr*Tsen_3p(k,1)+Br*Tsen_2p(k,1)+con*Tsen_p(k,1)) -
Jeq*(Mr*thetha_4p_sc(k,1)+Br*thetha_3p_sc(k,1)+con*thetha_2p_sc(k,1)
) - Ktr/Rp*(-nf/Rp*Ktr*(thetha_sc(k,1)) + 2*nB/NI*Ksl*(-
road(k))))/(5*1e8)); %( - nf/Rp*Ktr*(thetha_sc(k,1)) +
2*nB/NI*Ksl*(-road(k)));
               rcc_filted(k,1)=Frcc;
               Frcc = (1-1000*dt)*Frcc + 1000*rcross_check(k,1)*dt;
%%%%%%%
ryr(k,1) = Mr*Yr_2p(k,1) + Br*Yr_p(k,1) - nf/Rp*Ktr*(thetha_sc(k,1)
- Yr_sen(k,1)/Rp) + 2*nB/NI*Ksl*(Yr_sen(k,1)/NI-road(k));
           ryr_filted(k,1)=Fry/(7.5*10^5);
               Fry = (1-400*dt)*Fry + 400*ryr(k,1)*dt;
%%%%%%%%%%%%%%%%%%%%%% para plotear %%%%%%%%%%%%%%%%%%%%%%
Tm(k,1) = Jm*vel_p(k,1) + Bm*vel_motor_sen(k,1);
Tp(k,1) = Ktr*(thetha_sc(k,1) - rack(k)/Rp);
slip(k,1) = road(k);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%% DIAGNOSTICO DE RNA %%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%% VENTANA 150 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
sum1=[0;0;0;0;0;0];
  if (rem(k,150)==0)  % 20 milisegundos de toma de datos
      if (k==150)
       for (i=k:-1:k-150+1)
      sum1(1) = sum1(1) + r1_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(150-1)));
      sum1(2) = sum1(2) + r2_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(150-1)));
```

```
       sum1(3) = sum1(3) + r3_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(150-1)));
       sum1(4) = sum1(4) + r4_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(150-1)));
       sum1(5) = sum1(5) + rcc_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(150-1)));
       sum1(6) = sum1(6) + ryr_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(150-1)));
        end
        cont = cont + 1;
        yy(cont,:) = 1.1*[1*sum1(1); sum1(2); sum1(3); sum1(4);
sum1(5);  sum1(6) ]/150;
      else
      for (i=k:-1:k-200+1)
      sum1(1) = sum1(1) + r1_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(200-1)));
      sum1(2) = sum1(2) + r2_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(200-1)));
      sum1(3) = sum1(3) + r3_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(200-1)));
      sum1(4) = sum1(4) + r4_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(200-1)));
      sum1(5) = sum1(5) + rcc_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(200-1)));
      sum1(6) = sum1(6) + ryr_filted(i,1);%*(0.54-
0.46*cos(2*pi*i/(200-1)));
      end
       cont = cont + 1;
      yy(cont,:) = 1.1*[1*sum1(1); sum1(2); sum1(3); sum1(4);
sum1(5);  sum1(6) ]/200;
      end
%%%%%%%%%%%%%%%%%%% NORMALIZANDO %%%%%%%%%%%%%%%%%%%%%%%%%%%%%
rr=yy(cont,:);
  if (max(abs(yy(cont,:)))>0.05)
      rr = rr/max(abs(yy(cont,:)));
  end
%%%%%%%%% data input RNA
  datain(1,:) = rr';
  ndata = 1;

     datainput = [ datain ones(ndata,1) ];

        xnn = datainput(1,:);
        xnn = xnn';
        m = v'*xnn;
        n = 2.0./(1+ exp(-(m-c)./a)) - 1;
        p1 = v2'*n;
         q = 2.0./(1+exp(-(p1-c1)./a1)) - 1;
        ynn = w'*q;
        output(1,:) = ynn';
        for kx = 1:ns
           [maxout km] = max(output(1,:));
           outputmax(1,:)  = zeros(1,ns);
           outputmax(1,km) = 1;
        end
  outputmax;
        pred(cont,:) = km;
          if ((outputmax(1,1)~=0))
         fprintf('FALLO Corr en = %2.5f seg \n',tt);
          elseif ((outputmax(1,2)~=0))
        fprintf('FALLO vel en = %2.5f seg \n',tt);
```

```
          elseif ((outputmax(1,3)~=0))
         fprintf('FALLO Torq en = %2.5f seg \n',tt);
          elseif ((outputmax(1,4)~=0))
         fprintf('FALLO Yr en = %2.5f seg \n',tt);
          elseif ((outputmax(1,5)~=0))
         fprintf('FALLO Ra en = %2.5f seg \n',tt);
          elseif ((outputmax(1,6)~=0))
         fprintf('FALLO Mf en = %2.5f seg \n',tt);
          elseif ((outputmax(1,7)~=0))
         fprintf('FALLO Phi en = %2.5f seg \n',tt);
          elseif (max(outputmax(1,8)~=0))
         fprintf(' no FALLO  en = %2.5f seg \n',tt);
          elseif ((outputmax(1,9)~=0))
          fprintf('FALLO MULTIPLE Corr-Vel en = %2.5f seg \n',tt);
          elseif ((outputmax(1,10)~=0))
         fprintf('FALLO MULTIPLE Yr-Torque en = %2.5f seg \n',tt);
          elseif ((outputmax(1,11)~=0))
         fprintf('FALLO MULTIPLE Corr-Yr en = %2.5f seg \n',tt);
         elseif ((outputmax(1,12)~=0))
         fprintf('FALLO MULTIPLE Vel-Yr en = %2.5f seg \n',tt);
          elseif ((outputmax(1,13)~=0))
         fprintf('FALLO MULTIPLE Torque-Yr en = %2.5f seg \n',tt);
          end
   end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%% ESTIMACION PARAMETRICA ESPACIO DE PARIDAD %%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
vel_p_e(k,1) =vel_p(k,1);
   e1(k,1) = (phi*corr_sen(k,1) - Jm*vel_p_e(k,1) -
             mf*vel_motor_sen(k,1)); %Mf
%%%%%%%%
corr_p_e(k,1) = corr_p(k,1);
   e4(k,1) = volt(k,1) - La1*corr_p_e(k,1) -ra*corr_sen(k,1) -
             phi*vel_motor_sen(k,1); %Ra
%%%%%%%%%% detecta torque aplicado por el conductor %%%%%%%%%%%%%%%%
    if ((Tsen(k,1)>0.5)&(contt==0))
       contt = 1;
       gam(k-1,1) = 0;
       par(k-1,1)=0;
       p(k-1,1) = 1e6;
       gamJm(k-1,1) = 0;
       parJm(k-1,1) = 0;
       pJm(k-1,1) = 1e6;
       gamfi(k-1,1) = 0;
       parfi(k-1,1) = 0;
       pfi(k-1,1) = 1e6;
    end
%%%%%%%%%%%%%%%%%%%% ESTIMACION RECURSIVA DE  Ra %%%%%%%%%%%%%%%%%%%%
Ram(k,1) = Ra10;
bet(k,1) = -corr_sen(k,1);
   if (k>1)
       r(k,1) = e4(k,1);
       gam(k-1,1) = [1/(p(k-1,1)*bet(k,1)^2+lamda)]*p(k-
                    1,1)*bet(k,1);
       par(k,1)=par(k-1,1)+ gam(k-1,1)*[r(k,1) - bet(k,1)*par(k-
                  1,1)];
       p(k,1) = [1 - gam(k-1,1)*bet(k,1)]*p(k-1,1)/lamda;
       Raest(k+1,1) = Raest(k,1) + par(k,1); % valor final
   end
%%%%%%%%%%%%%%%%%%% ESTIMACION RECURSIVA DE Mf %%%%%%%%%%%%%%%%%%%%%%
inercia(k,1) = Bm10;
```

```
betJm(k,1) = -vel_motor_sen(k,1);
  if (k>1)
      rJm(k,1) = +e1(k,1);
      gamJm(k,1) = [1/(pJm(k-1,1)*betJm(k,1)^2+lamda)]*pJm(k-
                   1,1)*betJm(k,1);
      parJm(k,1)=parJm(k-1,1)+ gamJm(k,1)*[rJm(k,1) -
                 betJm(k,1)*parJm(k-1,1)];
      pJm(k,1) = [1 - gamJm(k,1)*betJm(k,1)]*pJm(k-1,1)/lamda;
      Mfest(k+1,1) =  Mfest(k,1) + parJm(k,1); % valor final
  end
%%%%%%%%%%%%%%%%%%%% ESTIMACION RECURSIVA DE phi %%%%%%%%%%%%%%%%%%%%
Fi(k,1) = Kb10*N1;
betfi(k,1) = corr_sen(k,1);
  if (k>1)
      rfi(k,1) = e1(k,1);
      gamfi(k,1) = [1/(pfi(k-1,1)*betfi(k,1)^2+lamda)]*pfi(k-
                   1,1)*betfi(k,1);
      parfi(k,1)=parfi(k-1,1)+ gamfi(k,1)*[rfi(k,1) -
                 betfi(k,1)*parfi(k-1,1)];
      pfi(k,1) = [1 - gamfi(k,1)*betfi(k,1)]*pfi(k-1,1)/lamda;
      fiest(k+1,1) =  fiest(k,1) + parfi(k,1); % valor final
  end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
k=k+1;
end
%%
figure (1)
  subplot(2,3,1);plot(t,r1_filted);grid;xlabel('Tiempo(seg)');ylabel
(' Residual 1');title('r1');%axis([0 10 -1.5 1.25]);
  subplot(2,3,2);plot(t,r2_filted);grid;xlabel('Tiempo(seg)');ylabel
(' Residual 2');title('r2');%axis([0 10 -1.5 1.25]);
  subplot(2,3,3);plot(t,r3_filted);grid;xlabel('Tiempo(seg)');ylabel
(' Residual 3');title('r3');%axis([0 10 -1.5 1.25]);
  subplot(2,3,4);plot(t,r4_filted);grid;xlabel('Tiempo(seg)');ylabel
(' Residual 4');title('r4');%axis([0 10 -1.5 1.25]);
  subplot(2,3,5);plot(t,rcc_filted);grid;xlabel('Tiempo(seg)');ylabe
l(' Residual 5');title('rT');%%axis([0 10 -1.5 1.25]);
  subplot(2,3,6);plot(t,ryr_filted);grid;xlabel('Tiempo(seg)');ylabe
l(' Residual 6');title('ryr');%axis([0 10 -1.5 1.25]);
  % figure (1)
  % subplot(6,1,1);plot(t,r1_filted);grid on;ylabel(' Residual
1');title('r1');%axis([0.0 9.4 -1 1]);
  % subplot(6,1,2);plot(t,r2_filted);grid on;ylabel(' Residual
2');title('r2');%axis([0.0 9.4 -1 0.2]);
  % subplot(6,1,3);plot(t,r3_filted);grid on;ylabel(' Residual
3');title('r3');%axis([0.0 9.4 -1 0.2]);
  % subplot(6,1,4);plot(t,r4_filted);grid on;ylabel(' Residual
4');title('r4');%axis([0.0 9.4 -1 0.5]);
  % subplot(6,1,5);plot(t,rcc_filted);grid on;ylabel(' Residual
5');title('rT');%axis([0.0 9.4 -0.5 2.5]);
  % subplot(6,1,6);plot(t,ryr_filted);grid
on;xlabel('Tiempo(seg)');ylabel(' Residual
6');title('ryr');%axis([0.0 9.4 -0.5 1.2]);
figure(2)
  subplot(3,3,1);plot(t,180/pi*ang_wheel);grid;legend('theta
sw');ylabel('angulo volante(grados)');xlabel('tiempo(seg)');axis([0
val -40 40]);
  subplot(3,3,2);plot(t,180/pi*thetha_sc);grid;legend('theta
sc');ylabel('angulo columna(grados)');xlabel('tiempo(seg)');axis([0
val -40 40]);
```

```
  subplot(3,3,3);plot(t,1000*Yr_sen);grid;legend('Rack');ylabel('pos
icion(mm)');xlabel('tiempo(seg)');axis([0 val -5 5]);
  subplot(3,3,4);plot(t,180/pi*road);grid;legend('rueda');ylabel('an
gulo rueda (grados)');xlabel('tiempo(seg)');
  subplot(3,3,5);plot(t,corr_sen);grid;legend('corriente');ylabel('c
orriente(A)');xlabel('tiempo(seg)');
  subplot(3,3,6);plot(t,Tsen);grid;legend('sensor
torque');ylabel('Torque(Nm)');xlabel('tiempo(seg)');
  subplot(3,3,7);plot(t,volt);grid;legend('voltaje');ylabel('voltaje
(V)');xlabel('tiempo(seg)');
  subplot(3,3,8:9);plot(t,Td(1:length(t)));grid;legend('Torque
Conductor');ylabel('Torque(Nm)');xlabel('tiempo(seg)');axis([0 val -
5 5]);
%%
figure(3)
  plot(t,(0.1-par),'b',t,Ram,'--r');ylabel('Resistencia
(ohm)');xlabel('Tiempo(seg)');title('Resistencia del
Motor');legend('Estimado','Real');grid;axis([0 9.4 0.095 0.16])
%%
figure(4)
  plot(t,(0.8-parJm),'b',t,inercia,'--r');title('Friccion
Viscoaa');ylabel('Friccion
(Nm/rad/seg)');xlabel('Tiempo(seg)');legend('Estimado','Real');grid;
axis([0 9.4 0.6 1.3])
%%
figure(5)
  plot(t,0.0533*N1-parfi,'b',t,Fi,'--r');title('Constante del
Motor');ylabel('Cte Motor
(Nm/A)');xlabel('Tiempo(seg)');legend('Estimado','Real');grid;axis([
0 9.4 0.3 0.9])
```

2.-La simulación entre simulink y Carsim se desarrolló con el objetivo de poder validar el sistema como si fuera instalado en un vehículo, Carsim permite simular el sistema de diagnóstico de simulink con interacción a un entorno vehicular real.

2.- SIMULACION CARSIM-SIMULINK

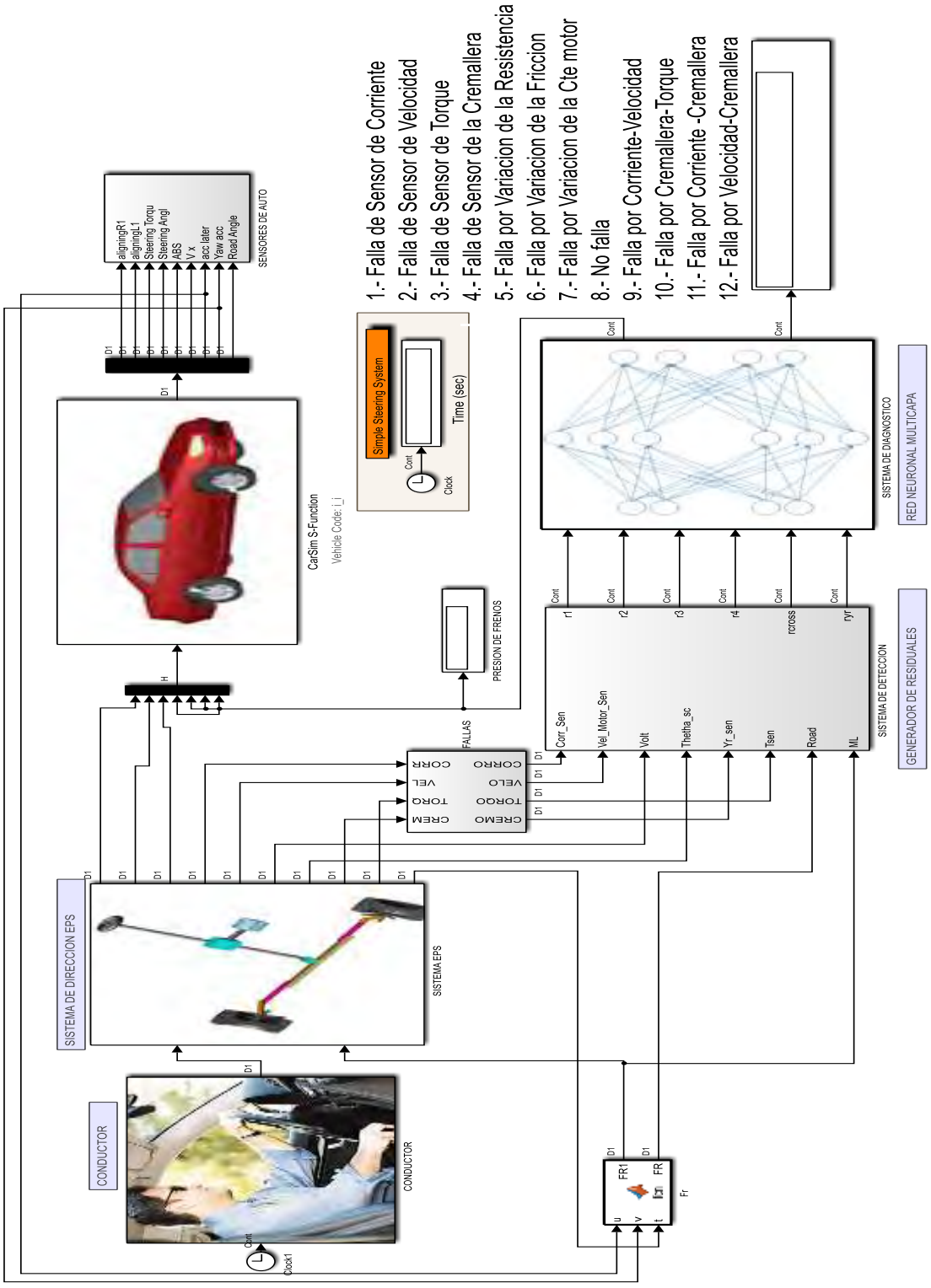

Figura A1.- Simulación Carsim - Simulink

2.1.- CONDUCTOR

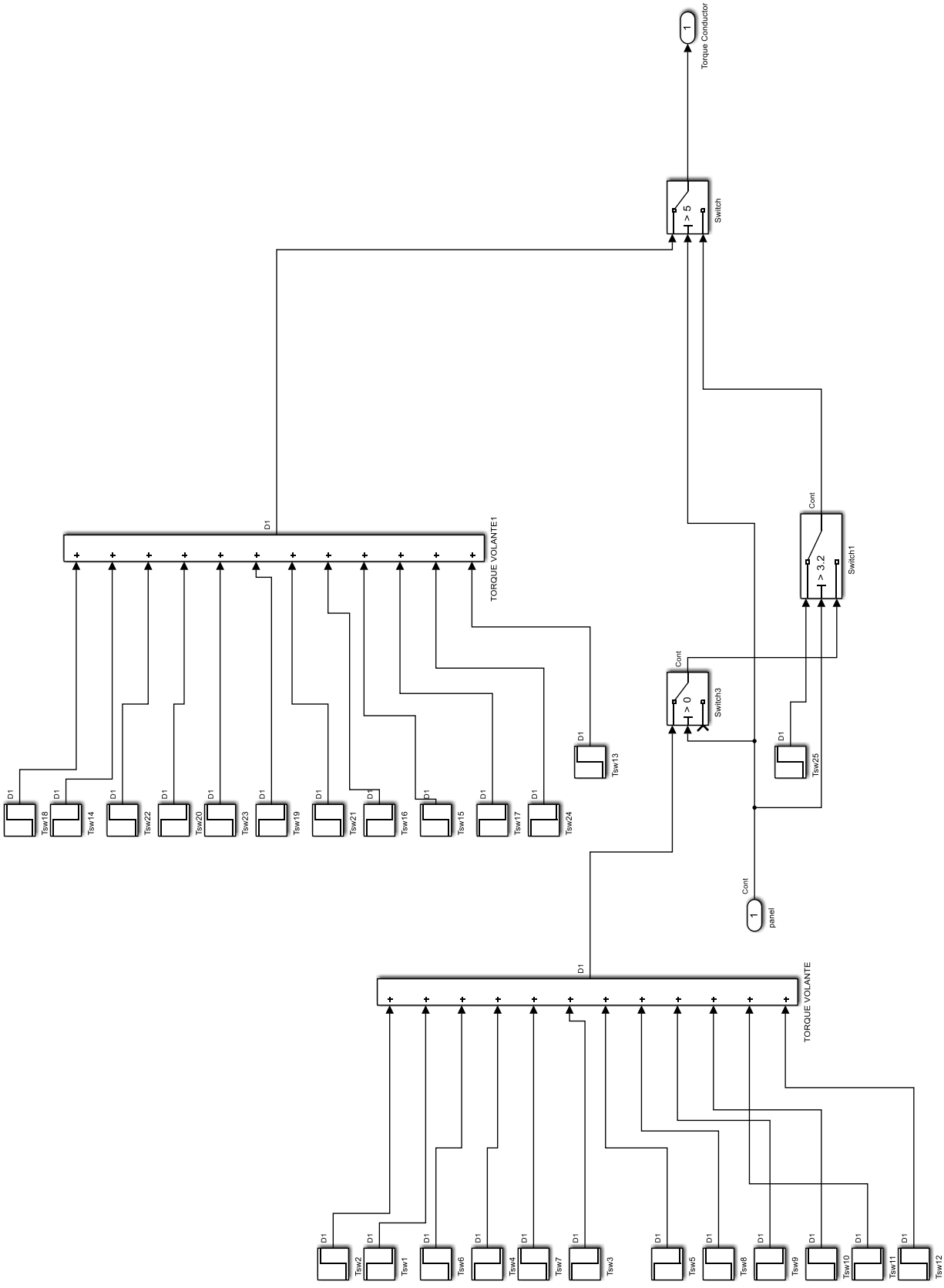

Figura A2.- Señal de Torque del conductor

2.2.- SISTEMA DE DIRECCION EPS

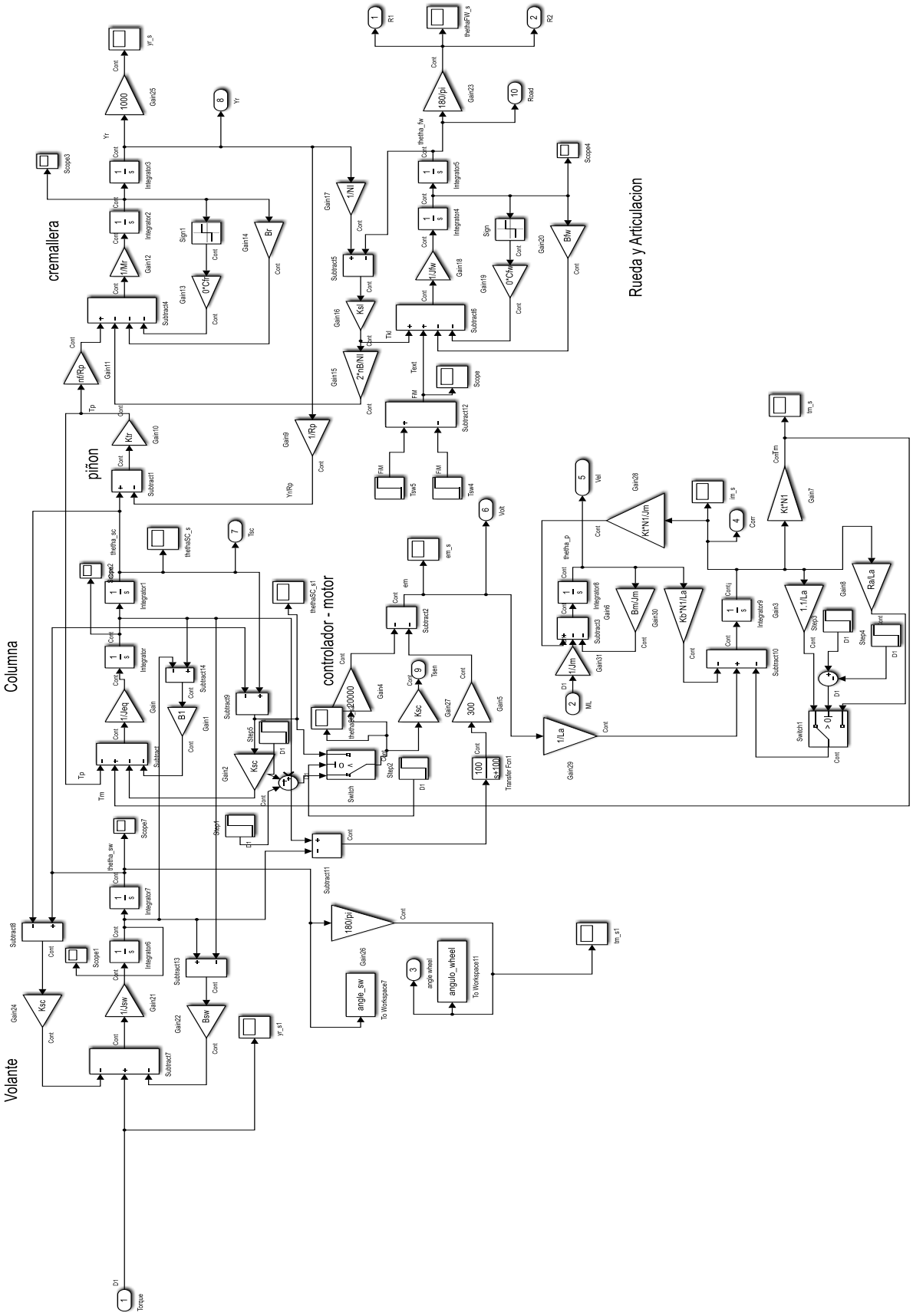

Figura A3.- Modelo de la dirección EPS

2.3.- BLOQUE DE FALLAS

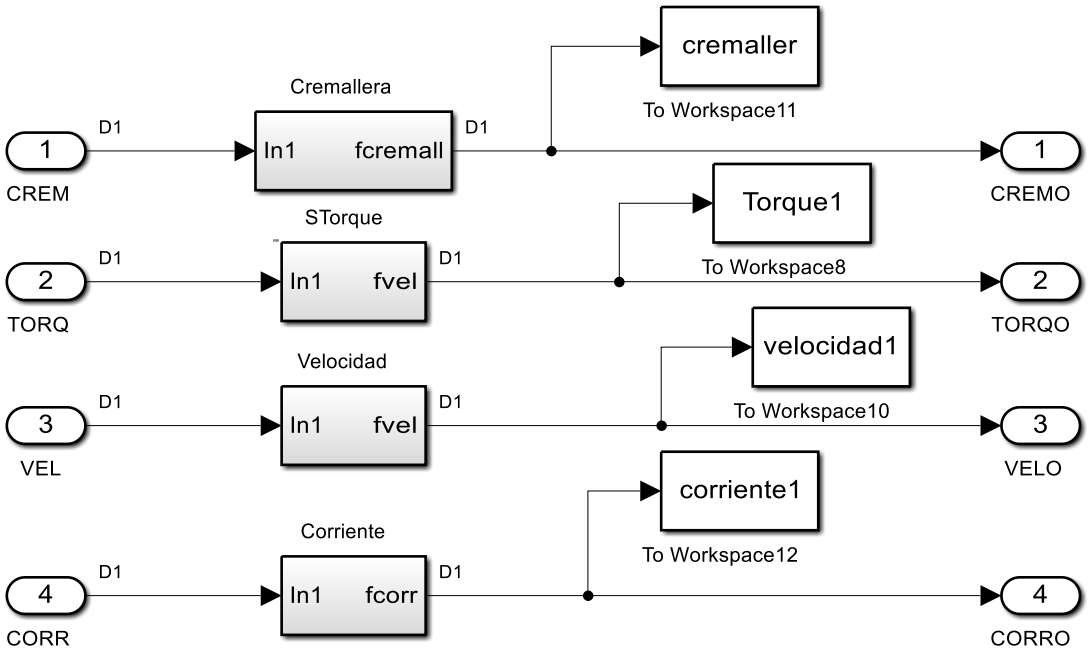

Figura A4.- Bloque 1 de falla

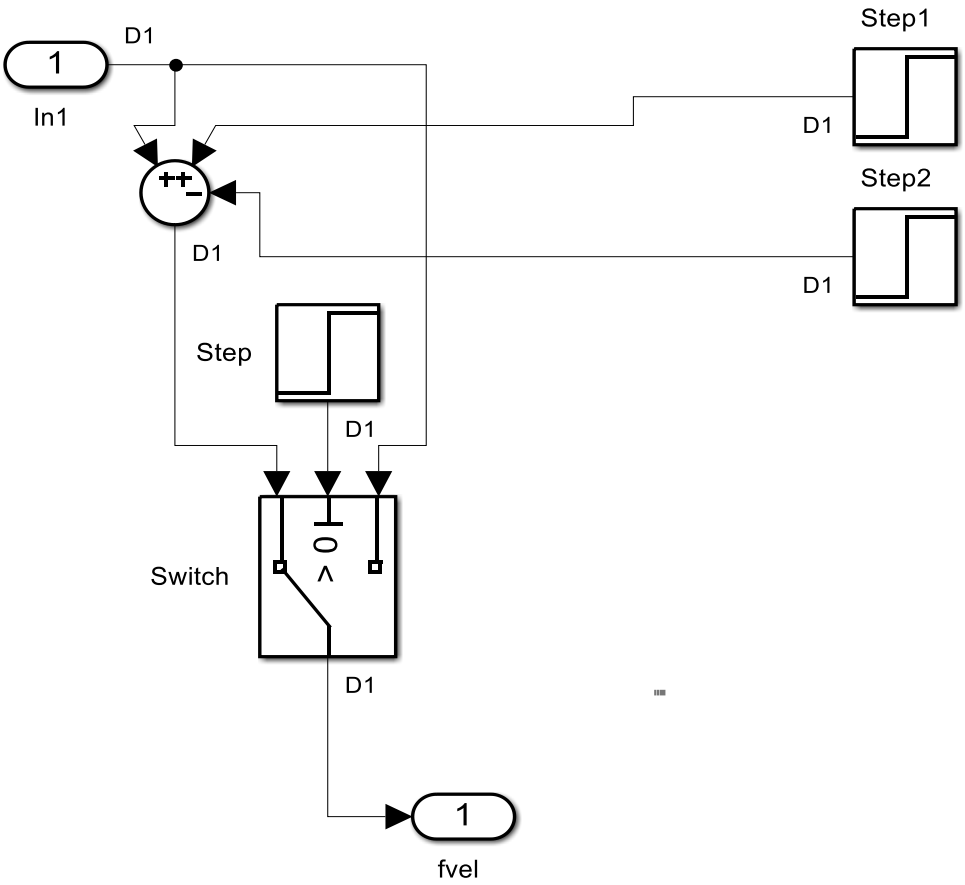

Figura A5.- Bloque 2 de falla

2.4.- GENERADOR DE RESIDUALES

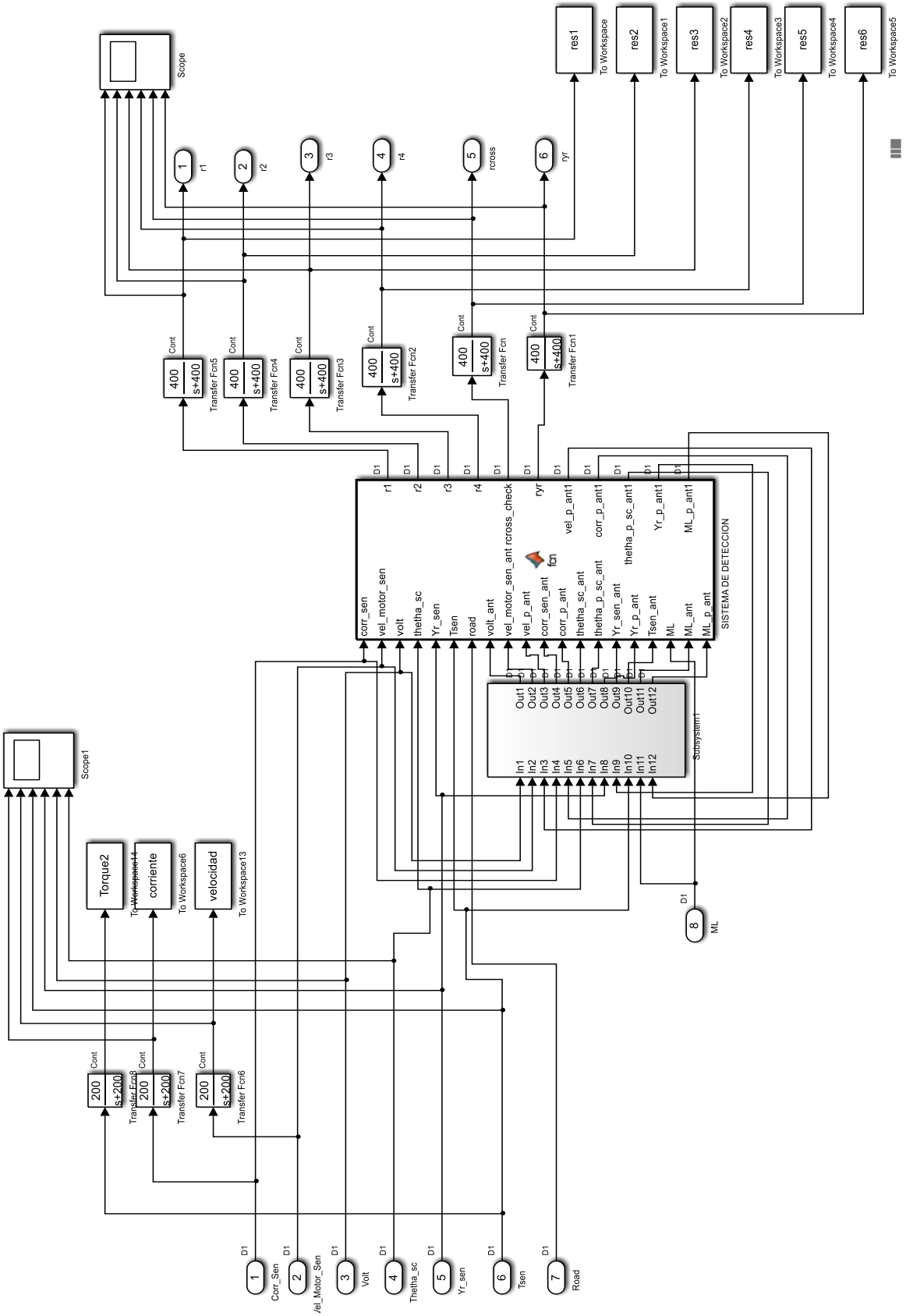

Figura A5.- Bloque del generador de residuales

2.5.- SISTEMA DE DETECCION S - FUNCTION

```
function
[r1,r2,r3,r4,rcross_check,ryr,vel_p_ant1,corr_p_ant1,thetha_p_sc_ant
1,Yr_p_ant1,ML_p_ant1] =
fcn(corr_sen,vel_motor_sen,volt,thetha_sc,Yr_sen,Tsen,road,volt_ant,
vel_motor_sen_ant,vel_p_ant,corr_sen_ant,corr_p_ant,thetha_sc_ant,th
etha_p_sc_ant,Yr_sen_ant,Yr_p_ant,Tsen_ant,ML,ML_ant,ML_p_ant)
%%%%%%%%%%%%%%%%%%%% MODELO DE ESTADO EPS %%%%%%%%%%%%%%%%%%%%%%%%%%
  Jsw = 0.03444;   %momento inercial volante
  Jsc = 0.03444;     %momento inercial de la columna de direccion
  Jfw = 0.61463;
  Jm =  3.5*1e-4;
  Mr = 2;         %masa de la cremallera
  Bsw = 0.36042;   %friccion viscosa volante
  Bfw = 88.128; %
  Bsc = 0.36042;     %Columna de dirección rigidez rotacional
  Br = 88.128; %friccion viscosa cremallera
  Bm = 0.8;%0.05;          %friccion viscosa motor
  Mf = Bm;
  Cfr = 0.04;    %friccion coulomb en cremallera
  Cfw = 0.04;     %La fricción de Coulomb fuerza de arranque
  Ksw = 42057;       %volante rigidez rotacional
  Ksc = 42057;    %Columna de dirección rigidez rotacional
  Ktr = 42057;    %barra de torsión rigidez rotacional
  Ksl = 14878;          % direccion rigidez rotacional
  La = 0.0001;         %inductancia motor
  Ra = 0.1;       %resistencia motor
  Kt = 0.0533;    %constante motor torque
  Kb = 0.0533;            %Fuerza           motor
  N1= 49/3;       %relación de transmisión caja de cambios del motor
  Rp = 0.007367; %radio del piñon
  NI = 0.11816;  %tasa de dirección de vinculación
  nf = 0.985;     %Relación de transmisión del par hacia adelante
  nB = 0.985;     %Relación de transmisión de par hacia atrás
  Kd=0*300;
  Kp=20000;
  B1=Bsc;
  Fcoulomb1=0*Cfr; %Friccion seca
  Fcoulomb2=0*Cfw; %Friccion seca
  Jeq=Jsc;%+N1^2*Jm;
  phi = Kb*N1;
  ra=Ra;
  mf=Mf;
  Jm1=Jm;
  La1=La;
  %#codegen
  dt=0.0001;
  F_tsc1=0;
  F_t2sc1=0;
  Fr1=0;
  Fr2=0;
  Fr3=0;
  Fr4=0;
  Frcc=0;
  Fry=0;
  pp=400;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  Tp_sen = (Tsen - Tsen_ant)/dt; % sensor
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  volt_p = (volt - volt_ant)/dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%  CALCULOS DERIVADAS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
      vel_p = (vel_motor_sen-vel_motor_sen_ant)/dt;
        vel_2p = (vel_p - vel_p_ant)/dt;
      corr_p = (corr_sen -corr_sen_ant)/dt;
        corr_2p = (corr_p - corr_p_ant)/dt;
%%%%%
      thetha_p_sc = (thetha_sc - thetha_sc_ant)/dt;
              thetha_p_sc1=F_tsc1;
                  F_tsc1 = (1-(1)*dt)*F_tsc1 + (1)*thetha_p_sc*dt;
%%%%%
      thetha_2p_sc = (thetha_p_sc - thetha_p_sc_ant)/dt;
              thetha_2p_sc1=F_t2sc1;
                  F_t2sc1 = (1-(1)*dt)*F_t2sc1 +
                            (1)*thetha_2p_sc*dt;
%%%%%
      Yr_p = (Yr_sen - Yr_sen_ant)/dt;
        Yr_2p = (Yr_p - Yr_p_ant)/dt;
%%%%%
      ML_p = (ML - ML_ant)/dt;
        ML_2p = (ML_p - ML_p_ant)/dt;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%  CALCULOS RESIDUALES %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  r1 =(phi*corr_sen - Jm1*vel_p - mf*vel_motor_sen)-ML;
%%%%%%
  r2 = phi*volt - (phi^2+ra*mf)*vel_motor_sen - (ra*Jm1 +
       La1*mf)*vel_p - La1*Jm1*vel_2p -Ra*ML -La*ML_p;
%%%%%%%
  r3 =mf*volt - (ra*mf + phi^2)*corr_sen - (mf*La1 + Jm1*ra)*corr_p
      - La1*Jm1*corr_2p +Jm1*volt_p +phi*ML;
%%%%%%%
  r4 = volt - La1*corr_p - ra*corr_sen - phi*vel_motor_sen;
%%%%%%%
  rcross_check =Jm1*vel_p + mf*vel_motor_sen - Ktr*(thetha_sc -
            Yr_sen/Rp) - Tsen - Bsc/Ksc*Tp_sen-Jeq*thetha_2p_sc + ML;
  if ((rcross_check>100)||(rcross_check<-100))
      rcross_check=rcross_check/(5708);
  end
%%%%%%%
  ryr = (Mr*Yr_2p + Br*Yr_p - nf/Rp*Ktr*(thetha_sc - Yr_sen/Rp) +
         2*nB/NI*Ksl*(Yr_sen/NI)-road)/(7.5*10^5);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%  GUARDA DATOS ANTERIORES %%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  vel_p_ant1 = volt_p;
  corr_p_ant1 = corr_p;
  thetha_p_sc_ant1 = thetha_p_sc;
  Yr_p_ant1 = Yr_p;
  ML_p_ant1 = ML_p;
```

2.6.- SISTEMA DE DIAGNOSTICO

```
  function [F,F1]    =
fcn(r1_filted,r2_filted,r3_filted,r4_filted,rcc_filted,ryr_filted)
%#codegen
  b(2)
  c = [  0
```

```
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0
        0 ];
%%
  ns = 13;
%%
  a = [  0.5018
       1.2139
       0.4462
       1.0381
       0.7401
       1.0144
       0.8551
       0.4516
       0.9873
       0.9999
       1.0852
       0.4093
       0.9899
       0.5615
       0.5427
       0.4015
       0.5215
       0.8384
       0.5572
       0.3063
       1.0689
       0.8526
       1.0171
       1.0264
```

```
       0.2431
       0.5621
       0.6789
       0.9624
       1.0456
       0.5052
       1.1051
       0.9932
       0.5285
       0.3810
       0.5708 ];
%%
  v1 = [      0.9643    0.2539   -0.0584   -0.7007    0.1498   -
0.2578   -0.8343
     -0.2429   -0.7434   -0.9673    0.0756   -0.0121    0.2865
0.1089
      0.9705   -0.2826   -0.1235    0.1899   -0.1788    1.1510
0.3774
      0.2301    0.4082    0.2910   -0.6664   -0.6272   -0.2608
0.4700
      0.3293   -0.5072   -0.4933   -0.2058   -0.7896    0.0101
0.2495
     -0.5374   -0.3620   -0.3087   -0.4231    0.5825   -0.0372
0.0585
     -0.5366   -0.5318    0.2650   -0.0100    0.6184    0.4476
0.1776
      0.4708    0.6120    0.6318    0.0602    0.3031    0.3986   -
1.1831
     -0.3834    0.4473    0.0890    0.0432    0.1456    0.0024
0.0889
      0.2578   -0.5330    0.0956    0.6152    0.0489   -0.0127
0.0704
     -0.0374    0.3893   -0.2060    1.0729    0.8710   -0.3989
0.1327
      0.4483   -0.2182   -0.8182    0.3901   -0.6600   -0.7907
0.1724
      0.0425    0.1794   -0.7760   -0.1926    0.2770    0.0790
0.4122
     -0.1456    1.1988    0.6242    0.2312   -0.5667   -0.2226   -
0.1220
      0.5098   -0.4549   -0.7845    0.6190   -0.7396    0.5011   -
0.2335
     -0.8291    0.3864   -0.2796    0.5155    0.5390    0.9816
0.1041
     -0.3442   -0.5122    0.0696   -0.1250   -0.5612   -0.6934   -
0.6156
     -0.0130    0.0724    0.2491   -0.2760    0.1654   -0.4694   -
0.8508
      0.0601    0.4806    0.5866    0.4748   -0.4870   -0.0592
0.4660
      0.4943   -0.7082   -0.7626   -0.1283    1.2136    0.1751   -
0.1361
     -0.1767    0.2614    0.4955    0.0752    0.7447   -0.3865
0.5415
      0.8359    0.2786   -0.2061   -0.6801    0.2793   -0.6251
1.0175
     -0.4704    0.0261   -0.6709   -0.0146    0.4503   -0.2302
0.1867
      0.1854   -0.1903   -0.1267   -0.1938   -0.6585    0.2139   -
0.4436
```

```
     -0.0793    0.2360    0.7093   -1.4078   -0.5880   -0.4382   -
0.5093
     -0.2631   -0.2386    1.1784   -0.2411    0.3696    0.7448
0.6741
     -0.4025   -0.5126   -0.8005   -0.4411   -0.2943    1.2468
0.0353
     -0.0385   -0.3176   -1.2093    0.5561    0.1838   -0.4518
0.2002
      0.3677   -0.0033   -0.0541   -0.0415    0.8663   -0.4007   -
0.2716
      0.2372    0.6137    0.1424    0.2104    0.8661   -0.5109
0.5663
     -0.7905    0.3569    0.2637    0.1531   -0.6620   -0.3095   -
0.5986
     -0.4107    0.1238   -0.1223   -0.5939    0.0528   -0.1270
0.2708
      0.8226   -0.3547   -0.2278   -1.7430   -0.2957    0.0543   -
0.6003
     -0.5880    0.2216   -0.1911   -0.2732   -0.4071    1.0511
0.2488
      0.2824    1.1385   -0.0185   -0.6273   -1.1492    0.1825   -
0.8565 ];
%%
  w = [ 0.1605   -0.6930   -0.5415   -0.0420   -0.7272    0.1387
1.1615   -0.3833    0.1713    0.5650    0.4024    0.1894    0.5302
      0.1885   -0.8924   -0.1016    0.3838   -0.3846    0.7418   -
0.0570    0.2883    0.2703    0.4467    0.5303    0.3140    0.2246
     -0.0208   -0.4274   -0.7234    0.2082    0.2315    0.1705   -
0.2769    0.4858   -0.5544    0.1859   -0.2593    0.7745    0.1617
      0.2709    0.2996   -0.0601   -0.0649   -0.0870    0.0117   -
0.8203   -0.3660   -0.7019    0.1585   -0.2031    0.3554   -0.3047
      0.3165   -0.2280    0.0703   -0.0838    0.1864   -0.6169
0.3913   -0.1477    0.4558   -0.1181   -0.2830   -0.3354   -0.2219
     -0.4236   -0.2334    0.0414   -0.0315   -0.0686   -0.6948   -
0.0237    0.6042   -0.7127    0.5950    0.2269   -0.7974    0.3671
      0.2880    0.4311    0.5671    0.0242   -0.0097    0.9712   -
0.0280    0.2355    0.4791    0.0519   -0.3845   -0.2117   -0.6564
      0.6347    0.1239    0.1019   -0.7207    1.2373   -0.2291   -
1.5308    0.1113    0.7095   -0.1826    0.3801   -0.2476    0.2692
      0.1848    0.9050   -0.0835    0.5026    0.2129    0.4860   -
0.8620    0.4864   -0.2124   -0.1887   -0.6823    0.0254    0.4273
     -0.6443    0.1280    0.0754    0.5067   -0.7240    0.5588
0.0409    0.0157   -0.7346    0.4627   -0.8290    0.6294    0.1608
     -0.4294   -0.4209   -0.3387    0.0271   -0.1241   -0.1207
0.4072   -0.7169    0.5496    0.1170   -0.3557   -0.6793   -0.2997
     -0.0143   -0.0113    0.0218   -0.5768    0.2919   -0.0936   -
0.5660    1.4287   -0.0876   -0.1551    0.3671    0.0973   -0.2009
     -0.4582    0.4269   -0.0714   -0.2307    0.1096   -0.0357   -
0.7235    0.3223    0.8131   -0.9439    0.3701   -0.2946    0.5708
      0.6610   -0.5153   -0.7981    0.9864   -0.3115    0.3266
0.9830    0.6356    1.4967   -0.5786   -0.6237   -0.5406   -0.2360
      0.3225    0.4170    0.3758    1.2074    0.1140   -0.4281   -
0.6897   -0.7513    0.2403    0.5940    0.1447   -0.7529   -0.2541
     -0.8556    0.3536    0.2098    0.0224   -0.1423   -0.1401
0.3378   -0.0602   -0.5918    0.3969    0.7392    0.3469   -0.3281
     -0.5595    0.5977    0.2644    0.2078   -0.1006   -0.1913
0.3548    0.2775    0.3042   -0.4730   -0.0303   -0.1739    0.2593
     -0.3386   -0.8097   -0.2301   -0.0117   -1.1339   -0.1857   -
0.1994   -0.8522   -0.5124   -0.6156    0.3993    0.1067    0.3813
      1.1303   -0.1006    0.0969   -0.4345    0.2808    1.0101
0.1503   -0.3496   -0.6923   -1.0133    0.4495   -0.2642    0.2521
```

```
      1.2464   -0.1862    0.3886    0.0326    0.0309   -0.0676
0.0487    0.1931    0.1149   -0.9159    0.0964    0.0680   -0.1257
      0.8739    0.4110    0.3125   -0.0170    0.2541    0.2545   -
0.9384   -0.2012   -0.1146    0.9719   -0.0662   -0.8251    0.0565
     -0.0611    0.2797   -0.1649    0.1614    0.8249    0.8017   -
0.5754    0.4279    0.4484    0.6324    0.5855   -0.1612    0.2458
      0.3376    0.3112   -0.3150   -0.2556   -0.2601    0.4757   -
0.7889   -0.1354    0.6223    0.6356    0.1629    0.2914    0.1572
     -0.4167    0.4878    0.6462   -0.1336   -0.5610   -0.6494   -
0.6819    0.8791    0.0830   -0.0633   -0.0756    0.0733   -0.6901
      0.2082    0.2753   -1.0601    0.1308    0.3778    0.3482   -
0.2627    0.7067   -0.6432    0.3328   -0.3080    0.1073   -0.2377
     -0.1139   -0.5810    0.0466    1.0612    0.4850   -0.6938   -
0.7004    0.2479    0.5003   -0.5738    0.2654   -0.2525   -0.5113
      0.2805    0.6330   -0.7431    0.9223   -0.1421    0.2268
0.2739    0.1863    0.2784   -0.4094   -0.8345   -0.8468    0.4119
     -0.3759   -0.1233    0.2161    0.1940   -0.5732    0.4334
0.0578   -0.0119    0.1014   -0.1542    0.0545   -0.7868   -0.6156
     -0.6134   -0.1882    0.2704   -0.2337    0.3742    1.0041   -
0.0332   -0.6559   -0.0979    0.1628   -0.3958   -0.2090    0.7486
     -0.2764    0.5910   -0.3521   -0.1254   -0.4038   -1.0045
0.6031    0.0562   -0.6031   -0.1056    0.2145    0.0429    0.8105
      0.6620    0.0576   -0.1243    0.2570   -0.1106   -0.1092   -
0.0851    0.2807   -0.4545    0.5924    1.0145    0.4307    0.4405
      0.3334   -0.3564    0.5346   -0.0766    0.1647   -0.1758   -
0.0850   -0.4607    0.9796   -0.1911   -0.2664    0.8296    0.1470
      0.3542    0.1454   -0.3551   -0.0978    0.5691    0.0649
0.1228   -1.0473   -0.3604   -0.5808    0.3291    0.3205   -0.3494
     -0.2862   -0.4986   -0.4881   -1.3541   -0.5682    0.2271
0.4631   -0.2112   -0.0263    0.2167    0.7625    0.0545    1.1525
     -1.1025    0.1319    0.8926    0.1049    0.1215    0.4961   -
0.2579   -0.2908   -0.2800    0.2936    0.0036   -0.2976    0.2764
];

v= v1';
yy = [r1_filted; r2_filted; r3_filted; r4_filted; rcc_filted;
ryr_filted];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% NORMALIZANDO %%%%%%%%%%%%%%%%%%%%%%%%%%
rr=yy;
  if (abs(max(yy))>0.1)
      rr = rr/abs(max(yy));
  end
  datain = rr'/1;
  ndata = 1;
     datainput = [ datain ones(ndata,1) ];
        xnn = datainput(1,:);
        xnn = xnn';
        m = v'*xnn;
        n = 2.0./(1+ exp(-(m-c)./a)) - 1;
        ynn = w'*n;
        output = ynn';
        for kx = 1:ns
           [maxout km] = max(output);
           outputmax  = zeros(1,ns);
           outputmax(1,km) = 1;
        end
  F=0;
  F1=0;
          if ((outputmax(1,1)~=0))
             F1=1;
          elseif ((outputmax(1,2)~=0))
```

```
    F1=2;
elseif ((outputmax(1,3)~=0))
 F=0;
    F1=3;
elseif ((outputmax(1,4)~=0))
    F1=4;
elseif ((outputmax(1,5)~=0))
F1=5;
elseif ((outputmax(1,6)~=0))
  F1=6;
elseif ((outputmax(1,7)~=0))
    F1=7;
elseif (max(outputmax(1,8)~=0))
 F1=8;
elseif (max(outputmax(1,9)~=0))
    F1=9;
elseif ((outputmax(1,10)~=0))
    F1=10;
elseif ((outputmax(1,11)~=0))
  F1=11;
elseif ((outputmax(1,12)~=0))
    F1=12;
elseif ((outputmax(1,13)~=0))
    F1=13;
end
```

2.7.- CARSIM – S FUNCTION

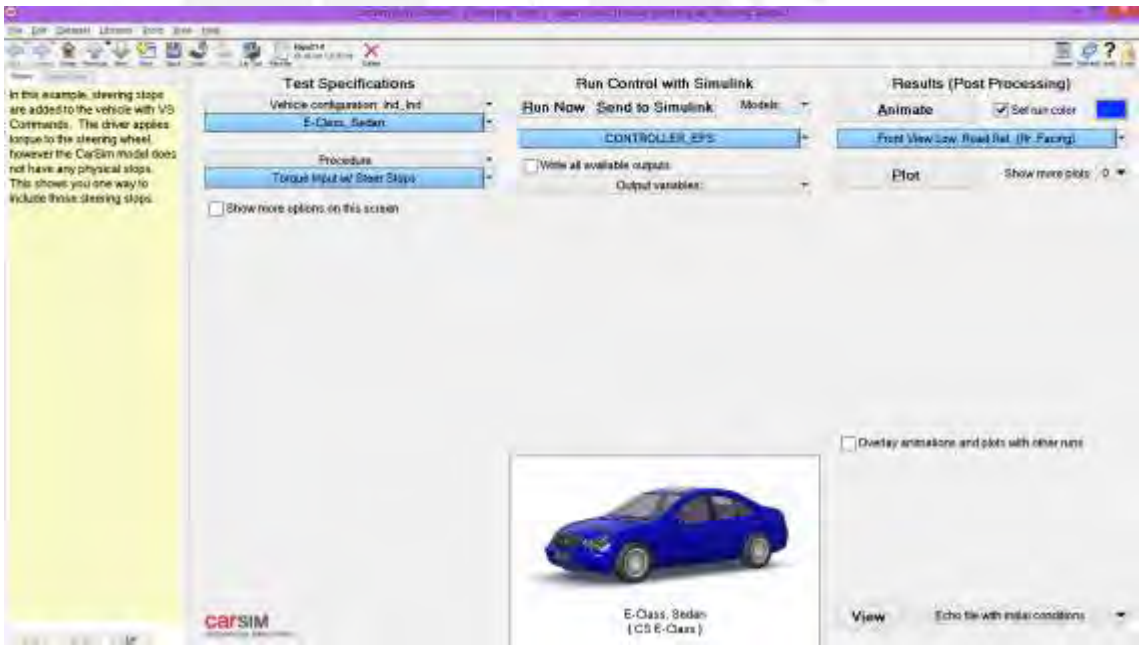

Figura A6.- Entorno Carsim

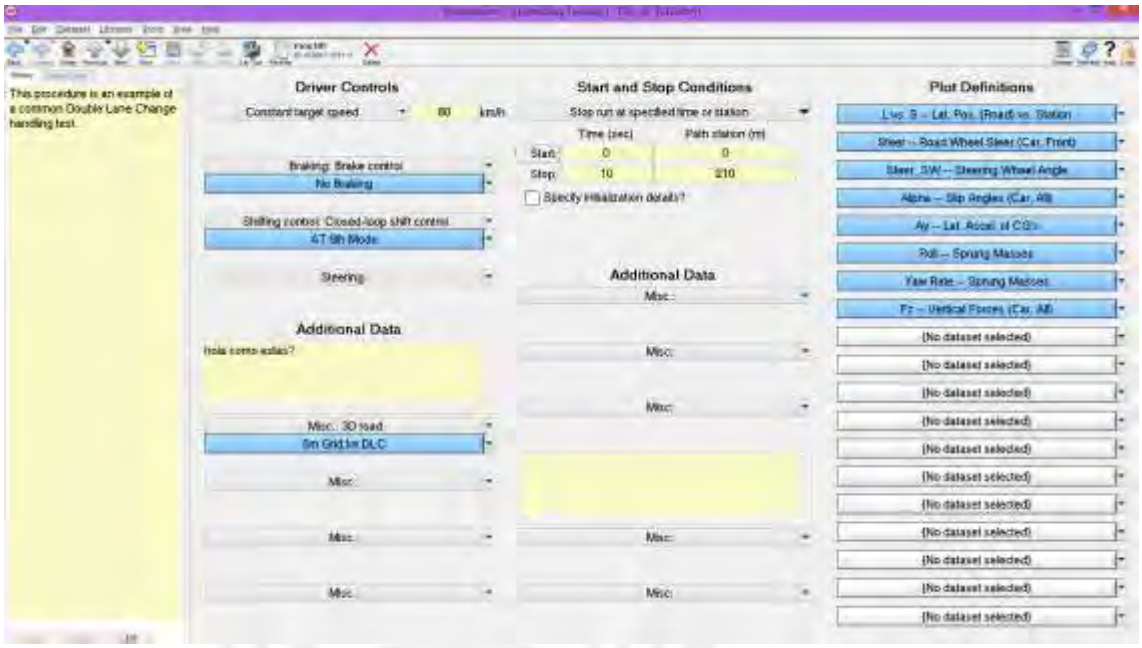

Figura A7.- Entorno Carsim 2(Procedimientos)

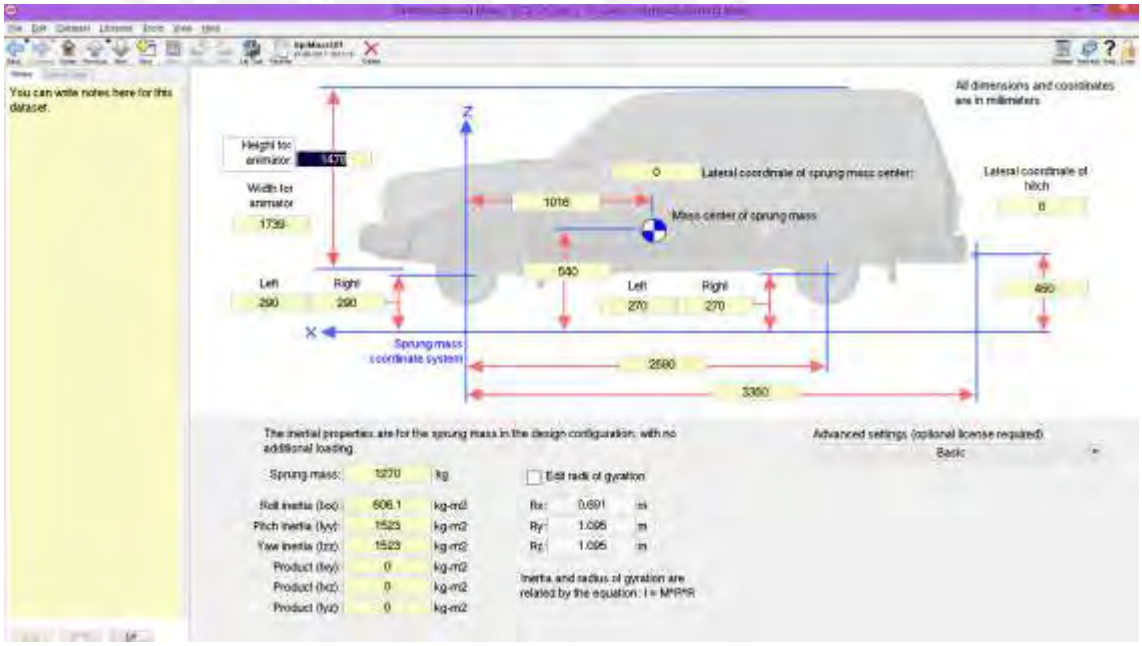

Figura A8.- Entorno Carsim 3 (dimensiones del vehiculo)

Figura A9.- Entorno Carsim 4 (variables de entrada)

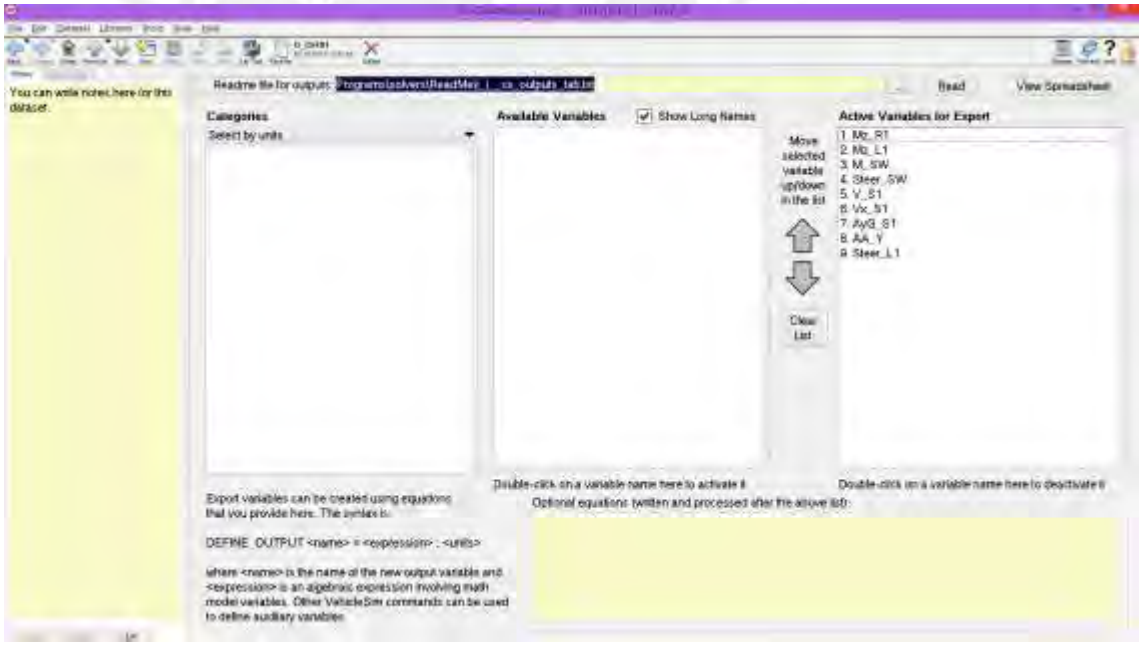

Figura A10.- Entorno Carsim 5 (variables de salida)