Anexo A

Script en MATLAB para control de barco

```
%Programa para control segun la
tesis
clear all, close all, clc
%Parametros del barco
n=1;
%Parametros Disponibles
directamente
L=1.255;
R_k=n*L;%criteria de aceptacion
m=23.8;%Masa
x_g=0.0425;
Iz=1.76;
%Estimados aproximados
X_du=-2;
Y_dv=-10;
Y_dr=0;
N_dv=0;
N_dr=-1;
%Identificados experimentalmente
X_u=-2;
Y_v=-7;
Y_r=-0.1;
N_v=-0.1;
N_r=-0.5;
h=[0,0,1]';
ud=0.25;

%Tiempo
dt=0.001;
ttt=0:dt:450;
tt=0;

%%
%Generacion de trayectoria
A=10;
lambda=15;
bb=0*[-1;1;0];
bb_hat=[0;0;0];
R=5;
x0=0;
y0=0;
theta= 0;
deltatheta_max=3*L;%Coeficiente
de amortiguamiento
deltatheta_min=L;
K_deltatheta=1;
%We=[1 0
%    0 1];
%gamma=10.0;



%%
%Condiciones iniciales de
simulacion
%Condiciones iniciales
x=-10;
y=3;
psi=0.785;

u=0.25;
v=0;
r=0;

nu=[u
    v
    r];
eta=[x
    y
    psi];

alpha_1=ud;
alpha_2=0;
alpha_3=0;

R_psi=[cos(psi) -sin(psi)  0
        sin(psi)  cos(psi)  0
        0          0        1];

%%
%Algoritmo Angulo
%psi=0;
accumulation=0;
psi_last=0;
state=0;

%%
%Matrices de modelo de barco
m11=m-X_du;
m22=m-Y_dv;
m23=m*x_g-Y_dr;
m32=m*x_g-Y_dr;
m33=Iz-N_dr;

c13=-(m-Y_dv)*v-(m*x_g-Y_dr)*r;
c23=(m-X_du)*u;

d11=-X_u
d22=-Y_v
d23=-Y_r
d32=-N_v
d33=-N_r

u=0.000;

n11=-X_u;
n22=-Y_v;
n23=m*u-Y_r;
n32=m*u-Y_r;
%n32=-N_v;
n33=m*x_g*u-N_r;
```

```
% u=0.1;

M=[m11 0   0
    0   m22 m23
    0   m32 m33]

C=[0    0     c13
   0    0     c23
   -c13 -c23 0]

D=[d11  0    0
    0   d22 d23
    0   d32 d33]

N_nu=[n11  0  0
       0   n22  n23
       0   n32  n33];

i=1;

%%
%Parametros del modelo de
referencia
%Angulo PSI
wc=1.5;
dddpsi_d=0;
ddpsi_d=0;
dpsi_d=0;
psi_d=0;

%Velocidad surge
wcu=0.5;
ddu_d=0;
du_d=0;
u_d=0.1;


%%
%Parametros del controlador
cc=0.75;
k_1=20;
k_2=20;
k_3=1;

K=diag([k_1;k_2;k_3]);

GAMMA_MTR=0.5*eye(3);

Mz11=-cc;
Mz12=h';
Mz21=-inv(M)*h;
Mz22=-inv(M)*K;
```

```
Mz=[Mz11 Mz12
    Mz21 Mz22];

%%
%Bucle de control
for i=1:1:length(ttt)

    %Angulos implicados
    beta=atan2(v,u);
    betav(i)=beta;


theta_ast=newtonr2(0,theta,1e-
6,1000,x,y);


xd_ast=A*sin(theta_ast/lambda);
    yd_ast=theta_ast;


dxd_ast=(A/lambda)*cos(theta_ast/
lambda);
    dyd_ast=1;

    ddxd_ast=-
(A/lambda^2)*sin(theta_ast/lambda
);
    ddyd_ast=0;


    Chip=atan2(dyd_ast,dxd_ast);
    Chipv(i)=Chip;


%
    R_chip=[cos(Chip) -sin(Chip)
            sin(Chip)  cos(Chip)];

%     varepsilon=Rp_chit'*[x-
xd;y-yd];

    Alon_Cros_e = R_chip'*[x-
xd_ast;y-yd_ast];

%     s=varepsilon(1);
%     e=varepsilon(2);
%
    x_e=Alon_Cros_e(1);
    y_e=Alon_Cros_e(2);

    deltatheta=(deltatheta_max-
deltatheta_min)*exp(-
K_deltatheta*y_e^2)+deltatheta_mi
n;
```

```
    %Chir=atan2(-e,deltatheta);
    Chir=atan2(-y_e,deltatheta);
    Chirv(i)=Chir;

    tt=tt+dt;
    t(i)=tt;
    XYPSI(:,i)=eta;
    nuv(:,i)=nu;



psi_los=Chip+Chir-beta;
psi_now=psi_los;
psidv(i)=psi_los;


%%
%REFERENCE MODEL

%Angulo PSI
dddpsi_d=-3*wc*ddpsi_d-
3*wc^2*dpsi_d-
wc^3*psi_d+wc^3*psi_los;
ddpsi_d=ddpsi_d+dt*dddpsi_d;
drd=ddpsi_d;
dpsi_d=dpsi_d+dt*ddpsi_d;
rd=dpsi_d;
psi_d=psi_d+dt*dpsi_d;
psi_dv(i)=psi_d;


%Velocidad surge
ddu_d=-2*wcu*du_d-
wcu^2*u_d+wcu^2*ud;
du_d=du_d+dt*ddu_d;
u_d=u_d+dt*du_d;
u_dv(i)=u_d;

%%
%Mapping angle from <??;?> to
<pi;-pi>
if( sign(psi_d)>0 ) %
sign(psi)==1
    n = floor(psi_d/pi);
elseif( sign(psi_d)<0 ) %
sign(psi)==-1
    n = ceil(psi_d/pi);
else
    n = 0;
end

remainder = rem(n,2);

if( remainder==0 )
    psi_mapped = psi_d - n*pi;
else % remainder~=0
    if( sign(remainder)>0 ) %
sign(remainder)==1
    psi_mapped = psi_d -
(n+1)*pi;
    else % sign(remainder)<0,
sign(remainder)==-1
    psi_mapped = psi_d - (n-
1)*pi;
    end
end

psi_d=psi_mapped;

%%
%Mapping angle from <pi;-pi> to
<0;2pi>
%Para el controlador

if(psi_d<0)
    psi_mapped = psi_d + 2*pi;
else
    psi_mapped = psi_d;
end

%psi_d=psi_mapped;

%%
%Controlador
    z1=psi-psi_d;
    z21=u-u_d;
    z22=v-alpha_2;
    z23=r-alpha_3;

    Z=[z1
        z21
        z22
        z23];
    Zv(:,i)=Z;

    % dZ=Mz*Z;
    % Z=Z+dt*dZ;

%Vector de control Alpha
alpha_1=u_d;
alpha_3=-cc*z1+rd;
dalpha_3=-cc*(r-rd)+drd;



dalpha_2=(1/m22)*(-
n22*alpha_2+(k_2-n22)*z22-
m23*dalpha_3-n23*r-
```

```
(bb_hat(1)*sin(psi)-
bb_hat(2)*cos(psi)));
alpha_2=alpha_2+dt*dalpha_2;

tau_1= m11*du_d+n11*u-k_1*(u-
u_d)-
(bb_hat(1)*cos(psi)+bb_hat(2)*sin
(psi));
tau_3=
m32*dalpha_2+m33*dalpha_3+n32*v+n
33*r-k_3*(r-alpha_3)-z1-
bb_hat(3);

dbb_hat=GAMMA_MTR*R_psi*Z(2:4,1);
bb_hat=bb_hat+dt*dbb_hat;

tau=[tau_1;0;tau_3];

tauv(:,i)=tau;

%Modelo del barco
dnu=inv(M)*(-
N_nu*nu+tau+R_psi'*bb);
nu=nu+dt*dnu;
%nuv(:,i)=nu;

R_psi=[cos(psi) -sin(psi) 0
        sin(psi)  cos(psi) 0
        0         0        1];

deta=R_psi*nu;
eta=eta+dt*deta;

u=nu(1);
v=nu(2);
r=nu(3);

x=eta(1);
y=eta(2);
psi=eta(3);


end

%%
%%Graficos

figure(2)
plot(0:0.1:40*pi,A*sin((0:0.1:40*
pi)/lambda),'--k','LineWidth',4)
hold on
%plot(y_losv,x_losv,'--r'),hold
on
%axis([-7 7 -2 10])
```

```
title('Posición X-Y')
xlabel('Este [m]')
ylabel('Norte [m]')
grid on
plot(XYPSI(2,:),XYPSI(1,:),'r','L
ineWidth',1.5)
legend('Ruta de referencia','Ruta
obtenida')

%Parametros del barco
La=2;%metros
L1=La/3;%metros
L2=La/6;%metros

nk=length(t);
for k = 1:50000:nk
  x = XYPSI(2,k);    y =
XYPSI(1,k);
  fi1 = pi-XYPSI(3,k);
  x1 = x - L2*cos(fi1);     y1 = y
- L2*sin(fi1);
  x2 = x1 + L1*cos(fi1);     y2 =
y1 + L1*sin(fi1);

  xA = x2 - La/2*sin(fi1);
  yA = y2 + La/2*cos(fi1);
  xB = x2 + La/2*sin(fi1);
  yB = y2 - La/2*cos(fi1);
  xC = x1 + La/2*sin(fi1);
  yC = y1 - La/2*cos(fi1);
  xD = x1 - La/2*sin(fi1);
  yD = y1 + La/2*cos(fi1);
  xE = x + 1.5*La/2*sin(fi1);
  yE = y - 1.5*La/2*cos(fi1);

  xcab  = [ xA; xB; xE; xC; xD;
xA; ];
  ycab  = [ yA; yB; yE; yC; yD;
yA; ];
  %plot(xE,yE,'gx');
  plot(xcab,ycab,'-
b','LineWidth',2)
  %pause(0.5);
  %plot(xcab,ycab,'-
w','LineWidth',2)

end

figure(3)
plot(t,(180/pi)*psidv,'r','LineWi
dth',2),hold on
plot(t,(180/pi)*psi_dv,'--
g','LineWidth',2),hold on
plot(t,(180/pi)*XYPSI(3,:),'k','L
ineWidth',2)
```

```
%plot(t,(180/pi)*Chitv,'b','LineW
idth',2)
plot(t,(180/pi)*betav,'m','LineWi
dth',2)
plot(t,(180/pi)*Chirv,'y','LineWi
dth',2)
plot(t,(180/pi)*Chipv,'c','LineWi
dth',2)
title('Ángulos de guiado')
%legend('PSI-LOS','PSI-LOS
REFERENCE MODEL','PSI-
OBTENIDO','Chit','SideSlip','Chir
','Chip')
legend('\psi_{REF} Ángulo yaw de
referencia','\psi_{MREF} Ángulo
yaw con modelo de
referencia','\psi_{LOS} Ángulo
yaw obtenido','\beta Ángulo de
deslizamiento','\chi_r Ángulo
rotación de marco móvil','\chi_p
Ángulo tangencial paramétrico')
%legend('PSI-LOS REFERENCE
MODEL','PSI-
OBTENIDO','Chit','SideSlip','Chir
')
grid on
xlabel('Tiempo [s]')
ylabel('Ángulo [grad]')

figure(4)
subplot(411)
plot(t,Zv(1,:)),grid on
title('Z (z1,z21,z22,z23)')
subplot(412)
plot(t,Zv(2,:)),grid on
subplot(413)
plot(t,Zv(3,:)),grid on
subplot(414)
plot(t,Zv(4,:)),grid on

figure(5)
subplot(211)
plot(t,tauv(1,:)),grid on
title('\tau (tau1,tau3)')
subplot(212)
plot(t,tauv(3,:)),grid on

figure(6)
subplot(311)
plot(t,nuv(1,:)),grid on,hold on
plot(t,u_dv,'g')
title('\nu (u,v,r)')
subplot(312)
plot(t,nuv(2,:)),grid on
subplot(313)
plot(t,nuv(3,:)),grid on
```

Anexo B

Script en MATLAB para eliminar puntos no ncesarios

```
Q=[Vx(p),Vy(p)];%Puntos X-Y
Pf(k,:)=Pini;%Punto inicial
for i=1:length(p)-3
   Q1=Q(k,:);
   Q2=Q(i+2,:);
   %P=Q(i+1,:);
   %if(norm(Q1-Q2))
   [xrr,yrr]=LineOffset([Q1(1) Q2(1)],[Q1(2) Q2(2)],1);%Tolerancia
   if(polyxpoly(xrr',yrr',x,y,'unique') ~= 0)
   k=k+1;
   plot(xrr,yrr,'c','LineWidth',1)
   else
   Q(k,:)=Q1;
   Q(k+1,:)=Q2;
   end
end
Q(k+1,:)=Q2;
Q(k+2,:)=Pfin;%Punto Final
```

Anexo C

Script en MATLAB para generar Rutas con el Polinomio Cúbico de Hermite

```
%POlINOMIO CUBICO DE HERMITE
clear all;
close all;
clc;
load('WayPoints')
yh=Wpt(:,1)';
xh=Wpt(:,2)';
nWpt=length(Wpt(:,1));
figure(2)
hold on
plot(yh,xh,'-*k','LineWidth',1.5);
t=xh(1):0.1:xh(length(xh));
PP=pchip(xh,yh,t);
PPs=spline(xh,yh,t);
%Matriz Hermita
MH=[2 -2 1 1
    -3 3 -2 -1
    0 0 1 0
    1 0 0 0];
MHa=[2*eye(2) -2*eye(2) 1*eye(2) 1*eye(2)
    -3*eye(2) 3*eye(2) -2*eye(2) -1*eye(2)
    0*eye(2) 0*eye(2) 1*eye(2) 0*eye(2)
    1*eye(2) 0*eye(2) 0*eye(2) 0*eye(2)];

for k=1:(nWpt-2)
    vin=(Wpt(k+1,:)-Wpt(k,:))/norm(Wpt(k+1,:)-Wpt(k,:),2);
    vinv(k,:)=vin;
    vout=(Wpt(k+2,:)-Wpt(k+1,:))/norm(Wpt(k+2,:)-Wpt(k+1,:),2);
    voutv(k,:)=vout;
end
    tannv(1,:)=vinv(1,:);
    tannv(nWpt,:)=voutv(nWpt-2,:);
for k=1:(nWpt-2)
    tann=(vinv(k,:)+voutv(k,:))/norm(vinv(k,:)+voutv(k,:),2);
    tannv(k+1,:)=tann;
end
omegav=0:0.001:1;
thetav=0:0.001:(nWpt-1);
inte=0;x1=0;x2=0;y1=0;y2=0;
```

```
for k=1:(nWpt-1)
    coef=MHa*[Wpt(k,:)';Wpt(k+1,:)';tannv(k,:)';...
    tannv(k+1,:)'];
    coefy(k,:)=(MH*[Wpt(k,1)';Wpt(k+1,1)';tannv(k,1)';...
    tannv(k+1,1)'])';
    coefx(k,:)=(MH*[Wpt(k,2)';Wpt(k+1,2)';tannv(k,2)';...
    tannv(k+1,2)'])';
end
for k=1:length(thetav)
    theta=thetav(k);
    if theta==0
        i=1;
    else
        i=ceil(theta);
    end
    omega=theta-(i-1);
    yp(k)=polyval(coefy(i,:),omega);
    xp(k)=polyval(coefx(i,:),omega);
    x2=xp(k);
   y2=yp(k);
   inte=inte+sqrt((x2-x1)^2+(y2-y1)^2);
   intev(k)=inte;
   x1=x2;
   y1=y2;
end
intev=intev-1;
%%
plot(yp,xp,'m','LineWidth',2)
title('PosiciÃşn X-Y')
xlabel('Y [m]');
ylabel('X [m]');
 legend('Ruta deseada','Ruta generada')
 grid on
 axis equal

figure(4)
subplot(211)
plot(intev,xp,'LineWidth',2)
title('Ruta en X')
```

```
ylabel('X [m]');
xlabel('Longitud de ruta [m]')
grid on
subplot(212)
plot(intev,yp,'LineWidth',2)
title('Ruta en Y')
ylabel('Y [m]');
xlabel('Longitud de ruta [m]')
grid on
```

Anexo D

Script en MATLAB para generar Rutas con la espiral de Fermat

```
%Espiral de Fermat
clear all;
close all;
clc;
load('WayPoints')
yh=Wpt(:,1)';
xh=Wpt(:,2)';
nWpt=length(Wpt(:,1));
R1=4;
kappa_max=1/R1;
w_theta=0:0.1:1;
w_theta1=0:0.1:1;
figure(2)
plot(yh,xh,'-*k','LineWidth',1.5);
hold on
for k=1:(length(Wpt)-2)
    vin=(Wpt(k+1,:)-Wpt(k,:))/norm(Wpt(k+1,:)-Wpt(k,:),2);
    vinv(k,:)=vin;
    Chi_ini=atan2(vin(1),vin(2));
    Chi_iniv(k)=Chi_ini;
    vout=(Wpt(k+2,:)-Wpt(k+1,:))/norm(Wpt(k+2,:)-Wpt(k+1,:),2);
    voutv(k,:)=vout;
    Chi_end=atan2(vout(1),vout(2));
    Chi_endv(k)=Chi_end;
    delta_Chi=acos(dot(vin,vout));
    delta_Chiv(k)=delta_Chi;
    rho=-sign(vin(1)*vout(2)-vin(2)*vout(1));
    rhov(k)=rho;
    tann=(vin+vout)/norm(vin+vout,2);
    tannv(k,:)=tann;
    tannL=rho*[tann(2) -tann(1)];
    tannLv(k,:)=tannL;
    cent=Wpt(k+1,:)+R1*tannL;
    centv(k,:)=cent;
    %plotcirc(cent(1),cent(2),R1)
    tic
    theta_end=halley(delta_Chi/2,pi/8,1e-5,100);
    toc
    theta_endv(k)=theta_end;
```

```
    theta_kmax=min(theta_end,sqrt(sqrt(7)/2-5/4));
K_param=(1/kappa_max)*2*sqrt(theta_kmax)*(3+4*theta_kmax^2)...
/(1+4*theta_kmax^2)^(3/2);
    K_paramv(k)=K_param;
    alpha=(pi-delta_Chi)/2;
    LL1=K_param*sqrt(theta_end)*cos(theta_end);
    hh=K_param*sqrt(theta_end)*sin(theta_end);
    LL2=hh/tan(alpha);
    LL=LL1+LL2;
    PP1=Wpt(k+1,:)-LL*vin;
    PP2=Wpt(k+1,:)+LL*vout;
    Wptff(3*k-1,:)=PP1;
    Wptff(3*k,:)=PP2;
    Wptff(3*k+1,:)=PP2;
    %plot(PP1(1),PP1(2),'g*')
   theta=theta_end*w_theta;
    theta1=theta_end*w_theta1;
FS1=[PP1(1)+K_param*sqrt(theta).*sin(rho*theta+Chi_ini);
PP1(2)+K_param*sqrt(theta).*cos(rho*theta+Chi_ini)];
    %plot(FS1(1,:),FS1(2,:),'-k')
    FS2=[PP2(1)-K_param*sqrt(theta_end-theta1).*sin(rho*...
    (theta1-theta_end)+Chi_end);
    PP2(2)-K_param*sqrt(theta_end-theta1).*cos(rho*(theta1...
    -theta_end)+Chi_end)];
    %plot(FS2(1,:),FS2(2,:),'-k')
end
nWptff=3*nWpt-4;
Wptff(1,:)=Wpt(1,:);
Wptff(nWptff,:)=Wpt(nWpt,:);
for k=1:(nWptff-1)
    vlinff=(Wptff(k+1,:)-Wptff(k,:));
    vlinffv(k,:)=vlinff;
end
thetav=0:0.001:(nWptff-1);
inte=0;x1=0;x2=0;y1=0;y2=0;
for k=1:length(thetav)
    theta=thetav(k);
    if theta==0
        i=1;
```

```
    else
        i=ceil(theta);
    end
    omega=theta-(i-1);
    dpar=(i+2)/3-floor((i+2)/3);
    dtri=(i+1)/3-floor((i+1)/3);
   if dpar==0
        yp(k)=Wptff(i,1)+omega*vlinffv(i,1);
        xp(k)=Wptff(i,2)+omega*vlinffv(i,2);
   elseif dtri==0
      omega=omega*theta_endv((i+1)/3);
      ufe=sqrt(omega);
yp(k)=Wptff(i,1)+K_paramv((i+1)/3)*ufe*sin(rhov((i+1)/3)*ufe^2...
+Chi_iniv((i+1)/3));
xp(k)=Wptff(i,2)+K_paramv((i+1)/3)*ufe*cos(rhov((i+1)/3)*ufe^2...
+Chi_iniv((i+1)/3));
   else
       omega=omega*theta_endv(i/3);
      yp(k)=Wptff(i,1)-K_paramv(i/3)*sqrt(theta_endv(i/3)-omega)...
      *sin(rhov(i/3)*(omega-theta_endv(i/3))+Chi_endv(i/3));
      xp(k)=Wptff(i,2)-K_paramv(i/3)*sqrt(theta_endv(i/3)-omega)...
      *cos(rhov(i/3)*(omega-theta_endv(i/3))+Chi_endv(i/3));
   end
   x2=xp(k);
   y2=yp(k);
   %inte=inte+(x2-x1)*(y1+y2)/2;
   inte=inte+sqrt((x2-x1)^2+(y2-y1)^2);
   intev(k)=inte;
   x1=x2;
   y1=y2;
end
intev=intev-1;
plot(yp,xp,'m','LineWidth',2)
 %legend('lineas','pchip','spline','cubic hermite')
 title('PosiciÃşn X-Y')
 xlabel('Y [m]');
 ylabel('X [m]');
 legend('Ruta deseada','Ruta generada')
 grid on
```

```
 axis equal
figure(4)
subplot(211)
plot(intev,xp,'LineWidth',2)
title('Ruta en X')
ylabel('X [m]');
xlabel('Longitud de ruta [m]')
grid on
subplot(212)
plot(intev,yp,'LineWidth',2)
title('Ruta en Y')
ylabel('Y [m]');
xlabel('Longitud de ruta [m]')
grid on
```

Anexo E

Propuesta de implentación de barco para monitoreo de variables marinas

E.1. Introducción

En este anexo se analizará una propuesta de implementación, para realizar las pruebas de los algoritmos y darle una aplicación real al sistema, que vendría a ser monitorear las variables marinas del litoral en todo momento (régimen 24/7), como primera fase se realizará las pruebas de funcionamiento en un ambiente controlado, por ejemplo una piscina, por lo cual el alcance de este anexo será ÃžnicamenteÃ implementar esta primera fase, una fase posterior sería integrar el barco a un sistema satelital para hacer un mapeo de todo el litoral y realizar todo el procesamiento en un computadora dentro de la embarcación. Las ventajas de tener un sistema autónomo, tienen que ver con la seguridad, tener data constante y ahorros económicos, debido a que actualmente para la toma de datos se usan barcos grandes y al menos dos personas conforman la tripulación por embarcación, personal que claramente no puede cumplir con el régimen 24/7. Además por estos tiempos la seguridad en las operaciones ha tomado un gran papel en las decisiones, por lo que frente a un fenómeno que tenga cierto grado de peligrosidad será poco probable enviar un equipo de personas a revisar las áreas en mención, diferente a enviar un robot autónomo, que a lo más puede causar gastos materiales pero no exponer al peligro vidas humanas. Para lograr este objetivo y luego de un análisis económico/técnico se ha seleccionado un barco prototipo de nombre Echo Boat RC (Ver Anexo F). El Echo Boat RC suministrado por la compañía SEAFLOOR, es un barco básico que solo cuenta con los actuadores, por lo que la implementación de los sensores y sistema control para monitoreo serán seleccionados, instalados y probados in-house.

A continuación se muestra una propuesta básica-práctica para la primera fase de implementación del barco autónomo, para control y monitoreo de variables marinas, Echo-Boat RC. (Ver Figura E.1). Los objetivos de la primera fase son los siguientes:

- Dar a conocer la lógica de funcionamiento del sistema.
- Proponer sensores y actuadores necesarios para el trabajo de monitoreo-autónomo.
- Proponer sistemas embebidos capaces de realizar el control y lectura de los sensores.

Para la implementación se establecerá comunicación a bajo nivel entre los sistemas embebidos y el barco de monitoreo. Se tendrá un acceso a los datos a través de la computadora principal, que estará en la estación remota de control.

Figura E.1: Echo boat RC, barco de monitoreo (Seafloor)

E.2. Propuesta de instrumentación

Para realizar la instrumentación del barco de monitoreo, se requiere la identificación de variables que requieren monitorear. En tal sentido el sistema deberá tener los siguientes componentes:

- Un sensor inercial, para determinar la aceleración del sistema.
- Un sensor de viento, para monitorear la velocidad del viento en determinado punto.
- Un sensor de humedad y temperatura.
- Un sensor de presión barométrica.
- Un sensor de PH.
- Controladores embebidos Arduino y Raspberry.
- Una antena Wireless, para la comunicación remota entre el barco y la estación de control. (Xbee)
- Motores.

E.2.1. Selección de sensores/transmisores

Como sabemos la utilidad de los sensores en la embarcación a implementar será para realizar el control de posición y monitoreo de variables marinas, por lo cual se determinó los rangos dentro de los que debía trabajar así como su compatibilidad con las tarjetas embebidas que servirán para realizar el control. Los sensores que se usarán para la implementación serán los siguientes:

E.2.1.1. Sensor de Inercia (IMU)

Este sensor nos servirá para realizar el control del barco de monitoreo. El sensor de inercia, mide aceleración y velocidad angular. Este sensor está compuesto por acelerómetros, giroscopios y magnetómetros. Cabe resaltar que para utilizar este sensor se debe pasar por una etapa de calibración. Para mayores detalles de presenta la ficha técnica en el Anexo G y una foto referencial, Figura E.2.

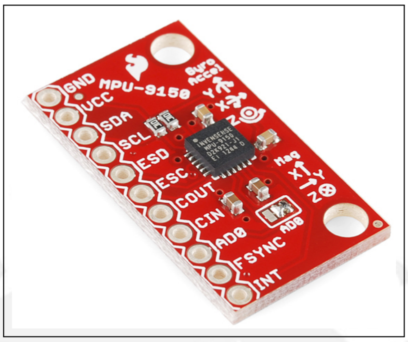


Figura E.2: Foto sensor inercial IMU

E.2.1.2. Sensor de viento

Sensor meteorológico que mide la velocidad y dirección del viento, este será un dato recolectado por el barco. La hoja técnica del sensor seleccionado se puede ver en el Anexo H.

E.2.1.3. Sensor de humedad y temperatura de ambiente

Una de las variables que se deben monitorear es la humedad relativa del área. Para esto se usará el sensor RHT03 que es un sensor de humedad y temperatura de muy bajo costo con un solo cable de interfaz. El sensor viene calibrado por lo cual no es necesario realizar alguna acción adicional. Para mayores detalles se deja la hoja técnica del mismo en el Anexo I y una foto referencial, Figura E.3.

E.2.1.4. Sensor de temperatura del agua

Para realizar esta labor se usará el sensor DS18B20. Este sensor es un sensor que se comunica en forma digital, para lo cual consta de 3 terminales, 2 de alimentación y 1 para los datos. Su interacción con los sistemas embebidos es muy sencilla. Para mayores detalles revisar la hoja técnica que se presenta en el Anexo J y una foto referencial se muestra en la Figura E.4.

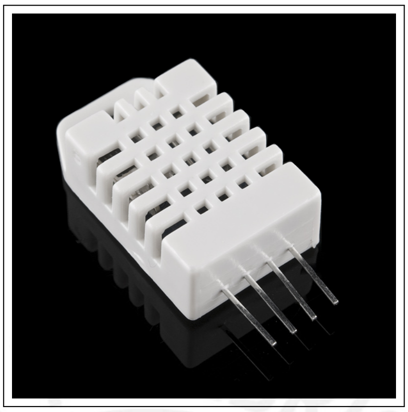


Figura E.3: Sensor de humedad seleccionado RHT03 (Sparkfun)

Figura E.4: Sensor de temperatura DS18B20-Spark Fun

E.2.1.5. Sensor de presión

Otra de las variables que se requieren medir es la presión para lo cual se usara el sensor de presión MPL3115A2, sensor de bajo costo y de alta resolución, la salida del sensor nos muestra el valor de presión en pascales, también nos puede entregar un valor de altura en metros. Ademas, cuenta con comunicación I2C que hace más fácil su integración con Arduino, se presenta una foto referencial en la Figura E.5 y las principales características se muestran en su hoja técnica mostrada en el Anexo K .

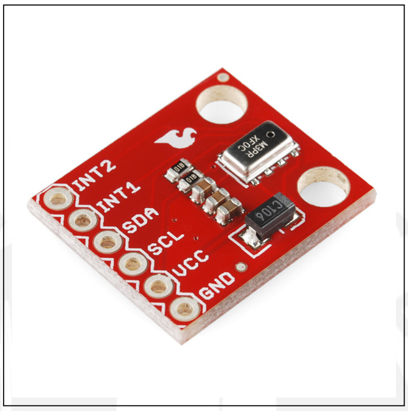


Figura E.5: Sensor de presión MPL3115A2-Sparkfun

E.2.1.6. Sensor de salinidad (Conductividad)

Una de las variables de monitoreo importante es la salinidad del agua, para ello se usará un sensor de conductividad, este sensor nos medirá la conductividad en microSiemens. Siemens es una unidad internacional que nos sirve para medir conductancia que es simplemente la inversa de la resistencia de un elemento, esto puede decirnos mucho de una sustancia en particular. Para poner en funcionamiento este kit, mostrado en la Figura E.6, solo basta con realizar las conexiones indicadas en la hoja de datos que se presenta en el Anexo L.

E.2.1.7. Sensor de PH

Para el registro del PH, se usará un kit,mostra en la Figura E.7, el cual contará con un punta de prueba y soluciones buffer para la calibración del sensor, además se tendrá una tarjeta que brindará la libertad de conectar el sensor con cualquier microcontrolador de forma directa. Para ver las principales características y conexiones, se sugiere de revisar el Anexo M.

Figura E.6: Kit de sensor de conductividad-Sparkfun

Figura E.7: Kit de sensor de PH-Sparkfun

E.2.1.8. Módulo XBee

Es un módulo de comunicación inalámbrica hecha por la empresa Digi. Este módulo es una solución embebida que provee conexión libre de cables hacia dispositivos, usa el protocolo de red IEEE 802.15.4 para comunicación punto-multipunto ó punto a punto. Esta desarrollado para aplicaciones de alto rendimiento que requieren baja latencia y tiempo de comunicación confiable, son ideales para aplicación de bajo consumo o bajo costo, las conexiones con el raspberry se muestran en la Figura E.8 y las principales características y especificaciones son presentadas en el Anexo N

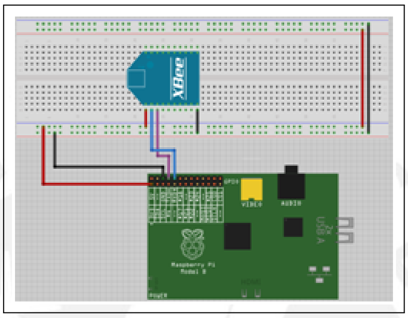


Figura E.8: Conexión típica, Raspberry PI + Xbee

E.2.2. Actuadores

E.2.2.1. Motores y hélices

El barco de monitoreo consta de 2 motores idénticos, los motores serán motores DC sin escobillas, de modelo LBP56110 âĂŞ 640KV, ver Anexo Ñ. Estos motores conectados mediante un eje a hélices servirán como actuadores en el barco de monitoreo, Figura E.9, de acuerdo a la configuración propia estos servirán para que el barco se desplace hacia adelante dándole la misma velocidad a los motores, mientras que para girar el barco se tendrá que asignar velocidades diferentes a los motores. Cabe resaltar que la etapa de potencia viene con los motores, por lo cual lo único que se requiere para activarlos es enviar señal de control del tipo ppm.

E.2.3. Sistema de Control

Respecto al controlador, para este caso al necesitar un sistema de bajo consumo de energía y capaz de realizar el control y adquisición de datos, se usará un computador de placa reducida (Sistema embebido), este será conectado a un sistema de radiocomunicación inalámbrica Xbee para tener comunicación con una computadora maestra que será el centro de control. Para la comunicación de bajo

Figura E.9: Actuadores de barco de monitoreo

nivel que será para los sensores y actuadores se trabajará con la placa de desarrollo Arduino.

A continuación se detallará más sobre los elementos asociados al sistema de control.

E.2.3.1. Raspberry PI

Es un computador de placa reducida, de bajo costo creado con el fin de estimular la enseñanza en ciencias de la computación. Esta placa cuenta con puertos de entrada, salida digitales, puertos usb, además puede soportar comunicación CAN, I2C. Es de fácil programación y por su gran difusión, se pueden encontrar muchos programas y librerías desarrolladas para aplicaciones como comunicación con sensores ó comunicación con las PC, en la Figura E.10, se muestra la versión Raspberry PI B+.

Para nuestra aplicación el Raspberry será conectado a un computador, que hará de estación de remota de control, a través de un Xbee. Además, el Raspberry será conectado a dos arduinos a fin de poder recibir la información de los sensores y enviar acciones con los actuadores a través de comunicación y no de cableado duro, esto con el fin de distribuir las funciones y no sobrecargar el sistema en un solo sistema embebido.

E.2.3.2. Arduino R3 uno

Es una plataforma de hardware libre, que posee un micro-controlador Atmel AVR, que tiene un entorno capaz de conectarse a diferentes sensores o actuadores, y hacer posible desarrollar proyectos electrónicos multidisciplinarios. En

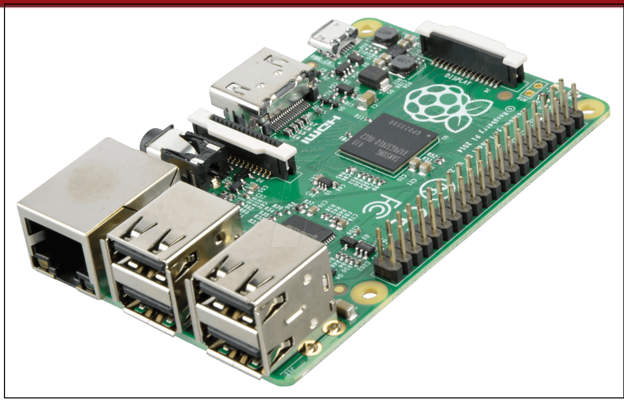


Figura E.10: Tarjeta Raspberry PI +

nuestra aplicación se usarán 2 placas arduino, la primera será para conectarse con los sensores de monitoreo (Temperatura, Presión, IMU, etc.) y poder tomar datos que serán enviados al Raspberry PI, la segunda será para accionar los actuadores (motores) a través de una señal de tipo ppm, que le dirá a los motores la velocidad a la que deben moverse. En la Figura E.11, se puede ver un Arduino 1.

Figura E.11: Placa arduino

E.2.3.3. Computador de monitoreo

Se implementará una estación remota de control. Para enviar y recibir datos desde el controlador Raspberry a través del Xbee. Con este se podrá leer y almacenar los valores de las variables, además de poder tomar acción sobre el barco de monitoreo. Será posible frente a una situación de emergencia pasar a modo manual, y poder maniobrar desde el computador el barco de monitoreo.

E.3. Propuesta de implementación del controlador desarrollado

La implementación del controlador desarrollado se realizará en la tarjeta Raspberry PI, para esto se realizará la programación del controlador no lineal teniendo como entradas las señales adquiridas por el sensor inercial para determinar las aceleraciones y un sistema mediante cámaras para determinar la posición, para lo demás será necesario implementar un observador capaz de estimar la velocidad. Luego de realizar el cálculo a partir de estos valores se procederá a obtener una señal de control que será enviada como referencia a la tarjeta Arduino, está a su vez enviar dicha referencia de velocidad a los motores de tal manera que el barco logre alcanzar los estados adecuados, el esquema se muestra en la Figura E.12.

El sistema de mayor nivel jerárgico , computadora, se encargara de enviar la referencia de posición y velocidad al barco, a través del modulo Xbee.

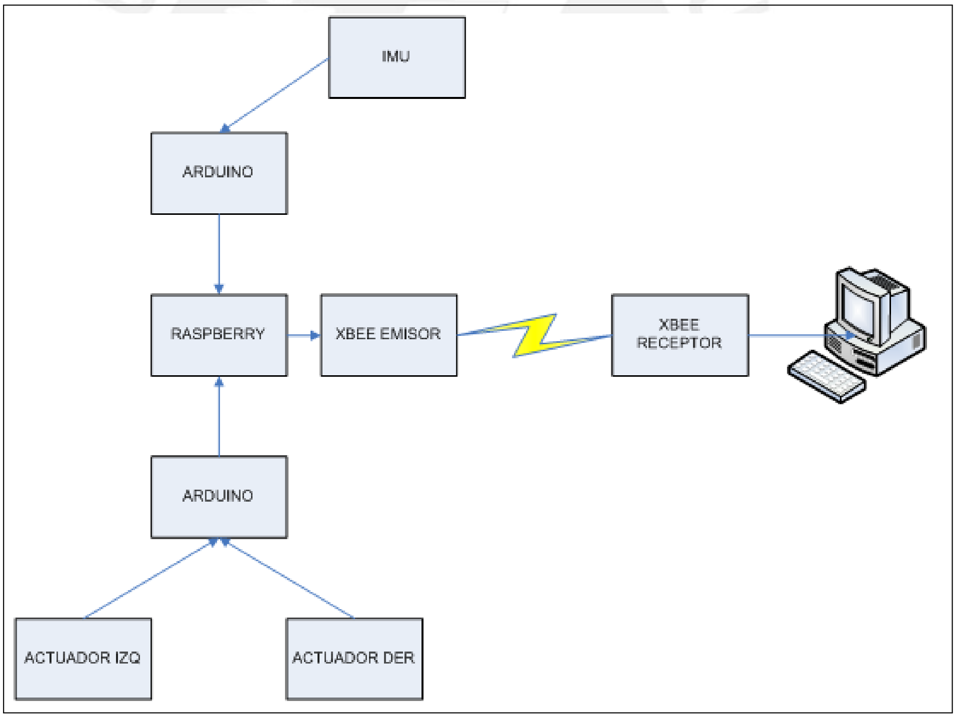


Figura E.12: Sistemas embebidos, sensores y actuadores que son partes del control autónomo del barco

E.4. Propuesta de sistema de control y monitoreo

Para la implementación de sistema de control, se hará uso de los sistemas embebidos Raspberry PI y Arduino, así como de un computador que hará de sistema de monitoreo. La arquitectura que se seguirá será la presentada en la Figura E.13).

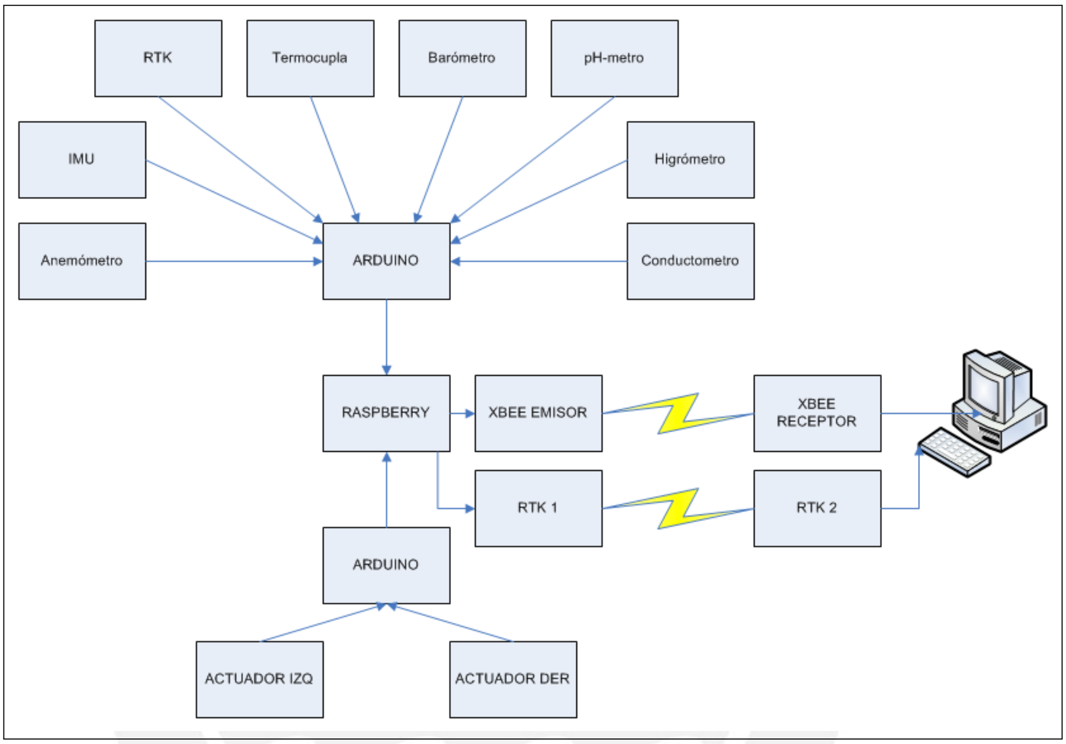


Figura E.13: Arquitectura del sistema de control y monitoreo

E.5. Conclusiones

- Se seleccionaron los sensores necesarios para realizar el control de la embarcación y el monitoreo de las variables marinas deseadas. Se detallaron uno a uno y se presentaron los sistemas embebidos que se usaran para el control y recolección de datos del sistema de monitoreo.

- Para la implementación práctica se propuso sensores y sistemas embebidos de bajo costo y de bajo consumo de energía a fin de hacer más viable la implementación. Además se debe considerar que hay librerías y programas desarrollados para integrar los sensores con los sistemas embebidos uno a uno, lo que se debe hacer es replantear a fin de lograr la conexión del sistema integral.

- Se propone que el monitoreo del barco sea mediante una PC remota, además se debe considerar que el sistema debe constar de una opción para control manual, para poder guiar al barco por si ocurre algún problema con el control autónomo del barco.

Anexo F

Echo Boat RC

Seafloor™

Hoja de datos

EchoBoat-RCVtm

Embarcación EchoBoat levantando en un río.

Beneficios

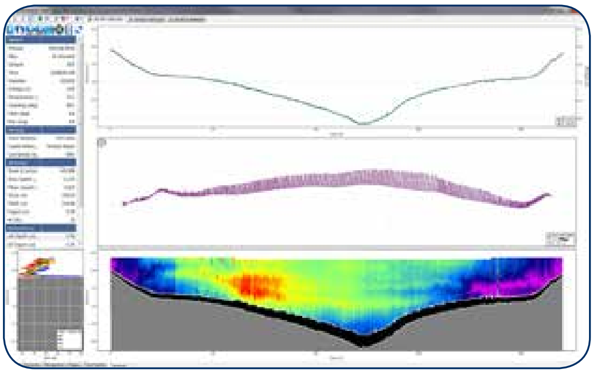
- Instrumentación personalizada a requisito del cliente.
- Acceso a creas remotas
- Operacion llave en mano.

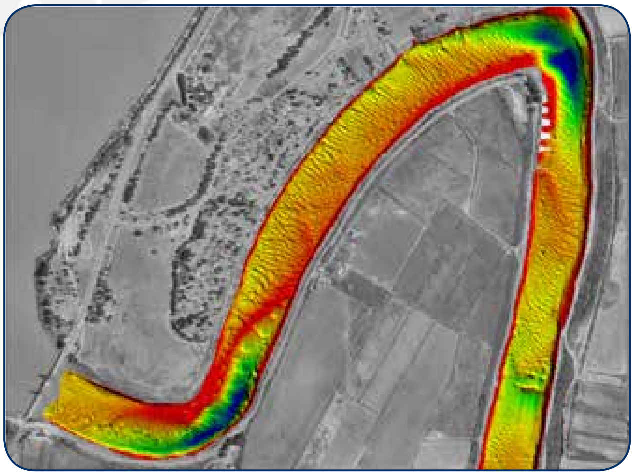
Acerca de

El sistema EchoBoat-RCV es una plataforma de estudios hidrograficos contralada remotamente. El control remoto de la embarcación de levantamiento es sencillo, utilizando la posición GPS y rumbo en tiempo real, visible en la orilla a través de la aplicación de escritorio remoto. El control remoto de alto poder tiene hasta 1 Km de alcance y la embarcación proporciona hasta 8 horas de operación con un solo paquete de baterías.

Para estudios hidrográficos profesionales, el EchoBoat-RCV puede cumplir con las especificaciones particulares del cliente. La embarcación se puede adquirir con la ecosonda preinstalada, o ser preparada para recibir uno de los equipos con los que cuente el cliente. Asimismo se puede incluir un cableado personalizado, aceptando equipos existentes de GPS, GNSS, y RTK. Para un sistema llave en mano con calidad hidrográfica, es el EchoBoat-RCV puede ser equipado con haz sencillo, multihaz, y sistemas de sonar de barrido lateral.

El EchoBoat-RCV es compatible con software de adquisición de datos hidrográficos como HYPACK, HYDROpro, y OINSY, y utiliza el formato de datos NMEA estándar para interfaz de datos.


Datos de ADCP (Perfilador Doppler) de levantamiento en río.


Levantamiento de río con ecosonda multihaz

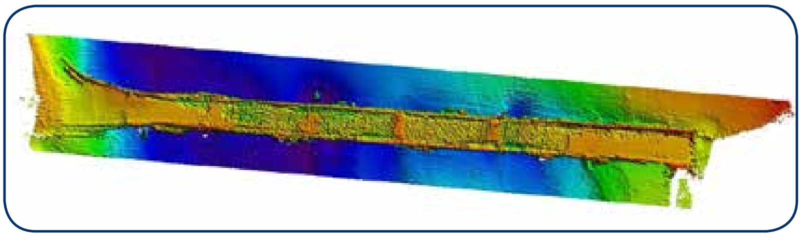
Rev 06/09/2015

Especificaciones

Velocidad típica de levantamiento	3 kts (1.5 m/s)
Velocidad máxima	10 kts (5 m/s)
Eslora	180 cm
Manga	90 cm
Duración de la batería (Velocidad máxima)	90 min = aprox 3 millas
Duración de la batería (velocidad de crucero)	240 min = approx 5 millas
Carga útil	40 libras/18 kg
Energía de batería	12v LiFe P04 12v (1)
Motor	DC sin escobillas outdrive
Material de casco de la embarcación	ABS resistente a UV
Peso del casco	23 kg / 46 libras
Herrajes	Acero inoxidable
Control remoto	Futaba 2.4 GHz
Antena	Omni-direccional
Rango de control remoto	1,000 m
GPS	Especificado por el clienteo
Comunicaciones	Radio modem Bluetooth/900 MHZ radio modem de amplio espectro
Montaje del transductor	A través del casco

Instrumentación

SONDA	GPS	AUXILIAR
Ecosonda Multihaz	RTK/GNSS	SVS
Ecosonda de haz sencillo	DGPS/ADCP	SVP
ADCP		CTD
Sonar de barrido lateral		



Levantamiento de ecosonda multihaz de Puente sumergido.

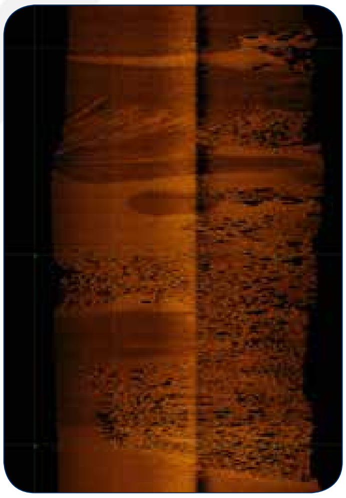


Imagen de sonar de barrido lateral.

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(530) 677–1019 · info@seafloorsystems.com · www.seafloorsystems.com

Rev 06/09/2015

Anexo G

Sensor de Inercia IMU

5 Features

5.1 Gyroscope Features

The triple-axis MEMS gyroscope in the MPU-9150 includes a wide range of features:

- Digital-output X-, Y-, and Z-Axis angular rate sensors (gyroscopes) with a user-programmable full-scale range of ±250, ±500, ±1000, and ±2000°/sec
- External sync signal connected to the FSYNC pin supports image, video and GPS synchronization
- Integrated 16-bit ADCs enable simultaneous sampling of gyros
- Enhanced bias and sensitivity temperature stability reduces the need for user calibration
- Improved low-frequency noise performance
- Digitally-programmable low-pass filter
- Factory calibrated sensitivity scale factor
- User self-test

5.2 Accelerometer Features

The triple-axis MEMS accelerometer in MPU-9150 includes a wide range of features:

- Digital-output 3-Axis accelerometer with a programmable full scale range of ±2*g*, ±4*g*, ±8*g* and ±16*g*
- Integrated 16-bit ADCs enable simultaneous sampling of accelerometers while requiring no external multiplexer
- Orientation detection and signaling
- Tap detection
- User-programmable interrupts
- High-G interrupt
- User self-test

5.3 Magnetometer Features

The triple-axis MEMS magnetometer in MPU-9150 includes a wide range of features:

- 3-axis silicon monolithic Hall-effect magnetic sensor with magnetic concentrator
- Wide dynamic measurement range and high resolution with lower current consumption.
- Output data resolution is 13 bit (0.3 µT per LSB)
- Full scale measurement range is ±1200 µT
- Self-test function with internal magnetic source to confirm magnetic sensor operation on end products

5.4 Additional Features

The MPU-9150 includes the following additional features:

- 9-Axis MotionFusion via on-chip Digital Motion Processor (DMP)
- Auxiliary master I^2C bus for reading data from external sensors (e.g., pressure sensor)
- Flexible VLOGIC reference voltage supports multiple I^2C interface voltages
- Smallest and thinnest package for portable devices: 4x4x1mm LGA
- Minimal cross-axis sensitivity between the accelerometer, gyroscope and magnetometer axes
- 1024 byte FIFO buffer reduces power consumption by allowing host processor to read the data in bursts and then go into a low-power mode as the MPU collects more data
- Digital-output temperature sensor
- User-programmable digital filters for gyroscope, accelerometer, and temp sensor
- 10,000 *g* shock tolerant

- 400kHz Fast Mode I^2C for communicating with all registers
- MEMS structure hermetically sealed and bonded at wafer level
- RoHS and Green compliant

5.5 MotionProcessing

- Internal Digital Motion Processing™ (DMP™) engine supports 3D MotionProcessing and gesture recognition algorithms
- The MPU-9150 collects gyroscope, accelerometer and magnetometer data while synchronizing data sampling at a user defined rate. The total dataset obtained by the MPU-9150 includes 3-Axis gyroscope data, 3-Axis accelerometer data, 3-Axis magnetometer data, and temperature data.
- The FIFO buffers the complete data set, reducing timing requirements on the system processor by allowing the processor burst read the FIFO data. After burst reading the FIFO data, the system processor can save power by entering a low-power sleep mode while the MPU collects more data.
- Programmable interrupt supports features such as gesture recognition, panning, zooming, scrolling, tap detection, and shake detection
- Digitally-programmable low-pass filters.
- Low-power pedometer functionality allows the host processor to sleep while the DMP maintains the step count.

5.6 Clocking

- On-chip timing generator ±1% frequency variation over full temperature range
- Optional external clock inputs of 32.768kHz or 19.2MHz

6 Electrical Characteristics

6.1 Gyroscope Specifications

Typical Operating Circuit of Section 7.2, VDD = 2.375V-3.465V, VLOGIC= 1.8V±5% or VDD, T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
GYROSCOPE SENSITIVITY						
Full-Scale Range	FS_SEL=0		±250		º/s	
	FS_SEL=1		±500		º/s	
	FS_SEL=2		±1000		º/s	
	FS_SEL=3		±2000		º/s	
Gyroscope ADC Word Length			16		bits	
Sensitivity Scale Factor	FS_SEL=0		131		LSB/(º/s)	
	FS_SEL=1		65.5		LSB/(º/s)	
	FS_SEL=2		32.8		LSB/(º/s)	
	FS_SEL=3		16.4		LSB/(º/s)	
Sensitivity Scale Factor Tolerance	25°C	-3		+3	%	
Sensitivity Scale Factor Variation Over Temperature	-40°C to +85°C		±0.04		%/°C	
Nonlinearity	Best fit straight line; 25°C		0.2		%	
Cross-Axis Sensitivity			±2		%	
GYROSCOPE ZERO-RATE OUTPUT (ZRO)						
Initial ZRO Tolerance	Component level (25°C)		±20		º/s	
ZRO Variation Over Temperature	-40°C to +85°C		±20		º/s	
GYROSCOPE NOISE PERFORMANCE	**FS_SEL=0**					
Total RMS Noise	DLPFCFG=2 (92Hz)		0.06		º/s-rms	
Rate Noise Spectral Density	At 10Hz		0.005		º/s/ √ Hz	
GYROSCOPE MECHANICAL FREQUENCIES						
X-Axis		30	33	36	kHz	
Y-Axis		27	30	33	kHz	
Z-Axis		24	27	30	kHz	
LOW PASS FILTER RESPONSE						
	Programmable Range	5		256	Hz	
OUTPUT DATA RATE						
	Programmable	4		8,000	Hz	
GYROSCOPE START-UP TIME	**DLPFCFG=0**					
ZRO Settling	to ±1º/s of Final		30		ms	

6.2 Accelerometer Specifications

Typical Operating Circuit of Section 7.2, VDD = 2.375V-3.465V, VLOGIC= 1.8V±5% or VDD, T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
ACCELEROMETER SENSITIVITY						
Full-Scale Range	AFS_SEL=0		±2		*g*	
	AFS_SEL=1		±4		*g*	
	AFS_SEL=2		±8		*g*	
	AFS_SEL=3		±16		*g*	
ADC Word Length	Output in two's complement format		16		bits	
Sensitivity Scale Factor	AFS_SEL=0		16,384		LSB/*g*	
	AFS_SEL=1		8,192		LSB/*g*	
	AFS_SEL=2		4,096		LSB/*g*	
	AFS_SEL=3		2,048		LSB/*g*	
Initial Calibration Tolerance			±3		%	
Sensitivity Change vs. Temperature	AFS_SEL=0, -40°C to +85°C		±0.02		%/°C	
Nonlinearity	Best Fit Straight Line		0.5		%	
ZERO-G OUTPUT						
Initial Calibration Tolerance	X and Y axes		±80		m*g*	
	Z axis		±150		m*g*	
Change over specified temperature – Component level -25°C to 85°C	X & Y Axis		±0.75		mg/°C	
	Z Axis		±1.50		mg/°C	
NOISE PERFORMANCE						
Power Spectral Density	X, Y & Z Axes, @10Hz, AFS_SEL=0 & ODR=1kHz		400		μ*g*/ √ Hz	
Total RMS Noise	AFS = 0 @100Hz		4		mg-rms	
LOW PASS FILTER RESPONSE	Programmable Range	5		260	Hz	
OUTPUT DATA RATE	Programmable Range	4		1,000	Hz	
INTELLIGENCE FUNCTION INCREMENT			32		mg/LSB	

Anexo H

Sensor de Viento

ARGENT DATA SYSTEMS

Weather Sensor Assembly p/n 80422

Imported by Argent Data Systems

Usage Notes

This kit includes a wind vane, cup anemometer, and tipping bucket rain gauge, with associated mounting hardware. These sensors contain no active electronics, instead using sealed magnetic reed switches and magnets to take measurements. A voltage must be supplied to each instrument to produce an output.

Assembly

The wind sensor arm mounts on top of the two-piece metal mast and supports the wind vane and anemometer. A short cable connects the two wind sensors. Plastic clips on the underside of the arm hold this cable in place. Screws are provided to secure the sensors to the arm.

The rain gauge may be mounted lower on the mast using its own mounting arm and screw, or it may be mounted independently.

Rain Gauge

The rain gauge is a self-emptying tipping bucket type. Each 0.011” (0.2794 mm) of rain causes one momentary contact closure that can be recorded with a digital counter or microcontroller interrupt input. The gauge’s switch is connected to the two center conductors of the attached RJ11-terminated cable.

Anemometer

The cup-type anemometer measures wind speed by closing a contact as a magnet moves past a switch. A wind speed of 1.492 MPH (2.4 km/h) causes the switch to close once per second.

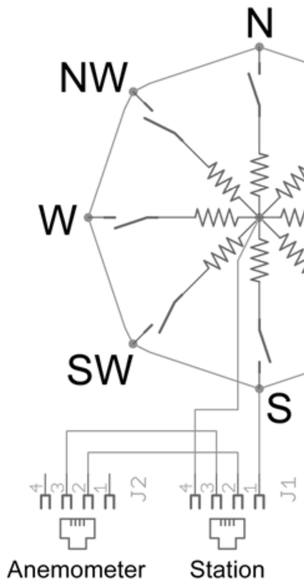
The anemometer switch is connected to the inner two conductors of the RJ11 cable shared by the anemometer and wind vane (pins 2 and 3.)

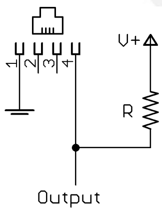
Wind Vane

The wind vane is the most complicated of the three sensors. It has eight switches, each connected to a different resistor. The vane's magnet may close two switches at once, allowing up to 16 different positions to be indicated. An external resistor can be used to form a voltage divider, producing a voltage output that can be measured with an analog to digital converter, as shown below.

The switch and resistor arrangement is shown in the diagram to the right. Resistance values for all 16 possible positions are given in the table.

Resistance values for positions between those shown in the diagram are the result of two adjacent resistors connected in parallel when the vane's magnet activates two switches simultaneously.





Example wind vane interface circuit. Voltage readings for a 5 volt supply and a resistor value of 10k ohms are given in the table.

Direction (Degrees)	Resistance (Ohms)	Voltage (V=5v, R=10k)
0	33k	3.84v
22.5	6.57k	1.98v
45	8.2k	2.25v
67.5	891	0.41v
90	1k	0.45v
112.5	688	0.32v
135	2.2k	0.90v
157.5	1.41k	0.62v
180	3.9k	1.40v
202.5	3.14k	1.19v
225	16k	3.08v
247.5	14.12k	2.93v
270	120k	4.62v
292.5	42.12k	4.04v
315	64.9k	4.78v
337.5	21.88k	3.43v

Anexo I

Sensor de Humedad y temperatura de ambiente

Digital relative humidity & temperature sensor RHT03

1. Feature & Application:

*High precision
*Capacitive type
*Full range temperature compensated
*Relative humidity and temperature measurement
*Calibrated digital signal
*Outstanding long-term stability
*Extra components not needed
*Long transmission distance, up to 100 meters
*Low power consumption
*4 pins packaged and fully interchangeable

2. Description:

RHT03 output calibrated digital signal. It applys exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements is connected with 8-bit single-chip computer.

Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in type of programme in OTP memory, when the sensor is detecting, it will cite coefficient from memory.

Small size & low consumption & long transmission distance(100m) enable RHT03 to be suited in all kinds of harsh application occasions. Single-row packaged with four pins, making the connection very convenient.

3. Technical Specification:

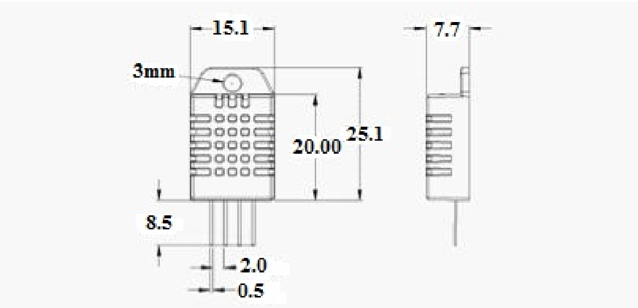
Model	RHT03	
Power supply	3.3-6V DC	
Output signal	digital signal via MaxDetect 1-wire bus	
Sensing element	Polymer humidity capacitor	
Operating range	humidity 0-100%RH;	temperature -40~80Celsius
Accuracy	**humidity +-2%RH**(Max +-5%RH);	temperature +-0.5Celsius
Resolution or sensitivity	humidity 0.1%RH;	temperature 0.1Celsius
Repeatability	humidity +-1%RH;	temperature +-0.2Celsius

MaxDetect Technology Co., Ltd. **http://www.humiditycn.com**

Thomas Liu (Sales Manager)
Email: thomasliu198518@yahoo.com.cn , sales@humiditycn.com

Humidity hysteresis	+-0.3%RH
Long-term Stability	+-0.5%RH/year
Interchangeability	fully interchangeable

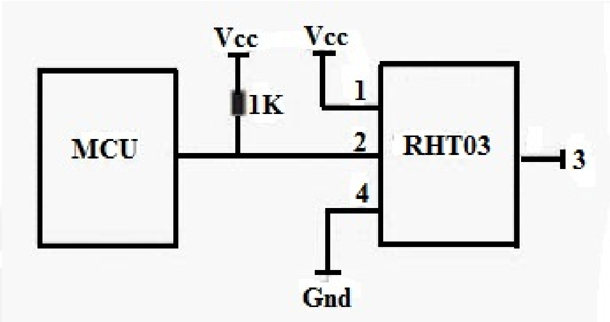
4. Dimensions: (unit----mm)



Pin sequence number: 1 2 3 4 (from left to right direction).

Pin	Function
1	VDD---power supply
2	DATA--signal
3	NULL
4	GND

5. Electrical connection diagram:



6. Operating specifications:

(1) Power and Pins

Power's voltage should be 3.3-6V DC. When power is supplied to sensor, don't send any instruction to the sensor within one second to pass unstable status. One capacitor valued 100nF can be added between VDD and GND for wave filtering.

(2) Communication and signal

MaxDetect 1-wire bus is used for communication between MCU and RHT03. (MaxDetect 1-wire bus is specially designed by MaxDetect Technology Co., Ltd. , it's different from Maxim/Dallas 1-wire bus, so it's incompatible with Dallas 1-wire bus.)

Illustration of MaxDetect 1-wire bus:

Data is comprised of integral and decimal part, the following is the formula for data.

DATA=8 bit integral RH data+8 bit decimal RH data+8 bit integral T data+8 bit decimal T data+8 bit check-sum

Thomas Liu (Sales Manager)

Email: thomasliu198518@yahoo.com.cn , sales@humiditycn.com

Anexo J

Sensor de temperatura del agua

PRELIMINARY

DS18B20 Programmable Resolution 1-Wire® Digital Thermometer

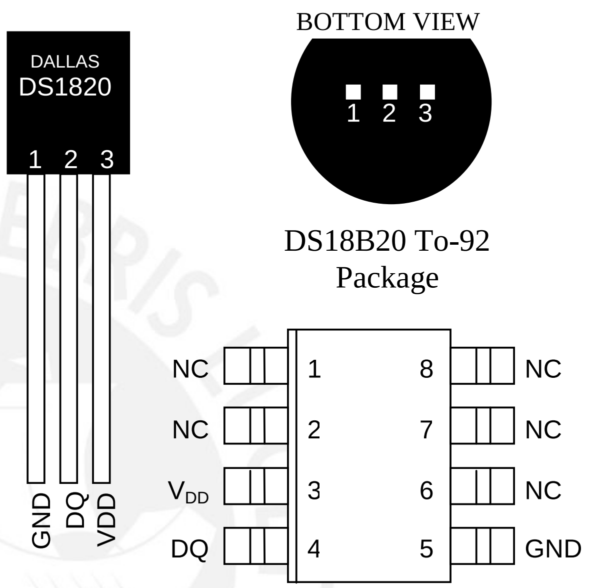
DALLAS SEMICONDUCTOR

www.dalsemi.com

FEATURES

- Unique 1-Wire interface requires only one port pin for communication
- Multidrop capability simplifies distributed temperature sensing applications
- Requires no external components
- Can be powered from data line. Power supply range is 3.0V to 5.5V
- Zero standby power required
- Measures temperatures from -55°C to +125°C. Fahrenheit equivalent is -67°F to +257°F
- ±0.5°C accuracy from -10°C to +85°C
- Thermometer resolution is programmable from 9 to 12 bits
- Converts 12-bit temperature to digital word in 750 ms (max.)
- User-definable, nonvolatile temperature alarm settings
- Alarm search command identifies and addresses devices whose temperature is outside of programmed limits (temperature alarm condition)
- Applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermally sensitive system

PIN ASSIGNMENT



DS18B20Z
8-Pin SOIC (150 mil)

PIN DESCRIPTION

GND - Ground
DQ - Data In/Out
V_{DD} - Power Supply Voltage
NC - No Connect

DESCRIPTION

The DS18B20 Digital Thermometer provides 9 to 12-bit (configurable) temperature readings which indicate the temperature of the device.

Information is sent to/from the DS18B20 over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor to a DS18B20. Power for reading, writing, and performing temperature conversions can be derived from the data line itself with no need for an external power source.

Because each DS18B20 contains a unique silicon serial number, multiple DS18B20s can exist on the same 1-Wire bus. This allows for placing temperature sensors in many different places. Applications where this feature is useful include HVAC environmental controls, sensing temperatures inside buildings, equipment or machinery, and process monitoring and control.

DETAILED PIN DESCRIPTION Table 1

PIN 8PIN SOIC	PIN TO92	SYMBOL	DESCRIPTION
5	1	GND	Ground.
4	2	DQ	**Data Input/Output pin.** For 1-Wire operation: Open drain. (See "Parasite Power" section.)
3	3	V_{DD}	**Optional V_{DD} pin.** See "Parasite Power" section for details of connection. V_{DD} must be grounded for operation in parasite power mode.

DS18B20Z (8-pin SOIC): All pins not specified in this table are not to be connected.

OVERVIEW

The block diagram of Figure 1 shows the major components of the DS18B20. The DS18B20 has four main data components: 1) 64-bit lasered ROM, 2) temperature sensor, 3) nonvolatile temperature alarm triggers TH and TL, and 4) a configuration register. The device derives its power from the 1-Wire communication line by storing energy on an internal capacitor during periods of time when the signal line is high and continues to operate off this power source during the low times of the 1-Wire line until it returns high to replenish the parasite (capacitor) supply. As an alternative, the DS18B20 may also be powered from an external 3 volt - 5.5 volt supply.

Communication to the DS18B20 is via a 1-Wire port. With the 1-Wire port, the memory and control functions will not be available before the ROM function protocol has been established. The master must first provide one of five ROM function commands: 1) Read ROM, 2) Match ROM, 3) Search ROM, 4) Skip ROM, or 5) Alarm Search. These commands operate on the 64-bit lasered ROM portion of each device and can single out a specific device if many are present on the 1-Wire line as well as indicate to the bus master how many and what types of devices are present. After a ROM function sequence has been successfully executed, the memory and control functions are accessible and the master may then provide any one of the six memory and control function commands.

One control function command instructs the DS18B20 to perform a temperature measurement. The result of this measurement will be placed in the DS18B20's scratch-pad memory, and may be read by issuing a memory function command which reads the contents of the scratchpad memory. The temperature alarm triggers TH and TL consist of 1 byte EEPROM each. If the alarm search command is not applied to the DS18B20, these registers may be used as general purpose user memory. The scratchpad also contains a configuration byte to set the desired resolution of the temperature to digital conversion. Writing TH, TL, and the configuration byte is done using a memory function command. Read access to these registers is through the scratchpad. All data is read and written least significant bit first.

Anexo K

Sensor de Presión

Freescale Semiconductor
Data Sheet: Advance Information
An Energy Efficient Solution by Freescale

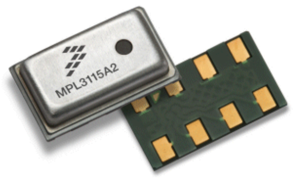
Document Number: MPL3115A2
Rev 2.2, 07/2012
RoHS

I^{2}C Precision Altimeter

The MPL3115A2 employs a MEMS pressure sensor with an I^{2}C interface to provide accurate Pressure/Altitude and Temperature data. The sensor outputs are digitized by a high resolution 24-bit ADC. Internal processing removes compensation tasks from the host MCU system. Multiple user-programmable, power saving, interrupt and autonomous data acquisition modes are available, including programmed acquisition cycle timing, and poll-only modes. Typical active supply current is 40 µA per measurement-second for a stable 30 cm output resolution. Pressure output can be resolved with output in fractions of a Pascal, and Altitude can be resolved in fractions of a meter.

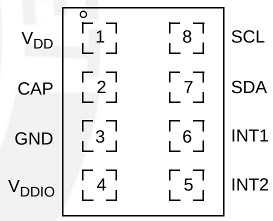
The MPL3115A2 is offered in a 5 mm by 3 mm by 1.1 mm LGA package and specified for operation from -40°C to 85°C. Package is surface mount with a stainless steel lid and is RoHS compliant.

MPL3115A2
50 to 110 kPa



LGA PACKAGE
5.0 mm by 3.0 mm by 1.1 mm

Top View



Pin Connections

Features

- 1.95V to 3.6V Supply Voltage, internally regulated by LDO
- 1.6V to 3.6V Digital Interface Supply Voltage
- Fully Compensated internally
- Direct Reading, Compensated
  - Pressure: 20-bit measurement (Pascals)
  - Altitude: 20-bit measurement (meters)
  - Temperature: 12-bit measurement (degrees Celsius)
- Programmable Events
- Autonomous Data Acquisition
- Resolution down to 1 ft. / 30 cm
- 32 Sample FIFO
- Ability to log data up to 12 days using the FIFO
- 1 second to 9 hour data acquisition rate
- I^{2}C digital output interface (operates up to 400 kHz)

Application Examples

- High Accuracy Altimetry
- Smartphones/Tablets
- Personal Electronics Altimetry
- GPS Dead Reckoning
- GPS Enhancement for Emergency Services
- Map Assist, Navigation
- Weather Station Equipment

ORDERING INFORMATION

Device Name	Package Options	Case No.	# of Ports			Pressure Type			Digital Interface
			None	Single	Dual	Gauge	Differential	Absolute	
MPL3115A2	Tray	2153	•					•	•
MPL3115A2R1	Tape & Reel (1000)	2153	•					•	•

This document contains information on a new product. Specifications and information herein are subject to change without notice.

Anexo L

Sensor de Salinidad

AtlasScientific™
Environmental Robotics

Conductivity Circuit

EZO™

EZO™ class embedded electrical conductivity circuit

v1.6
This is an evolving document check back for updates.

Features

Reads
- Conductivity
- Total dissolved solids
- Practical salinity units
- Specific gravity of sea water

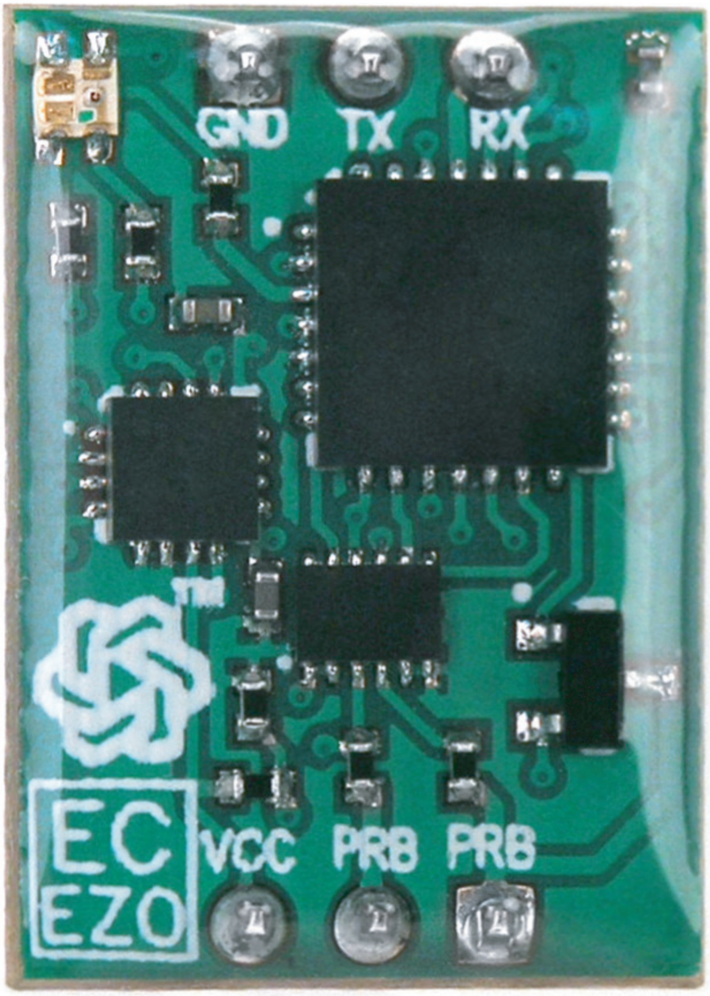
- E.C. readings +/- 2 μs/cm
- Full E.C. range from 0.55 μs/cm to 500,000+ μs/cm
- Temperature dependent or temperature independent readings
- Flexible calibration protocol supports single point or dual point calibration
- Calibrate to any E.C. value

Two data protocols
- UART asynchronous serial connectivity (RX/TX voltage swing 0-VCC)
- I2C (default I2C address 0x64)

- Operating voltage: 3.3V to 5V

- Works with any off-the-shelf two conductor conductivity probe
- Works with any K value from K=0.1 to K=10

Sleep mode power consumption
- 0.4mA* at 3.3V

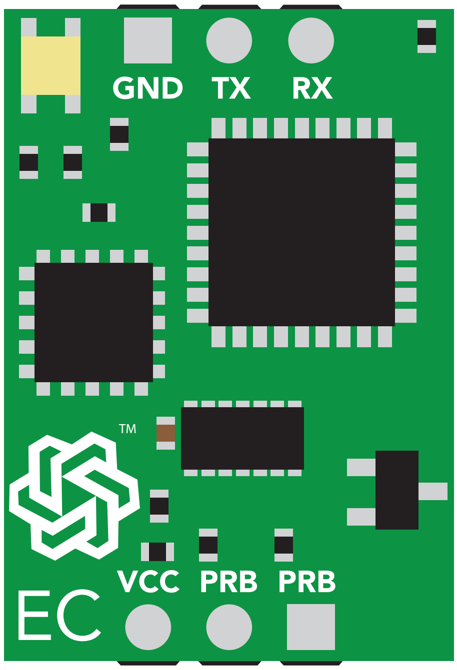


Patent pending

Description

The Atlas Scientific™ EZO™ class embedded electrical conductivity circuit is our 6th generation embedded electrical conductivity circuit. The EC-EZO™ electrical conductivity circuit can work with any off-the-shelf two conductor conductivity probe from K=0.1 to K=10. This includes any value between K=0.1 and K=10 such as K=0.66 or K=4.78. This device reads electrical conductivity from an E.C. probe/sensor/electrode. This device does not include an E.C. probe/sensor/electrode.

Pin out



GND Return for the DC power supply

Vcc Operates on 3.3V – 5.5V

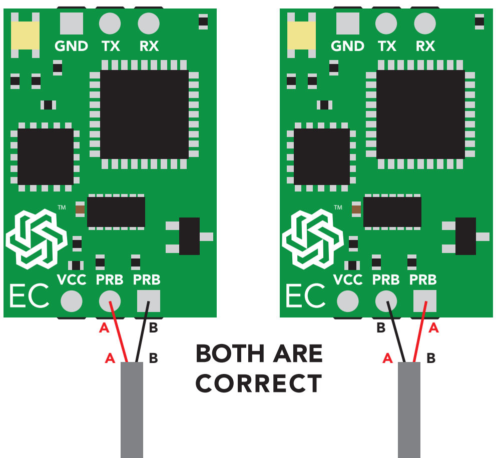
TX / SDA All EZO™ class circuits can operate in eitherUART mode or I²C mode

The default state is UART mode.
In UART mode, this pin acts as the transmit (TX) line.
The default baud rate is 38400, 8 bits, no parity, no flow control, one stop bit. If standard RS232 voltage levels are desired, connect an RS232 converter such as a MAX232.
If the device is in I²C mode, this pin acts as the Serial Data Line (SDA). The I²C protocol requires an external pull up resistor on the SDA line (resistor not included).

RX / SCL All EZO™ class circuits can operate in either UART mode, or I²C mode.

The default state is UART mode.
In UART mode, this pin acts as the receive (RX) line.
If the device is in I²C mode, this pin acts as the Serial Clock Line (SCL). The I²C protocol requires an external pull up resistor on the SCL line (resistor not included).

PRB Two pins are marked PRB. These pins are to be connected to an E.C. probe. It makes ***no difference*** which lead of the E.C. probe is connected to the two probe pins.



Anexo M

Sensor de PH

AtlasScientific™
Environmental Robotics

pH Circuit
EZO™

EZO™ class embedded pH circuit

V 1.3
This is an evolving document check back for updates.

Features

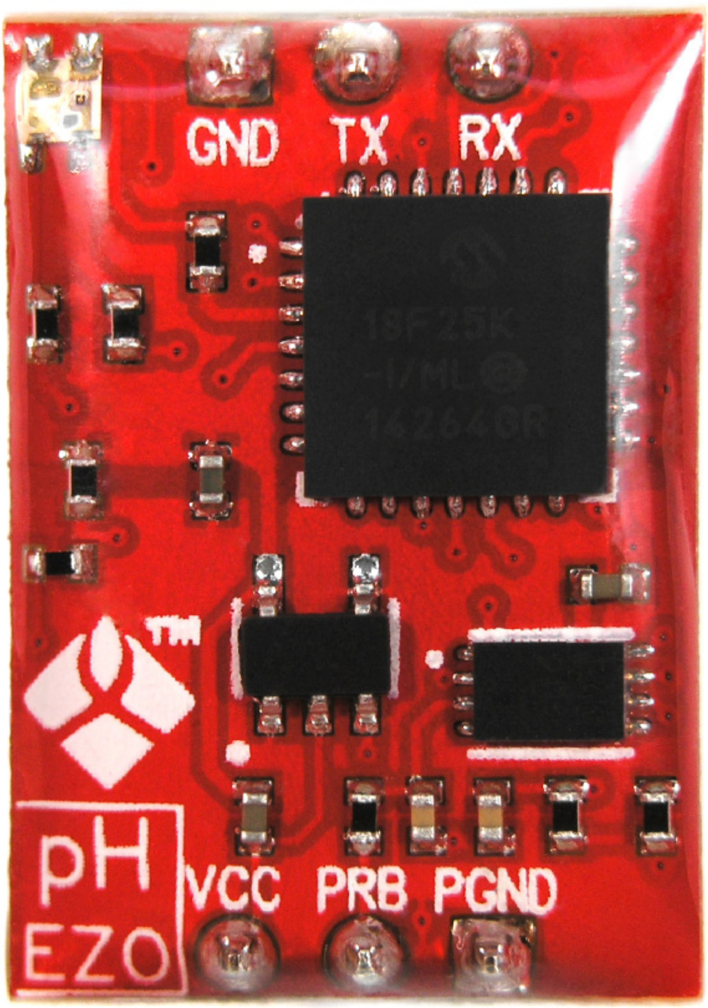
- Full range pH reading from .001 to 14.000
- Accurate pH readings down to the thousands place **(+/- 0.02)**
- Temperature dependent or temperature independent readings
- Flexible calibration protocol supports single point, 2 point, or 3 point calibration
- Calibration required only once per year with Atlas Scientific pH probe
- Single reading or continuous reading modes
- **Data format is ASCII**

Two data protocols

- UART asynchronous serial connectivity
- (RX/TX voltage swing 0-VCC)
- I²C (default I²C address 0x63)
- Compatible with any microprocessor that supports UART, or I²C protocol
- Operating voltage: 3.3V to 5V
- Works with any off-the-shelf pH probe

Sleep mode power consumption

- 0.995mA at 3.3V



Patent pending

Description

The Atlas Scientific™ EZO™ class embedded pH circuit, is our 6th generation embedded pH circuit. This EZO class pH circuit, offers the highest level of stability and accuracy. With proper configuration the EZO class pH circuit, can meet, or exceed the accuracy and precision found in most bench top laboratory grade pH meters. The pH-EZO™ pH circuit, can work with any off-the-shelf pH probe/sensor/electrode. This device reads pH from a pH probe/sensor/electrode. This device does not include a pH probe/sensor/electrode.

Pin Out

GND Return for the DC power supply

Vcc Operates on 3.3V – 5.5V

TX / SDA All EZO™ class circuits can operate in either UART mode, or I^2C mode

The default state is UART mode.
In UART mode, this pin acts as the transmit (TX) line.
The default baud rate is 38400, 8 bits, no parity, no flow control, one stop bit. If standard RS232 voltage levels are desired, connect an RS232 converter such as a MAX232.
If the devices is in I2C mode, this pin acts as the Serial Data Line (SDA). The I2C protocol requires an external pull up resistor on the SDA line (resistor not included).

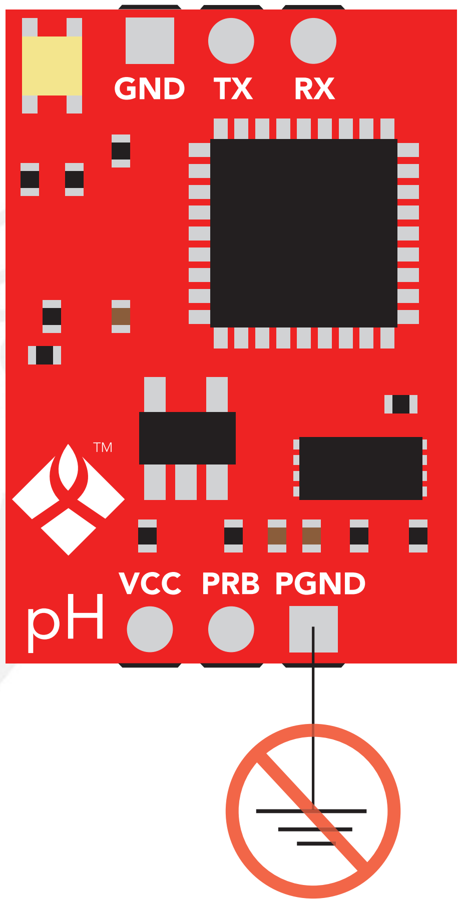
RX / SCL All EZO™ class circuits can operate in either UART mode, or I^2C mode.

The default state is UART mode.
In UART mode, this pin acts as the receive (RX) line.
If the devices is in I^2C mode, this pin acts as the Serial Clock Line (SCL). The I^2C protocol requires an external pull up resistor on the SCL line (resistor not included).

PRB This pin connects to the output lead of a pH probe/sensor/electrode

PGND This pin connects to the ground lead of a pH probe/sensor/electrode

This pin is not ground.
Do not tie this pin to system ground



Anexo N

Módulo de comunicación inalámbrica Xbee

1. XBee®/XBee-PRO® RF Modules

The XBee and XBee-PRO RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices.

The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

Key Features

Long Range Data Integrity

XBee

- Indoor/Urban: up to 100’ (30 m)
- Outdoor line-of-sight: up to 300’ (90 m)
- Transmit Power: 1 mW (0 dBm)
- Receiver Sensitivity: -92 dBm

XBee-PRO

- Indoor/Urban: up to 300’ (90 m), 200' (60 m) for International variant
- Outdoor line-of-sight: up to 1 mile (1600 m), 2500' (750 m) for International variant
- Transmit Power: 63mW (18dBm), 10mW (10dBm) for International variant
- Receiver Sensitivity: -100 dBm

RF Data Rate: 250,000 bps

Advanced Networking & Security

Retries and Acknowledgements

DSSS (Direct Sequence Spread Spectrum)

Each direct sequence channels has over 65,000 unique network addresses available

Source/Destination Addressing

Unicast & Broadcast Communications

Point-to-point, point-to-multipoint and peer-to-peer topologies supported

Low Power

XBee

- TX Peak Current: 45 mA (@3.3 V)
- RX Current: 50 mA (@3.3 V)
- Power-down Current: < 10 µA

XBee-PRO

- TX Peak Current: 250mA (150mA for international variant)
- TX Peak Current (RPSMA module only): 340mA (180mA for international varian
- RX Current: 55 mA (@3.3 V)
- Power-down Current: < 10 µA

ADC and I/O line support

Analog-to-digital conversion, Digital I/O

I/O Line Passing

Easy-to-Use

No configuration necessary for out-of box RF communications

Free X-CTU Software
(Testing and configuration software)

AT and API Command Modes for configuring module parameters

Extensive command set

Small form factor

Worldwide Acceptance

FCC Approval (USA) Refer to Appendix A [p64] for FCC Requirements.
Systems that contain XBee®/XBee-PRO® RF Modules inherit Digi Certifications.

ISM (Industrial, Scientific & Medical) **2.4 GHz frequency band**

Manufactured under **ISO 9001:2000** registered standards

XBee®/XBee-PRO® RF Modules are optimized for use in the United States, Canada, Australia, Japan, and Europe. Contact Digi for complete list of government agency approvals.

Specifications

Table 1-01. Specifications of the XBee®/XBee-PRO® RF Modules

Specification	XBee	XBee-PRO
Performance		
Indoor/Urban Range	Up to 100 ft (30 m)	Up to 300 ft. (90 m), up to 200 ft (60 m) International variant
Outdoor RF line-of-sight Range	Up to 300 ft (90 m)	Up to 1 mile (1600 m), up to 2500 ft (750 m) international variant
Transmit Power Output (software selectable)	1mW (0 dBm)	63mW (18dBm)* 10mW (10 dBm) for International variant
RF Data Rate	250,000 bps	250,000 bps
Serial Interface Data Rate (software selectable)	1200 bps - 250 kbps (non-standard baud rates also supported)	1200 bps - 250 kbps (non-standard baud rates also supported)
Receiver Sensitivity	-92 dBm (1% packet error rate)	-100 dBm (1% packet error rate)
Power Requirements		
Supply Voltage	2.8 – 3.4 V	2.8 – 3.4 V
Transmit Current (typical)	45mA (@ 3.3 V)	250mA (@3.3 V) (150mA for international variant) RPSMA module only: 340mA (@3.3 V) (180mA for international variant)
Idle / Receive Current (typical)	50mA (@ 3.3 V)	55mA (@ 3.3 V)
Power-down Current	< 10 µA	< 10 µA
General		
Operating Frequency	ISM 2.4 GHz	ISM 2.4 GHz
Dimensions	0.960" x 1.087" (2.438cm x 2.761cm)	0.960" x 1.297" (2.438cm x 3.294cm)
Operating Temperature	-40 to 85º C (industrial)	-40 to 85º C (industrial)
Antenna Options	Integrated Whip, Chip or U.FL Connector, RPSMA Connector	Integrated Whip, Chip or U.FL Connector, RPSMA Connector
Networking & Security		
Supported Network Topologies	Point-to-point, Point-to-multipoint & Peer-to-peer	
Number of Channels (software selectable)	16 Direct Sequence Channels	12 Direct Sequence Channels
Addressing Options	PAN ID, Channel and Addresses	PAN ID, Channel and Addresses
Agency Approvals		
United States (FCC Part 15.247)	OUR-XBEE	OUR-XBEEPRO
Industry Canada (IC)	4214A XBEE	4214A XBEEPRO
Europe (CE)	ETSI	ETSI (Max. 10 dBm transmit power output)*
Japan	R201WW07215214	R201WW08215111 (Max. 10 dBm transmit power output)*
Austraila	C-Tick	C-Tick

* See Appendix A for region-specific certification requirements.

Antenna Options: The ranges specified are typical when using the integrated Whip (1.5 dBi) and Dipole (2.1 dBi) antennas. The Chip antenna option provides advantages in its form factor; however, it typically yields shorter range than the Whip and Dipole antenna options when transmitting outdoors.For more information, refer to the "XBee Antennas" Knowledgebase Article located on Digi's Support Web site

Mechanical Drawings

Figure 1-01. Mechanical drawings of the XBee®/XBee-PRO® RF Modules (antenna options not shown)

Anexo Ñ

Motor de hélices

LEOPARD Brushless Motor for LBP56110

Thank you for purchasing one of Leopard Hobby's products. Leopard motors represent the latest brushless motor technology – all the latest innovations combined with the best materials available on the market. This motor is perfectly matched with Leopards range of ESCs. Please kindly visit our website **www.leopardhobby.com** for more details about Leopard Hobby's range of products.
All motors have six weeks limited warranty from the date of purchase that does not cover crash damage, improper use or overheating.

Features:

- High efficiency,high power,high torque
- Sintered neodymium rotor magnets
- 12 slot stator
- Powerful four pole design
- Minimal motor maintenance is required
- Excellent heat dissipation , a high overload ability
- Handwound
- long service life
- Low current , low temperature
- Low electromagnetic interference
- Precision ball bearings
- Capable of high overloads for short periods

Specifications:

LBP56110 Series

Model	Max Amps	Max voltage	Max Power	KV (RPM /Volt)	Resis-tance	No-load Current (15V)	Diameter × Length (mm)	Mounting hole depth	Length of extend Shaft	Shaft Diameter (mm)	Weight
LBP56110 /2Y	170A	44V	7600W	780	0.0072	3.7A	Φ55.8×110	8mm	30mm	Φ8.0	1160g
LBP56110 /3Y	113A	67V	7600W	520	0.0152	2.1A	Φ55.8×110	8mm	30mm	Φ8.0	1160g
LBP56110 /4Y	82A	92V	7600W	380	0.0265	1.8A	Φ55.8×110	8mm	30mm	Φ8.0	1160g
LBP56110 /2D	300A	24V	7600W	1430	0.0027	7.4A	Φ55.8×110	8mm	30mm	Φ8.0	1160g
LBP56110 /3D	210A	36V	7600W	950	0.0055	4.3A	Φ55.8×110	8mm	30mm	Φ8.0	1160g
LBP56110 /4D	158A	48V	7600W	720	0.0092	3.1A	Φ55.8×110	8mm	30mm	Φ8.0	1160g
LBP56110 /4.5D	140A	54V	7600W	640	0.0149	3.0A	Φ55.8×110	8mm	30mm	Φ8.0	1160g

Caution:

- Do not immerse the motor in Acid/Alkaline solvent.
- Do not bend wires excessively. Secure wires to prevent breakage due to vibration.
- Avoid over gearing by monitoring the temperature.
- Be sure to use the proper size mounting screws to avoid a short circuit or damage to other components.
- Do not apply full throttle if motor is not installed, this can cause severe motor damage (high RPMs without a load).
- Do not cut motor wires.