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Title: Plataforma educativa para desarrollo de sistemas de Software Radio mediante modulación QPSK en Octave y Arduino

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INTRODUCTION

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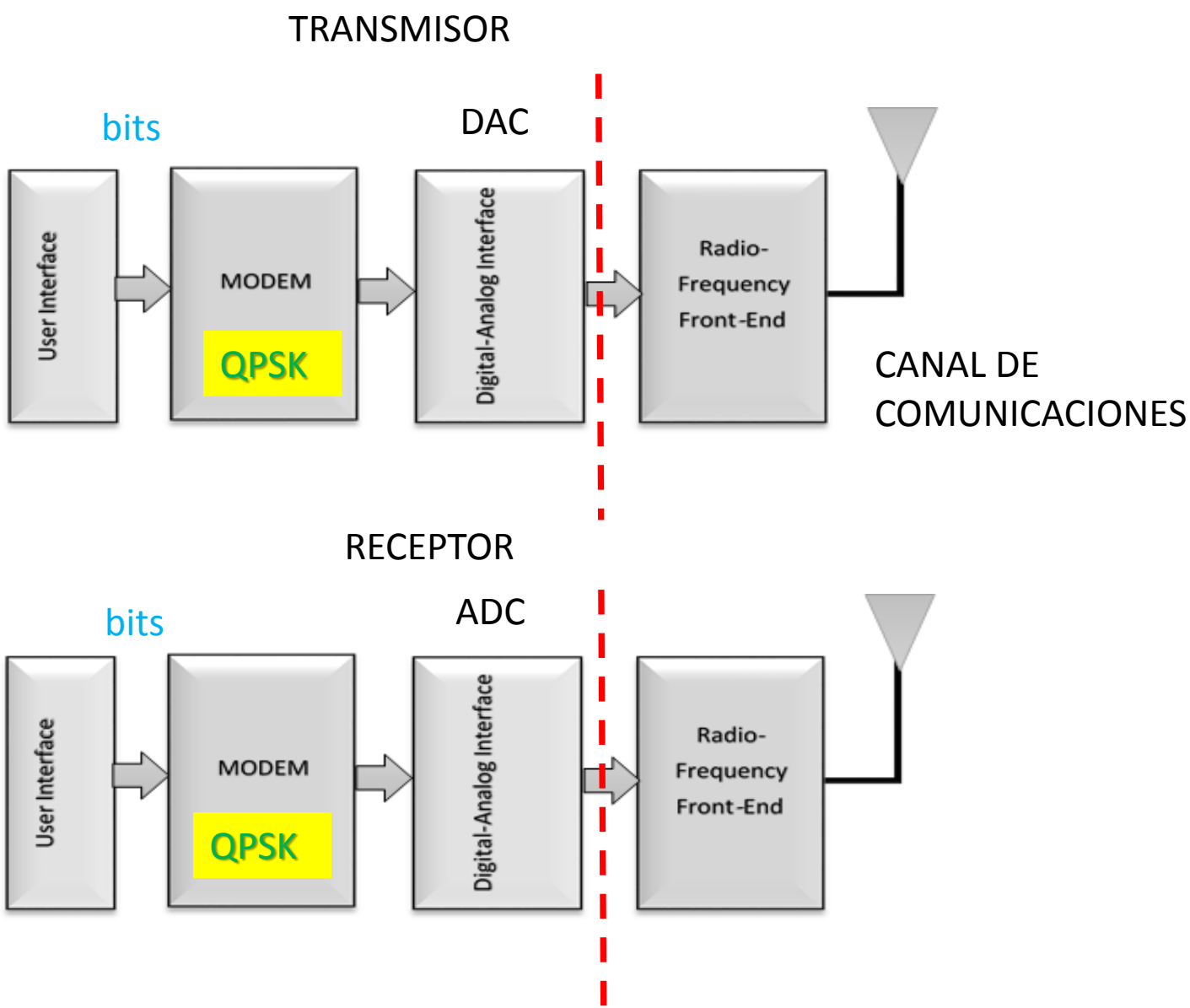
Los sistemas de radio comunicación definidos por Software (SDR) o **Software Radio**, son implementados con sistemas digitales basadas en microprocesadores o sistemas embebidos, los cuales permiten realizar modulaciones digitales y el tratamiento de la señal aplicando técnicas de procesamiento digital de señales



INTRODUCTION

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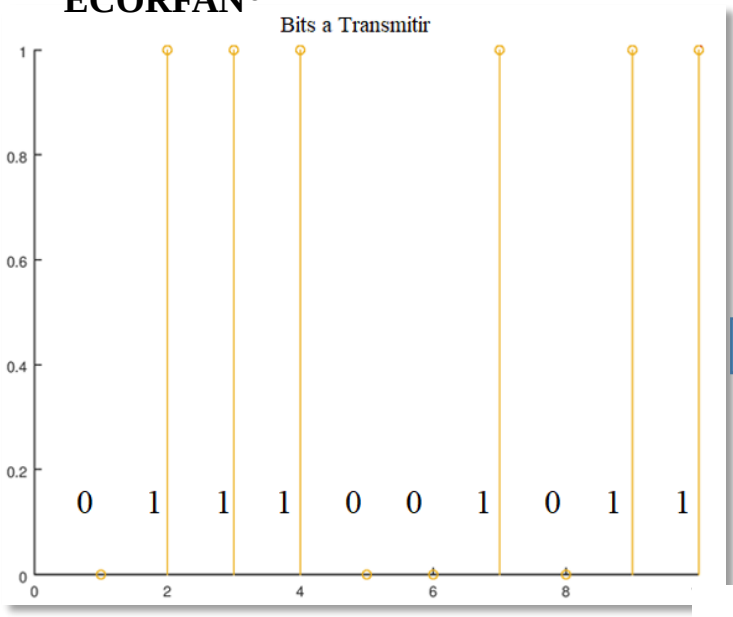
QPSK



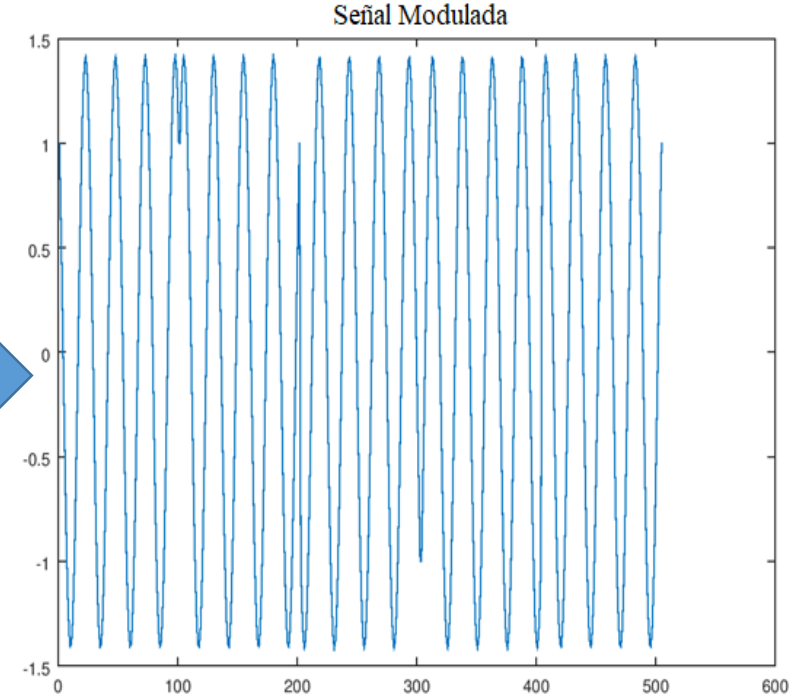
$$S_n(t) = \sqrt{\frac{2E_s}{T_s}} \sin\left(2\pi f_c t + (2n-1)\frac{\pi}{4}\right),$$

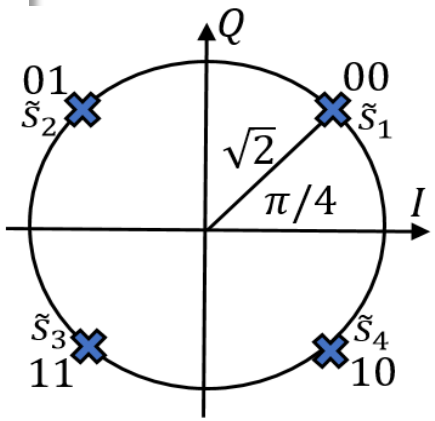
s_n: *Símbolo modulado*, $n \in \{1,2,3,4\}$

f_c: *Frecuencia portadora*

E_s: *Energía del símbolo*

T_s: *Duración del símbolo*





sym1 = A*sin(wc*2*tb+5*pi/4); (2)

sym2 = A*sin(wc*2*tb+3*pi/4); (3)

sym3 = A*sin(wc*2*tb+7*pi/4); (4)

sym4 = A*sin(wc*2*tb+pi/4); (5)

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METHODOLOGY

- Los datos binarios se modulan digitalmente mediante QPSK en Octave.
- Los valores de la señal analógica a transmitir se acondicionan con respecto al nivel de voltaje
- Se modula por ancho de pulso (PWM) para ser transmitida en el Canal
- Se aproxima a una conversión ADC mediante un circuito (RC) y un Amplificador Operacional.
- El Arduino receptor adquiere la señal de un puerto analógico mediante la resolución de su ADC interno.
- Los datos obtenidos por el Arduino receptor se envían a Octave de forma serial para comparar la señal transmitida y recibida.

METHODOLOGY

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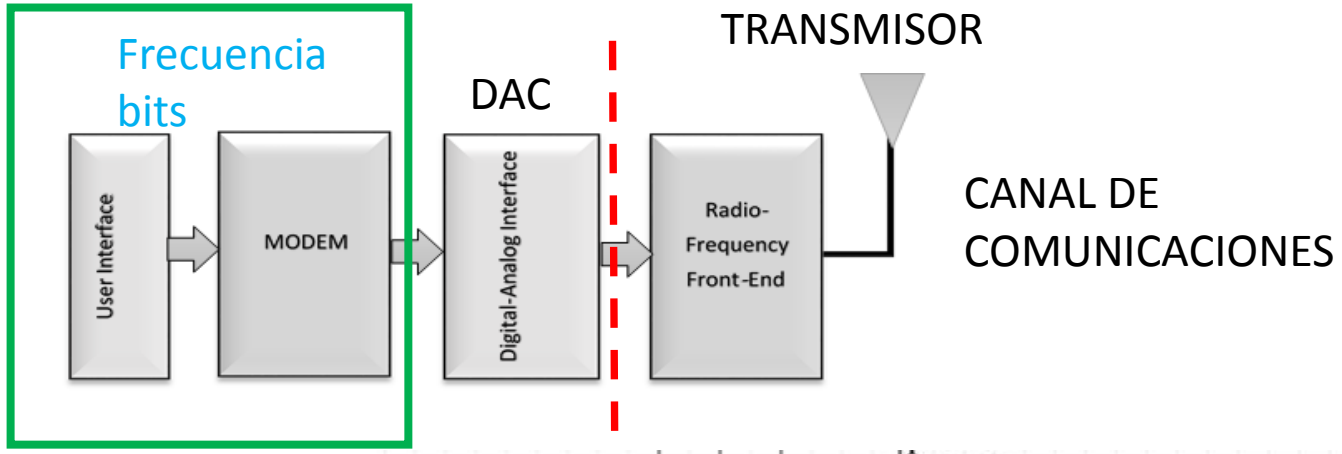
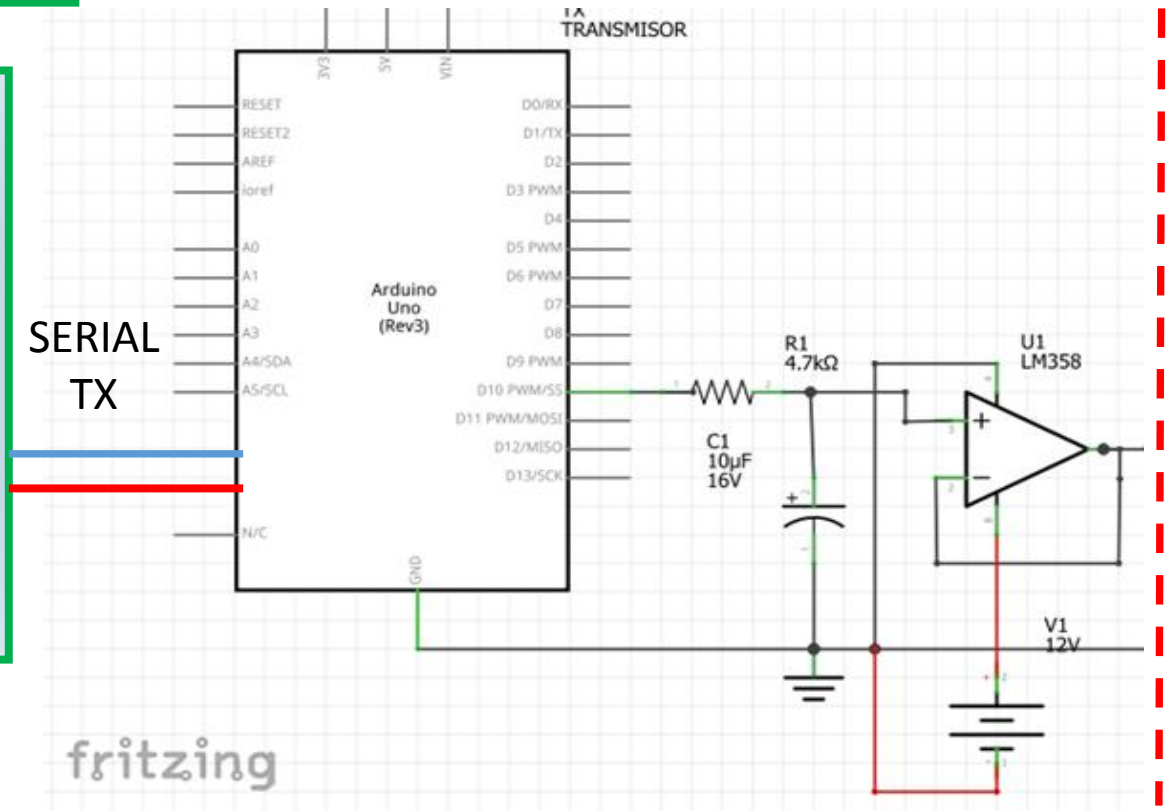


CANAL DE COMUNICACIONES

OCTAVE
Bits, QPSK
Modem

SERIAL
TX



CANAL DE COMUNICACIONES

RESULTS

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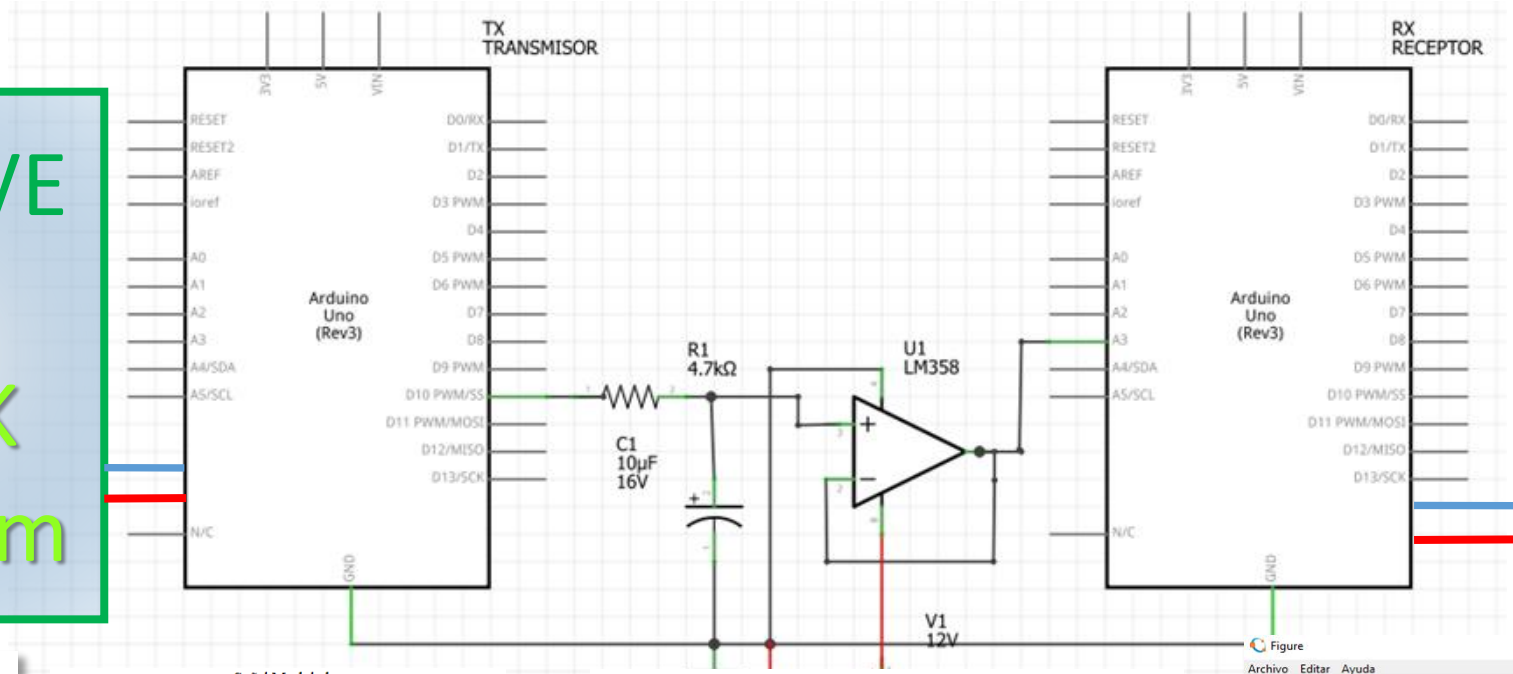
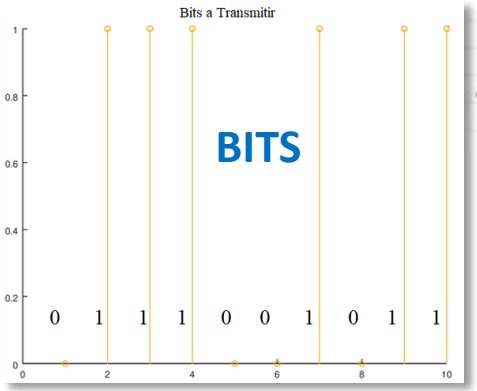
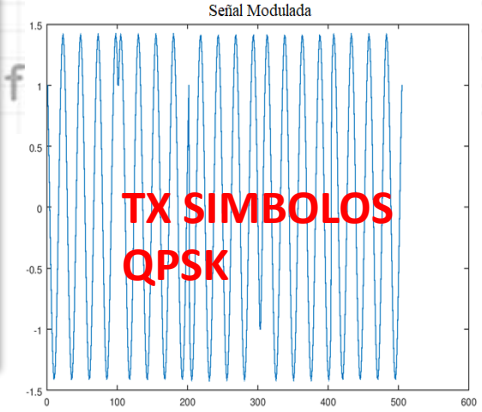
OCTAVE Bits, QPSK Modem



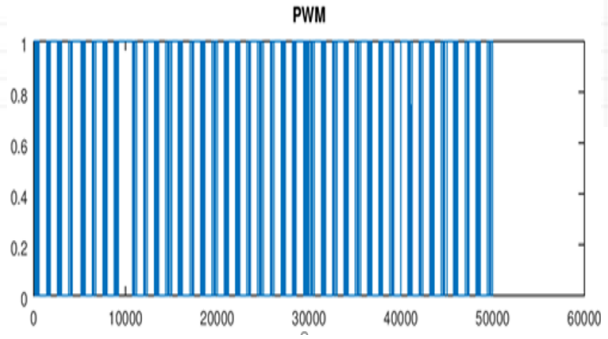
OCTAVE Bits, QPSK Modem



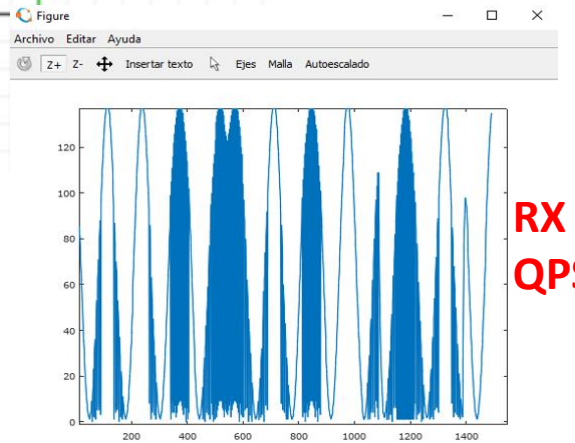
BITS



TX SIMBOLOS QPSK



PWM TX



RX SIMBOLOS QPSK

ANNEXES

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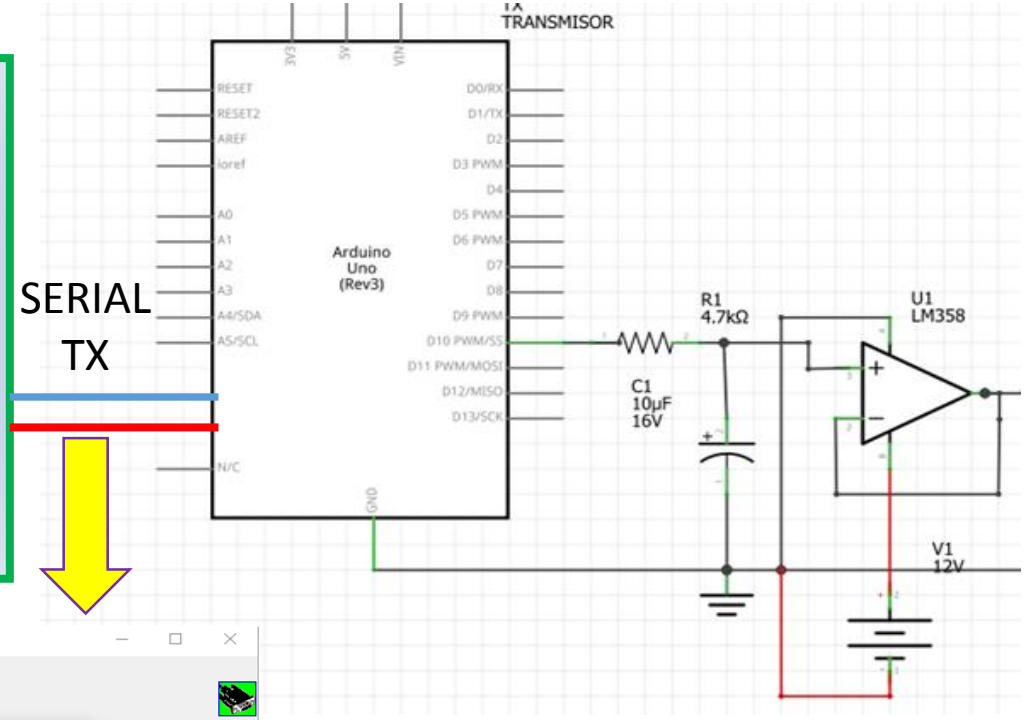
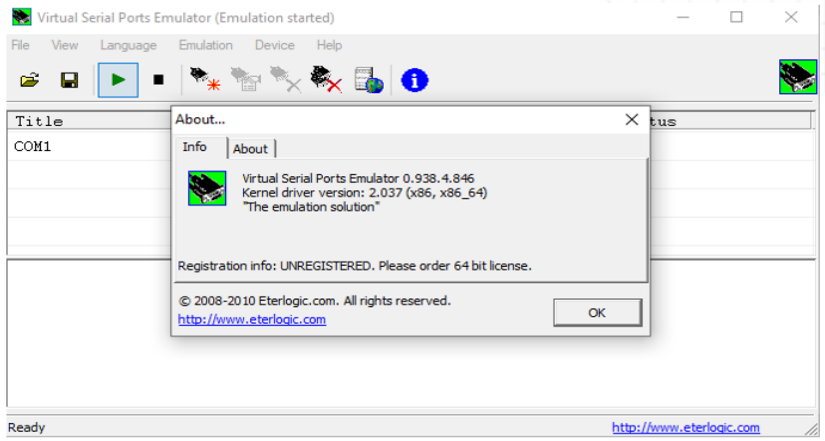
OCTAVE
Bits, QPSK
Modem

SERIAL
TX





PUERTO SERIAL VIRTUAL

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ANNEXES

QPSK en OCTAVE (Software Radio)

```
pkg load signal
paso = 0.0001;
tb = 0:paso:1;
n = 10;
bits = randi(1,n);
for i = 1:n
   bits(1,i)=0;
   bits(5,i)=0;
   bits(6,i)=0;
   bits(8,i)=0;
end
```

```
figure(1);
stem(bits);
title('Bits a transmitir');
A = (2)^0.5;
Tc = 1/2;
fc =1/Tc;
wc = 2*pi*fc;
sym1 = A*sin(wc*2*tb+5*pi/4); % 00
sym2 = A*sin(wc*2*tb+3*pi/4); % 01
sym3 = A*sin(wc*2*tb+7*pi/4); % 10
sym4 = A*sin(wc*2*tb+pi/4); % 11
```

```
figure(2);
subplot(2,2,1); plot(sym1); title('00');
subplot(2,2,2); plot(sym2); title('01');
subplot(2,2,3); plot(sym3); title('10');
subplot(2,2,4); plot(sym4); title('11');
mod = [];
for i=1:2:n-1
   if(bits(i) == 0 && bits(i+1)==0) mod = [mod sym1];
   elseif (bits(i) == 0 && bits(i+1)==1) mod = [mod sym2];
   elseif (bits(i) == 1 && bits(i+1)==0) mod = [mod sym3];
   elseif (bits(i) == 1 && bits(i+1)==1) mod = [mod sym4];
   end
end
```

ANNEXES

QPSK en OCTAVE (Software Radio)

```
figure(3);
plot(mod);
lenmod=length(mod)
title('Señal Modulada');
A=90;
y = round(A*mod)+127;
figure(4)
subplot(211)
plot(mod)
subplot(212)
plot(y)
```

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ANNEXES

Firmware Arduino Transmisor

```
int pwmOut = 10;
float val=0;
float valr=0;
byte
valx504[]={217,192,163,131,99,69,43,22,7,0,1,10,26,49,76,107,139,170,199,222,240,251,254,249,237,217,192,163,131,99,69,43,22,7,0,1,10,26,49,76,107,139,170,199,222,240,251,254,249,237,217,192,163,131,99,69,43,22,7,0,1,10,26,49,76,107,139,170,199,222,240,251,254,249,237,217,192,163,131,99,69,43,22,7,0,1,10,26,49,76,107,139,170,199,222,240,251,254,249,237,217,217,237,249,254,251,240,222,199,170,139,107,76,49,26,10,1,0,7,22,43,69,99,131,163,192,217,237,249,254,251,240,222,199,170,139,107,76,49,26,10,1,0,7,22,43,69,99,131,163,192,217,237,249,254,251,240,222,199,170,139,107,76,49,26,10,1,0,7,22,43,69,99,131,163,192,217,237,249,254,251,240,222,199,170,139,107,76,49,26,10,1,0,7,22,43,69,99,131,163,192,217,37,17,5,0,3,14,32,55,84,115,147,178,205,228,244,253,254,247,232,211,185,155,123,91,62,37,17,5,0,3,14,32,55,84,115,147,178,205,228,244,253,254,247,232,211,185,155,123,91,62,37,17,5,0,3,14,32,55,84,115,147,178,205,228,244,253,254,247,232,211,185,155,123,91,62,37,17,5,0,3,14,32,55,84,115,147,178,205,228,244,253,254,247,232,211,185,155,123,91,62,37,37,62,91,123,155,185,211,232,247,254,253,244,228,205,178,147,115,84,55,32,14,3,0,5,17,37,62,91,123,155,185,211,232,247,254,253,244,228,205,178,147,115,84,55,32,14,3,0,5,17,37,62,91,123,155,185,211,232,247,254,253,244,228,205,178,147,115,84,55,32,14,3,0,5,17,37,62,91,123,155,185,211,232,247,254,253,244,228,205,178,147,115,84,55,32,14,3,0,5,17,37,217,237,249,254,251,240,222,199,170,139,107,76,49,26,10,1,0,7,22,43,69,99,131,163,192,217,237,249,254,251,240,222,199,170,139,107,76,49,26,10,1,0,7,22,43,69,99,131,163,192,217,237,249,254,251,240,222,199,170,139,107,76,49,26,10,1,0,7,22,43,69,99,131,163,192,217}; // QPSK signal simulation
```

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ANNEXES

Firmware Arduino Transmisor

```
int delayt=50;
void setup()
{
  pinMode(pwmOut, OUTPUT);
  Serial.begin(9600);
}
void loop()
{
  for(byte i=0; i<=504; i++)
  {
    analogWrite(pwmOut,valx504[i]);
    delay(delayt);
    Serial.println(valx504[i]);
  }
}
```

ANNEXES

Firmware Arduino Receptor y Octave

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```
float val=0;
float valr=0;
float vrx=0;
int
valx6[]={0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,
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};
int delayt=500;
void setup()
{
  Serial.begin(9600);
}
```

```
void loop()
{

  for(int i=0; i<=64; i++)
  {
    vrx=analogRead(A3);
    valx6[i]=vrx/4;
    Serial.println("indice i:");
    Serial.println(i);
    Serial.println("Valor en i:");
    Serial.println(valx6[i]);

    delay(delayt);
  }
}
```

```
clc;clear all;close all;
pkg load instrument-control
pkg load signal
s1 = serial("\\\\.\\COM1")   % Open the virtual port
srl_flush(s1)
y_temp = cell(10,1)
y = 0
while true
  for i = 1:10
    y_serial = str2num(char(srl_read(s1,10)))
     y_temp{i,1} = y_serial
  endfor
  y = cat(1, y, y_temp{1:10})
  plot(y)
  %pause(1)   % realiza una medición continua de
datos
endwhile
srl_close(s1)
fclose(s1);
```

CONCLUSIONS

- El diseño de esta plataforma puede ser aplicada en **laboratorios de ingeniería y prácticas de comunicaciones digitales**, emulando la transmisión y recepción de señales que caracterizan el sistema de Software Radio utilizando Octave y Arduino.
- En la plataforma se aplica comunicación serial, **conversión ADC y DAC**, se sintetizan los datos mediante un Conversor Digital Analógico con PWM para transmitir una señal modulada.
- Mediante el software Octave es posible realizar el **software radio** de una señal utilizando una modulación digital, en nuestro caso es QPSK.
- Esta plataforma nos permitió **comprobar algoritmos de transmisión y recepción de datos**, codificación de canal, representa una herramienta de desarrollo con un gran potencial al interactuar con la plataforma Arduino de forma serial.
- Una de las limitaciones de esta plataforma es la velocidad de transmisión de los puertos y la lectura de los datos, así como **la sincronización de la señal** y estas son áreas de oportunidad para contribuir en el desarrollo de esta plataforma.

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