Trabajo Fin de Grado

Desarrollo de un sistema de comunicaciones VVLC con implementación de filtro adaptado en SoC FPGA

Realizado por: Andrés Casasola Domínguez

Dirigido por: Antonio García Zambrana

Ingeniería de Comunicaciones - UNIVERSIDAD DE MÁLAGA

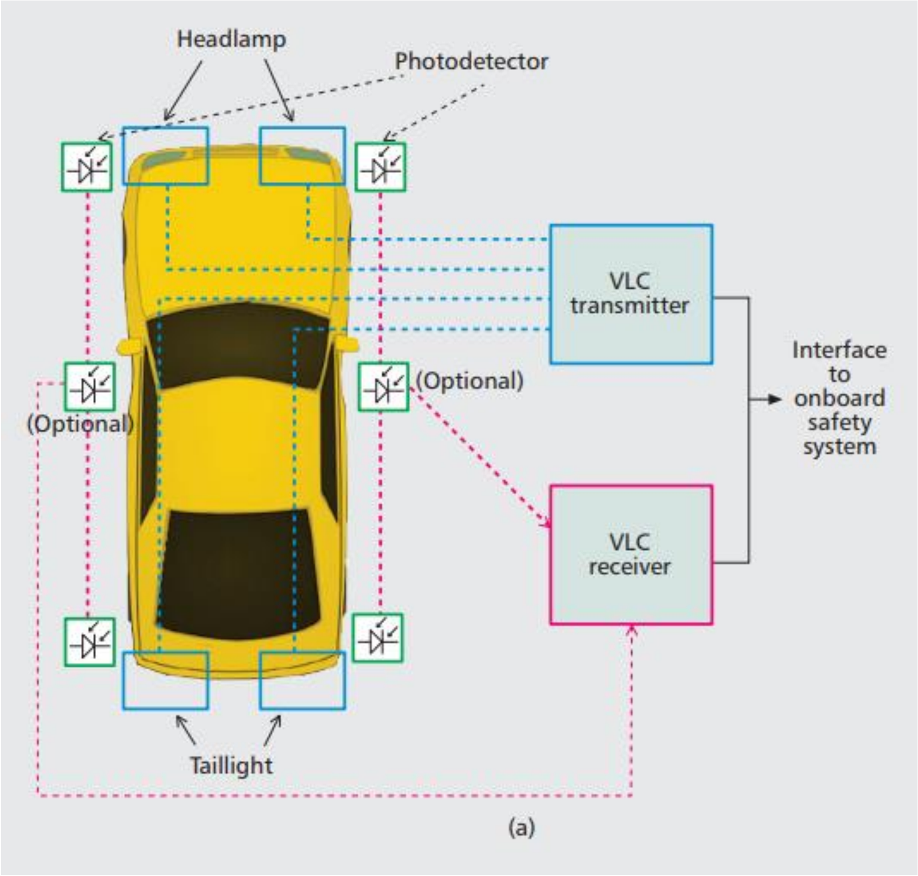
Málaga, 12 de marzo de 2020

Índice de contenidos

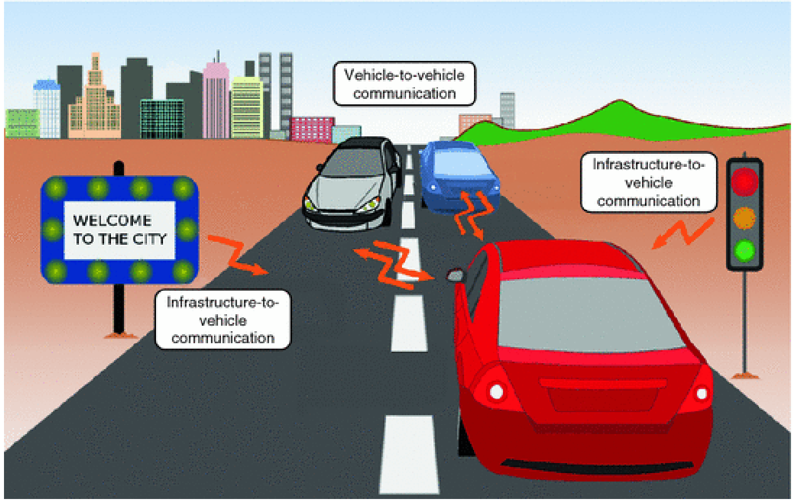
Objetivo

Mejorar las capacidades de un sistema de comunicación VVLC, diseñando e implementando un receptor óptimo, probando su funcionamiento y cuantificando sus capacidades.

Vehicular Visible Light Communications

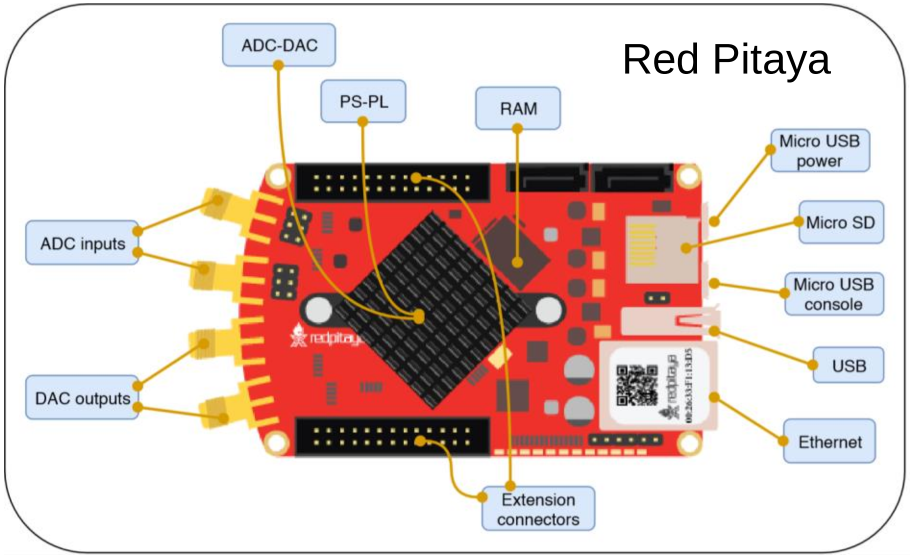


Fuente: Smart Automotive Lighting for Vehicle Safet, IEEE Communications Magazine.

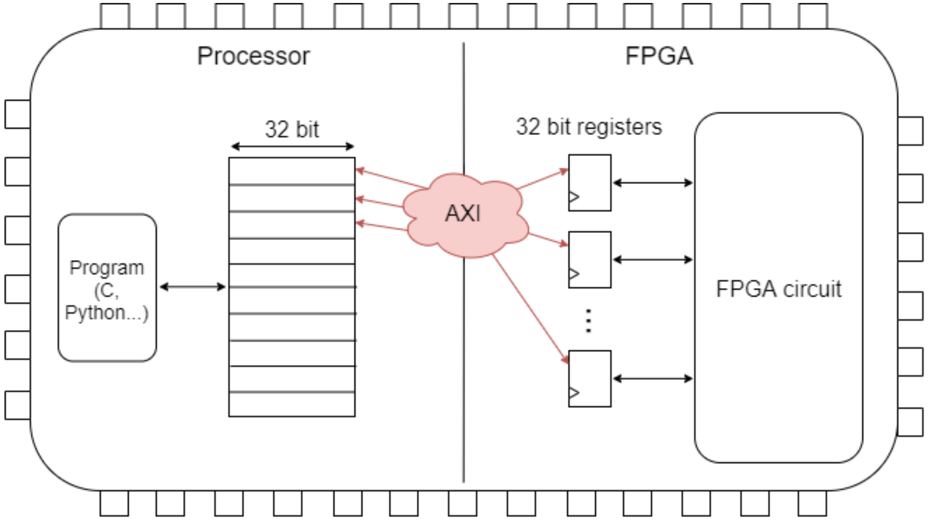


Fuente: Visible Light Communication for Cooperative ITS.

Hardware

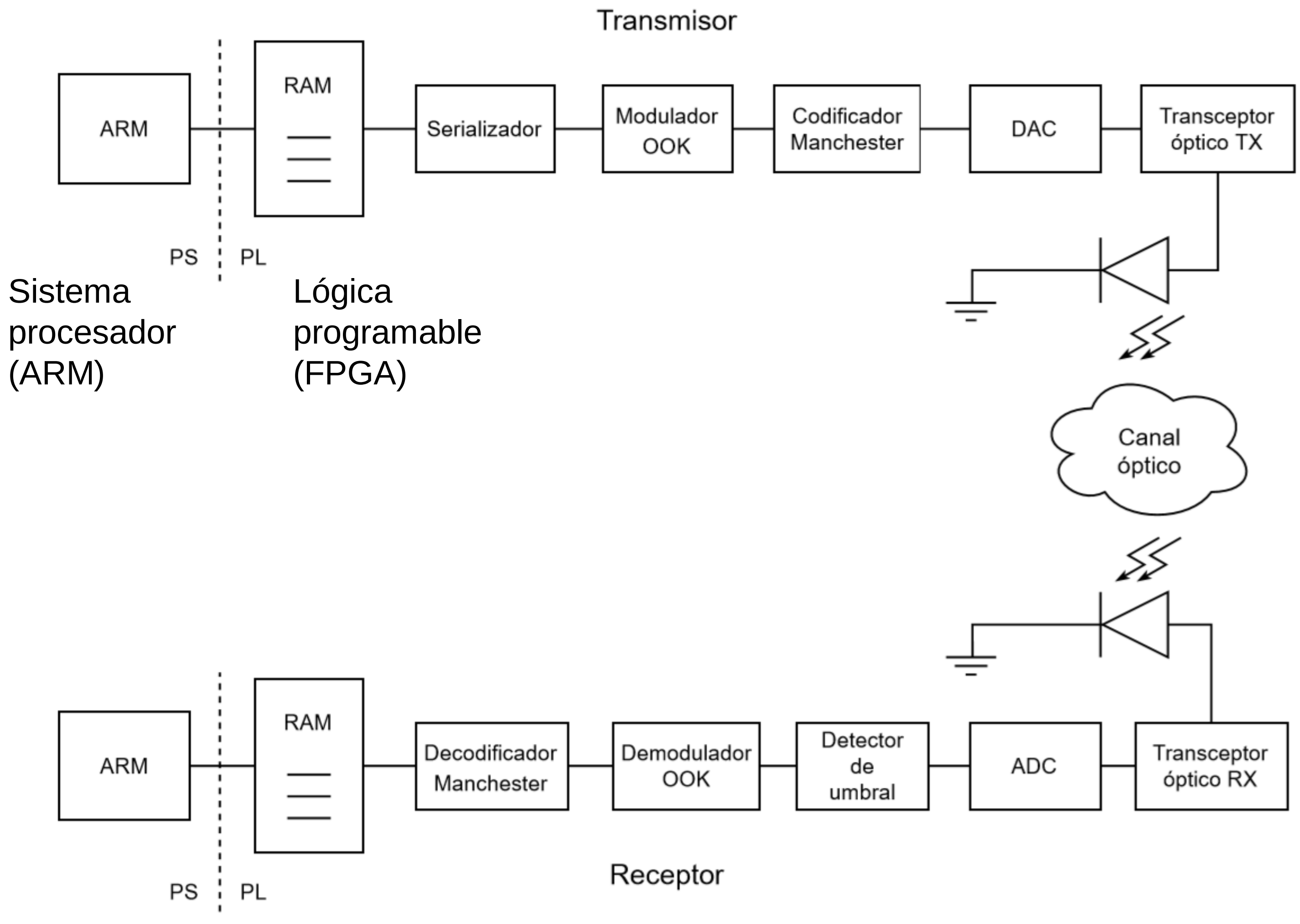

Red Pitaya
ADC-DAC
PS-PL
RAM
Micro USB power
Micro SD
Micro USB console
USB
Ethernet
ADC inputs
DAC outputs
Extension connectors


XILINX®
ZYNQ®


Processor
FPGA
32 bit
32 bit registers
AXI
Program (C, Python...)
FPGA circuit

Sistema base

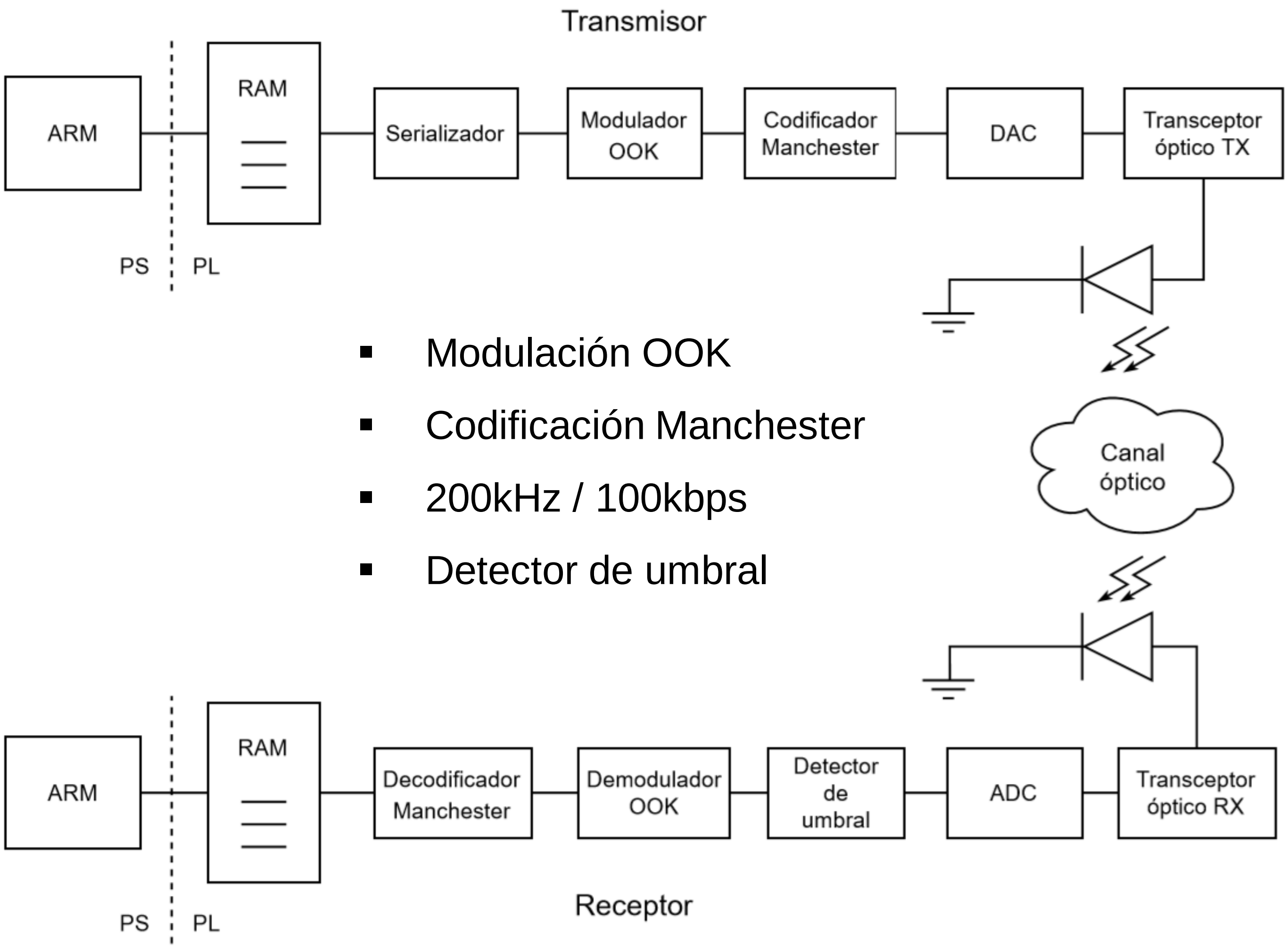
Sistema base



Sistema procesador (ARM)

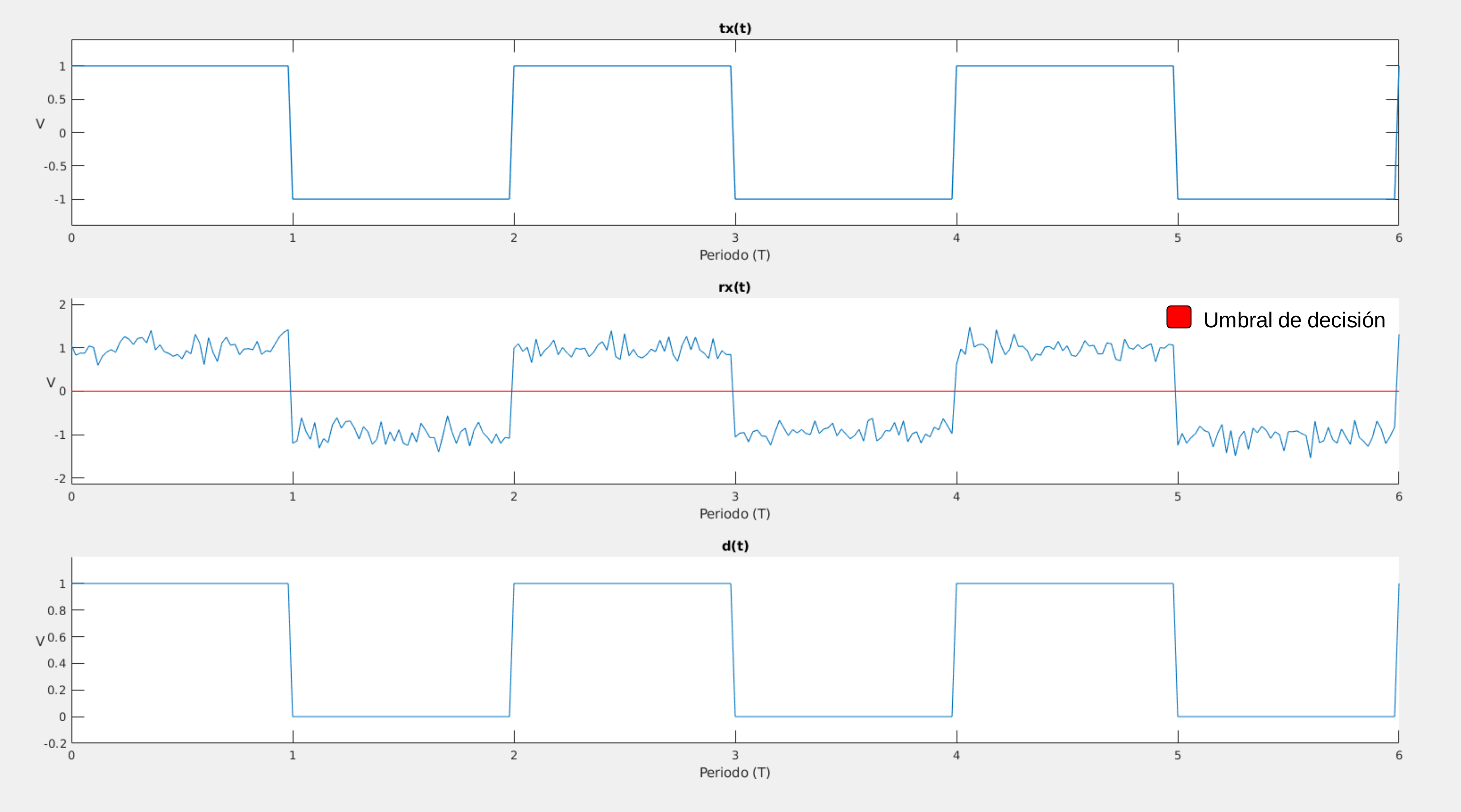
Lógica programable (FPGA)

Sistema base

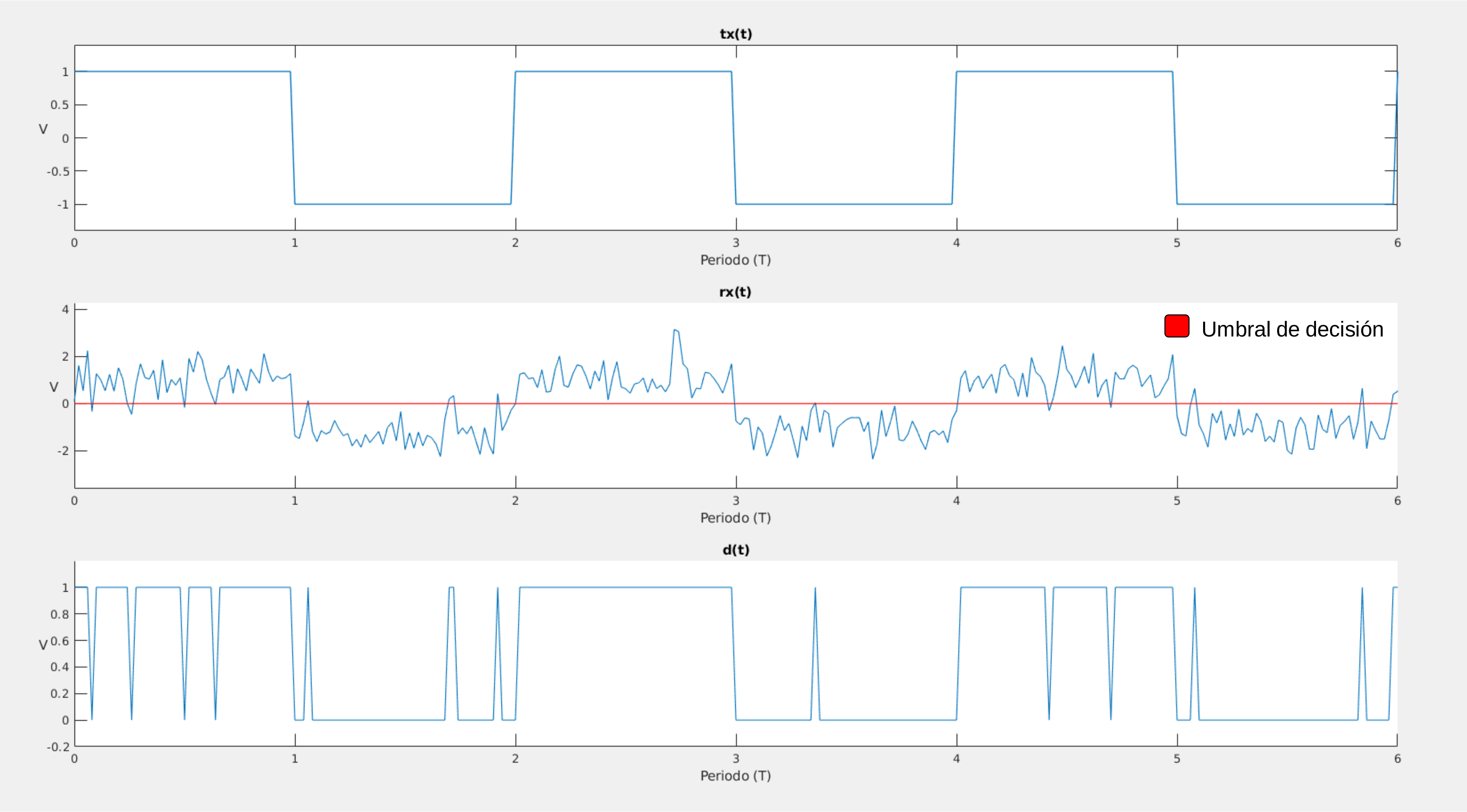


- Modulación OOK
- Codificación Manchester
- 200kHz / 100kbps
- Detector de umbral

Sistema base: Gráficas



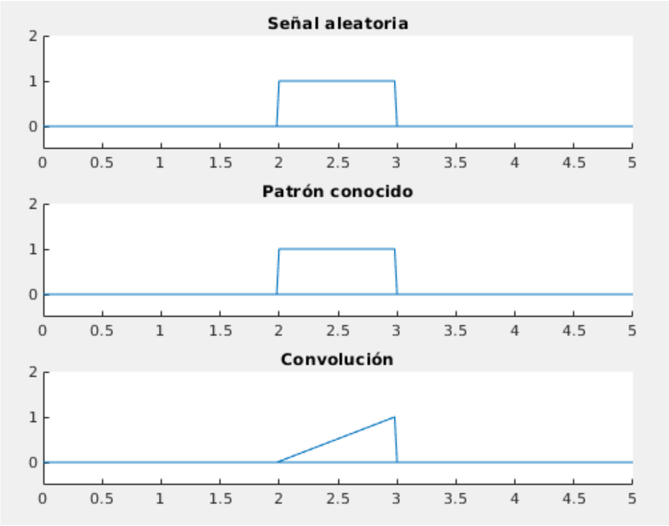
Sistema base: Gráficas

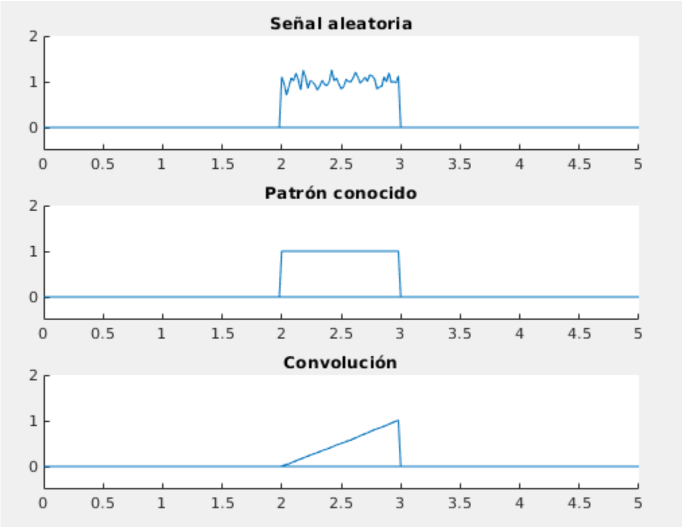


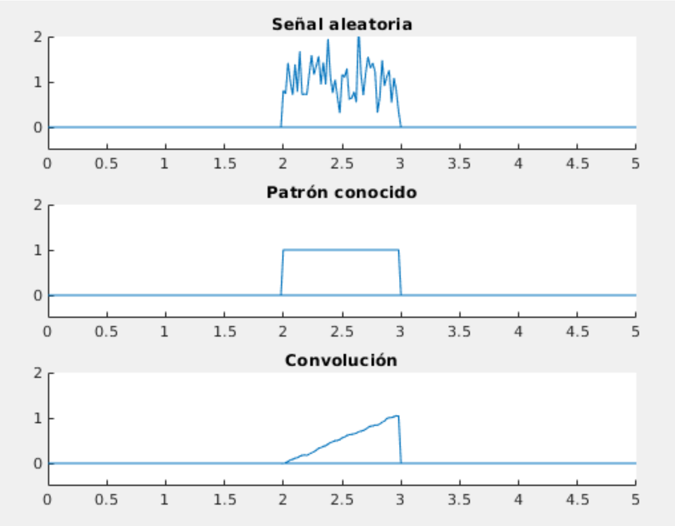
Filtro adaptado

Filtro adaptado

Filtro adaptado a un patrón conocido

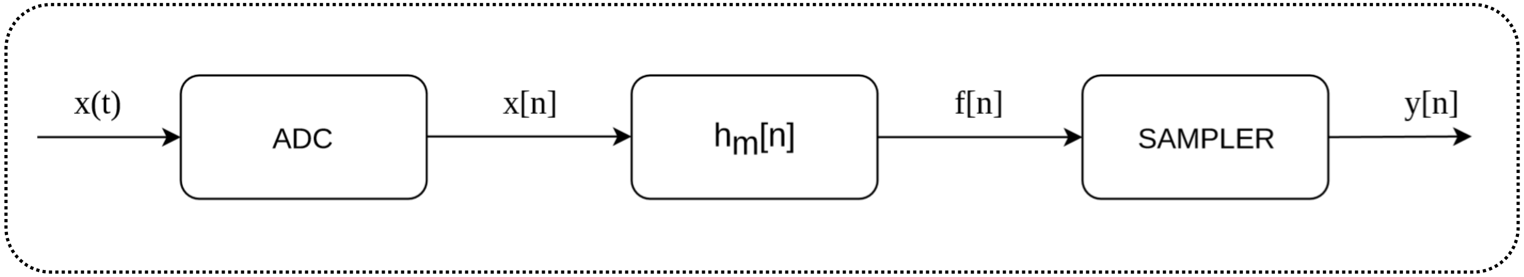






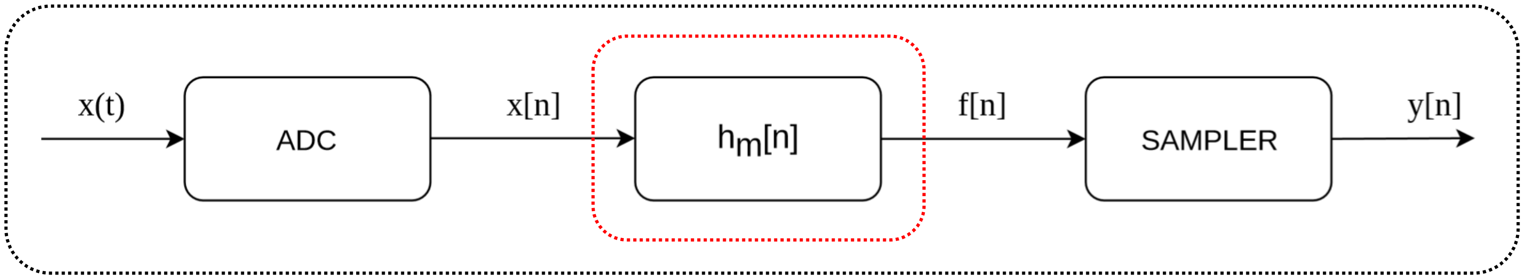
Filtro adaptado

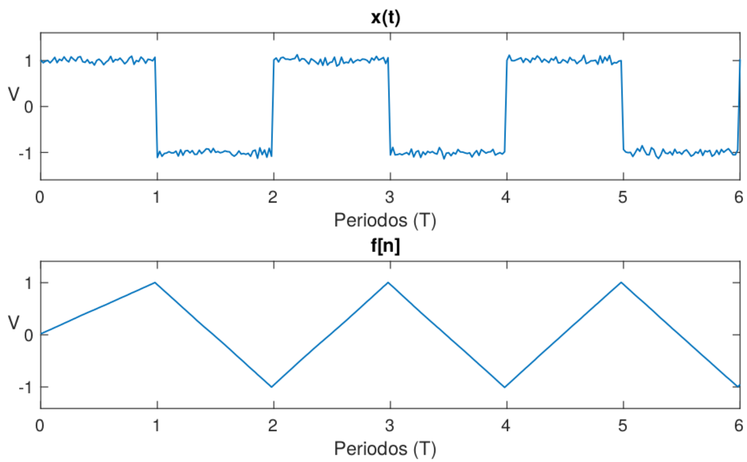
Diagrama de bloques del filtro adaptado

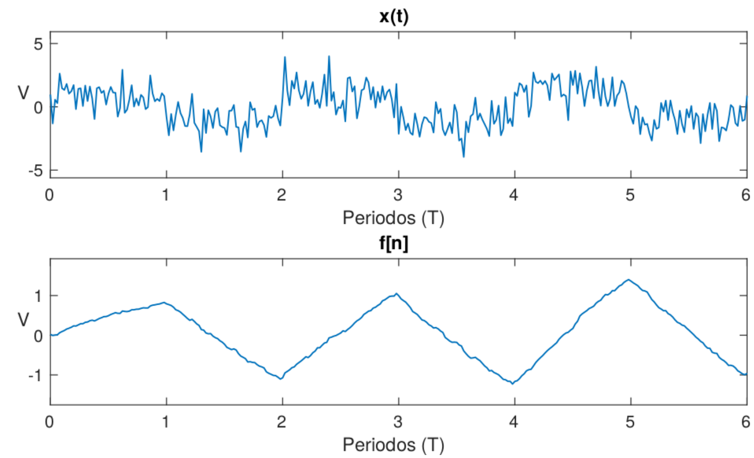


Filtro adaptado

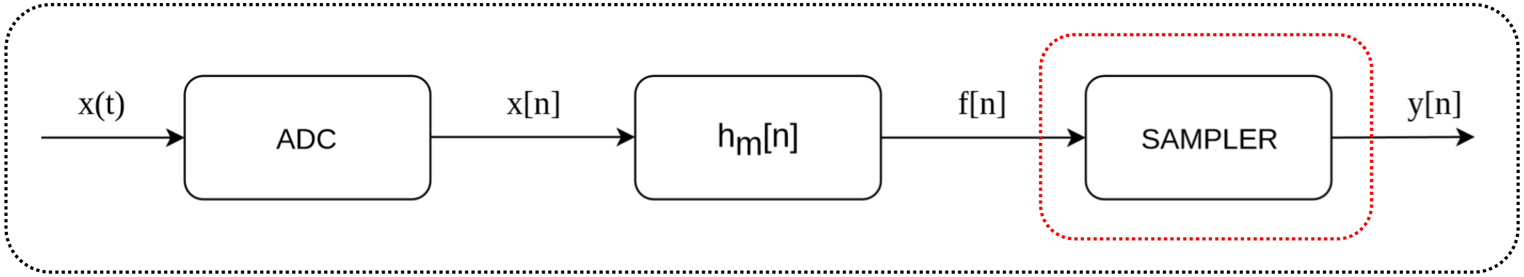
Sistema $h_m[n]$

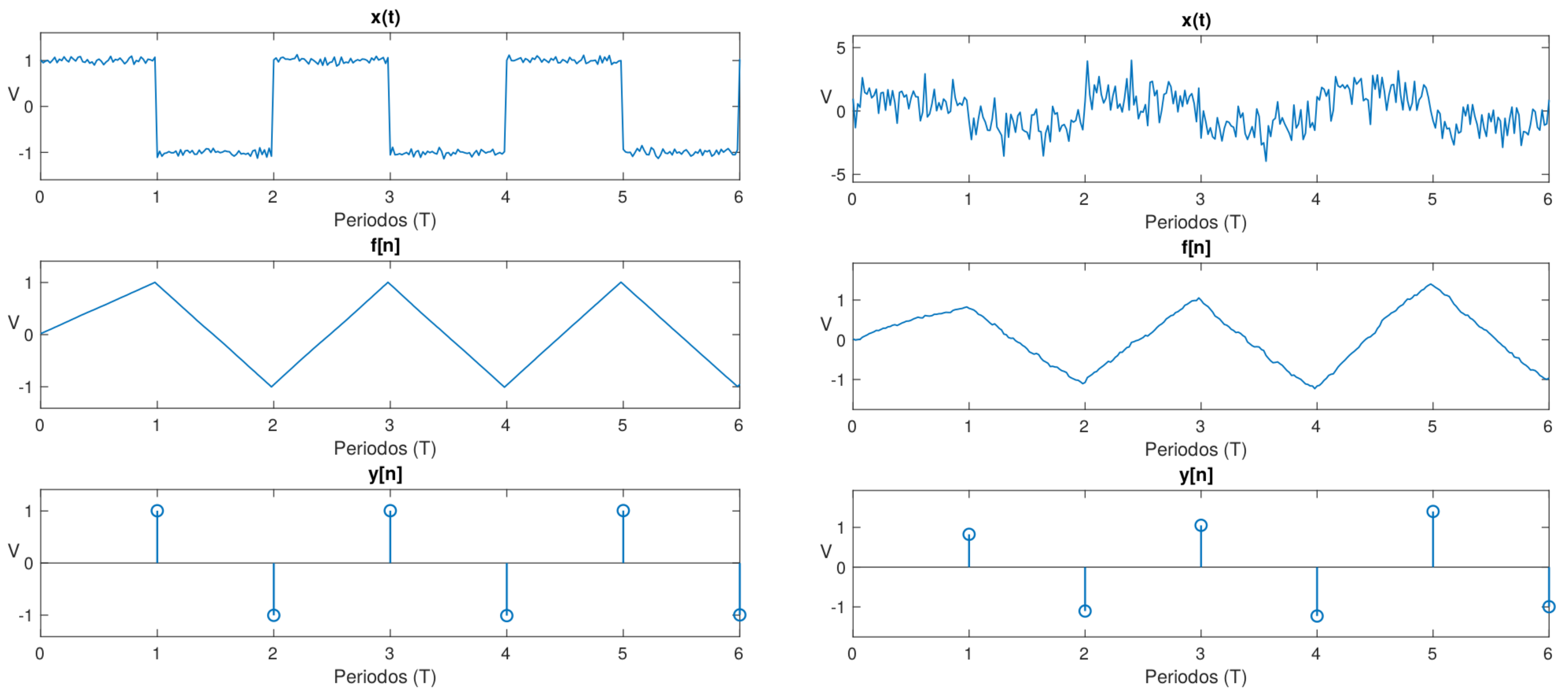




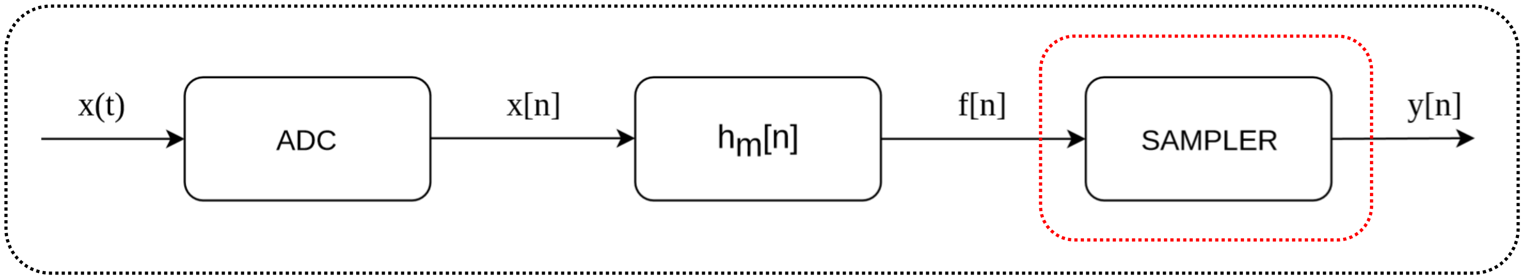


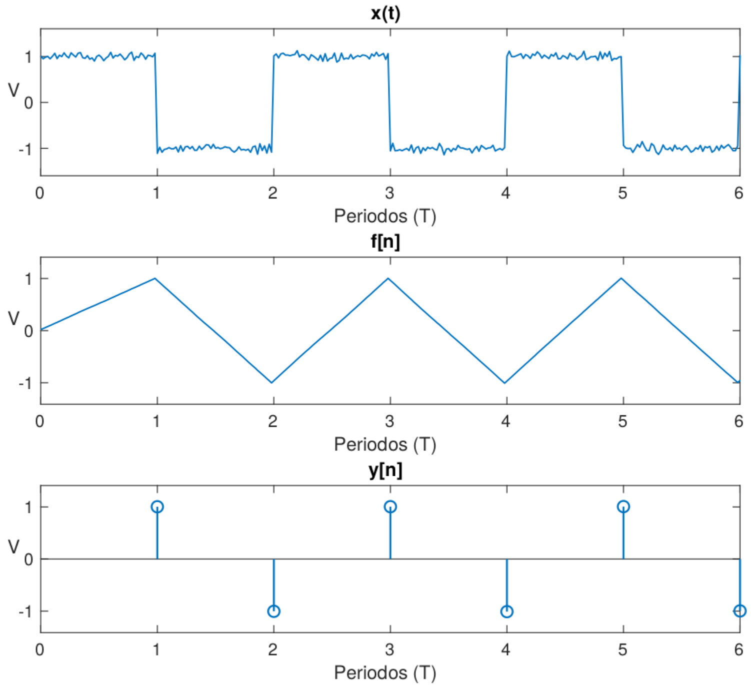
Sistema sampleador





Sistema sampleador





El sistema sampleador debe:

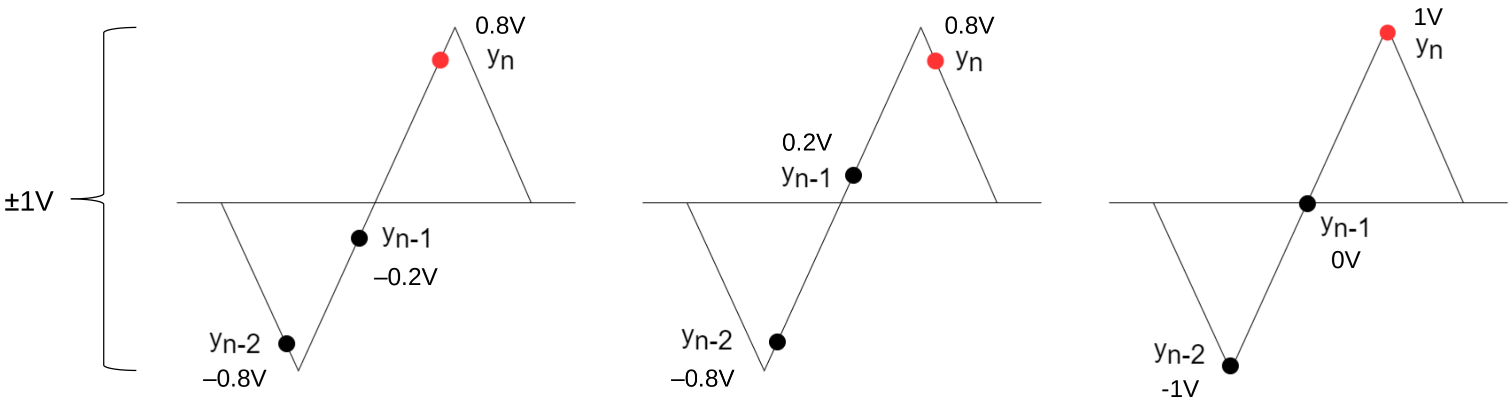
1. Capturar las muestras.
2. Calcular el error en fase de muestreo.
3. Desfasar la señal de muestreo.

Algoritmo de Gardner

$$\text{Error} = (y_n - y_{n-2}) \cdot y_{n-1}$$

Ecuación de Gardner

Muestreo adelantado | Muestreo atrasado | Muestreo óptimo



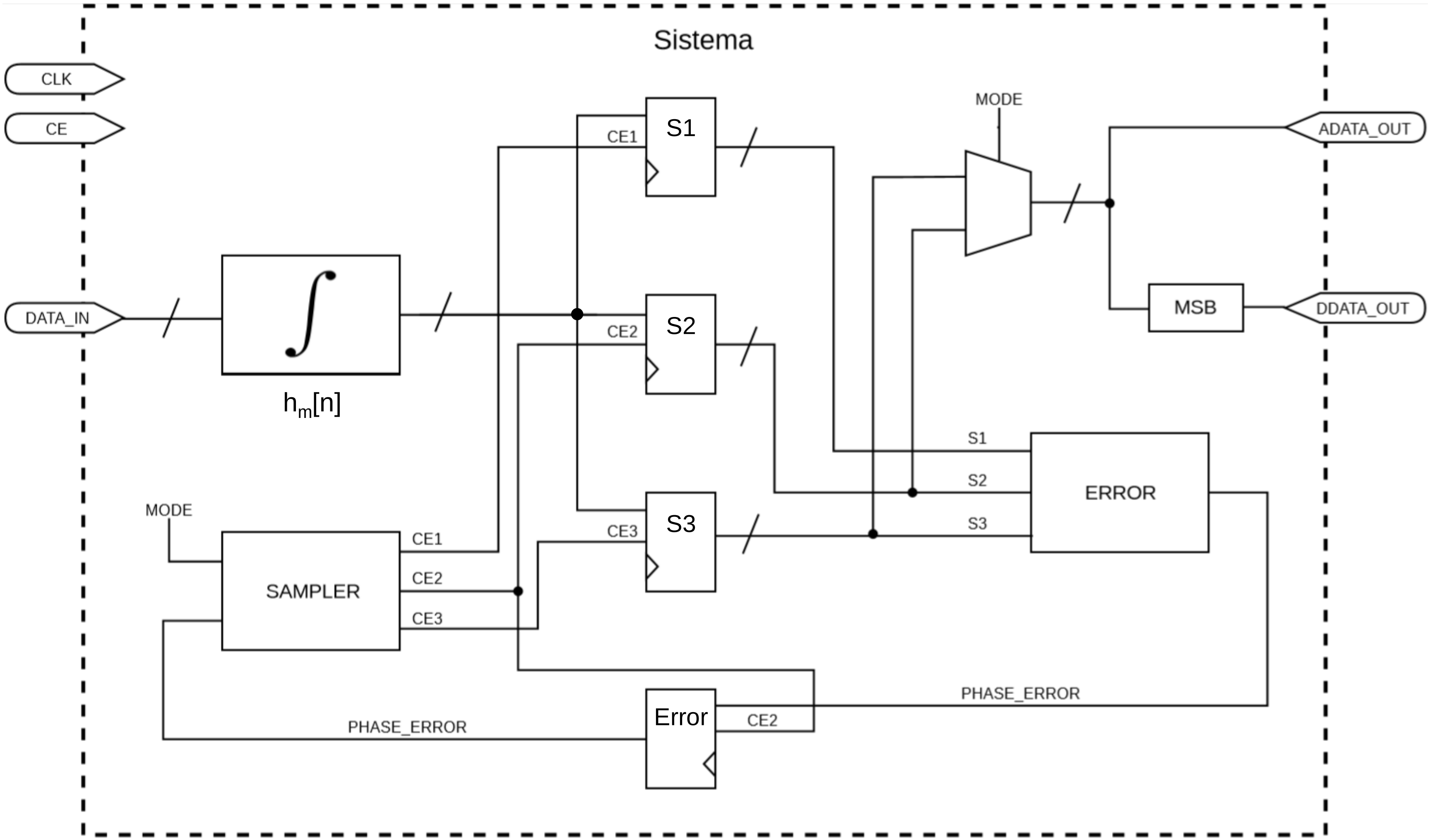
$$\text{Error} = (0.8 - (-0.8)) \cdot (-0.2) = -0.32$$

$$\text{Error} = (0.8 - (-0.8)) \cdot 0.2 = 0.32$$

$$\text{Error} = (1 + 1) \cdot 0 = 0$$

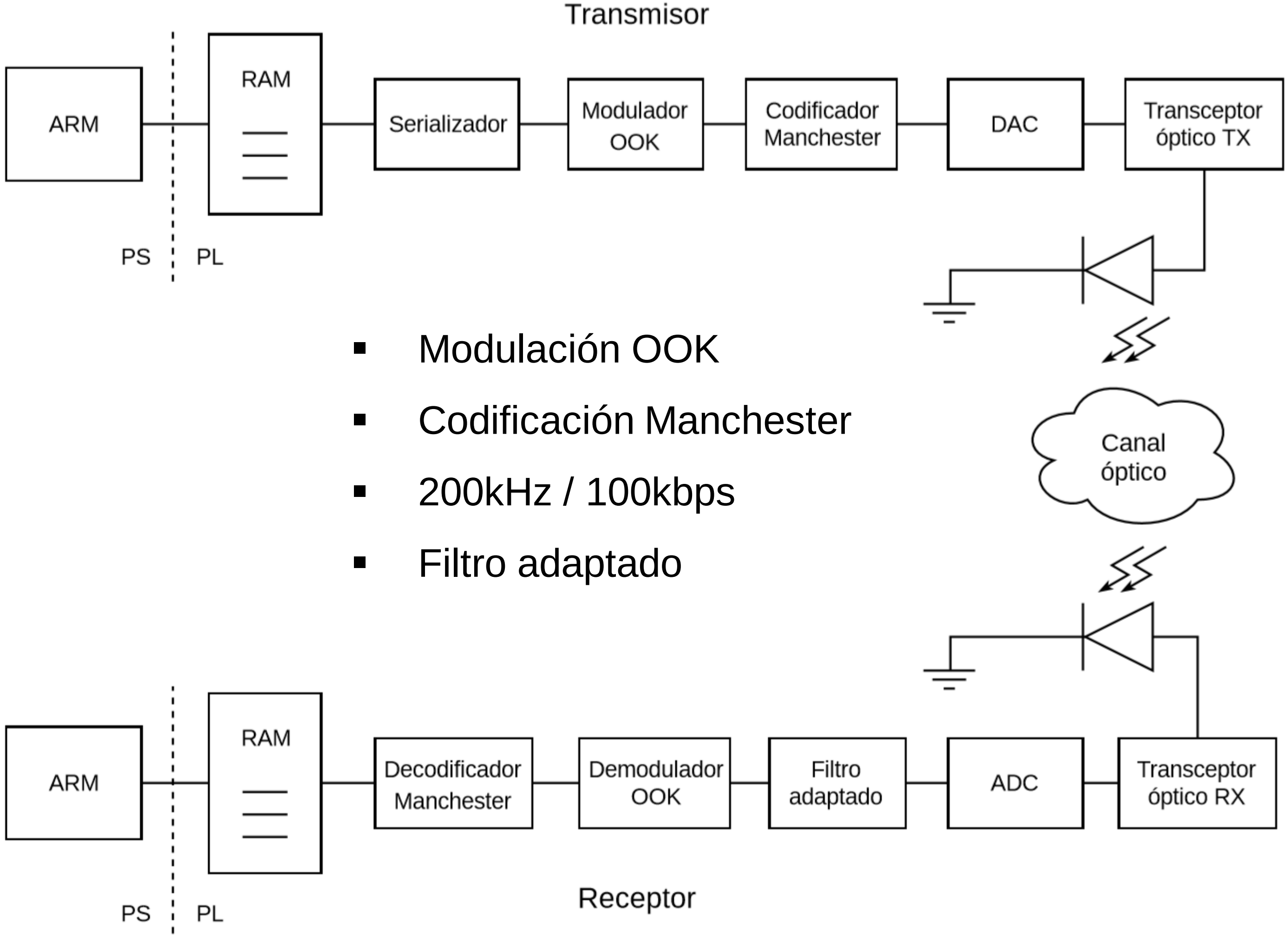
Implementación

Implementación



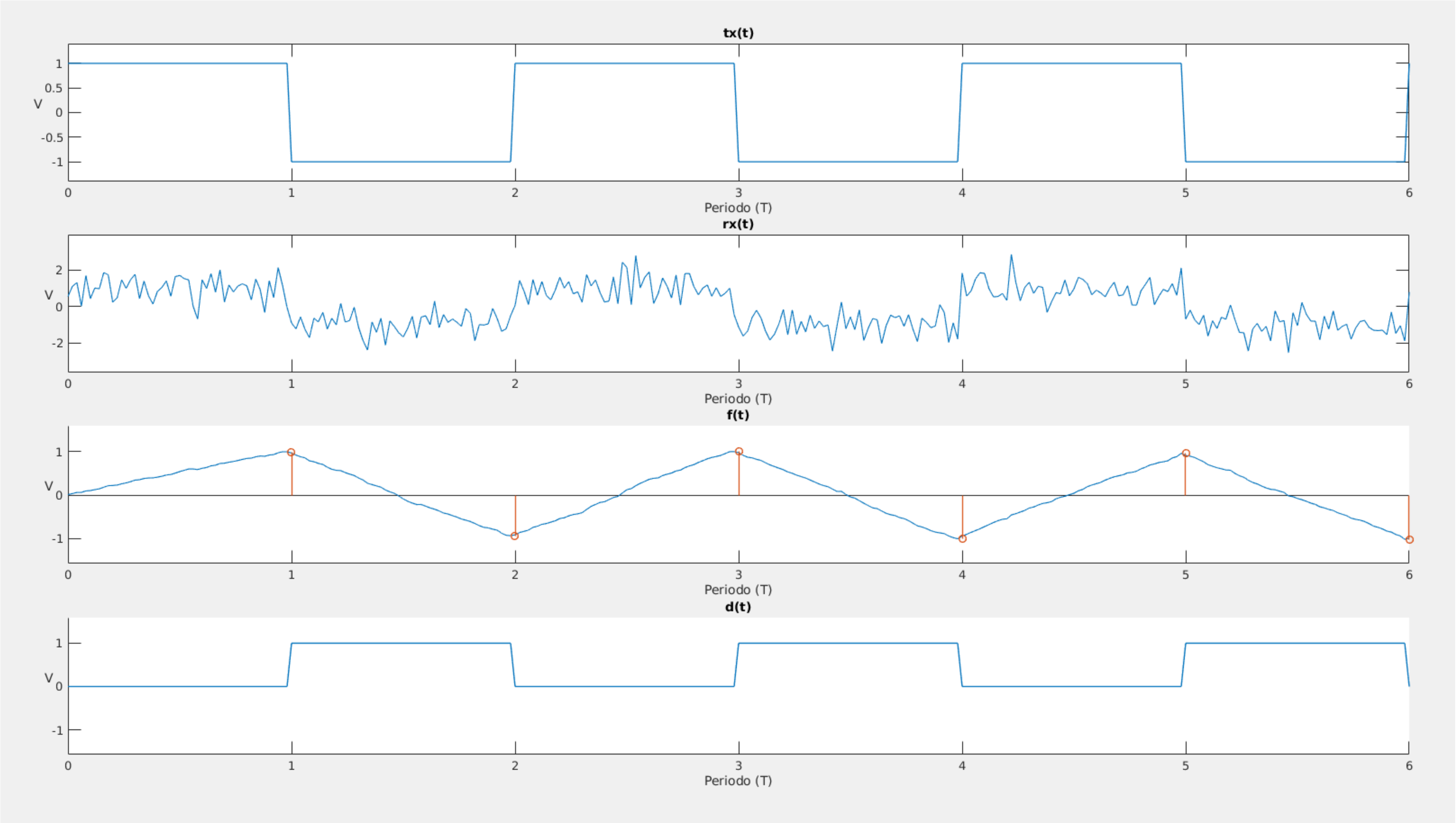
Sistema mejorado

Sistema mejorado



- Modulación OOK
- Codificación Manchester
- 200kHz / 100kbps
- Filtro adaptado

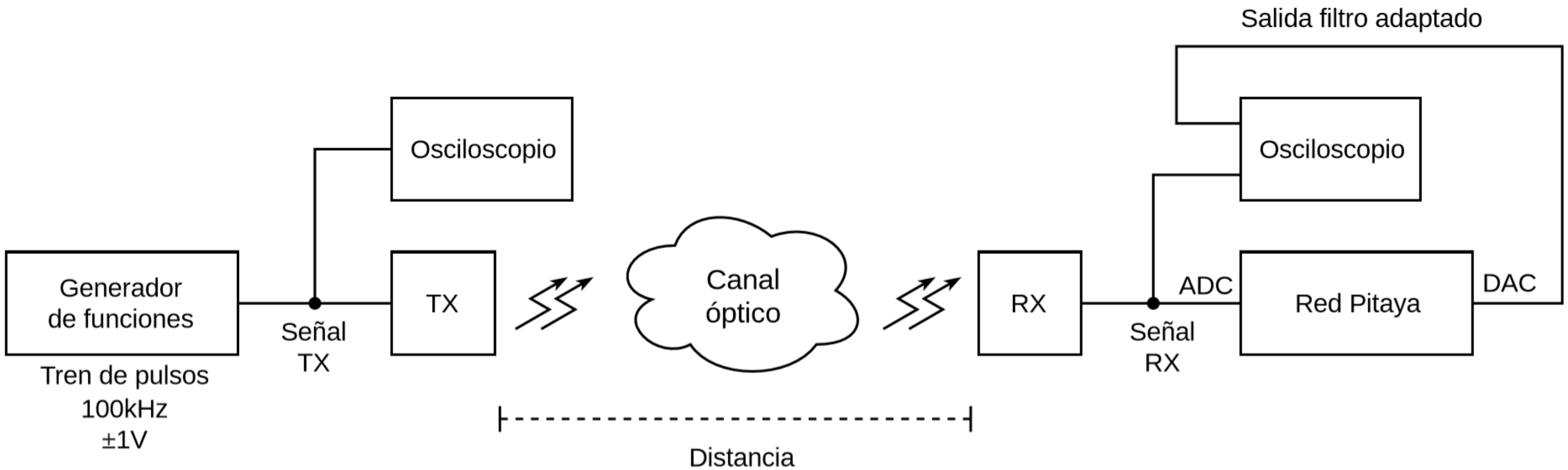
Sistema mejorado: Gráficas

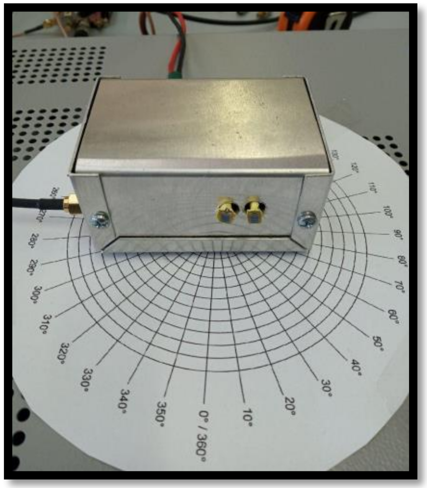


Pruebas

Recuperación de tren de pulsos

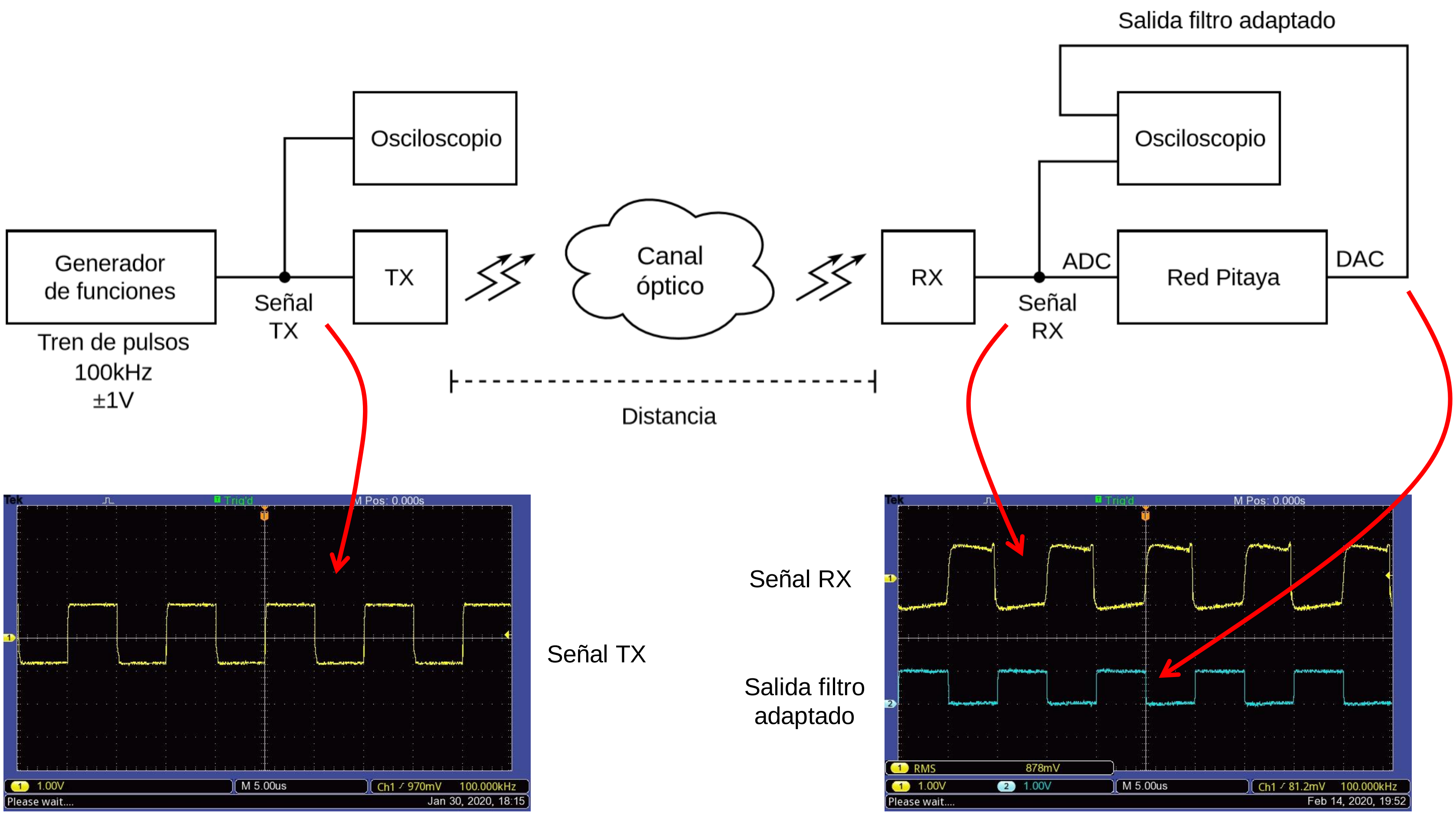
Configuración de equipos





Recuperación de tren de pulsos

Configuración de equipos

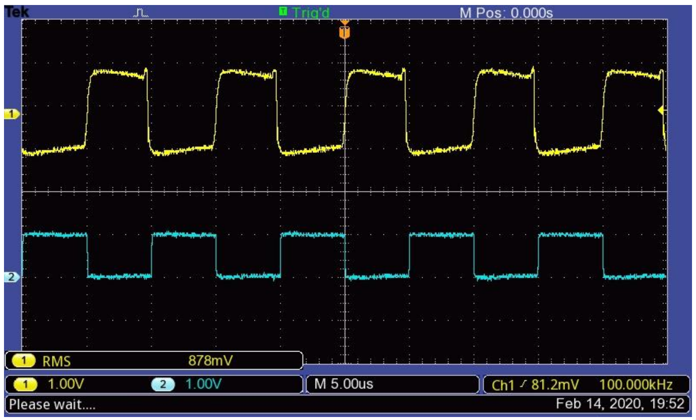


Recuperación de tren de pulsos

Experimentos de alcance

1

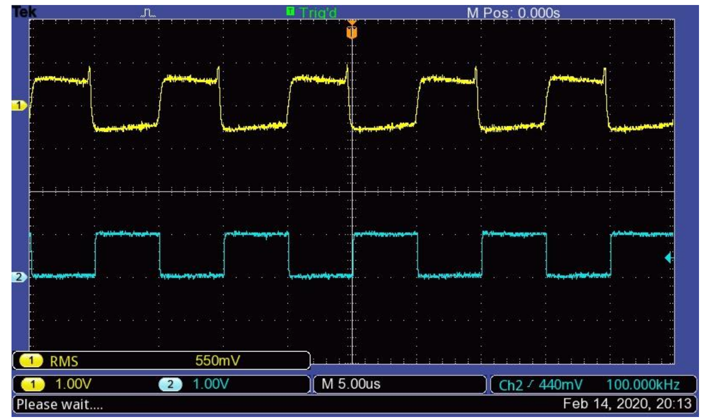
RMS:
878mV



Distancia de 2 metros

2

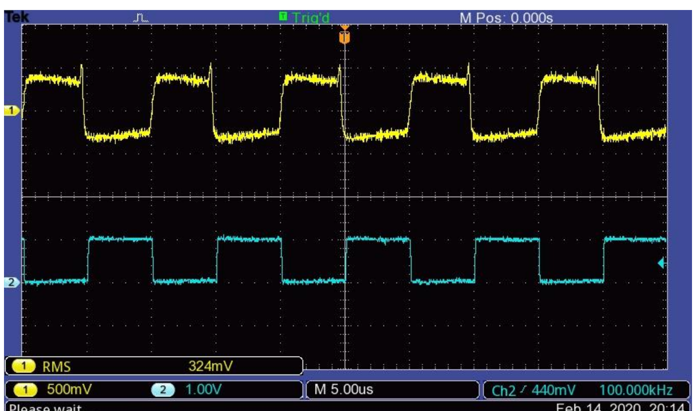
RMS:
550mV



Distancia de 3 metros

3

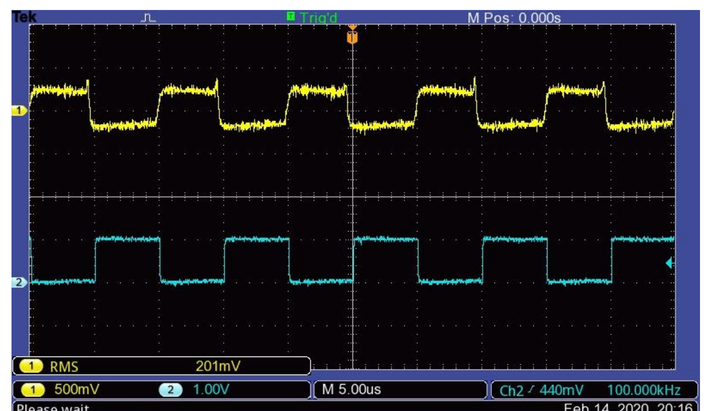
RMS:
324mV



Distancia de 4 metros

4

RMS:
201mV



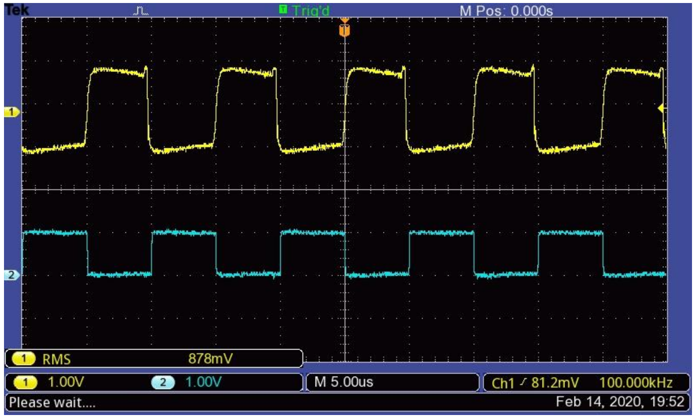
Distancia de 5 metros

Recuperación de tren de pulsos

Experimentos de desapuntamiento

1

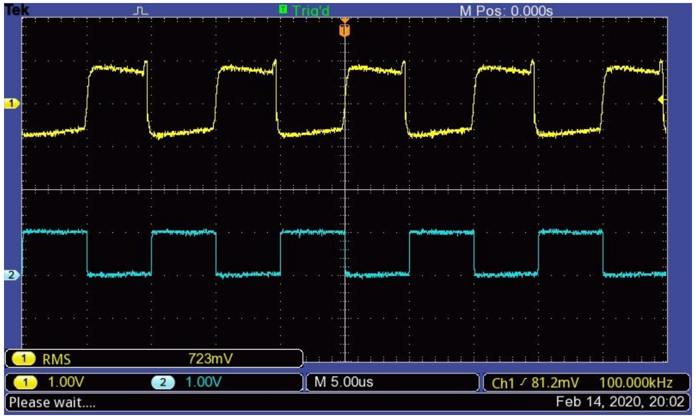
RMS: 878mV



Desapuntamiento de 0º

2

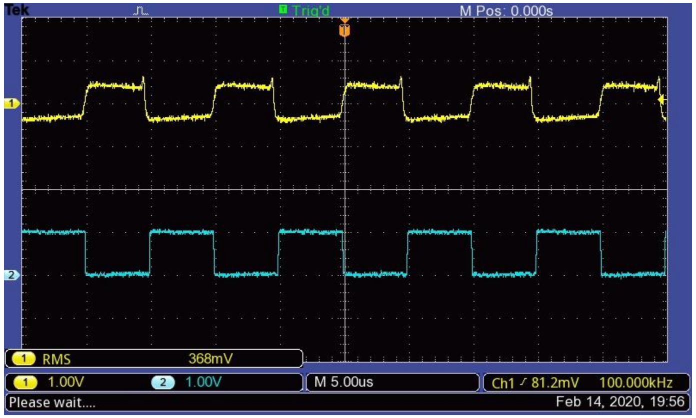
RMS: 723mV



Desapuntamiento de 30º

3

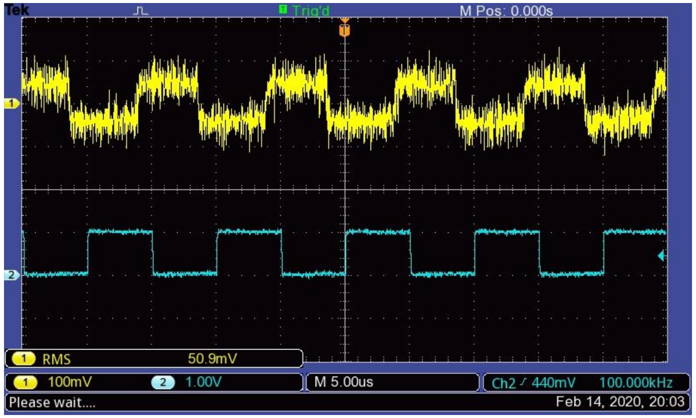
RMS: 368mV



Desapuntamiento de 60º

4

RMS: 50mV



Desapuntamiento de 90º

Conclusions and future lines

- The main goal of this project was to upgrade the base transceiver system capabilities.
- A matched filter has been studied and implemented.
- The matched filter has been tested and integrated into the transceiver system.
- Successfully transmissions have been achieved with distances near to 4 meters and disorientation up to 90º in the receiver.

- In futures works…
- Automatic programmable gain must be implemented via hardware to fit the receiver signal with the ADC dynamic range.
- A high pass filter must be implemented to achieve a better SNR.
- The transceiver should be upgraded to perform streaming communications. Audio streaming is the closest goal.