

Ankara Yıldırım Beyazıt University
EEE Department- Spring, 20-21
EE226 Introduction to Microprocessors Laboratory
Universal Asynchronous Receiver-Transmitter (UART)

1. Introduction

In this laboratory, you will learn how UART works and utilization of HC-SR04 ultrasonic distance measurement sensor with Tiva TM4C.

- **UART[1]**

UART is a hardware communication protocol that uses asynchronous serial communication with configurable speed. Asynchronous means there is no clock signal to synchronize the output bits from the transmitting device going to the receiving end.

The main purpose of a transmitter (T_X) and receiver (R_X) line for each device is to transmit and receive serial data intended for serial communication.

In UART, the mode of transmission is in the form of a packet. The piece that connects the transmitter and receiver includes the creation of serial packets and controls those physical hardware lines. A packet (Figure-1) consists of a start bit, data frame, a parity bit, and stop bits.



Figure -1: UART Packet

Steps of UART transmission

- First: The transmitting UART receives data in parallel from the data bus (Figure-2).

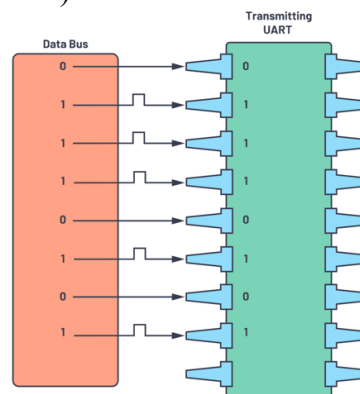


Figure-2: Data bus to the transmitting UART

- Second: The transmitting UART adds the start bit, parity bit, and the stop bit(s) to the data frame (Figure-3).

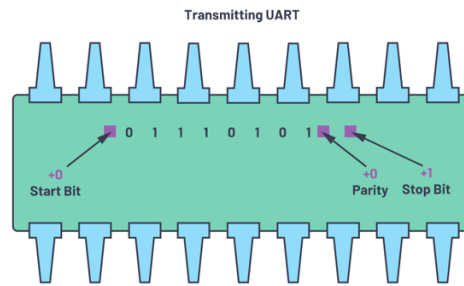


Figure-3: UART data frame at the Tx side

- Third: The entire packet is sent serially starting from start bit to stop bit from the transmitting UART to the receiving UART. The receiving UART samples the data line at the preconfigured baud rate (Figure-4).

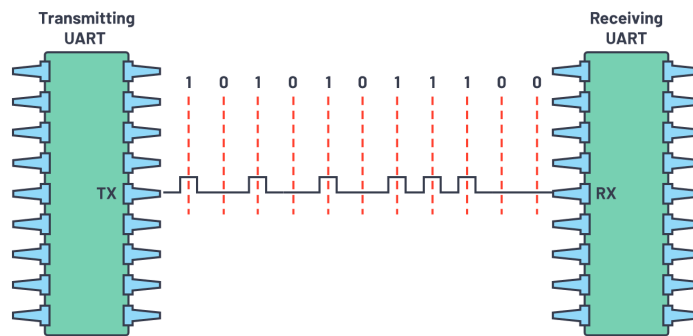


Figure-4: UART transmission

- Fourth: The receiving UART discards the start bit, parity bit, and stop bit from the data frame.

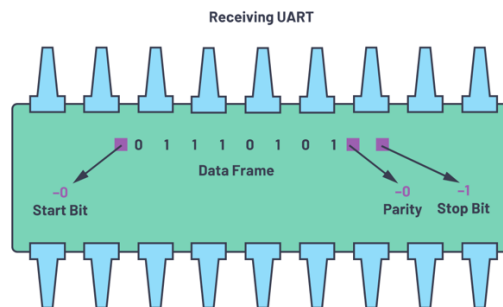


Figure-5: The UART data frame at the Rx side.

- Fifth: The receiving UART converts the serial data back into parallel and transfers it to the data bus on the receiving end.

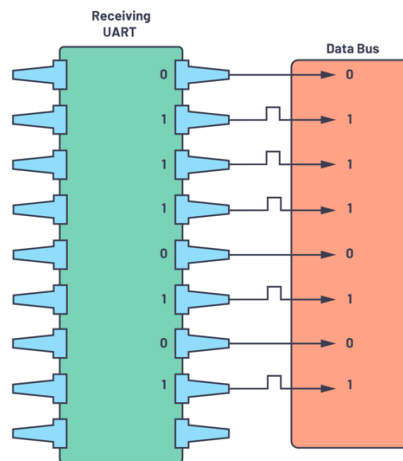


Figure-6: Receiving UART to data bus

- **UART-TTL Converter [2]**

USB-TTL serial converter cable allows you to use USB unit as TTL interface. You can connect any TTL interface unit like a sensor or developer board via this cable to computer and start a communication between them. This module is compatible with a large number of devices as it uses 5 V/3.3 V logic and supply. One end of the cable is standard USB A type connector and the other side is female pin header.

- **HCSR04 Ultrasonic Distance Sensor [3,4]**

The HC-SR04 Ultrasonic Distance Sensor is a sensor used for detecting the distance to an object using sonar.

The HC-SR04 uses non-contact ultrasound sonar to measure the distance to an object and consists of two ultrasonic transmitters (basically speakers), a receiver, and a control circuit. The transmitters emit a high frequency ultrasonic sound, which bounce off any nearby solid objects, and the receiver listens for any return echo. That echo is then processed by the control circuit to calculate the time difference between the signal being transmitted and received. This time can subsequently be used, along with some clever math, to calculate the distance between the sensor and the reflecting object.

The HC-SR04 Ultrasonic Range Sensor Features:

- Input Voltage: 5 V (also works 3.3 V)
- Current Draw: 20 mA (Max)
- Digital Output: 5 V
- Digital Output: 0 V (Low)
- Working Temperature: -15°C to 70°C
- Sensing Angle: 30° Cone
- Angle of Effect: 15° Cone
- Ultrasonic Frequency: 40 kHz

Transmitted wave and returned echo, which are used to measure the distance between object and sensor are depicted in Figure-7.

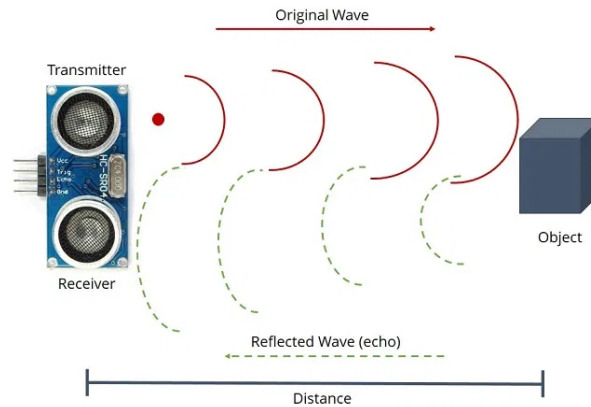


Figure 7: Sensor Wave Propagation

2.Experiment

Design a distance measurement system using HC-SR04 ultrasonic sensor. Track the following steps:

1.Make connections as shown in Figure-8.

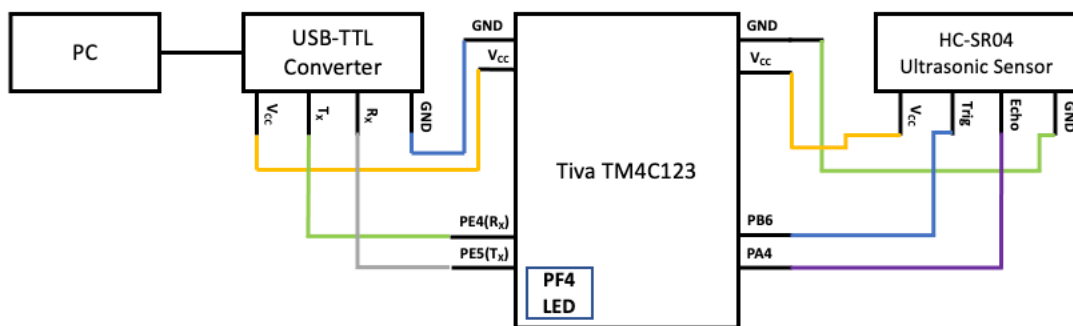


Figure-8: Experiment Setup

2.Make UART, sensor and internal LED (PF4) initializations.

3.Design your code, sensor measures distance dynamically and print the distance to PC screen via **PuTTY** at the same time LED should lights four different color according to the measured distance. The color scheme for measurement is indicated in Figure-9.

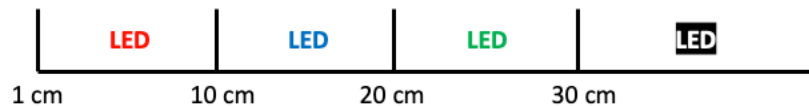


Figure-9: Distance Table

- **PuTTY**

PuTTY is a free implementation of SSH and Telnet for Windows and Unix platforms, along with an xterm terminal emulator. It is written and maintained primarily by Simon Tatham [5]. You can download in the following link:

<https://www.putty.org>

3.References

- [1]<https://www.analog.com/en/analog-dialogue/articles/uart-a-hardware-communication-protocol.html#>, Access date: May 11, 2021.
- [2]<https://www.robotistan.com/pl2303-usb-ttl-serial-converter-cable>, Access date: May 11, 2021.
- [3]<https://www.piborg.org/sensors-1136/hc-sr04>, Access date: May 9,2021.
- [4]<https://randomnerdtutorials.com/complete-guide-for-ultrasonic-sensor-hc-sr04/>, Access date: May 9, 2021.
- [5]<https://www.chiark.greenend.org.uk/~sgtatham/putty/>, Access date: May 11, 2021.

4.Acknowledgements.

Thank you for all contributions of preparing of this lab manual M. Fatih SERTKAYA and Emre KIRKAYA.

Appendix

- Please check your Device Manager (Aygıt Yöneticisi) after connected USB-TTL converter. Then, if you get such an error when you connect your USB-TTL converter, illustrated in Figure-A1,

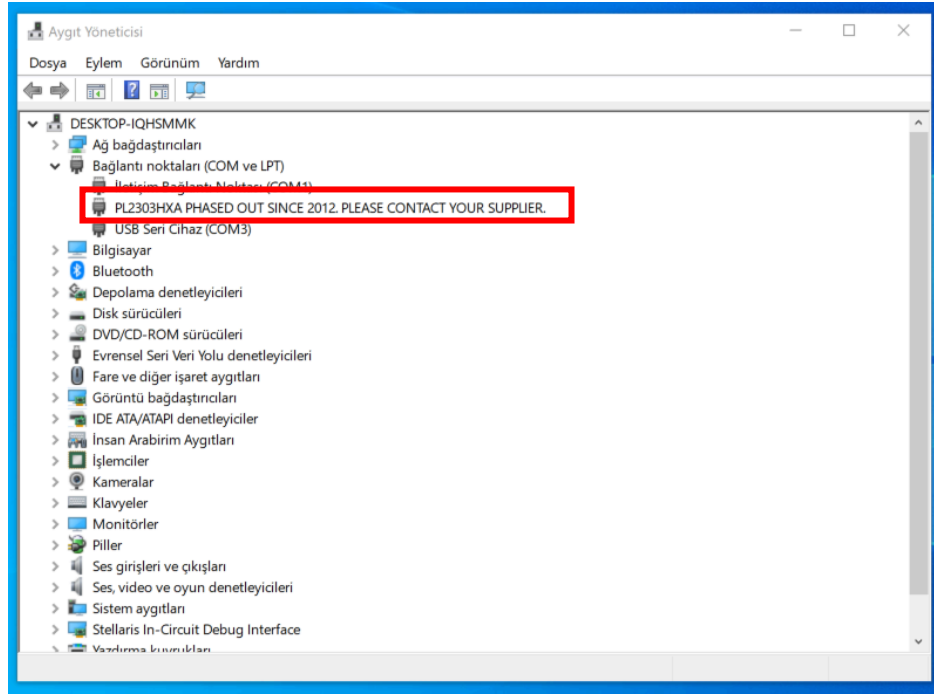


Figure-A1

- Click right on “PLK2303HXA PHASED OUT...” and update drivers. Then, the following window opened (Figure-A2) and choose **search in my computer** option (bilgisayarımdaki sürücülere göz at).

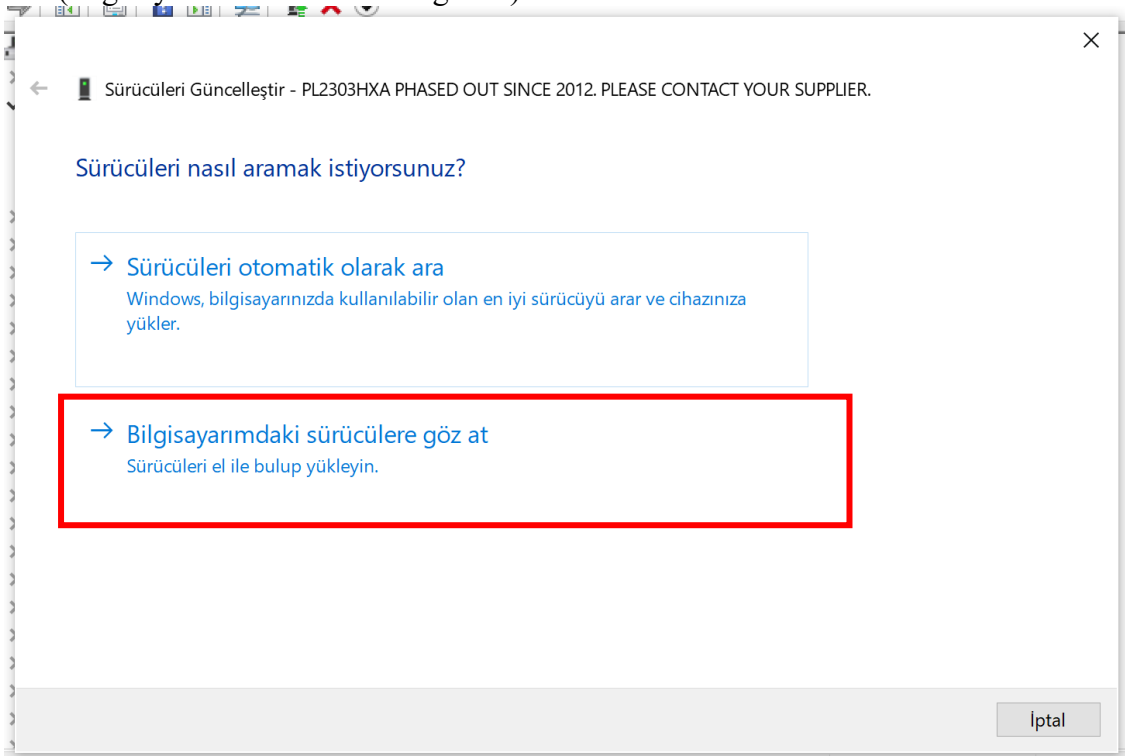


Figure-A2

- Download an older version of the drive in the following link (<http://wp.brodzinski.net/2014/10/01/fake-pl2303-how-to-install/>) and arrange the path in which you downloaded. (Figure-A3). Then choose 27.10 2008 version (Figure-A4).

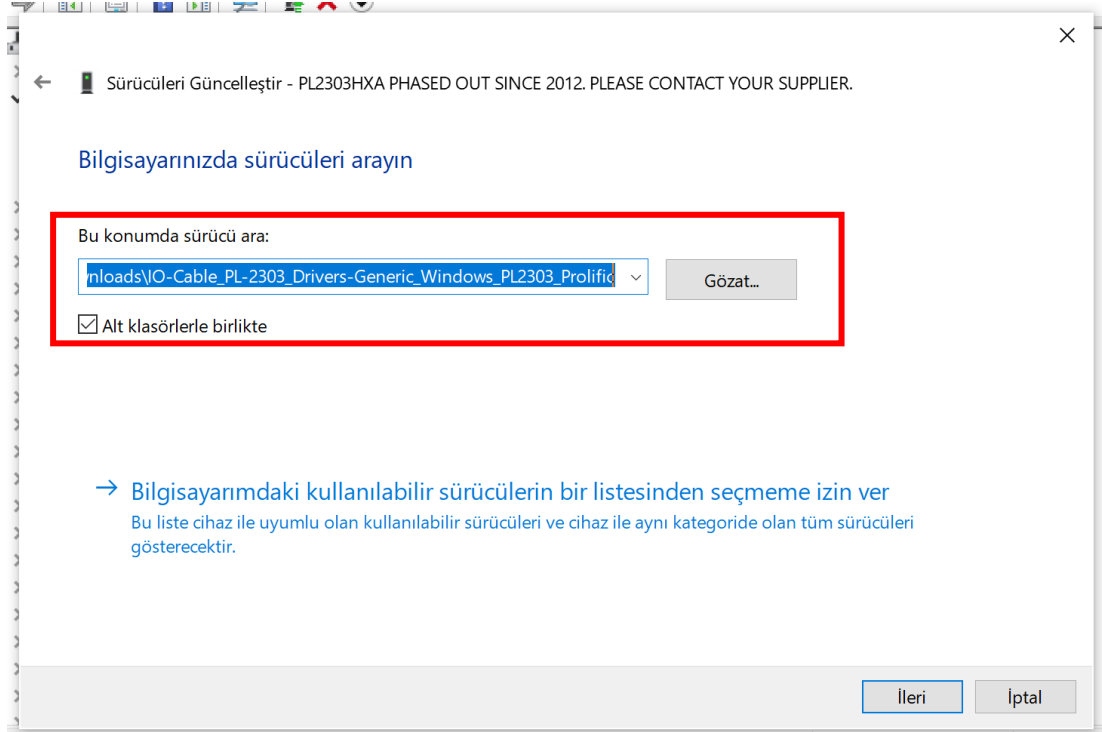


Figure-A3

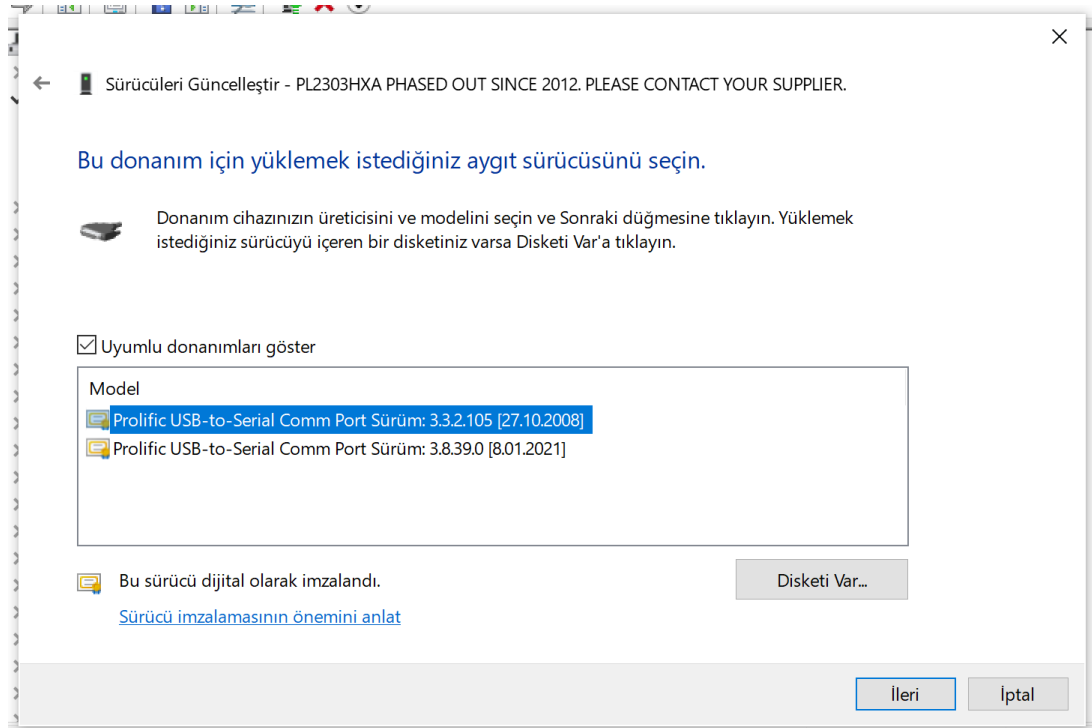


Figure-A4

- It is installed successfully, as shown in Figure-A5.

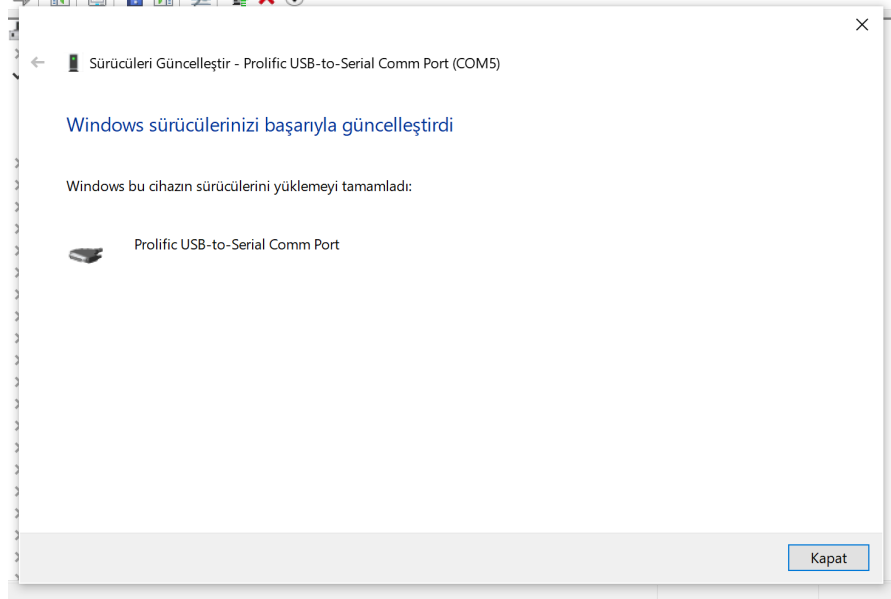


Figure-A5