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

1. Introduction

In this laboratory, you will learn how UART works and utilization of LM35 temperature 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).

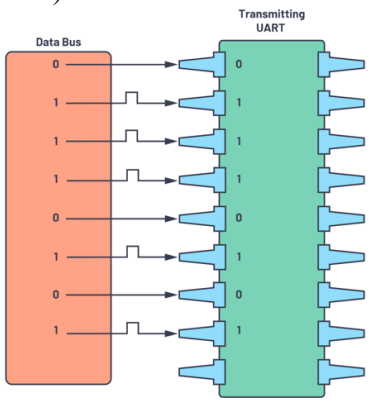

Figure-2: Data bus to the transmitting UART

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

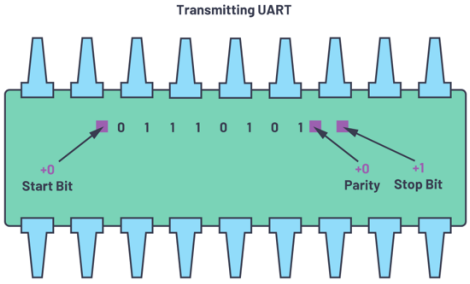

Figure-3: UART data frame at the Tx side

- 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).

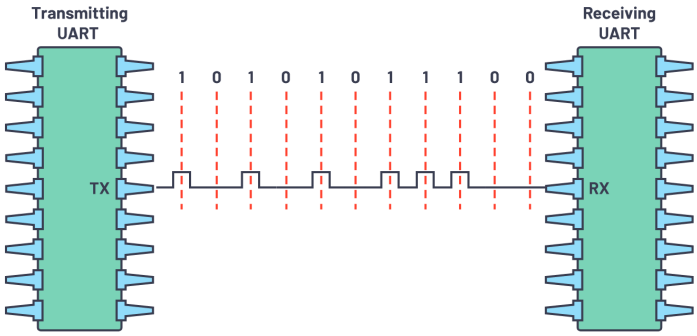

Figure-4: UART transmission

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

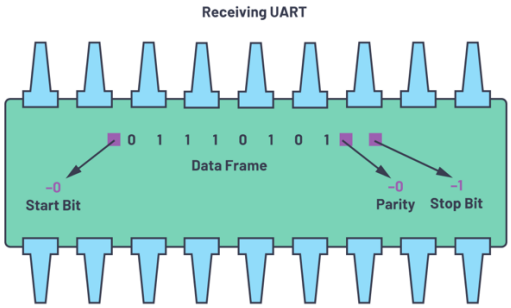

Figure-5: The UART data frame at the Rx side.

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

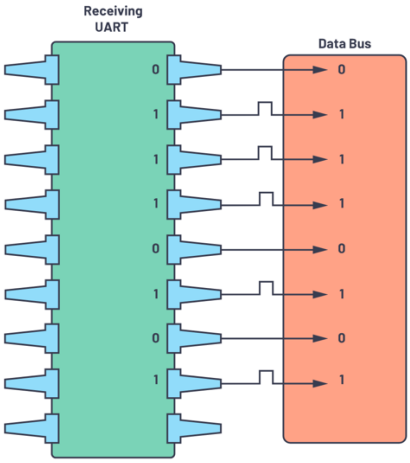

Figure-6: Receiving UART to data bus

- **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.

- **LM35 Temperature Sensor [3]**

  The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius or Centigrade temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin. the user need not do any external calibration or trimming to provide typical accuracies of ±1⁄4C at room temperature and ±3⁄4C over a full −55 to +150C temperature range. It gives accuracy by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make lm35dz temperature sensor circuit especially easy. It is applicable to single power supplies or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1C in still air. The LM35 can operate over a −55 to +150C temperature range, while the LM35C −40 to the +110C range, −10 with improved accuracy.

  The LM35 series is available in different packaged like hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available on an 8-lead surface to mount small outline package and a plastic TO-220 package.

  The LM35 Temperature Sensor Features:

  - Calibrated directly in Celsius (Centigrade)
  - Linear + 10.0 mV/C scale factor
  - 5C accuracy guaranteeable (at +25C)
  - Rated for full −55 to +150C range
  - Suitable for remote applications

- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08C in still air n Nonlinearity only ±1⁄4C typical
- Low impedance output, 0.1 for 1 mA load

The sensor picture are shown in Figure-7.

Figure 7: LM35 Temperature Sensor

2.Experiment

Design a temperature measurement system using LM35 temperature sensor. Track the following steps:

1.Make connections as shown in Figure-8.

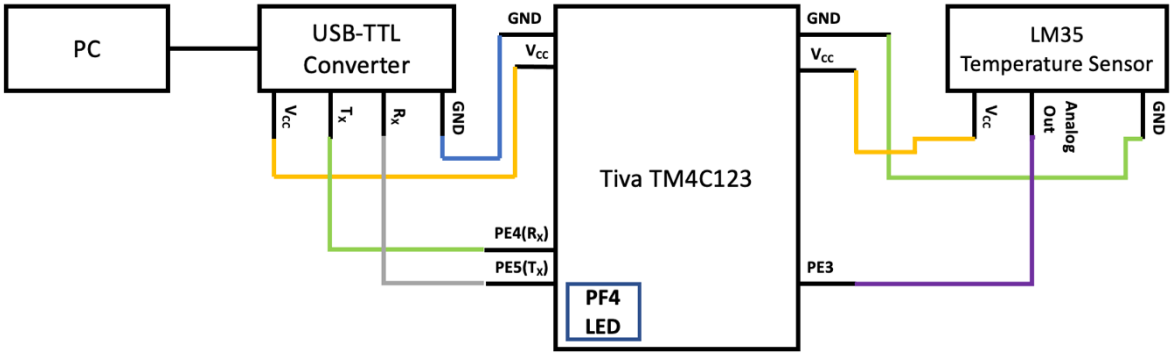

Figure-8: Experiment Setup

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. The values which are given by Figure-9 can be changed according to your design. It is important to design three intervals.

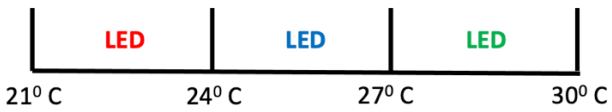

Figure-9: Temperature Table

- **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 [4]. 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.indiamart.com/proddetail/lm35-temperature-sensor-18798074573.html Access date: May 31,2021.
[4]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,

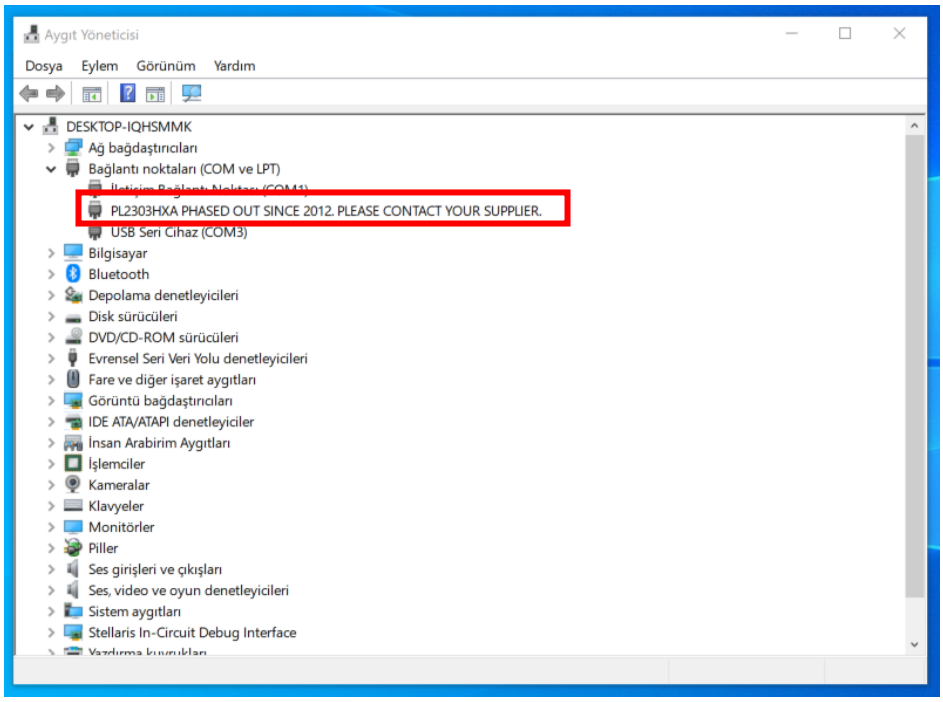

Figure-A1

- 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).

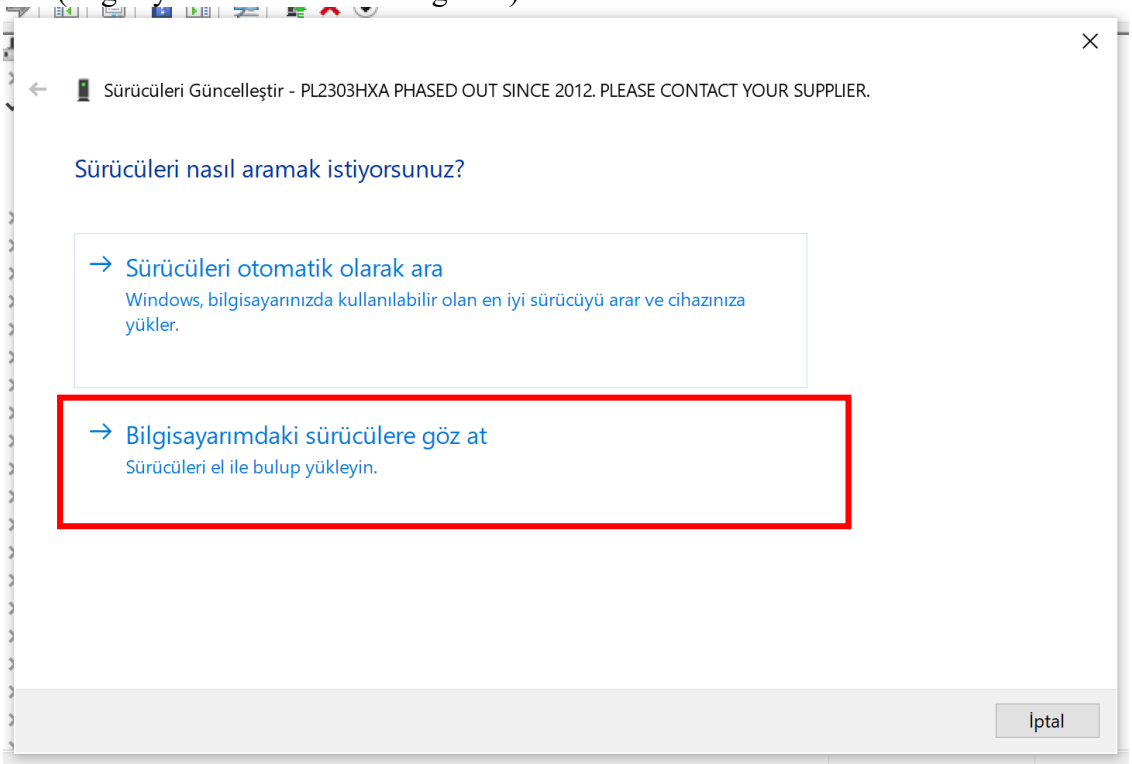

Figure-A2

- 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).

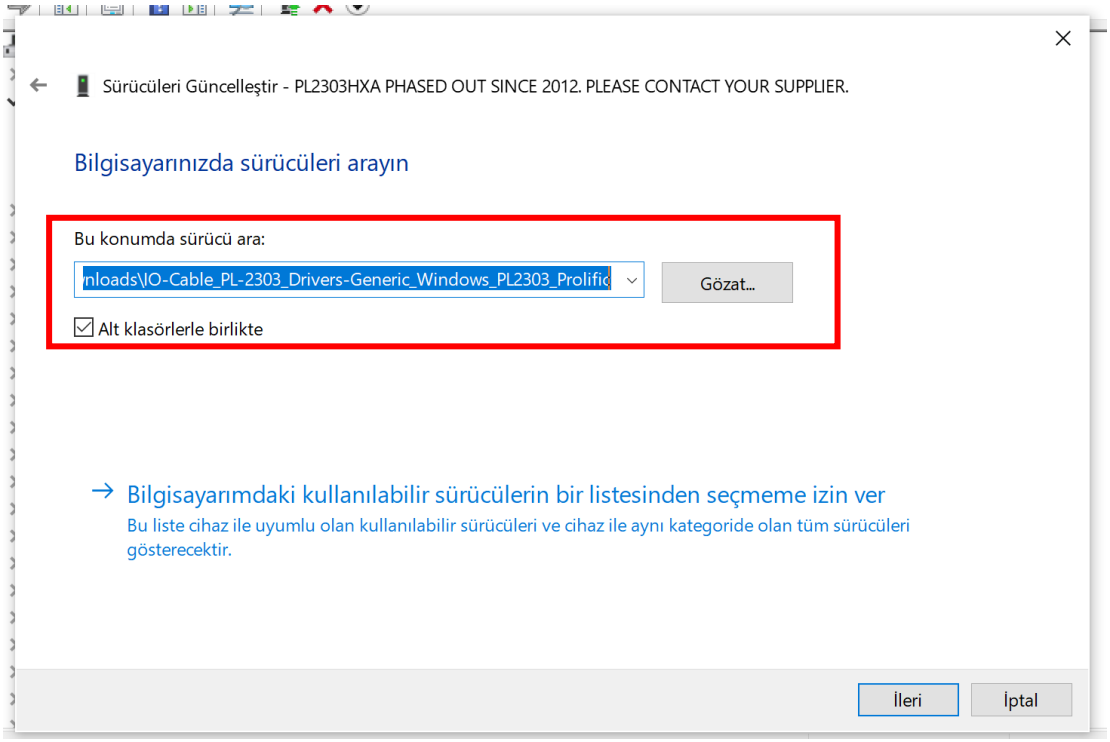

Figure-A3

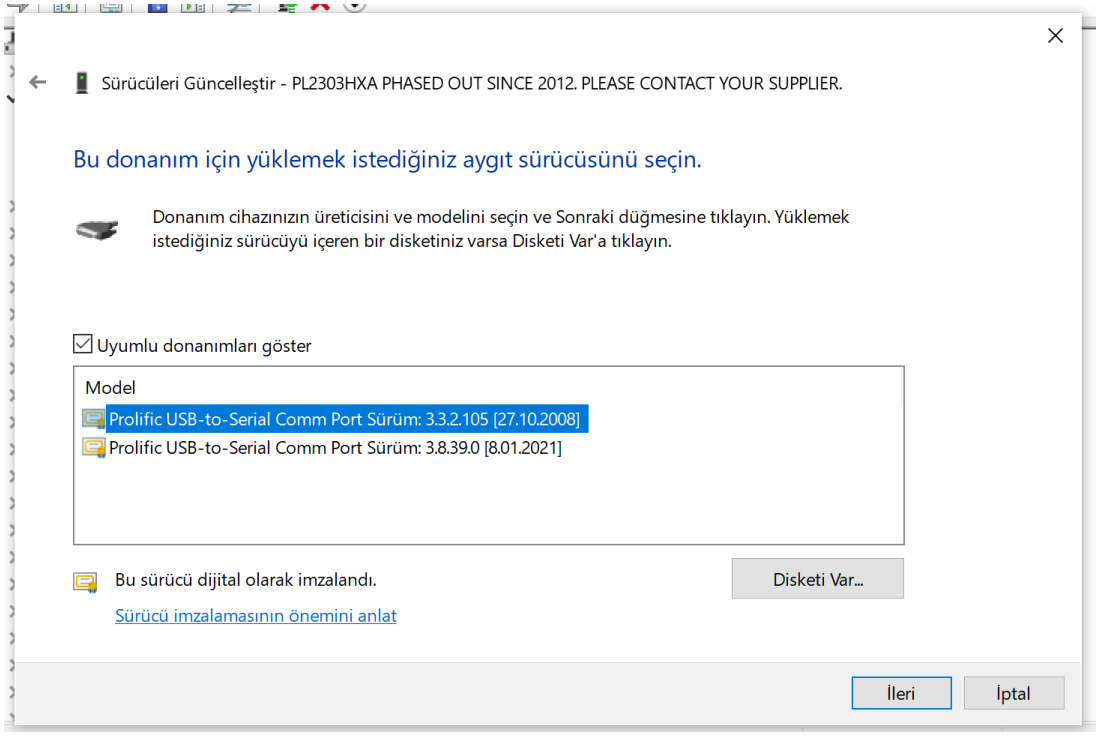

Figure-A4

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

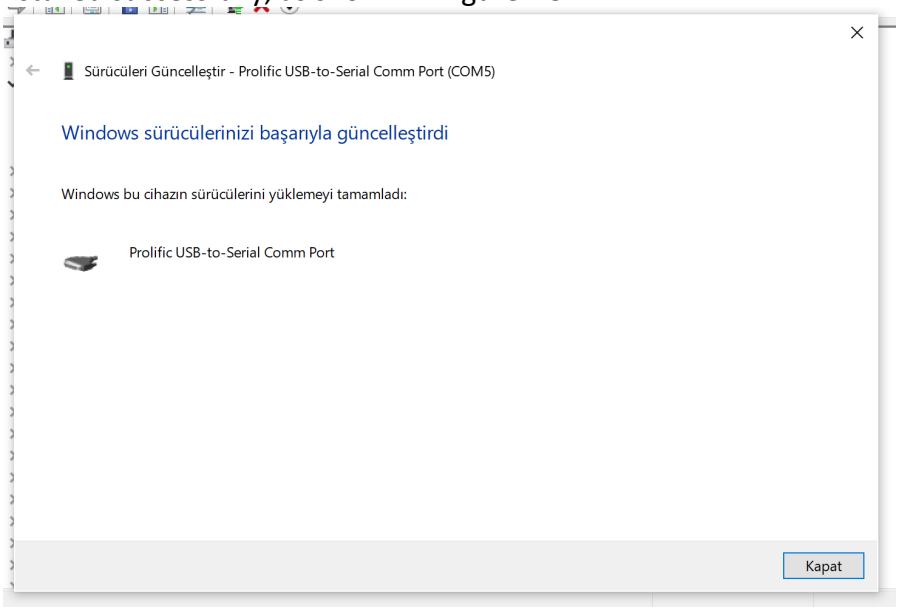

Figure-A5