ELECTRICAL AND ELECTRONICS ENGINEERING DEPARTMENT

Laboratory Project: Audio Recorder and Player

Laboratory Project

Objectives

In the EE447 laboratory experiments, you were expected to familiarize yourself with the operation of TM4C123 and its utility modules. Now, in this final project you are expected to gather the previous experience on the microcontroller with novel information to achieve a multi-functional task. The objectives of the project are as follows:

- Interpretation of the necessities of complex task and encapsulation into sub-task
- Fulfillment of co-operation of utility modules
- Understanding a given complex hardware and compatibility of its components
- Writing a multi-task software for a given complex set up
- Introduction of the serial communication on TM4C123 and utilisation of the facility on I2C protocol.

1 Project Definition

In this project you are expected to set up a system that records short audio sequences and plays them in a loop. The objectives are two-fold and they are required to be achieved sequentially.

- Raw vocal data is captured through a microphone module.
- The very same vocal data is played using a speaker module afterwards.

Please notice that synchronous capture & play is not compulsory.

The setup is given in Figure 1 and in a brief manner the operation can be summarized as given.

The audio information is captured by the microphone to be sampled by the built-in Analag-to-Digital utility module on TM4C123 and the converted data is written to a memory block for further processing. Then the raw or processed vocal data is exported through the Serial Communication utility module and is sent as an input to an external Digital-to-Analog IC. Finally, the reconverted analog output of the DAC is send to a audio amplifier for pre-amplification and later to the speaker module to allow the generation of the sound.

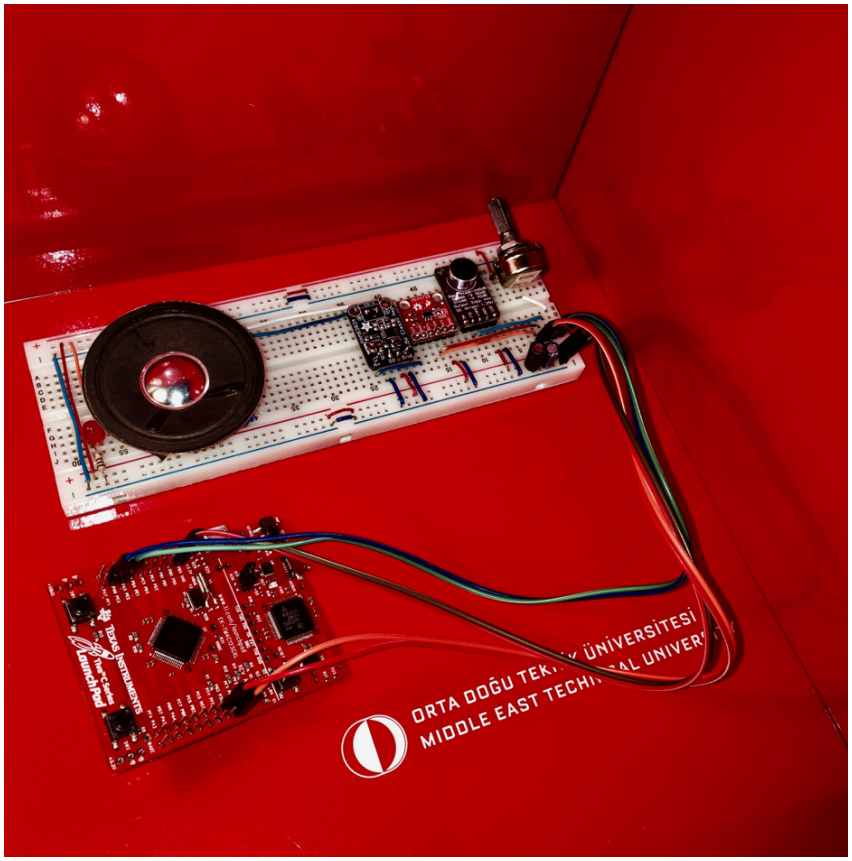

Figure 1: Record & Play Kit Setup

2 Background Information

2.1 System Requirements

System Clock is to be taken from PLL output with a frequency of 20 MHz. You can implement the required configurations from Chapter 5.3 from the TM4C Manual. The oscillator source must be set as PIOSC, (default). No further configurations on the crystal value of the main oscillator, as it is not used.

Please notice that for correct operation of the whole circuitry 3.3V is to be fed as V_{cc}.

2.2 Voice Capture and Recording

The primary task to be completed is the capture of audio data through a microphone module and it is controlled using push-button. You assign one of the built-in push buttons on the LaunchPad for that task, to start recording. Please keep in mind that the internal memory of the microcontroller is limited and the recording interval must be adjusted accordingly. Pay attention to the available SRAM memory and the maximum stack size. An inverval of 3 seconds will suffice.

The output of the mic is available as analog data and it is required to be digitized in order to preserve the recording in the microcontroller memory. In this step of the task, you are expected to realize time critical sampling using the built-in ADC module on TM4C123. An essential notice is to be made that audio sampling is to remain in a certain frequency band to provide interpretable information to human hearing system. Therefore, this frequency is to be adjusted to 8 kHz.

ADC on TM4C123 is utility module that you have hands on experience already, thanks to the lab

experiments conducted, hence, you are expected to figure out all the required configuration based on the given specs and datasheets of the hardware to be used.

2.3 Digital Audio Conversion and Sound Generation

For playing the audio data, the digital values are needed to be converted into analog data using an external hardware called DAC, Digital-to-Analog Converter. The module to be included in the setup, Section 2.4.2, is operated using I2C Serial Communication Protocol; therefore you are to use the Serial Communication Utility Module of the microcontroller.

I2C is another serial communication protocol, similar to UART, SSI, SPI and RS232 that you have already covered in lectures. For introductory information on I2C, you may refer Chapter 16 of TM4C123 Manual and for initialization of I2C Serial Communication to transfer a single byte you may check Chapter 16.4.1 directly. The slave address of the DAC module is 0x60. Instead of a single byte, the DAC Module uses the convention given in Figure 2 and some modifications on initialization are to be made on the procedure provided in the manual to comply with its convention. You may also refer the

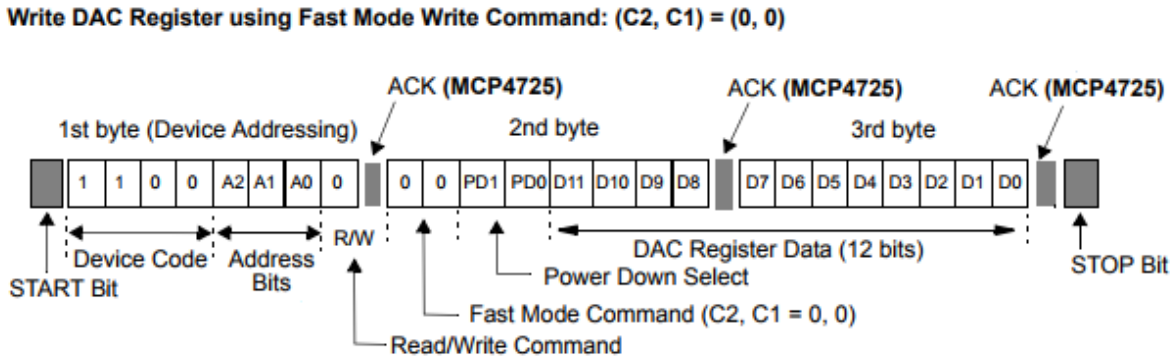

Figure 2: The convention to send digital data serially to DAC for a single conversion.

TM4C123 Manual for the flowchart of multiple-byte data transmission. Please note that the address of the peripheral (slave) is automatically appended before the 1st data byte and the transmission is completed by sending an EOT sequence. Contrary to what is indicated in the manual, while sending the last byte of a single data chunck, do not set the STOP bit. Instead, send the last byte as is,and transmit an EOT by clearing START & RUN bits and setting STOP bit afterwards.

To create vocal effects on the recording during replay, the output frequency should vary between 2 kHz-10 kHz, which will be adjusted using a potentiometer.

2.4 Required Hardware

Apart from the TM4C123 Launchpad, the following components are to be included in the hardware to fulfill the requirements of the project.

2.4.1 MAX9814 Microphone Module

The MAX9814 is a low-cost, high-quality microphone amplifier with automatic gain control (AGC) and low-noise microphone bias. The device features a low-noise preamplifier, variable gain amplifier (VGA), output amplifier, microphone-bias-voltage generator, and AGC control circuitry.

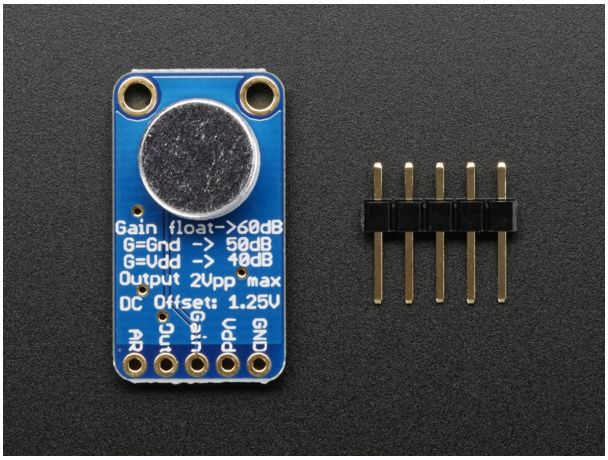

Figure 3: MAX9814 Microphone Module

2.4.2 MCP4725 I2C DAC Breakout Module

MCP4725 is a single channel, 12-bit, voltage output Digital-to-Analog Converter with integrated EEPROM and an I2C Compatible Serial Interface. The MCP4725 DAC offers integrated non-volatile memory (EEPROM) which allows DAC register and configuration bit values to be saves at powered off.

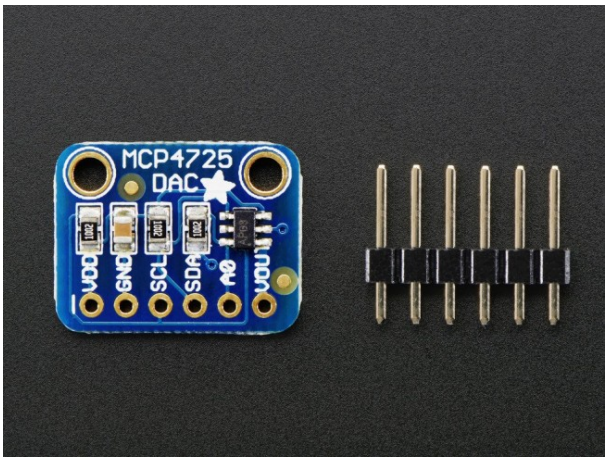

Figure 4: MCP4725 I2C DAC Breakout Module

2.4.3 PAM8302A Audio Amplifier Module

The PAM8302A is a 2.5W Class-D mono audio amplifier. Its low THD+N feature offers high quality sound reproduction. The new filterless architecture allows the device to drive speakers directly instead of using low-pass output filters, therefore saving system cost and PCB area.

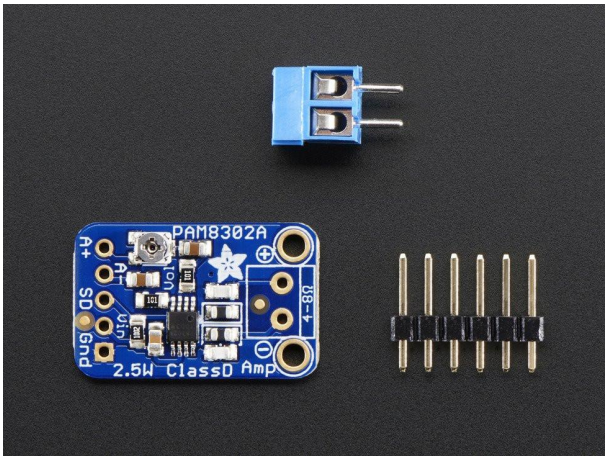

Figure 5: PAM8302A Audio Amplifier Module

Instead of using this audio amplifier module, you may choose to set-up your own amplifier circuitry.

2.5 Deliverables

Your are supposed to attempt the project work in pairs, you may send a e-mail single for each group to the coordination, until Dec 20th,2019 to let us know the identities of the partners in collaboration.

- **Pre-Report:** A summary of the framework, at most 3 pages. **Deadline: Dec 27th, 2019**
- **Final Report:** A full description of your work, including photos of your setup and fully executable codes(printed). **Deadline: Jan 13th, 2020**
- **Source Code:** A Keil μvision project folder with fully executable codes. **Deadline: Jan 13th, 2020**
- **Lab Demo:** Demonstration of the operation of the project. **On Jan 13-14th, 2020**