EE2016 Microprocessor Lab & Theory July-Nov 2022

EE Department, IIT, Madras.

Experiment 8: Serial Communication & ADC / DAC Implementation in ViARM 2378 Development Board (through C - Interface)

1 Aim

1. To understand C-interfacing (use C-programming) in an ARM platform
2. To study and implement serial communication in ARM platform
3. To study and implement ADC / DAC in ARM platform

2 Equipments, Hardwares / Softwares Required

The list of equipments, components required are:

1. ARM ViARM 2378 Development board and accessaries
2. RS-232 cable
3. Keil microvision 5 (C - interface)
4. flash magic
5. Burn o-mat
6. DSO (Digital Storage Oscilloscope)
7. Sample programs for generating digital inputs. (For analog inputs, potentiometer is used)

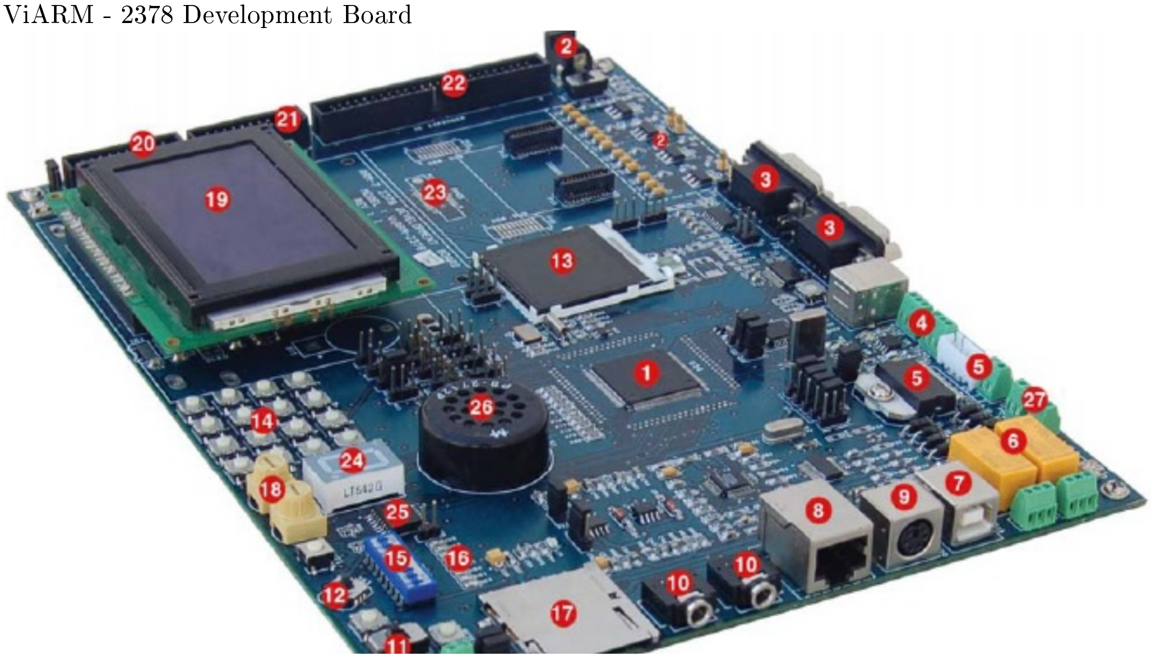
3 Background Information

In this Section we would discuss the following background information which are very much essential to do the above experiment

1. ViARM-2378 Development Board
2. Serial Interfacing in LPC 2378 ARM processor
3. ADC/ DAC Concepts
4. Specifications of ADC /DAC in LPC-2378 ARM processor
5. Demo programs

3.1 ViARM-2378 development board - Anatomy

ViARM - 2378 Development Board



ViARM-2378 Development Board Parts Details

1. NXP LPC2378 Micro controller (TQFP-144 Packaging).
2. Power supply section.
3. UART.
4. CAN Port.
5. Stepper Motor.
6. Relay.
7. USB 2.0 Device Connector.
8. 10/100 Base T Ethernet Connector.
9. PS2- Keyboard connector.
10. Stereo Jack for USB Audio Device.
11. Prog/Exec Switch.

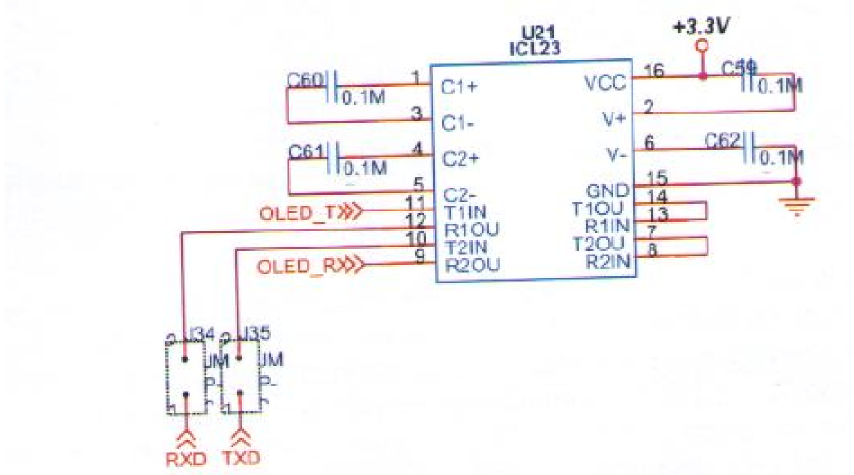
12. Joystick.
13. TFT LCD.
14. 4 x 4 Matrix Keypad.
15. 8 Way DIP switch.
16. LED.
17. SD Card Socket.
18. Analog input Trimmer.
19. 128 x 64 Pixels Graphics LCD.
20. Jtag Connector.
21. ADC, DAC and PWM Expansion slot.
22. 50Pin Expansion Header.
23. J-Trace.
24. Seven Segment Display.
25. Serial EEPROM.
26. Speaker.
27. Temperature Sensor

3.2 Serial Interface Using RS-232

In telecommunications, RS-232 (Recommended Standard 232) is a standard introduced in 1960 for transmission of data through serial communication. It formally defines the signals connecting between a DTE (data terminal equipment) such as a computer terminal, and a DCE (data circuit-terminating equipment or data communication equipment), such as a modem. The RS-232 standard had been commonly used in computer serial ports. The standard defines the electrical characteristics and timing of signals, the meaning of signals, and the physical size and pinout of connectors. The current version of the standard is TIA-232-F Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange, issued in 1997. An RS-232 serial port was once a standard feature of a personal computer, used for connections to modems, printers, mice, data storage, uninterruptible power supplies, and other peripheral devices.

3.2.1 RS-232 Implementation in ViARM-2378

Since the voltage levels of a micro-controller and PC are not directly compatible with each other, a level transition buffer such as MAX232 must be used.



ViARM-2378 development board has two UART termination at 9 pin D-type male connector. While using the UART1, close the jumpers J1 & J2. While using the UART2, close the jumpers J3 & J4.

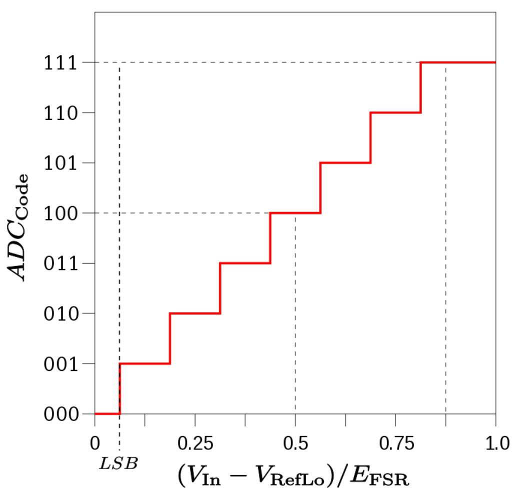
3.3 ADC / DAC: Concepts & their Specs in ARM-2378 Processor

Today virtually all of the userside equipments (communication, health care, IoT, automobile and most of industry) are digitized, while ALL the signals in nature are analog (both in its value and time of its evolution). [Strictly speaking, nothing in this world is digital, it is we humans have this convention of '*digital*' representation of signals with suitable transformation]. The engine which transforms (converts) an analog signal to digital format is called '*Analog to digital converter*' (ADC & vice versa is called as DAC).

Concepts from wiki:

3.3.1 ADC Theory

Analog-to-Digital Converter (ADC) Definition An ADC converts a continuous-time and continuous-amplitude analog signal to a discrete-time and discrete-amplitude digital signal. Note that the discretizations happens in both the domains. In the time domain, it results in (a) 'sampling' the signal, (b) the above sampling interval allows the ADC to do the conversion (before it is ready for the next sample), while in the amplitude domain, this mapping (conversion) involves quantization of the input, so it necessarily introduces a small amount of error or noise. The limitation on the ADC for conversion time limits the allowable bandwidth of the input signal (for this one needs to understand the Nyquist's sampling theorem).



The performance of an ADC is primarily characterized by its bandwidth and signal-to-noise ratio (SNR). The bandwidth of an ADC is characterized primarily by its sampling rate. The SNR of an ADC is influenced by many factors, including the resolution, linearity and accuracy (how well the quantization levels match the true analog signal), aliasing and jitter. The SNR of an ADC is often summarized in terms of its effective number of bits (ENOB), the number of bits of each measure it returns that are on average not noise. An ideal ADC has an ENOB equal to its resolution. ADCs are chosen to match the bandwidth and required SNR of the signal to be digitized. If an ADC operates at a sampling rate greater than twice the bandwidth of the signal, then per the Nyquist–Shannon sampling theorem, perfect reconstruction is possible. The presence of quantization error limits the SNR of even an ideal ADC. However, if the SNR of the ADC exceeds that of the input signal, its effects may be neglected resulting in an essentially perfect digital representation of the analog input signal.

Quantization Noise Quantization error is the noise introduced by quantization in an ideal ADC. It is a rounding error between the analog input voltage to the ADC and the output digitized value. The noise is non-linear and signal-dependent. In an ideal analog-to-digital converter, where the quantization error is uniformly distributed between $-1/2$ LSB and $+1/2$ LSB, and the signal has a uniform distribution covering all quantization levels, the Signal-to-quantization-noise ratio (SQNR) can be calculated from

$\text{SQNR} = 20\log_{10}(2^Q) \approx 6.02 \cdot Q$ dB [2] where Q is the number of quantization bits.

3.3.2 DAC Theory

4 Tasks

4.1 Serial Communication

Write a program (in C) to display the ASCII code in LEDs, corresponding to the key pressed in the key board of the PC interfaced to ViARM-2378. Use the RS232 serial cable interfaced to the Vi Microsystem's ViARM 2378 development board

4.2 ADC

Given a real-time (analog) signal from a sensor, convert it into a digital signal (Implement an ADC). Decrease the step size? Do you see any change in the bits used to represent the whole range? What is the quantization error?

4.3 DAC

Given the ViARM2378 ARM development board, generate

1. Square wave
2. Triangular wave
3. Sine wave (using lookup table)

5 Demo Program

5.1 Serial Communication

A C demo code (SrlCmmnctnFrmPC2ARM.c) is uploaded in the moodle, with comments. This code receives the characters serially from the PC to which the ViARM is connected to. To get an idea, please see page no 131 Vi Microsystems lab manual (Eg. 4)

5.2 ADC / DAC

<include here the c-code> To get an idea, see page 136 Eg 8 of Vi-Microsystems lab manual.

6 Procedure

Analog to digital (ADC) & DAC Converter

1. Write a C program, which does the serial transmission of frames (a group of contiguous bits) to the PC
2. Edit the above program file in Keil software. In Keil software one can edit, recompile and run etc.
3. Compile it in Keil platform
4. Dump it in ViARM 2378
5. Connect the serial cable from ViARM 2378 and PC
6. Run the program on the development kit by resetting

7 Results

1. Run the program and ask the TA to see the output
2. Take a snapshot using your mobile and make a report