AUDIT COURSE-5

Embedded and DTSP Lab

Unit I : ARM7, ARM9, ARM11 Processors

Introduction to ARM processors and its versions, ARM7, ARM9 & ARM11 features, advantages & suitability in embedded application, ARM7 data flow model, programmer's model, modes of operations, Instruction set, programming in assembly language.

Unit II: ARM7 Based Microcontroller

ARM7 Based Microcontroller LPC2148: Features, Architecture (Block Diagram and Its Description), System Control Block (PLL and VPB divider), Memory Map, GPIO, Pin Connect Block, timer, interfacing with LED, LCD, GLCD, KEYPAD.

Unit III: Real World Interfacing with ARM7 Based Microcontroller

Interfacing the peripherals to LPC2148: GSM and GPS using UART, on-chip ADC using interrupt (VIC), EEPROM using I2C, SDCARD using SPI, on-chip DAC for waveform generation.

Unit IV : ARM CORTEX Processors

Introduction to ARM CORTEX series, improvement over classical series and advantages for embedded system design. CORTEX A, CORTEX M, CORTEX R processors series, versions, features and applications. Need of operating system in developing complex applications in embedded system, desired features of operating system & hardware support from processor, Firmware development using CMSIS standard for ARM Cortex. Survey of CORTEX ~~M3~~ M4 based controllers, its features and comparison.

Unit V : ARM CORTEX M4 based Microcontroller

ARM Cortex-M4F based Microcontroller TM4C123GH6PM: Block diagram, address space, on-chip peripherals (analog and digital) Register sets, Addressing modes and instruction set basics. Programming system registers using TivaWare, GPIO control, Watchdog Timer, System Clocks and control, Hibernation Module in TM4C microcontrollers, Interrupts, Interrupt vector table, interrupt programming, Timers and Real Time Clock (RTC), Motion Control Peripherals: PWM Module & Quadrature Encoder Interface (QEI).

Unit VI : Real World Interfacing with ARM-CortexM4F Based Microcontroller

Analog interfacing and data acquisition: ADC, Analog Comparators, DMA, Serial communication basics, Interfacing digital and analog external device: I2C protocol, SPI protocol & UART protocol. Concept of USB, CAN, and Ethernet based communication using microcontrollers. CAN, USB, ETHERNET applications in embedded c.

Text Books:

1. Andrew Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide – Designing and Optimizing System Software", ELSEVIER
2. Joseph Yiu, "The Definitive Guide to the ARM Cortex-M", Newness, ELSEVIER
3. Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers,2014, Jonathan W Valvano CreateSpace publications ISBN: 978-1463590154.
4. Embedded Systems: Introduction to ARM Cortex - M Microcontrollers, 5th edition Jonathan W Valvano, CreateSpace publications ISBN-13: 978- 1477508992

Reference Books:

1. LPC 214x User manual (UM10139) :- www.nxp.com
2. LPC 17xx User manual (UM10360) :- www.nxp.com
3. ARM architecture reference manual : - www.arm.com
4.http://processors.wiki.ti.com/index.php/HandsOn_Training_for_TI_Embedded_Processors6.
http://processors.wiki.ti.com/index.php/MCU_Day_Internet_of_Things_2013_Workshop

List of Experiments:

1. Learn and understand how to configure EK-TM4C123GXL digital I/O pins. Write a C program for configuration of GPIO ports for Input and output operation (blinking LEDs, push buttons interface).

Exercises:

a) Modify the code to make the red LED of EK-TM4C123GXL blink.
b) Modify the code to make the green and red LEDs blink:
   I. Together
   II. Alternately
c) Alter the code to turn the LED ON when the button is pressed and OFF when it is released.
d) Modify the delay with which the LED blinks.
e) Alter the code to make the green LED stay ON for around 1 second every time the button is pressed.
f) Alter the code to turn the red LED ON when the button is pressed and the green LED ON when the button is released.

2. Learn and understand Timer based interrupt programming. Write a C program for EK-TM4C123GXL and associated Timer ISR to toggle onboard LED using interrupt programming technique.

Exercises:

a) Modify the code for a different timer toggling frequency.
b) Write the code to turn on interrupt globally.

3. Configure hibernation module of the TM4C123GH6PM microcontroller to place the device in low power state and then to wake up the device on RTC (Real- Time Clock) interrupt.

Exercises:

a) Write a program to configure hibernation mode and wake up the EK-TM4C123GXL when onboard switch SW2 is pressed.

4. Configure in-build ADC of TM4C123GH6PM microcontroller and interface potentiometer with EK-TM4C123GXL to observe corresponding 12- bit digital value.

Exercises:

a) Tabulate ten different position of the Potentiometer and note down the Digital value and calculate the equivalent analog value.
b) Use the ADC to obtain the analog value from the internal temperature sensor.
c) Configure Dual ADC modules to read from 2 analog input (could be from 2 potentiometers)
d) What are the trigger control mechanism for this ADC?
e) What does the resolution refer on ADC Specification?
f) The current sampling method is single ended sampling. This ADC could also be configured to do differential sampling. What is the difference between the two methods of sampling?

5. Learn and understand the generation of Pulse Width Module (PWM) signal by configuring and programming the in-build PWM module of TM4C123GH6PM microcontroller.

Exercises:

a) Change the software to output a set Duty Cycle, which can be user programmed.
b) Change the frequency of the PWM Output from 6.25 KHz to 10 KHz and do the tabulation again.
c) Generate Complementary signals, route it to two pins, and observe the waveforms.
d) What is dead band generation mean and where is it applied?
e) Is it possible to construct a DAC from a PWM? Identify the additional components and connection diagram for the same.
f) Sketch the gate control sequence of 3 phase Inverter Bridge and how many PWM generator blocks are required? Can we generate this from TM4C123x ?

6. Configure the PWM and ADC modules of TM4C123GH6PM microcontroller to control the speed of a DC motor with a PWM signal based on the potentiometer output.

Exercises:

a) With the same ADC input configure 2 PWM generator modules with 2 different frequencies.
b) Read the Internal temperature sensor and control a DC Motor that could be deployed in fan Controller by observing the unit or ambient temperature.
c) What is the resolution of the PWM in this experiment?
d) What would be the maximum frequency that can be generated from the PWM generator?
e) Briefly explain an integrated application of ADC and PWM based control.

7. Interfacing LPC2148 to LCD/GLCD

8. Interfacing SD card to LPC2148

9. Interfacing EEPROM to LPC2148 using I2C protocol

10. Learn and understand to connect EK-TM4C123GXL to PC terminal and send an echo of the data input back to the PC using UART.

Exercises:

a) Change the baud rate to 19200 and repeat the experiment.
b) What is the maximum baud rate that can be set in the UART peripheral of TIVA?
c) Modify the software to display "Switch pressed" by pressing a user input switch.

11. Learn and understand interfacing of accelerometer in Sensor Hub Booster pack with EK-TM4C123GXL using I2C.

Exercises:

a) Make a LED ON when the acceleration value in the x axis crosses a certain limit, say +5.
b) What is the precaution taken in this experiment in order to avoid the overflow of UART buffer?
c) Change the value of PRINT_SKIP_COUNT to 100 and see the difference in the output.
d) Change MPU9150_ACCEL_CONFIG_AFS_SEL_2G to MPU9150_ACCEL_CONFIG_AFS_SEL_4G on line 461 of the same source file and Observe the difference.

12. USB bulk transfer mode:

Learn and understand to transfer data using bulk transfer mode with the USB2.0 peripheral of the TM4C123GH6PM device.

Exercises:

a) What are the different modes offered by USB 2.0?
b) What are the typical devices that use Bulk transfer mode?

DTSP

Instructions:

a) Minimum eight practical's to be performed.
b) Practical number 12 is mandatory.

Note: Practical 1 to 11 can be performed in any appropriate software like C/MATLAB/SCILAB etc.

1. Implement the sampling theorem and aliasing effects by sampling an analog signal with various sampling frequencies.
2. To study the properties of DFT. Write programs to confirm all DFT properties.
3. To study the circular convolution for calculation of linear convolution and aliasing effect. Take two sequences of length
4. Write a program to find 4 point circular convolution and compare the result with 8 point circular convolution to study aliasing in time domain.

(a) To find Z and inverse Z transform and pole zero plot of Z-transfer function.
(b) To solve the difference equation and find the system response using Z transform.

5. To plot the poles and zeros of a transfer function when the coefficients of the transfer function are given, study stability of different transfer functions.

6. To study the effect of different windows on FIR filter response. Pass the filter coefficients designed in experiment 6 via different windows and see the effect on the filter response.

7. Design Butterworth filter using Bilinear transformation method for LPF and write a program to draw the frequency response of the filter.

8. To plot the mapping function used in bilinear transformation method of IIR filter design.(assignment may be given)

9. Effect of coefficient quantization on the impulse response of the filter using direct form I and II realization and cascade realization.(theory assignment)

10. Design and implement two stage sampling rate converter.

11. Computation of DCT and IDCT of a discrete time signal and comment on energy compaction density.

12. To implement at least one of the following operations using DSP Processor i) Linear and Circular convolution. ii) Low pass filter an audio signal input to DSK with FIR filter. iii) Low pass filter an audio signal input to DSK with IIR filter. To generate sine wave using lookup table with table values generated within the programme.