Audit Course-1

Microcontroller and Applications

Unit I : Introduction to Microcontrollers

8 bit and 16-bit Microcontroller architecture, comparison, advantages & applications of each. Harvard & Von Neumann architecture, RISC & CISC comparison. Survey of 8 bit controllers and its features Definition of embedded system & its characteristics. Role of microcontroller in embedded System. Limitation of 8 bit microcontrollers. Study of RS232, RS 485, I2C,SPI protocols. Software & hardware tools for development of microcontroller based system such as assembler, compiler, IDÉ, Emulators, debugger, programmer, development board, DSO, Logic Analyzer,

Unit II : 8051 Architecture

MCS-51 architecture, family devices & its derivatives. Port architecture, memory organization, Interrupt structure, timers and its modes & serial communication and modes. Overview of Instruction set.

Unit III : MSP430 Microcontroller Architecture and Low Power Features

Low Power 16-bit MSP430x5xx microcontroller architecture, address space, on-chip peripherals (analog and digital), and Register sets. Instruction set, instruction formats, and various addressing modes of MSP430 devices; Variants of the MSP430 family viz. MSP430x2x, MSP430x4x, MSP430x5x and their targeted applications, System clocks. Low Power aspects of MSP430: low power modes, Active vs Standby current consumption, FRAM vs Flash for low power; reliability.

Unit IV : Real World Interfacing

GPIO programming and I/O multiplexing; Interrupts and interrupt programming. Watchdog timer. Timers & Real Time Clock (RTC), PWM control. Analog interfacing and data acquisition: ADC and Comparator in MSP430, data transfer using DMA. Serial communication basics, Synchronous/Asynchronous interfaces (like UART, USB, SPI, and I2C). UART protocol, I2C protocol, SPI protocol. Implementing and programming UART, I2C, SPI interface using MSP430, Interfacing external devices.

Unit V : Embedded Networking and Internet of Things

IoT overview and architecture, Overview of wireless sensor networks and design examples. Various wireless connectivity: NFC, ZigBee, Bluetooth , Bluetooth Low Energy , Adding Wi-Fi capability to the Microcontroller , Wi-Fi MCUs (e.g., CC3200). Embedded Wi-Fi, User APIs for Wireless and Networking applications, Building IoT applications using CC3100 user API for connecting sensors.

Unit VI : Case studies with MSP430

Case Study I: MSP430 based embedded system application using ADC &PWM demonstrating peripheral intelligence. "Remote Controller of Air Conditioner Using MSP430"

Case Study II: MSP430 based embedded system application using the interface protocols for communication with external devices: "A Low-Power Battery less Wireless Temperature and Humidity Sensor with Passive Low Frequency RFID"

Case Study III: MSP430 based Embedded Networking Application: "Implementing Wi-Fi Connectivity in a Smart Electric Meter"

Text Books:

1. Mazidi, 8051 microcontroller & embedded system 3rd Edition ,Pearson 2. Mazidi, PIC microcontroller & embedded system 3rd Edition ,Pearson
2. Getting Started with the MSP430 Launchpad by Adrian Fernandez, Dung Dang, Newness publication ISBN-13: 978-0124115880
3. MSP430 microcontroller basics 1st Edition by John H. Davies (Author), Newnes Publication ISBN- 13: 978-0750682763
4. Ajay V. Deshmukh, "Microcontrollers, Theory and applications", Tata McGraw-Hill Companies – 2005
5. A.K.Ray and Bhurchandi, "Advanced Microprocessors and Peripherals", 2nd Edition, TMH Publications.
Reference Books:
1. Krishna Kant, "Microprocessors and Microcontrollers", PHI Publishers

Reference Books
1. I2C, EEPROM,RTC data sheets from www.ti.com
2. http://processors.wiki.ti.com/index.php/MSP430_LaunchPad_Low_Power_Mode
3. http://processors.wiki.ti.com/index.php/MSP430_16-Bit_UltraLow_Power_MCU_Training

Microcontroller Applications and Data Communication Lab
Microcontroller Applications Lab
List of Practical:

Embedded C Experiments using MSP430:
1. Learn and understand how to configure MSP-EXP430G2 digital I/O pins. Write a C program for configuration of GPIO ports for MSP430 (blinking LEDs, push buttons interface).
Exercises:
a) Modify the code to make the green and red LEDs blink:
b) Modify the delay with which the LED blinks.
c) Modify the code to make the green LED blink.
      i. Together
      ii. Alternately
d) Alter the code to turn the LED ON when the button is pressed and OFF when it is released.
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. Usage of Low Power Modes:

Configure the MSP-EXP430G2 for Low Power Mode (LPM3) and measure current consumption both in active and low power modes. Use MSPEXP430FR5969 as hardware platform and measure active mode and standby mode current.

Exercises:

a) How many Low power modes are supported by the MSP430G2553 platform?

b) Measure the Active and Standby Current consumption in LPM3 mode for the same application using MSP430F5529

3. Learn and understand GPIO based Interrupt programming. Write a C program and associated GPIO ISR using interrupt programming technique.

Exercises:

a) Write the code to enable a Timer interrupt for the pin P1.1.

b) Write the code to turn on interrupts globally

4. Implement Pulse Width Modulation to control the brightness of the on-board, green LED. This experiment will help you to learn and understand the configuration of PWM and Timer peripherals of the MSP430G2553.

Exercises:

a) Observe the PWM waveform on a particular pin using CRO.

b) What is the maximum resolution of PWM circuitry in MSP430G2553?

c) Change the above code to create a PWM signal of 75% duty cycle on particular PWM pin.

5. The main objective of this experiment is to control the on-board, red LED by the analog input from a potentiometer. This experiment will help you to learn and understand how to configure an ADC to interface with a potentiometer.

Exercises:

a) Alter the threshold to 75% of Vcc for the LED to turn on.

b) Modify the code to change the Reference Voltage from Vcc to 2.5V.

6. Learn and understand how to configure the PWM and ADC modules of the MSP-EXP430G2 to control the DC motor using external analog input.

Exercises:

a) What is the maximum resolution of PWM circuitry in MSP430G2553 and how it can be achieved using program?

b) Create a PWM signal of 75% duty cycle on particular PWM pin.

c) Create Switch case code from the example code to run the DC Motor in 3 set of speeds.

7. Configure of Universal Serial Communication Interface (USCI) module of MSP430G2553 for UART based serial communication. The main objective of this experiment is to use UART of the MSP430G2553 to communicate with the computer.

Exercise:

Modify the above code to transmit the set of strings to the serial terminal via UART as shown below:

char str1[]="MSP430G2553 MCU"

char str2[]= " Ultra low power mixed signal processing applications"

8. Understand and Configure 2 MSP430F5529 in master-slave communication mode for SPI protocol.

Exercises:
a) Which port pins of MSP430 can be configured for SPI communication?
b) What is the data transfer rate supported by MSP430 for SPI communication?
9. A basic Wi-Fi application: Configure CC3100 Booster Pack connected to MSP430F5529 as a Wireless Local Area Network (WLAN) Station to send Email over SMTP.
Exercises:
a) Identify the code that helps in establishing connection over SMTP. Modify the code to trigger E-mail application based upon external analog input.
b) How to configure the AP WLAN parameters and network parameters (IP addresses and DHCP parameters) using CC3100 API.

10. The main objective of this experiment is to enable Energy Trace and Energy Trace++ modes in MSP-EXP430G2 by using MSP430FR5969. This experiment will help you learn how to analyze the Energy and Power graphs by enabling the Energy Trace Technology of MSP430 in CCS studio.
Exercises:
a) What is the difference between the Energy Trace and Energy Trace ++?
b) What hardware options available that supports Energy Trace++?

11. Understand Energy Trace Technology analysis tool that measures and displays the application's energy profile. Compute and measure the total energy of MSP-EXP430G2 running an application and estimate the lifetime of an AA battery if the device is powered using standalone AA battery.
Exercises:
Compute the energy measurement and the estimated lifetime of a battery in various low power modes.

Lab Manual:
1) www.ti.com/lab-maunals
  • Embedded System Design using MSP430 Launchpad Development Kit – Lab Manual

Data Communication Lab
List of Practical :(Any Six from 1 to 8):
1) Differential Pulse Code Modulation or delta modulation and signal reconstruction
2) Basic line codes and Multi level line codes
3) Matched filter receiver
4) ASK, PSK, FSK and comparison
5) QPSK and OQPSK modulation and demodulation
6) Design of PN sequence generator
7) Spread Spectrum System (DSSS)
8) Orthogonal Frequency Division Multiplexing Software Assignments: (Any Two from 9 to 11)
9) Implementation of linear block code
10) Implementation of Convolution code and Viterbi algorithm
11)Implementation of Shannon Fano and Huffman codes

Audit Course-2
Embedded Processors

Unit I : ARM7, ARM9, ARM11 Processors   **7L**
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   **7L**
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   **7L**
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   **7L**
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 M4 based controllers, its features and
comparison.

Unit V : ARM CORTEX M4 based Microcontroller   **7L**
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   7L
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. Trevor Martin,"An Engineer's Introduction to the LPC2100 series", Hitex (UK) Ltd.
5.http://processors.wiki.ti.com/index.php/HandsOn_Training_for_TI_Embedded_Processors
http://processors.wiki.ti.com/index.php/MCU_Day_Internet_of_Things_2013_Workshop

Audit Course-3

Power Electronics and Applications

Unit I : AC-DC power converters   7L

Concept of line & forced commutation, Single phase Semi & Full converters for R, R-L loads, Performance parameters, Effect of freewheeling diode, Three phase Semi & Full converters for R and RL load. Simple triggering circuits for single phase converters, triggering circuit requirement for three phase converters

Unit II : DC-AC Converters   7L

Single phase bridge inverter for R & R-L load using MOSFET / IGBT, performance parameters, single phase PWM inverters. Three phase voltage source inverter for balanced star R load. Control circuits for single phase bridge inverters, control circuit requirement for three phase inverters

Unit III : DC-DC converters & AC Voltage Controller   7L

Working principle of step down chopper for R-L load (highly inductive), control strategies. Performance parameters, Step up chopper, 2-quadrant & 4-quadrant choppers, SMPS, Buck regulator e.g. TPS54160, hysteretic buck regulator e.g. LM3475, Switching Regulator and characteristics of standard regulator ICs – TPS40200, TPS40210, Low Drop out (LDO) Regulators ICs-TPS 7A4901, TPS7A8300; Typical control circuits for single quadrant and two quadrant choppers. Single-phase full wave AC voltage controller with R load.

Unit IV: 7L
a) Resonant converters: Need for resonant converters, Classification, Resonant Switch: ZC resonant switch and ZV resonant switch, Quasi Resonant Converters: ZCS and ZVS, their comparison, Load resonant converters: SLR half bridge DC/DC converter in low frequency.

b) Power Quality: Power Quality considerations, Reactive Power and Harmonic Compensation, Active filters for power conditioning.

Unit V: Power Electronics Applications   7L

ON-line and OFF line UPS with battery AH, back up time, battery charger rating. Electronic ballast: Characteristics of fluorescent lamps and advantages over conventional ballast. Power Electronics in Capacitor Charging Applications. HVDC transmission: Main components of HVDC Converter station, Types of HVDC systems. Universal motor speed control.

Unit VI:Power Electronics for Renewable Energy Sources   7L

Power Electronics for Photovoltaic Power Systems: Basics, Types, Stand-alone PV systems, Grid connected PV systems. Power Electronics for wind power systems: Basics, Types, Standalone wind energy systems, Grid connected wind energy systems, Control of wind turbines.

Text Books
1. M. H. Rashid, "Power Electronics Handbook", Academic Press, 2001. 2. M. S. Jamil Asgar, "POWER ELECTRONICS", PHI, 2004, New Delhi
Reference Books
 1. Ned Mohan, T. Undeland& W. Robbins, "Power Electronics Converters applications and design" 2nd edition, John Willey & sons, Singapore
2. U. R. Moorthi, "POWER ELECTRONICS, DEVICES, CIRCUITS & INDUSTRIAL APPLICATIONS" , Oxford University Press, New Delhi, 2005
3. "GE SCR MANUAL" 6th edition, General Electric, New York, USA
4. Timothy Skvarenina, "The Power Electronics Handbook", CRC Press, 2002

Audit Course-4

Instrumentation and Power Lab

Instrumentation
List of Experiments : (Any 8 experiments)
1. Weight measurement using load cell and strain gauges.
2. Measurement of vibration.
3. Liquid level measurement(Capacitance probe/ Ultrasonic/Hydrostatic-any one technique)
4. Flow measurement with orifice plate and differential pressure transmitter (DPT).
5. Measurement of speed of rotation of shaft using optical incremental encoder.
6. Temperature measurement. (RTD signal conditioning with bridge circuit, instrumentation amplifier, ADC and microcontroller)
7. Simulation of temperature measurement experiment with anysoftware's (RTD signal conditioning with bridge circuit, instrumentation amplifier, ADC and microcontroller)
8. Determine RTD characteristic and find the sensitivity PT 100/500
9. Determine thermistor or Thermocouplecharacteristic and find its sensitivity.
10. Design of signal converters using Electronics/electro-mechanical components (any one out of V/I, I/V, I/P, P/I)
11. Pneumatic cylinder sequencing with simple logic.
12. Data acquisition and analysis using PC.
13. Study of various switches
14. Study of different valves and their characteristics.
15. Study of characteristics of valves

Power Electronics

Lab setup requirement:

PMLK Buck Kit, PMLK LDO Kit, DC power supply 0-50V/4A with dynamic voltage mode capability ,5-100 ohm/50W resistance,2-100 ohm potentiometer/50 W , 4 digital multimeters with 4 1/2-digit resolution ,250MHz 2-channels Digital Oscilloscope,10 MHz Function Generator.

List of Experiments:

1. Single phase Semi / Full Converter with R & R-L load
2. Three phase Semi / Full Converter with R load
3. Single phase AC voltage controller using SCRs for R load
4. Single-Phase PWM bridge inverter for R load
5. Three-Phase inverter for R load
6. With TPS7A4901 and TPS7A8300, study-
   i.   Impact of line and load conditions on drop out voltage
   ii. Impact of line and load conditions on efficiency
   iii. Impact of capacitor on PSRR
   iv. Impact of output capacitor on load-transient response

7. Study of DC-DC Buck converter
   v.   Analyze the influence of voltage loop feedback compensation on load-transient response of current-mode control TPS54160 buck regulator.
   vi. Analyze the way the operating conditions influence the current ripple and voltage ripple of a TPS54160 buck regulator, depending on the type of core material of the inductor and on core saturation..

8. Study of DC-DC Boost Converter
   a. Analyze the influence of Input voltage, load current and switching frequency on continuous and discontinuous mode of operation of boost converter LM5122
   b. Analyze the impact of operating conditions and of the operation mode on the power loss and efficiency of boost converter LM5122

9. Case study of any one of the following: HVDC transmission system, Photovoltaic System, Wind generator system

10. **Webench Experiment:**
Design Statement 1:

Design a low cost synchronous buck converter
Vin (Max): 15 V Vout: 5 V
Vin (Min): 10 V Iout: 1 A
Ambient Temp: 30°C
Ambient temperature: 30 degree Celsius
- IC should be a synchronous step down regulator
- IC should operate in advance eco-mode
- The efficiency should be greater than 90%
- Foot print should be less than 130mm2
- BOM cost should be less than 2$ and the solution should have lowest BOM cost
- BOM count should be less than 10
- Should consist of Maximum WEBENCH tools (minimum 5 tools)
- IC should support a soft start feature
- Design should not exceed 50 Degree Celsius Temperature at IC-Die (use thermal simulation
- optimization if required)

Design Statement 2:
Vin(Min) = 8 V   Vin(Max) = 16 V

Vout = 5 V   Iout = 2 A
Ambient temperature: 30 Degree Celsius
Design must support these four Webench tools (Electrical Simulation ,WebTherm, CAD Export, Schematic Editor)
IC must have frequency synchronization pin to reduce EMI
Frequency of the design must be less than 300KHz
Efficiency of the design should be above 85%
Foot print size should be less than 450mm2
The design maximum output voltage Vout Max(V) should be 42V DC
The minimum input voltage Vin Min(V) should be equal to 6.0V DC
Highest temperature on the PCB should be less than 40 Degree Celsius (use thermal simulation optimization as required)
Design should have better transient response for Load current
The design should have low BOM cost
****

References:
- PMLK BUCK Lab manual - http://www.ti.com/lit/ug/ssqu007/ssqu007.pdf
- PMLK LDO Lab manual - http://www.ti.com/lit/ug/ssqu006/ssqu006.pdf
- WEBENCH – www.ti.com/webench
- ASLK PRO – ASLK PRO Manual

Audit Course-5

Embedded and DTSP Lab

Unit I : ARM7, ARM9, ARM11 Processors   7L
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   7L
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   7L
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   7L
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   7L

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   7L
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
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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.

Audit Course-6

Power Electronics

Unit I : Power Devices   6L
Construction, Steady state characteristics & Switching characteristics of SCR, Construction, Power MOSFET:N-Channel and P-Channel e.g.CSD17313Q2Q1 and CSD25404Q3, Steady state characteristics Power MOSFET & IGBT, MOSFET and IGBT Gate Drivers and Types,Gallium Nitride (GaN) FET Drivers e.g. UCC27511, SCR ratings: IL, IH, VBO, VBR, dv/dt, di/dt, surge current & rated current. Gate characteristics, Gate drive requirements, Synchronized UJT triggering for SCR, triggering of SCR using IC-785, gate drive circuits for   Power MOSFET / IGBT.

Unit II : AC-DC Power Converters   6L
Concept of line & forced commutation, Single phase Semi & Full converters for R, R-L loads, Performance parameters, Effect of freewheeling diode, Three phase Semi & Full converters for R load.

Unit III : DC-AC Converters   6L
Single phase bridge inverter for R and R-L load using MOSFET / IGBT, performance parameters, single phase PWM inverters. Three phase voltage source inverter for balanced star R load.

Unit IV : DC-DC converters & AC Voltage Controller   6L
Working principle of step down chopper for R-L load (highly inductive), control strategies. Performance parameters, Step up chopper, 2-quadrant & 4-quadrant choppers, SMPS. Buck regulator e.g. TPS54160, hysteretic buck regulator e.g. LM3475, Switching Regulator and characteristics of standard regulator ICs – TPS40200, TPS40210, Low Drop out (LDO) Regulators ICs-TPS 7A4901, TPS7A8300;   Single phase full wave AC voltage controller with R load.

Unit V :Power Electronics Applications   6L

ON-line and OFF line UPS with battery AH, back up time, battery charger rating. Electronic ballast: Characteristics of fluorescent lamps and advantages over conventional ballast. Single phase separately excited DC motor drive, stepper motor drive, BLDC motors. Variable voltage & variable frequency three phase induction motor drive.

Unit VI: Resonant Converters & Protection of Power Devices & Circuits   6L
Need for resonant converters, SLR half bridge DC/DC converter in low frequency, Concept of zero current switching (ZCS) and zero voltage switching (ZVS) resonant converters. Cooling & heat sinks, over voltage conditions, over voltage protection circuits, over current fault conditions, over current protection. Electromagnetic interference: Sources, minimizing techniques.

Text Books: 1. M. H. Rashid, "Power Electronics circuits devices and applications", PHI 3rd edition, 2004 edition, New Delhi. 2. M. S. Jamil Asghar, "POWER ELECTRONICS", PHI, 2004, New Delhi
Reference Books: 1. Ned Mohan, T. Undeland& W. Robbins, "Power Electronics Converters applications and design" 2nd edition, John Willey & sons, Singapore 2. U. R. Moorthi, "POWER ELECTRONICS, DEVICES, CIRCUITS & INDUSTRIAL APPLICATIONS" , Oxford University Press, New Delhi, 2005 3. P.C. Sen, "Modern Power Electronics", S Chand & Co New Delhi. 4. "GE SCR MANUAL" 6th edition, General Electric, New York, USA 5. Dr. P. S. Bimbhra, "Power Electronics", Khanna Publishers, Delhi. 6. Nagrath Kothari, "Electrical Machines", TMH.

Embedded and Power Lab

Embedded Processors

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 TIVA ?

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?

Audit Course-7

Electronic Devices and Circuits

UNIT I: JFET   (8 Hrs)
Introduction to JFET, Types, Construction, Operation, Static Characteristics, Pinch off voltage, FET Volt-Ampere characteristics, FET Configurations (CS/CD/CG) and their Comparison. Biasing of FET (Self). FET as an amplifier and its analysis (CS) and its frequency response. Small signal model, FET as High Impedance circuits.

Unit II :MOSFET& its DC Analysis   (8 Hrs)
Basics of MOS Transistor operation, Construction of n-channel E-MOSFET, E-MOSFET characteristics & parameters, non-ideal voltage current characteristics viz. Finite output resistance, body effect, sub-threshold conduction, breakdown effects and temperature effects. Common source circuit, Load Line & Modes of operation, common MOSFET configurations: DC Analysis, constant current source biasing.

Unit III : MOSFET AC Circuit Analysis: (8 Hrs)
The MOSFET CS small signal amplifier, Small signal parameters, small signal equivalent circuit, Modeling, Body effect, Analysis of CS amplifier. Introduction to BiCMOS technology. The MOSFET internal capacitances and high frequency model. Introduction to MOSFET as basic element in VLSI, V-I characteristic equation in terms of W/L ratio, MOSFET scaling and small geometry effects, MOSFET capacitances.

Unit IV : MOSFET Circuits   (7 Hrs)
 MOSFET as switch, diode/active resistor, Current sink and source, current mirror, Voltage references, Basic principle of band gap reference, CMOS Inverter as amplifier: Active load, Current source and Push pull configurations.

Unit V : Feedback amplifiers and Oscillators   (8 Hrs)
Four types of amplifiers. Feedback topologies. Effect of feedback on terminal characteristics of amplifiers. Examples of voltage series and Current series FET feedback amplifiers and their analysis. Barkhausen criterion, stability with feedback. General form of LC oscillator. FET RC Phase Shift oscillator, Wein bridge oscillator, Hartley and Colpitts oscillators.

Unit VI :VoltageRegulator: (7 Hrs)
Block diagram of an adjustable three terminal positive and negative regulators (317,337).Typical connection diagram, current boosting,Fixed and Adjustable Voltage Regulators , Low drop out voltage regulators. Low Drop out (LDO) Regulators ICs- TPS7A4901, TPS7A8300, TPS7250; Introduction to Switch Mode Power supply (SMPS), Block diagram of SMPS, Types of SMPS, Basic Switching Regulator and characteristics of standard regulator ICs –TPS40200, TPS40210, Comparison of Linear Power supply and SMPS.

Text Books:
1.MillmanHalkias, "Integrated Electronics-Analog and Digital Circuits and Systems", Tata   McGraw Hill, 2000.

2. Donald Neaman, "Electronic Circuit Analysis and Design",3 rd Edition, Tata McGraw Hill.

Reference:
1. David A.Bell,"ElectronicDevicesandCircuits",5th Edition, Oxford press
2. R. L. Boylstad, L. Nashlesky, "Electronic Devices and circuitsTheory", 9thEdition, PrenticeHall of India, 2006.
3. Anil K. Maini and Varsha Agarwal "Electronic Devices and Circuits", Wiley India
4. Phillip E. Allen, Douglas R. Holberg, "CMOS Analog Circuit Design", Second Edition, Oxford.
5. K. R. Botkar, "Integrated Circuits", 5th Edition, Khanna Publication.

Other References:
1. TPS40200: http://www.ti.com.cn/cn/lit/ds/symlink/tps40200.pdf
2. TPS40210: http://www.ti.com/lit/ds/symlink/tps40210.pdf
3.TPS7A4901: http://www.ti.com/lit/ds/symlink/tps7a49.pdf
4 TPS7A8300: http://www.ti.com/lit/ds/symlink/tps7a8300.pdf

List of Practical

Lab Setup Requirement:
Dual Channel Cathode Ray Oscilloscope (0-20 MHz), Function Generator (10MHz and above), Dual Power Supply , ASLKPRO, standard regulator ICs – TPS40200, TPS7250, PMLK LDO ,TPS 7A4901, TPS7A8300, Clip Probes, digital multimeter.

1. Design a single stage FET Amplifier in CS configuration and verify DC operating point.
2. Build and test single stage CS amplifier using FET. Calculate Ri, Ro and Av.
3. Simulate frequency response of single stage CS amplifier (use same circuit) and find the bandwidth.
4. SimulateVoltage-Series feedback amplifier and calculate Rif, Rof, Avf and Bandwidth.
5. Implement current series feedback amplifier and find Rif, Rof, Gmf and Bandwidth.
6. Simulate LC oscillator using FET.   OR
7. Implement Weinbridge /RC phase shift oscillator using FET/MOSFET.
8. Simulate MOSFET/ CMOS Inverter.   OR
9. Build and test MOSFET as a switch.
10. Design and implement an adjustable voltage regulator using three terminals voltage regulator
11. Design and test a Low Dropout regulator using op-amps for a given voltage regulation characteristic and compare the characteristics with TPS7250 IC
12. Design of a switched mode power supply that can provide a regulated output voltage for a given input range and compare the characteristics using the TPS40200 IC.
13. With TPS7A4901 and TPS7A8300, study-
    a. Impact of line and load conditions on drop out voltage
    b. Impact of line and load conditions on efficiency
    c. Impact of capacitor on PSRR
    d. Impact of output capacitor on load-transient response

Reference Material:
1. ASLK Pro Manual: http://download.mikroe.com/documents/specials/educational/aslk-pro/aslk-pro-manual-v103.pdf
2. PMLK LDO Lab manual - http://www.ti.com/lit/ug/ssqu006/ssqu006.pdf

Audit Course-8

Integrated Circuits

Unit I : OP-AMP Basics   (6 Hrs)
Block diagram of OP-AMP, Differential Amplifier configurations, Differential amplifier analysis for dual-input balanced-output configurations using 'r' parameters, Need and types of level shifter, current mirror circuits. Voltage series and voltage shunt feedback amplifier and its effect on Ri, Ro, bandwidth and voltage gain, Study of Various types of Operational and their applications; Power supply configurations for OP-AMP applications , ; DC and AC parameters of opamp ; interpretation of TL082 datasheet.

Unit II : Linear Applications of OP-AMP   (8 Hrs)
Inverting and Non-inverting amplifier, voltage follower. Summing, averaging scaling amplifier, difference amplifier, Ideal integrator, practical integrator with frequency response, Ideal differentiator, practical differentiator with frequency response, isolation amplifier and ISO12X IC, Instrumentation amplifiers.

 Unit III : Non-linear Applications of OP-AMP   (8 Hrs)
Comparator, Comparator contrary to op amp e.g. LMX93,TLV350X, characteristics of comparator, applications of comparator, Schmitt trigger (symmetrical/asymmetrical), Monostable and AstableMultivibrator ,Multivibrator IC CD4047B, clippers and clampers, voltage limiters, Square wave generator, triangular wave generator, Need of precision rectifier, Half wave , Full wave precision rectifiers, peak detectors, sample and hold circuits and LF-398N S/H IC .

Unit IV : Converters using OP-AMP   (6 Hrs)
V-F, I-V and V-I converter, DAC: types of DAC, characteristics, specifications, advantages and disadvantages of each type of DAC,Study of DAC 7821 IC, ADC: types of ADC, characteristics, specifications, advantages and disadvantages of each type of ADC, Study of ADC32XX IC

Unit V : Phase Locked Loop &Oscillators   (8 Hrs)
Introduction to analog multiplier e.g.MPY634,Basic application of Analog multiplier: AM,FM,FSK; Typical application using op-AMP and analog multipliers: Voltage Controlled Oscillator, Block diagram of PLL and its function, PLL types, characteristics/parameters of PLL, and different applications of PLL, AGC/AVC ,Self-tuned filters and VCA820; Oscillators principle, types and frequency stability, design of phase shift, wein bridge, Quadrature, voltage controlled oscillators.

Unit VI : Active filters   (8 Hrs)
Design and frequency scaling of First order and second order Active LP, HP, BP and wide and narrow band BR Butterworthfilters and notch filter. All pass filters, Universal Active filter design and UAF42 IC

TextBooks:

1. Ramakant A. Gaikwad, "Op Amps and Linear Integrated Circuits", Pearson Education 2000.
 2. Salivahanan and KanchanaBhaskaran, "Linear Integrated Circuits", Tata McGraw Hill,India 2008
Reference:
1. George Clayton and Steve Winder, "Operational Amplifiers", 5th Edition Newnes.
 2. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", Tata McGraw Hill.
3. Bali,"Linear Integrated Circuits", Mc Graw Hill 2008.

4. Gray, Hurst, Lewise, Meyer, "Analysis & Design of Analog Integrated Circuits", Wiley Publications.

Other References:

1.TL082: http://www.ti.com/lit/ds/symlink/tl082.pdf
2.Various Type of Op amp: http://www.ti.com/lsds/ti/amplifiers-linear/operational-amplifier-op-amp-products.page
3. LMX93: http://www.ti.com/lit/ds/symlink/lm2903-n.pdf
4. TLV350X: http://www.ti.com.cn/cn/lit/ds/symlink/tlv3501.pdf
5. LF-398N :http://www.ti.com/lit/ds/symlink/lf398-n.pdf
6. INAXXX: http://www.ti.com/lsds/ti/amplifiers-linear/instrumentation-amplifier-products.page
7. IS012X: http://www.ti.com/lit/ds/symlink/iso121.pdf
8. UAF42:http://www.ti.com/lit/ds/symlink/uaf42.pdf
9.MPY634: http://www.ti.com/lit/ds/symlink/mpy634.pdf
10. VCA820: http://www.ti.com.cn/cn/lit/ds/symlink/vca820.pdf
11. CD4046: http://www.ti.com/lit/ds/symlink/cd4046b.pdf
12. TPS40200: http://www.ti.com.cn/cn/lit/ds/symlink/tps40200.pdf
13. TPS40210: http://www.ti.com/lit/ds/symlink/tps40210.pdf
14.TPS7A4901: http://www.ti.com/lit/ds/symlink/tps7a49.pdf
15. TPS7250: http://www.ti.com.cn/cn/lit/ds/symlink/tps72.pdf
16.DAC 7821:http://www.ti.com/lit/ds/symlink/dac7821.pdf
17.ADC32X: http://www.ti.com/lsds/ti/data-converters/analog-to-digital-converter-products.page.

List Of Practical's
Lab Setup Requirement:
Dual Channel Cathode Ray Oscilloscope (0-20 MHz), Function Generator (10MHz and above), Dual Power Supply , TL082, MPY634, ASLKPRO, Clip Probes, digital multimeter,System with installed circuit simulation software(Tina/Pspice/MultiSim)
 1. Measure Op-Amp parameters and compare with the specifications.   Input bias current, input offset current and input offset voltage. slew rate , CMRR of TL082 Compare the result with datasheet of corresponding Op-Amp.

2.To design and study the characteristics of negative feedback amplifier
a) Inverting and non inverting using operational amplifier TL082
b) Voltage follower using operational amplifier using TL082.
3. Design, build and test integrator and Differentiator for given frequency fa using TL082.
 4. Design, build and test three Op-Amp instrumentation amplifiers for typical application using TL082
5.To design and study the characteristics of regenerative amplifier
a) Schmitt Trigger using operational amplifier TL082
b) Astable and Monostable using operational amplifier using TL082.
6.Design of a function generator and VCO using op-Amp and MPY634
7.Examine the operation of a PLL designed using TL082 and MPY634 and to determine the free running frequency, the capture range and the lock in range of PLL
8. 2 bit DAC and 2 bit ADC. A) Design and implement 2bit R-2R ladder DAC.   B) Design and implement 2bit flash type ADC.
9. Design, build and test square & triangular wave generator.
10.Design Low pass, High pass and Band pass, stop band 2nd order Butterworth active filters using universal active filter topology

Optional Experiments:

1. Verify and understand practically virtual ground and virtual short concept in inverting and non-inverting configuration.
2. Plot DC transfer characteristics of emitter coupled differential amplifier.
3. Study effect of emitter resistance and constant current source on figure of merit (CMRR) of emitter coupled differential amplifier.
4. Design and implement V-I converter.
5. Any experiment based on application of Op-Amp.
6. Design, build and test precision half & full wave rectifier.

Reference Material:
1. Data Sheet: http://www.ti.com/lit/ds/symlink/tl082.pdf
2. Application Note: http://www.ti.com/lit/an/sloa020a/sloa020a.pdf
3. MPY634 Data Sheet: http://www.ti.com/lit/ds/symlink/mpy634.pdf
4. Application Note: http://www.ti.com/lit/an/sbfa006/sbfa006.pdf
5. ASLK Pro Manual: http://download.mikroe.com/documents/specials/educational/aslk-pro/aslk-pro-manual-v103.pdf

Audit Course-9

Analog And Digital Electronics

Unit 01 : Number system & Boolean's Algebra: (8 Hrs)
Numbering systems-binary, octal, decimal and hexadecimal and their conversion, codesBCD, Grey and excess3, Binary arithmetic: - addition and subtraction by 1's and 2's compliment. Booleans algebra, De-Morgan's theory etc. K-map: - structure for two, three and four Variables, SOP and POS form reduction of Boolean expressions by K-map.

Unit 02 : Combinational & Sequential circuits: (9 Hrs)
 Concept of Combinational & Sequential circuits, Flip flops – R-S, Clocked S-R, D latches, Edge Triggered D flip-flops, Edge triggered JK flip flops, JK Master - slave flip flop, Register- Buffer registers, shift registers, controlled shift registers, ring counter, Counters – asynchronous Counters, synchronous counter, up - down counter , twisted ring counters, N –module Counters.

Unit 03 : Operational Amplifier & Applications: (8 Hrs)
Op-Amp: Block diagrams of 741 and TL082, ideal and practical parameters, open loop and close loop configuration of Op-Amp. Study of Various types of Operational Amplifiers and their applications; Power supply configurations for OP-AMP applications Applications of Op- Amp- Comparator, Comparator: Comparator contrary to op amp e.g. LMX93,TLV350X, , zero crossing detectors, Schmitt trigger,Voltage limiters, Integrator and Differentiator ,V-I and I-V converters, Instrumentation amplifier, peak detector,Monostable and AstableMultivibrator ,Multivibrator IC CD4047B , Sample and hold Circuit and LF-398N S/H IC, isolation amplifiers and ISO12X IC

 Unit 04 : Waveform generators, Filters & Regulators: (8 Hrs)
Waveform generation using Op-amp - sine, square, saw tooth and triangular generator, Active filters-Its configuration with frequency response, Analysis of first order Butterworth   low pass and high pass filters,bandpass and bandstop filters, notch filter, All pass filters, Universal Active filter design and UAF42, IC 555 –construction, working and modes of operation- astable and monostable multi vibrators, Sequence generator, Introduction to analog multiplier e.g.MPY634,Basic application of Analog multiplier:AM,FM,FSK; Typical application using op-AMP and analog multipliers: Voltage Controlled Oscillator, Phase Locked Loop and features of CD4046 IC, voltage regulators using ICs 78xx, 79xx, LM 317 ; OP-AMP Voltage regulator, Fixed and Adjustable Voltage Regulators, Basic Switching Regulator and characteristics of standard regulator ICs –TPS40200, TPS40210, Low Drop out (LDO) Regulators ICs- TPS7A4901, TPS7250;

Unit 05 : BJT & Applications: (8 Hrs)
 BJT amplifier: Introduction, Class A amplifier, AC-DC load line analysis, Single stage and Multistage BJT amplifier, direct coupled, RC coupled and transformer coupled, Darlington pair, Push-Pull amplifier and differential amplifier FET-construction, Parameters, Characteristics.

Unit 06 : Diode & Precision Rectifiers: (7 Hrs)
 Diode rectifier: Introduction, Single phase half wave rectifier with R, RL loads. Single phase full wave rectifier-Center tap and bridge rectifier supplying R and RL load and performance parameters. Three phase full wave bridge rectifier with R load. Comparison of single phase half wave and full wave rectifiers, Precision rectifiers: Half wave and Full wave. Comparison of diode and precision rectifier.

Other References:

1.TL082: http://www.ti.com/lit/ds/symlink/tl082.pdf
2.Various Type of Op amp: http://www.ti.com/lsds/ti/amplifiers-linear/operational-amplifier-op-amp-products.page
3. LMX93: http://www.ti.com/lit/ds/symlink/lm2903-n.pdf
4. TLV350X: http://www.ti.com.cn/cn/lit/ds/symlink/tlv3501.pdf
5. LF-398N :http://www.ti.com/lit/ds/symlink/lf398-n.pdf
6. INAXXX: http://www.ti.com/lsds/ti/amplifiers-linear/instrumentation-amplifier-products.page
7. ISO12X: http://www.ti.com/lit/ds/symlink/iso121.pdf
8. UAF42:http://www.ti.com/lit/ds/symlink/uaf42.pdf
9.MPY634: http://www.ti.com/lit/ds/symlink/mpy634.pdf
10. VCA820: http://www.ti.com.cn/cn/lit/ds/symlink/vca820.pdf
11. CD4046: http://www.ti.com/lit/ds/symlink/cd4046b.pdf
12. TPS40200: http://www.ti.com.cn/cn/lit/ds/symlink/tps40200.pdf
13. TPS40210: http://www.ti.com/lit/ds/symlink/tps40210.pdf
14.TPS7A4901: http://www.ti.com/lit/ds/symlink/tps7a49.pdf
15. TPS7250: http://www.ti.com.cn/cn/lit/ds/symlink/tps72.pdf

Lab
Lab Setup Requirement: Dual Channel Cathode Ray Oscilloscope (0-20 MHz), Function Generator (10MHz and above), Dual Power Supply , TL082, MPY634, ASLKPRO, standard regulator ICs – TPS40200, TPS 7250, Clip Probes, digital multimeter,System with installed circuit simulation software(Tina/Pspice/MultiSim)

1. Study of ring counter and twisted ring counter.
2. Study of up - down counters (IC 74192/74193) and N- modulo counter. (IC 7490/7493).
3. Measurement and Comparison of Op-Amp parameters for TL082– CMRR,SVRR, slew rate, Open loop gain, input bias current and input offset current and Unity gain bandwidth
4.To design and study the characteristics of negative feedback amplifier
a) Inverting and non inverting using operational amplifier TL082
b) Voltage follower using operational amplifier using TL082.
5.To design and study the characteristics of regenerative amplifier
a) Schmitt Trigger using operational amplifier TL082
b) Astable and Monostable using operational amplifier using TL082.
6.Design of a function generator and VCO using op-Amp and MPY634
7. Design and test a Low Dropout regulator using op-amps for a given voltage regulation characteristic and compare the characteristics with TPS7250 IC
8. Design of a switched mode power supply that can provide a regulated output voltage for a given input range and compare the characteristics using the TPS40200 IC
9*. Study of IC-555 applications- astable, monostable multivibrator.
10*. Study of Single Phase Full-wave bridge rectifier with RL load.

Any three experiments are to be conducted of following experiments:
1. Study of Three Phase Full-wave Rectifier with R load.
2.Design Low pass, High pass and Band pass, stop band 2nd order Butterworth active filters using universal active filter topology.
3. Study of Instrumentation amplifier using three Op-amp, CMR measurement using TL082.

4.Examine the operation of a PLL designed using TL082 and MPY634 and to determine the free running frequency, the capture range and the lock in range of PLL

5. Transistor amplifiers: frequency response of BJT, multistage BJT amplifier.
 6*. Study of Single Phase Half-Wave Rectifier.
7. Study of op-amp as a ZCD & Comparator
8. Study of various flip-flops and verification of truth table.
9. Study and verify shift register operation (IC 7495).

Reference Material:
1. Data Sheet: http://www.ti.com/lit/ds/symlink/tl082.pdf
2. Application Note: http://www.ti.com/lit/an/sloa020a/sloa020a.pdf
3. MPY634 Data Sheet: http://www.ti.com/lit/ds/symlink/mpy634.pdf
4. Application Note: http://www.ti.com/lit/an/sbfa006/sbfa006.pdf
5. ASLK Pro Manual: http://download.mikroe.com/documents/specials/educational/aslk-pro/aslk-pro-manual-v103.pdf

Audit Course-10

PROCESSOR ARCHITECTURE AND INTERFACING

UNIT – I INTRODUCTION TO ASSEMBLY LANGUAGE PROGRAMMING & 80386PROCESSOR8 Hours

Introduction to assembly language programming, ALP tools- Assembler, Linker, Loader, Debugger, Emulator, Assembler directives, Far and near procedure, Macros, DOS Internals, DOS Calls, 80386 and - Features and Architecture, Register Set, 80386 Real mode segmentation and Address translation Addressing modes, Instruction set.

UNIT – II 80386 MEMORY MANAGEMENT   8 Hours
Pin Description of 80386, 16/32-bit data transfer mechanism, Pipelined & Non pipelined bus cycles.Segmentation - support registers and Data structures, Descriptors, Memory management throughsegmentation, Logical to linear/physical address translation.
Privileged instructions, Protection in segmentation, Inter-privilege level transfer using Call gatesandconfirming code segment.

UNIT – III 80386 – PRIVILEGE PROTECTION, MULTITASKING & INTERRUPTS, EXCEPTIONS   8 Hours

Paging - support registers and Data structures, Descriptors, Linear to physical address translation, Page level protection.
Multitasking - Support registers and Data structures, Descriptors, Task switching.
Real and Protected mode Interrupt structure - IVT, IDT, Type of exceptions and Processing.

UNIT – IV INTRODUCTION TO ~~8051~~ MSP430 MICROCONTROLLER   8 Hours
Difference between microprocessor and microcontroller,16-bit low power MSP430 microcontroller - Features, Architecture, Pin Description. On-Chip data memory and program memory organization - Register set, Register bank and Special Function Registers (SFRs).
Addressing modes, Instruction set. External data memory and program memory organization.

UNIT – V PORTS, INTERRUPTS & TIMERS/COUNTERS OF MSP430   8 Hours

I/O ports programming ,Programming System registers, pull up/down registers concepts, Interrupts and Interrupt programming - Structure and Response, Related SFRs and Configuration.
Timers/counters programming - Structure, Related SFRs, Operating modes, Configuration, Low Power aspects of MSP430: low power modes
Serial port programming - Related SFRs, Operating modes, Baud rate calculation and Configuration, Implementing and programming UART, I2C, SPI interface using MSP430.

**UNIT - VI EMBEDDED NETWORKING USING MSP430 AND INTERNET OF THINGS
                                        8 Hours**

IoT overview and architecture, Overview of wireless sensor networks and design examples. Various wireless connectivity: NFC (e.g., RF430CL330H, RF430CL331H, RF430FRL15xH), ZigBee (e.g. CC2538), Bluetooth (e.g., CC256x), Bluetooth Low Energy (e.g., CC2640), Wi-Fi (e.g. CC3100). Adding Wi-Fi capability to the Microcontroller, Embedded Wi-Fi (e.g., CC3200), User APIs for Wireless and Networking applications, Building IoT applications using CC3100 user API for connecting sensors

Text Books

1. James Turley, "Advanced 80386 Programming Techniques", McGraw Hill Education.
2. M. A. Mazidi, J. G. Mazidi, "The 8051 Microcontroller and Embedded Systems", Pearson Education
3. Getting Started with the MSP430 Launchpad by Adrian Fernandez, Dung Dang, Newness publication ISBN-13: 978-0124115880
4. MSP430 microcontroller basics 1st Edition by John H. Davies (Author), Newnes Publication ISBN-13: 978-0750682763
5. Ajay V. Deshmukh, "Microcontrollers, Theory and applications", Tata McGraw-Hill Companies – 2005
6. A.K.Ray and Bhurchandi, "Advanced Microprocessors and Peripherals", 2nd Edition, TMH Publications.

Reference Books

1. Walter A. Tribel, Avtar Singh, "The 8088 and 8086 Microprocessors", 4th edition, Prentice Hall of India
2. Ray Duncan, "Advanced MS DOS Programming", 2nd edition, BPB Publications
3. Peter Abel, NiyazNizamuddin, "IBM PC Assembly Language and Programming", Pearson Education
4. Kenneth Ayala ,"The 8051 Micro Controller", 3rd edition, Delmar Cengage Learning
5. I. Scott MacKenzie, Raphael C.-W. Phan, "8051 Microcontroller", 4th edition, Pearson Education
6. Joshi, "Processor Architecture and Interfacing", Wiley, ISBN-9788126545605
7. Douglas V. Hall, "Microprocessors and Interfacing", 2nd Revised Edition, TMH Publications.
8. Liu & Gibson, "Microcomputer Systems: The 8086/8088 Family: Architecture, Programming and Design", 2nd ed., PHI
9. Krishna Kant, "Microprocessors and Microcontrollers", PHI Publishers

Other References:
1. http://processors.wiki.ti.com/index.php/MSP430_LaunchPad_Low_Power_Mode
2. http://processors.wiki.ti.com/index.php/MSP430_16-Bit_Ultra-Low_Power_MCU_Training
3. RF430CL330H :
   - Datasheet: http://www.ti.com/lit/ds/symlink/rf430cl330h.pdf
4. RF430CL331H:
   - Datasheet: http://www.ti.com/lit/ds/symlink/rf430cl331h.pdf
5. Datasheet: RF430FRL15xH:
   - Datasheet: http://www.ti.com/lit/ds/symlink/rf430frl152h.pdf
   - User Guide: http://www.ti.com/lit/ug/slau506/slau506.pdf
6. CC2538:
   - Datasheet: http://www.ti.com/lit/ds/symlink/cc2538.pdf
7. CC256x:
   - Datasheet: http://www.ti.com/lit/ds/symlink/cc2560.pdf
8. CC2640:
   - Datasheet: http://www.ti.com/lit/ds/symlink/cc2640.pdf
   - User Guide: http://www.ti.com/lit/ug/swcu117f/swcu117f.pdf

9. CC3100 and CC3200: http://www.ti.com/lit/ug/swru368a/swru368a.pdf

Processor Interfacing Laboratory

Group A: Microprocessor Programming
1. Write Assembly Language Program (ALP) to add array of N numbers stored in the memory.
2. Write menu driven ALP to convert 4-digit Hex number into its equivalent BCD number and 5-digit BCD number into its equivalent HEX number. Make your program user friendly to accept the choice from user for
i. HEX to BCD ii. BCD to HEX iii. EXIT.
Display proper strings to prompt the user while accepting the input and displaying the result. Write near procedures to complete the task.
3. Write ALP to perform following operation on string:
i. Find and display length
ii. Display reverse
iii. Check whether string is palindrome or not.
Display proper strings to prompt the user while accepting the input and displaying the result. Write near procedures to complete the task.
4. Write menu driven ALP to perform string manipulations. The strings to be accepted from the user is to be stored in code segment Module_1 and write FAR PROCEDURES in code segment Module_2 to perform any two of the following string operations:
i. Concatenation of two strings.
ii. Comparison of two strings.
iii. Finding Number of occurrences of a sub-string in the given string
iv. Finding number of alphabets, digits, special characters, lower & upper case alphabets, words and number of lines from the text.
Note: Use PUBLIC and EXTERN directives. Create .OBJ files of both the modules and link them to create an .EXE file.
Group B: Microcontroller Programming
Embedded C Experiments using MSP430:

1. Learn and understand how to configure MSP-EXP430G2 Launchpad digital I/O pins. Write a C program for configuration of GPIO ports for MSP430 (blinking LEDs, push buttons interface).
   Exercises:
   a) Modify the delay with which the LED blinks.
   b) Modify the code to make the green LED blink.
   c) Modify the code to make the green and red LEDs blink:
      i. Together
      ii. Alternately
   d) Alter the code to turn the LED ON when the button is pressed and OFF when it is released.
   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. Usage of Low Power Modes:
   Configure the MSP-EXP430G2 Launchpad for Low Power Mode (LPM3) and measure current consumption both in active and low power modes. Use MSPEXP430FR5969 as hardware platform and measure active mode and standby mode current.
   Exercises:
   a) How many Low power modes are supported by the MSP430G2553 platform?
   b) Measure the Active and Standby Current consumption in LPM3 mode for the same application using MSP430F5529 LaunchPad

3. Learn and understand GPIO based Interrupt programming. Write a C program and associated GPIO ISR using interrupt programming technique.
   Exercises:
   a) Write the code to enable a Timer interrupt for the pin P1.1.
   b) Write the code to turn on interrupts globally

4. Implement Pulse Width Modulation to control the brightness of the on-board, green LED. This experiment will help you to learn and understand the configuration of PWM and Timer peripherals of the MSP430G2553.
   Exercises:
   a) Observe the PWM waveform on a particular pin using CRO.
   b) What is the maximum resolution of PWM circuitry in MSP430G2 Launchpad?
   c) Change the above code to create a PWM signal of 75% duty cycle on particular PWM pin.

5. Learn and understand how to configure the PWM and ADC modules of the MSP-EXP430G2 Launchpad to control the DC motor using external analog input.
   Exercises:
   a) What is the maximum resolution of PWM circuitry in MSP430G2 LaunchPad and how it can be achieved using program?
   b) Create a PWM signal of 75% duty cycle on particular PWM pin.
   c) Create Switch case code from the example code to run the DC Motor in 3 set of speeds.

6. Configure of Universal Serial Communication Interface (USCI) module of MSP430G2553 for UART based serial communication. The main objective of this experiment is to use UART of the MSP430G2553 to communicate with the computer.
   Exercise:
   Modify the above code to transmit the set of strings to the serial terminal via UART as shown below:
   char str1[]="MSP430G2 launchpad"
   char str2[]= "Ultra low power mixed signal processing applications"

7. Understand and Configure 2 MSP430F5529 Launchpad in master-slave communication mode for SPI protocol.
   Exercises:
   a) Which port pins of MSP430 can be configured for SPI communication?
   b) What is the data transfer rate supported by MSP430 for SPI communication?

8. A basic Wi-Fi application: Configure CC3100 Booster Pack connected to MSP430F5529 launchpad as a Wireless Local Area Network (WLAN) Station to send Email over SMTP.

   Exercises:
   a) Identify the code that helps in establishing connection over SMTP. Modify the code to trigger E-mail application based upon external analog input.
   b) How to configure the AP WLAN parameters and network parameters (IP addresses and DHCP parameters) using CC3100 API.

Lab Manual:
1) www.ti.com/lab-maunals
   - Embedded System Design using MSP430 Launchpad Development Kit - Lab Manual,

Audit Course-11

Digital Electronics and Logic Design

Unit I Combinational Logic Design   **09 Hours**
Logic minimization: Representation of truth-table, Sum of Product (SOP) form, Product of Sum(POS) form, Simplification of logical functions, Minimization of SOP and POS forms using KMaps up to 4 variables and Quine-McCluskey Technique, realization of logic gates.
Design of Combinational Logic: Code converter - BCD, Excess-3, Gray code, Binary Code.
Half- Adder, Full Adder, Half Subtractor, Full Subtractor, Binary Adder (IC 7483), BCD adder, Look ahead carry generator, Multiplexers (MUX): MUX (IC 74153, 74151), MUX tree, Demultiplexers (DEMUX)- Decoder. (IC 74138, IC 74154). DMUX Tree, Implementation of SOP and POS using MUX, DMUX, Comparators, Parity generators and Checker, Priority Encoders.

Unit II Sequential Logic Design   **09 Hours**
Flip- flop: SR, JK, D, T; Preset & Clear, Master and Slave Flip Flops, Truth Tables and Excitation tables, Conversion from one type to another type of Flip Flop. **Registers:** Buffer register, shift register, Applications of shift registers. **Counters:** Asynchronous counter. Synchronous counter,ring counters, BCD Counter, Johnson Counter, Modulus of the counter (IC 7490).

Synchronous Sequential Circuit Design: Models – Moore and Mealy, State diagram and State Tables, Design Procedure, Sequence generator and detector. **Asynchronous Sequential Circuit Design:** Difference with synchronous circuit design, design principles and procedure, applications

Unit III Algorithmic State Machines   **09 Hours**
Algorithmic State Machines: Finite State Machines (FSM) and ASM, ASM charts, notations, construction of ASM chart and realization for sequential circuits, Sequence Generator, Types of Counters. **VHDL:** Introduction to HDL, Data Objects & Data Types, Attributes., VHDL- Library, Design Entity, Architecture, Modeling Styles, Concurrent and Sequential Statements,
Design Examples: VHDL for Combinational Circuits-Adder, MUX, VHDL for Sequential Circuits, Synchronous and Asynchronous Counter.

Unit IV Programmable Logic Devices   **09 Hours**
ROM as PLD, Programmable Logic Array (PLA), Programmable Array Logic (PAL), Designing combinational circuits using PLDs.

Unit V Logic Families   **09 Hours**

Classification of logic families: Unipolar and Bipolar Logic Families, Characteristics of Digital ICs: Speed, power dissipation, figure of merits, fan-out, Current and voltage parameters, Noise immunity, operating temperature range, power supply requirements. **Transistor-Transistor Logic:** Operation of TTL, Current sink logic, TTL with active pull up, TTL with open collector output, Schottkey TTL, TTL characteristics, TTL 5400/7400 series, **CMOS:** CMOS Inverter,CMOS characteristics, CMOS configurations- Wired Logic, Open drain outputs, **Interfacing:** TTL to CMOS and CMOS to TTL. Tristate Logic and Tristate TTL inverter.
Unit VI Microcontrollers   **09 Hours**
Comparison of typical microprocessor and microcontroller. **16- bitMicrocontroller MSP430:** Features, architecture, Pin description, **Programming model**– Special Function Registers, addressing modes, instruction set, Timers and Counters, serial communication, interrupts, interfacing with ADC and DAC.

TextBooks:
1. R.P. Jain, —Modern Digital Electronics‖, TMH, 2012, ISBN–13: 978-0-07- 066911-6.
2. Stephen Brown, ZvonkoVranesic, —Fundamentals of Digital Logic with VHDL Design‖,
McGraw-Hill, ISBN–13:978-1-25-902597-6.
3. MuhammasMazidi, Janice Mazidi and RolinMcKinlay, —The 8051 Microcontroller and
Embedded Systems using Assembly and C‖, Pearson Education, ISBN-13: 9788131758991
4. MSP430 microcontroller basics 1st Edition by John H. Davies (Author), Newnes Publication ISBN-
13: 978-0750682763

References:
1. John Yarbrough, —Digital Logic applications and Design‖, Cengage Learning, ISBN – 13:
978-81-315-0058-3
2. D. Leach, Malvino, Saha, —Digital Principles and Applications‖, Tata McGraw Hill, ISBN
– 13:978-0-07-014170-4.
3. Anil Maini, —Digital Electronics: Principles and Integrated Circuits‖, Wiley India Ltd,
ISBN:978-81-265-1466-3.
4. Norman B & Bradley, —Digital Logic Design Principles, Wiley India Ltd, ISBN:978-81-
265-1258-4.
5. Scott Mackenzie, —The 8051 Microcontroller‖, Prentice Hall India, ISBN-13: 978-
0130195623

Digital Electronics Lab
Suggested List of Laboratory Assignments
Group A
1. Realize Full Adder and Subtractor using a) Basic Gates and b) Universal Gates
2. Design and implement Code converters-Binary to Gray and BCD to Excess-3
3. Design of n-bit Carry Save Adder (CSA) and Carry Propagation Adder (CPA). Design and
Realization of BCD Adder using 4-bit Binary Adder (IC 7483).
4. Realization of Boolean Expression for suitable combination logic using MUX 74151 / DMUX 74154
5. Verify the truth table of one bit and two bit comparators using logic gates and comparator IC
6. Design & Implement Parity Generator using EX-OR.
Group B
7. Flip Flop Conversion: Design and Realization
8. Design and implement a system using flip-flops, to monitor number of vehicles entering and
exiting from a car parking area with maximum capacity of 15 and having separate entry and
exit gates.
9. Design of Ripple Counter using suitable Flip Flops
10. a. Realization of 3 bit Up/Down Counter using MS JK Flip Flop / D Flip Flop
b. Realization of Mod -N counter using (7490 and 74193)
11. Assume a scenario of a hall where students are entering to attend seminar. Design and
implement a system which will increment count if student is entering in the hall and will
decrement count if student is exiting the hall. Assume seating capacity of a hall is 63.
12. Design and Realization of Ring Counter and Johnson Ring counter.
13. Design and implement Sequence generator using JK flip-flop.
14. Design and implement pseudo random sequence generator.
15. Design and implement Sequence detector using JK flip-flop
16. Design of ASM chart using MUX controller Method.

Group C
17. Design and Implementation of Combinational Logic using PLAs.
18. Design and simulation of - Full adder , Flip flop, MUX using VHDL (Any 2)
Use different modeling styles.
19. Design & simulate asynchronous 3- bit counter using VHDL.
20. Design and Implementation of Combinational Logic using PALs.
Group D (Study Assignments)
21. Study of Shift Registers (SISO,SIPO, PISO,PIPO)
22. Study of TTL Logic Family: Feature, Characteristics and Comparison with CMOS Family
23.Learn and understand how to configure MSP-EXP430G2 Launchpad digital I/O pins. Write a C
program for configuration of GPIO ports for MSP430 (blinking LEDs, push buttons interface).

> **Exercises:**
> c) Modify the delay with which the LED blinks.
> d) Modify the code to make the green LED blink.
> c) Modify the code to make the green and red LEDs blink:
>> i. Together
>> ii. Alternately
>
> d) Alter the code to turn the LED ON when the button is pressed and OFF when it is
> released.
> 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.

24.Learn and understand GPIO based Interrupt programming. Write a C program and associated
GPIO ISR using interrupt programming technique.

> **Exercises:**
> a) Write the code to enable a Timer interrupt for the pin P1.1.
> b) Write the code to turn on interrupts globally

25.Implement Pulse Width Modulation to control the brightness of the on-board, green LED. This
experiment will help you to learn and understand the configuration of PWM and Timer peripherals
of the MSP430G2553.

> **Exercises:**
> d) Observe the PWM waveform on a particular pin using CRO.
> e) What is the maximum resolution of PWM circuitry in MSP430G2 Launchpad?
> f) Change the above code to create a PWM signal of 75% duty cycle on particular
> PWM pin.

26.The main objective of this experiment is to control the on-board, red LED by the analog input
from a potentiometer. This experiment will help you to learn and understand how to configure an
ADC to interface with a potentiometer.

> **Exercises:**
> a) Alter the threshold to 75% of Vcc for the LED to turn on.
> b) Modify the code to change the Reference Voltage from Vcc to 2.5V.

27.Learn and understand how to configure the PWM and ADC modules of the MSP-EXP430G2
Launchpad to control the DC motor using external analog input.

> **Exercises:**
> d) What is the maximum resolution of PWM circuitry in MSP430G2 LaunchPad and
> how it can be achieved using program?
> e) Create a PWM signal of 75% duty cycle on particular PWM pin.

f) Create Switch case code from the example code to run the DC Motor in 3 set of speeds.

28.Configure of Universal Serial Communication Interface (USCI) module of MSP430G2553 for UART based serial communication. The main objective of this experiment is to use UART of the MSP430G2553 to communicate with the computer.

Exercise:
Modify the above code to transmit the set of strings to the serial terminal via UART as shown below:

char str1[]="MSP430G2 launchpad"
char str2[]= "Ultra low power mixed signal processing applications"

Lab Manual:
2) www.ti.com/lab-maunals
- Embedded System Design using MSP430 Launchpad Development Kit - Lab Manual