SREE VIDYANIKETHAN ENGINEERING COLLE

(An autonomous institution affiliated to JNTUA, Anantapuramu)

SreeSainath Nagar, Tirupati – 517 102.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Lab Manual

EMBEDDED SYSTEMS LAB (16BT70432)

(IV B. Tech., I-Semester, EEE)

Prepared by
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Department of EEE

SREE VIDYANIKETHAN ENGINEERING COLLEGE

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Department of Electrical and Electronics Engineering

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Department of Electrical & Electronics Engineering

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Embedded Systems Lab (16BT70432)

SREE VIDYANIKETHAN ENGINEERING COLLEGE

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Sree Sainath Nagar, Tirupati – 517 102

Vision

To be one of the Nation's premier Engineering Colleges by achieving the highest order of excellence in Teaching and Research.

Mission

Through multidimensional excellence, we value intellectual curiosity, pursuit of knowledge building and dissemination, academic freedom and integrity to enable the students to realize their potential. We promote technical mastery of Progressive Technologies, understanding their ramifications in the future society and nurture the next generation of skilled professionals to compete in an increasingly complex world, which requires practical and critical understanding of all aspects.

Department of Electrical & Electronics Engineering

Vision

To become the Nation's premiere Centre of excellence in electrical engineering through teaching, training, research and innovation to create competent engineering professionals with values and ethics.

Mission

1. Department of Electrical Engineering strives to create human resources in Electrical Engineering to contribute to the nation development and improve the quality of life.
2. Imparting Knowledge through implementing modern curriculum, academic flexibility and learner centric teaching methods in Electrical Engineering.
3. Inspiring students for aptitude to research and innovation by exposing them to industry and societal needs to create solutions for contemporary problems.
4. Honing technical and soft skills for enhanced learning outcomes and employability of students with diverse background through comprehensive training methodologies.
5. Inculcate values and ethics among students for a holistic engineering professional practice.

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PEOs, POs & PSOs

Embedded Systems Lab (16BT70432)

Program Educational Objectives - B.Tech - EEE

1. Graduates will be enrolled in academic program in the disciplines of electrical engineering or other disciplines.
2. Graduates will be employed as productive and valued engineers in reputed industries.
3. Graduates will assume increasingly responsible positions and use the technical skills and analytical acumen to address professional values, ethics, leadership, and team skills for execution of complex technological solutions.

Program Outcomes - B.Tech – EEE

1. Acquire knowledge of computing mathematics, sciences and concepts of electrical engineering.
2. Ability to perform analysis of electrical power systems.
3. Design and develop electric machines power electronic converters, control systems and schemes of electrical power transmission and protection.
4. Skills to solve problems in electric circuits, efficiency of electric machines and power system stability.
5. Use of electrical engineering principles to modern electric generation, transmission and distribution.
6. Create solutions of social context the impact of electrical engineering.
7. Practice electrical engineering in compliance with environmental standards.
8. Follow ethical code of conduct in professional activities.
9. Achieve personal excellence and ability to work in groups.
10. Develop effective communication in professional transactions.
11. Life skills for effective project management.
12. Appreciate the significance and applications of electrical engineering and to engage in lifelong learning for knowledge and skill up gradation.

Program Specific Outcomes

On successful completion of the program, engineering graduates will

1. Demonstrate knowledge of Electrical and Electronic circuits, Electrical Machines, Power Systems, Control Systems, and Power Electronics for solving problems in electrical and electronics engineering.
2. Analyze, design, test and maintain electrical systems to meet the specific needs of the Industry and society.
3. Conduct investigations to address complex engineering problems in the areas of Electrical Machines, Power Systems, Control Systems and Power Electronics.
4. Apply appropriate techniques, resources and modern tools to provide solutions for problems related to electrical and electronics engineering.

Syllabus

IV B.Tech.,I-Semester, EEE

16BT70432: EMBEDDED SYSTEMS LAB

L	T	P	C
-	-	3	2

DAY-TO-DAY EVALUATION	INTERNAL EVALUATION	END LAB EXAMINATION	TOTAL
30 MARKS	20 MARKS	50 MARKS	100 MARKS

PREREQUISITES: Course on Embedded systems.

COURSE DESCRIPTION:
IDE for Embedded System Design using MSP430; Interfacing Switch & LED; Timers-WDT, Configuring, Programming; ADC-usage; Power down modes; DAC; PWM Generator; Networking - SPI, Wi-Fi.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge in designing complex energy efficient embedded systems.
CO2. Analyze usage of various on-chip resources like GPIO, Timers, Interrupts, ADC, DAC, Comparator, SPI.
CO3. Design embedded systems to suit market requirements.
CO4. Solve engineering problems by proposing potential solutions using industry choice advanced Microcontrollers.
CO5. Apply appropriate techniques, resources, and CCSV6 based IDE for modeling embedded systems with understanding of limitations.
CO6. Provide embedded system solutions for societal needs.
CO7. Work individually and in a group to develop embedded systems.
CO8. Communicate effectively in oral and written form in the field of embedded systems.

DETAILED SYLLABUS:

Conduct any TEN experiments from the following:

1. Introduction to MSP430 launch pad and Programming Environment.
2. Read input from switch and Automatic control/flash LED (soft-ware delay).
3. Interrupts programming example using GPIO.
4. Configure watchdog timer in watchdog & interval mode.
5. Configure timer block for signal generation (with given frequency).
6. Read Temperature of MSP430 with the help of ADC.
7. Test various Power Down modes in MSP430.
8. PWM Generator.
9. Use Comparator to compare the signal threshold level.
10. Speed Control of DC Motor
11. Master slave communication between MSPs using SPI.
12. Networking MSPs using Wi-Fi.

TOOL REQUIREMENT:
Code Composer Studio Version 6, MSP430 based launch pads, Wi-Fi booster pack.

REFERENCE BOOKS:

1. John H Davies, *MSP430 Microcontrollers Basics*, Newnes Pub-lishers, 1st edition, 2008.
2. C P Ravikumar, *MSP430 Microcontrollers in Embedded Sys-tem Projects*, Elite Publishing House , 1st edition, 2012.

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Department of Electrical & Electronics Engineering

IV B.Tech., I-Semester, EEE

Embedded Systems Lab (16BT70432)

Course Outcomes	Program Outcomes								Program Specific Outcomes			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
	DEMONSTRATION	**ANALYSIS**	**DESIGN**	**PROBLEM SOLVING**	**APPLY**	**ENG & SOCIETY**	**WORK INDIVIDUAL**	**COMMUNICATION**	**CO1**	**CO2 & CO3**	**CO4**	**CO5**
CO1	H								H			
CO2	M	H								H		
CO3	M	M	H							H		
CO4	M	M	M	H							H	
CO5	M	L	M	M	H							H
CO6	M	M	M	M	M	H						
CO7	M	M	M	M	M	M	H					
CO8	M	M	M	M	M	M	M	H				

Correlation Levels: H - High M - Medium L – Low

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Rubrics

Embedded Systems Lab (16BT70432)

S. No	Course Outcome			Rubric 1 (1-2)M Average	Rubric 2 (3-4) M Good	Rubric 3 (5)M Very Good	Score X (Max 5M)
1	CO1	PO1	emonstrate knowledge in designing complex energy efficient embedded systems.	Unable to recall the basic theoretical knowledge of the experiment and unable to follow the practical procedure	Able to recall the basic theoretical knowledge of the experiment and unable to follow the practical procedure	Able to recall the basic theoretical knowledge of the experiment and able to follow the practical procedure.	
	CO2	PO2	Analyze usage of various on-chip resources like GPIO, Timers, Interrupts, ADC, DAC, Comparator, SPI.	Unable to analyse Characteristics of servomotor.	Able to explain the operation of motors	Able to analyse and apply, Power electronics circuits for real time	
3	CO3	PO3	Design embedded systems to suit market requirements.	Unable not able to follow the experimental procedures and mathematical calculations	Able to follow the experimental procedures and mathematical calculations. But unable to evaluate and interpret properly.	Able to follow experimental procedures and mathematical calculations. Also able to present and interpret properly and co-relate the practical with the theory.	
4	CO4	PO4	Solve engineering problems by proposing potential solutions using industry choice advanced Microcontrollers.	Unable to interpret the experimental results with the programming and control strategy to meet the required specifications	able to interpret the experimental results with the programming and control strategy to meet the required specifications. Unable to plan and design.	Able to plan and design and also to interpret the experimental results with the programming and control strategy to meet the required specifications.	
5	CO5	PO5	Apply appropriate techniques, resources, and CCSV6 based IDE for modeling embedded systems with understanding of limitations.	Unable to select appropriate tool and develop the program for simulation	Able to select appropriate tool for simulation but lags in developing the model/program for simulation.	Able to select appropriate tool and develop the program logic for simulation. Able to interpret the results and correlate them with practical.	
6	CO6	PO6	Provide embedded system solutions for societal needs.	Unable to handle as an individual.	Occasionally works as an individual	Able to work and execute the problem individually.	
7	CO7	PO9	Work individually and in a group to develop Embedded Systems.	Lab report is not systematic	Lab report is systematic at some places to demonstrate	Report is fully systematic and also in specified format.	
	CO8	PO10	Communicate effectively in oral and written form in the field of Embedded Systems.	Unable to follow the professional code of ethics	able to follow the professional code of ethics and can unable to define standard code of ethics	able and apply the professional code of ethics.	
8	**Total Score** (Max 30M)				$Y = \sum_{i=1}^{6} X_i$		
9	**Average Marks Obtained**				$Z = \frac{Y}{6}$		
10	**Marks Obtained**			= Z * 3			
11	**Assessment**				Average /Good / Very Good		

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Year and Semester:	**IV B.Tech. I Semester**	Roll No. :	
Name of the Laboratory:	**Embedded Systems Lab**	Course Code:	**16BT70432**

S. No.	Experiment Name	CO1 DEMONSTRATION	CO2 ANALYSIS	CO3 DESIGN	CO4 PROBLEM SOLVING	CO5 APPLY	CO6 ENG & SOCIETY	CO7 WORK INDIVIDUAL	CO8 COMMUNICATION	TOTAL	Signature of the Faculty
		3 M	3 M	6 M	3 M	3 M	3 M	3 M	6 M	30 M	
1	Introduction to MSP430 launch pad and Programming Environment. (Study Experiment)										
2	Read input from switch and Automatic control/flash LED (soft-ware delay).										
3	Interrupts programming example using GPIO.										
4	Configure watchdog timer in watchdog mode & interval mode.										
5	Configure timer block for signal generation (with given frequency)										
6	Read Temperature of MSP430 with the help of ADC.										
7	Test various Power Down modes in MSP430.										
8	PWM Generator										
9	Use Comparator to compare the signal threshold level										
10	Speed Control of DC Motor										
11	Master slave communication between MSPs using SPI										
12	Networking MSPs using Wi-Fi.										

IV B.Tech., I-Semester, EEE
Embedded Systems Lab (16BT70432)

General Instructions

1. Shirts should be tucked in.
2. Perform only appropriate experiments and be sure that you understand the procedure involved before you begin.
3. Supply to test table should be obtained only through the lab technician.
4. Energize the circuit only after getting approval from the faculty-in-charge.
5. Students who are not appropriately attired will not be allowed to perform experiments.
6. No horse-play before, during or after lab.
7. Be familiar with emergency procedures & know the location of emergency equipment. First aid kit for minor injuries is with the lab technician.
8. Do not modify equipment settings unless instructed by lab handout or lab instructor.
9. Unauthorized experiments and working in the laboratory outside the class hours without permission are strictly prohibited.
10. Keep bags in the designated areas.
11. If you feel unhealthy or dizzy while doing the experiment, stop immediately, sit down and notify the instructor.

1. BLINK IN-BUILD LED1 & LED2

(1A) To Blink GREEN LED with GPIO

AIM: The main objective of this experiment is to blink the on-board, GREEN LED (connected to P1.0) using GPIO.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable
	4) Patch Chords

THEORY :

The MSP430F5529 has two LED's connected to GREEN LED (P1.0) and RED LED (P4.6) on the MSP430F5529 Launch-Pad for visual feedback. In this experiment, the code programmed into the MSP430F5529 processor toggles the output on Port P1.0 at fixed time intervals computed within the code. A HIGH on P1.0 turns the LED ON, while a LOW on P1.0 turns the LED OFF. Thus, the toggling output blinks the GREEN LED connected to it.

PROGRAM:

```
#include<msp430.h>
intmain(void)

{
    WDTCTL = WDTPW | WDTHOLD;           // Stop watchdog timer
    PM5CTL0 &= ~LOCKLPM5;  // Disable the GPIO power-on default high-
    impedance mode to activate previously configured port settings
    P1DIR |= 0x01; // set the pin 1.0 direction to O/P
    while(1)

    {
        volatile unsigned long i;
        P1OUT ^=0x01; // blink LED
         i = 50000;
        doi--;
        while(i != 0);
    }

    return 0;

}
```

PROCEDURE:

1. 1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.

2. Build, program and debug the code into the LaunchPad using CCS to view the status of the LED.

3. In the CCS debug perspective, select **View --> Registers**.

RESULT :

(1B) To Blink an RED LED with GPIO

AIM: The main objective of this experiment is to blink the onboard, RED LED (connected to P4.6) using GPIO.

PROGRAM:

```
#include<msp430.h>
intmain(void)

{
        WDTCTL = WDTPW | WDTHOLD;           // Stop watchdog timer
        PM5CTL0 &= ~LOCKLPM5; // Disable the GPIO power-on default high-
                        //impedance mode to activate previously configured port settings
        P4DIR |= 0x40; // set the pin 4.6 direction to O/P
                while(1)
                        {
                volatileunsignedlongi;
                P4OUT ^=0x40;// blink LED
                i = 50000;
                doi--;
                while(i != 0);
                        }
        return 0;
}
```

RESULT :

(1C) To Blink an RED LED & GREEN LED Together

AIM: The main objective of this experiment is to blink the onboard, RED LED (connected to P4.6) and GREEN LED(connected to P1.0) together using GPIO.

PROGRAM:

```
#include<msp430.h>
intmain(void)
{
        WDTCTL = WDTPW | WDTHOLD;           // Stop watchdog timer
        PM5CTL0 &= ~LOCKLPM5; // Disable the GPIO power-on default //
                high-impedance mode to activate previously configured port settings
        P1DIR |= 0x01; P4DIR |= 0x40;
        P1OUT |= 0x01; P4OUT |= 0x40;
        while(1)
                {
                        volatileunsignedlongi;
                        P1OUT ^= 0x01;
                        P4OUT ^=0x40;
                        i = 50000;
                        doi--;
                        while(i != 0);
                }
        return 0;
}
```

RESULT :

(1D) To Blink an RED LED & GREEN LED Alternatively

AIM: The main objective of this experiment is to blink the onboard, RED LED (connected to P4.6) and GREEN LED(connected to P1.0) alternatively using GPIO.

PROGRAM:

```
#include<msp430.h>
intmain(void)
{
        WDTCTL = WDTPW | WDTHOLD; // Stop watchdog timer
        PM5CTL0 &= ~LOCKLPM5; // Disable the GPIO power-on default //high-
                        //impedance mode to activate previously configured port settings
```

```
        P1DIR |= 0x01;
        P4DIR |= 0x40;
        P1OUT |= 0x01;
        P4OUT &= ~0x40;
        while(1)
                {
                        volatileunsignedlongi;
                        P1OUT ^= 0x01;
                        P4OUT ^=0x40;
                        i = 50000;
                        doi--;
                        while(i != 0);
                }
        return 0;
}
```

RESULT :

2. READ INPUT FROM SWITCH AND GLOW LED

(2A) To Blink an GREEN LED using Button

AIM: The main objective of this experiment is to blink the onboard, GREEN LED (connected to P1.0) whenever button (connected to P.1.1) is pressed and OFF when released using GPIO.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable
	4) Patch Chords

THEORY :

The MSP430F5529 has two LED's and two push BUTTONS connected to GREEN LED (P1.0),S2(P1.1) and RED LED (P4.6),S1(P4.5) on the MSP430F5529 LaunchPad for visual feedback. In this experiment, the code programmed into the MSP430F5529 processor to turn on GREEN LED when button is pressed & OFF when button is released are computed within the code.

PROGRAM:

```
#include<msp430.h>
int main(void)
{
        WDTCTL = WDTPW | WDTHOLD;           // Stop watchdog timer
        PM5CTL0 &= ~LOCKLPM5; // Disable the GPIO power-on default high-
                impedance mode //to activate previously configured port settings
        P1DIR |= 0x01;
        P1REN |= 0x02;
        while(1)
                {
                        if(P1IN & BIT1)
                        {
                        P1OUT &= ~BIT0;
                        }
                        else
                        {

                        }
                }
```

```
        P1OUT |= BIT0;

return 0;
}
```

PROCEDURE:

1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS to view the status of the LED.
3. In the CCS debug perspective, select **View --> Registers**.

RESULT :

(2B) To Blink an GREEN LED using Button with Delay 1sec

AIM: The main objective of this experiment is to make the green LED stay ON for around 1 second every time the button is pressed.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

The MSP430F5529 has two LED's and two push BUTTONS connected to GREEN LED (P1.0),S2(P1.1) and RED LED (P4.6),S1(P4.5) on the MSP430F5529 LaunchPad for visual feedback. In this experiment, the code programmed into the MSP430F5529 processor make the green LED stay ON for around 1 second every time the button is pressed.

PROCEDURE:

1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS to view the status of the red LED.
3. In the CCS debug perspective, select **View --> Registers**.

PROGRAM:

```
#include<msp430.h>
int main(void) {
WDTCTL = WDTPW | WDTHOLD;           // Stop watchdog timer
// Disable the GPIO power-on default //high-//impedance mode to activate previously
configured port settings
PM5CTL0 &= ~LOCKLPM5;
P1DIR |= 0x01;
P1REN |= 0x02;
while(1){ volatileunsignedlongi;
if(P1IN & BIT1){
P1OUT &= ~BIT0;
 }else
{

}
P1OUT |= BIT0; i = 50000;
doi--;
while(i != 0);
}
return 0;
}
```

(2C) To Blink an GREEN LED & RED LED using Button

AIM: The main objective of this experiment is to turn the red LED ON when the button is pressed and the green LED ON when the button is released.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

The MSP430F5529 has two LED's and two push BUTTONS connected to GREEN LED (P1.0),S2(P1.1) and RED LED (P4.6),S1(P4.5) on the MSP430F5529

LaunchPad for visual feedback. In this experiment, the code programmed into the MSP430F5529 processor turn the red LED ON when the button is pressed and the green LED ON when the button is released.

PROCEDURE:

1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS to view the status of the LED.
3. In the CCS debug perspective, select **View**

--> Registers PROGRAM:

```
#include<msp430.h>
intmain(void) {

WDTCTL = WDTPW | WDTHOLD;   // Stop watchdog timer

// Disable the GPIO power-on default //high-impedance mode to activate previously
configured port settings
PM5CTL0 &= ~LOCKLPM5;
P1DIR |= 0x01;
P1REN |= 0x02;
P4DIR |= 0x40;
while(1){
volatileunsignedlongi;
if(P1IN & BIT1){
        P1OUT |= BIT0;
        P4OUT &= ~BIT6;
}else{
        P1OUT &= ~BIT0;
        P4OUT |= BIT6;
    }
}
return 0;
}
```

RESULT:

3. INTERRUPTS PROGRAMMING EXAMPLE USING GPIO

AIM: The main objective of this experiment is to write a C program and associated GPIO ISR using interrupt programming technique.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

The MSP430F5529 has two LED's and two push BUTTONS connected to GREEN LED (P1.0),S2(P1.1) and RED LED (P4.6),S1(P4.5) on the MSP430F5529 LaunchPad for visual feedback. In this experiment, the code programmed into the MSP430F5529 processor toggle the GREEN LED whenever interrupt is generated.

```
     MSP430FR59xx
      -----------------
     /|\|              XIN|-
     | |               | 32kHz
   --|RST              XOUT|-
     |                 |
     |        P1.0     |--> LED
     |        P1.1     |--->S2
```

PROCEDURE:

1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS to view the status of the LED.
3. In the CCS debug perspective, select **View --> Registers**
4. Press the S2 and observe the GREEN LED toggled.

PROGRAM:

```
#include<msp430.h> intmain(void)
{
WDTCTL = WDTPW + WDTHOLD; // Stop WDT PM5CTL0 &= ~LOCKLPM5;
P1DIR |= BIT0; // Set P1.0 to output direction
P1REN |= BIT1; // Enable P1.1 internal resistance
P1OUT |= BIT1; // Set P1.1 as pull up resistance
```

```
P1IES |= BIT1; // P1.1 High/Low Edge
P1IFG &= ~BIT1; // P1.1 IFG Cleared
P1IE |= BIT1; // P1.1 Interrupt Enabled
_bis_SR_register(LPM4_bits + GIE); // Enter LPM4 w/ interrupt
_no_operation();
return 0;
}
#pragma vector=PORT1_VECTOR
  interruptvoidPort_1 (void)
{
P1OUT ^= BIT0; // Toggle P1.0
P1IFG &= ~BIT1; // P1.1 IFG Cleared
}
```

RESULT:

4. CONFIGURE WATCHDOG TIMER IN WATCHDOG MODE & INTERVAL MODE

AIM: The main objective of this experiment is to configure watchdog timer module in watchdog and Interval time mode and observe its output.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

WDT_A Operation

The watchdog timer module can be configured as either a watchdog or interval timer with the WDTCTL register. WDTCTL is a 16-bit password-protected read/write register. Any read or write access must use word instructions and write accesses must include the write password 05Ah in the upper byte. Any write to WDTCTL with any value other than 05Ah in the upper byte is a password violation and triggers a PUC system reset, regardless of timer mode. Any read of WDTCTL reads 069h in the upper byte. Byte reads on WDTCTL high or low part result in the value of the low byte. Writing byte wide to upper or lower parts of WDTCTL results in a PUC.

Watchdog Timer Counter (WDTCNT)

The WDTCNT is a 32-bit up counter that is not directly accessible by software. The WDTCNT is controlled and its time intervals are selected through the Watchdog Timer Control (WDTCTL) register. The WDTCNT can be sourced from SMCLK, ACLK, VLOCLK, or X_CLK on some devices. The clock source is selected with the WDTSSEL bits. The timer interval is selected with the WDTIS bits.

Watchdog Mode

After a PUC condition, the WDT module is configured in the watchdog mode with an initial ~32-ms reset interval using the SMCLK. The user must setup, halt, or clear the watchdog timer prior to the expiration of the initial reset interval or another PUC is generated. When the watchdog timer is configured to operate in watchdog mode, either writing to WDTCTL with an incorrect password, or expiration of the selected time interval triggers a PUC. A PUC resets the watchdog timer to its default condition.

Interval Timer Mode

Setting the WDTTMSEL bit to 1 selects the interval timer mode. This mode can be used to provide periodic interrupts. In interval timer mode, the WDTIFG flag is set at the expiration of the selected time interval. A PUC is not generated in interval timer mode at expiration of the selected timer interval, and the WDTIFG enable bit WDTIE remains unchanged.

When the WDTIE bit and the GIE bit are set, the WDTIFG flag requests an interrupt. The WDTIFG interrupt flag is automatically reset when its interrupt request is serviced, or it may be reset by software. The interrupt vector address in interval timer mode is different from that in watchdog mode.

WDTCTL Register

Watchdog Timer Control Register

WDTCTL Register

15	14	13	12	11	10	9	8
WDTPW							
7	6	5	4	3	2	1	0
WDTHOLD	WDTSSEL		WDTTMSEL	WDTCNTCL	WDTIS		
rw-0	rw-0	rw-0	rw-0	r0(w)	rw-1	rw-0	rw-0

PROGRAM:

1. A WATCHDOG TIMER:INTERVAL TIMER MODE C PROGRAM:

```
{

WDTCTL = WDT_ADLY_250;   // WDT 250ms, ACLK, interval timer
  IE1 |= WDTIE;                          // Enable WDT
  P1DIR |= 0x01;                        // Set P1.0 to  __bis_SR_register(LPM3_bits + GIE);     //
Enter LPM3
}

// Watchdog Timer interrupt service routine
#pragma vector=WDT_VECTOR
__interrupt voidwatchdog_timer(void)
{
  P1OUT ^= 0x01;           // Toggle P1.0 using exclusive-OR
}
```

2. WATCHDOG MODE: C PROGRAM

```
intmain(void)
{
  WDTCTL = WDT_ARST_1000;
           P1DIR |= 0x01;
           P1OUT ^= 0x01;
__bis_SR_register(LPM3_bits);
}
```

3. WATCHDOG TIMER: WATCDOG MODE ALP PROGRAM

WDCNT: 0000 0001

```
RESET       mov.w   #0280h,SP              ; Initialize stackpointer
SetupWDT    mov.w   #WDT_ARST_1000N,&WDTCTL  ; Set Watchdog Timer
                bis.b   #WDTIE,&IE1
            bis.b   #001h,&P1DIR           ; P1.0 output
            xor.b   #001h,&P1OUT           ; Toggle P1.0
            bis.w   #LPM3,SR               ;
Mainloop    jmp     $
```

RESULT

5.CONFIGURE TIMER BLOCK FOR SIGNAL GENERATION

AIM: The main objective of this experiment is to write a C program and TIMER ISR using interrupt programming technique.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

The MSP430F5529 has two LED's and two push BUTTONS connected to GREEN LED (P1.0),S2(P1.1) and RED LED (P4.6),S1(P4.5) on the MSP430F5529 Launch-Pad for visual feedback. In this experiment, the code programmed into the MSP430F5529 processor Toggle P1.0 using software and TA_0 ISR. Timer0_A is configured for continuous mode, thus the timer overflows when TAR counts to CCR0. In this example, CCR0 is loaded with 50000.

// ACLK = n/a, MCLK = SMCLK = TACLK = default DCO = ~1MHz

```
            MSP430FR59xx
          -----------------
       /|\|            XIN|-
        | |               | 32kHz
        --|RST        XOUT|-
          |               |
          |         P1.0 |--> LED
```

PROCEDURE:

1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS to view the status of the LED.
3. In the CCS debug perspective, select **View --> Registers**
4. Observe the GREEN LED blinks whenever timer overflows.

PROGRAM:

```
#include<msp430.h> intmain(void)
{
WDTCTL = WDTPW | WDTHOLD; // Stop WDT
// Configure GPIO
P1DIR |= BIT0; P1OUT |= BIT0;
```

```
// Disable the GPIO power-on default high-impedance mode to activate
// previously configured port settings
PM5CTL0 &= ~LOCKLPM5;
TA0CCTL0 = CCIE;  // TACCR0 interrupt enabled TA0CCR0 = 20000;
 TA0CTL = TASSEL  SMCLK | MC  UP;    // SMCLK, UP mode
  bis_SR_register(LPM0_bits + GIE);           // Enter LPM0 w/ interrupt
  no_operation();         // For debugger
}
// Timer0_A0 interrupt service routine
#if defined( TI_COMPILER_VERSION ) || defined( IAR_SYSTEMS_ICC )
#pragma vector = TIMER0_A0_VECTOR
  interruptvoidTimer0_A0_ISR (void)
#elif defined( GNUC )
void attribute   ((interrupt(TIMER0_A0_VECTOR))) Timer0_A0_ISR (void)
#else
#error Compiler not supported!
#endif
{
P1OUT ^= BIT0;
}
```

RESULT:

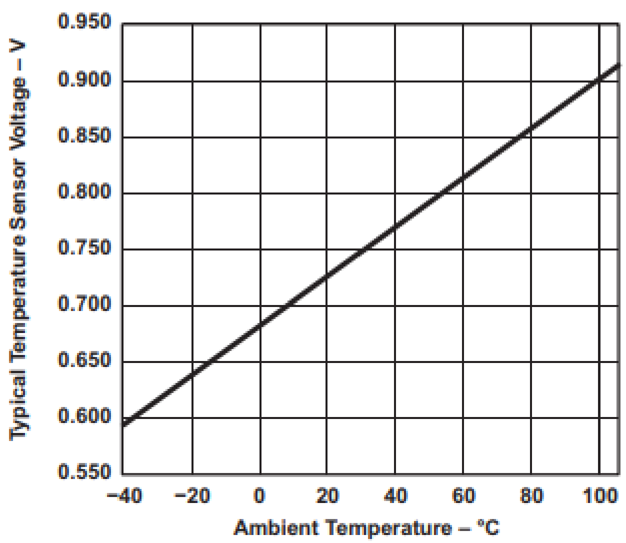
6. READ TEMPERATURE OF MSP430 WITH THE HELP OF ADC

AIM: The main objective of this experiment is to measure temperature using inbuilt ADC module.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

To use the on-chip temperature sensor, select the analog input channel INCHx = 1010. Any other configuration is done as if an external channel were selected, including reference selection and conversion-memory selection. The temperature sensor is part of the reference. Therefore, for devices with the REF module, in addition to the input channels selection INCHx = 1010, configuring ADC12REFON = 1 (for REFMSTR = 0) or REFON = 1 (for REFMSTR = 1) is required to enable the temperature sensor. For the MSP430F54xx (non-A) devices, which do not include the REF module, selecting the temperature sensor by configuring INCHx = 1010 automatically enables the reference generator required for the temperature sensor. Any other configuration is done as if an external channel were selected, including reference selection and conversion-memory selection.



Typical Temperature Sensor Transfer Function

Figure shows a typical temperature sensor transfer function. The transfer function that is shown is only an example; the device-specific data sheet contains the actual parameters for a given device. When using the temperature sensor, the sample period must be greater than 30 µs. The temperature sensor offset error can be large and may need to be calibrated for most applications. Temperature calibration values are available for use in the TLV descriptors (see the device-specific data sheet for locations). Some MSP430 devices include calibration data that can be used to compute temperature more accurately.

PROGRAM:

Read Temperature of MSP430 with the help of ADC

```
#include<msp430.h>
long temp;
long IntDegC;
intmain(void)
{
  WDTCTL = WDTPW + WDTHOLD;                // Stop WDT
  ADC10CTL1 = INCH_10 + ADC10DIV_3;        // Temp Sensor ADC10CLK/4
  ADC10CTL0 = SREF_1 + ADC10SHT_3 + REFON + ADC10ON + ADC10IE;
while(1)
  {
    ADC10CTL0 |= ENC + ADC10SC;            // Sampling and conversion start
__bis_SR_register(CPUOFF + GIE);        // LPM0 with interrupts enabled
     temp = ADC10MEM;
IntDegC = ((temp - 673) * 423) / 1024;
__no_operation();                       // SET BREAKPOINT HERE
  }
}
// ADC10 interrupt service routine
#pragma vector=ADC10_VECTOR
__interrupt voidADC10_ISR (void)
{
    __bic_SR_register_on_exit(CPUOFF);        // Clear CPUOFF bit from 0(SR)
}
```

RESULT:

7. TEST VARIOUS POWER DOWN MODE IN MSP430

AIM: The main objective of this experiment is to Configure the MSP-EXP430FR Launchpad for Low Power Mode (LPM3) and measure current consumption both in active and low power modes.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

The RTC_B module is used to set the time, start RTC operation,and read the time from the respective RTC registers. Software will set the original time to 11:59:30 am on Friday October 7, 2011. Then the RTC will be activated through software, and an alarm will be created for the next minute (12:00:00 pm). The device will then enter LPM3.5 awaiting the event interrupt. Upon being woken up by the event, the LED on the board will be set.we will use MSP-EXP430FR5969 as hardware platform and measure active mode and standby mode current.

ACLK = 32.768kHz, MCLK = SMCLK = DCO = ~1MHz

```
  MSP430FR59xx
   -----------------
  /|\|              XIN|-
  | |               | 32kHz
--|RST        XOUT|-
  |                 |
  |       P1.0     |--> LED
```

PROCEDURE:

1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS to view the status of the LED.
3. In the CCS debug perspective, select **View --> Others-->Energy Trace Technology**
4. Note down the power consumption in Active mode and Low power mode 3.5.

PROGRAM:

```
#include<msp430.h>
voidBoard_Init(void);
voidRTC_Init(void);
voidEnterLPM35(void);
voidWakeUpLPM35(void);
intmain(void)
{
WDTCTL = WDTPW | WDTHOLD;          // Stop WDT
// Determine whether we are coming out of an LPMx.5 or a regular RESET.
if (SYSRSTIV == SYSRSTIV_LPM5WU)
{
}
else
{
}
 // When woken up from LPM3.5, reinit
WakeUpLPM35();     // LPMx.5 wakeup specific init code
  enable_interrupt();    // The RTC interrupt should trigger
while (1);       // Forever loop after returning from RTC ISR.
// Init board & RTC, then enter LPM3.5
Board_Init();   // Regular init code for GPIO and CS
RTC_Init();              // Regular init code for RTC_B EnterLPM35();
}
voidBoard_Init(void)
{
// Port Configuration
P1OUT =  0x00;
P1DIR =  0xFF;
P2OUT =  0x00;
P2DIR =  0xFF;
P3OUT =  0x00;
P3DIR =  0xFF;
```

```
P4OUT =  0x00;
P4DIR =  0xFF;
PJOUT = 0x00;
PJSEL0 |= BIT4 | BIT5;
PJDIR = 0xFFFF;
PM5CTL0 &= ~LOCKLPM5;
CSCTL0_H = CSKEY >>8;   // Unlock CS registers
CSCTL1 = DCOFSEL_0;     // Set DCO to 1MHz
CSCTL2 = SELA LFXTCLK | SELS DCOCLK | SELM DCOCLK;
CSCTL3 = DIVA  1 | DIVS  1 | DIVM 1;     // Set all dividers to 1
CSCTL4 &= ~LFXTOFF;
do
{
CSCTL5 &= ~LFXTOFFG;   // Clear XT1 fault flag
SFRIFG1 &= ~OFIFG;
}while (SFRIFG1&OFIFG);  // Test oscillator fault flag
CSCTL0_H = 0;         // Lock CS registers
}
voidRTC_Init(void)
{
// Configure RTC_B
RTCCTL01 = RTCBCD | RTCHOLD | RTCTEV MIN | RTCTEVIE; // BCD mode, RTC
hold,
enable RTC                // event interrupt for each minute
RTCYEAR = 0x2011;
RTCMON = 0x10;     // Month = 0x10 = October
RTCDAY = 0x07;     // Day = 0x07 = 7th
RTCDOW = 0x05;     // Day of week = 0x05 = Friday
RTCHOUR = 0x11;             // Hour = 0x11
RTCMIN = 0x59;     // Minute = 0x59
RTCSEC = 0x30;     // Seconds = 0x30
RTCCTL01 &= ~RTCHOLD;         // Start RTC calendar mode
voidEnterLPM35(void)
```

```
{
PMMCTL0_H = PMMPW_H;          // Open PMM Registers for write
PMMCTL0_L |= PMMREGOFF;
  bis_SR_register(LPM4_bits | GIE);
}
voidWakeUpLPM35(void)
{
// Restore Port settings P1OUT = 0x00;
P1DIR = 0xFF;
P2OUT = 0x00;
P2DIR = 0xFF;
P3OUT = 0x00;
P3DIR = 0xFF;
P4OUT = 0x00;
P4DIR = 0xFF;
PJOUT = 0x00;
PJSEL0 |= BIT4 | BIT5;
PJDIR = 0xFFFF;
RTCCTL01 |= RTCBCD | RTCHOLD | RTCTEV MIN | RTCTEVIE;
RTCCTL01 &= ~RTCHOLD;
PM5CTL0 &= ~LOCKLPM5;
CSCTL0_H = CSKEY >>8;   // Unlock CS registers
CSCTL1 = DCOFSEL_0;      // Set DCO to 1MHz
CSCTL2 = SELA LFXTCLK | SELS DCOCLK | SELM DCOCLK;
// Set ACLK = XT1;   MCLK = DCO
CSCTL3 = DIVA  1 | DIVS  1 | DIVM 1;      // Set all dividers to 1
CSCTL4 &= ~LFXTOFF;      // Enable LFXT1
do
{
CSCTL5 &= ~LFXTOFFG;   // Clear XT1 fault flag
SFRIFG1 &= ~OFIFG;
}while (SFRIFG1&OFIFG);  // Test oscillator fault flag
CSCTL0_H = 0;          }
```

```
#if defined( TI_COMPILER_VERSION ) || defined( IAR_SYSTEMS_ICC )
#pragma vector=RTC_VECTOR
  interruptvoidRTC_ISR(void)
#elif defined( GNUC )
void attribute   ((interrupt(RTC_VECTOR))) RTC_ISR (void)
#else
#error Compiler not supported!
#endif
{
switch ( even_in_range(RTCIV, RTCIV_RTCOFIFG)){
case RTCIV_NONE:  break;
case RTCIV_RTCRDYIFG: break;
case RTCIV_RTCTEVIFG:
P1OUT |= BIT0;         // Turn on LED
break;
case RTCIV_RTCAIFG: break;
case RTCIV_RT0PSIFG: break;
case RTCIV_RT1PSIFG: break;
case RTCIV_RTCOFIFG: break;
}
}
```

RESULT:

8. PWM GENERATOR

AIM: The main objective of this experiment is to understand how to configure the PWM module of the MSP-EXP430FR5969 Launchpad to control the brightness of LED using external input.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

The MSP430F5529 has two LED's and two push BUTTONS connected to GREEN LED (P1.0),S2(P1.1) and RED LED (P4.6),S1(P4.5) on the MSP430F5529 LaunchPad for visual feedback. In this experiment, the code programmed into the MSP430F5529 processor increase the brightness of LED when button is pressed gradually and decrease the brightness of LED when another button is presses gradually.Actually here we are increasing and decreasing the width of the pulse by varying the values in CCR1 of the Timer.

```
                MSP430FR59xx
                -----------------
             /|\|             XIN|-
              | |                | 32kHz
              --|RST         XOUT|-
                |                |
        LED<--| P4.6      P1.0 |--> LED
           S1←| P4.5      P1.1 |-->S2
                -------------------
```

PROCEDURE:

1. Connect the MSP430F5529 LaunchPad to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS to view the status of the LED.
3. In the CCS debug perspective, select **View --> Registers**
4. Observe the GREEN LED brightness increase whenever S1 is pressed and decreases when S2 is pressed.

PROGRAM:

```
#include<msp430.h>
int j=0; intmain(void) {
WDTCTL = WDTPW | WDTHOLD;           // Stop watchdog timer
PM5CTL0 &= ~LOCKLPM5; // Disable the GPIO power-on default high-impedance
//mode to activate previously configured port settings
P1DIR |= BIT0;          // Set P1.0 to output direction
```

```
P1OUT &= ~BIT0;     // Switch LED off
P1DIR &= ~BIT1;                 // Set P1.1 as input
P1OUT |= BIT1;      // Configure P1.1 for Pull-Up
P1REN |= BIT1;      // Enable Pull Up of P1.1
P4DIR &= ~BIT5;     // Set P4.5 as input
P4OUT |= BIT5;      // Configure P4.5 for Pull-Up
P4REN |= BIT5;      // Enable Pull Up of P4.5
TA0CCTL1 = OUTMOD_7;  // Reset/Set Mode
TA0CTL = TASSEL_2 + MC_1 +TACLR ; // SMCLK / Upmode
TA0CCR0 = 100-1;    // PWM Frequency 10 kHz
TA0CCR1 = 50;       // 50% Duty Cycle
P1SEL0 |= BIT0;     // PWM output to LED P1.0
P1SEL1 &= ~BIT0;
while(1)
{
if(!(P1IN & BIT1))
{
if(TA0CCR1 <= 90)
{
TA0CCR0 = 0;
TA0CCR1 += 10;
TA0CCR0 = 100;
}
}
elseif(!(P4IN & BIT5))
{
if(TA0CCR1 >= 10)
{
TA0CCR0 = 0;
TA0CCR1 -= 10;
TA0CCR0 = 100;
}
}
for(j=100;j>0;j--)
{
 delay_cycles(1000);
}
}
}
```

RESULT:

9. USE OF COMPARATOR TO COMPARE THE SIGNAL THRESHOLD LEVEL

AIM: The main objective of this experiment is to understand how to configure comparator to compare the signal threshold level using MSP-EXP430FR5969 Launchpad

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable

THEORY:

MSP430 Comp_B module supports precision slope analog-to-digital conversions, supply voltage supervision, and monitoring of external analog signals. The comparator compares the analog voltages at the + and - input terminals. If the + terminal is more positive than the - terminal, the comparator output CBOUT is high. The comparator can be switched on or off using control bit CBON. The comparator should be switched off when not in use to reduce current consumption. When the comparator is switched off, CBOUT is always low. The bias current of the comparator is programmable.

PROGRAM:

```
#include <msp430.h>
int main (void)
{
  WDTCTL = WDTPW + WDTHOLD;                // Stop WDT
  P1DIR |= 0x01;                           // P1.0 output
  CACTL1 = CARSEL + CAREF0 + CAON;         // 0.25 Vcc = -comp, on
  CACTL2 = P2CA4;                          // P1.1/CA1 = +comp
  while (1)                                // Test comparator_A output
  {
    if ((CAOUT & CACTL2))
      P1OUT |= 0x01;                       // if CAOUT set, set P1.0
    else P1OUT &= ~0x01;                   // else reset
  }
}
```

RESULT

10. SPEED CONTROL OF DC MOTOR

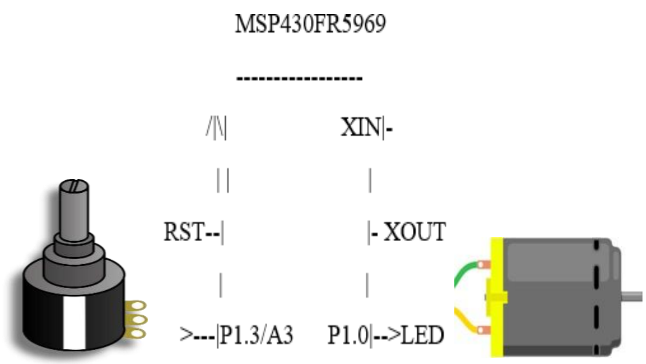
AIM: The main objective of this experiment is to understand how to configure the PWM module of the MSP-EXP430FR5969 Launchpad to control the brightness of LED using external input.

APPARATUS:	1) Code Composer studio software
	2)MSP430F5529 target Launch-pad
	3) USB cable
	4) Patch Chords

THEORY:

A potentiometer is connected to the pin P1.3(A3) and DC MOTOR is connected to P1.2. Timer operates in UP MODE with Reset/set(output MODE 7) and set the PWM frequency in Capture/Compare register 1(CCR1). Software sets ADC12SC to start sample and conversion

- ADC12SC automatically cleared at EOC. ADC12 internal oscillator times sample (16x) and conversion. In Main loop MSP430 waits in LPM0 to save power until ADC12 conversion complete, ADC12_ISR will force exit from LPM0 in Mainloop on reti. Values of potentiometer is stored in ADC memory. The Contents of ADC memory is assigned to Capture/Compare register 0 (CCR0) which sets the duty cycle of the generated pulse. The full, correct handling of and ADC12 interrupt is shown as well.



15	14	13	12	11	10	9	8
CSTARTADDx				SHSx		SHP	ISSH
rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)
7	6	5	4	3	2	1	0
ADC12DIVx			ADC12SSELx		CONSEQx		ADC12BUSY
rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)

ADC12CTL1, ADC12 Control Register 1

15	14	13	12	11	10	9	8
CSTARTADDx				SHSx		SHP	ISSH
rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)
7	6	5	4	3	2	1	0
ADC12DIVx			ADC12SSELx		CONSEQx		ADC12BUSY
rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)	rw-(0)

PROGRAM:

```
#include<msp430.h>
intmain(void)
{
WDTCTL = WDTPW | WDTHOLD;           // Stop WDT

// GPIO Setup
P1OUT &= ~BIT2;               // Clear MOTOR to start
P1DIR |= BIT2;          // Set P1.2/MOTOR to output
P1SEL1 = BIT3;         // Configure P1.3 for ADC
P1SEL0 = BIT3 | BIT2;          // PWM output to MOTOR P1.2

// Disable the GPIO power-on default high-impedance mode to activate
// previously configured port settings
PM5CTL0 &= ~LOCKLPM5;

// Configure TimerA0
TA0CCTL1 = OUTMOD_7;  // Reset/Set Mode
TA0CTL = TASSEL_2 + MC_1 +TACLR ; // SMCLK / Upmode
TA0CCR0 = 64-1;      // PWM frequency

// Configure ADC12
ADC12CTL0 = ADC12SHT0_2 | ADC12ON;          //  Sampling  time,  S&H=16,  ADC12
on
ADC12CTL1 = ADC12SHP; // Use sampling timer
ADC12CTL2 |= ADC12RES_2;                    // 12-bit conversion results
ADC12MCTL0 |= ADC12INCH_3;              // A3 ADC input select; Vref=AVCC
ADC12IER0 |= ADC12IE0;   // Enable ADC conv complete interrupt

while (1)
{
  delay_cycles(5000);
ADC12CTL0 |= ADC12ENC | ADC12SC;   // Start sampling/conversion
```

```
  bis_SR_register(LPM0_bits | GIE); // LPM0, ADC12_ISR will force exit
  no_operation();         // For debugger
}
}

#pragma vector = ADC12_VECTOR
  interrupt voidADC12_ISR(void)
{
switch( even_in_range(ADC12IV, ADC12IV_ADC12RDYIFG))
{
case ADC12IV_NONE:          break;  // Vector          0: No interrupt
case ADC12IV_ADC12OVIFG:        break;  // Vector          2: ADC12MEMx Overflow
case ADC12IV_ADC12TOVIFG: break;      // Vector          4: Conversion time overflow
case ADC12IV_ADC12HIIFG: break; // Vector 6: ADC12BHI case
ADC12IV_ADC12LOIFG: break; // Vector 8:
ADC12BLO case ADC12IV_ADC12INIFG: break; // Vector 10: ADC12BIN
 case ADC12IV_ADC12IFG0:
TA0CCR1 = ADC12MEM0/64;        // Vector 12: ADC12MEM0 Interrupt
  bic_SR_register_on_exit(LPM0_bits); // Exit active CPU
break;  // Clear CPUOFF bit from 0(SR)
case    ADC12IV_ADC12IFG1:     break;  //       Vector 14:     ADC12MEM1
case    ADC12IV_ADC12IFG2:     break;  //       Vector 16:     ADC12MEM2
case    ADC12IV_ADC12IFG3:     break;  //       Vector 18:     ADC12MEM3
case    ADC12IV_ADC12IFG4:     break;  //       Vector 20:     ADC12MEM4
case    ADC12IV_ADC12IFG5:     break;  //       Vector 22:     ADC12MEM5
case    ADC12IV_ADC12IFG6:     break;  //       Vector 24:     ADC12MEM6
case    ADC12IV_ADC12IFG7:     break;  //       Vector 26:     ADC12MEM7
case    ADC12IV_ADC12IFG8:     break;  //       Vector 28:     ADC12MEM8
case    ADC12IV_ADC12IFG9:     break;  //       Vector 30:     ADC12MEM9
case    ADC12IV_ADC12IFG10:    break;  //       Vector 32:     ADC12MEM10
case    ADC12IV_ADC12IFG11:    break;  //       Vector 34:     ADC12MEM11
case    ADC12IV_ADC12IFG12:    break;  //       Vector 36:     ADC12MEM12
case    ADC12IV_ADC12IFG13:    break;  //       Vector 38:     ADC12MEM13
case    ADC12IV_ADC12IFG14:    break;  //       Vector 40:     ADC12MEM14
case    ADC12IV_ADC12IFG15:    break;  //       Vector 42:     ADC12MEM15
case    ADC12IV_ADC12IFG16:    break;  //       Vector 44:     ADC12MEM16
case    ADC12IV_ADC12IFG17:    break;  //       Vector 46:     ADC12MEM17
case    ADC12IV_ADC12IFG18:    break;  //       Vector 48:     ADC12MEM18
case    ADC12IV_ADC12IFG19:    break;  //       Vector 50:     ADC12MEM19
case    ADC12IV_ADC12IFG20:    break;  //       Vector 52:     ADC12MEM20
case    ADC12IV_ADC12IFG21:    break;  //       Vector 54:     ADC12MEM21
case    ADC12IV_ADC12IFG22:    break;  //       Vector 56:     ADC12MEM22
case    ADC12IV_ADC12IFG23:    break;  //       Vector 58:     ADC12MEM23
case    ADC12IV_ADC12IFG24:    break;  //       Vector 60:     ADC12MEM24
case    ADC12IV_ADC12IFG25:    break;  //       Vector 62:     ADC12MEM25
```

```
case    ADC12IV_ADC12IFG26:     break;  //      Vector 64:      ADC12MEM26
case    ADC12IV_ADC12IFG27:     break;  //      Vector 66:      ADC12MEM27
case    ADC12IV_ADC12IFG28:     break;  //      Vector 68:      ADC12MEM28
case    ADC12IV_ADC12IFG29:     break;  //      Vector 70:      ADC12MEM29
case    ADC12IV_ADC12IFG30:     break;  //      Vector 72:      ADC12MEM30
case    ADC12IV_ADC12IFG31:     break;  //      Vector 74:      ADC12MEM31
case    ADC12IV_ADC12RDYIFG: break;  //      Vector 76:      ADC12RDY
default: break;
}
}
```

RESULT :

11. MASTER SLAVE COMMUNICATION BETWEEN MSPs USING SPI

AIM: The main objective of this experiment is to establish the SPI master-slave communication using 3- wire mode in MSP430F5529 Launchpad. This experiment will help understand the configuration of USCI_A0 SPI 3-Wire Master Incremented Data in MSP430F5529.

APPARATUS REQUIRED:

- Code composer studio software.
- MSP430FR5529 target Launchpad.
- USB cable.

Registers Used

The Registers used in our program are:

- **WDTCTL: 16-bit Watchdog Timer Control Register** - The Watchdog Timer (WDT) is typically used to trigger a system reset after a certain amount of time. The register is set to WDT_MDLY_32 for 32ms interval interrupt.
- **P3SEL and P2SEL: Function Select Register -** Each bit in the function select register is used to select the pin function - I/O port or peripheral module function. Here, the pins P3.3, P3.4 and P2.7 are configured for SPI communication.
- **UCA0CTL0: USCI_A0 Control Register 0 -** This register configures the USCI module. Here the master and slave are configured for 3-bit synchronous SPI.
- **UCA0CTL1: USCI_A0 Control Register 1** - This register is used to configure clock source and enable software interrupts. The master uses SMCLK as clock source.
- **UCA0BR0 & UCA0BR1: USCI_A0 Baud Rate Control Register 0 and 1** - These 16-bit registers configure the clock prescaler setting of the bit rate. In the master, the registers are configured to have clock prescaler of 2.
- **UCA0IE: USCI_A0 Interrupt Enable Register -** This register enables the USCI transmit and receive interrupts.Here, the USC RxI interrupt is enabled.
- **UCA0TXBUF: USCI Transmit Buffer Register -** This register contains the data to be transmitted by the USCI module.
- **UCA0RXBUF: USCI Receive Buffer Register -** This register contains the data received by the USCI module.
- **UCA0IFG: USCI_A0 Interrupt Flag Register -** This flag is set when UCA0TXBUF is empty.

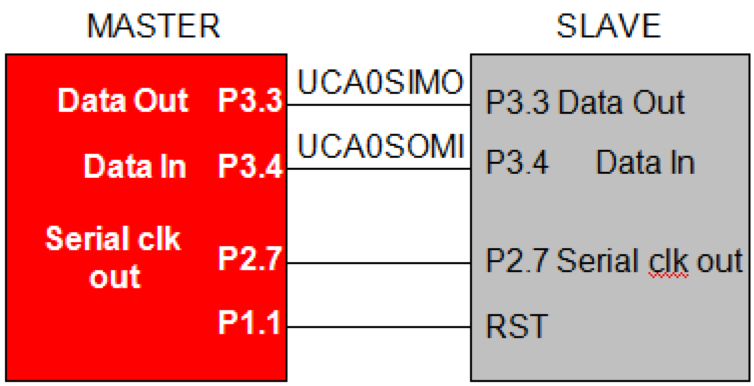
THEORY

Master:

The program code first disables the watch dog timer to prevent a processor restart on expiry of the WDT count. The port pin P1.1 is set as slave reset and port pin P1.0 is configured for the red LED. The port pins P3.3, P3.4 and P2.7 are configured for SPI communication. The USCI logic is held in reset state and the 3-pin, 8- bit synchronous SPI master is enabled. The SMCLK is selected as clock source and the USCI logic initiated. The USCI_RX interrupt is enabled in low power mode and the slave is reset via out- put pin P1.1 and allowed to initialize. The data values to be transmitted to the slave is also initial- ized and transmitted via the transmit buffer UCA0TXBUF. On receiving data from the slave, the USCI_RX interrupt occurs. If the data received is same as the data transmitted, the red LED is turned on and the data transmission is continued.

SLAVE

The program code first disables the watch dog timer to prevent a processor restart on expiry of the WDT count. Since, the connec- tion is synchronous, the slave receives the clock source from the master on port pin P2.7. If a clock signal is detected from the master, the port pins P3.3, P3.4 and P2.7 are configured for SPI communication and the USCI logic is held in reset state. The 3-pin, 8-bit synchronous SPI master is then enabled. The USCI logic is initiated and the USCI Rx interrupt is enabled in low power mode 4. When the slave receives data from the master, the USCI Rx interrupt occurs. The received data is copied into the transmit buffer UCA0TXBUF for echo transmission to the master.



Connection Diagram for Master Slave

<u>PROGRAM</u>

C Program Code for Master and Slave

Master:

```
#include <msp430.h>
unsigned char MST_Data,SLV_Data; unsigned char temp;
```

```
int main(void)
{
volatile unsigned int i;
WDTCTL = WDTPW+WDTHOLD;                                  //          Stop watchdog
timer
P1OUT |= 0x02; // Set P1.0 for LED
P1DIR |=  0x03;                                          // Set P1.1 for
slavereset
* P3SEL |= BIT3+BIT4; // P3.3,4 option select
P2SEL |= BIT7; // P2.7 option select
UCA0CTL1 |= UCSWRST;  // **Put state machine in reset**
UCA0CTL0 |= UCMST+UCSYNC+UCCKPL+UCMSB; // 3-pin, 8-bit SPI synchronous
master
// Clock polarity high, MSB
UCA0CTL1 |= UCSSEL_2;   // SMCLK
UCA0BR0 = 0x02; // /2
UCA0BR1 = 0;
UCA0MCTL = 0; // No modulation
UCA0CTL1 &= ~UCSWRST; // **Initialize USCI state machine**
UCA0IE |= UCRXIE; // Enable USCI_A0 RX interrupt
P1OUT &= ~0x02;                                          // Now with SPI signals
initialized,
P1OUT |= 0x02;                                           // reset slave
for(i=50;i>0;i--);                                       // Wait for slave to
initialize
MST_Data = 0x01;          // Initialize data values
SLV_Data = 0x00;
while (!(UCA0IFG&UCTXIFG)); // USCI_A0 TX buffer ready?
UCA0TXBUF = MST_Data; // Transmit first character
_bis_SR_register(LPM0_bits + GIE); // CPU off, enable interrupts
}
#if defined(_TI_COMPILER_VERSION_) || defined(_IAR_SYSTEMS_ICC__)
#pragma vector=USCI_A0_VECTOR
_interrupt void USCI_A0_ISR(void)
#elif defined(_GNUC__)
```

```
void attribute ((interrupt(USCI_A0_VECTOR))) USCI_A0_ISR (void)
#else
#error Compiler not supported!
#endif
{
volatile unsigned int i;
switch(__even_in_range(UCA0IV,4))
{
case 0: break; // Vector 0 - no interrupt
case 2: // Vector 2 - RXIFG
while (!(UCA0IFG&UCTXIFG)); // USCI_A0 TX buffer ready?
if (UCA0RXBUF==SLV_Data)// Test for correct character RX'd P1OUT |= 0x01; // If correct, light LED
else
P1OUT &= ~0x01;// If incorrect, clear LED
MST_Data++; // Increment data SLV_Data++;
UCA0TXBUF = MST_Data; // Send next value
for(i = 20;i>0; i--); // Add time between transmissionsto
// make sure slave can process
//information
break;
case 4: break; // Vector 4 - TXIFG default: break;
}
}
```

Slave:

```
#include <msp430.h>
int main(void)
{
WDTCTL = WDTPW+WDTHOLD; // Stop watchdog timer
while(!(P2IN&0x80)); // If clock sig from mstr stayslow,
P3SEL |= BIT3+BIT4;          // P3.3,4 option select
P2SEL |= BIT7;          // P2.7
UCA0CTL1 |= UCSWRST;   // **Put state machine in reset**
UCA0CTL0 |= UCSYNC+UCCKPL+UCMSB;       // 3-pin, 8-bit SPI slave,
UCA0CTL1 &= ~UCSWRST;          // **Initialize USCI state machine**
```

```
UCA0IE |= UCRXIE; // Enable USCI_A0 RX interrupt
  bis_SR_register(LPM4_bits + GIE); // Enter LPM4, enable interrupts
}
#if defined( TI_COMPILER_VERSION ) || defined( IAR_SYSTEMS_ICC )
#pragma vector=USCI_A0_VECTOR
  interrupt void USCI_A0_ISR(void)
#elif defined( GNUC )
 void attribute
#else
 ((interrupt(USCI_A0_VECTOR))) USCI_A0_ISR (void)
 #error Compiler not supported!
#endif
{
switch( even_in_range(UCA0IV,4))
{
case 0:break;   // Vector 0 - no interrupt
case 2: // Vector 2 - RXIFG
while (!(UCA0IFG&UCTXIFG));     // USCI_A0 TX buffer ready? UCA0TXBUF =
UCA0RXBUF;
break;
case 4:break;   // Vector 4 - TXIFG default: break;
}
}
```

Procedure

1. Connect the MSP430 LaunchPads to the PC using the USB cable supplied.
2. Build, program and debug the code into the LaunchPad using CCS.

Observation

A successful SPI communication has been established between 2 MSP430 devices. This fact is verified by the blinking red LED in the master after receiving the exact echo data from the slave that the master had previously transmitted.

RESULT

12. NETWORKING MSPs USING WI-FI

AIM: The main objective of this experiment is to configure CC3100 Booster Pack as a Wireless Local Area Network (WLAN) Station to send Email over SMTP. This experiment will help you understand the WLAN concepts and CC3100 configuration to send Email over SMTP.

APPARATUS REQUIRED:

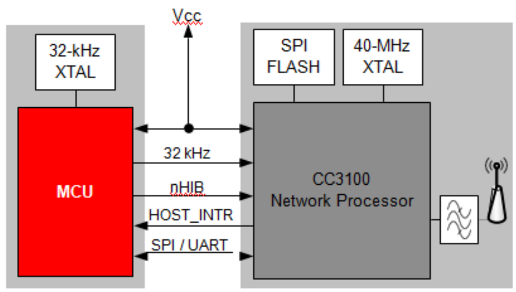
Code Composer Studio
CC3100 SDK
Tera Term Software (or any Serial Terminal Software)
MSP430 Launchpad
CC3100 Booster Pack

THEORY

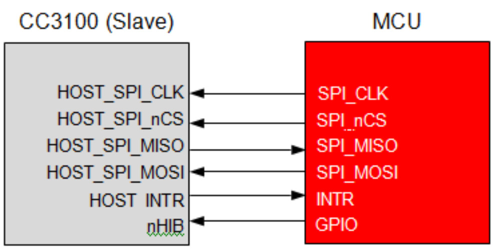
A wireless local area network (WLAN) is a wireless computer network that connects two or more devices without wires within a confined area, for example: within a building. This stay connected without physical wiring constraints and also access Internet. WiFi is based on IEEE 802.11 standards including IEEE 802.11a and IEEE802.11b.

All nodes that connect over a wireless network are referred to as stations (STA). Wireless stations can be categorized into Wireless Access Points (AP) or clients. Access Points (AP) work as the base station for a wireless network. The Wireless clients could be any device such as computers, laptops, mobile devices, smart phones, etc.

The Simplelink WIFI CC3100 device is the industry's first Wi-Fi Certified chip used in the wireless networking solution that simplifies the implementation of Internet connectivity. This device supports WPA2 personal and enterprise security and WPS 2.0 and Embedded TCP/IP and TLS/SSL stacks, HTTP server, and multiple Internet protocols. The functional block diagram for the CC3100 is shown in Figure.



Functional block diagram of CC3100



Steps for Creating and Debugging the Project

Install CC3100 SDK.

Open CCS and create a new workspace.

Choose the Import Project link on the TI Resource Explorer page. Import "email_application" project from CC3100 SDK using the following steps:

a.Choose the Import Project link on the TI Resource Explorer page.
b.Select the Browse button in the Import CCS Eclipse Projects dialog.
c.Select the email_application within
4.Open sl_common.h(line 50 of main.c) and change SSID_NAME, SEC_TYPE and PASSKEY as per the properties of your Access Point(AP). SimpleLink device will connect to this AP when the application is executed.
a.Expand the imported project
b.Click on includes.
c.Click on C:ti/CC3100SDK_1.1.0/cc3100sdk/examples/common
d.Open sl_common.h
#include "simplelink.h"
#include "sl_common.h" << Line 50
5.Replace with SSID of your Access Point.
#define SSID_NAME "XXXXXXXX" /* Security type of the Access point */
6.Specify Security Type and Password as below if network is protected with security.

#define SEC_TYPE SL_SEC_TYPE_WPA_WPA2 /*Security type of the Access point */
7.If network is protected with security, replace passkey with your network password.
#define PASSKEY "XXXXXXXXXX" /* Password in case of secure AP */
8.If the Security is open, replace the definitions as below:
#define SEC_TYPE SL_SEC_TYPE_OPEN /*Security type of the Access point*/
9.If the Network has no password
#define PASSKEY "" /* No password for open type */
10.Open config.h and change values for USER and PASS for setting up the source email using the following steps:
a. Replace the username of your source email id
#define USER "<username>" Write the password of your email id #define PASS "<password>"
11.Edit the same config.h file and change the values of DESTINATION_EMAIL, EMAIL_SUB-
JECT and EMAIL_MESSAGE for setting up the email properties using the following steps:
a.Replace your destination email id
#define DESTINATION_EMAIL "<destination_email>"
b.Write the subject of your mail
#define EMAIL_SUBJECT "<email_subject>"
c.Write your email message
#define EMAIL_MESSAGE "<email_body>"
12. Save, Debug and Run

Procedure

1. Connect MSP430F5529 Launchpad and CC3100 BoosterPack as shown below in **Figure.**
2. Build, program and debug the code into the LaunchPad using CCS.

Observation

Open Tera Term Terminal Software on the PC where the MSP-EXP430 LaunchPad is connected. The serial port parameters to be set are 9600 baud rate, 8 bits, No parity and 1 stop bit.The serial window outputs the debug messages received from the MSP-EXP430 Hardwar.

RESULT