MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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DEPARTMENT OF MECHATRONICS
III SEMESTER B. TECH (MECHATRONICS)
END SEMESTER EXAMINATION [Dec] [2022]

Subject: Microcontroller-Based System Design **Subject Code: MTE 2153**

Date: 13-12-2022

Time: 3 Hours **Exam Time: 2:30-5:30 PM** **MAX. MARKS: 50**

Instructions to Candidates:

- *Answer ALL the questions.*
- *Missing data may be suitably assumed and justified.*

Q. No	Question	M	CO	PO	LO	BL
1A	Traction control unit is an active vehicle safety feature designed to help vehicles while moving on the slippery surface. The wheel slip makes the tires spin quickly on the surface without gaining the grip so that the vehicle does not accelerate. Traction control activates when it senses the slip, and controls the vehicle. Traction control uses the following components; wheel speed sensors to monitor the rotation of all four wheels; a hydraulic modulator that pumps the brakes; and an ECU to direct the pumps based on speed sensor inputs. Identify the modules that aid to detect the speed of the wheels and control the brake pressure if MSP432 is employed in the ECU. Also, mention the industry standards to be complied with.	4	1	2,6	2,5	4
1B	An Automotive Industrial plant has 14 industrial robots working in a synchronized way i.e., each robot can operate in its own workspace. The entire job shop is protected with a metal cage for human safety. The cage has only one door with a laser sensor module for counting the people. One day, the sensor counted 10 humans entering the job for maintenance and on exit door, 9 people have come out, while the display counter showed 10 due to hardware fault, and the control engineer started the operation. The human left behind was accidentally hit by an industrial robot. The human is in critical condition and the onboard safety inspector calls for an inspection of the electronics safety system. As a safety engineer and representative of the Government, address the above case and generate the report addressing the workmen's compensation act 1923 for Industrial accidents with legal actions of violations. Also, address IEC standards for electrical safety measures as a future guideline for the industry.	4	1	6	2,5	4

1C	The Embedded design process involves the sequence of operations carried out starting from the requirement of the customer to product development. The main purpose of a requirement document is to aid as an agreement between the developer and the customer describing what the system will do. This agreement can become a legally binding contract. Write the document involving every step of the embedded design process so that it is easy to read and understand by others. It should be unambiguous, complete, verifiable, and modifiable and involve the industry standards to be met.	**2**	**1**	**7**	**13**	**4**
2A	Compare Timer32, Timer A, and Watchdog Timer in the embedded design process.	**3**	**3**	**1,2**	**1,2**	**4**
2B	Develop an Embedded C code to move the robot as per the description using the Timer A0 module. Consider a 3-wheeled robot with 2 rear wheels and one castor wheel. Timer A0 is used for driving the rear wheels using a PWM signal. Generate 70% duty cycle using outmode 7 for PWM signal on P2.4 in the up count mode. This is fed to the left motor through the L293N driver circuit. Similarly, generate a 30% PWM signal on P2.5 to feed the right motor. Draw the neat waveform of the TA0R count value, PWM signal from P2.5, and P2.4. Infer, the direction of the robot when the above PWM signal is fed to the robot. Use SMCLK clock with 3 MHz settings.	**4**	**3**	**1,3**	**1,2,5**	**6**

Bits	9-8	7-6	5-4	2	1	0
TIMER_A**y**->CTL	**TASSEL**	**ID**	**MC**	TA**CLR**	TA**IE**	TA**IFG**
TIMER_A_CTL_**XX**_x	00-TACLK, 01-ACLK 10-SMCLK, 11-INCLK	00-/1, 01=/2, 10=/4, 11=/8	00- stop, 01- up 10- continuous, 11- up/down	0- clear counter	1-enable timer interrupt	1-timer overflow flag set

Bits	15-14	13-12	11	10	8	7-5	4	3	2	1	0
TIMER_Ay->CCTL	**CM**	**CCIS**	**SCS**	**SCCI**	**CAP**	**OUTMOD**	**CCIE**	**CCI**	**OUT**	**COV**	**CCIFG**
TIMER_A_CCTLN_**XX**_x	00-no edge, 01-rising, 10-falling, 11-both	00-CCInA, 01-CCInB, 10-GND, 11-VCC	Synchronize timer clock	Observe synchronized input	1-capture 0-compare	000-output, 001-set, 010-toggle/reset, 011-set/reset, 100-toggle, 101-reset, 110-toggle/set, 111-reset/set	1-enable interrupt	Capture input value	Bit value		Set for capture in capture mode Set if compare is true in compare mode

8	Timer_A0	TA0_0_IRQn	TA0_0_IRQHandler	TA0CCR0-CCIFG
9	Timer_A0	TA0_N_IRQn	TA0_N_IRQHandler	TA0CCR1-6, TAIFG

2C	Develop an Embedded C code to indicate the distance of an obstacle based on the sensor input. Assume the sensor provides the value of 255 if the car is at 2 meters from the obstacle and alerts the driver using a low-frequency beep sound. The frequency of the sound increases gradually as the sensor provides less value based on the distance. Use software delay for generating the square wave signal that is fed to the speaker.	**3**	**3**	**1,3**	**1,2,5**	**6**
3A	Develop an Embedded C code to address the manufacturer's specifications. The washing machine has several washing options to satisfy the user's needs, and to safeguard the user. Use Timer 32 module of the MSP432 microcontroller for this operation. 1. The door lock option is connected to P2.4 2. If the user selects the auto option, the water valve opens for 30 seconds, followed by the rinse operation for 3 minutes. In rinse operation, the motor rotates clockwise and anticlockwise direction continuously. This is followed by the spin operation, in which the motor spins at high speed for 3 minutes. The motor is connected to pins P3.4 and P3.5. 3. The safety mechanism in washing machine ensures that the washing operation stops if the door is opened at any time.	5	**4**	**1,3**	**1,2,5**	**6**

Bits	7	6	5	3-2	1	0
TIMER32_y->CONTROL	**ENABLE**	**MODE**	**IE**	**PRESCALE**	**SIZE**	**ONESHOT**
TIMER32_CONTROL_**XX**_x	**1-enable, 0-disable**	**0- free running mode, 1- periodic**	**1- enable interrupt 0- disable**	**00=/1, 01=/16, 10=/256**	**1- 32 bit, 0- 16 bit**	**1-oneshot, 0-wrap**

25	Timer32_INT1	T32_INT1_IRQn	T32_INT1_IRQHandler
26	Timer32_INT2	T32_INT2_IRQn	T32_INT2_IRQHandler

TIMER32_y->LOAD	Load register
TIMER32_y->INTCLR	Clear flag
TIMER32_y->VALUE	Check the counter value

3B	Summarise the functional safety requirements required in the washing machine design process.	3	**4**	**6**	**5**	**4**
3C	Justify the importance of IEC in embedded system design and IEC/ISO standards needed in washing machine applications.	2	**4**	**6**	**5**	**4**

4A	Implement the ARM assembly language program to compute the area of square, rectangle, and triangle. Write a function to find the area of the given shape.	4	**2**	**1,2**	**1,2**	**3**
4B	Implement the ARM assembly language program to count the number of words in the given sentence. (Hint: ASCII code of space is 0x20.)	**4**	**2**	**1,2**	**1,2**	**3**
4C	Choose an ARM assembly instruction example where the Q flag is set. Justify, the word used sticky flag used for saturation flag.	**2**	**2**	**2**	**2**	**4**
5A	Integrate the Embedded C code to establish UART communication between 2 MSP432 launchpads to generate different colors randomly (xR+yG+zB for x,y,z is either 0 or 1) for the RGB LED of the second microcontroller when a person enters the lift. Assume that the sensor provides a low signal on the P1.5 pin of the first microcontroller when a person enters the lift using the LDR hardware module. This information is transferred to second MC through P1.3 pin. The following parameters are selected for UART configuration: Parity disabled, LSB-first, 8-bit data length, One stop bit, Select the Baud rate of 115200 from 6 MHz SMCLK clock signal, Use UART module for the operation in both MCs. Develop the transmitter code to send the signal to the receiver when a person enters the lift.	**4**	**3**	**1,3**	**1,2,5**	**6**
5B	For the application mentioned in Q. 5A, implement the receiver code to glow LED with different colors when the indication of a person entry is detected in pin P1.5.	**4**	**3**	**1,3**	**1,2,5**	**6**
5C	Generate the Baudrate of 115200 for the transmitter and receiver using the SMCLK with 6 MHz clock settings. Compute the values to be loaded into the registers BRW, BRS, and BRF for UART communication.	**2**	**3**	**1,3**	**1,2,5**	**3**

Bits	15	14	13	12	11
EUSCI_Ax->CTLW0	UC**PEN**	UC**PAR**	UC**MSB**	UC7BIT (UC**SEVENBIT**)	UCSPB
EUSCI_A_CTLW0_**XX**_x	**1- enable parity**	**1-even parity, 0-odd parity**	**1- MSB first, 0- LSB first**	**1- 7 bits, 0- 8 bits**	**1- 2 stop bits, 0- 1 stop bit**
Bits	**10-9**	**8**	**7-6**	**0**	
Bits	UC**MODE**x	UC**SYNC**	UC**SSEL**x	UC**SWRST**	
	00-UART, 01-idle, 10-address, 11- automatic baud rate	**1- asynchronous 0- synchronous**	**0-UCLK, 1-ACLK, 2-SMCLK**	**1- reset the module**	

Bits	15-8	7-4	0
EUSCI_Ax->MCTLW	UC**BRS**x	UC**BRF**x	UC**OS16**
EUSCI_A_MCTLW_**XX**	**Modulation property for BITCLK XX-BRS_OFS**	**Modulation property for BITCLK16 XX-BRF_OFS**	**1- oversampling, 0- disable over sampling**

16	EUSCI_A0	EUSCIA0_IRQn	EUSCIA0_IRQHandler
17	EUSCI_A1	EUSCIA1_IRQn	EUSCIA1_IRQHandler
18	EUSCI_A2	EUSCIA2_IRQn	EUSCIA2_IRQHandler
19	EUSCI_A3	EUSCIA3_IRQn	EUSCIA3_IRQHandler

Fractional Portion of N	UCBRSx	Fractional Portion of N	UCBRSx
0	0x00	0.500	0xAA
0	0x01	0.571	0x6B
0	0x02	0.600	0xAD
0	0x04	0.625	0xB5
0	0x08	0.643	0xB6
0	0x10	0.666	0xD6
0	0x20	0.700	0xB7
0	0x11	0.714	0xBB
0	0x21	0.750	0xDD
0	0x22	0.786	0xED
0	0x44	0.800	0xEE
0	0x25	0.833	0xBF
0	0x49	0.846	0xDF
0	0x4A	0.857	0xEF
0	0x52	0.875	0xF7
0	0x92	0.900	0xFB
0	0x53	0.917	0xFD
0	0x55	0.928	0xFE

PIN	PxSEL1=0, PxSEL0=1
P1.2	UCA0RXD
P1.3	UCA0TXD

Bits	23	22	18-16	9-0
CS->CTL0	DCOEN	DCORES	DCORSEL	DCOTUNE
CS_CTL0_XX_x	1-enable DCO clock source		0-1.5MHz,1-3MHz, 2-6MHz, 3-12MHz, 4- 24MHz, 5- 48MHz	

Bits	30-28	26-24	22-20	18-16	12	10-8	6-4	2-0
CS->CTL1	DIVS	DIVA	DIVHS	DIVM	SELB	SELA	SELS	SELM
CS_CTL1_XX_x	x=/2^x for SMCLK	x=/2^x for ACLK	x=/2^x for HSMCLK	x=/2^x for MCLK	BCLK 1- REFO 0- LFXT	ACLK 000- LFXT/REFO 001- VLO 010- REFO	SMCLK, HSMCLK 000- LFXT/REFO, 001- VLO, 010- REFO,	MCLK 000- LFXT/REFO 001- VLO, 010- REFO 011- DCO,