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Major Examination: EEL3090 Embedded Systems (Apr'25)

Guidelines (Total time: 180 minutes, Maximum Marks: 45):

- **In case of any doubt, assume whatever you wish to and state that in your answer.**

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1. A temperature sensor system has an in-built ADC and display. This sensor system needs to send the recorded temperature to the CPU. Only 2 pins are available for this transfer (between sensor system and CPU) that has to be synchronous and the sensor system must support medium to fast transfer rates (with 7 to 10-bit addressing mechanism). Explain properly (with a diagram showing all the related connections) with justification which interfacing protocol you would use here in this scenario? [1+3]

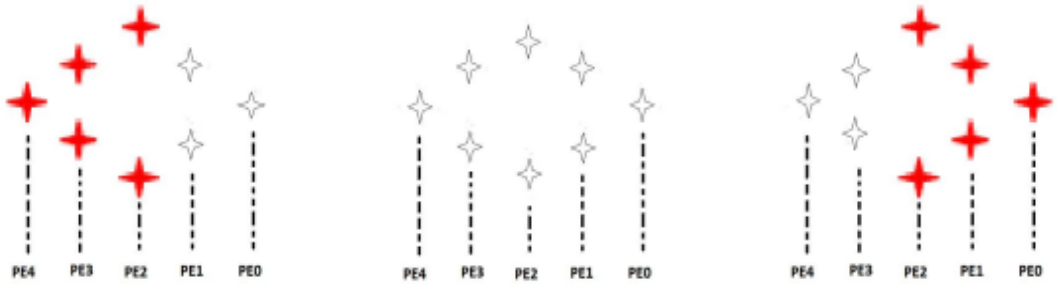
2. Assume that you are provided the description of a function written in assembly language. Consider that num=1000, root=sqr=1. Write down the equivalent C program for this function explaining its utility. (BHI means conditional branch if the carry flag (C) is set and the zero flag (Z) is clear.) [3+1]

```
Func
    LDR R0,=root
    MOV R1,#1
    STRH R1,[R0]
    LDR R2,=sqr
    STR R1,[R2]
    LDR R3,=num
    LDR R3,[R3]
Loop
    LDR R1,[R2]
    CMP R1,R3
    BHI Next
    LDR R1,[R0]
    ADD R1,#1
    STRH R1,[R0]
    MUL R1,R1,R1
    STR R1,[R2]
    B   Loop
Next
    LDR R1,[R0]
    SUB R1,#1
    STRH R1,[R0]
    BX  LR
```

3. Because of a mistake in the programming, pre-load (PR) value of Timer 6 is given by the LCM of PR values of Timer 2, Timer 4 and Timer 5. The PR values of Timer 2, Timer 4 and Timer 5 are respectively given by 1024, 2048 and 8192. Find out the frequency with which a LED glows when Timer 6 output is connected to that LED if it is known that the reference clock frequency is 1 KHz? [2]

4. You are employed as an embedded engineer in a company and looking after its pump machinery monitoring system (PM2S). This system has 3 important tasks: check pressure gauge, check water valve, measure effluent ejection velocity. The respective period (in ms) of these 3 tasks are given as 8, 5, 10 whereas the execution time (in ms) is respectively given by 2, 1, 2. Considering the deadlines same as period of tasks, please schedule these 3 tasks (upto 20 ms) in PM2S such that all deadlines are successfully met. [3]

5. Write the embedded software (in C language) that controls the turn indicators for a motor-bike. There are eight indicator LEDS that are interfaced as shown in the figure below to 5 output pins on the TM4C microcontroller. Note, PE3,2,1 control two LEDs each and PE4 and PE0 each control one LED.



An accelerometer interfaced externally to input pins PA7-PA0 gives the accelerometer reading in the x-direction. The reading is a signed number between -90 and +90. The accelerometer is mounted on the rider's helmet, so when the rider tilts her head to the left the readings are negative [-90,0) and when she tilts her head to the right the readings are positive (0,90]. You can consider any value between -20 and 20 to be false indicators of rider's intent to turn. Indication of left or right has to flash (on/off) the corresponding LEDS (see the above figure) at 4Hz with 50% duty cycle. [6]

6. If R0 equals -10, what will be in register R0 after executing these instructions? (You may note that LSL means left shift logical.) LSL R1,R0,3 ; ADD R0,R0,R1 ; [1.5]

7. A microcontroller-based development board has an in-built 0 to 3V 10-bit ADC. What will be the dig- ital output of the ADC if the input voltage is 0.75 V? [1.5]

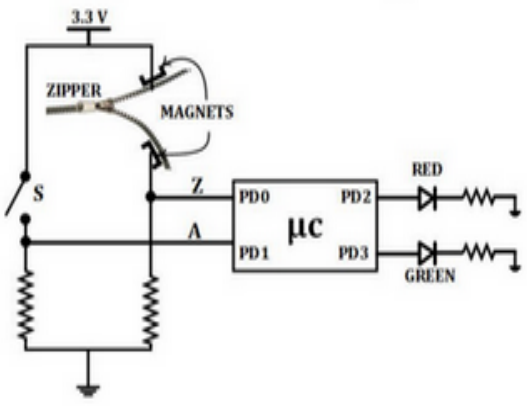
8. With proper assumptions, develop the software architecture for a biometric-based attendance system to be installed in LHC-110 to avoid the rampant proxy menace (during EEL3090 class). Use suitable interupt service routines (ISR) in your software package if needed. Consider the input as finger-print of each student stored in a database (gets completed during the period of course registration). [5]

9. You are supplied with an open-source library that allows you to create threads (parallel codes running in a system). Using this library (i.e., assume related required functions), develop the code for a toy car (which can be driven by 8-10 year old kids for a few meters). The 2 key functionalities are: keep checking the seat-belt being worn by the kid or not. The system keeps producing a beep-like music whenever the kid is driving the toy car with the seat-belt ON, but changes to loud alarm-like buzz the moment the kid is in the car but the seat-belt is OFF. Draw a basic hardware module to achieve this functionality. [3+1]

10. An automotive microcontroller is connected to a diagnostic tool over UART. The engine control unit (ECU) continuously checks if a new command has arrived via UART or not. Once a command is received, it performs the action (e.g., read the engine temperature) and sends back the response to the diagnostic system. Mention any 2 ways in which this can be achieved and compare these two methods. Also, provide the pseudo-codes (i.e., basic code skeletons) in both these scenarios? [2 + 2 + 3]

11. A SysTick timer is programmed with 1048576 in its LOAD register with input clock of 6400 KHz. Meanwhile, the ADC is programmed for converting analog voltages with a sampling time of 112 cycles (and 16 additional cycles for conversion) and the ADC clock is driven by a slow peripheral clock of 3200 KHz. The ADC generates an interrupt after every conversion. The high-speed interrupt controller prioritizes the interrupt that arrives first to it and simply pushes the other interrupt to a secondary interrupt controller. Find the frequency at which this secondary interrupt controller is servicing interrupts in this system? [3]

12. Assume that one of your friends has been hired to write a piece of software for a project called Backpack Zipper Breach Detector (BZBD) shown as the attached Figure. You decide to help your friend. The purpose of the project is to detect when a zipper on a backpack is breached (opened). Two magnets that together act like a switch are attached to the backpack zipper. The microcontroller (μC) reads (Z) an open zipper as an open switch and a closed zipper as a closed switch on PD0. A switch S (interfaced on PD1, creating signal A), serves as an Off/On switch to disable or enable the system. The microcontroller reads an open switch S as disable and a closed switch S as enable of the BZBD system. There are two LEDs interfaced (red on PD2 and green on PD3) that indicate whether the zipper is breached (Red ON, Green Off) or is secure (Red Off, Green On). When the system is disabled both



A	Z	Green	Red	Meaning
0	0	0	0	system off
0	1	0	0	system off
1	0	0	1	zipper breached
1	1	1	0	system secure

LEDs must be Off. In addition to showing the status, the microcontroller sends a message to a Bluetooth (BT) enabled smartphone. The code (BT_Update) to enable Bluetooth, connect to a smartphone and send messages has been written by somebody else. You have to call the BT_Update function to send updates to the smartphone. This function returns code as 0 to show disabled, 1 for enabled & zipper breached, and 2 for enabled & zipper secure. Your friend presents this table explaining the whole system operation and relation with inputs: At the beginning, send one update, and then an update must only be sent if there is a change in the status of the system. You can assume that all GPIO port initialization is already done for you and you only need to access the Data register for completing the software module. Please write the software code for the described BZBD system either in C or ARM assembly (with appropriate comments and relative assumptions) to finish this task assigned to your friend. [4]