IIT JODHPUR

Minor-1 Examination: EEL3090 Embedded System (Feb'24)

Guidelines (Total time: 60 minutes, Maximum Marks: 15):

- Please read the question paper very carefully (both sides of this paper).
- **NO clarification is required in any question.** In case of any doubt, assume whatever you wish to and state that in your answer.

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1. In a microcontroller board-based experiment, some push-buttons are connected to pins of GPIO portH i.e., PH0, PH1,..... till PH15. However, only even-numbered pins are chosen for providing input (i.e., logic value 1) via the connected push-buttons to the microcontroller development board from the outside environment. Given that 0 (for pin numbered PH0) is an even number, find the content of GPIOH− >IDR in hexadecimal representation? [1]

2. Assume that for a system running with ARM CPU, R0=0x00A0, R1=0x0020, R5=0x0010. What is content of R3 after executing these three instructions in this order: a) ADD R2, R1, R0 b) EOR R3, R2, R5 c) SUB R3, R5? [1]

3. Suppose 8 GPIOs (A,B,C,D,E,F,G,H) are to be supported in a microcontroller unit (MCU)-based development board intended for real-time object detection. Given that the address where GPIOA starts is 0x68000000 and each GPIO is having capacity of 2 KB, the address where GPIOF ends is obtained as *Loc*. Calculate the value of *Loc* for programming this development board? [1]

4. Consider that because of aggressive optimizations implemented inside the compiler, the number of instructions in the program binary is given by L.C.M(i1, i2, i3) where i1, i2 and i3 are the probable instruction counts for the CPU modeled at 3 MHz. Further, we observe a change in the program execution time when the cycle per instruction (CPI) is reduced by 25% as the CPU model improves because of different architectural optimizations. Find the new execution time observed by the architecture simulator when values of i1, i2, i3 are given as 12, 15 and 25 respectively and the original CPI was 4? [1.5]

5. We are using asynchronous serial transmission output from a MCU board onto a peripheral. It is provided to us that each character consists of 10 bits and the symbol rate is 200000 bits/sec. Suppose we observe the bits at ten time intervals and we observed that the bits are 0, 0, 1, 0, 1, 0, 1, 1, 1, 1 respectively. Deduce the data item value (in hexadecimal representation)? [1.5]

6. During an user-application execution on an embedded system, a subroutine gets called from main program when the PC is at an address Z. If it is known that the control-flow of the processor execution gets back to the main program at the address 0x000040C4, then what is address Z? [1]

7. In a particular CPU model, the cycles per instruction is 6, find the value of the MIPS (Million instructions per second) metric as measured by a computer architecture simulator if this simulator is simulating the above mentioned CPU with an operational frequency of 24 MHz? [1]

8. In an embedded systems programming, the amount of memory usage (in terms of bytes) is very critical for implementation on resource-constrained devices. For a particular application, 19 library functions are to be utilized and the memory usage per library function is calculated as a sum of fixed component and variable component. The fixed component is 10 bytes for each function and the variable component depends on the numbering of the function e.g., function 1 takes 1 byte, function 2 takes 2 bytes, ... function n takes n bytes. If the same application is implemented

by bare-metal programming (i.e., programming the registers), only 40 registers (each register is of 4 bytes) need to be programmed. Find out the memory savings with bare-metal programming compared to the library function usage? [1]

9. If it is known that during asynchronous transmission with UART, each bit takes approximately 104.16 microseconds for transmission and the contents of Baud rate register (bit 15^{th} to bit 0^{th}) is given as 0x249F, please find the frequency of the main (i.e., global) clock that is used for sampling the data (given that 16 samples are getting used to denote 1 bit). Note that the main clock is fed to the baud rate generation block of UART logic after division by a factor of 4? [2]

10. In a microcontroller-based development board design, an external device with storage capacity of 1 GB has been assigned the memory address from *Address*1 to 0xDFFFFFFF. What is the value of *Address*1 in this scenario? [1]

11. Consider that a device (Device A) transmits a character "11" to another device (Device B) over an unverified communication channel. It is known to us that Device B employs a subroutine shown below in order to optimize its performance instead of running a C program for doing some task with the received character. Write down the equivalent C program for the below subroutine? Why is this subroutine required by Device B? (*Hint: CBZ means compare and branch if zero, MOVEQ and MOVNE mean move if equal to zero or not zero respectively.*) [1.5 + 0.5]

```
__main PROC
       MOVS   r0, #11
       MOVS   r1, #0
loop   CBZ    r0, stop
       CMP    r1, #0
       MOVEQ  r1, #1
       MOVNE  r2, #0
       SUBS   r2, r0, #1
       ANDS   r0, r0, r2
       B      loop
stop   B      stop
```

12. Consider an implementation of Edge AI on a resource-constrained MCU board where 200 pages of textual data needs to be transferred to the processor core from a peripheral device via the UART method of serial communication. If it is known that the symbol rate is 8K bits/sec and the total time required for this transfer to take place is 10 seconds, find the size of each transferred page in terms of the number of characters in it? [1]
