Indian Institute of Technology Kharagpur
Mid-Spring Semester Examination 2017-18

Date of Examination: 23 Feb. 2018 **Session:** FN **Duration:** 2 Hours
Subject No.: EE30004 **Subject:** Embedded Systems
Department/Center/School: Electrical Engineering **Credits:** 3 **Full marks:** 70

Instructions

1. This question paper contains 4 pages and 7 questions. All questions are compulsory. Marks are indicated in parentheses. This question paper has been cross checked and no errors exist.
2. Detach the pages 3-4, fill the answers on them and attach with the answer script.
3. Please write your name, roll number, subject name and code, date and time of examination on the answer script before attempting any solution.
4. Use of electronic calculators only is permitted. No extra resources viz. graph papers, log-tables, trigonometric tables would be required.
5. **Organize your work**, in a reasonably neat and coherent way. Work scattered all over the page or across the answer script without a clear ordering will receive very little marks.
6. **Mysterious or unsupported answers will not receive full marks**. A correct answer, unsupported by calculations, explanation, or circuit diagrams will receive no marks; an incorrect answer supported by substantially correct calculations and explanations may receive partial marks.

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1. In case of an ATmega128 the following data address range is used. $0000 - $001F for general purpose registers (GPR), $0020 - $005F for standard I/O registers (SFR), $0060 - $00FF for extended I/O memory and $0100 - $10FF for internal SRAM. On the other hand for ATmega2560 the data address range used is $0000 - $001F for GPR, $0020 - $005F for SFR, $0060 - $01FF for extended I/O memory and $0200 - $21FF for internal SRAM.
   (a) (8 points) Calculate the size in bytes of the GPR, SFR, extended I/O memory and internal SRAM for ATmega128 and ATmega2560?
   (b) (1 point) What is the size of program memory in bytes for ATmega128 and ATmega2560 and what is the width of the program address bus in each?

(c) (1 point) What would be the minimum width of the data address bus for ATmega128 and ATmega2560 with the above configuration when no additional external SRAM is connected?

2. The following program resides on the program memory of an ATmega128.

```
1  LDS R0, 0x0380
2  STS 0x230, R0
```

(a) (5 points) Draw the connection busses for program and data memory for an ATmega128 controller where this program resides. Indicate the bus width for each following the address configuration in Q1.

(b) (5 points) Assuming that all memory states are 0x00 at start of the controller, draw the timing diagram for all the involved busses while executing the program. Also mention the state of the PC at each time state.

3. (a) (4 points) Draw the schematic of a circuit for connecting a 3×4 keypad with an ATmega128 controller on PORTD using minimum number of pins. Clearly mention the electrical specification of each of the components to be used. The keyboard enters numbers 0-9 and special characters * and #.

(b) (3 points) Write down the AVR assembly language program for driving this circuit such that R16 stores the value of the scanned key and * corresponds to value of DEC(10) and # corresponds to DEC(11).

(c) (3 points) Draw the timing diagram of PORTD when the key corresponding to number 2 is pressed on the keyboard till the value gets lodged in R16 from the start of the scanning sequence.

4. (10 points) Draw the circuit diagram and write down the assembly language code to implement a LED blinking with a time period of 2 seconds and 50% duty cycle when the ATmega128 us driven with a 16 MHz crystel oscillator. Clearly mention the electrical power rating of the components as well. Justify your answer with timing diagrams as necessary.

5. (a) (5 points) Write a program to add the numbers stored in the data memory locations \$0240 - \$0243 and store the resultant in \$0220 and \$0221 following little endian representation.

(b) (5 points) Write down an assembly language program to read the serially received data in little endian representation in Pin B1 and store it in R21 and R22 in little endian representation where the data is packed with one high at start and end of data.

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Please continue with questions on the next page.

Name: _____ **Roll no:** _____

Fill up the answers on this sheet before submitting. Extra calculations, explanations and circuit diagrams if necessary are to be performed on the answer script and not on this sheet. Remember to fill in your name and roll no. before attempting any solution. Anonymous sheets will not be evaluated. Write all answers and draw plots or diagrams using a pen.

Detach this sheet and attach with answer script before submission.

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6. Expand the following acronyms in the context of embedded systems.

(a) (1 point) EEPROM _____

(b) (1 point) SRAM _____

(c) (1 point) NVRAM _____

(d) (1 point) AVR _____

(e) (1 point) DRAM _____

(f) (1 point) ASIC _____

(g) (1 point) FPGA _____

(h) (1 point) ARM _____

(i) (1 point) QFP _____

(j) (1 point) USART _____

7. (a) (8 points) Write down the status of the following at the end of execution of each machine cycle when the following code is executed on an AVR microcontroller.

		R21	R22	SREG
1	`LDI R21, 0x27`		0x2E	
2	`LDI R22, 0xE8`			0b10000001
3	`ADC R22, R21`			
4	`SBIW R22:R21, 0x18`			
5	`SBIW R21:R22, 0x20`			
6	`EOR R22, R21`			

(b) (2 points) The following assembly code is intended to be used for an AVR microcontroller. Identify the line number where a fault would occur and mention the type of fault.

```
 1  LDI R16, 0x28
 2  LDI R31, 0x37
 3  MOV R2, R31
 4  ADD R2, R31
 5  ADC R2, R16
 6  STS 0xF1, R5
 7  LDS R6, 0xF2
 8  OUT DDRB, R16
 9  OUT B, R4
10  LDI R16, HIGH(RAMEND)
11  OUT SPH, R16
12  LDS R8, 0xF3
13  OUT C, R8
14  LDI R16, LOW(RAMEND)
15  LDI R4, 0xF1
16  OUT SPL, R16
17  PUSH R31
18  ADD R2, R31
19  POP R22
20  ADC R2, R16
21  POP R23
22  OUT D, R23
```

Line number _____

Type of fault _____