SINGAPORE POLYTECHNIC **ET0104**

2017/2018 SEMESTER ONE EXAMINATION

Diploma in Computer Engineering
Diploma in Electrical and Electronic Engineering
3rd Year Full-Time

EMBEDDED COMPUTER SYSTEMS Time Allowed: 2 Hours

Instructions to Candidates

1. The examination rules set out on the last page of the answer booklet are to be complied with.

2. This paper consists of **THREE** sections:

Section A	-	10 Multiple Choice Questions, 2 marks each.
Section B	-	6 Short Questions, 10 marks each.
Section C	-	1 Long Question, 20 marks.

3. **ALL** questions are **COMPULSORY**.

4. All questions are to be answered in the answer booklet. Start each question in Sections B and C on a new page.

5. Fill in the Question Numbers, in the order that it was answered, in the boxes found on the front cover of the answer booklet under the column "Question Answered".

6. This paper consists of 9 pages, inclusive of data sheets.

SECTION A

MULTIPLE CHOICE QUESTIONS [2 marks each]

1. Please **tick** your answers in the **MCQ box** behind the front cover of the answer booklet.
2. No marks will be deducted for incorrect answers

A1. An address decoder needs to select among 16 devices. Which one of the following statements is true?

(a) It requires 4 address inputs.
(b) It requires 16 address inputs.
(c) There is a danger that partial decoding will cause errors in device selection.
(d) Additional logic gates are always needed for proper decoding. (2 marks)

A2. How many pins are used for transferring data in a 16 by 2 alphanumeric LCD module?

(a) 0
(b) 1
(c) 8
(d) 16 (2 marks)

A3. How can the direction of a stepper motor be changed?

(a) By modifying the torque rating.
(b) The switching speed has to be changed.
(c) Change the polarity of the voltages applied to the windings.
(d) Reverse the original pulse sequence. (2 marks)

A4. A stepper motor is best used in which one of the following situations?

(a) Moving a fan.
(b) Rotating an LED display.
(c) Positioning an object to be spray painted.
(d) Powering a drill. (2 marks)

A5. Which Analog to Digital Conversion technology is best used for low-precision high-frequency sampling?

(a) Integrating
(b) Flash
(c) Successive approximation
(d) Σ-Δ (2 marks)

A6. What is true about the refresh rate of a computer display?

(a) The lower the refresh rate, the smoother is the display.
(b) The refresh rate is often derived from the power line AC frequency.
(c) It is normally lower than the rate of data transfer to the video subsystem.
(d) The quality of the cable limits the refresh rate. (2 marks)

A7. A rubbish bin is used to represent the action of deleting an object. Which one of the following principles of user interface design does this illustrate?

(a) The use of a metaphor.
(b) Ergonomic design.
(c) User efficiency.
(d) Consistent use of colours. (2 marks)

A8. In what way does a thread differ from a function?

(a) Threads do not allow sharing of data through global variables, but functions do.
(b) Threads cannot be coded within the same C program, but functions can.
(c) A thread does not return to the main program when it ends.
(d) Functions take up more memory when running. (2 marks)

A9. In an embedded C program, what is *false* about using global variables?

(a) It lessens stack corruption but is not good programming practice.
(b) It is difficult to keep track of how the variables are being updated.
(c) Programs in general use less RAM but it is not good programming practice.
(d) Programs in general use more RAM and it is good programming practice.
(2 marks)

A10. In embedded systems supporting multitasking, what is the purpose of the C command `Sleep()`?

(a) Causes the processor to enter its sleep mode.
(b) Calls a delay consisting of a series of software loops.
(c) Implements FIFO task scheduling.
(d) Implements a non-blocking delay. (2 marks)

SECTION B [60 marks]

B1. The C programming language is popular for embedded system development.

(a) What are the advantages of using C over assembly language? (4 marks)

(b) Low cost embedded systems do not have much resources in terms of RAM, ROM processor speed, and so on. In the C language, what are at least six ways to optimise the use of these resources? (6 marks)

B2. Listing B2 shows a segment of C code that initialises an LCD module and displays a text message. To control the LCD, the functions `lcdcmd()` and `lcddata` are used to output commands and data respectively. The function `sprintf()` prepares a string, as described in the laboratory notes. For the following questions, *write all answers into the answer booklet.*

(a) Initialise the one line LCD by filling in the blanks according to the comments in Listing B2. (4 marks)

(b) On executing the code, sketch the expected display on the 16 character LCD. (6 marks)

```
char message[] = "Alarm@";
char LCDStr[17];
int number;

lcdcmd(0x__);      /* 1. 5x7 dot font, 1 line, 8-bit interface */
lcdcmd(0x__);      /* 2. Cursor on, turn on the display */
lcdcmd(0x__);      /* 3. DDRAM address incr/cursor shift on o/p */

lcdcmd(0x81);      /* function executes LCD COMMAND */
number = 5;
sprintf(LCDStr, "%s %d", message, number);
for (j = 0; j < 16;j++)
{
      k = LCDStr[j];
      lcddata(k);
}
```

Listing B2

B3. A Digital to Analogue Converter is used to generate a half wave rectified sine wave. For an input of 0FFH, it outputs 5V which will be the *peak to peak* voltage of the signal. One cycle of this wave is sampled at six equal time intervals, starting at a time when the corresponding angle is 0 degrees.

(a) In a table form, list the values needed to produce this signal and sketch the output waveform for a multibit converter. (7 marks)

(b) To generate the waveform using single bit PWM, sketch the output signal before filtering. Show the width of the pulses as a decimal fraction. (3 marks)

B4. A stepper motor with a mechanical movement of 1.8 degrees per step is used to control the rotation of a circular platform to which an audiovisual surveillance system is fixed. It was planned that the platform will move 9.9 degrees at a time, whereby the system will acquire data.

(a) The motor phases A,B,C,D are connected to bits 0-3 respectively of a latch. Suggest two ways to achieve the 9.9 degrees movement. You may use a *combination* of position control methods. (2 marks)

(b) List down in two tables, one for each method specified in (a), the phase sequences needed to achieve the 9.9 degree movement. (8 marks)

B5. A video surveillance system runs on a PC/104 system. In the video capture, higher resolution and colour is more important than the need for high frame rates.

(a) A resolution of 640 by 480 pixels is deemed sufficient. For a true colour display at 50 frames/sec, show with calculations that it is *not* possible to display the video on a PC/104 system. (5 marks)

(b) Since the video cannot be displayed, suggest a suitable parameter to change. Explain your choice together with calculations using integers only. (5 marks)

B6. (a) Give two benefits of multitasking for computer operating systems. (4 marks)

(b) In a multitasking environment, what are two possible ways currently executing tasks allow other tasks to run on the processor? (4 marks)

(c) What are the differences between threads and processes? (2 marks)

SECTION C [20 marks]

C1. As part of the drive to enhance National Security, there is a need to perform surveillance over a wide area. A customized system allows the mounting of video and audio monitoring equipment.

A rotating platform driven by a stepper motor will allow the mounting of the monitoring devices. The video device will have its own subsystem. The audio device will feed into an Analogue to Digital Converter to detect unusual sound levels. A keypad with 8 keys allows the user to set and operate the device. A Liquid Crystal Display using 4 bit data transfer will show the status of the operation.

Assume that a PC/104 system will be used to drive the rotating platform. Design a decoding scheme for the hardware, using a 74LS688, a 74LS138, buffers and latches. The starting address is 330H. The data sheets for the devices are in the appendix.

(a) What is the minimum number of buffers and latches needed? Describe how you derive these quantities. (5 marks)

(b) Draw the I/O map and truth table. (8 marks)

(c) Draw a schematic diagram of the decoding circuit. (7 marks)

- End of Paper -

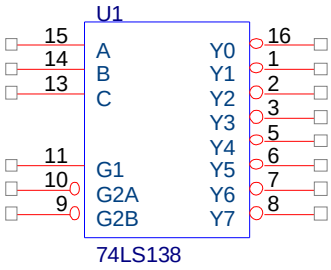
APPENDIX

LCD Instruction Table

Instruction	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	Execution Time (when F_{cp} or f_{osc} is 250KHz)
Clear Display	0	0	0	0	0	0	0	0	0	1	Clears Display and returns cursor to the Home Position (Address 00)	80uS = 1.64mS
Return Home	0	0	0	0	0	0	0	0	1	*	Returns cursor to Home Position. Returns shifted display to original position. Does not clear display	40uS = 1.6mS
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets DD RAM counter to increment or decrement (I/D) Specifies cursor or display shift during to Data Read or Write (S)	40uS
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Sets Display ON/OFF (D), cursor ON/OFF (c), and blink character at cursor position	40uS
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	Moves cursor or shifts the display w/o changing DD RAM contents	40uS
Function Set	0	0	0	0	1	DL	N	F	*	*	Sets data bus length (DL), # of display lines (N), and character font (F)	40uS
Set CG RAM Address	0	0	0	1	A_{CG}						Sets CG RAM address. CG RAM data is sent and received after this instruction	40uS
Set DD RAM Address	0	0	1	A_{DD}							Sets DD RAM address. DD RAM data is sent and received after this instruction	40uS
Read Busy Flag & Address	0	1	BF	AC							Reads Busy Flag (BF) and address counter contents	1uS
SIZE=2>Write Data from DD or CG RAM	1	0	Write Data								Writes data to DD or CG RAM and increments or decrements address counter (AC)	40uS
Read Data from DD or CG RAM	1	1	Read Data								Reads data from DD or CG RAM and increments or decrements address counter (AC)	40uS
I/D=1: Increment S=1: Display Shift on data entry S/C=1: Display Shift (RAM unchanged) R/L=1: Shift to the Right DL=1: 8 bits N=1: 2 Lines F=1: 5x10 Dot Font D=1: Display ON C=1: Cursor ON B=1: Blink ON BF=1: Cannot accept instruction				I/D=0: Decrements S=0: Cursor Shift on data entry S/C=0: Cursor Shift (RAM unchanged) R/L=0: Shift to the Left DL=0: 4 bits N=0: 1 Line F=0: 5x7 Dot Font D=0: Display OFF C=0: Cursor OFF B=0: Blink OFF BF=0: Can accept instruction							Definitions: DD RAM: Display data RAM CG RAM: Character generator RAM A_{CG}: CG RAM Address A_{DD}: DD RAM Address(Cursor Address) AC: Address Counter used for both DD and CG RAM Address	Execution Time changes when Frequency changes per the following example: If F_{CP} or f_{osc} is 27 KHz 40uS x 250/270 = 37uS

* Don't Care

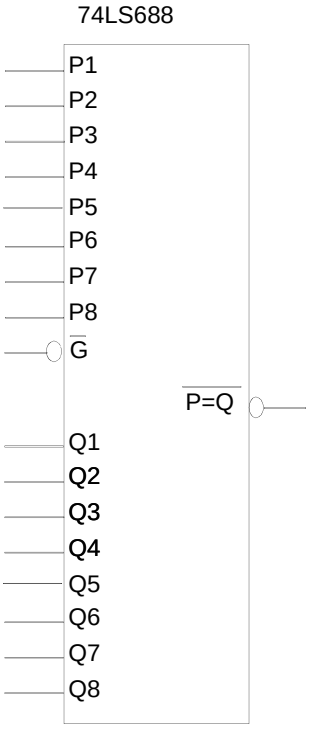
LCD Character Map



74LS138 schematic

INPUTS						OUTPUTS							
ENABLE			SELECT										
G2B	G2A	G1	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	X	L	X	X	X	H	H	H	H	H	H	H	H
X	H	X	X	X	X	H	H	H	H	H	H	H	H
H	X	X	X	X	X	H	H	H	H	H	H	H	H
L	L	H	L	L	L	L	H	H	H	H	H	H	H
L	L	H	L	L	H	H	L	H	H	H	H	H	H
L	L	H	L	H	L	H	H	L	H	H	H	H	H
L	L	H	L	H	H	H	H	H	L	H	H	H	H
L	L	H	H	L	L	H	H	H	H	L	H	H	H
L	L	H	H	L	H	H	H	H	H	H	L	H	H
L	L	H	H	H	L	H	H	H	H	H	H	L	H
L	L	H	H	H	H	H	H	H	H	H	H	H	L

Truth table



74LS688 schematic

Inputs		$\overline{P = Q}$
Data P,Q	Enable $\overline{G}$	
P = Q	L	L
P > Q	L	H
P < Q	L	H
X	H	H