NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
DEPARTMENT OF ELECTONIC ENGINEERING
BACHELOR OF ENGINEERING (HONS) DEGREE

Final Exam May 2013

TEE 3232 EMBEDDED COMPUTER SYSTEMS

Duration of Examination – 3 Hours

OPEN BOOK EXAMINATION

INSTRUCTIONS TO CANDIDATES

1. Answer any **THREE**questions only.
2. Each question carries 33.3% of the total marks.
3. **Each candidate may bring into the examination room** one annotated copy of NUST Lecture Notes Series No. 6 (An Introduction to Microcontrollers and Picocontrollers), but no other papers are permitted.
4. Answers should show circuitry, flowcharts and commented assembly language programs.
5. Assume that an "include" file provides the following subroutines: delay10ms, delay100ms, delay1s, delay5s, delay10s producing delays of 10ms, 100ms, 1s, 5s and 10s respectively.

Question 1

A digital controller uses four terms to determine its control function. These terms are four separate bytes received from a supervisory computer. When sending the control terms, the computer first sends an 8-bit identification code to the controller. If the identification code matches an internally stored code in the controller, the controller sends a code to request transmission of the first byte. When the first byte has been received, the controller sends a code to request transmission of the second byte, and so on until all the bytes have been received and stored.

Design a system based on the 8031 microcontroller that can receive the control terms from a supervisory computer and store them. Produce the circuitry and the assembly language in ASM51.

Question 2

A digital PID algorithm is implemented using an 8751 microcontroller. The process variable is provided by an ADC connected to a relevant sensor. The ADC output value is equal to the actual process value (e.g. a decimal output of 14 means 14 units). The ADC updates its output value once every 100ms (one sample per 100ms) and also the PID algorithm is to be designed to run once very 100ms. The PID algorithm is expressed as:

$$u(k) = u(k-1) + [(K_P + K_I + K_D) \times e(k)] - [(K_P + 2K_D) \times e(k-1)] + [K_D \times e(k-2)]$$

*k*denotes sampling instants (i.e. it increments with samples).***u(k)*** is the PID algorithm output for the current sample, ***u(k-1)*** is the PID algorithm output for the previous sample. ***e(k)*** is the error at the current sample, ***e(k-1)*** is the error at the previous sample and ***e(k-2)*** is the error at the previous sample but one. K_P is the proportional control term, K_I is the integral control term and K_D is the derivative control term.The set point and the control terms are to be stored in the internal RAM.

The output from the algorithm is sent to a DAC that will in turn interface to the process actuator.

Design a circuit using an 8751 microcontroller for the PID controller. Write a program in ASM51 to perform the PID algorithm.Assume all the operations can be implemented in 8 bit registers only.

Question 3

A traffic control system is used to control an intersection where two roads cross. Vehicles from the four directions are considered to be four streams of traffic. Four lights are mounted facing each stream : red light means **STOP**, green light means **PROCEED WITH CAUTION**,green flashing light at a frequency of 1Hz combined with a red light means**TRAFFIC TURNING RIGHT MAY PROCEED WITH CAUTION** and amber light indicates that a **GREEN IS CHANGING TO RED**. The lights are powered from 24V*dc*. The sequence of operation of the traffic lights in a cycle is given in table Q3 as phases.

Table Q3.

Phase	Stream A	Stream B	Stream C	Stream D	Duration
1	Stop	Stop	Stop	Stop	5s
2	Turn right with caution	Stop	Stop	Stop	10s
3	Stop	Stop	Turn right with caution	Stop	10s
4	Stop	Stop	Stop	Stop	5s
5	Proceed with caution	Stop	Proceed with caution	Stop	20s
6	Green is changing to red	Stop	Green is changing to red	Stop	5s
7	Stop	Stop	Stop	Stop	5s
8	Stop	Proceed with caution	Stop	Proceed with caution	20s
9	Stop	Green is changing to red	Stop	Green is changing to red	5s

Using either an 8051 microcontroller or a PIC16F84, design a circuit for control of the traffic lights at the intersection. Develop an assembly program using the relevant assembly language.

Question 4

A data-logger is required for use in a water catchment system. Water flow in a canal is measured by a rotating wheel mechanism which outputs one 5-volt pulse of 1ms duration after every 10 litres of water has passed. Design a battery-driven unit using a PIC16F84 to measure the total amount of water which has passed since the device was last reset. The total number of the litres should be stored in the EEPROM data memory, using up to four bytes to hold the number. The circuitry and Parallax assembler software should be given.

It is only required to store the data in EEPROM, since it is envisaged that the water engineers will periodically return the machine to the laboratory for reading of the information.

Question 5

A certain industrial process uses a heater element and a cooling fan. Each is controlled by a dc chopper and each chopper uses a transistor turned on by a 5V signal from a PIC16F84. The transistor on time for each chopper ranges linearly from 0 to 20ms in equal steps with the magnitude of an 8 bit input on one of the ports. The magnitude of the input is given by the seven lower bits. The MSB of the input is used to show whether cooling or heating is required. When the MSB is set, cooling is required, else heating is required. The chopper frequency is 50Hz. Design the circuitry and develop an assembly language program in Parallax to achieve the task. Assume and clearly state the assumptions for all delay routines that you may require if they are not given under the instructions section.

END OF PAPER