



**UNIVERSITY OF MORATUWA**  
Faculty of Engineering  
B.Sc. Engineering  
Level 2 – Semester 1 Examination  
**EN 2060 – ROBOT DESIGN AND COMPETITION**

Time Allowed: **1 hour and 30 minutes**

January 2010

**INSTRUCTIONS TO CANDIDATES**

This paper contains **40%** of the total grading of the subject

This paper has two sections: **Section A** and **Section B**. Both sections and all questions in them are compulsory.

**Section A** carries **30%** of the final grading. **Section B** carries **10%** of the final grading.

**Section A** contains 45 multiple-choice questions (MCQ) in 6 pages (page 3 to page 8). Use the paper provided for answering for this section.

**Section B** contains 2 essay type questions. Use the answer booklet for answering

## Section A

[carries 30% of the final grading]

1. Which of the followings is not involved in A/D conversion of a PIC microcontroller?
  - a. Channel
  - b. Voltage reference source
  - c. Duty cycle
  - d. Clock source
  
2. In a four-phase unipolar step motor
  - a. 8-step sequence doubles the resolution of motion
  - b. 8-step sequence increases torque by 1.4 times
  - c. energizing two coils at a time increases resolution of motion
  - d. energizing two coils at a time doubles the torque
  
- ③ 3. Proper implementation of pulse width modulation (PWM)
  - a. needs a very high switching frequency
  - b. is used for speed control of DC motors
  - c. is used for servo position control
  - d. can be used for step motor control
  
4. A switch sensor can be used for
  - a. contact sensing ✓
  - b. collision detection ✓
  - c. limiting rotation ✓
  - d. all of the above tasks
  
5. Referring to the figure 1, the error amplifier
  - a. is an operational amplifier with positive feedback ✗
  - b. always tries to minimize the difference between inverting (negative) and non-inverting (positive) inputs by driving its output in the appropriate direction ✓
  - c. is an electronic circuit which converts a pulse width signal to a voltage signal ✓
  - d. is a position sensor
  
- ⑥ 6. Passive IR sensors are commonly used to
  - a. measure IR intensity at some place
  - b. measure distances ✗
  - c. measure humidity ↑
  - d. measure temperature ✗
  
7. The register that is used to set the direction of PIC microcontroller pins is
  - a. INTCON
  - b. STATUS
  - c. PIR
  - d. TRIS

8. Your DC power adapter is rated for 9V/500mA. You check the output voltage without a load connected and found that it reads 14V. What is your conclusion?
- regulator specification is wrong
  - regulator specification is correct
  - open circuit voltage is higher than the rated voltage
  - it is wise not to use the regulator
9. The block C in figure 1 is
- a position sensor
  - an error amplifier
  - a pulse width to voltage converter
  - a pulse generator
10. In an active-IR sensor
- there is only IR detector +
  - there is only IR transmitter +
  - both IR emitter and detector exist ✓
  - there is IR reflector +
11. How can you identify different coils of a stepper motor?
- using an ohmmeter ✓
  - ask the manufacturer
  - trial and error
  - by a drive test
12. A PWM motor control circuit is shown in figure 2. Which of the following statements is not true about it?
- motor draws roughly 2/3 of the rated power
  - Motor runs at roughly 2/3 of its rated speed
  - motor draws roughly 2/3 of the rated current
  - diode conducts when the transistor is OFF
13. A servo system does not generally contain
- a DC motor ✓
  - a gear reducer ✓
  - a shaft encoder ✓
  - a speed sensor
14. Which of the following statements most accurately describes an H-bridge?
- it is used for direction control of DC motors ✓
  - it has 4 switching signals
  - it has 3 logic control signals
  - it has 4 logic gates
15. Which of the following statements is not true about unipolar stepper motors?
- unipolar stepper motors have 5 or 6 wires ✓
  - direction of motion is changed by changing direction of current through coils x
  - motor coils can be identified by measuring resistance between wires ✓
  - motor speed is proportional to pulse frequency ✓

16. If the external oscillator of a microcontroller (PIC18f452) has a value of 40MHz, then what is the time taken to execute one instruction cycle?

- a. 25ms
- b. 40ms
- c. 100us
- d. 200us

$$\frac{1}{40 \times 10^6} = 25 \times 10^{-9} \text{ s}$$

17. DC motor torque is proportional to

- a. PWM frequency +
- b. motor current
- c. motor speed +
- d. motor voltage +

18. How many analogue pins are available in the PIC18f452 microcontroller?

- a. 5
- b. 10
- c. 8
- d. 12

19. A microcontroller unit consists of

- a. a CPU only +
- b. a CPU, memory, and I/O
- c. a memory only +
- d. a memory and I/O only +

20. What are the parameters that are to be considered for generating a PWM waveform using a microcontroller?

- a. duty cycle, frequency, resolution
- b. duty cycle, amplitude, resolution
- c. phase, duty cycle, resolution
- d. resolution, frequency, phase

21. Which of the followings is not applicable for asynchronous serial transmission?

- a. baud rate
- b. voltage level ✓
- c. modulation frequency
- d. communication protocol ✓

22. What does the C18 instruction "TRISCbits.TRISC7 = 1" stand for?

- a. Setting PORTC7 pin direction as inputs
- b. Setting PORTC7 register value as 1 ✓
- c. Setting PORTC7 pin direction as outputs ✓
- d. Setting TRISC7 register direction as inputs +

23. Which of these statements is not true about servo motors?

- a. a servo motor has three wires ✓
- b. PWM is used for reference command ✓
- c. its shaft can be positioned anywhere within 360deg +
- d. it does not allow speed control ✓



24. Which of the following devices can be used for bidirectional dc motor control?
- a. triac
  - b. H-bridge
  - c. relays
  - d. diodes
25. Which of the followings is not related to A/D converter in a PIC microcontroller?
- a. select channel ✓
  - b. select duty cycle ✗
  - c. select voltage reference source ✓
  - d. select clock source ✓
26. The communication protocol used by the boot loader to communicate with the robot development board is
- a. USB
  - b. RS232
  - c. RS422
  - d. RS485
27. Winch servo
- a. is a servo motor without feedback signal ✗
  - b. is a modified servo system for speed control ✓
  - c. is a modified servo for more power ✗
  - d. uses the PWM control signal to command the speed
28. The standard servo pulse period is
- a. 20us
  - b. 2ms
  - c. 1us
  - d. 20ms
29. Wheel speed measurement in low speed is to be done
- a. by counting pulses of a break-beam sensor ✗
  - b. by measuring time between break-beam pulses ✓
  - c. by using a tachometer ✗
  - d. by using a distance sensor ✗
30. Quadrature shaft encoding
- a. has two break-beam sensors ✓
  - b. has a lookup table
  - c. senses direction of motion of the wheel ✓
  - d. all of the above statements are true
31. Which of the following statements is not true about Sense-Plan-Act strategy of robot control?
- a. it slows down robot motion ✓
  - b. it is not appropriate to achieve multiple objectives ✗
  - c. at each step, sensor fusion, world modeling, and planning take place ✓
  - d. is not applicable for complex, dynamic environments ✓

32. Which of the following scenarios can easily distract a mobile robot navigated using IR sensors?

- a. navigation in maze with white walls  $\times$
- b. tracking a white line in black background  $\sim$
- c. navigating in dark environment
- d. navigation in bright daylight

33. How can you use a 9.6 V battery to drive a 6 V servo motor?

- a. do not worry about the little extra voltage  $\times$
- b. use a resistor to drop the voltage  $\times$
- c. not possible  $\times$
- d. use IN4001 diodes to drop the voltage

34. Ultrasound sensor consists of an ultrasound transmitter and a receiver. Ultrasound sensors turn off its receiver when transmitting the ultrasound burst to avoid receiver being saturated from the transmitting signal. A particular ultrasound sensor turns on its receiver, 100us after transmitting the ultrasound burst. Given the speed of sound as 340m/s, the minimum distance which can be measured by the sensor is

- a. 6.8cm.
- b. 3.4cm.
- c. 1.7cm.
- d. 7.2cm.

$$50\mu s \times 340 = 1.7 \text{ cm.}$$

$$\frac{50\mu s}{5\mu s} = 10$$

35. Pull-up resistors are used in sensor interfacing to improve

- a. dynamic range
- b. response time
- c. linearity
- d. sensitivity



36. What types of motors are generally used in hobby robotics?

- a. brushed DC motor, AC motor, RC servo motor
- b. brushed DC motor, stepper motor, RC servo motor
- c. AC motor, stepper motor, RC servo motor
- d. brushless DC motor, Stepper motor, RC servo.

37. Which of the followings is not possible with a PIC18f452 microcontroller?

- a. Drive a stepper motor  $\checkmark$
- b. Drive a servo motor with encoder feedback  $\checkmark$
- c. Read an analogue inputs  $\checkmark$
- d. Output an analogue signal

38. If the TIMER0 of PIC 18f452 has been configured 10bit, PS = 2 (prescaler) with 40 MHz external oscillator, what will be the time taken for a one timer counter?

- a. 0.1 us
- b. 0.4 us
- c. 0.25 us
- d. 0.8 us

$$(PR+1) T_{osc} \times 4 \times \text{prescaler}$$

$$\frac{2 \times 4 \times 1}{40 \times 10^6} = 6 \text{ us}$$

$$\frac{4}{60 \times 10^6} = 66.6 \text{ ns}$$

39. For a DC motor control using PWM, the acceptable frequency range for the PWM frequency is

- a. 20Hz – 200Hz
- b. 1kHz – 20kHz
- c. 2KHz – 1MHz
- d. 2MHz – 20 MHz

40. Which of the following properties has the most significant contribution in determining the range of an ultrasound sensor?

- a. Frequency of the ultrasound signal ✗
- b. Power of the ultrasound burst
- c. Power of the ultrasound burst
- d. Input voltage of the sensor

41. The recommended maximum voltage for analogue input in PIC18f452 is

- a. 3.3 V
- b. 5 V
- c. 6 V
- d. 12 V

42. Which of the followings is possible for a PIC18f452 microcontroller?

- a. drive a stepper motor ✓
- b. drive servo motor with encoder feedback ✓
- c. output an analogue signal ✗
- d. read analogue inputs ✓

43. Referring to the figure 1, if the circuit finds the angle position of the RC servo motor is not correct

- a. the motor shuts off ✗
- b. the motor will turn for 180 degrees ✗
- c. it will always try to minimize the difference between the inverting (negative) and non-inverting (positive) inputs by driving its output
- d. it will stop implementing PWM

44. Maximum resolution of the A/D converter of PIC18F452 is

- a. 128 bits
- b. 256 bits
- c. 512 bits
- d. 1024 bits

45. Which of the following components is used to protect motor control IC from the back EMF of the motor?

- a. a zenner diode ✗
- b. a voltage regulator IC ✗
- c. a resistor ✗
- d. a free wheeling diode

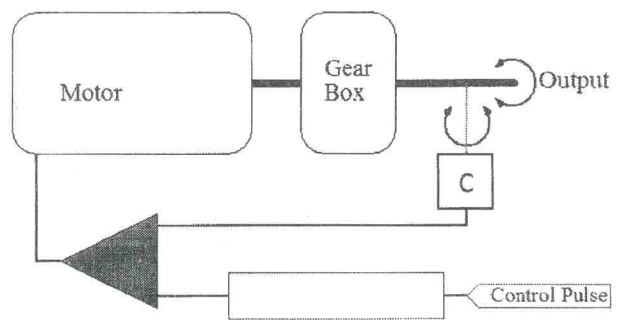


Figure 1

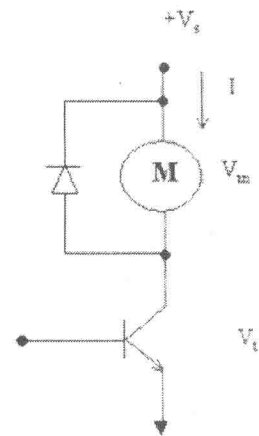


Figure 2



## Section B

[carries 10% of the final grading]

### Question 1

- a) Mention the protection circuits used in power supply when driving microcontroller circuits and other ICs on a single board. Draw necessary diagrams to clarify your answer. [10marks]
- b) Mention the protection methods and circuits used in designing a DC motor controller [7 marks]
- c) Draw a basic schematic diagram of a DC motor controller circuit including the protection circuits that you have mentioned above. [8 marks]

### Question 2

- a) Compare the features and advantages of using the PIC18F452 microcontroller instead of the PIC16F877A microcontroller for your robot applications. [6 marks]
- b) Explain how you can interface a digital encoder module to the microcontroller to get a feedback of the motor movement. Draw the necessary circuit and interfacing diagrams of the motor, encoder, and the microcontroller. [9 marks]
- c) Extend your circuit to measure the rotation speeds and distances travelled of each motor in a two-wheel robot to increase the quality of line following. Mention the methodologies and algorithms used (diagrams if needed) to clarify your answer. [10 marks]