UNIVERSITY OF DERBY

School of Arts, Design and Technology

EXAMINATION PAPER

BSc/BSc (HONS) MUSIC TECHNOLOGY & AUDIO SYSTEM DESIGN
BSc/BSc (HONS) SOUND, LIGHT AND LIVE EVENT TECHNOLOGY
BSc/BSc (HONS) ELECTRONICS
BSc/BSc (HONS) ELECTRICAL AND ELECTRONIC ENGINEERING
LEVEL SIX

EMBEDDED SYSTEMS
6EJ005

DATE: SUMMER 2005

TIME ALLOWED: 2 HOURS

Instructions to Candidates

Answer all *three* questions.
All questions carry equal marks.
The symbolism |X is used to indicate the logical inversion of logic variable X.

DO NOT TURN OVER UNTIL INSTRUCTED

1. A PIC 16F84A microcontroller is to be used to control a simple autonomous guided vehicle (AGV), whose block diagram is shown in Fig. 1. The pinout of the microcontroller is shown in Fig. 2. The AGV has two main wheels, each driven by a reversible DC motor.

Further information on actuators and sensors is as follows:

Bump Sensors: Simple single-pole single-throw electromechanical switches.

Diagnostic Light Emitting Diodes (LEDs): These require a forward current of 8mA for adequate illumination, and at this current have a forward voltage across them of 1.9V. They are to be independently controllable by the microcontroller.

Ultrasound Ranging Module: Requires a single digital pulse (TTL/CMOS compatible) to initiate, and returns a digital echo pulse.

Motor Drive Interface: An L293D “four channel driver” integrated circuit (Fig. 3) has been found suitable to interface between microcontroller and motors.

The digital input/output port pins of the microcontroller have an output resistance of 75Ω approximately.

Develop a preliminary design for this AGV, including the following:

i) Any calculations made,
ii) Any assumptions made, with explanations,
iii) A clear circuit diagram, showing as much detail as possible.

100%

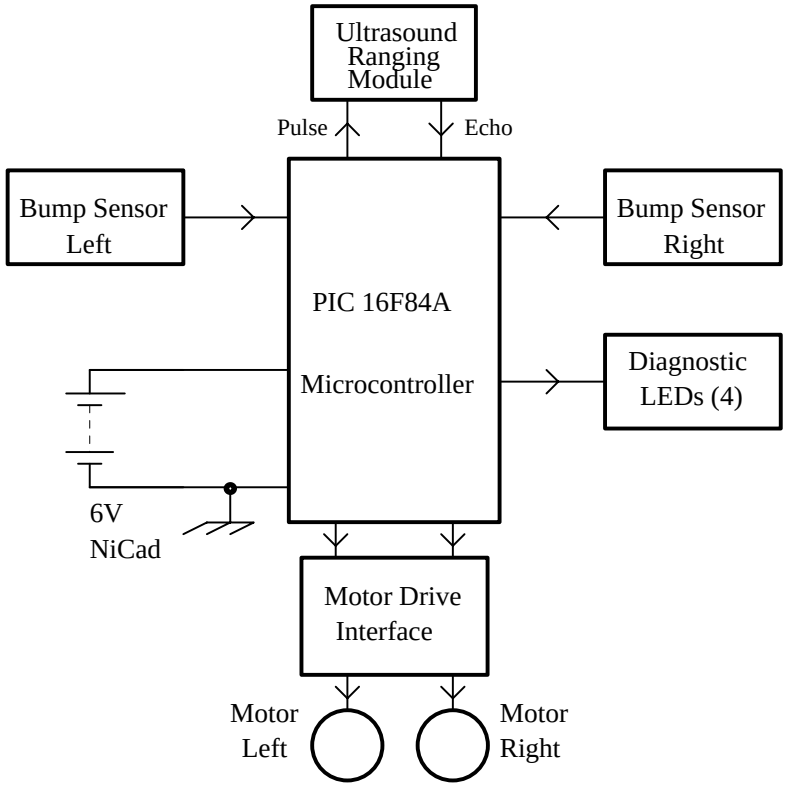
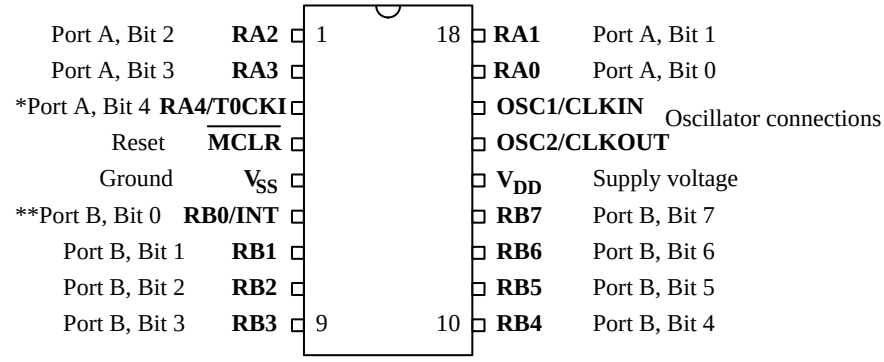


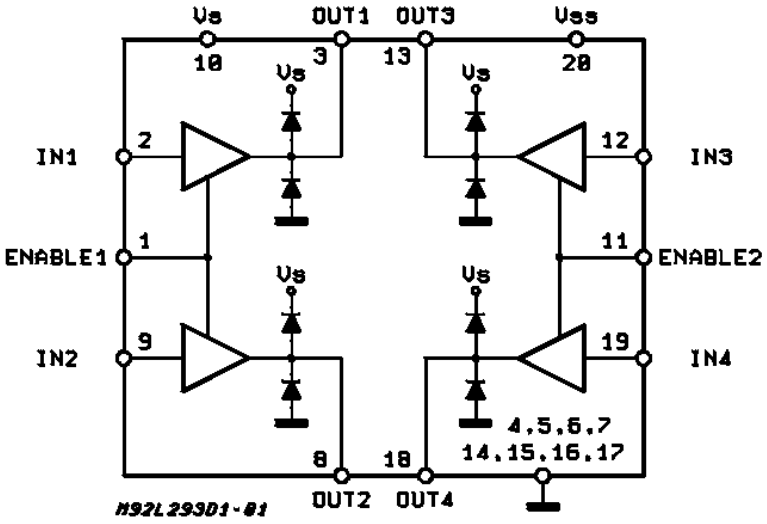
Fig. 1



*also Counter/Timer clock input
**also external Interrupt input

Fig. 2

TURN OVER



Vs: Load Supply Voltage Vss: Logic Supply Voltage

Fig. 3

TURN OVER

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2. The block diagram of the PIC 16F874 analogue to digital converter (ADC) is shown in Fig. 4, and the ADCON0 register which controls it in Fig. 5.

a) What is the setting of the ADCON0 register if an external voltage reference is required, input channel 2 is selected, with clock source being Fosc divided by 2, and the ADC is switched on but not running? **20%**

b) Why are different clock sources available for use with the ADC? **20%**

c) What are the relative advantages in using an external or an internal (VDD) reference? **20%**

d) When using the ADC, what are the main phases of operation which need to be considered? Describe any precautions which need to be taken, and any timing considerations. **40%**

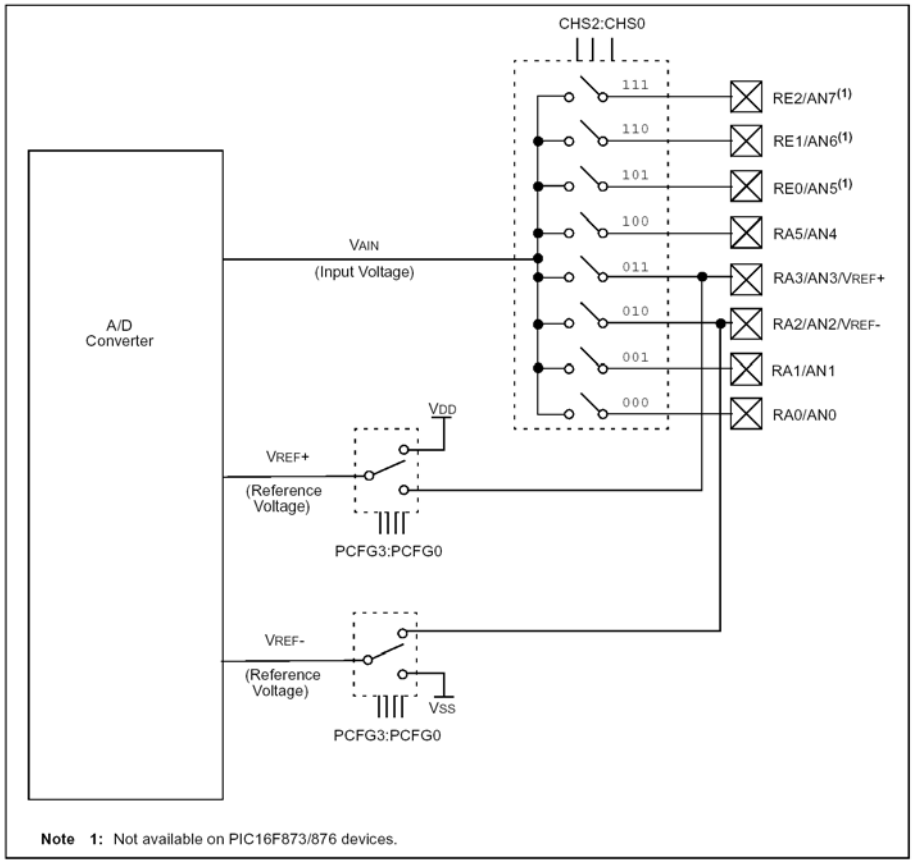

CHS2:CHS0
111
110
101
100
011
010
001
000
RE2/AN7(1)
RE1/AN6(1)
RE0/AN5(1)
RA5/AN4
RA3/AN3/VREF+
RA2/AN2/VREF-
RA1/AN1
RA0/AN0
VAIN
(Input Voltage)
A/D
Converter
VDD
VREF+
(Reference
Voltage)
PCFG3:PCFG0
VREF-
(Reference
Voltage)
VSS
PCFG3:PCFG0
Note 1: Not available on PIC16F873/876 devices.

Fig. 4

REGISTER 11-1: ADCON0 REGISTER (ADDRESS: 1Fh)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit 7							bit 0

bit 7-6 **ADCS1:ADCS0:** A/D Conversion Clock Select bits
00 = Fosc/2
01 = Fosc/8
10 = Fosc/32
11 = FRC (clock derived from the internal A/D module RC oscillator)

bit 5-3 **CHS2:CHS0:** Analog Channel Select bits
000 = channel 0, (RA0/AN0)
001 = channel 1, (RA1/AN1)
010 = channel 2, (RA2/AN2)
011 = channel 3, (RA3/AN3)
100 = channel 4, (RA5/AN4)
101 = channel 5, (RE0/AN5)(1)
110 = channel 6, (RE1/AN6)(1)
111 = channel 7, (RE2/AN7)(1)

bit 2 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
If ADON = 1:
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (this bit is automatically cleared by hardware when the A/D conversion is complete)

bit 1 **Unimplemented:** Read as '0'

bit 0 **ADON:** A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shut-off and consumes no operating current

Note 1: These channels are not available on PIC16F873/876 devices.

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

Fig. 5

3. i) Microwire, SPI (Serial Peripheral Interface), Inter-Integrated Circuit (I^2C) and CAN bus are serial protocols. Describe briefly the principal characteristics and relative advantages of each, and their intended application. **20%**

ii) It is desired to connect serially a PIC 16F873 microcontroller to a Microwire/SPI compatible Maxim 1282 analogue to digital converter (ADC).

The Synchronous Serial Port of the 16F873, configured in SPI mode, is shown in Fig. 6.

The pinout and timing diagrams of the ADC are shown in Figs. 7 and 8 respectively. To operate the ADC the |CS line is set low, and a byte of control data is first sent, which is clocked in through its DIN (Data In) line. This starts a conversion. With further serial clock pulses the ADC then transfers its output data (bits B11 to B0) via its DOUT (Data Out) line, as seen in Fig. 8.

With the aid of a clear diagram, indicate how interconnection should be made to implement the serial link required. All other interconnections can be omitted. Clearly explain your interconnections, and describe in broad terms how you would expect the serial port to be configured and used. **80%**

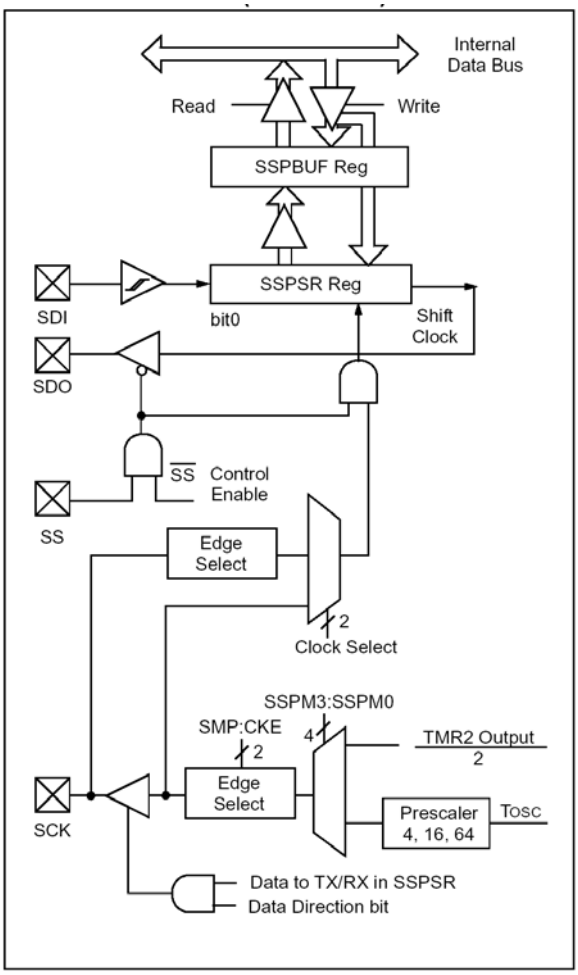

Internal
Data Bus
Read
Write
SSPBUF Reg
SSPSR Reg
SDI
bit0
Shift
Clock
SDO
SS
Control
Enable
SS
Edge
Select
2
Clock Select
SSPM3:SSPM0
SMP:CKE
4
2
TMR2 Output
2
Edge
Select
Prescaler
4, 16, 64
Tosc
SCK
Data to TX/RX in SSPSR
Data Direction bit

Fig. 6

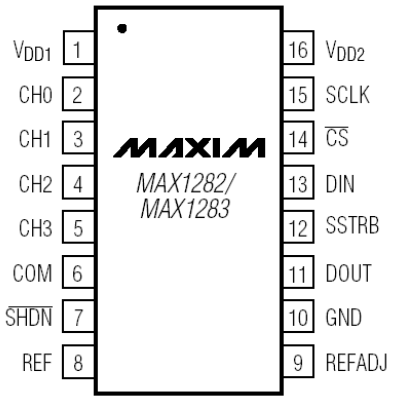
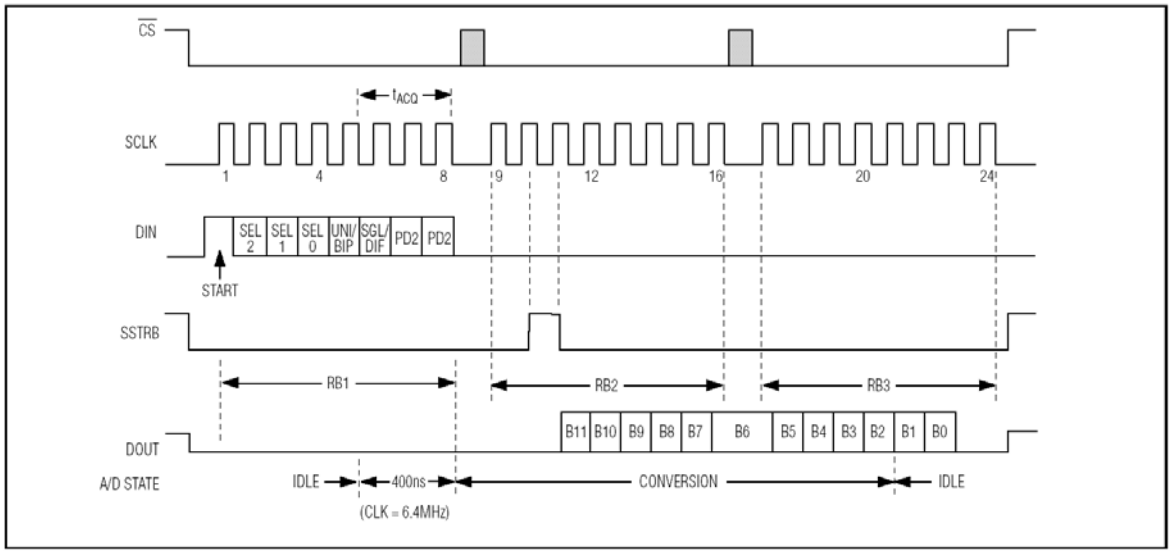


Fig. 7



Serial Strobe (SSTRB) pulses high for one clock period before the MSB decision. High impedance when |CS is high.

Fig. 8