Microcontroller Based Ultrasonic Range Meter

MUDIT AGARWAL

Contact-less distance measurement can be done in many ways. For electrically conductive metal objects, the eddy current method is an option, and capacitive sensors that are independent of the metal used in the measured objects can be used. Some products uses infrared light emitters and receivers that determine object distance by implementing the optical triangulation method. Other devices have laser-based systems that increase accuracy and precision. I decided to use ultrasonic waves. My ultrasonic RangeFinder measures the amount of time it takes for a pulse of sound to travel to a particular surface and return. Then, the device calculates the distance based on the estimated speed of sound.

The RangeFinder has numerous applications. You can use it for the positioning of robots as well as measuring generic distances, liquid levels in tanks, and the depth of snow banks. The device can also serve as a motion detector in production lines where surfaces must not be damaged. The RangeFinder has a 40-kHz operating frequency, a range of 25 to 400 cm. We have tested for a range of 300 cms.

Microcontroller

The PIC 16F877A has 40 pins Operating speed: DC to 20 MHz clock input, Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM),Up to 256 x 8 bytes of EEPROM Data Memory.

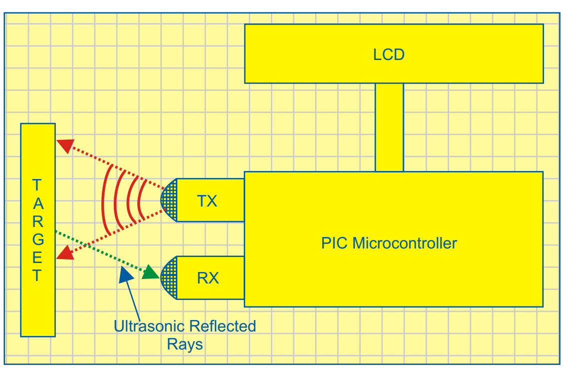

Fig. 1 : Block Diagram of Ultrasonic Range Meter

LCD Display

LCD is used for user interaction with the system, 16*2 LCD display based on Hitachi HD 44780 controller. LCD is interfaced to microcontroller by using four Data lines D7, D6, D5, D4 and control signals RS, R/W and En.

Power Source

5V Regulated power supply is required for microcontroller, LCD. Ultrasonic sensor is driven by +12V DC.

Ultrasonic Transducer

40KHZ Ultrasonic sensors are used here.

Circuit Description

The PIC Range Finder works by transmitting a short pulse of sound at a frequency inaudible to the ear (ultrasonic sound or ultrasound). Afterwards the microcontroller listens for an echo. Block Diagram is shown in fig. 1. The time from transmission to echo reception lets you calculate the distance from the object.

The time from transmission of the pulse to reception of the echo is the time taken for the sound energy to travel through the air to the object and back again. Since the speed of sound is constant through air measuring the echo reflection time lets you calculate the distance to the object using the following equation

Distance = (Speed X Time Taken)/2

You need to divide by 2 as the distance is the round trip distance i.e. from transmitter to object and back again. You can get ultrasonic transducers optimized for 25kHz, 32kHz, 40kHz or wide bandwidth transducers. This project uses a 40kHz transducer.

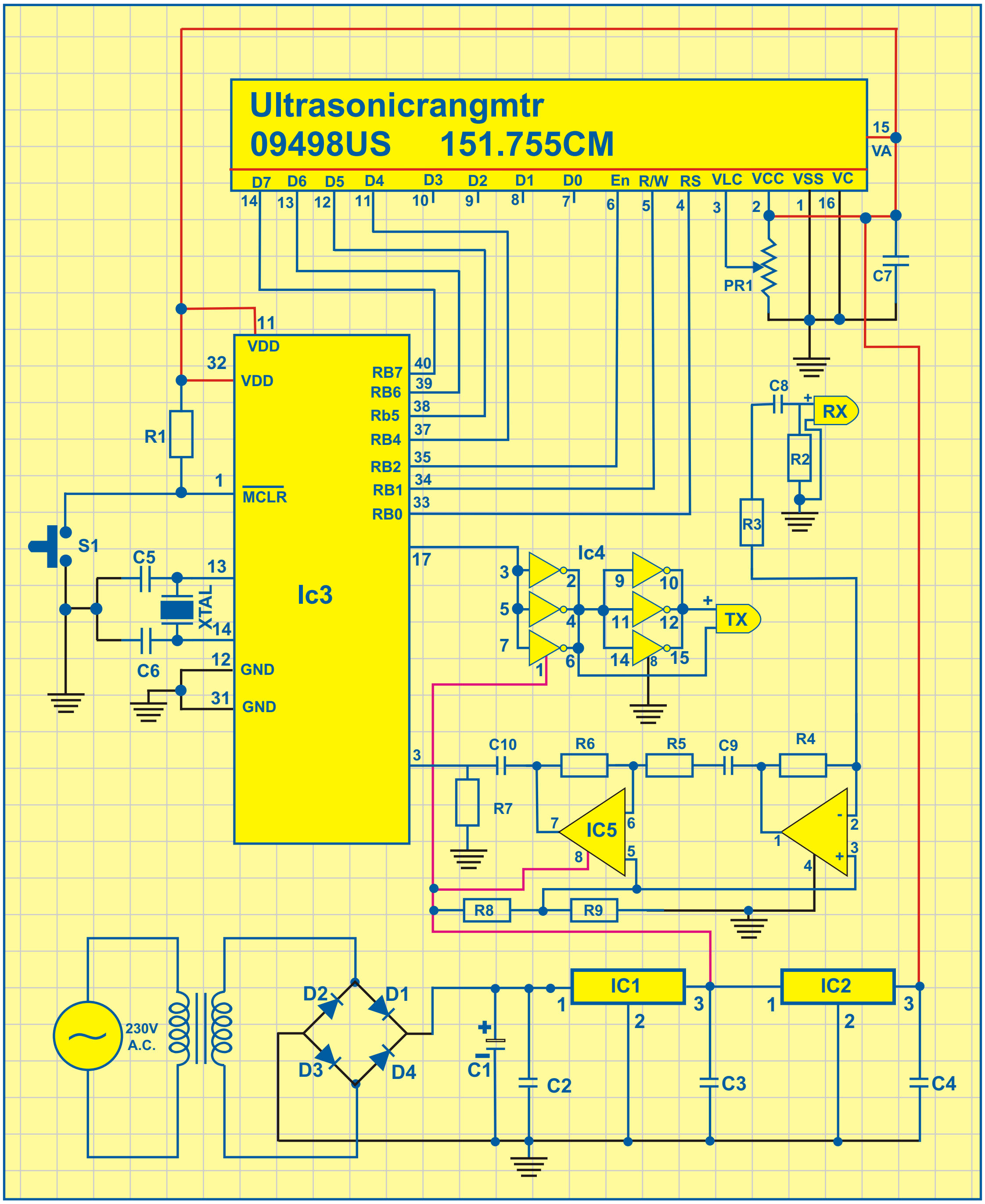

Fig. 2 : Circuit Diagram of Ultrasonic Range Meter

The 40KHZ signal is easily generated by the microcontroller but detection requires a sensitive amplifier. To generate 40KHZ signal for Ultrasonic transmitter circuit uses PWM module of the microcontroller. In Pulse Width Modulation mode, the CCPx pin produces up to a 10-bit resolution PWM output. Since the CCP1 pin is multiplexed with the PORTC data latch, the TRISC<2> bit must be cleared to make the CCP1 pin an output. A PWM output has a time base (period) and a time that the output stays high (duty cycle). The frequency of the PWM is the inverse of the period (1/period). The PWM period is specified by writing to the PR2 register. The PWM period can be calculated using the following formula:

PWM Period = [(PR2) + 1] X 4 X TOSC X (TMR2 Prescale Value)

When TMR2 is equal to PR2, the following three

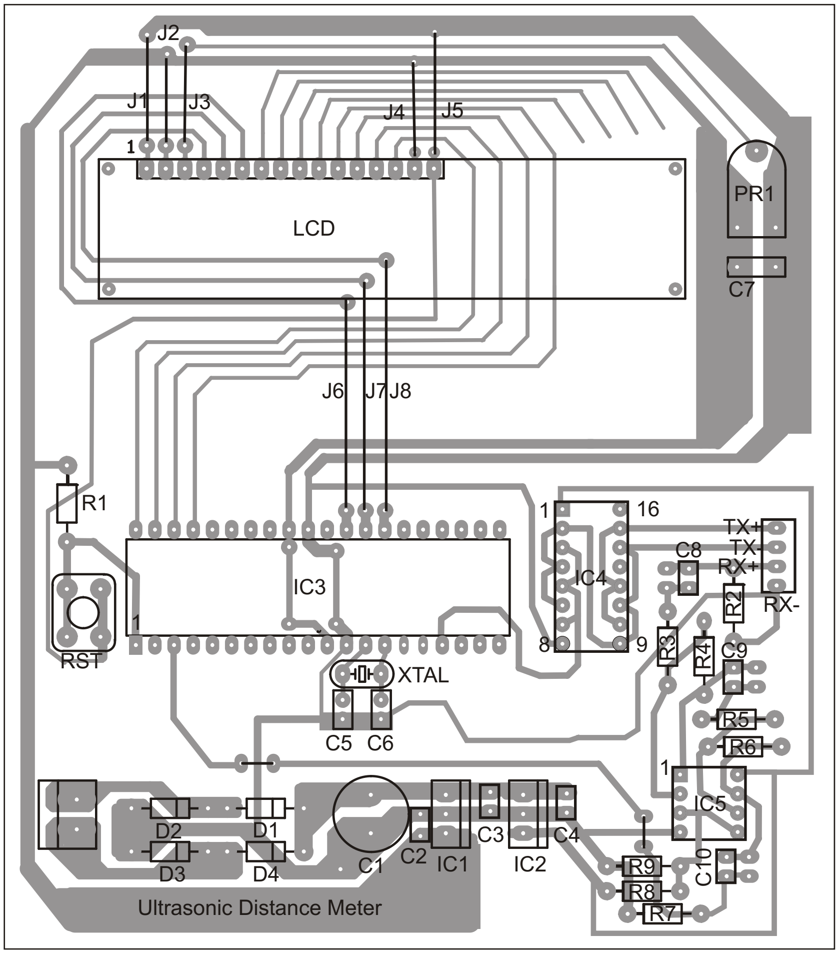

Fig. 3 : Component Layout of Ultrasonic Range Meter

events occur on the next increment cycle:
TMR2 is cleared, CCP1 pin is set, PWM duty cycle is latched from CCPR1L into CCPR1H. The PWM duty cycle is specified by writing to the CCPR1L register and to the CCP1CON<5:4> bits. Up to 10-bit resolution is available. The CCPR1L contains the eight MSbs and the CCP1CON<5:4> contains the two LSbs. This 10-bit value is represented by CCPR1L:CCP1CON<5:4>. The following equation is used to calculate the PWM duty cycle in time:

PWM Duty Cycle =(CCPR1L:CCP1CON<5:4>) X TOSC X (TMR2 Prescale Value)

CCPR1L and CCP1CON<5:4> can be written to at any time, but the duty cycle value is not latched into CCPR1H until after a match between PR2 and TMR2 occurs . In PWM mode, CCPR1H is a read-only register. The CCPR1H register and a 2-bit internal latch are used to double-buffer the PWM duty cycle. This double-buffering is essential for glitch-free PWM operation. When the CCPR1H and 2-bit latch match TMR2, concatenated with an internal 2-bit Q clock or 2 bits of the TMR2 prescaler, the CCP1 pin is cleared.

Setup For Pwm Operation

The following steps should be taken when configuring the CCP module for PWM operation:

1. Set the PWM period by writing to the PR2 register.
2. Set the PWM duty cycle by writing to the CCPR1L register and CCP1CON<5:4> bits.
3. Make the CCP1 pin an output by clearing the TRISC<2> bit.
4. Set the TMR2 prescale value and enable Timer2 by writing to T2CON.
5. Configure the CCP1 module for PWM operation.

On the receiver side ultrasonic Receiver transducer receive the reflected signal, this signal is amplified via operational amplifier LM358 and finally applied to microcontroller. PIC microcontroller starts PWM module and outputs 40KHZ waveform from pin 17, which is further applied to Ultrasonic transmitter. Microcontroller generate 40KHZ signal for a specified time say 500us. Then waits for received signal from the Ultrasonic receiver. If microcontroller receive the reflected signal then it will display the distance on LCD. If receiver fails to detect signal then microcontroller again transmit a 40KHZ burst. Circuit diagram of microcontroller based ultrasonic range meter is shown in fig. 2. component layout is shown in fig. 3. and PCB layout in fig. 4.

The Software

```
#define PULSELEN        300
#define BUFSIZE 10
#define LCDPORT PORTD
#define LCDTRIS TRISD
unsigned char   outOfRange ;
unsigned int    buf[BUFSIZE] ;
void wait(void);
void ready(void);
void command(unsigned char);
```

```
void display(unsigned char
*);
void busycheck(void);
void calllcd(unsigned short);
void calllcd5(unsigned long);
void calllcddistancecm(unsi
gned long);
void calllcd1(unsigned
short);
void interrupt(void)
{
if(PIR1.TMR1IF)
{
outOfRange = 1 ;
PIR1.TMR1IF = 0 ;
}
}
void main()
{
unsigned char i;
unsigned int a1,a2,a3,a4;
unsigned int a5,a6,a7,a8;
unsigned long total ;
unsigned char str[5] ;
unsigned long distancecm;
TRISA = 0xff ;
PORTA = 0 ;
TRISC = 0 ;
PORTC = 0 ;
TRISD=0xff;
T1CON = 0b00001100 ;
command(0x28);
command(0x0E);
command(0x06);
command(0x01);
command(0x80);
PWM_Init(40000) ;
 PWM_Change_Duty(128) ;
INTCON.GIE = 1 ;
INTCON.PEIE = 1 ;
PIE1.TMR1IE = 0 ;
PIR1.TMR1IF = 0 ;
for(;;)
{
```

For rest of the code,
E-mail at : info@electronicsmaker.com

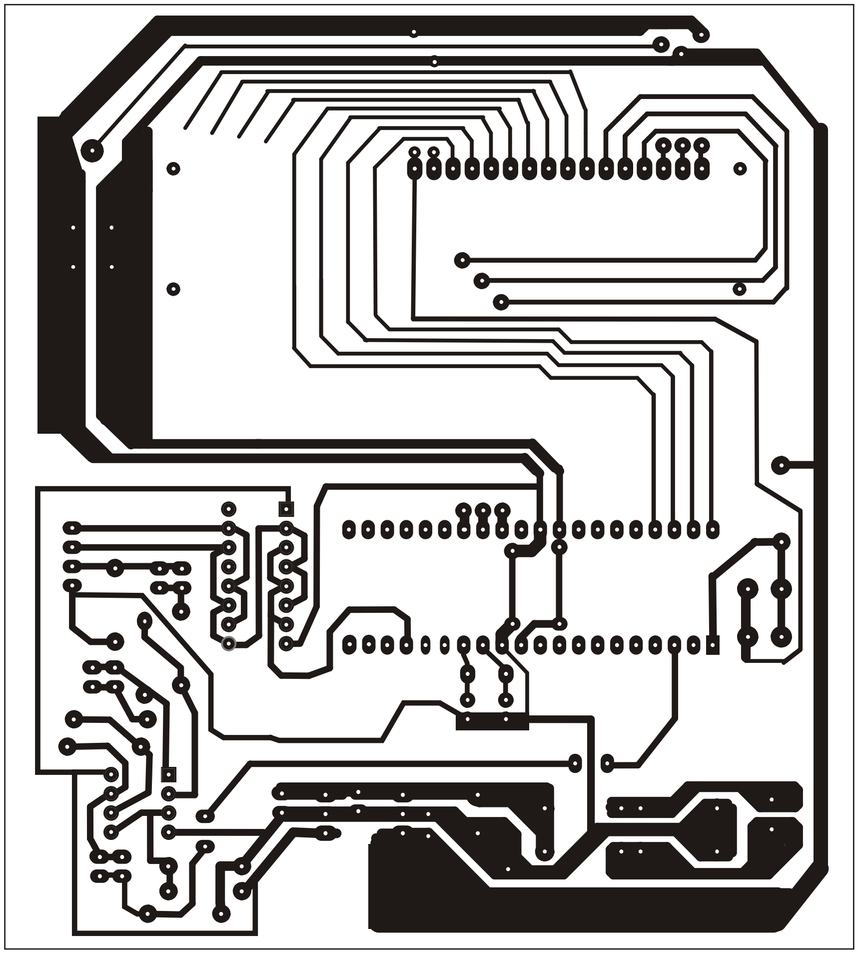

Fig. 4: PCB Layout of Ultrasonic Range Meter

Component List

SEMICONDUCTOR DEVICES	
IC1	7812
IC2	7805
IC3	PIC16F877A
IC4	CD4049
IC5	LM358
D1-D4	1N4007
CAPACITORS	
C1	1000uf/50V
C2,C3 ,C4	0.1uf
C5,C6	22pf
C7,C8,C9,C10	0.02uf
RESISTORS	
R1	4.7K
R2,R4,R7	100K
R3,R5,R8,R9	10K
R6	330K
Preset PR 1	2K
MISCELLANEOUS	
TXFR	12 volt/500 Ampere
XTAL	4 MHZ
LCD	16 x 2 Liquid Crystal display
TX	40KHZ Ultrasonic Transmitter
RX	40KHZ Ultrasonic Receiver
S1	Push to ON switches