Ultrasonic Distance Meter

Device: UCM-R40K1
Ultrasonic sensor Tx, Rx

Sensor Specification

Introduction

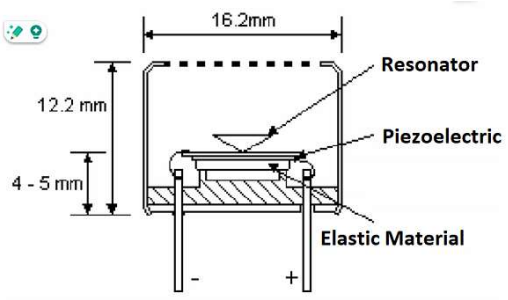
This application note describes the implementation of a distance meter using ultrasonic sensors of the UCM-R40K1 type. A 40KHz burst is transmitted through an ultrasonic sensor, the reflected ultrasound is received by another receiving sensor. The distance calculation is done with a PIC16F873. The measured distance range is 25cm to 300cm

Ultrasonic sensor

Ultrasound refers to frequencies above 20KHz (limit of audible sound). High frequencies have short wavelengths which means they can be read when reflected off objects. Unfortunately, very high frequencies are difficult to generate and read.
The generation and reading of ultrasound is done through two piezoelectric units where one of them is the emitter and the other the receiver of ultrasonic pressure waves. For this, the transmitting unit must be excited with a signal adequate in amplitude and frequency. The receiving unit will transduce all those 40KHz ultrasonic pressure waves that excite it.

Ultrasound is commonly applied in motion detectors, distance meters, medical diagnosis, cleaning, non-destructive testing (to detect imperfections in materials), and welding, among others.

Characteristics	UCM-R40K1
Resonance frequency:	40KHz
Sound Pressure Level:	115dB<
Sensitivity:	-64dB<
Maximum entry of voltage:	20Vrms
Typical directivity:	55º

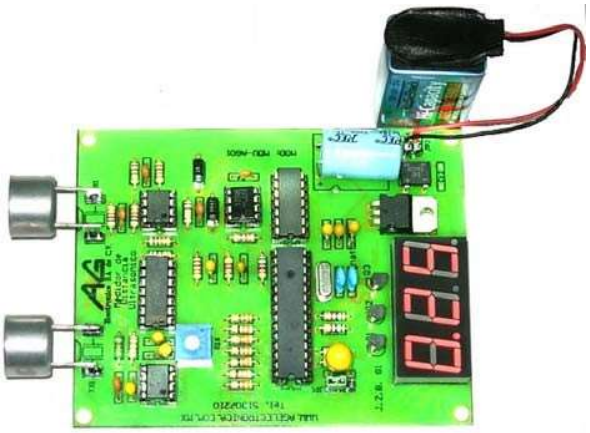


UCM-R4OK1

The part number includes the transmitter and receiver, marked T and R.

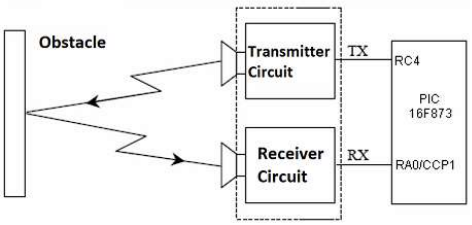
Ultrasonic Distance Meter

Characteristics	MDU
Type of Sensor	Ultrasonic reflection
Frequency	40KHz
Minimal distance	25cm
Maximum distance	300cm
Resolution	1 cm
Sensitivity	Detects an object with a diameter of 8cm at < 1m
input voltage	9V
current consumption	60mA tip.



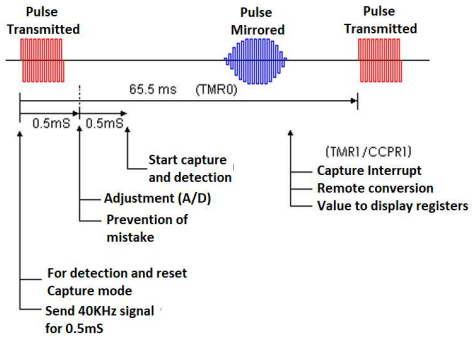
The distance is calculated by reading the time it takes for a reflected ultrasonic wave to return. Ideally, the obstacle should have a large cross-section and not absorb ultrasound. The most used method for determining distance is to send trains of 40 KHz pulses with very short periods. The time elapsed between the beginning of the emission and the beginning of the reception will be proportional to the distance travelled by the ultrasonic waves.

As the echoes must travel a greater distance, they will be received by the receiver a period later than the direct waves, and will not disturb when quantifying the distance.



Functioning

If a signal of 40 KHz with a duration of 5 mS is generated every 65 mS. Upon detecting the reflected wave, an interrupt is generated which stops a 16-bit timer.



To calculate the distance, we know that the speed of sound is 343m/s = 34300cm/s (at 20ºC), therefore:

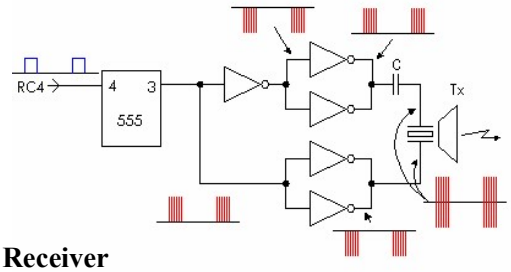
$$1cm = 1sec/34300cm = 29.15us$$

To calculate the distance, divide the timer value (fosc = 4MHz, value equal to 1uS) twice by the time of one centimetre.

Total time of the reflected wave = 3887us. The distance between the sensor and the object: (3887us/2)/29= 67.017 cm. The division by two is because it is considered that the wave when reflected travels twice the distance from where it was emitted.

Transmitter

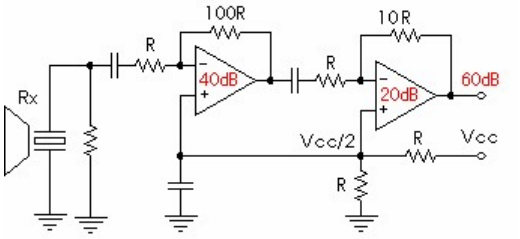
The transmitter is built with a 555 and CMOS inverters, the CMOS feature is used to put them in parallel and increase the transmission power. The signal coupled between the positive and negative terminals is 180º out of phase, so the voltage applied between the terminals is double.



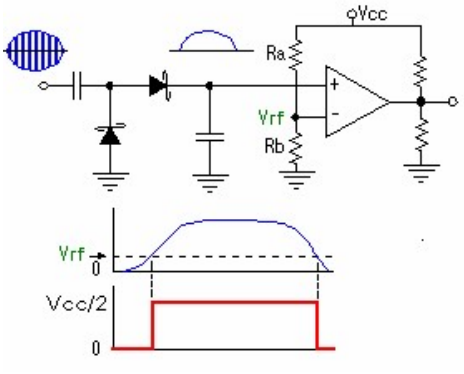
Receiver

The receiver is composed of two circuits: a signal amplifier and a detection circuit. The signal is received by the receiving sensor and amplified 1000 times (60dB) in two

steps an amplifier for 100 (40dB) and an amplifier for 10 (20dB).

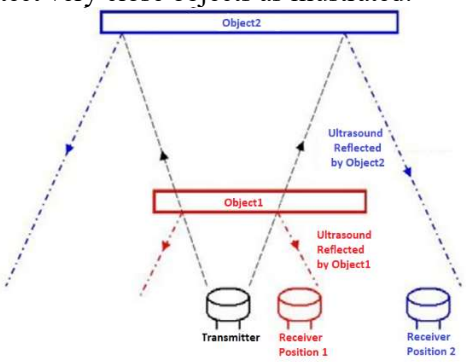


The signal detector consists of a half-bridge rectifier and a comparator. The comparison voltage is set at 0.045Vdc



Limitations

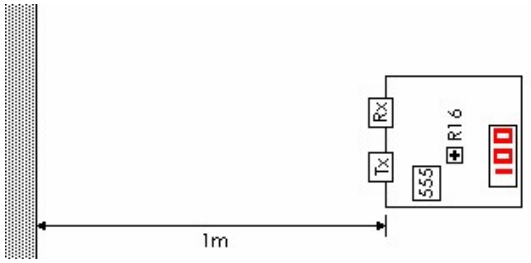
The main consideration is the position of the sensors, if the receiving sensor is placed far from the transmitter it may not be able to detect very close objects as illustrated:



For applications where it is required to measure small distances, the optimal separation distance is 3.5cm considering the axes of the sensors.

Adjustment

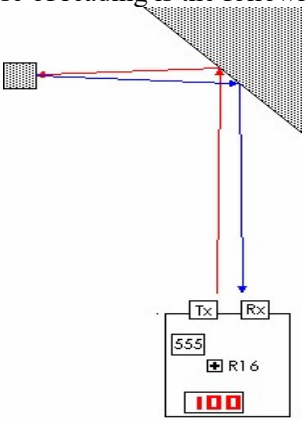
One meter away from a flat wall, move R16 until the measurement is obtained. The measurement includes approximately 7 mm of the sensor body. The maximum distance is achieved if the frequency with which the transmitter is powered reaches the resonance frequency (40KHz).



For an adequate measurement, especially over long distances, the following conditions must be perfect:

- The object must be perpendicular to the meter.
- The surface of the object must be flat
- There should be no objects around that could cause a reflection.
- The object should not be very absorbent, such as fabric or a corrugated wall

A special case of reading is the following:

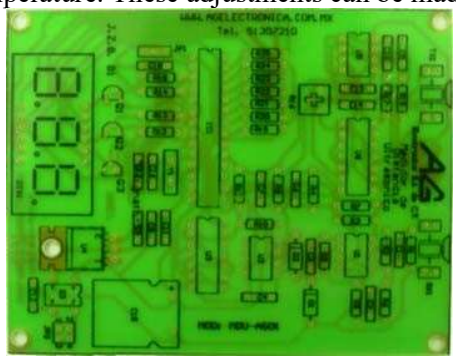


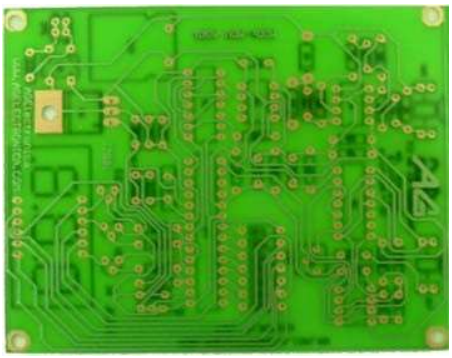
In this case the reflection is made on a surface at 45º, which will cause the ultrasound to deviate perpendicularly, the measurement will be according to the object that is closest or, failing that, if it goes out of range it will mark an error.

Note1: The distance calculation is calculated for 20º. According to the equation:

v = 331.5 + 0.6 * t [m/sec], t=ºC

The divider should vary concerning temperature. These adjustments can be made with the A/D converter. Another adjustment that can be made by software is an auto-range to measure distances from 3cm (minimum tested with sensors) to 11m.





Material list

Component	Value	Code
C1,2,3,4,5	1nF	CC-.001/50V
C6,7,8,9,10,11	0.1uF	CT-.1/35V
C12,13,14	0.1uF	CT-.1/35V
C18	100uF	CT-100/16V
C15	2200uF	CE-2200/16V
C16, 17	22P	CC-22/1000V
D1 ,2	1N5818	1N5818
D3	DB102	DB102
DIS1	FJS5361BH	FJS5361BH
IC1	PIC16F873	PIC16F873-04/SP
JP1, JP2	HEADER	HEADER-1
Q1,2,3	BC558B	BC558B
R1,2,3,4,5,16	10K	RC-10K/1/4
R6,7	1M	RC-1M/1/4
R8	100K	RC-100K/1/4
R9,10	47K	RC-47K/1/4
R10	4K7	RC-4K7/1/4
R12,13,14	5K6	RC-5K6/1/4
R15	8K2	RC-8K2/1/4
R16	10K	3386P-103
R17	1K5	RC-1K5/1/4
R18 - 25	330	RC-330E/1/4
RX1,TX1	UCM-R40K1	UCM-R40K1
U1	LM358N	LM358N
U2	LM358N	LM358N
U3	HEF4011BP	HEF4011BP
U4	L7805CV	L7805CV
U5	LM555C	LM555CN
U6	CD4069	CD4069UBCN

Component	Value	Code
Y1	4MHz	4MHz-MINI
3 x base 8p		8P
2 x base 14p		14P
1 xbase 28p		28P
PCB		MDU-AG01

Note: Be careful when assembling the tantalum capacitors since on the PCB symbols were not added with polarities especially in C18

References

AN0403006/Rev.1.00