Circuit Connections

The four pins are labeled as follows: VCC, TRIG, ECHO, GND.

VCC **(INPUT)**: This is the voltage into the circuit. In this case 5VDC.

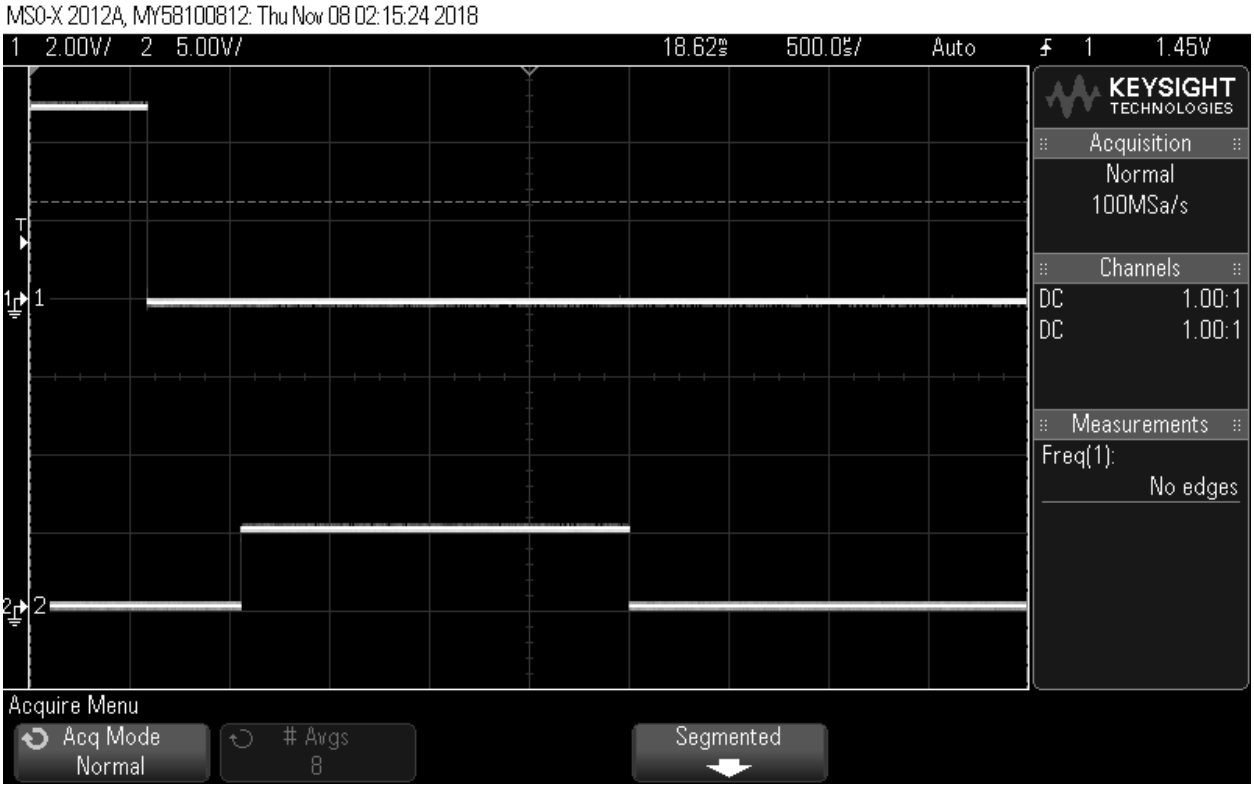
TRIG **(INPUT)**: This is the trigger pulse that turns on the ultrasonic transducers. It need to have an amplitude of no more than 5V, and a duration greater than 10µs. If you are triggering with the function generators, make sure that the function generator is set to "High Z" before continuing. Damage is likely to result otherwise. Arduinos should not have any issues using a digital output pin.

ECHO **(OUTPUT)**: This is an output of 5V. The duration of this pulse represents the time that it takes for a signal to be sent, hit the target, and return.

GND **(INPUT)**: Connect ground here so the circuit sees 5VDC.

Theory of Operation

Measurement taken at D=12”



$$Length\ of\ Pulse\ (Channel\ 2) \approx (500\mu s * 3) + 445\mu s \approx 1945\mu s$$

This is the time it takes for a pulse to be sent, hit the object, and then return. Estimate or measure the pulse width of the echo pulse. Estimate by counting the squares on the oscilloscope (as done here), or measure via Matlab (or Python) using GPIB or USB.

$$Speed\ of\ Sound\ (in\ air\ at\ STP)\ \approx 13{,}500\frac{in}{s}$$

This is typically given at STP conditions. That is **Standard Temperature** and **Pressure**. The relative humidity also plays a role, but it is not explicitly mentioned. You can look up a better estimate at Engineeringtoolbox.com, along with an explanation of STP conditions.

https://www.engineeringtoolbox.com/air-speed-sound-d_603.html

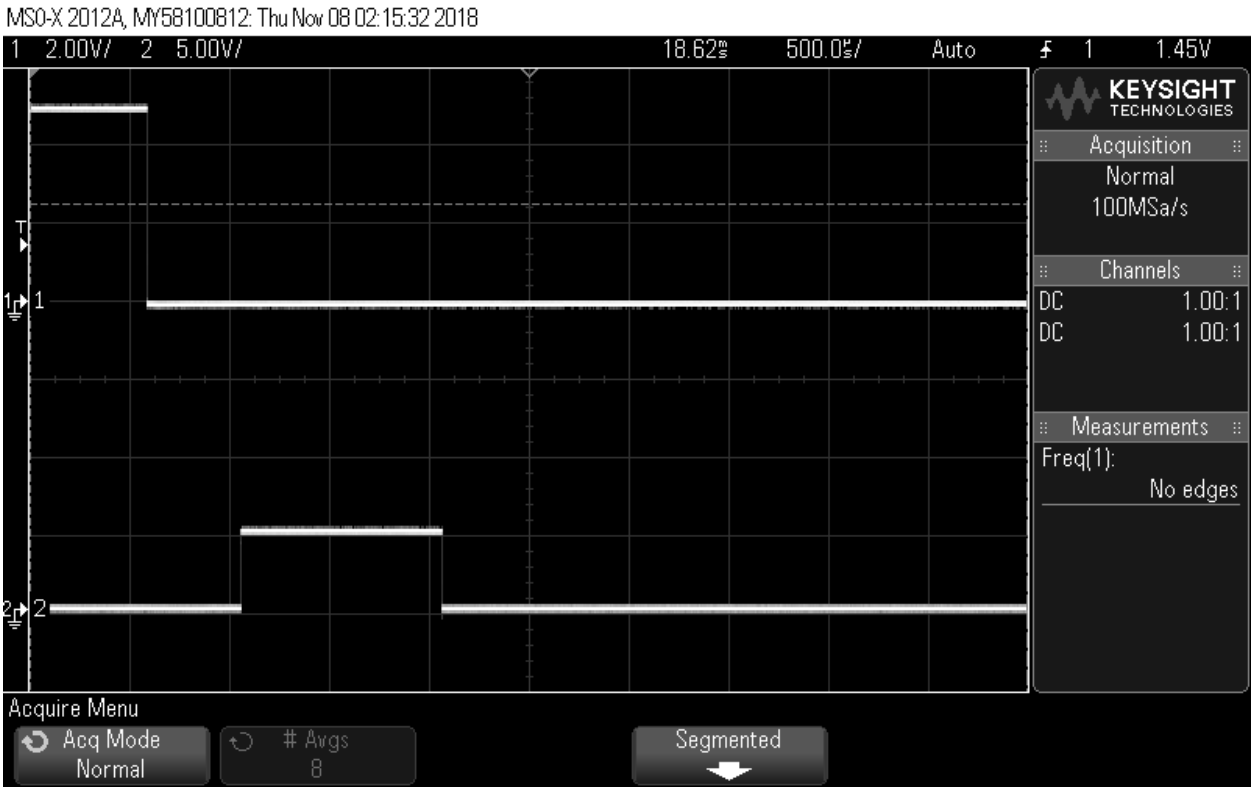
$$Travel\ Distance = \frac{Length\ of\ Pulse}{2} * Speed\ of\ Sound\ (in\ air)$$

$$Travel\ Distance = \frac{.001945}{2} * 13500 = 13.13"$$

As you can see this is not a good approximation of the actual distance (12”). Included in this error is the estimation of the length (it is not actually a straight line that the wave follows, but a triangular shape; so you need to use trigonometry, to simply divide by 2), the speed of sound in air, and simple error in estimating the pulse length.

The next two pictures show the response of the sensor at 6” and 3”. As you can see, the length of the pulse decreases by a factor of 2 each time.

Measurement taken at D= 6”



Measurement taken at D=3”