Lab Exercise 5
Prototype Design of a SONAR Receiver

Objective

The objective of this lab assignment is:

a. To develop a prototype of a SONAR receiver on a breadboard and test its desired outcome.
b. With SONAR Tx and Rx, observe the Doppler shift in the received signal from a moving metal target.

Description

The transmitted signal from the SONAR Tx is approximated by the equation below.

$$S_{tx}(t)=A_{tx}\cos(2\pi f_o t) \text{ ---------- (1)}$$

The received signal from a moving target consists of a Doppler shifted signal.

$$S_{rx}(t)=A_{rx}\cos(2\pi(f_O+f_D)t) \text{ ---------- (2)}$$

The received signal is much weaker than the transmitted signal ($A_{rx} < A_{tx}$). Hence, the signal is passed through a low noise amplifier for voltage amplification. Then the signal is band pass filtered to remove higher order harmonics and limit external interference. The signal is then captured in the oscilloscope. The frequency domain of the received signal should show a shift in the frequency from 40KHz when a target moves before the sonar. Note that when the hand is moving, the Doppler frequency shift may change with time. Also note that the sonar must be configured such that the strong transmitted signal does not directly leak into the receiver. The transducers are typically very directional, so the sonar must be carefully configured such that the transmitter and receiving transducers do not face each other and instead face the target. While performing experiments with a moving target, please ensure that the target is within the field of view of the sonar.

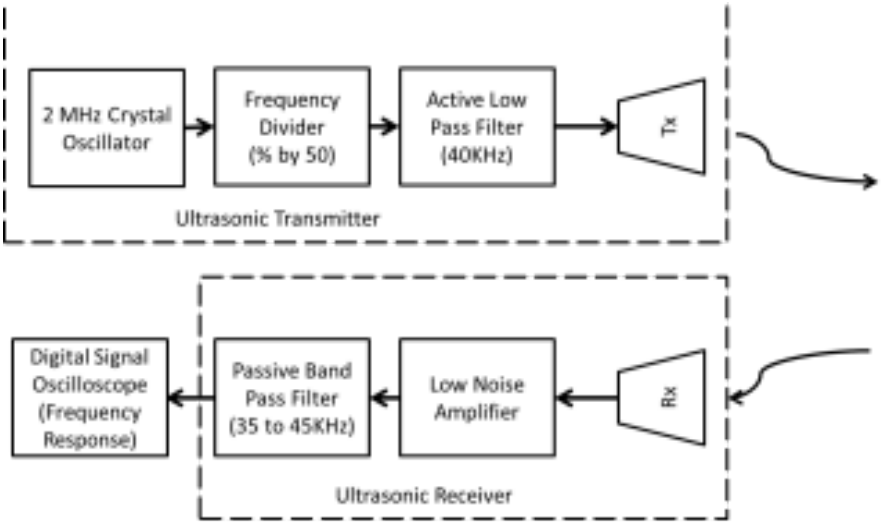


Fig. 1. Ultrasonic narrow band Doppler sensor

PART A

In this lab we will design the Rx part of the SONAR, as indicated in the below figure, to achieve the desired output.

Circuit Diagram of Receiver Circuit

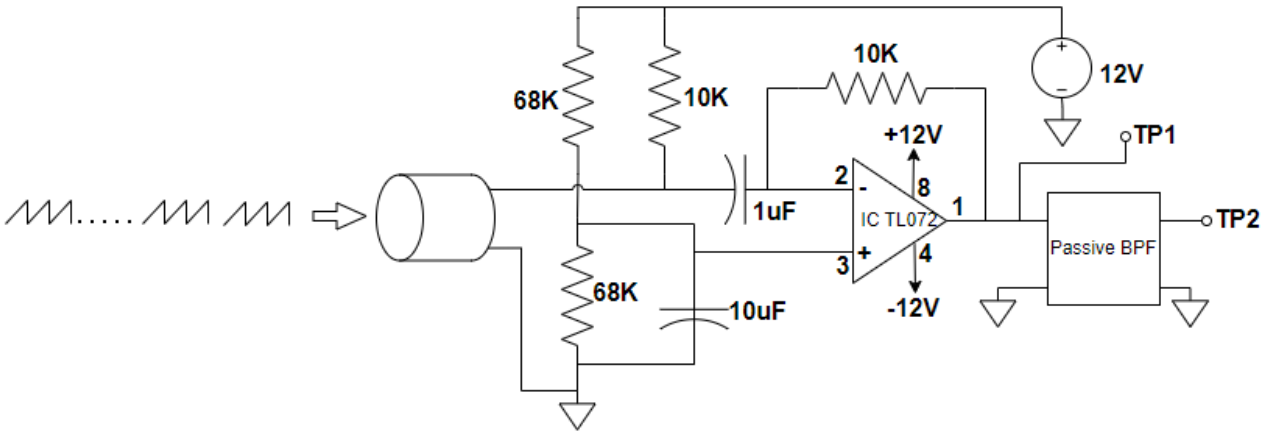
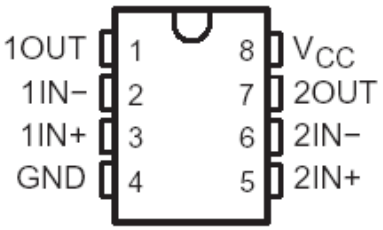


Fig. 2: Receiver Circuit Diagram

Components Utilized in the Rx Section of the SONAR:

Components Part Number	Type	Purpose	Link for the Datasheet
TL072	Low Noise Amplifier	Amplify received signal without introducing too much noise	Link
MCUSD16A40S12R0	Piezoelectric Transducer	Convert electrical to ultrasonic signal and back (Transmitter and Receiver)	Link
	R, L, C	Resistors, inductors, capacitors	

IC Pin Diagram



IC TL072 pinout

PART B

With SONAR Tx and Rx, we will also observe the Doppler shift in the received signal from a moving metal target. We have seen in the previous lab that the final output signal after the LPF block in Tx practically differs from the exact sinusoid as indicated in Eq 1, hence while the signal will be received on the Rx side it will not be of exact sinusoid nature as indicated by equation 2, however, we can compare the outputs of Tx and Rx block and can observe the Doppler shift in an Oscilloscope.

Lab Exercise:

In the circuit designed on the breadboard for the SONAR Rx, as indicated in Fig.2.

1. ***First use the wave gen function of DSO and generate a 40kHz frequency and provide it in the input of LNA.***
2. ***Check the response at the node marked by TP1 in DSO. This is the LNA output.***

   3 marks, no partial marking

3. ***Check the response at TP2, here we should get the output signal of BPF.***

   2 marks, no partial marking

4. ***Now place both Transmitter & Receiver Circuit suitably so that their respective transducers do not face each other and instead face the target. Keep a rotating metal target within the field of view of the SONAR & compare the output response of the received pulse wrt the transmitted pulse, using an oscilloscope. Mention the change in frequency, when the target is moving (doppler shift).***

   3 marks, no partial marking

5. ***Correct circuit & file submission***

   2 marks: 1+1 (Circuit+File Submission)
