Data Transmission through Ultrasonic Sound

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Problem Statement

Design a prototype that is able to transfer digital data using ultrasonic sound

#	Details	Value	Unit	Remark
1	Transmission Length	30	centimetre	Maximum length
2	Transmitter Power	TBD	Watt	
3	Power Supply	5	Volts	
4	Transmission Speed	40	kHz	
5	Communication Protocol	UART		
6				
7				

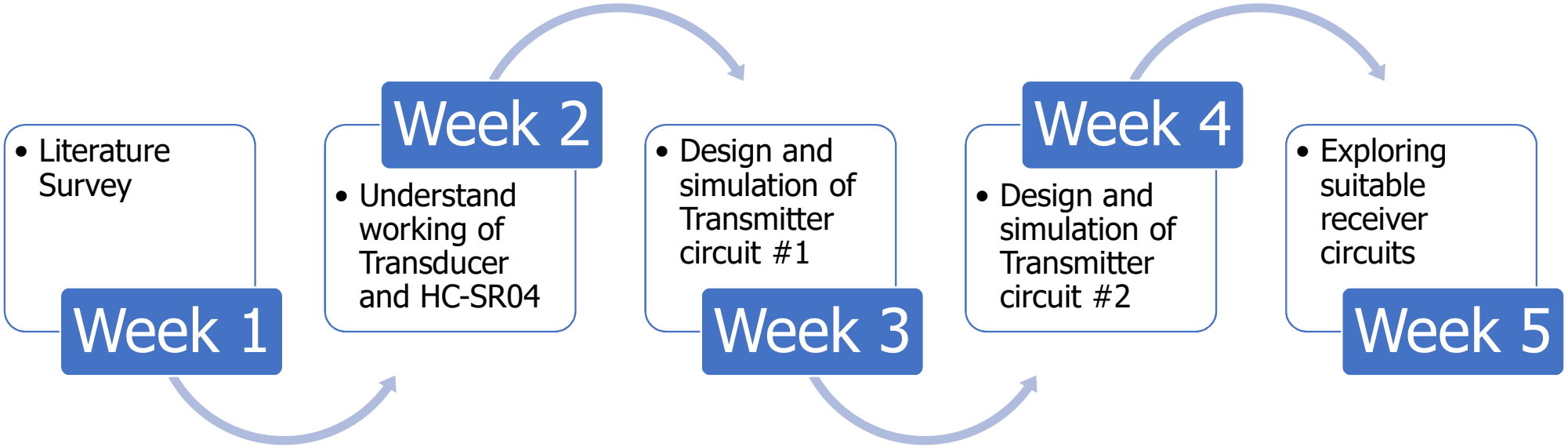
Introduction

- Short-range connectivity among electronic devices is essential to build a connected world.
- With billions of connected devices, the need for devices to identify and communicate with each other is increasing.
- Radio Frequency based wireless communication rely on high power radio transmitters

Why Ultrasonic Data Transmission?

- Data can be transmitted with standard speakers and microphones.
- Ultrasonic bypasses the physical limitation of short-range RF.
- Similar to other communication protocols, data can be encrypted and transmitted.
- Properties of sound enable quick localised data transfers which is key factor in sharing resources based on proximity.

Progress Timeline



Literature Survey

- The 18.5 to-20 kHz is inaudible to most humans and yet realizable with commodity speakers and microphones in mobile devices.
- Modulation is made in such a way that makes it robust to noise and reverberation in the environment.
- Speakers of common phone produces 74 dB SPL at 18 kHz whereas the threshold is 86 dB SPL to be audible.
- The range is reliable for a maximum distance ranging from 2 m to 10 m.

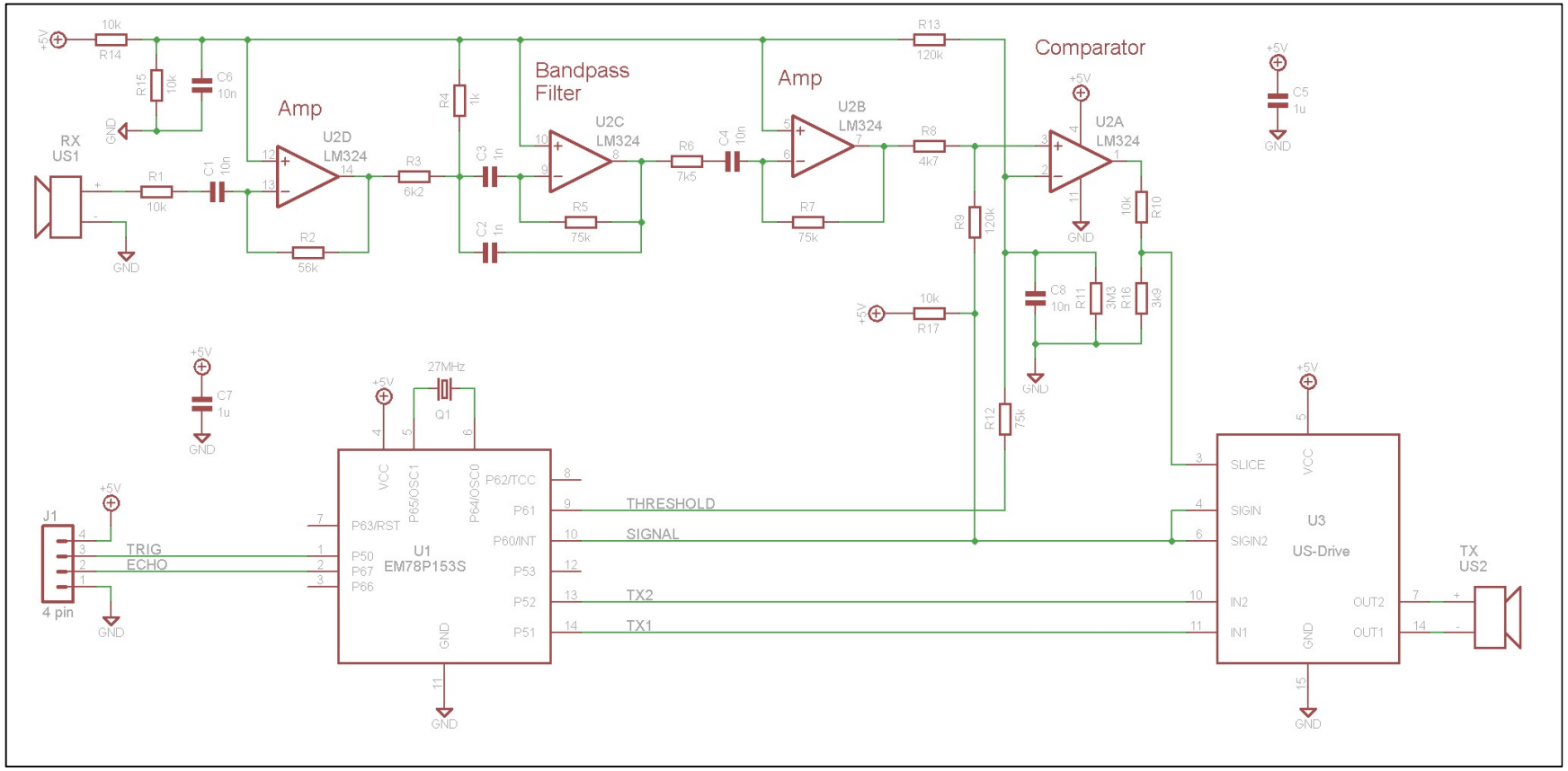
Applications

- Ultrasonic data transmission can be used under-water.
- Short-range, secure resource sharing between devices.
- Data transmission in places where electromagnetic radiations are harmful e.g. Petrol bunks, Healthcare

HC-SR04

- HC-SR04 is an ultrasonic distance sensor.
- It has two transducers – one acting as a transmitter and the other as receiver.
- It has four pins:
  - VCC – Positive terminal of the power source.
  - Trig – Trigger pin to send burst of ultrasonic.
  - Echo –Echo pin to receive the reflected ultrasonic sound.
  - GND – Negative terminal of power source

HC-SR04 Circuit

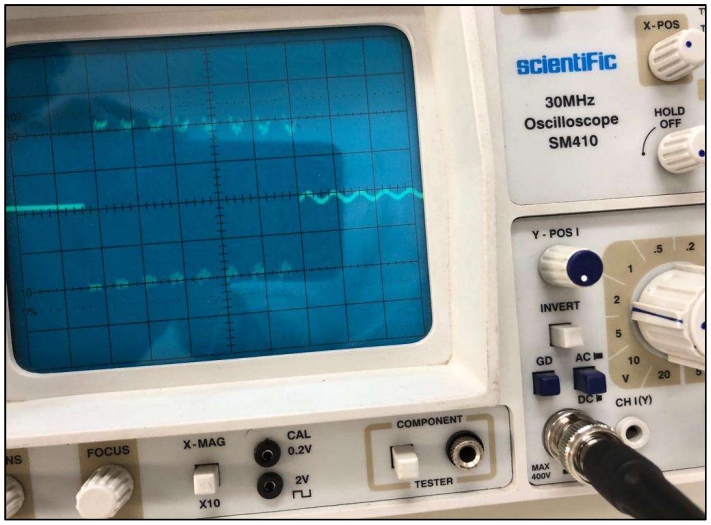


HC-SR04 Ultrasonic sensor circuit

Working of HC-SR04

- Trigger pin is given a pulse.
- A burst of 8 pulses of 40 kHz is sent via transducer.
- The echo pin is set high.
- Once reflected wave is detected, the echo pin is set low.

Scope shot of signal timing
(Source: pcserviceselectronics.co.uk)



Scope shot at Tx
(Taken at lab)

Approach


Microcontroller (with UART)
Ultrasonic Transmitter
Ultrasonic Receiver
Microcontroller (with UART)
Data to be sent
Data received

Transducers

- The transducer is a device that converts electrical signal to physical quantity or vice versa.

- The main criteria to choose a ultrasonic transducer are the resonant frequency, radiation pattern and sensitivity.
- Sensitivity affects the efficiency of the transducer and also attributes to the SNR.
- For the receiver and transmitter, we would be using 40 kHz ultrasonic transducer.

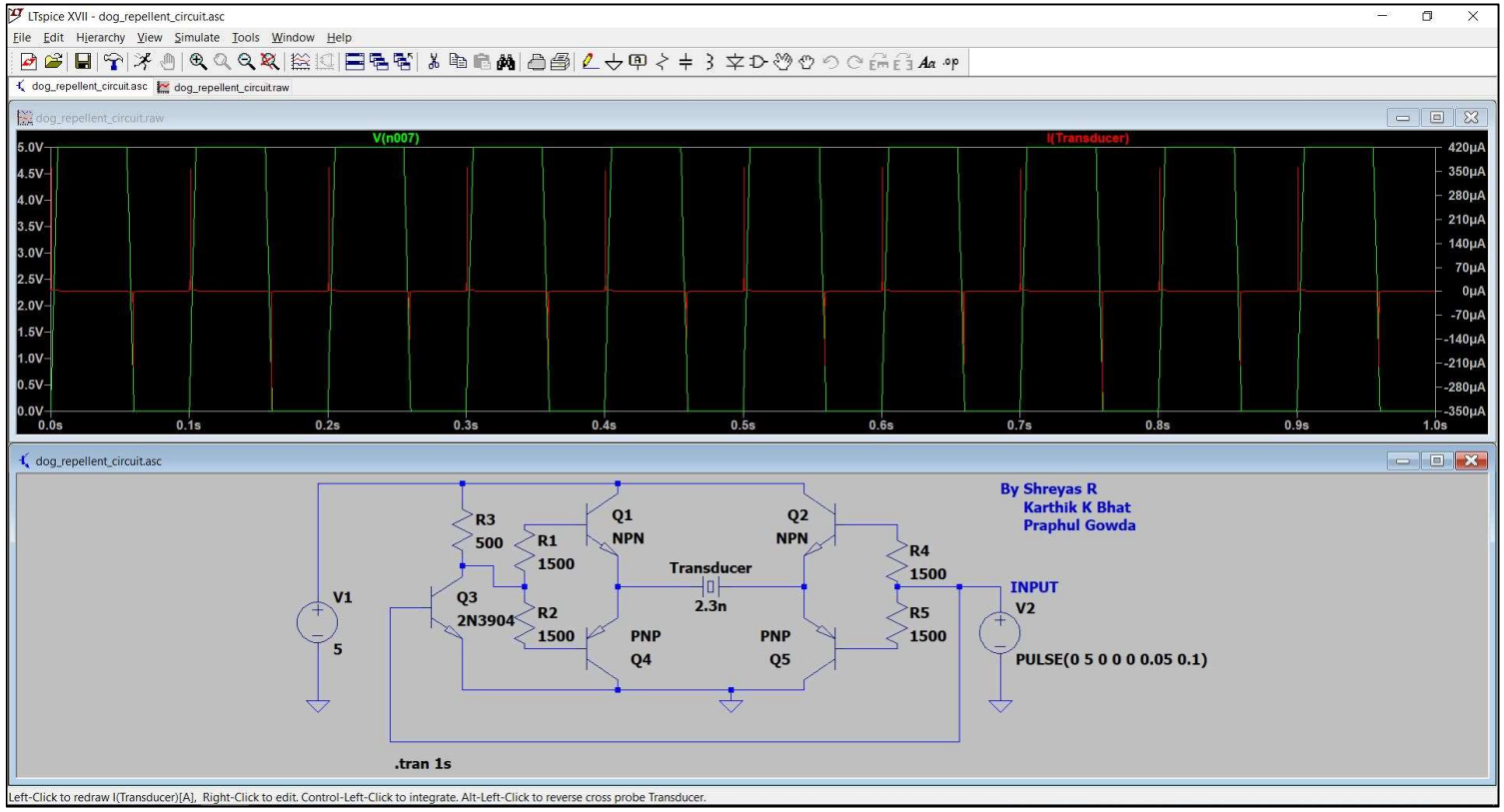
Transmitter Circuits

- Transmitter Circuit #1
  - The circuit uses a JFET to modulate the amplitude of carrier signal with respect to the message signal.
  - Generating high-frequency carrier signals is not easy and required output was not obtained in this circuit.
- Transmitter Circuit #2
  - Uses PNP and NPN transistors to bring the current levels to an optimum range which is suitable for the ultrasonic transducers to operate.
  - The current levels varies with respect to the message signal.

Transmitter Circuit #1 Simulation

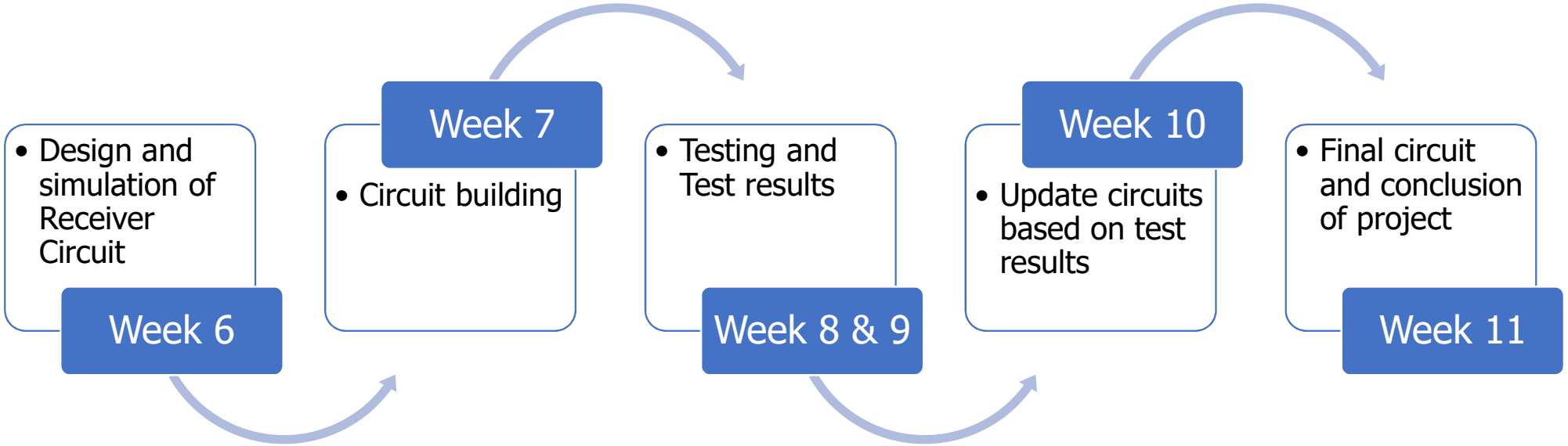
Simulation of Amplitude Modulation Circuit using JFET on LTSpice software

Transmitter Circuit #2 Simulation



Simulation of Ultrasonic Transducer Driver Circuit on LTSpice software

Planned Timeline



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kHz	Kilo Hertz
UART	Universal Asynchronous Receiver Transmitter
RF	Radio Frequency
dB	Decibels
dB SPL	Sound Pressure Level (1 Pascal is equal to SPL of 94 dB)
m	meter
SNR	Signal to Noise Ratio
GND	Ground
JFET	Junction Field effect transistor