**Ultrasonic Sensor**

**Abstract:**

**Part 1 – Analog Front-End (AFE).**  
The analogue front-end transforms the faint 40 kHz ultrasonic wave picked up by the piezo-electric transducer into a robust envelope that mirrors the “1” and “0” intervals of the ASK modulation. The two transducer pins, which together carry the signal, are AC-coupled through small capacitors and biased to a mid-supply “virtual ground’’ (≈ V\_CC ⁄ 2) formed by a resistor divider and decoupling capacitor. Finally, a low-forward-drop Schottky diode followed by an RC network with a time-constant around one-tenth of the bit period strips away the carrier, yielding a unipolar envelope (≈ 0–1 V) whose amplitude cleanly tracks the transmitted data.

**Part 2: Arduino board interface.**

**Part A. Background**

# ASK modulation

In ASK [modulation](https://www.geeksforgeeks.org/what-is-modulation/), a carrier wave (usually a sinusoidal wave) is modified in accordance with the digital message signal. The amplitude of the carrier signal is changed between two predefined values i.e. (0 and 1 to represent binary data).

The carrier wave is represented by continuous signal. The carrier's amplitude changes between two levels, particularly '0' and '1'. When the input data is '0', the amplitude might be lower, and when the input data is '1', the amplitude could be higher. The changes in amplitude effects the carrier signal in accordance with the digital signal.

# ASK demodulation

There are two ways of demodulating: Coherent & Envelop detection.

Coherent detection requires a reference carrier signal synchronized with the transmitter to detect both amplitude and phase—higher accuracy but more complex. Non-coherent detection does not require carrier phase alignment—typically detects only amplitude (envelope), using an envelope detector, then spot the respective digital output from the output waveform of the envelop detector.

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Figure : A typical envelope detector.

# UART communications

UART (Universal Asynchronous Receiver/Transmitter) communication is a serial communication protocol used to transmit and receive data between electronic devices. It operates asynchronously, meaning that it does not require a separate clock signal; instead, both the sender and receiver agree on a common baud rate (data transmission speed). UART transmits data one bit at a time over a single wire, usually in a format that includes a start bit, data bits (typically 7 or 8), an optional parity bit for error checking, and one or more stop bits to signal the end of transmission. It's commonly used for communication between microcontrollers and peripherals such as GPS modules, Bluetooth devices, or computers.

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Figure : Example duck name communication format.

Description:

It begins in the **Idle** state, where the line is held high (logic 1). When data transmission begins, the line first drops to **logic 0**, indicating the **Start bit (S)**. For **Character 0**, the data transmitted is 0x23 (which is the ASCII code for #), and the data bits are sent **least significant bit (LSB) first**. This is followed by a **Stop bit (P)**, which is a logic 1 to signal the end of the character. The waveform then proceeds to **Character 1**, beginning again with a Start bit (logic 0), after which the data bits for the next character follow. The timing and bit structure follow the standard UART framing convention: Start bit, 8 data bits, optional parity (not shown here), and Stop bit.

**Part B. Implementation**

# Part 1 – **Sensor circuit.**

We use an ultrasonic transducer from SR-HC04 and use RC circuit to build an envelope detector to perform demodulation, the digital output is obtained by using a comparator as the last stage.

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Figure 3: Breadboard circuit implementation (LT1366 to be replaced).

The circuit schematic:

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Figure 4: Schematic for ultrasonic transducer.

Both op-amps are biased at . The first stage of the circuit is an inverting amplifier. The resistors of this stage are 30k and 1.5k, signal is amplified by 20. Phase is this stage doesn’t matter because we only need to preserve the information from the transducer.

The second stage is an envelope detector, a Schottky diode first rectifies the carrier so that every ultrasonic half-cycle becomes a unipolar pulse; the following RC network then low-pass–smooths those pulses, stripping away the 40 kHz ripple and leaving a DC-like “envelope” that rises during a logic-1 burst and falls toward zero during a logic-0 gap.

The third stage is a low pass filter, it takes the output of the envelope detector and removes fast fluctuations, leaving only the slow, averaged changes in signal level. By smoothing out short-term variations such as bit transitions and ripple from the rectified carrier, it produces a stable voltage that reflects the long-term strength of the received signal.

The final stage is a comparator. It compares the smoothed envelope signal to a reference threshold and outputs a digital high or low level depending on which is greater. Its role is to convert the analogue envelope into a clean digital bitstream by determining when the signal represents a logic 1 or logic 0. The threshold is set to 2.5V according to the signal from the low-pass filter.

Performance of the circuit:

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