Ultrasonic 3 Dimensional Mouse

Anand Bora, Abrar Chapalgaonkar, Vanita More

Abstract*— With the advent of 3D technology in our daily lives, need of the hour is to develop 3D interactive devices. In this paper, review an air mouse that interacts with PC in 3 Dimensions. The device will not only need any contact surface, but also provide the user with three degrees of freedom. Setup of the project consists of a non-echo ultrasonic system with three receivers at different corners of the display screen and one hand held transmitter, which acts as the mouse. Upon measuring the three distances, position of transmitter in three dimensions can be determined. Above calculated distances will be sent to the PC serially. A 3D image is used to demonstrate the functionality in three dimensions, and changes in transmitter coordinates will result in corresponding changes in 3D image.

***Keywords*— 3D, mouse, ultrasonic, spatial, interrupts.**

I. INTRODUCTION

The standard computer mouse has been in use for over 40 years, and recent developments in 3D technologies are testing the limits of the mouse's design. To compensate for the two-dimensional nature of the mouse, a scroll wheel has been added to the mouse, which can traverse the third dimension when needed. However, this design does not allow for simultaneous movement in three dimensions, nor does it have a high resolution along the depth axis. Ultrasonic 3 Dimensional Mouse is a spatial human interface device that lets the user interact with PC programs in 3 Dimensions. The device times the delay of high-frequency ultrasonic waves from the unit held by the user to each of three receivers and then passes this information along a serial cable to the PC. The accompanying 3D application on desktop will calculate the coordinates of the transmitter in three dimensions and demonstrate corresponding 3D movements in the image. Ultrasonic transmitter-receiver pair works at 40 KHz. Controller generates a 40 KHz square wave, using timer, which is transmitted by the mouse. Time of generation of pulse is known to the controller. The three receivers will detect this signal, which will be amplified to TTL level. Controller will note time of reception of each receiver. Time delay is then calculated for each of the three receivers. Speed of wave is assumed to be 345m/s and thus we can calculate three distances, using the formula Speed=Distance/Time.

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Distances are transmitted serially to the PC. 3D application will demonstrate the corresponding 3D movements.

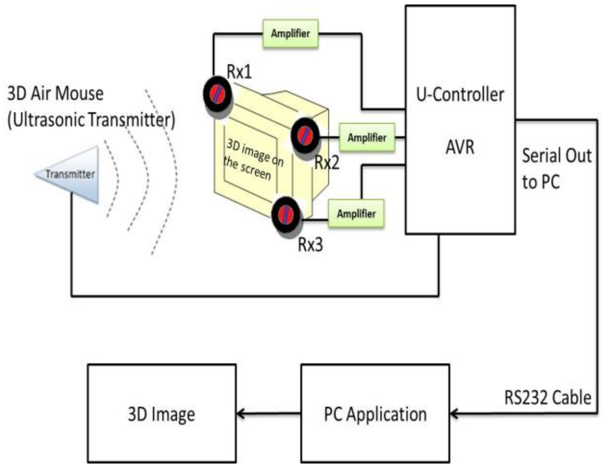

Figure1: Block Diagram

II. 3 DIMENSIONAL POSITIONING USING ULTRASONIC

Figure 2 shows the placement of Ultrasonic sensors to find out the spatial coordinates of the transmitter. There are three sensors at the three corners of the screen. Minimum of three sensors are needed to find out the spatial coordinates, but different combinations of three or more sensors are also possible for more accurate coordinates.

Ultrasound travels through air at approximately 345 m/s. From this, the time it takes for sound to travel between a transmitter and receiver can be described as:

Time = Distance/345. From this, a reasonably fast counter could keep track of a time delay between transmission and reception and back calculate a distance [1].

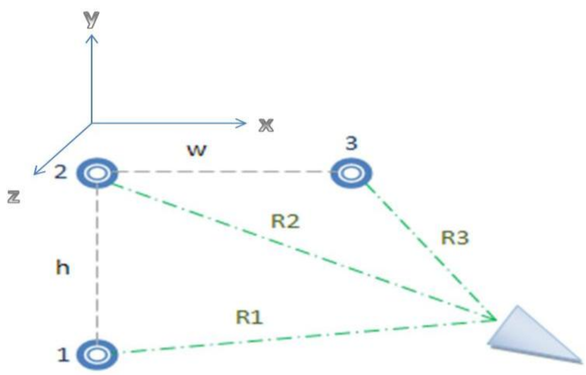

Figure2: Placement of Sensors for 3D positioning [1]

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If the time of transmission and the time of reception on each of three receivers are known, distances from transmitter to their respective receivers, R1, R2, and R3 can be calculated [2]. Assuming Receiver 2 at origin, and with known values of w and h, the 3d coordinates of the transmitter can be calculated by solving a system of equations:

Coordinates of Receiver 2 = (0,0,0)

Coordinates of Receiver 1 = (0,-h,0)

Coordinates of Receiver 3 = (w,0,0)

$R1^2 = x^2 + (y+h)^2 + z^2$

$R2^2 = x^2+y^2 + z^2$

$R3^2 = (x - w)^2 + y^2 + z^2$

Thus, we get coordinates of the Transmitter (x,y,z) as:

$x = (R2^2 - R3^2 + w^2)/2w$

$y = (R1^2 - R2^2 + h^2)/2h$

$z = \text{sqrt} (R2^2 - x^2 - y^2)$

III. TRANSMITTER

To drive the ultrasonic transmitter an alternating voltage at 40 kHz must supplied across the transmitters two leads. To accomplish this, we used a digital output pin the MCU to drive the gate of a power transistor [1]. By placing the transmitter, in parallel with a resistor, between the transistors drain and the supply voltage, a 40 kHz signal supplied by the MCU can drive a 40 kHz signal across the transmitter ranging from supply to ground. To transmit as strong a signal as possible, we use the voltage coming directly out of the AC/DC transformer which tends to range from 9- 13 volts.

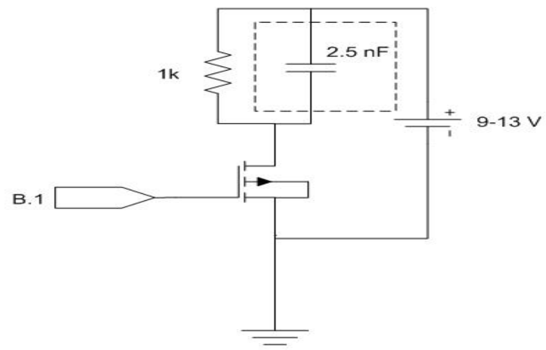

Figure3: Transmitter Circuitry [1]

Ultrasonic transmitter oscillates at frequency of 40 Khz. Controller generates a 40 Khz square pulse, and boosting the pulse will help to have sufficiently large levels at the receiver.

IV. RECEIVER

Ultrasonic signals at receiver are of magnitude 15mV and above. And noise levels are approximately 5mV. We, propose a BJT amplifier with a gain of 100 for amplification of the signal and further use of comparator to convert the received signal to TTL levels [3].

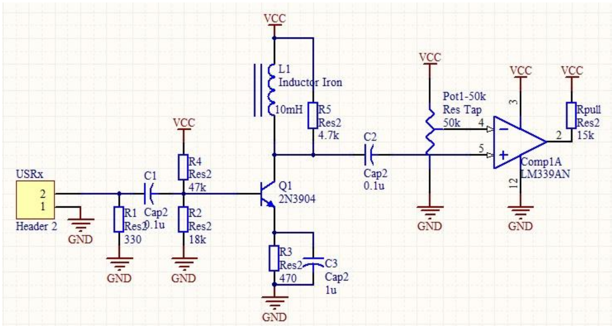

Figure3: Receiver circuit

Whenever an ultrasonic pulses is detected by the receiver, comparator will be triggered and a TTL high will be observed at the output of the comparator. This signal will again go the microcontroller and in turn, time of reception is is calculated by the controller. Absence of ultrasonic inpul will result in a Ground at output of the comparator. Three such receiver circuits will be needed for each of the receiver.

V. MICROCONTROLLER SOFTWARE

Microcontroller first initiates the pulses. Then, it notes the reception times of the three receivers and calculates their respective distances.

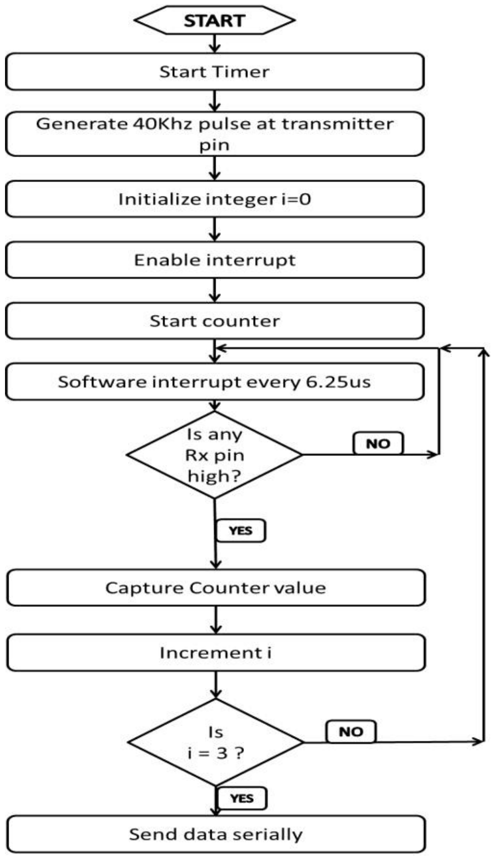

Figure4: Flow Chart

Pulses from the transmitter are initiated by the MCU. The MCU then checks input pins from each of three receivers every 6.25 us while keeping track of a counter variable. When an input is detected, the current counter value is saved. After all three inputs have been detected, the three saved counter times are sent to the PC for processing and update of the mouse position.

VI. PC SOFTWARE DESIGN

Once the three distances are sent to the PC serially, application will calculate Transmitter's coordinates in space and trigger the 3D image [1]. To demonstrate, corresponding 3D changes in position of transmitter, we shall create a 3D image which is linked to the above mentioned App. A basic 3D image can be created with the help of DirectX SDK, a free development tool by Microsoft.

The PC software has three main functions. Firstly 'Create' function initializes the serial port and 3D Image. Then 'Update' function gets the distances from the controller and determines the coordinates. Finally 'Destroy' function cleans up the structure when program exits [1].

APPLICATIONS:

This device has many applications for a wide variety of users, including students, professional engineers, gamers, and general consumers. At this point the limitations of the device can be easily solved after a moderate amount of time and debugging. Future work such as hardware gesture recognition can also be readily implemented. Indeed, the versatility and small form factor of this design are the first steps to a unique and innovative device.

Few of the applications are:

1) To develop 3D movies, Cartoon characters
2) To develop 3D images
3) Useful for gaming purpose
4) Useful aid in presentations, seminars and classroom lectures as mouse movements are not surface dependent.

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