THE UNIVERSITY OF TEXAS AT ARLINGTON

EE6314

INDOOR LOCALISATION

PROJECT REPORT

BY

THE ULTRASONIC GROUP

TEAM MEMBERS

ABHINAV VYAS - 1001409382

ABHISHEK ANAND - 1001171500

KAUSHIK VEDANARAYANAN - 1001358118

MAYUR BHARAT JAIN – 1001408736

NAVEEN BHIMAPPA KORI - 1001409638

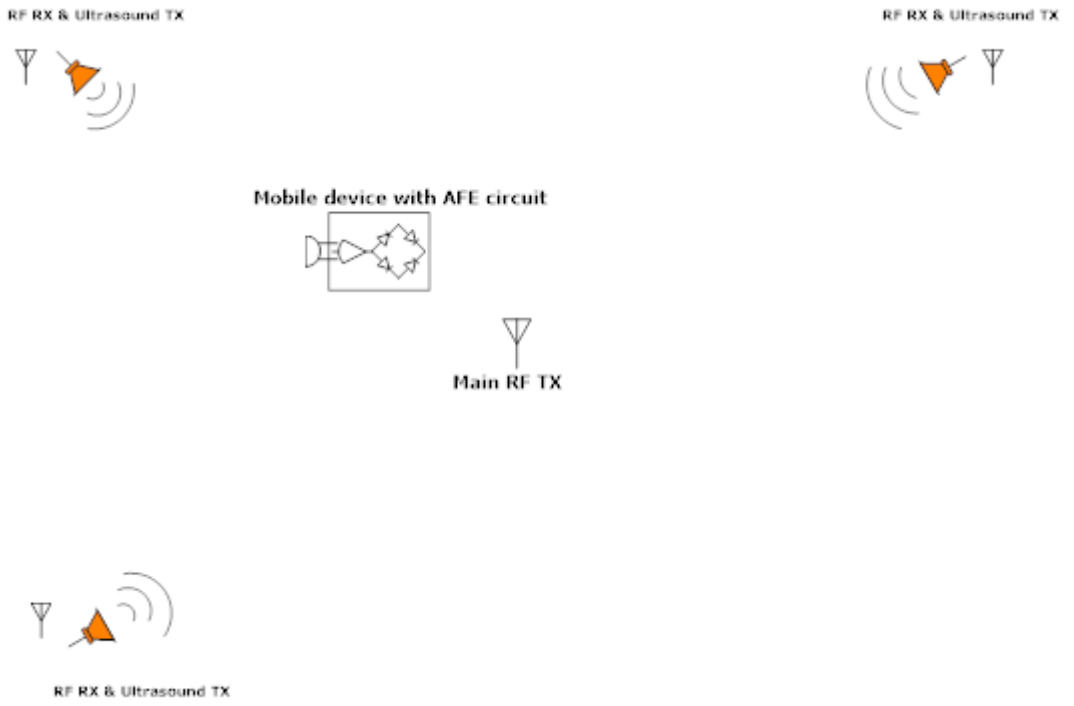
PANDIAN AYYAR KARUPPASWAMY-1001453372

SHIKHAR TANDON-1001397516

SUMMARY

The project is involved in finding the location of a person inside a room/building. This is achieved using ultrasound, where a bunch of ultrasound transmitters transmit sound at 24.2KHz at regular intervals and the mobile device receives this signal and based on the delay in receiving the signal from each transmitter we can track the position of the device.

BLOCK DIAGRAM



BASIC OPERATION

The ultrasound transmitters are synchronized with the help of a centralized RF transmitter and three RF receivers at three corners of a room. The main RF transmitter sends a sync signal every 1 second and based on this sync signal each ultrasound transmitter waits for a predefined time specified at its end. Each ultrasound transmitter has a time slot for transmission so that no two signals are transmitted at the same time. In this project the time slot was 300 ms.

The mobile device receives signals from all the 3 ultrasound transmitters and with a prior knowledge of the transmission time, it calculates the time required for the signal to reach the device. Based on these time from all the beacons, the location team will do the necessary mathematical operations to find the coordinates of the mobile device with respect to the 3 beacons.

ANALOG FILTER CIRCUIT

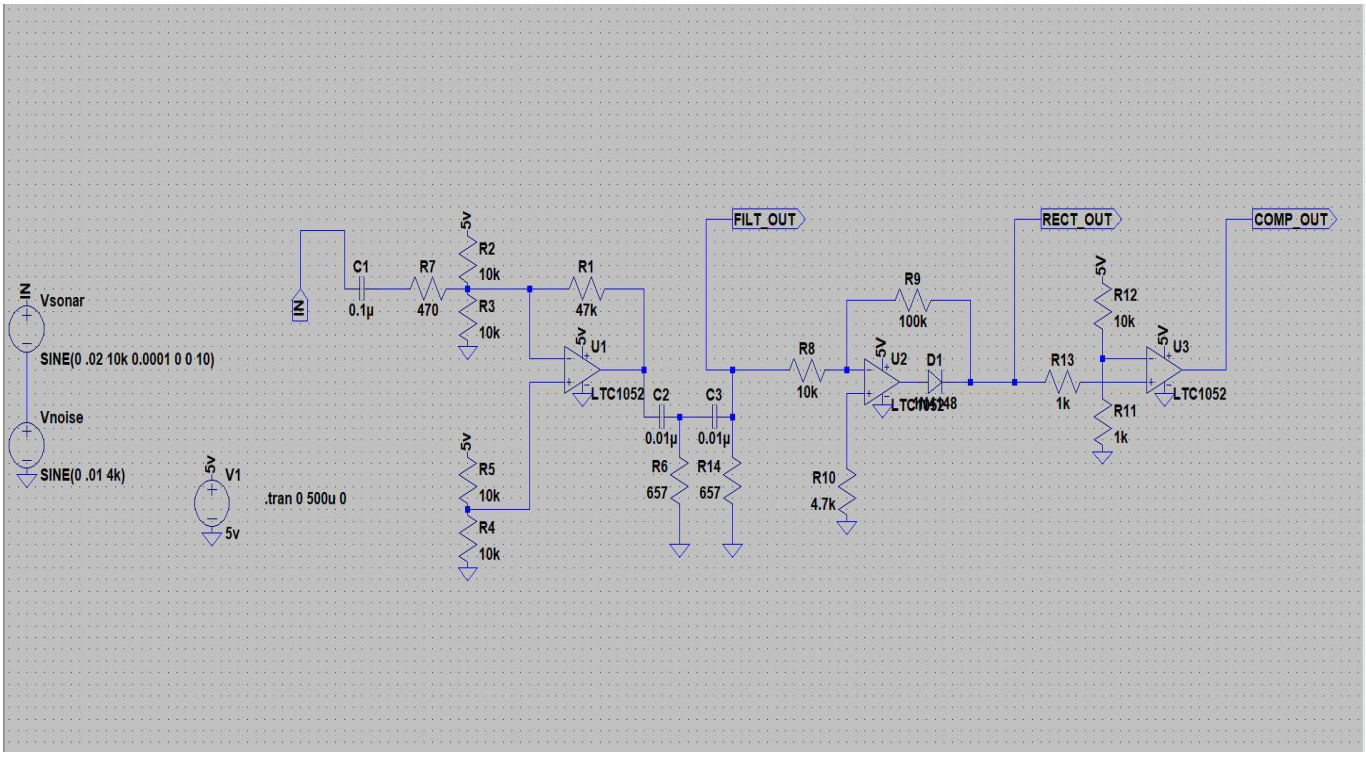
The AFE circuit consists of four parts: Amplifier, Filter, Rectifier and a Comparator.

Bursts from the beacons will be received as weak signals by the microphone which needs to be amplified and separated from the surrounding noise. The gain factor for this amplifier was decided to be 100 based on a series of tests. After amplifying this signal, we had to filter it out and block the frequencies of no interest.

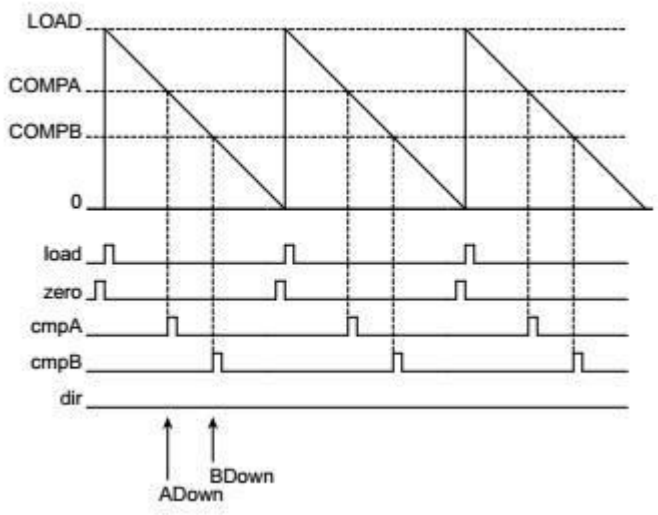
The ultrasound transmitters operated at 24.2KHz, so we designed a second order filter which let in all the frequencies from 19KHz to 28Khz.

After rectification and amplifying it again with a gain of 10, it was compared against a set voltage of 500mV. This voltage was also chosen based on the tests we carried out with various voltage levels.

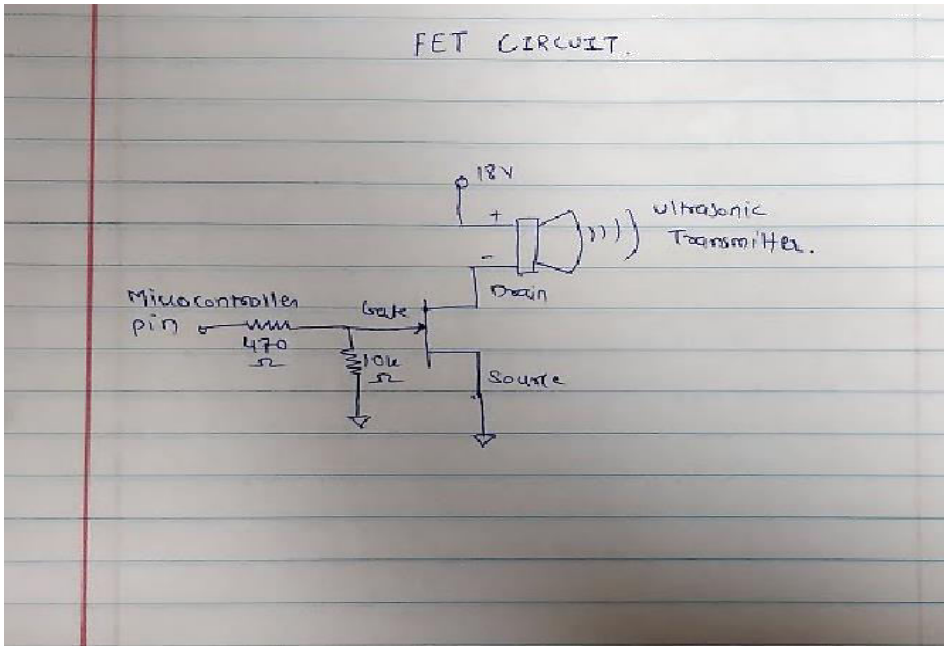
The output of the comparator was fed to the WideTimer CCP pin, which then triggered an interrupt whenever the comparator output goes high.



PWM and FET circuit



PWM Generator A and module 0 is used to give burst of pulses at output. The load and COMPA values are calculated and loaded into the PWM generator. When the load counter value crosses the COMPA value, square pulses are obtained in the output. These pulses are passed through MOSFET circuit which acts as a switch to give the modulating sine wave. To obtain certain number of bursts, PWM ISR is configured in such a way that an interrupt is triggered every time a new value gets loaded into the counter. In PWM ISR function, disable the PWM and interrupt flag when interrupt count crosses the required burst count.



SOFTWARE

RF team's receiver code had been modified a bit and used for the AFE receiver. Along with the sync signal the RF team also transmitted the location of the beacons.

Systick was used to monitor the slot timings. Its value was set so that it triggers an interrupt every 300ms. Each time the interrupt triggered, we started the WideTimer5 timer which would keep track of the time required to receive a burst.

Any signal perceived as a burst by the AFE circuit will result in a voltage more than 500mV at the comparator input and would output a 1 from the comparator. This voltage in turn triggered the WideTimer 5 interrupt which would execute a routine which captured the time.

Times for all the slots were captured and the function to find the location was called which calculated the coordinates based on these times. The location was also made to display on a LCD screen.

Ultrasonic Team Review

Initially, the team started testing hardware, various transmitters, and receivers to choose the right one for the project. Once the mic and the ultrasonic transmitters were chosen, the next step was designing the Analog Filter Circuit(AFE) to be attached to the mic. The first choice was to use a frequency/tone decoder to discriminate and filter out the 24.2Khz signal being transmitted by the ultrasonic transmitter. A series of tests were carried out by Naveen B Kori, Mayur B Jain, Kaushik Vedanarayanan, Karthika Prasannakumar, Manish Thakur, Pandian A K as well as certain members of the current RF team. But the tone decoder proved to be very unstable and not robust enough for the required frequency. Hence, the second method was chosen, using high pass filter to remove unwanted noise and using amplitude as a discriminating factor to trigger a comparator on receiving a signal.

The testing of this circuit which would go on to be the final AFE circuit after some modification was carried out by Kaushik Vedanarayanan, Naveen B Kori, Mayur B Jain, Karthika Prasannakumar, Shikhar Tandon, Pandian A K and Manish Thakur.

The idea and the design of the 2^{nd} order filter was done by Mayur B Jain. Coinciding with the development of the final circuit design, the formal makeup of the team was decided along with its members. There were some changes in the ultrasonic team, Karthika Prasannakumar and Manish Thakur moved to the Location team, Abhishek Anand and Abhinav Vyas who till then were working on the ZigBee modules got them working and tested for the delay timing on them which proved very high up to 100 us, they had then joined the Ultrasonic Team.

Abhinav Vyas and Abhishek Anand started working on the algorithm and code for detection of the sync signal as well as the burst using the microcontroller to be interfaced with the AFE circuit. The decision to use Interrupt driven approach, systick and wideTimer5 to this issue of slot timings and sync timing was taken by them.

Simultaneously, work started on PWM code which would be run on a microcontroller interfaced with the FET circuit driving the Ultrasonic transmitters. This part of the project was done by Pandian A K and Mayur B Jain.

Once all coding portions were done, there was lot of testing done by the ultrasonic team to decide slot times and the comparator trigger voltage.

Then design and the 3D printing of the ultrasonic beacon holders was done by Mayur B Jain as well as work on making the project equipment portable including powering the microcontroller via an external supply not using the USB connector and the connections and stacking of all the modules integrated with the AFE Circuit

The final PCB layout design, connections and soldering of the AFE circuit was done by Shikhar Tandon. The final AFE comparator trigger voltage was set by him to prevent low voltage noises from generating false interrupts and increasing circuit robustness.

Once the 3D printing of the holders was done, the integration of the FET and the RF circuits were done by Kaushik Vedanarayanan, Pandian A K along with members of the RF team. The setup of the 18V battery packs as well as the portability issues were solved.

Now with beacons ready as well as the AFE circuit along RF modules the integration of the whole code along with that of the location team and debugging was done by Naveen B Kori, Shikhar Tandon, Abhishek Anand, Abhinav Vyas along with members of the other teams. The addition of an LCD screen to the AFE circuit was done Mayur B Jain and Manish Thakur.