

Group C Project Proposal: Ultrasonic Receiver

Brian Markus, Daniel Viselman, and Chen Jia

Project Definition: The project proposed is to build a 4-channel ultrasonic receiver with operating frequency range of 30 kHz to 50 kHz that will be designed to communicate with Group B's Ultrasonic Transmitter. The customer is Dr. Allen. Our design team consists of Brian Markus (Team Leader), Daniel Viselman, and Chen Jia.

Project Objectives: Our ultrasonic receiver will have 4-channels and will be designed to have an operating frequency of at least 30 kHz to 50 kHz but expand the range to 100 kHz if possible, a signal bandwidth of 1 kHz to 20 kHz, and a dynamic range of 50 dB. The final product will use an ultrasonic microphone to accept the analog signals, an Arduino Due microcontroller will be used for control, timing, signal acquisition, A/D conversion, and other digital applications. A professionally fabricated board will mount seamlessly as a daughter board to the Due, which will then output the results via a USB interface. To prevent component damage, we will implement an over-voltage protection (OVP) circuit.

Strategy for Achieving Objective: To achieve our proposed goals, we plan on doing independent research about ultrasonic receivers to get a greater knowledge of the scope of the project, as well as where our individual skills will be best applied. For the technical strategy, we will follow these steps:

1. Use an Arduino Due microcontroller for the control, timing, signal acquisition, and other digital functions.
2. Use the Due's on-chip, 12-bit, analog-to-digital converters (ADCs) to acquire the required signals.
3. Use a custom-designed, professionally-fabricated, printed-circuit board with a form factor and pin arrangement so that it attaches to the Due as a daughter board (at least three functional circuit board assemblies shall be delivered at the end of the project).
4. Acquire ultrasonic signals with operating frequencies between 30 kHz and 50 kHz.
5. Acquire the signal(s) using techniques with the following characteristics:
 - Selectable sample frequency (f_s) at least 2.5x the highest bandwidth to be acquired (5x preferred)
 - Programmable local oscillator (LO) frequency or use of externally-generated LO signal
 - Programmable signal duration (30 μ s to 1 s or more)
 - Signal acquisition begins on rising edge of trigger signal
 - Programmable interval between signal acquisition episodes
6. Output a TTL-compatible synchronization pulse (duration between 1 μ s and 100 μ s) or square wave (50% duty cycle) whose rising edge indicates the beginning of the signal acquisition episode.

7. Input a synchronization pulse (TTL compatible, duration between 1 μ s and 100 μ s) or square wave (50% duty cycle) whose rising edge will trigger the acquisition episode.
8. Have a four-channel receiver (programmable amplifier, mixer, low-pass filter) that accepts analog signals from ultrasonic microphones (e.g., Knowles SPU0410HR5H-PB) and outputs the processed signals to external connectors or to the Due's analog-to-digital converter (ADC) pins (selectable by jumper placement) [suggested programmable amplifier LTC6910].
9. Have an on-board programmable oscillator (e.g., LTC6903 or LTC6904) that can be used as the mixer's local oscillator (LO), [this oscillator shall be capable of being disabled via software when not being used], this oscillator signal shall also be available on a connector for probing or to serve as a clock or timing signal for another circuit; possible for all four channels to use the same LO signal.
10. Provide a connection (selectable via jumper) such that an off-board generated Tx waveform can be used as the LO for the on-board receiver's mixers [signal buffering required].
11. Shall protect the 3.3-V Due inputs (where applicable) from potential overvoltage damage through the use of voltage dividers and/or clamping diodes.

Plan of Action: The plan of action to build our receiver is to break it up into system blocks and design each block independently. We plan on starting with signal acquisition and amplification of the analog ultrasonic signal. After it is determined that we are properly accepting and amplifying the analog signal, we will design the bulk of the system which contains mixers, local oscillators, amplifiers, and filters. Once that process begins, we will also start programming the software of the system. These two tasks are the crux of our project and will most likely demand the most time. Once these are complete we will collaborate with Team B's transmitter design and begin testing, while also designing the over-voltage protection circuit. This schedule and plan of action is illustrated in the Gantt chart in Figure 1.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Task	2/01-2/07	2/08-2/14	2/15-2/21	2/22-2/28	3/01-3/07	3/08-3/14	3/15-3/21	3/22-3/28	3/29-4/04	4/05-4/11	4/12-4/18	4/19-4/25	4/26-5/02	5/03-5/06
Signal Acquisition and Amplification	█	█	█	█										
Mixer/ LO/Filter/Amplifier Hardware		█	█	█	█	█	█	█	█	█	█			
Embedded Control (software)						█	█	█	█	█	█	█	█	
OverVoltage Protection											█	█	█	█
Testing and Evaluation											█	█	█	█
Presentations														
PDR				█										
CDR								█						
Final														█

Reporting: We will keep management informed by having weekly meeting with the customer to discuss progress and future goals.

Budget: Many of the components that will be used for our receiver are already available from Dr. Allen or from the manufacturer free of charge. The remainder of the budget will be spent on Arduino Dues, various components, the fabrication of our circuit, and Dr. Allen's 16-channel microphone board. We plan on acquiring an additional \$500 dollars for telemetric applications, making out total budget \$1,000.

Component	Cost
Various Components	\$ 30.00
Arduino Due (3)	\$ 150.00
Board Fabrication	\$ 250.00
16-channel Mic. Board	\$ 175.00
Total	\$ 605.00

Evaluation: Ideally, we will get together with Group B and have them send an ultrasonic signal between 30 kHz and 50 kHz. We will look at and record the analog output of their transmitter. The analog signal will be received and processed by our receiver, then reconstructed at the output. The signal at the output will be recorded and compared to the original analog signal that was sent from the transmitter.