E.V.D.S

Emergency Vehicle Detection System

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leidos

BOEING

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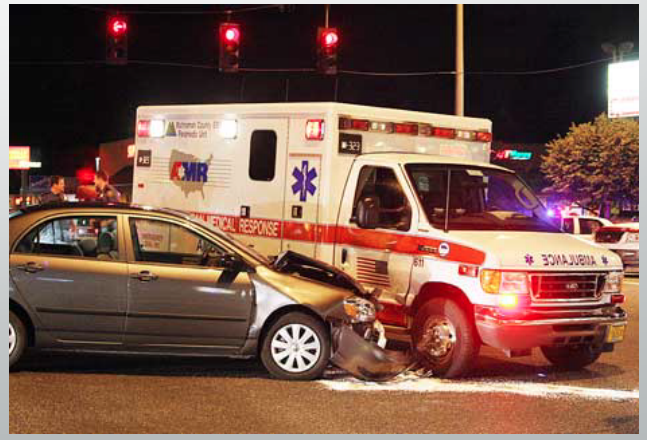
- Motivation
  - To decrease frequency of accidents involving Emergency Vehicles
  - Modern soundproofing technology has muted the driver to the outside world
  - Provide a link between the driver and the outside world

An ambulance carrying a patient in critical condition is struck by an unaware driver in Portland, Oregon.



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- Objective
  - To alert drivers to the presence of emergency vehicles
  - Identify an emergency vehicle within 50 yards (stationary)
  - Identify position of emergency vehicle relative to vehicle
- Requirements
  - Compatible with most consumer vehicles

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- Standards
  - USDoT Emergency Vehicle Siren Standards
    - States that Sirens must be below 120 dB
  - No Applicable Automotive Standards for this stage
    - 12 volt battery or alternator for power
    - DC power

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- Specifications

Part	Function	Specification
Microphone	Polar Pattern	120° Cardioid Pattern
Filter	Bandpass	300-3000 Hz
	Gain	1000
ADC	Bit Resolution	12 bit
	Sampling Rate	>44000 Hz
DSP/Decision Logic	Response TIme	2.5 seconds
	Accuracy	<5% false negative
	Accuracy	<10% false positive

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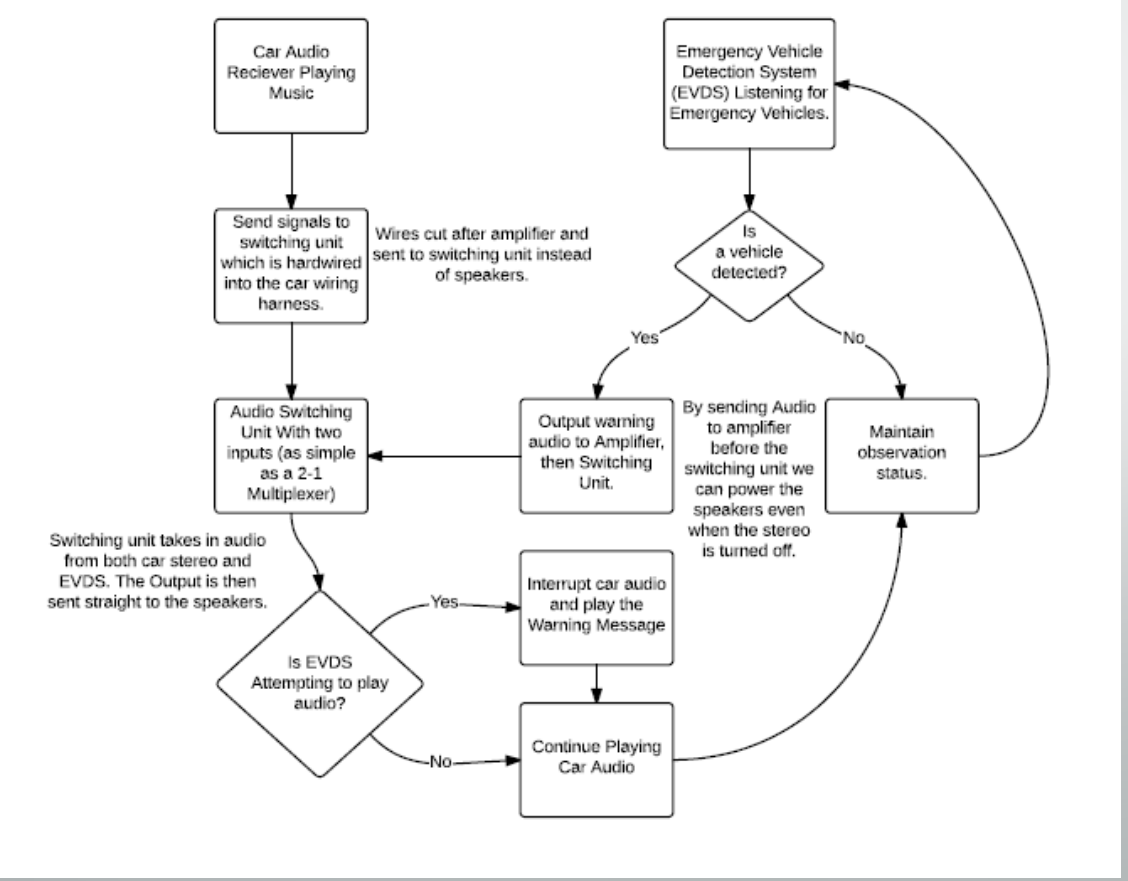
Car Audio Reciever Playing Music
Send signals to switching unit which is hardwired into the car wiring harness.
Wires cut after amplifier and sent to switching unit instead of speakers.
Audio Switching Unit With two inputs (as simple as a 2-1 Multiplexer)
Switching unit takes in audio from both car stereo and EVDS. The Output is then sent straight to the speakers.
Is EVDS Attempting to play audio?
Yes
No
Interrupt car audio and play the Warning Message
Continue Playing Car Audio
Output warning audio to Amplifier, then Switching Unit.
By sending Audio to amplifier before the switching unit we can power the speakers even when the stereo is turned off.
Emergency Vehicle Detection System (EVDS) Listening for Emergency Vehicles.
Is a vehicle detected?
Yes
No
Maintain observation status.

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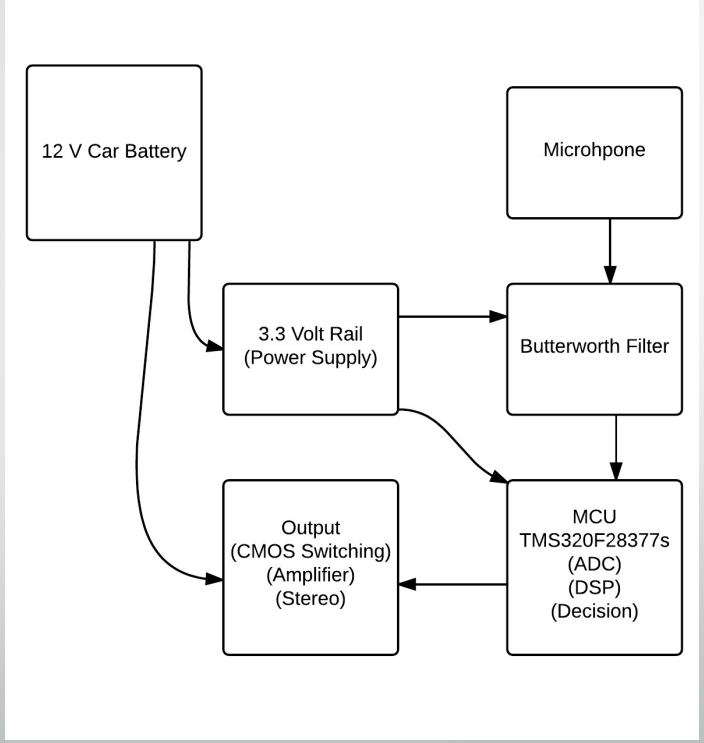
12 V Car Battery
Microhpone
3.3 Volt Rail
(Power Supply)
Butterworth Filter
Output
(CMOS Switching)
(Amplifier)
(Stereo)
MCU
TMS320F28377s
(ADC)
(DSP)
(Decision)

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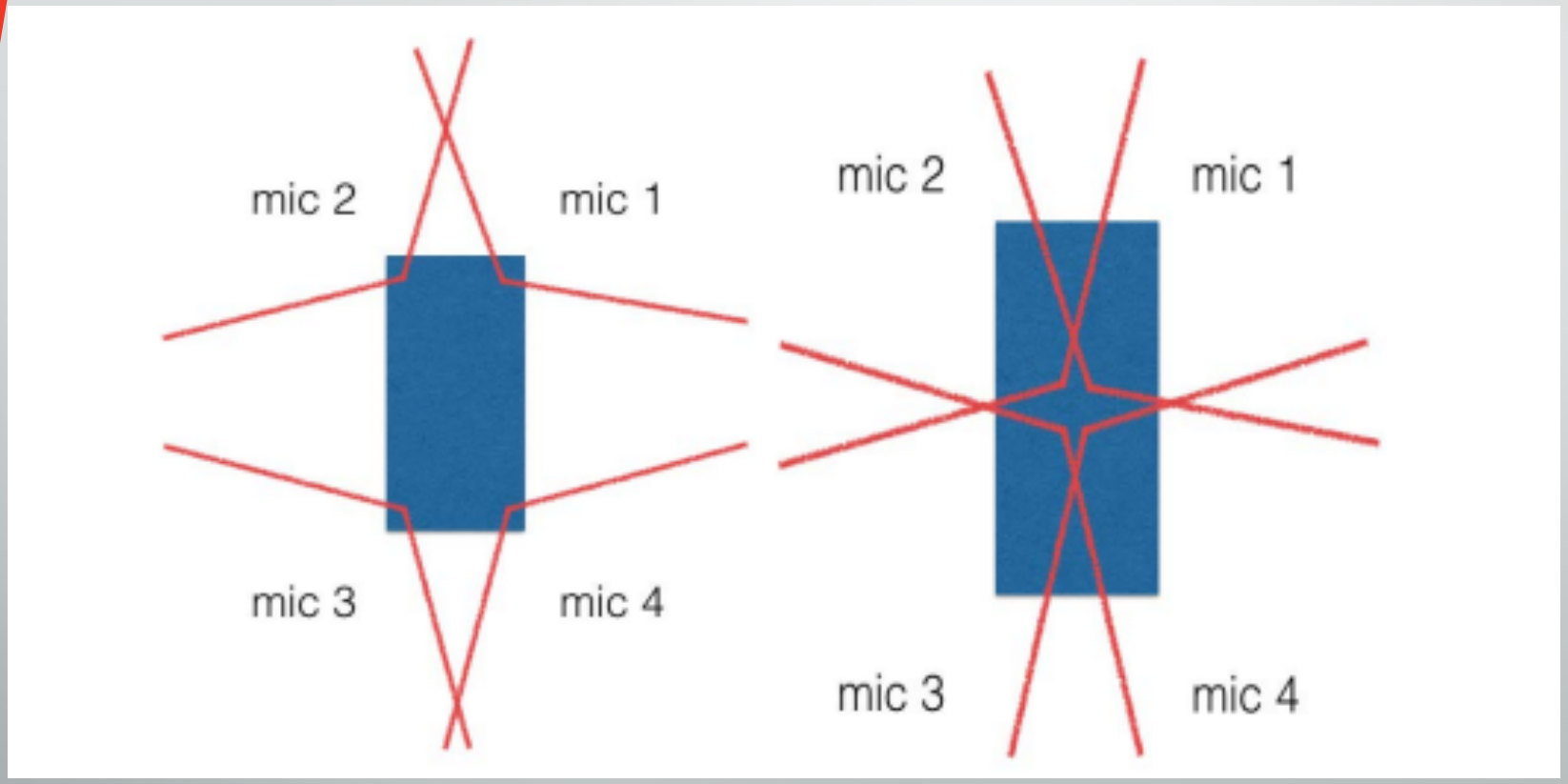
- Microphones
  - Shure SM 58
    - Frequency Response
    - Cardioid Polar Pattern
    - Affordable
    - Versatile
    - Dynamic
  - Number
  - Orientation
  - Positioning


mic 2
mic 1
mic 3
mic 4
mic 2
mic 1
mic 3
mic 4

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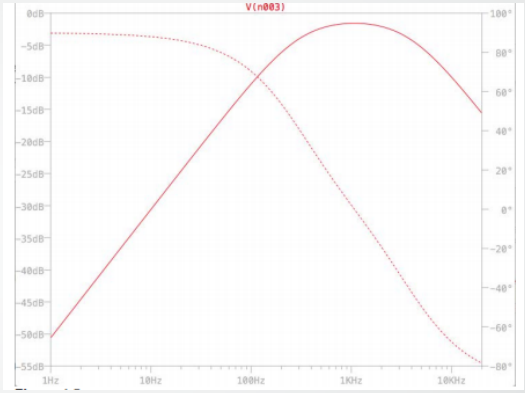
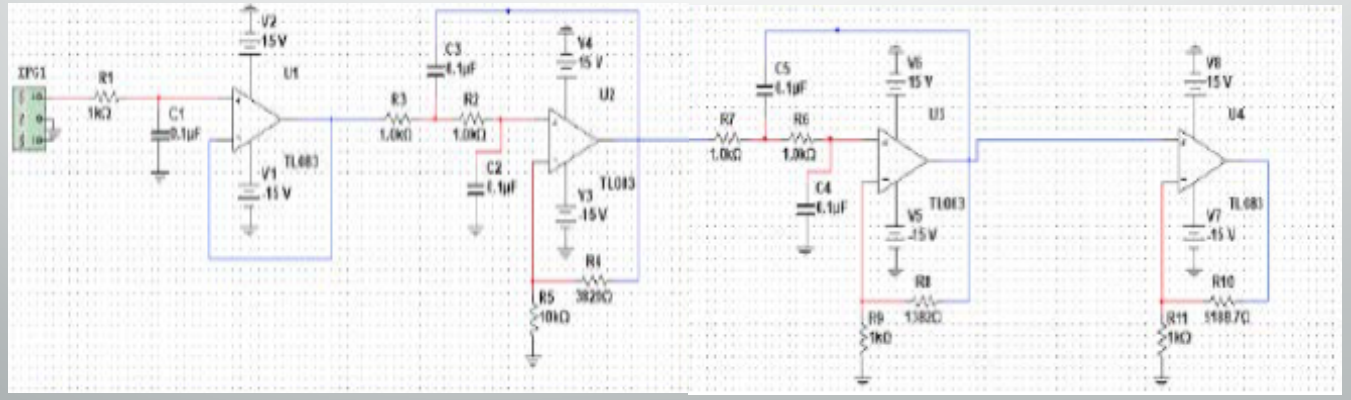
- Filter
  - Two fifth order Butterworth filters
  - Bandpass Filter
    - Low-pass Filter Shown Below





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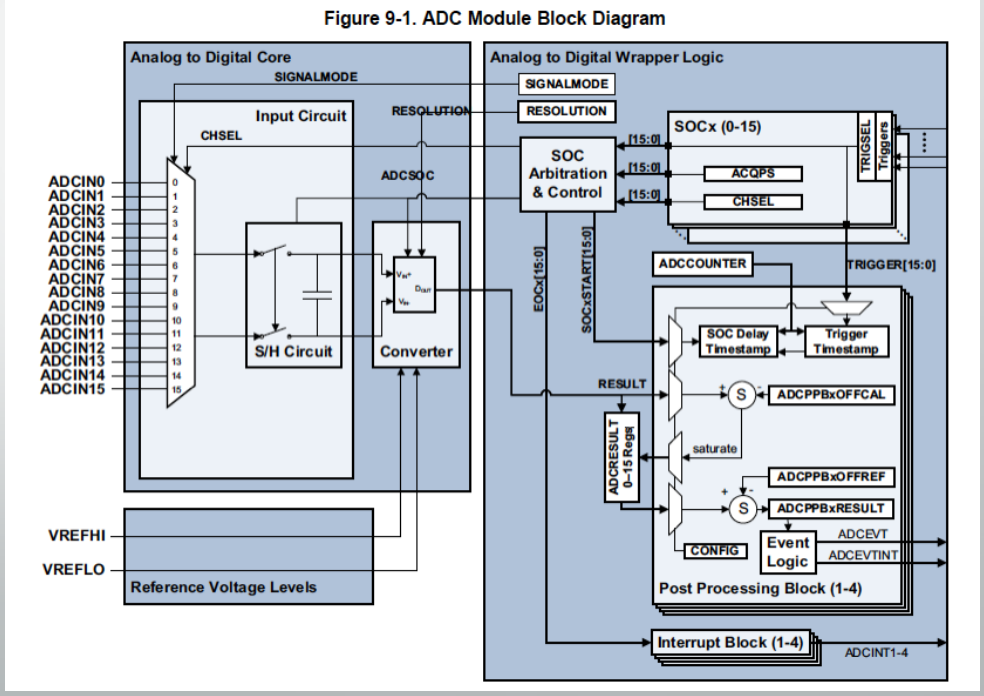
- Processor - ADC
  - TMS320F28377S
    - Sample and Hold ADC
  - Bit Resolution- 12 Bit
  - 100 KHz clock rate



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- Processor - DSP
  - TMS320F28377S
    - Fourier Transformations
  - Sample segments
    - 26 transforms a second
  - Finding frequency and amplitude

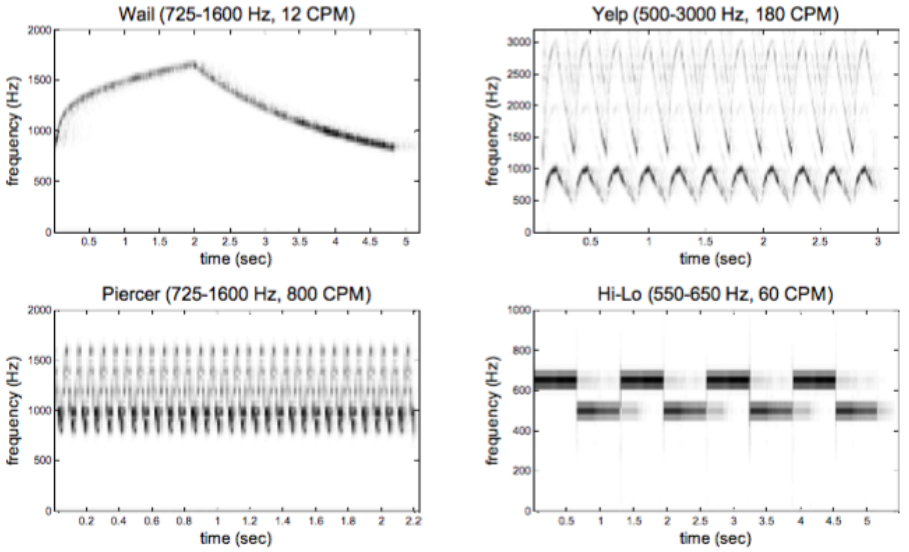

Figure 1. Frequency vs. time for the four types of sirens.

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- Processor – Decision Logic
  - TMS320F28377S
    - Using calculated frequencies
  - Compares sampled frequencies to known siren frequencies
  - Compares sampled frequencies to previous sampled frequencies
  - Determines when input frequencies match siren pattern range

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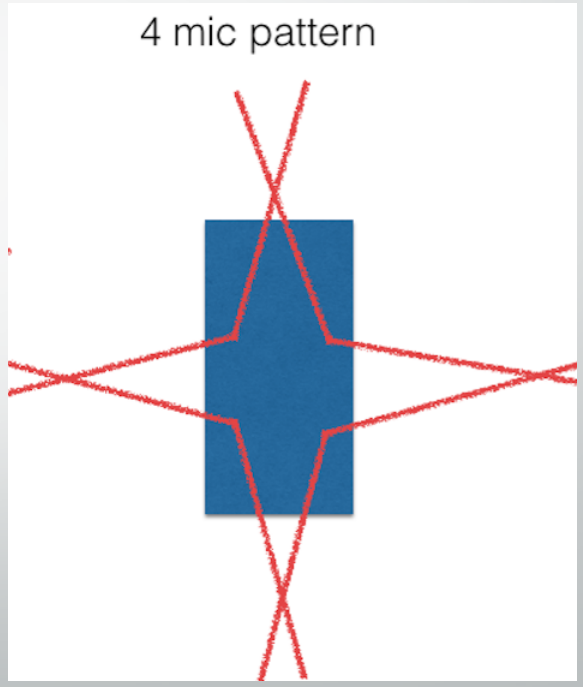
- Processor – Directional Identification
  - TMS320F28377S
    - Using Recorded Amplitudes
  - Compare the four amplitude values
  - The microphone(s) with the greatest amplitude indicate the direction of the Emergency Vehicle



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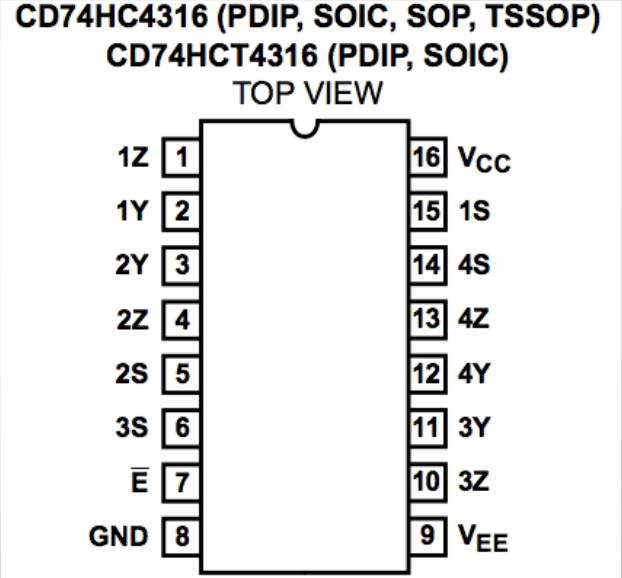
- Processor – DAC/SD Card
  - TMS320F28377S
    - Generating output audio signal
  - Storing prerecorded warning audio files on SD
  - CMOS switching unit
    - 1 Control Line
    - 4 CMOS units



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- Audio System – Receiver
  - Fujitsu AA160 (Primary)
    - Inputs 1
    - Outputs 5
    - Power Source 12 V DC
  - Yamaha HTR-5540 (Backup)
    - Inputs 8
    - Outputs 5
    - Power Source 120V AC

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- Audio System – External Amplifier
  - LePai LP-2020A
    - Inputs 2
    - Outputs 2
    - Power Source 12 V DC

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- Audio System – Speakers
  - Bose Model 101
  - RCA Home Monitors
  - Boston Acoustics Micro monitors

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- Power Supply
  - Car Battery
    - 12.6 V Supplied
    - 3.3 V for Processor
      - Voltage Regulator incorporated into PCB Design
    - 12.6 V for Amplifier and receiver

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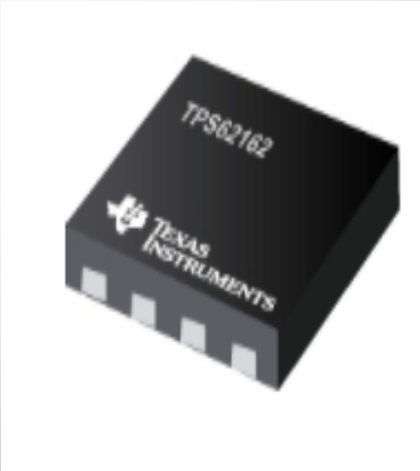
- PCB
  - TPS62162 – Buck Voltage Converter
    - 3-17 V input range
    - Output Voltage .9 – 6 V
    - Output current up to 1 A
      - Common use is with 12 V rails
    - Cost: Sampled from TI



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- PCB
  - FT2232H – USB to Multipurpose
  - USB to JTAG
  - Allows for one port for power and computer communication
  - 3.3 V input
  - Cost: $6.71- Digikey

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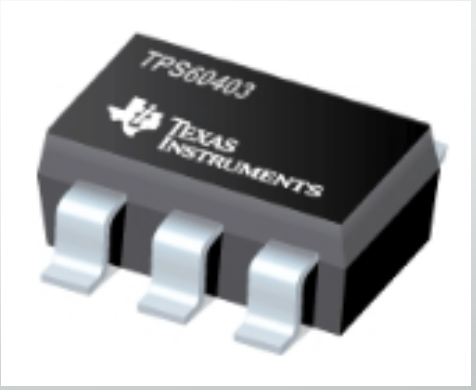
- PCB
  - TPS 60403- Charge Pump Voltage Inverter
  - Vin: 2.7 – 5.5V
  - Vout: -Vi
  - Switching frequency 250KHz
  - Output current up to 250 mA
  - Used to power Op-amp negative terminals
  - Cost: Sample TI



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Initial Budget	
Description	Amount
Microphones (4)	$548
Processor	$50
PCB	$100
Wiring	$20
Battery	$50
Siren	$50
Car Receiver	$100
Speakers	$50
Amplifier	$100
Hardware	$10
"Car"	$10
ADC (4)	$20
Total	$1108

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Updated Budget	
Description	Amount
Microphones (4)	$300
Processor	$0
PCB	$150
Wiring	$20
Battery	$50
Siren	$0
Car Receiver	$0
Speakers	$0
Amplifier	$30
Hardware	$10
"Car"	$10
ADC (4)	$0
Testing Supplies	$100
Total	$670

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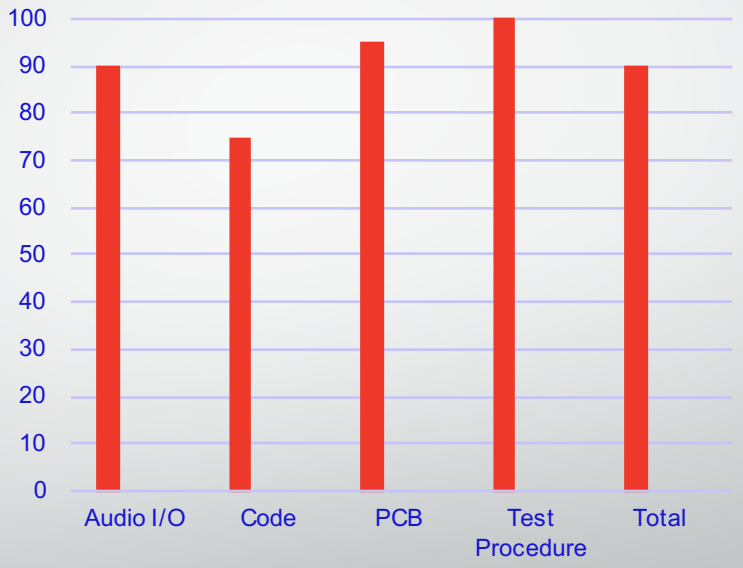
- Design Progress
  - Audio Input/Output
    - 90%
  - Code
    - 75%
  - PCB
    - 95%
  - Testing Procedure
    - 100%
  - Total
    - 90%



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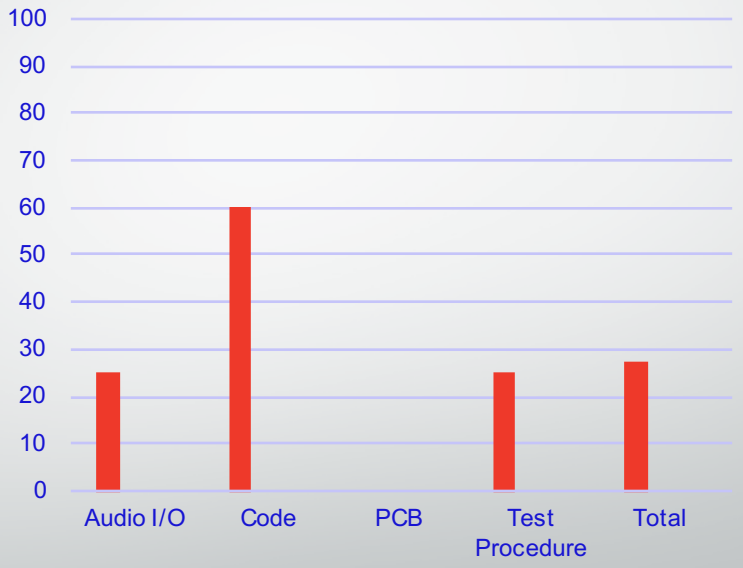
- Build Progress
  - Audio Input/output Build
    - 25%
  - Code Build
    - 60%
  - PCB Print
    - 0%
  - Testing Platform Build
    - 25%
  - Total
    - 27.5%



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Component	Primary	Secondary
Microphones	Ryan	John
ADC	Daniel	Ryan
DSP	Ryan	Daniel
Decision Logic	John	Ryan
Switching Unit	John	Daniel
Power	Daniel	John
Testing Platform	John	Ryan
Testing	Everyone	
PCB	Daniel	Ryan
Administrative Content	Ryan	Daniel

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- What is Next?
  - DAC for audio output/SD card interface
  - Integrate system to all 4 microphones
  - Achieve identification with all four microphones
  - Implement notification system
  - Retest everything on PCB vs current Breadboard results
  - Final Assembly
  - For $i < \infty$
    - Testing
    - Debugging
  - End

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Questions?