

Team E0

Jonathan Duffy and Ryan Oh and Jung Eun Park

Add your 12 slides after this slide... [remember, 12 min talk + 3 min Q/A]

For more information about formatting or importing slides see:

<https://gsuite.google.com/learning-center/products/slides/get-started/>

Make sure to cover:

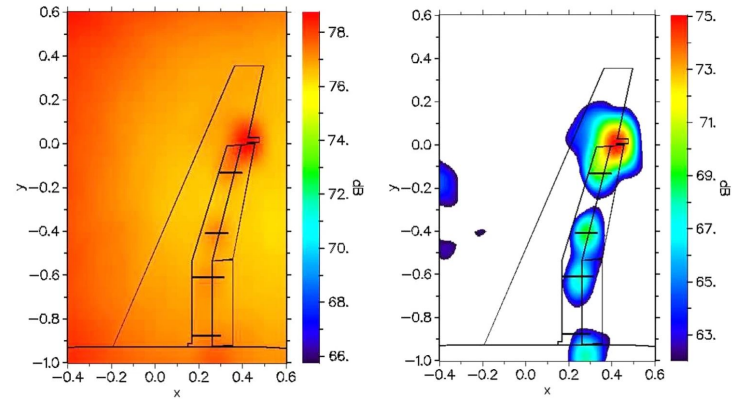
- Use Case
- Requirements
- Solution Approach
- Testing, Verification and Metrics
- Tasks and Division of Labor
- Schedule

Sonicam

Jonathan Duffy, Ryan Oh, Sarah (Jung Eun) Park

Use Case

- Using a phased array of microphones, implement a device to visualize sound as an image
- During manufacturing, a product may be tested for noise emissions. Accurate sound characterization (location, loudness, frequency) helps pinpoint the area of concern.



Source:

<https://link.springer.com/article/10.1007/s13272-019-00383-4/figures/8?shared-article-renderer>

Requirements

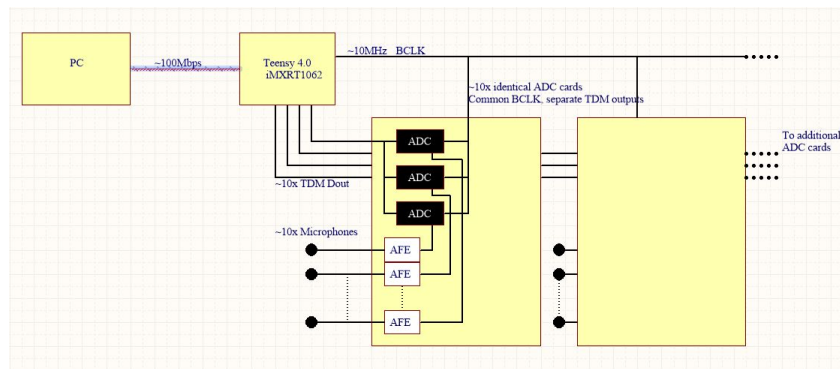
Requirement	Details	Reason
Resolution	Produces at least 16 horizontal by 8 vertical zones as image output.	The Sonicam must be able to produce useful directionality information to the user. Identifying the source within 128 zones is sufficient for further investigation.
Image processing latency	Processes and presents the image output within 30 seconds of capturing audio.	Ford produces one new car every 10 seconds . With assembly line parallelism, 30 second is the maximum amount of delay to prevent a production bottleneck.

Requirements

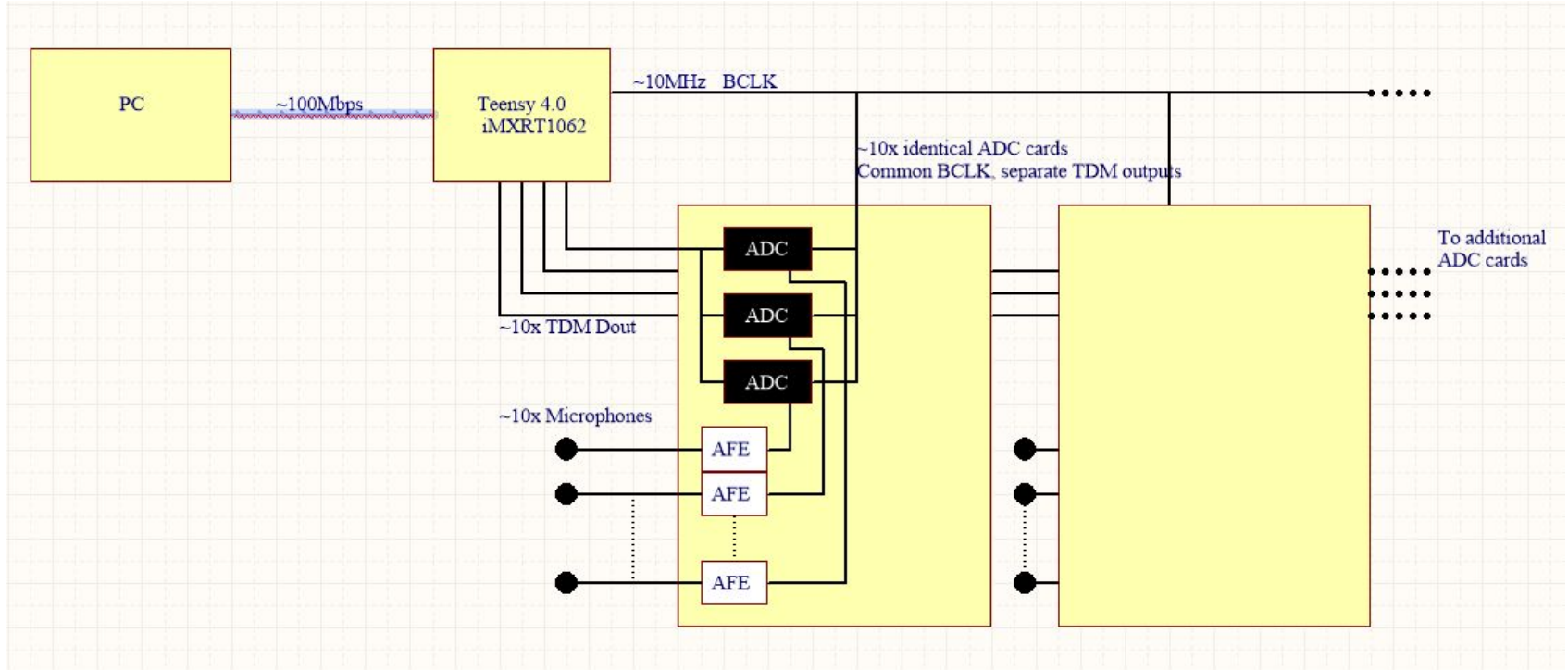
Requirement	Details	Reason
Frequency response	Accurate (± 6 dB) response from 1,000-10,000Hz	Humans have a peak hearing sensitivity between 2-4kHz along the voice frequency band. Sounds with a fundamental frequency significantly above 10kHz are uncommon in physical systems.
Form factor	Phased array of microphones smaller than 4x4ft and weighs less than 10kg.	This device may be used for portable applications such as in field testing. A maximum size limit of 4x4ft ensures portability and a weight limit of 10kg reduces the setup time and accessibility.

Solution

- MCU: Teensy 4
 - Communication: USB 2.0 to PC
 - Fast: 600MHz
- Microphones
 - Lapel Mic
 - Already wired to a 3.5mm jack
 - ADC required: TI TLV320AIC3204 (synchronized sampling)
 - Output: TDM (multi-channel I2S)
 - Digital PDM Mic
 - Board mounted
 - Input clock: up to 3MHz
 - Output: Pulse Density Modulation
 - No ADC required
 - FPGA required for the number needed
- PC: Signal Processing
 - Higher processing power than Teensy 4
 - Faster code development than on an FPGA
 - Java/Python: high and low level programming capabilities



Solution



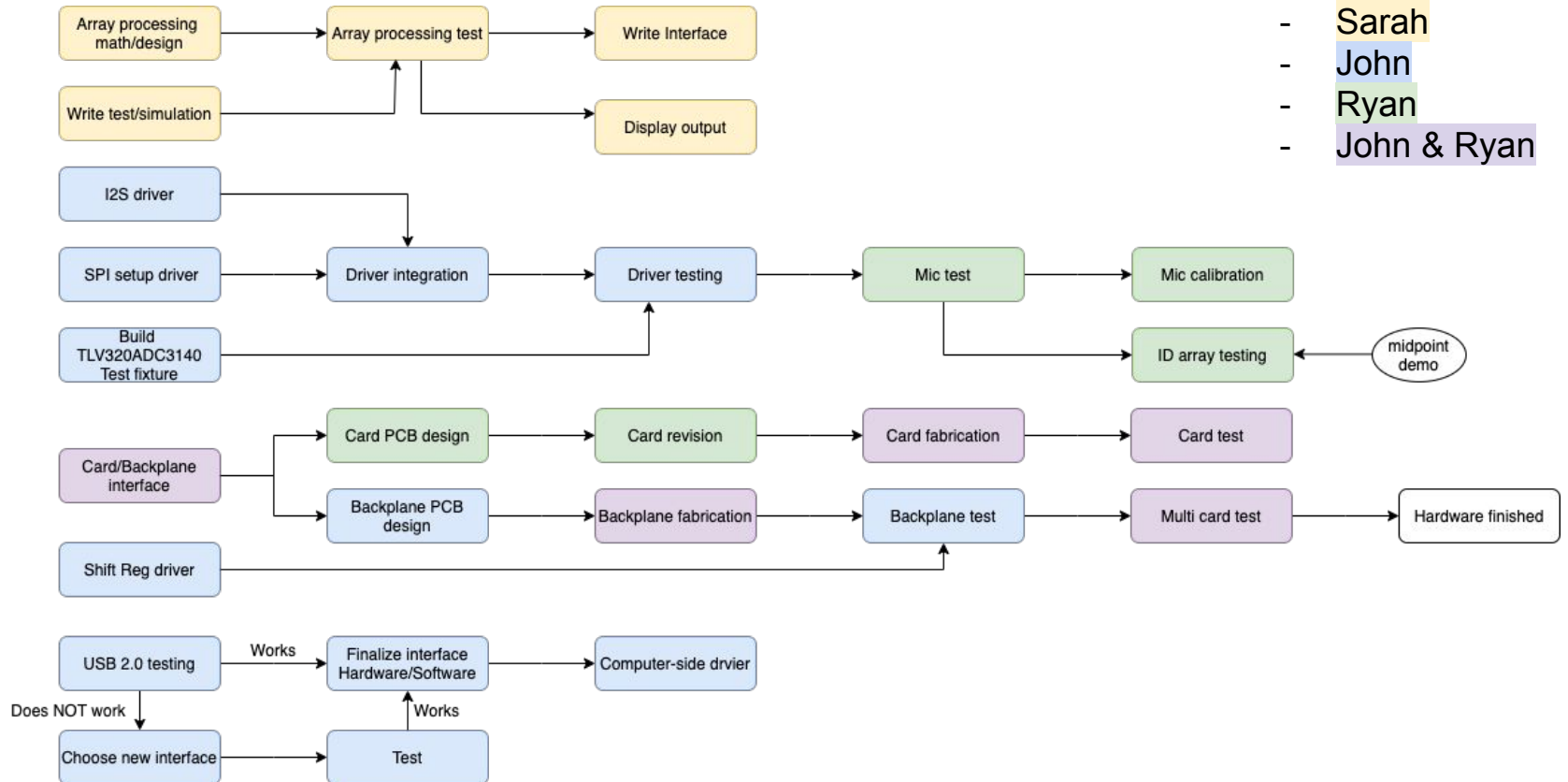
Solution

- ECE Areas
 - Circuits
 - Microphone A/D conversion
 - PCB design
 - Design for manufacture - scalable design
 - Software
 - Embedded software
 - Acquisition
 - Data transmission
 - PC software
 - USB driver
 - Signal Processing
 - Phased array processing
 - Graphical visualization

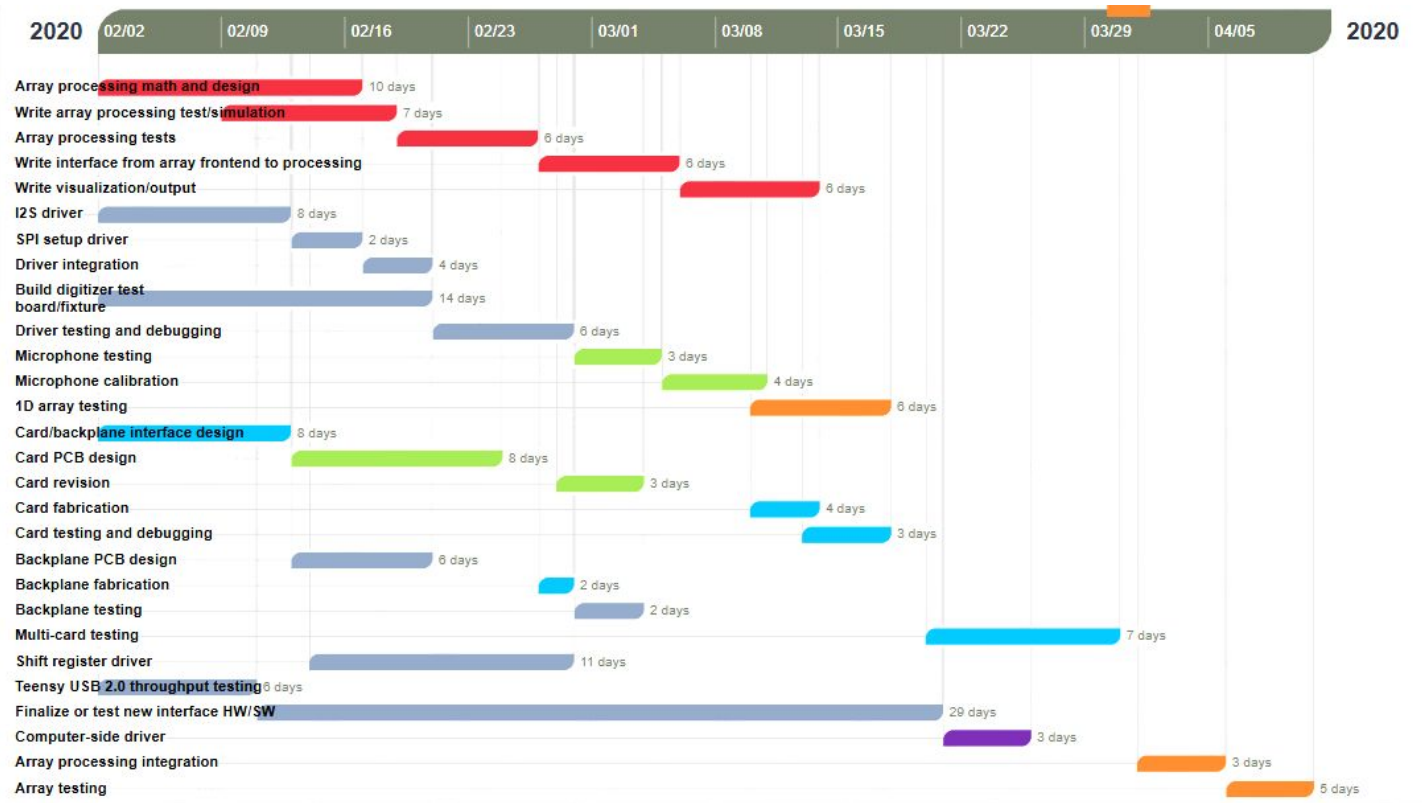
Testing, Verification & Metrics

Requirement	Details	Testing, Verification, and Metrics
Resolution	Produces at least 16 horizontal by 8 vertical zones as image output.	We verify that the image outputs 16x8 regions, and that each zone is functional with an audio source producing a 70dB SPL sine wave at 2m. Randomly sample 10% of the 128 zones and manually scan over the selected zones to verify each zone's response.
Image processing latency	Processes and presents the image output within 30 seconds of capturing audio.	Start a stopwatch when the Sonicam starts recording audio. Stop the stopwatch when the image is displayed, and take the difference in time.
Frequency response	Accurate (± 6 dB) response from 1,000-10,000Hz	Sweep from 1kHz to 10kHz in 10 logarithmic increments. Compare Sonicam's output with a calibrated measurement microphone's output.
Form factor	Phased array of microphones smaller than 4x4ft and weighs less than 10kg.	Measure the end to end dimension of the microphone array with a tape measure to verify size requirement. Use a bathroom scale to verify weight requirement.

Tasks and Division of Labor



Schedule



Sarah
John
Ryan
Ryan & John
Sarah & John
All

Challenges

- High bandwidth data transport
 - Analog Mic: $48\text{kHz} * 96 \text{ channels} * 16 \text{ bits/sample} = 73.7\text{Mbits/s}$
 - Digital Mic : $3\text{MHz} * 96 \text{ channels} = 288\text{Mbits/s}$
 - USB 2.0: 480Mbits/s
 - Teensy 4 has USB 2.0, but achievable throughput is uncertain
 - Gigabit Ethernet: 1,000Mbits/s
 - Must be implemented with FPGA
 - High-speed, relatively complex hardware layer
- Acquisition
 - All 96 channels must be captured within approximately 5uS of each other
 - Acquisition processor must collect data from all channels within 20.8uS (48Ksps)
- Fabrication
 - Have to physically assemble and wire almost a hundred separate channels
- Array processing
 - Must combine and process data from all 96 microphones at the same time

Conclusion

- Audio to visual translation using phased array microphones
- Key technologies
 - Phased arrays
 - Phase sensitive data acquisition
 - Analog to Digital conversion
 - High bandwidth data transport
 - Signal processing and data visualization
- Key Areas
 - Signal processing
 - Circuits
 - Software