Optimization of Distributed Phased Arrays

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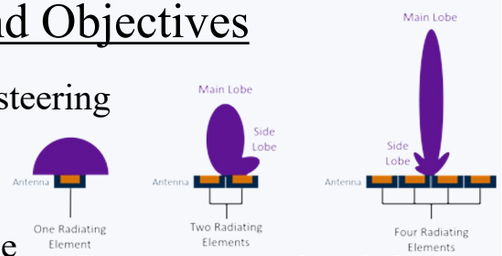
Engineering Problem and Objectives

- Phased arrays allow for **inexpensive** beam steering
- Necessary for **new technology such as 5G**

Problem: As current phased arrays increase in size, they become very expensive and inflexible



Beamforming of a Signal. Credit: Metaswitch.

Self Developed CAD of UAV for 5G

Objectives:

1. **Mathematically derive** calibration equations for phase and frequency
2. Write **original MATLAB code** to validate calibration equations
3. Build hardware model (**full software defined phased array prototype)** to validate equations and simulation

Data Analysis and Results

$$d = \frac{\Delta\phi}{2\pi}\left(\frac{\lambda_1\lambda_2}{\lambda_1 - \lambda_2}\right)$$ ⟵ Distance/Phase Offset Calibration Equation

- A **chi-square analysis** has p-value = 0.952
- With **99% certainty**, calculated distances matches actual distances

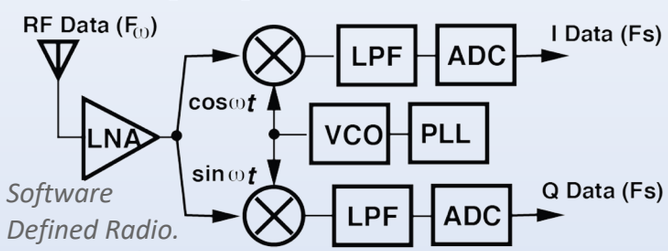
Calibration Testing Data Table

Actual Distance (m)	Phase @ 1210 MHz (deg)	Phase @ 1215 MHz (deg)	Phase @ 1220 MHz (deg)	Phase @ 1225 MHz (deg)	Phase @ 1230 MHz (deg)	Calculated Distance (m)	Percent Off (%)
4.62	-50.768	-82.735	-105.208	-137.147	-162.474	4.6312	-0.242%
4.72	159.79	133.776	106.698	76.199	49.82	4.6149	2.227%
4.92	-121.592	-159.468	172.592	142.078	116.214	5.0512	-2.667%
5.22	157.447	118.744	91.328	63.255	28.01	5.2614	-0.793%
5.62	-70.515	-98.696	-134.118	-171.817	161.628	5.4513	3.002%

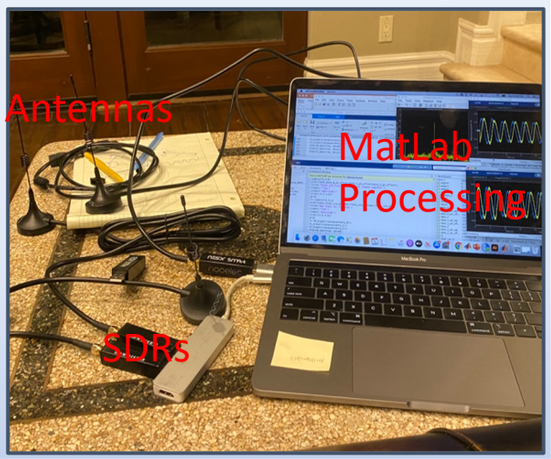
Project Design

Software Defined Radio-based hardware built to **validate** mathematical model

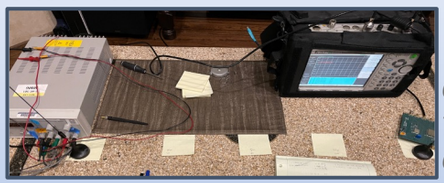
Complex processes I learned : **radios, SDRs, PCB build, and testing**



Software Defined Radio. Credit: Author



Hardware Data Collection. Credit: Author



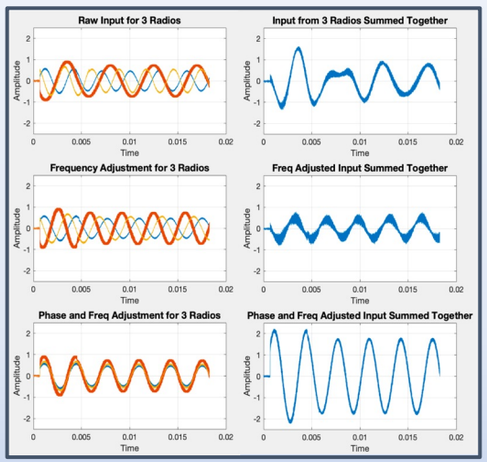
Calibration Testing Setup. Credit: Author

Interpretations and Conclusions

- Newly derived calibration equations **correlate** with the MATLAB simulation and hardware test results – **verifies results** 😁
- **Power increases** by 6 dB

Main **Benefits** of Distributed Phased Arrays

1. Transmitter to receiver distance can **remain unknown**, very helpful for sending signals to moving objects
2. Software based system is much **more flexible**
3. Able to **reduce costs** by 80% compared to a hardware phased array



Phase/Frequency Adjustments of Waves created by me