Jack Mullen, Jacob Hulvey, Dawit Yerdea
Passive RF
System Analysis Report

The total coherent radar system works as follows. The 90-degree hybrid coupler takes in a stable design frequency pulse from the input oscillator. It is 90 degrees phase shifted on both outputs; one of the split signals is sent to output at the antenna through the bandpass filter, which removes noise and unwanted harmonics. The other signal is sent to the 20dB coupler. The 20dB coupler then couples the input at 20dB, and this is sent to the LO port of the mixer. The antenna emits an echo signal produced by the original wave bouncing off the desired object, which is filtered by the bandpass filter, fed back through the 90-degree hybrid coupler, and fed into the mixer. The mixer compares the two signals (clean and returned) and produces a beat note containing velocity and range information.

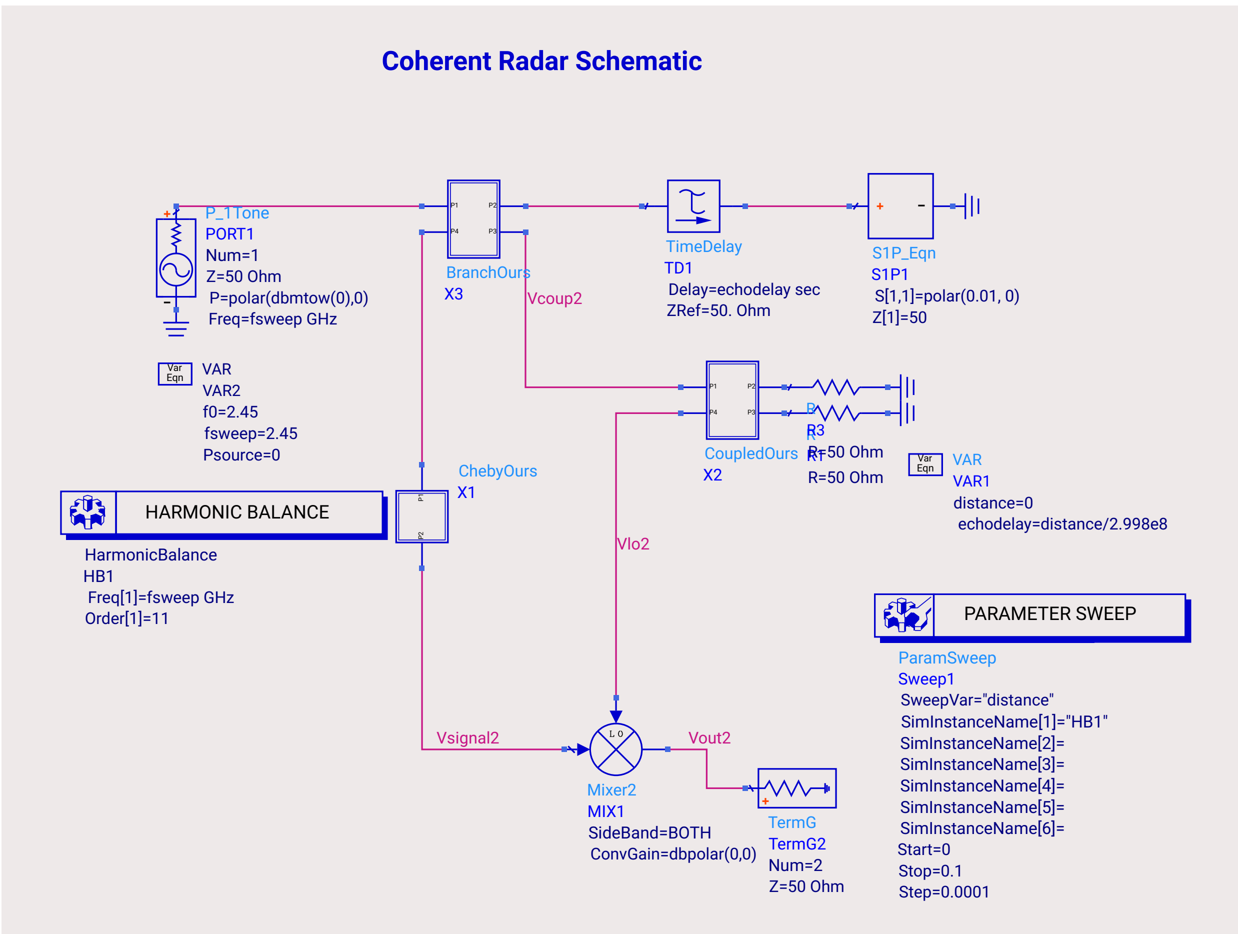

Figure 1. Schematic

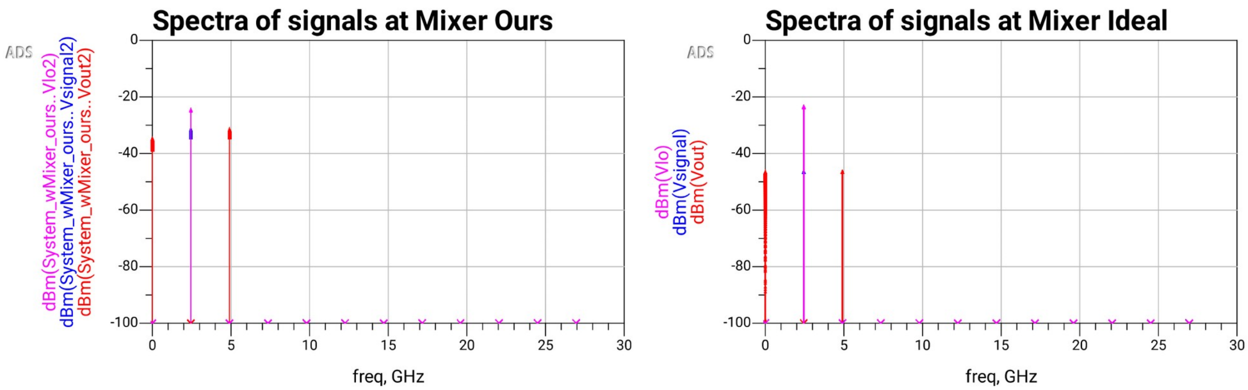

Figure 2. Spectra of signals at the mixer, ideal versus our design comparison.

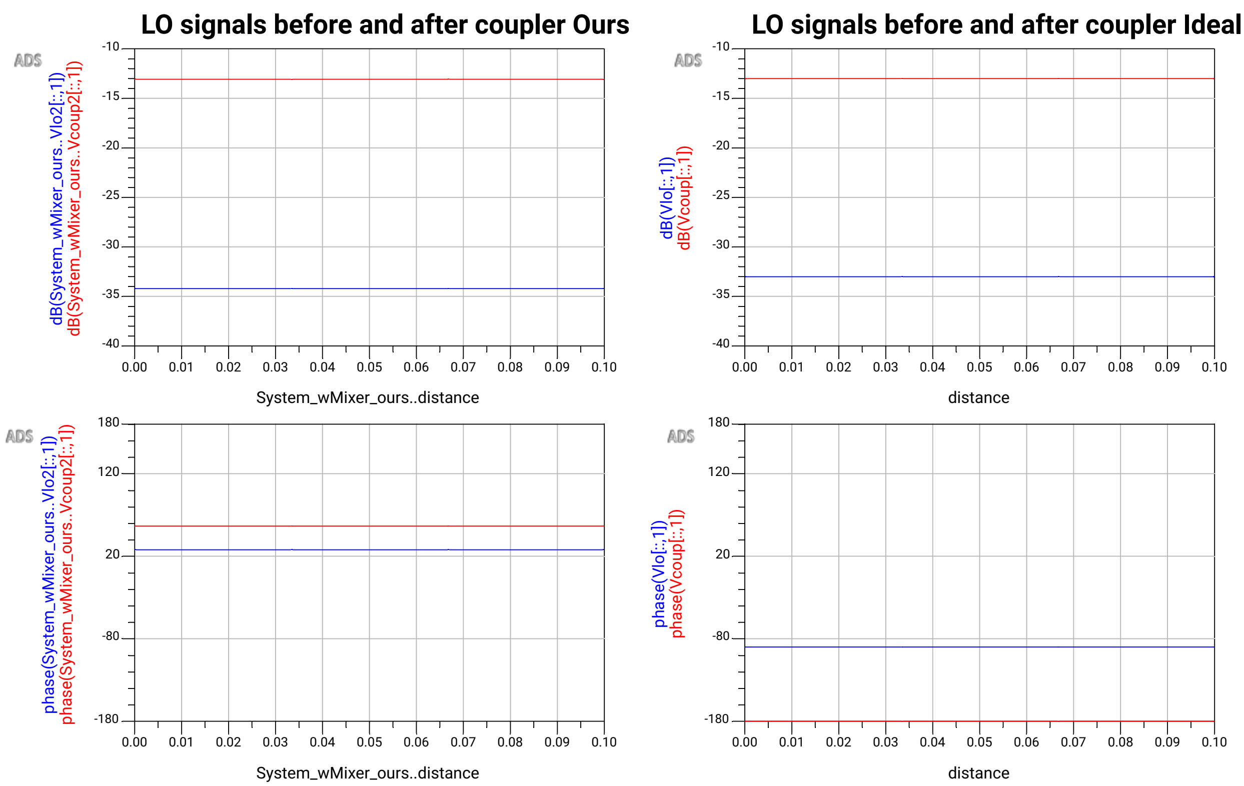

Figure 3. Signal input and output comparison for coupled line coupler, includes magnitude in dB and phase in degrees.

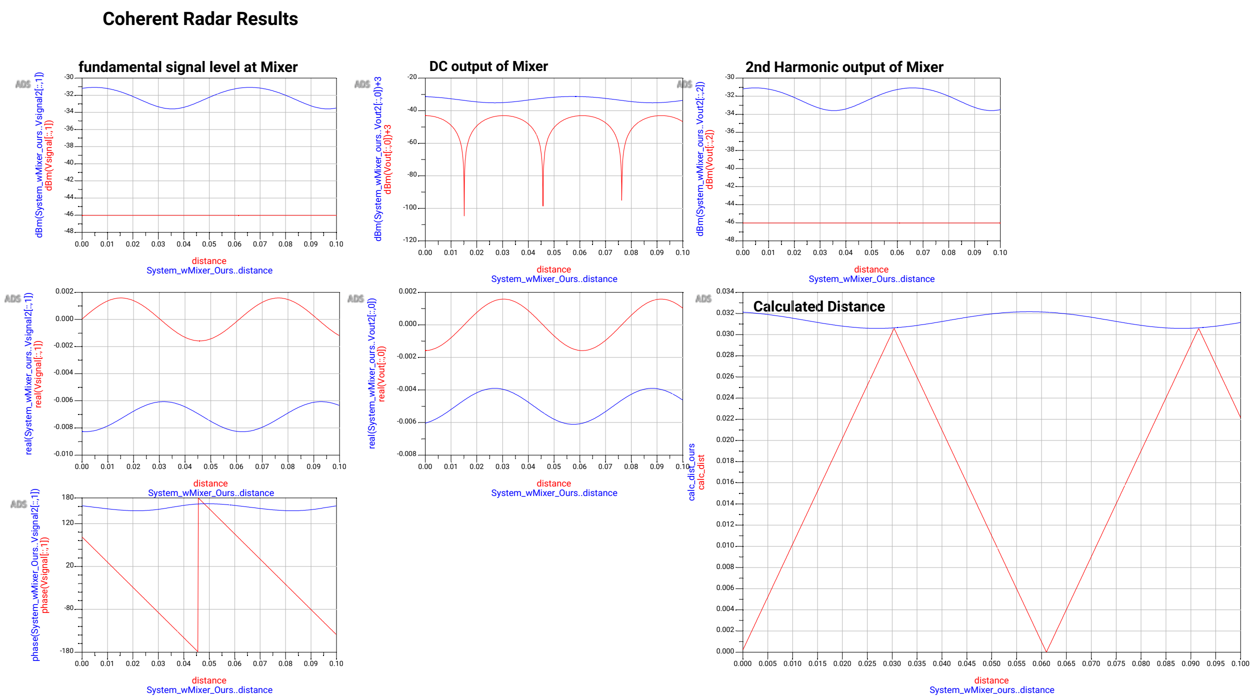

Figure 4. Compilation of all other radar results (red plots are ideal, and blue plots are the outputs of our designs).

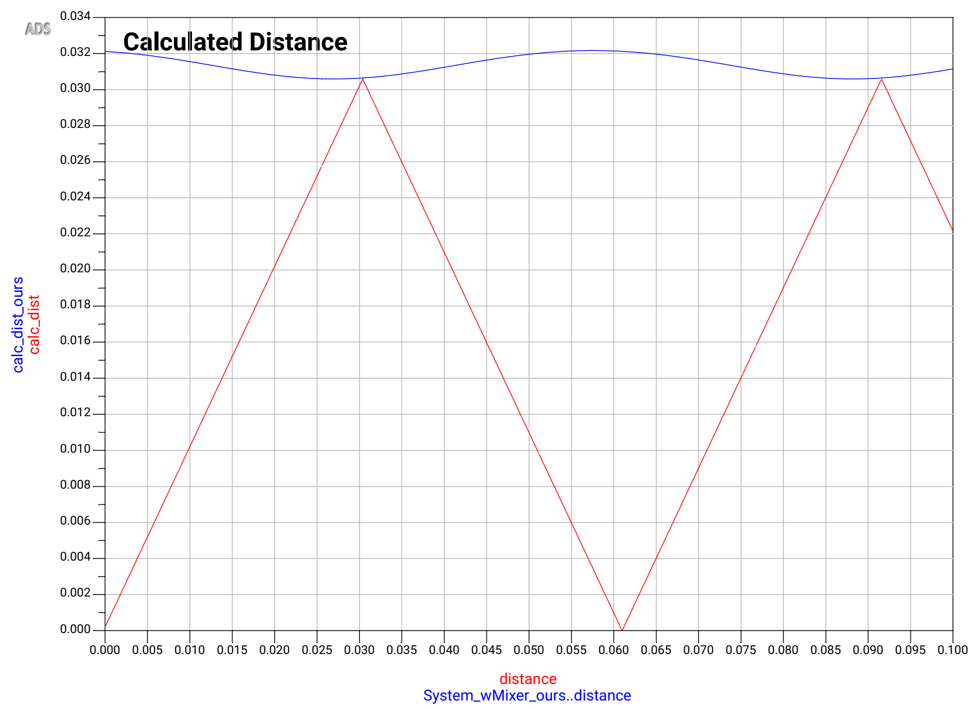

Figure 5. Calculated distance (red plots are ideal, and blue plots are the outputs of our designs).

Calculated distance did not appear to be particularly accurate with our designs. Our design captured a general oscillation, but this was out of phase with the ideal plot, having a much smaller magnitude and a large bias. The most likely culprit for this is poor isolation metrics coming from the branchline coupler. Because the isolation through our branchline coupler was shifted from the design frequency range, isolation values were higher than we wanted them to be. Part of the signal from the output path has the potential to leak into the return path, corrupting the signal a lot.

Another possible factor affecting calculated distance discrepancies was the coupling of the 20 *dB* coupler. Our coupling was very close to the 20 *dB* spec, but slightly lower. With less power making it to the LO port of the mixer, the comparison made between ports to determine distance would be more difficult.

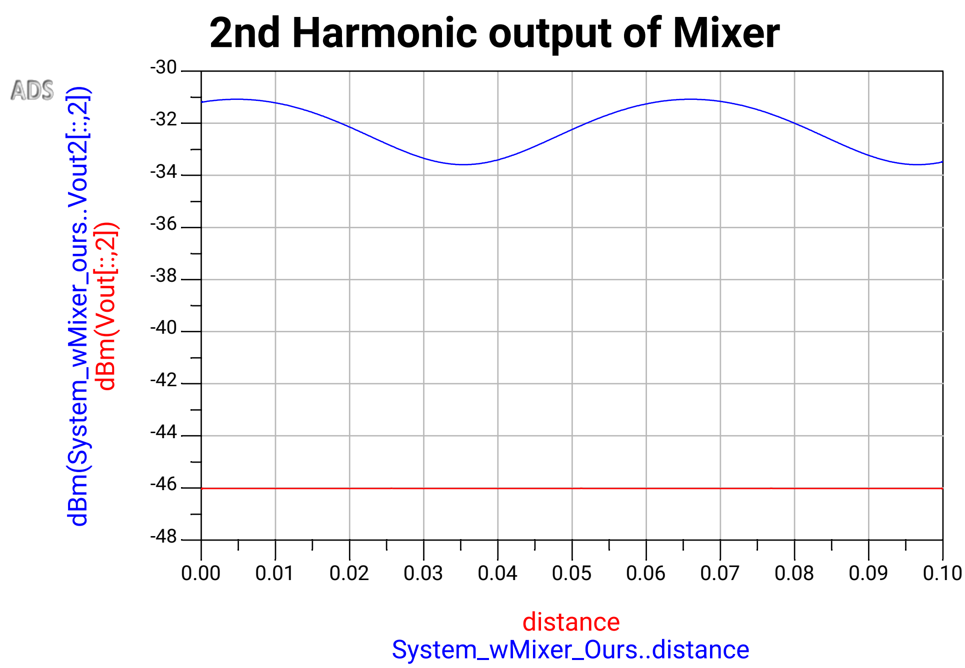

Figure 6. Magnitude of 2^{nd} harmonic output of mixer in *dB* (red plots are ideal and blue plots are the outputs of our designs).

Figure 6. shows the 2nd harmonic power at the mixer output versus distance. The ideal mixer produces a strongly suppressed harmonic at 46dB. Our implemented design exhibits a 2nd harmonic that is approximately 14 dB higher due to non-ideal hybrid isolation and phase imbalance.

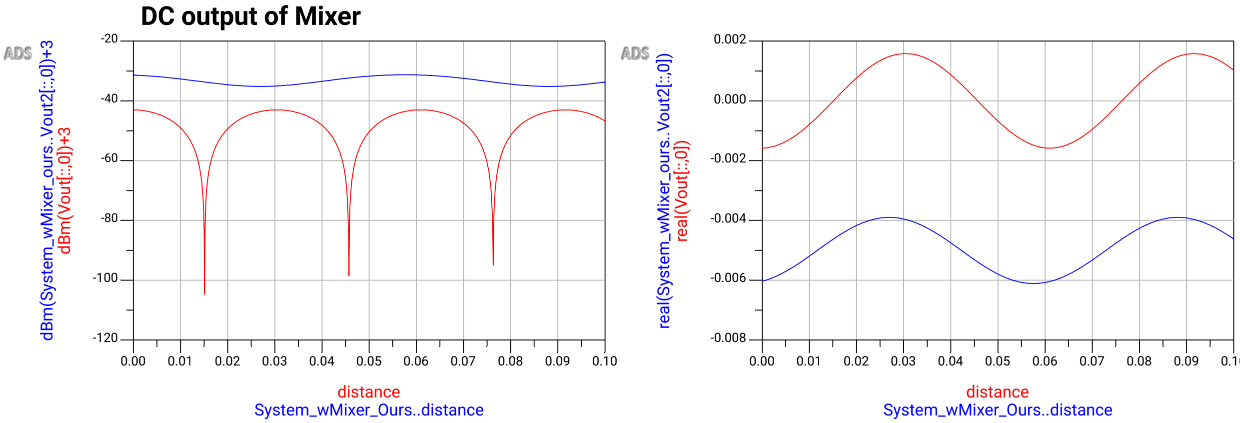

Figure 7. Magnitude DC output of mixer in *dB* and real (red plots are ideal, and blue plots are the outputs of our designs).

The DC outputs further confirm there are issues with isolation of the 90-degree hybrid coupler; we are not getting deep rejection at $\frac{n\lambda}{4}$ wavelengths, which the ideal gets, most probably due to corruption of the RF mixer signal.

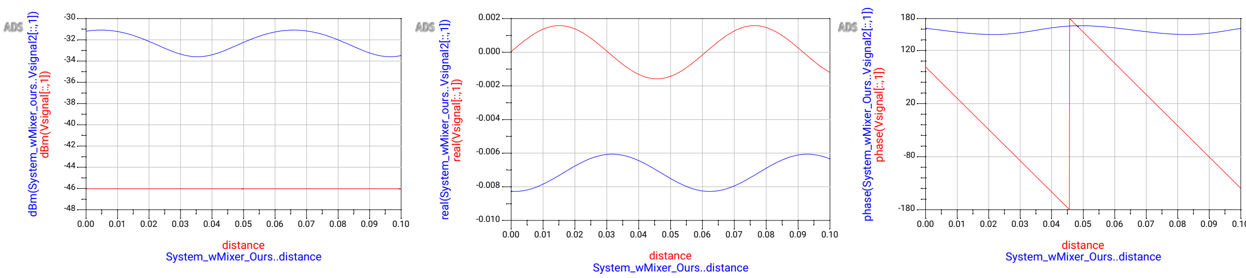

Figure 8. Magnitude and phase of the fundamental signal at the mixer in dB real, and degrees (red plots are ideal, and blue plots are the outputs of our designs).

Magnitude and phase are corrupted similarly. We see significant offset differences primarily because of the RF port leakage coming from poor $90°$ hybrid isolation. The magnitude difference could be due to a weak signal entering the LO port, which comes directly from worse coupling on the coupled line component.

Overall, our designs would not work very well as radar feedline components for this purpose. Our designs lead to very inaccurate calculations of distance, especially compared to the ideal, meaning the primary purpose of this system is not functioning.