Reference Antenna Techniques for Cancelling RFI due to Moving Sources

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Overview

- **Reference Antenna Techniques**
  A quick review of the techniques.
- **Varying Delays**
  How do the algorithms deal with moving transmitters.
- **Examples**
- **Summary**
Pre-Correlation Cancellers

Setting cross-correlation to zero must set the canceller output interference to zero.
Use two filters to average down reference receiver noise

Diagram:
- Antenna j
- Reference 1
- Reference 2
- Antenna k
- Filter Reference 1
- Generate Weights
- Cross Correlate
- Filter Reference 2
- Generate Weights
- Summation
- Summation
Post-Correlation Cancellers

These weights are generated and applied on time scales of seconds rather than nanoseconds.
Moving Sources

- Antennas are tracking the sky, so even fixed interferers will move through fringes
  - $\Rightarrow$ decorrelated cross-power measurements

- **Pre-Correlation**: Vary weights at the RF sample rate (ns)
- **Post-Correlation**: Need to modify the algorithms (s)
Moving Sources

- **Pre-Correlation:**

  Can make the pre-correlation mitigation algorithm adaptive to track any changes

  RFI voltage model is created from the addition of weighted and delayed reference voltage samples (equivalent to amplifying and phase shifting in frequency domain)
Example weights for broadband noise delayed by 5 samples
The weights track the changing geometric delay
Adaptive weights (red dots) result in correct cancellation

Canceller Failing

\[ \Delta T = 0 \]

\[ \Delta T = 1 \]

\[ \Delta T = 10 \]
Moving Sources

- **Post-Correlation:**

  If fringe rate is known and not too large, modify the post-correlation mitigation algorithms

  Here applied in the frequency domain
GPS Interference

Cross-power between the main signal and the reference signal

Canceller output power using decorrelated power measurements

Canceller output power using corrected power measurements

Want to be here

Canceller fails here
Canceller Output Spectra for Three Integration Lengths

a. Power remaining in $P(M,M)$

b. Power in $P(M,M)$ when decorrelation has been accounted for.

Using decorrelated power results in cancellation failure

Corrected power measurements restore cancellation

Spectral Channel
Moving Sources

- Both pre- and post-correlation mitigation algorithms can be made to work with moving sources

But both lead to a noise increase
Simulation

- Use simulated broadband noise to compare the pre- and post-correlation mitigation algorithms

Over the course of the correlation, the geometric delay between reference and primary antennas changes by 1.5 RF sample lengths
Broadband Noise Simulation. Higher frequencies have a larger fringe rate.

a. Cross-Power, $P_{mr}$

Amplify back to the correct power level.

b. Corrected Cross-Power, $P'_{mr}$

RMS noise increase

$P'_{mr} = P_{mr} / F_{mr}$
A Comparison of the Techniques

a. Residual Power

Residual Power Relative to $P_{mm}$

Frequency Channel, $N$

'no Cancellation' level

Post-correlation cancelling with decorrelated spectra

Post-correlation cancelling with corrected spectra

Pre-correlation cancelling with adaptive weights
Summary

- Modifications can be made to track varying interference
  - Pre-correlation -> allow weights to adapt
  - Post-correlation -> allow for decorrelation

- Both increase the amount of injected receiver noise