



# Application of Optoelectronic RF Noise Cancellation to Mid-IR Sensor Networks

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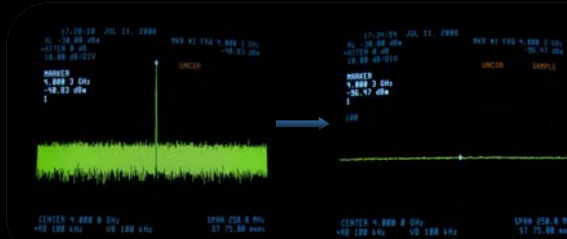
## Introduction

- Spreading a network of Mid-IR sensors over a large area to collect data about the environment creates a number of challenges for communicating that data
- Sensor systems of Mid-IR lasers and detectors would collect data and then communicate it wirelessly to a base station for storage, processing, and so on
- Sensors could be designed to communicate through an ad hoc network (relaying the data between themselves back to a base station) or to each communicate directly to the base station
- Size and power consumption is limited, so sensors must be placed within a few miles of each other (in an ad hoc network) or the base station (in a centralized network)
- What if the sensors are to be placed in a remote location such that the base station is not easily accessible and cannot be configured for wired communication?
- The base station would need use a high power RF signal to forward the information gathered in the remote area
- However, the high power RF signal generated at the base station would be present at its antenna for receiving signals from the sensors, interfering with its ability to receive them
- Thus, we approach the general problem of receiving a weak signal while simultaneously transmitting a strong signal
- This work is concerned with characterizing an experimental optoelectronic system for cancelling interference that is generated locally

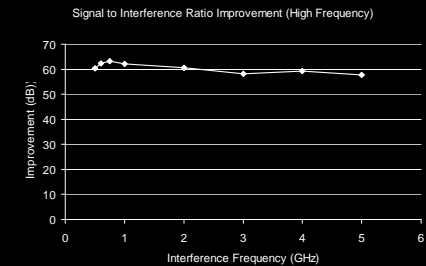
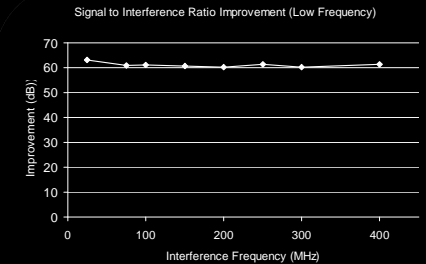
## Experiment: Cancellation of a Single Sinusoid

- Measure the system's ability to cancel a single sinusoid (at a designated frequency) generated by a signal generator and received as an interference signal
- Measure the cancellation bandwidth by testing with the interference signal at a number of frequencies between 25 MHz and 5 GHz
- In this experiment the sinusoid simulated the high power broadcast signal at the base station which would interfere with the base station's reception of broadcasts from the sensors
- The desired signal was simulated by inputting a low power sinusoid which served as the signal that was to be recovered at the output of the cancellation system
- Interference reduction can be qualitatively described by the interferer's proximity to the noise floor after cancellation
- Here, it was possible to reduce the interferer to within a few dB of the noise floor (about -98 dBm) across a bandwidth of approximately 5 GHz
- The system's ability to recover the desired signal was measured with "improvement," the ratio of the signal to interference ratio at the output to the signal to interference ratio at the input

$$\text{Improvement} = \frac{\text{SIR}_{\text{out}}}{\text{SIR}_{\text{in}}} = \frac{\left(\frac{P_{\text{desired}}}{P_{\text{interference}}}\right)_{\text{out}}}{\left(\frac{P_{\text{desired}}}{P_{\text{interference}}}\right)_{\text{in}}}$$



- Cancellation of an interference signal at 4 GHz by 55.7 dB
- The same experiment was performed from 25 MHz to 5 GHz, yielding similar amounts of cancellation
- 55.7 dB reduction = factor of 0.00000269
- Similar to reducing the interference signal from the power of a TV station antenna to the power of a handheld radio



Signal to interference ratio improvement of approximately 60 dB from 25 MHz to 5 GHz

## Criteria for the System

- Amount of cancellation**
  - By how much can the power of the interfering signal be reduced at the output of the cancellation system?
- Cancellation bandwidth**
  - Over what range of interference frequencies can a significant amount of cancellation be achieved?
- Linearity**
  - The linearity of the system determines how well it can avoid distorting the desired part of the received signal, while attempting to cancel interference
  - This system was measured to have a very low amount of intermodulation distortion
  - The more linear the system, the better it will be able to pass the desired signal through to its output without distortion

## Experiment: Recovery of a TV Signal



- TV Channel 3 is broadcast in the band 60-66 MHz with the video signal centered at 61.25 MHz
- A TV signal was produced using the output of a home VCR playing a videocassette, and the output of the cancellation system was connected directly to a TV set
- This signal was coupled with a high power sinusoidal signal and input to the system, effectively jamming reception of the video signal when cancellation was disabled (above left)

- With cancellation enabled, it was possible to fully recover the video signal without significant degradation (center)
- Some degradation of the input signal is caused by the system itself with no interference present (above right)—future research will focus on improving this
- The system is able to reduce the interference signal dramatically in order to bring the quality of the recovered signal very close to the baseline of the system with no interference present

## Discussion

- Locally generated high power RF interference was significantly reduced at individual frequencies across a very large bandwidth
- Recovery of a real analog TV video signal, subject to high power jamming at the center frequency of the signal, was demonstrated
- High linearity and high sensitivity allowed recovery of a signal with relatively little degradation due to the system itself
- Employed at the base station of the Mid-IR sensor network proposed in the introduction, this system would permit:
  - Much better reception of sensor signals
  - Use of a higher power forwarding signal at the base station
  - More distant placement of the station
- Future research will focus on decreasing system losses. For example, improving the system loss by 10 dB would allow a 1 W sensor signal (900 MHz) transmitted over 0.5 km (free space) to be recovered in the presence of a 10 W interferer (the base station's forwarding signal) placed 1 m from the receiving antenna.