

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

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As wireless communication technologies have proliferated, interference from devices utilizing similar communication bands in the same environment has become an increasing concern. The ability to cancel high power RF signals in the surrounding environment, which amount to significant ambient noise for low power transmitter/receiver systems, would be extremely useful if not absolutely necessary for some applications. In this work we will relate a new and robust RF noise cancellation system implemented with optoelectronics to the problems which would inevitably hinder a proposed network of mid-infrared (Mid-IR) air quality sensors in an urban environment.

One approach to the problem of monitoring air quality in an urban environment would be to deploy sensor systems with Mid-IR lasers and detectors for analyzing trace gases in air samples at different points in the city. Such an arrangement would not only permit accurate detection of pollutants, but also profiling of pollution patterns and their evolution with time and different meteorological conditions. How should the sensor systems communicate their data? Since the sensors may be placed where wired communications would be impractical or unavailable, radio communication seems to be the most viable option. A radio frequency of about 900 MHz would allow sensors to be separated by a number of miles and connected either directly to a central station or to each other in an ad hoc network. However, devices which communicate in this band must tolerate interference from any number of other devices utilizing the same band. We expect that in an urban environment there could be a significant number of other devices creating interference on this band. A method for cancelling the interference, improving signal reception over long distances would be among the desiderata for the sensor network. In an ad hoc network, the cancellation system could be employed at each sensor node in order to reliably broadcast over long distances; in a centralized network, the sensors could be set to broadcast, with very little need to receive, so the interference cancellation system could be incorporated only at the central station.

We present the results from a number of measurements which characterize the aforementioned optoelectronic RF noise cancellation system. Sinusoidal inputs from two signal generators were used to simulate narrow-band system inputs: a low power (approximately -45 dBm) desired signal and a high power (12 dBm) interference or noise signal. The interference signal was varied from 60 MHz to 5 GHz. Across this band it was possible to reduce the interference signal to the noise floor of the system and recover the desired signal (keeping it above the noise floor). Thus, it was possible to reduce the interference signal in excess of 60 dB and do so at frequencies across a very large band. Another measurement was performed with similar test inputs in order to characterize the linearity of the system. It was found that the system is highly linear. Thus, the system should be able to cancel very high power interference and do so without distorting the desired signal. To further demonstrate this, a TV signal from a VCR was input as the desired signal and a high power interference signal was input at the same center frequency as the TV signal: it was possible to recover the desired TV signal with relatively low distortion from the system and almost no effect from the interference signal.

The interference cancellation system described above could be employed at one point in the sensor network by connecting to the system the sensor's receiving antenna and an antenna designed to sample the interfering noise. The output of the system, with the interference significantly reduced, would serve as the new input to the sensor's receiver.