# Analog Cancellation of Periodic Frequency-Modulated Jamming

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**Abstract**

Interference mitigation techniques often rely on suppressing the interference in the digital domain only. However, strong in-band interference from jamming can saturate a receiver's front-end and, thus, limit the usefulness of plain digital methods. This is especially so in case of the self-interference (SI) encountered in enclosed full-duplex (FD) radios, but also in case of powerful interference in co-located radios. This work presents a digitally-assisted method and its implementation for the mitigation of narrowband periodic interference before quantization in co-located radios where, unlike in FD radios, the receiver does not have access to the transmitted interference waveform. Measurement results are presented that illustrate how the implementation affects GPS reception in the presence of such interference.

## 1 Introduction

Radios with full-duplex (FD) capabilities are not only expected to increase the spectral efficiency of wireless communications but also to reshape both the wireless defense and security domains, e.g., in the form of a so-called FD radio shield [1]. Inside the radio shield, a central node would be capable of receiving wireless signals while jamming the reception of those or other malign signals for others. It would be highly desirable for authorized co-located receivers to also be capable of receiving signals of interest inside the radio shield. The interference problem encountered in case of co-located radios is similar to the self-interference (SI) challenge in FD radios and such co-located receivers would benefit from suppressing the interference in the analog domain before quantization to improve the effective resolution of the signal of interest [2]. To that end, we propose a digitally assisted analog interference cancellation technique using a single input antenna and adaptive filtering [3, 4]. Previous experimental results have characterized the performance of the proposed method in a laboratory environment and revealed that phase noise of the interference source is one of the main limiting factors for interference mitigation [4]. Herein we present measurement results that include Global Positioning System (GPS) signals as signals of interest and analyze the impact of interference and its cancellation on GPS reception.

## 2 Interference Mitigation

The mitigation method is based on using an auxiliary transmit chain to subtract the reconstructed, delayed, and filtered interference from the received signal in the analog domain as illustrated in Fig. 1 [4]. The implementation requires estimating the instantaneous frequency of the narrowband jamming signal $x(n)$ and constructing a digital representation $\hat{x}(n)$ of the jamming signal such that it exactly follows the estimated frequencies. In order to obtain an interference-free version of $s(n)$, the input signal corrupted by interference $s(n)+x(n)$ is employed as the reference signal for the adaptive filter, whose input is the estimated jamming signal $\hat{x}(n)$ that is strongly correlated to the actual jamming signal $x(n)$. The adaptive mechanism adjusts the filter coefficients of $W(z)$ in such a manner that the filter output $y(n)$ approximates the jamming signal $x(n)$, thus forcing the error signal $e(n)$ to resemble the signal of interest $s(n)$. Due to the computational delays involved, the system's response is noncausal and the system is capable of effectively canceling only narrowband or periodic interference [5].

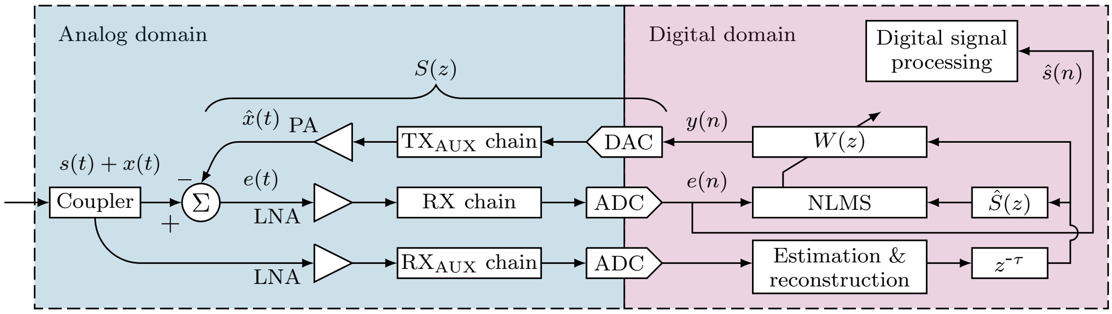



Fig. 1: Digitally assisted analog mitigation of instantaneously narrowband periodic interference.

## 3 Measurements

Previous measurements, which considered the power reduction after cancellation, showed that the cancellation results are highly dependant on the phase noise of the interference generator [4]. However, those measurements lacked any signals of interest besides the interference. Fig. 2 gives an overview of the measurement setup for characterizing the performance of the interference mitigation platform in front of a commercial off-the-shelf GPS receiver. The measurements are carried out in an anechoic chamber in order to avoid interfering with any other GPS receivers in the vicinity and to be able to use a controlled GPS source. Both the sinusoidally frequency-modulated interference and the GPS signals are generated by separate vector signal generators. The interference mitigation prototype is built using an USRP B210 software-defined radio (SDR).

The effect of mitigating the periodic frequency-modulated interference in the analog domain before the commercial off-the-self (COTS) GPS receiver is illustrated in Fig. 3a in terms of the jammer-to-signal ratio (JSR) and the GPS receiver's ability to correctly determine its geographical position. With the interference mitigation platform, the GPS receiver is able to correctly determine its position under considerably worse conditions than without the mitigation platform. For the lack of a better metric, the number of satellites reportedly visible to the GPS module is plotted for different JSRs with and without interference mitigation in Fig. 3b. The signal generator simulates only five satellites and this is correctly expressed by the GPS receiver when it is not jammed. As the level of interference increases, so does the receiver's confusion about the number of available satellites, which perhaps results from the receiver not adapting the acquisition threshold according to the interference and noise level.

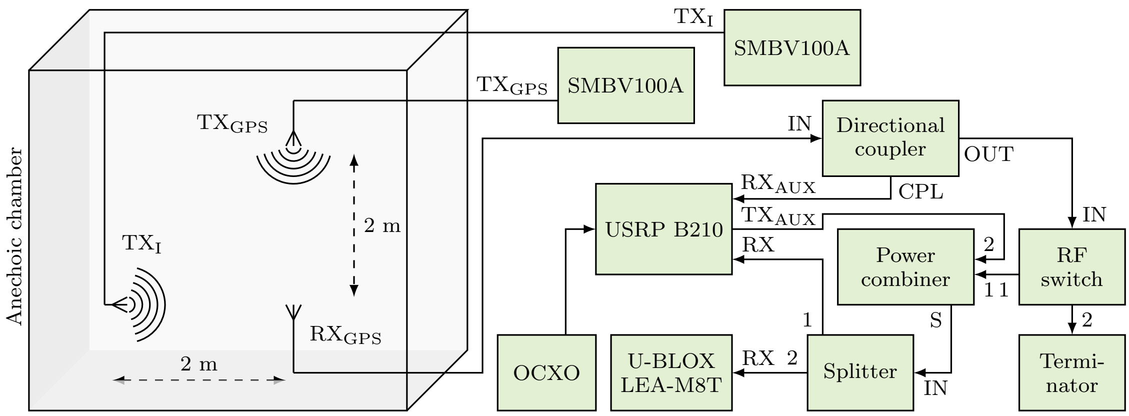
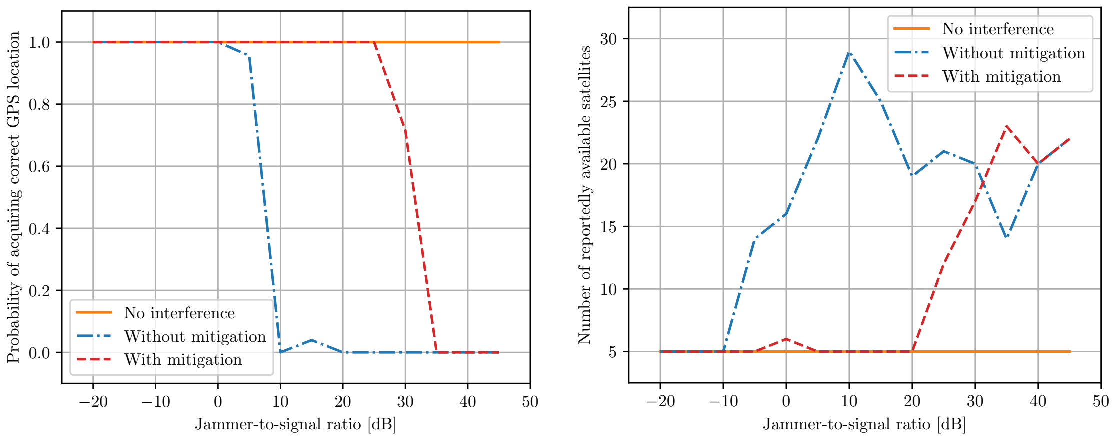



Fig. 2: Setup for measuring the performance of the interference mitigation platform in an anechoic chamber using GPS as signals of interest.




(a) probability of acquiring position fix

(b) confusion about satellites available

Fig. 3: Performance comparison of the GPS receiver with and without interference mitigation.

## 4 Conclusion

Analog interference mitigation, as opposed to plain digital solutions, becomes necessary when the interference starts to limit the receiver's sensitivity due to the limited dynamic range of the receiver's analog-to-digital converter (ADC). This is an issue in full-duplex radios but can also cause problems in co-located radios. In this work, we analyzed how a simple digitally assisted analog interference mitigation scheme affects GPS reception in the presence of narrowband periodic interference, whereas the interference parameters are unknown to the receiver. The experimental results show promising performance in terms of interference cancellation and improving the GPS position acquiring.

## References

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