# Impacts of Phase Noise on the Performance of Adaptive Side-lobe Cancellation System

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## Introduction

Adaptive side-lobe cancellation (SLC) is an effective means of anti-jamming for communication systems. The principle of this technology is to add an auxiliary antenna outside the main antenna, adaptively adjust the interference signal to get the cancellation signal, which has the equal amplitude and opposite phase with the interference signal. Then the cancellation signal and the interference signal are combined to achieve the purpose of interference cancellation. In the process of adaptive SLC, the signals received by the main antenna's sidelobe and auxiliary antenna need to be down converted to baseband, and then processed in the digital domain. In the down-conversion process, the phase noise of local oscillator (LO) will be introduced into baseband signals, which leads to random phase differences between the reference signal and the interference signal. As a result, the interference signal cannot be completely cancelled, which limits the interference cancellation performance of the system.

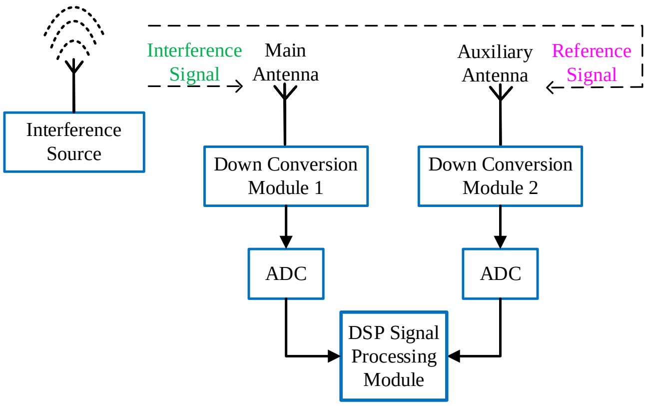


Fig. 1. Structure diagram of adaptive SLC system.

## System Model

Interference signal

$$x_i'(t) = S(t)e^{j2\pi f_c t}$$

Reference signal

$$x_r'(t) = S(t)e^{j2\pi f_c t}$$

LO signal

$$x_{LO}(t) = e^{-j2\pi f_c t + j\phi(t)}$$

After Down Conversion

Interference signal

$$x_i(t) = S(t)e^{j\phi_1(t)}$$

Reference signal

$$x_r(t) = S(t)e^{j\phi_2(t)}$$

After Cancellation

Error signal

$$e(t) = S(t)\left[e^{j\phi_1(t)} - E\left(e^{j[\phi_2(t)-\phi_1(t)]}\right)e^{j\phi_2(t)}\right]$$

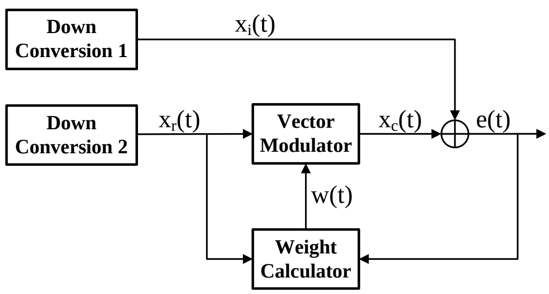


Fig. 2. Block diagram of cancellation system

$$ICR = \frac{E\left(|x_i(t)|^2\right)}{E\left(|e(t)|^2\right)} = \frac{\int_f |S_1(f)|^2 df}{\int_f |S_1(f) - \rho S_2(f)|^2 df}$$

## Simulation & Results

we verify the theoretical results by simulation. First, we add the same phase noise to different signals and observe whether the ICR of different signals have the same value after cancellation. Next, we change the level of the phase noise, and observe the change of ICR with the phase noise.

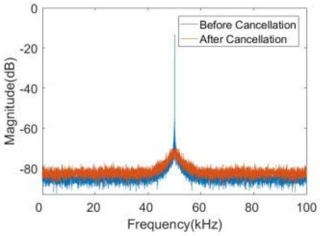


Fig. 3. Results of single-tone signal

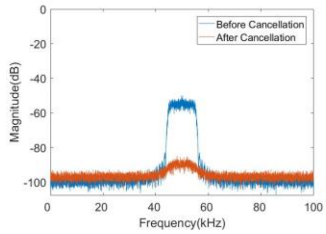


Fig. 4. Results of wideband signal

The ICR of single-tone signal is 33.8dB and the ICR of wideband signal is 33.7dB, which are approximately the same. It proves that ICR is not related with the specific form of the signals, but only with the phase noise. The simulation results are consistent with the theoretical analysis results.

In the following, different intensities of phase noises are added to the single-tone signal, the wideband signal and the narrowband signal respectively to observe the change curve of ICR.

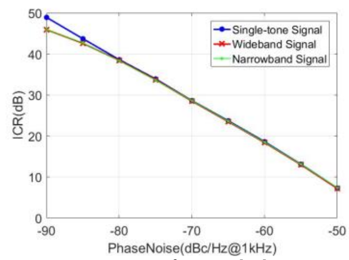


Fig. 5. Variation of ICR with phase noise

It can be seen that the variation of the ICR of different signals with phase noise is consistent, which all decrease with the increase of phase noise. When the phase noise level is between -80dBc/Hz@1kHz and -50dBc/Hz@1kHz, the ICR of signals is approximately the same. When the phase noise level increases to -60dBc/Hz@1kHz, the ICR decreases to below 20dB, which has seriously affected the cancellation performance of the system. Therefore, in order to keep good cancellation performance, the phase noise level of the down-conversion module should not be higher than -60dBc/Hz@1kHz.

## Conclusion

Through the above research, we have found that ICR is not related to the specific form of the interference signal. Numerical analysis considering practical phase noise levels shows that phase noise is a critical factor that limits the ICR. In order to achieve good ICR, a certain level of phase noise has to be achieved. For example, to achieve ICR of 40 dB, phase noise level lower than -85dBc/Hz@1kHz is required. The required phase noise level can be easily found using our proposed model.

## Reference

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