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The Least Mean Squares Adaptive FIR Filter for RFI Suppression in Radio Detectors of Cosmic Rays

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The radio emission from the Extensive Air Showers (EAS), initiated by ultra-high energy cosmic rays, was theoretically suggested over 50 years ago, however, due to technical limitations, successful detection can be taken for several years.
Nowadays, this detection technique is used in many experiments consisting on detecting EAS. One of them is Auger Engineering Radio Array (AERA), located within the Pierre Auger Observatory (PAO). AERA focus on the radio emission, generated by electromagnetic part of the shower, mainly in geomagnetic and charge excess processes. Frequency band observed by AERA radio stations is 30 - 80 MHz. Chosen frequency range is contaminated by human-made and narrow-band radio frequency interferences (RFI). Suppression of these contaminations is very important to lower the rate of false triggers.

AERA uses two kind of digital filters in radio stations to suppress the RFI contaminations: the median filter based on the Fast Fourier Transform (FFT) and the notch filter, which is composed of four Infinite Impulse Response (IIR) filters. Both filters have been successfully working in field for many years, however they also have some disadvantages. FFT based median filter is complicated and power consuming, IIR filter suppresses only fixed frequency ranges.

We propose an adaptive FIR filter based on the Least Mean Squares (LMS) algorithm, which can be an alternative for currently used filters. Simulations in MATLAB are very promising and show, that FIR filter based on LMS algorithm can be very efficient in suppressing RFI and only slightly distorts radio signals.

The LMS algorithm was implemented into Cyclone V FPGA for testing the stability, efficiency and adaptation time to new conditions. First results show that FIR filter based on the LMS algorithm can be successfully implemented and used in real AERA radio stations.

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