DESIGN AND IMPLEMENTATION OF RECEIVER SYSTEM

FOR SUPPPRESSING RADIO FREQUENCY INTERFERENCE

USING ADAPTIVE FILTERS.

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ABSTRACT

Radio Frequency Interference (RFI) is increasingly affecting radio astronomy observations. Recent interference mitigation techniques developed for communication engineering have been applied in radio astronomy. However, RFI rejection achieved till now is not sufficient for radio astronomy. Research in developing new techniques is therefore essential.

This paper describes an improvised technique of RFI suppression by adaptive filters by constraining the bandwidth of the reference signal and also to study the effects of quantisation of bits to suppress RFI.

The adaptive cancellation technique requires two receivers: a primary channel that will be the radio telescope and a reference channel. For this experimental research, a reference receiver system has been designed and built which could be used along with the existing 10.4m diameter radio telescope functioning at Raman Research Institute, Bangalore. The receiver setup is designed around the 1.4 GHz receiver system of the 10.4-m telescope, and thus the research is to mitigate RFI in the 1.4204 GHz frequency band.

The reference antenna system constructed is used to receive the man made RFI .The bandwidth of the reference signal is reduced by 25 MHz and then is processed by an adaptive filter .The 1.4 GHz signal from the telescope and antenna are down converted to 50MHz and connected to a data recording system.

By simulations in Matlab, we studied the effect of constraining the bandwidth of reference signal on the suppression achieved in a LMS adaptive filter when the signal to noise ratio of the RFI in the reference channel is moderate. It is found that constraining the bandwidth

improves the suppression depending on the Signal to Noise Ratio(SNR). The improvement is due to increased SNR of RFI in reference channel when the bandwidth is limited to the frequency components of RFI.

INTRODUCTION

Radio astronomy observations are increasingly affected by interference due to improved mobile, wireless communications etc. They produce interference, which affect the observations and there have certain measures to eliminate these interference to a certain level. Some of the techniques are:

- blanking techniques to remove pulse type signals from adjacent components
- notch filters to eliminate fixed frequency interference
- post processing of datas
- adaptive beam forming
- adaptive interference cancellation

All these methods have their own shortcomings though reduce interference to a certain extent. We have considered the case of adaptive interference cancellation and simulated the results of suppressing RFI when the bandwidth of the reference signal is constricted.

BASIC CONCEPTS OF ADAPTIVE INTERFERENCE CANCELLATION

An adaptive interference canceling systemis illustrated in figure 1.The 10.4 m telescope of RRI, Bangalore receives the astronomical signal s(n), along with the interference i(n). The reference antenna ,described later ,is the second receiver which receives only the man-made RFI.

The interference in the reference channel is uncorrelated with the interference in the primary channel .The adaptive filter used will have to estimate the correlation as a function of time.

The adaptive algorithm compares the previous solution to current information and sends updated coefficients to the digital filter. The digital filter uses the updated coefficients to alter the reference signal to produce a signal closely resembling the interference in primary channel. The signal produced is subtracted with the primary input to produce system output.

The adaptive algorithm used here is Least Mean Squares (LMS) algorithm. LMS algorithm updates the filter coefficients by minimizing the total output power. The power is the square of the system output:

$$e^2(n) = s^2(n) + [i(n) - y(n)]^2 + 2s(n)[i(n) - y(n)]$$

The average value of the system of the $e^2(n)$

$$E\{e^2(n)\} = E\{s^2(n)\} + E\{[i(n) - y(n)]^2\}$$

As the filter adjusts the coefficients to minimize $E\{e^2(n)\}$, the power in the astronomical signal $E\{s^2(n)\}$ is unaffected and so $E\{[i(n) - y(n)]^2\}$ reaches a power minimum. Thus, minimizing the total output power minimizes the output interference power and, thus maximizes the output signal to interference ratio.

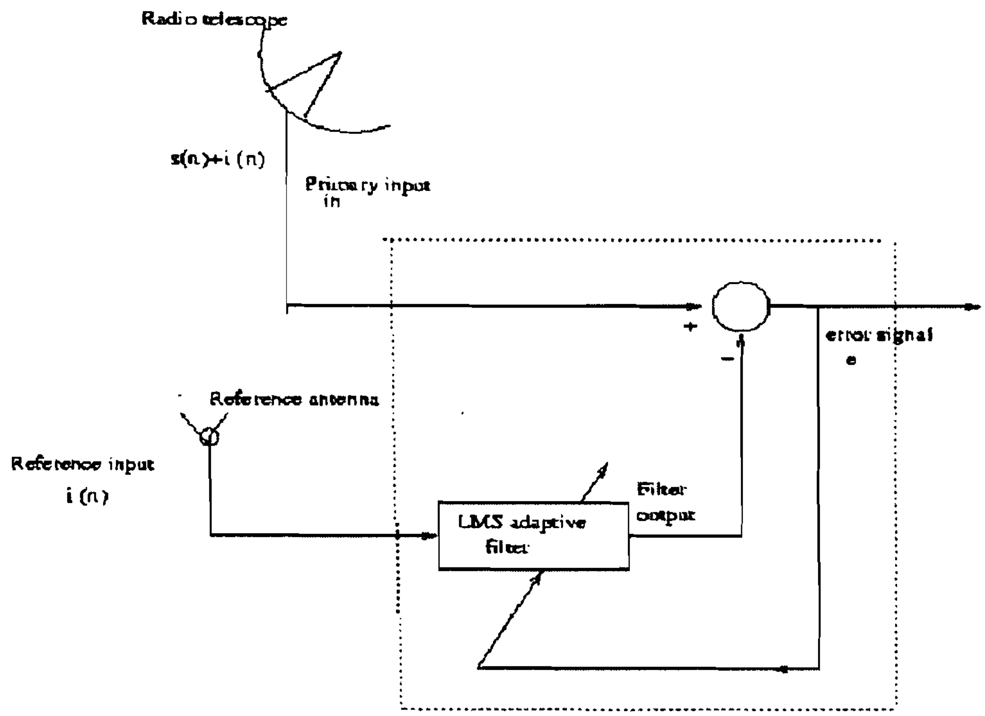

Figure 1:Schematic of RFI mitigation using adaptive interference cancellation

DESIGN AND CONSTRUCTION OF THE REFERENCE ANTENNA

A reference antenna has been designed and constructed to use it for receiving the interference alone .The overall gain of the reference antenna system has been designed as 65 dB. The block schematic of the reference antenna is shown in figure 2.

The reference antenna comprises a pyramidal horn coupled to a broadband low noise amplifier with a gain of 38 dB. The bandwidth of the reference receiver system is reduced to 25 MHz by a coupled resonator filter. The filter is placed after the first stage amplifier, to avoid saturation of the rest of the receiver system due to excessive RFI power, to a circulator to prevent it from reentering the system. The output of the circulator is further amplified and is connected to one of the Intermediate Frequency (IF) systems of the 10.4-m telescope. The reference and the 10.4m telescope system are currently capable of receiving one polarization. The 1.4204 GHz is down converted to 50 MHz and connected to a data recording system which is capable of taking a maximum of 60 MHz as RF input .The recording system can record 2 bit quantized voltage over 1MHz bandwidth from 2 channels, basically the telescope and reference antenna output.

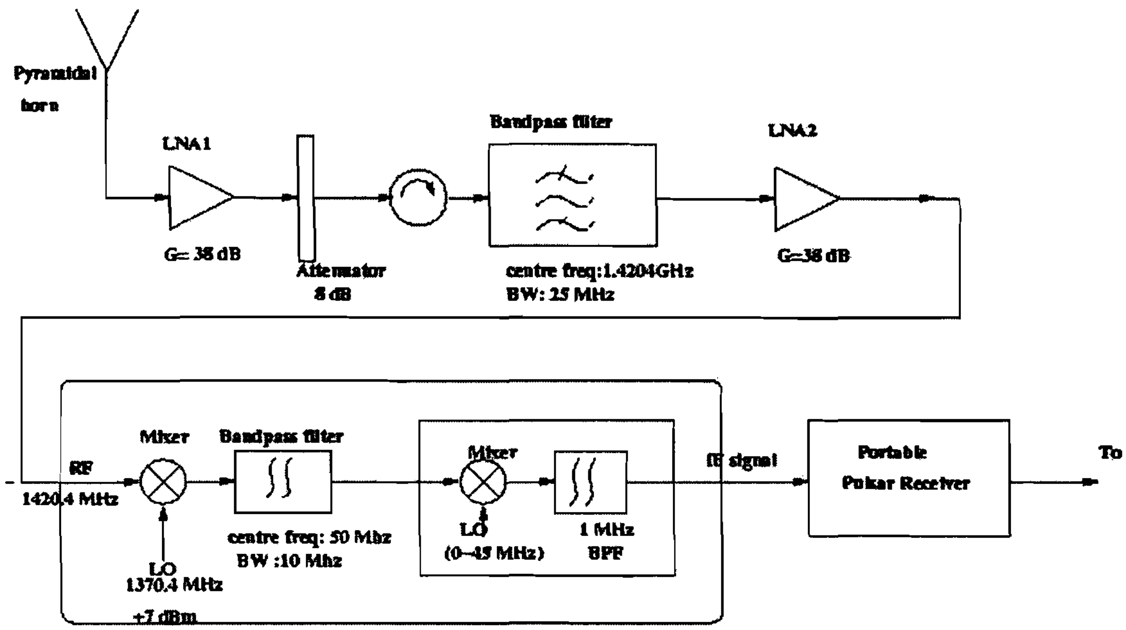

Figure 2:Block schematic of the receiver system for the reference signal . Portable Pulsar receiver is used for acquiring data and formats data to transfer into PC.

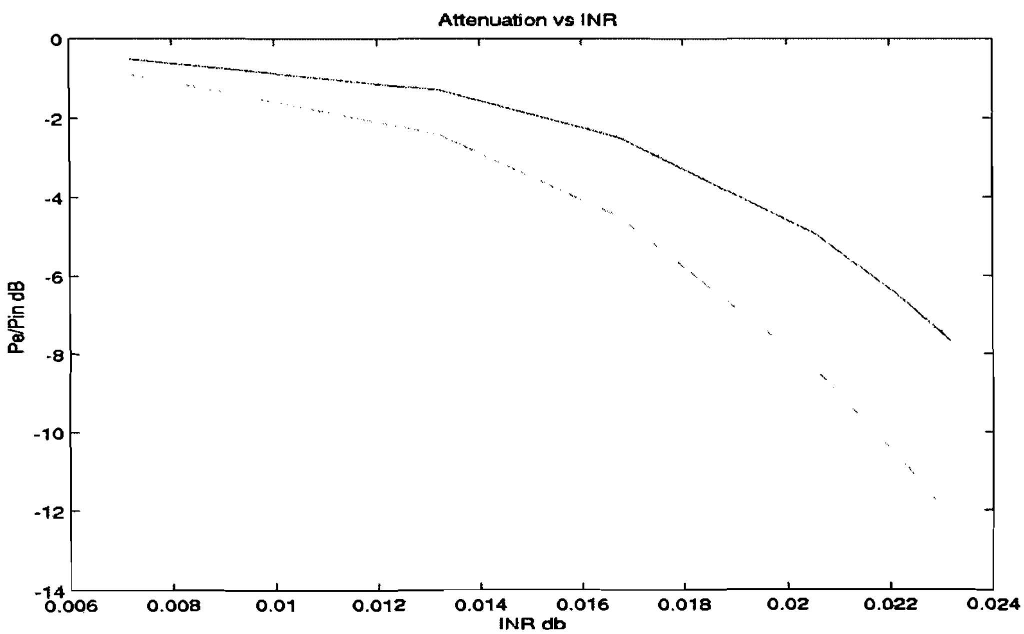

Figure 3:Simulation results of adaptive interference cancellation, Attenuation vs INR. The results show that constraining the bandwidth of the reference signal, the suppression of RFI improves with SNR

CONCLUSION

The results of simulation show that Reducing the bandwidth of the reference signal and adaptively filtering the signal suppresses RFI depending on the SNR value.

References:

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