

# Performance Evaluation of Interference Cancellation methods in Cognitive Radio for Aeronautical Communication System

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**Abstract-** The Very High Frequency band (VHF) currently used for aeronautical communications is becoming congested, and hence L band is used for meeting the future capacity requirements in aeronautical communications which will require much greater use of data communications. Due to air traffic, cognitive radio based air to ground communication is introduced which provides dynamic spectrum access to airplanes to overcome the spectrum scarcity problem and in that spectrum sensing is done to find vacant place for effective communication. In the spectrum sensing, the DME and LDACS is the primary and secondary system. When the secondary system access the primary's vacant place, the DME interference exist in the LDACS signal. This affects the effective communication from air to ground. Thus we propose three new approaches to mitigate the interference, one of which is a space time block coding method and the another two types are Pulse blanking algorithm and Decision directed noise estimation. In this work, we analyse and remove the interference in LDACS signal and compare the performance of these interference reducing algorithms.

**Keywords-** Cognitive radio network, Interference mitigation, LDACS, DME, BER.

## I. INTRODUCTION

Over the past two decades, the air transport industry has experienced continuous growth and the demand for passenger air traffic is forecast to double the current level by about 2025. The growth of air traffic in the airport required an advanced and efficient air traffic management (ATM) infrastructure that is able to cope with the spectral scarcity problem and also the ever-growing demand for more bandwidth and higher data rates.

The Controller-Pilot Data Link Communications (CPDLC) system has traditionally used high-frequency (HF) and very high frequency (VHF) bands as well as higher frequency bands used for satellite communications (SATCOM). However, SATCOM systems are not always available during all phases of flight and the HF and VHF bands are getting very congested. Due to air traffic, spectrum becomes underutilized.

For example, the utilization rate in the VHF band is less than 5%. so it is necessary to identify new spectrum for air-to-ground data links. Therefore, cognitive radio based aeronautical communication systems is proposed that allows an aircraft to identify vacant spectral bands in the air-to-ground spectrum and choose a suitable channel to initiate an LDACS air-to-ground transmission to mitigate the interference. Because, the L-Band, which is already used for several other aeronautical communication

functions and has recently become available for Aeronautical Mobile Route Service (AMRS), has been tentative designated as the next desired band.

EUROCONTROL, the European organization for the Safety of Air Navigation, have made separate proposals called L-Band Digital Aeronautical Communications System. The L-band digital aeronautical communications system (L-DACS) technology provides the air-to-ground data link services within the future communications infrastructure (FCI) for aviation. L-DACS1, which uses orthogonal frequency division multiplexing (OFDM) modulation with frequency-division duplex (FDD) as an access scheme of the forward and reverse links.

The authors of [6] suggested that the B-VHF system is capable of fulfilling expectations of future ATC communications like high efficiency, increased capacity and improved communications system safety. Due to the limited amount of available spectrum in L-band, the authors of [4] suggested to limit the LDACS1 transmission bandwidth to 500kHz between the two adjacent distance measuring equipment (DME) channels of bandwidth 1 MHz, for each forward and reverse link (FL/RL).

The authors of [5] analysed various possible interference scenarios between LDACS1 and DME for both co-site and co-channel environments and found an important issue that needs to be addressed in LDACS1 system is the radio

frequency compatibility as it has to coexist with several legacy systems that are already operating at L-band. The effect of DME interference onto the LDACS1 leads to high performance loss as the transmission power of DME interference is high compared to that of LDACS1. The authors of [10] proposed several impulse noise cancellation schemes to achieve reliable communications. Due to the impulsive nature of DME pulses, impulse noise cancellation schemes have been developed in order to mitigate the impact of DME interference.

An algorithm for impulsive noise suppression in OFDM receivers is proposed in [8]. The traditional methods for impulsive noise suppression are implemented in a time domain before OFDM demodulation and the proposed algorithm compensates impulsive noise in a frequency domain after OFDM demodulation and channel equalization.

To suppress both intersymbol and intersubcarrier interference caused by the channel impulse response or timing and frequency errors, an equalization algorithm is suggested in [7]. Space-time coding (STC) is introduced in [9] and it is a promising method. These code symbols are generated by the space-time encoder in such a way that diversity gain, coding gain, as well as high spectral efficiency are achieved.

In [3], a clipping and blanking detector is suggested which uses a memoryless nonlinear operation to either limit or blank the impulse noise affecting received signals. Even though clipping and blanking nonlinearities nonlinearities in OFDM, there is no complexity to L-DACS1, they require perfect knowledge of DME impaired samples.

The authors of [2] proposed Pulse blanking and pulse clipping (PC), a well-known time domain approaches for pulsed interference mitigation. In the case of PC, the received samples exceeding a certain threshold are set to the threshold value rather than setting to zero as for pulse blanking. These approaches have the advantage of simplicity. Decision directed noise estimation (DDNE)-based mitigation method is proposed in [1], it mitigates the impulse noise in the OFDM system.

## II. EXISTING METHOD

B-VHF (Broadband Very High Frequency) is used as datalink in VHF band. It was designed for 118-137 MHz. Global navigation satellite system (GNSS) is used for aircraft navigation. But, GNSS signal can be easily lost in the presence of interference and jamming because of its weak signal power.

## III. PROPOSED METHOD

Due to air traffic, the VHF band was getting congested, hence Lband is used. Therefore, LDACS is used as

datalink in Lband. It was designed for 950-1450 MHz. Here, DME is used for navigation. It will provide slant distance, thus tracks the aircraft using the time difference.

## IV. LDACS

LDACS Broadband system based on OFDM, it supports data and voice (optional) A/G communications for improved performance and spectral efficiency. LDACS1 system is the radio frequency compatibility as it has to coexist with several legacy systems that are already operating at L-band.

The band is shared by various legacy systems such as Secondary surveillance radar (SSR), DME, Multifunction information distribution system (MIDS), Joint tactical information distribution system (JTIDS). In particular, the DME is a strong interfere to LDACS1 due to the inlay deployment. DME is the radio navigation technology, which measures the slant distance between the aircraft, and the ground station (GS) and operates in UHF frequency spectrum between 960-1164 MHz. DME transponder expressed in Nautical Miles (NM).

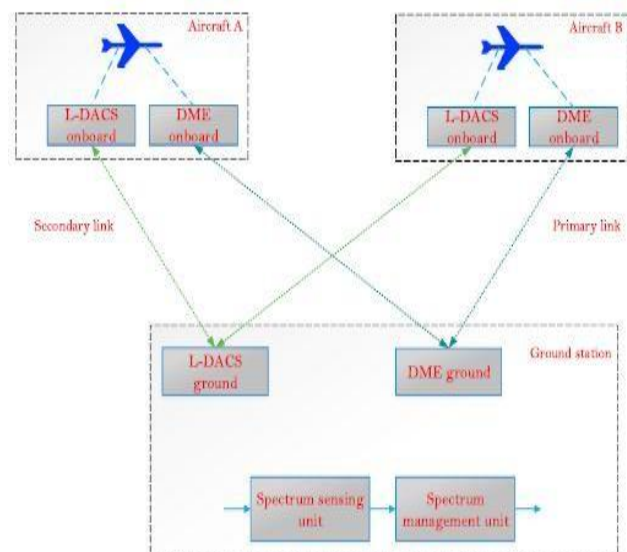


Fig 1. Cognitive Radio based Air to Ground Communication.

In the Figure 3.1, the DME that currently operates in the L-band spectrum is considered as the primary system and the L-DACS system is considered as the secondary system. Further, there is spectrum sensing and management unit for detecting an idle L-band in DME and allocate them to an L-DACS. The primary responsibility of the cognitive radio based Spectrum Sensing Unit (SSU) is to search and detect the vacant band (spectrum holes). The SSU not only detecting the spectrum, also used for detecting the interference from the legacy aeronautical systems operating in the same L band.

Spectrum Management Unit (SMU) will decide the most suitable vacant band for each airplane depending on the QoS requirement of the data that needs to be transmitted from L-DACS on aircraft to L-DACS on ground station and allocate these vacant bands to airplanes for dynamic spectrum access.

## V. INTERFERENCE MITIGATION SCHEMES

The information in the spectrum management unit is broadcast to all aircrafts within that ground station to know the existing frequency assignments. While accessing the vacant bands, there exist interference. Therefore a possible solution to mitigate the impact of pulsed interference from the L-band is through three methods.

### 1. Pulse Blanking:

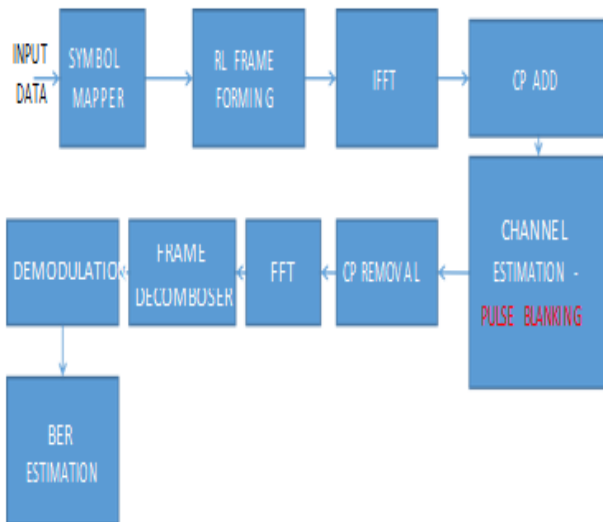


Fig 2. Block diagram of pulse blanking.

Pulse blanking and pulse clipping are two wellknown time domain approaches for pulsed interference mitigation. In pulse blanking, the received samples are set to zero when the power of the samples exceeds a certain threshold level. The pulse blanking removes all samples of the received signal with amplitude exceeding a predefined threshold. It is an effective approach adopted for removing pulsed interference. The received signal in time domain after pulse blanking yields,

$$y[n] = y(n) \leq \text{threshold}$$

$$y(n) > 0 \quad (5.1)$$

### 2. Space Time Block Coding (STBC):

STBC for the first time was proposed by Alamouti at 1997. In MIMO, channels can be used to increase the data rate by sending different data streams on the different channels. But another possibly a better way is to transmit different blocks, containing encoded data, in different

channels. This phenomena is known as Space Time Block Coding (STBC).

In order to separate these block of information many detection techniques are used like ZF, MMSE and ML and after decoding, the interference can be eliminated. STBC utilizes multiple antennas to create spatial diversity, this allows a system to have better performance in fading environment.

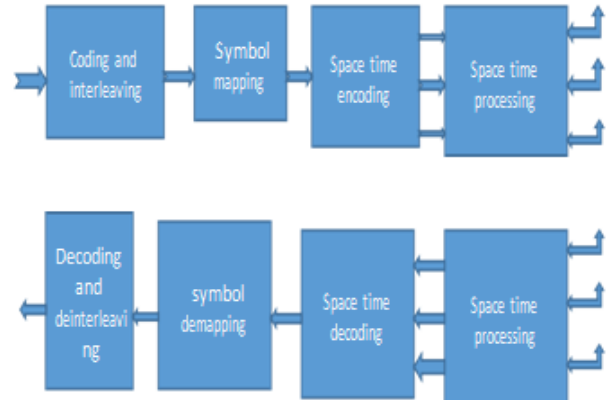


Fig 3. Block diagram of STBC.

### 3. Decision Directed Noise Estimation (DDNE):

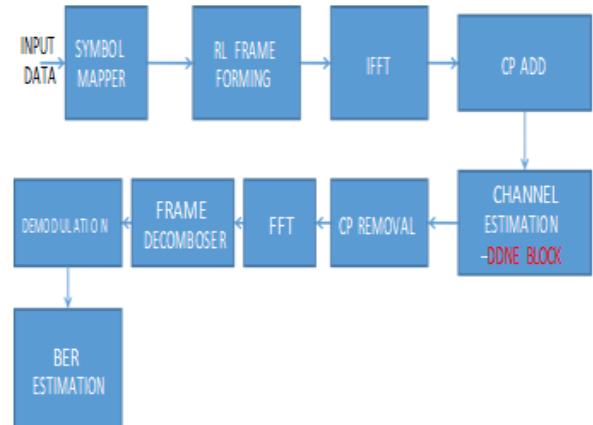


Fig 4. Block diagram of DDNE.

A Decision directed noise estimation (DDNE) approach mitigating the pulsed interference from DME. The proposed method removes the effect of inter-carrier interference (ICI) which is a major Problem.

In DDNE method, the impulsive noise component in the received signal is detected and deleted from the input sample before the final OFDM demodulation. Due to the fact that the power level of the wanted received LDACS1 signal is normally lower than the unwanted DME signal, the DME pulses can be identified in the time domain received signal.

The received LDACS1 samples for pth OFDM symbol is given by

$$rp(k)=up(k)+np(k) \quad (5.2)$$

Where  $up(k)$  is the useful pth OFDM symbol and  $np(k)$  is the total interference at the input.

Two important steps are involved in the proposed method are

- DME interference component in the received LDACS1 signal based on the preliminary decision made about the transmitted data ( $DpP(n)$ )
- Then subtraction of the estimated DME interference from the received LDACS1 signal before final LDACS1 decoding section

The observed interference is obtained and it is expressed as

$$NpP(n)=Rp(n)-DpP(n) \quad (5.3)$$

## VI. RESULTS AND DISCUSSIONS

To mitigate the interference in LDACS signals, performance of pulse blanking, STBC, DDNE is compared based on BER.

### 1. Channel Selection:

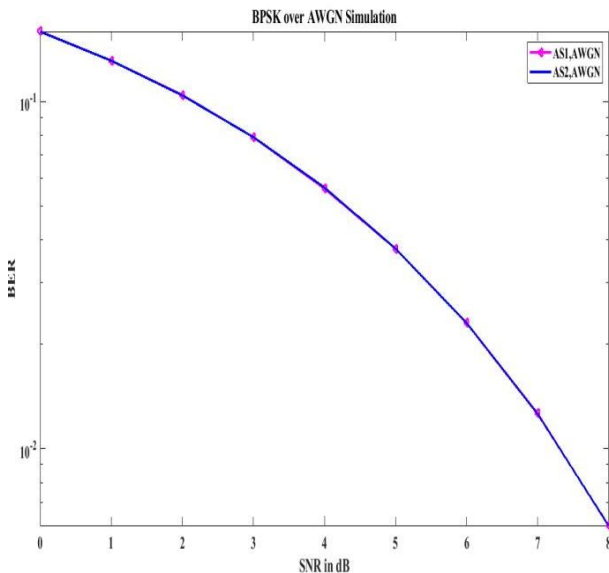


Fig 5. BPSK over AWGN channel.

Figure 6.1 shows that the performance of BPSK in AWGN channel. Because of Line of Sight (LOS) between air station and ground station, both air stations having same SNR at 8 dB without any fluctuations. The performance of BPSK in Rayleigh channel is shown in Figure 6.2, it shows poor performance when compared to AWGN since its SNR is 10dB.

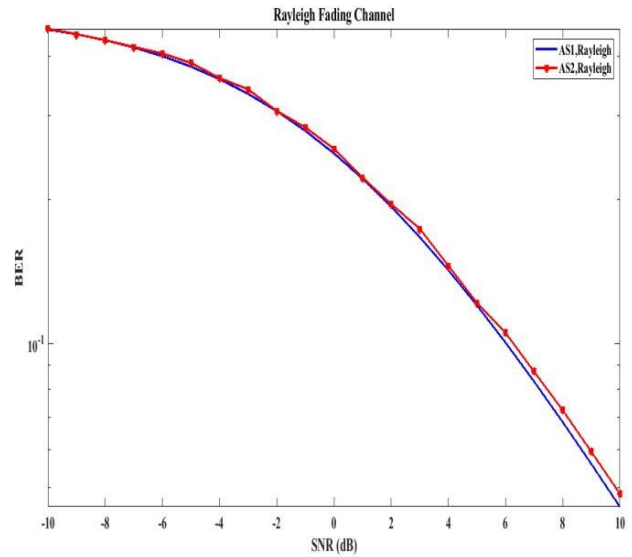


Fig 6. BPSK over Rayleigh channel.

### 2. Space Time Block Code:

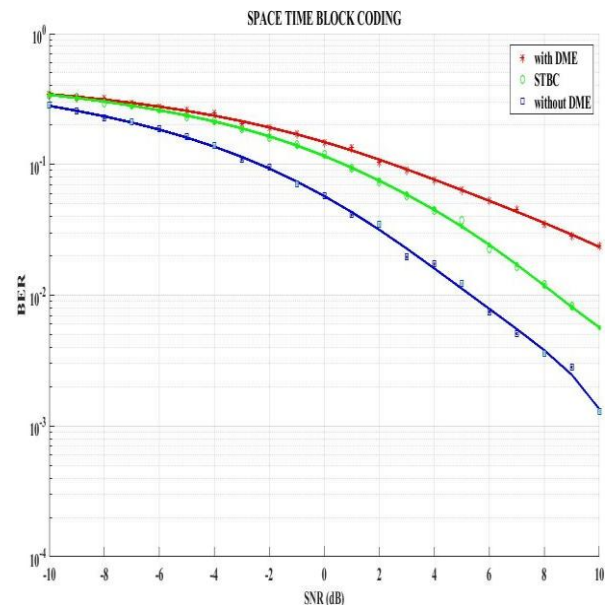


Fig 7. Performance analysis of BER for STBC.

From Figure 6.3, Space Time Block Code reaches a BER of  $10^{-2}$  at 10dB. It clearly shows that the performance of STBC gives better performance than the DME interference.

### 3. Pulse Blanking:

From the Figure 6.4, Pulse blanking achieves BER of  $10^{-5}$  at 8dB SNR. A significant amount interference from the DME station can be reduced by the pulse blanking method, thus it gives better performance than the DME interference.

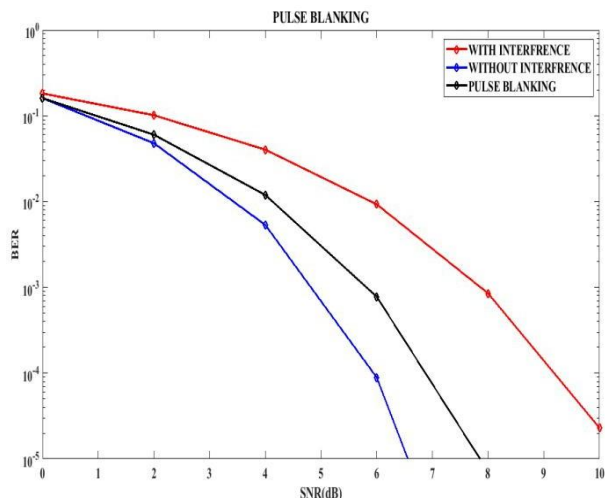


Fig 8. Performance analysis of BER for pulse blanking.

#### 4. Decision Directed Noise Estimation:

DDNE achieves BER of  $10^{-5}$  at 7dB. From Figure 6.5, it is clearly shows that the performance of DDNE gives better performance than the DME interference.

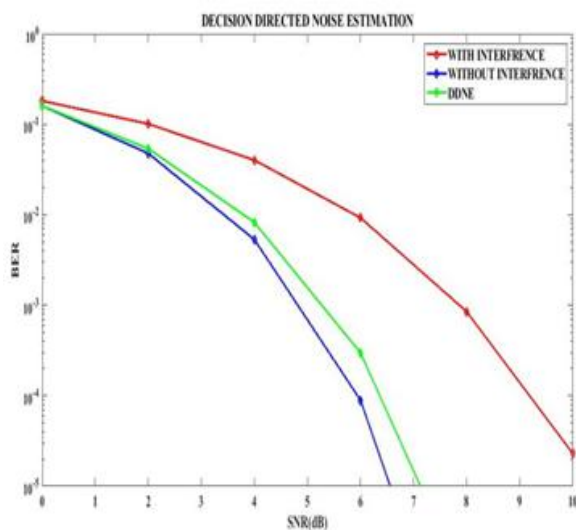


Fig 9. Performance analysis of BER for DDNE.

## VII. CONCLUSION

Aircraft Communications Addressing and Reporting System (ACARS) has been used in recent years for A/G communications for sending information, including maintenance (health) data from aircraft to ground station. However, it is still limited to relatively simple messages and its bandwidth is limited. With the proliferation of airplanes, spectrum congestion will severely affect this system. The proposed cognitive radio based A/G communication system overcomes this problem by providing opportunistic spectrum access to airplanes in a seamless manner for communicating with the ground station.

To mitigate the interference during this process, pulse blanking, STBC, DDNE are analyzed. Directed Noise Estimation (DDNE) shows better results and it reduces DME interference more than the other two interference mitigation techniques. Hence DDNE scheme can be used for interference free communication between the air station and ground station.

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