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Appendix-A List of Publications


Problems of GNSS and 4G Wireless Networks

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Abstract: This paper presents problem list of most buzzing two radio technology 1) GNSS (Global navigation satellite system) is nowadays essential integrated part of our life style and business. GNSS is now mature radio technology after long time span & evaluation but can easily victim of others. 2) Now days you are in the 4th generation in mobile technology which provide QOS to end user. Yet both technologies have different utility and application they make great impact on radio technology usage and management. Here we focus on problems and challenges of the both radio technology.

Keywords: GNSS, 4G, LTE, eNodeB, RFI

1. Introduction of GNSS

The GNSS is satellite based navigation system comprised of a network of orbiting satellites that provide location and time information, anywhere on or near earth. [1]

A. Importance & utility of GNSS

The tightest synchronization requirements lead to the need of highly accurate clock settings that can be accomplished by means of GPS satellites systems.[2] Preventing collisions involving surface mining equipment.[3] GPS is utilized within the public safety services in a number of ways.

B. Why GNSS more likely to be a victim?

The main reason behind the victim is that the signal received from satellite are very weak. First satellite is far away at least 20,000 km. Second Transmitter power is 27W. The signal power is low near ground level 19° and 20db below background noise level. In radio signal applications, if the signal is not above the noise, it is not useful. [4]

C. Limitation & Problems of GNSS

GPS is designed for open-sky applications and its coverage is often limited in many indoors and urban canyon areas.[5] A GPS receiver must lock onto the signal from at least four satellites then track them accurately. Radio frequency interference is a major source for potential degradation of GPS accuracy and reliability. Other sources of error which degrades GPS accuracy and make RFI mitigation harder include satellite and user motions which introduce Doppler effects, slow power fluctuations (due to changes in effective antenna gain and path loss) and fast power changes (due to multipath fading, blocking and shadowing). Doppler fluctuations make it difficult to distinguish between user motion and receiver clock drift. Power fluctuations make it difficult to determine the thresholds for acquisition and tracking whereas atmospheric errors introduces range and range-rate errors.[6]

Narrowband interference can severely degrade the performance of GPS receiver. It affects the operation of the automatic gain control (AGC) and low noise amplifier (LNA) in the RF front-end [7] and depending on how much of it passes through these primary modules. It can also effect the carrier and code tracking loops[9] which results in deterioration of all the GPS.

GPS signals can be severely affected by scintillations due to plasma irregularities, especially in the equatorial regions.[6] GPS can have significant impact of solar radio emission and GPS positioning was partially disrupted on the entire sunlit side of the earth.[7]GPS signals were initially designed with cross-correlation interference immunity of about 20 dB which is apparently not sufficient for ad-hoc networking in weak signals. [4]

1) Survey Reports of GPS Accident/Incidence

Figure 1: [San Diego Harbour In January 2007, GPS services were significantly disrupted throughout San Diego, California]

Many radio technology equipment stopped working near harbour like Naval Medical centre emergency pages, traffic management system for guiding boats failed, and airport traffic control, cell phones users found they had no signal, and bank customer found Automated Teller Machines (ATMs) problems. They also blocked GPS signals across most area the city. It took three days to find an explanation for this mysterious event: two Navy ships in the San Diego harbor had been conducting a training exercise when technicians jammed radio signals.

To view the full paper visit www.ijsr.net
iii) New York Airport
In August 2015, the FCC fined a truck driver, after concluding he interfered with New York Liberty International Airport’s satellite based tracking system by using an illegal GPS jamming device in his pickup truck to hide from his employer. The signals emanating from the vehicle blocked the reception of GPS signals used by the air traffic control system.

Same incident in late 2009, engineers notice that satellite positioning receiver lose signal during certain times of the day. The Federal Aviation administrator (FAA) inspected the problem and after two months found a local truck driver was using the jammer. When he passed the airport area in his daily routine, the airport’s systems would temporarily fail.

Airports and the FAA have back-up plans, processes and redundant systems that keep passengers safe. The GPS interference threat is real, but airports are better equipped to handle GPS outages than other industries that also rely on accurate GPS time and/or location data.

iii) Ships in the English Channel
The U.K. has deployed a back-up ship navigation system in the English Channel to tackle the ever increasing risk of disruption to vessel GPS navigation devices. Seagoing vessels employ GPS to efficiently navigate and without it dense traffic patterns (Figure 2) would require additional shipboard crew. The General Lighthouse Authorities (GLA) of the U.K. and Ireland launched a radio-based back-up system called eLoran to counter threats of jamming and GPS signal loss.

Figure 2: eLoran system for efficiently navigate and without it dense traffic patterns[11]

2. Introduction of 4G Wireless Network
The 4G networks are all-IP based heterogeneous networks that allow users to use any system at anytime and anywhere, and support a variety of personalized, multimedia applications such as multimedia conferencing, video phones, video/movie-on-demand, education-on-demand, streaming media, multimedia messaging, etc. As the technology matures, traffic congestion increases, and competitive pressures mount, QoS and policy management will become more and more important. 4th generation wireless network consist of WiMax and LTE (Long Term Evolution). Here, we are focus on LTE only as 4G.

A. Overview of LTE Architecture
LTE architecture is designed for improving the performance, reducing the cost and delivering the services in more efficient way. Fig shows the Service Architecture Evolution (SAE) of LTE. It has two nodes, eNodeB (evolved Node B) as base station of LTE, and AGW (SAE Gateway). Fig shows the Service Architecture Evolution (SAE) of LTE. It has two nodes, eNodeB (evolved Node B) as base station of LTE, and AGW (SAE Gateway). LTE system standardizes the existing interfaces of HSPA for the interconnection of networks.

Figure 3: Architecture interconnection of networks

The existing architecture of WCDMA, CDMA2000, HSPA, and SGSN are integrated for developing the design of LTE. This helps the system to achieve the handovers in various networks. The architecture has several modules, each and
Fourth Generation Wireless Network AND GPS Signal Measurement

(Problem & Solution and new Application)

B. Importance
LTE is a 4G wireless technology standardized by the 3GPP (3G Partnership Project) that is being deployed today by leading operators around the world to provide high-speed data and multimedia services. The LTE market is growing rapidly. According to telecom research firm IDATE, there were more than 10 million LTE subscribers and 50 deployed LTE networks at the end of 2011, growing to an estimated 118 million subscribers and 200 networks in 2013. All leading operators are moving to LTE.

C. Different types of problems in 4G
As LTE networks proliferate and network traffic increases, interference is becoming an issue for LTE operators. Due to limited spectrum resources, most operators are deploying their LTE networks in a frequency reuse =1 configuration, which means that a single carrier frequency is reused in all cells of the network. This deployment scheme is also referred to as a single-frequency network, and it is different from schemes used in predecessor cellular networks, where predefined planning ensured limited inter-cell interference.

Single frequency networks are the most efficient in terms of overall spectral efficiency, but by nature they are limited by inter-cell interference.

Radio devices operating on Broadband wireless Access (BWA) 4G wireless technologies like IEEE 802.16 (WiMAX) and LTE-A require very low noise floor. So sometime will could be interfere if radio spectrum adjacent to 4g. [14]

The iPhone 5’s battery life is greatly reduced depending on the strength of the cellular signal received by the phone, according to extensive testing performed by Lounge Monday.[15]

Your first 4G phone is likely to be heavier than it should be. This is going to be a function of adding a larger battery to the device.

However, the all-IP architecture of LTE networks introduces more security risks. Attackers could potentially access unencrypted user traffic, or network control signalling.

An additional security risk for both 3G and 4G networks comes from the increasing deployment of public-access microcell base stations, aimed at providing additional local capacity in public areas such as shopping centres, shared offices and more. These small devices placed in areas accessible to the public cannot be physically secured in the same way as a conventional base station, giving attackers a potentially easier entry point from which to attack the network [16].

4g be could cause the coexistence problem of interference with other radio service like S-band Radar, such as...
degradation of performance due to lower throughput indicated by and increasing block error rate (BELR) and Digital TV Technology if band overlap is there.

The in-device co-existence interference a matter of concerns due to the extreme closeness of multiple transceivers within the same device which can potentially interfere with each other.[17]

FCC found potential interference at GPS low power receiver if 4g LTE is adjacent and canceled a deal of LightSquared Company of USA.[18]

3. Conclusions

Any new technology come with advantage and with some disadvantages but we have radio spectrum limited by nature so we have to use it wisely and use it optimum by checking its limitations and resolve it at low cost.

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Interference effect Measurement of GPS and LTE by simulation

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ABSTRACT

This paper presents a measurement study of interference effect GPS and LTE signal using Simulation in MATLAB2014. We here stated basic physical characteristic of GPS signal as BPSK modulation and LTE signal as QAM. We quantify the impact of LTE and GPS signals on the BER checking. In our controlled testing, we characterize the interference properties of both technologies.

SUMMARY

On the BER simulation of radio signal one can easily judge the susceptibility of interference.

Keywords:GPS, LTE, MATLAB, SIMULATION

INTRODUCTION

Today, GPS is essential and core technology of our day to day navigation and many other time precision technology for accurate timing. 4G technology which helps us to provide data much faster to feel like WiFi on the go up to 10Mbps and the most promising for the Data hungry tech savvy. Potential interference of 4G LTE and GPS receiver is an essential problem to attend. Research and testing of this possible interference source are necessary because GPS has a chief role in so many important systems that the public depends upon for its safety and welfare. We are here using MATLAB base desktop programming environment, which grants you to do simulation interactively with our test data. In MATLAB one can
easily modify the code on the go. The Graphical output can be visualized. Many benefits we can count of MATLAB, so we selected best simulation environment, MATLAB for our Simulation tool. If we have basic knowledge of programming than it's easy to put our logic in MATLAB.

Physical-Layer Characteristics

2.1 GPS Signal Structure

L1 and L2 two carrier frequencies which are used in GPS signal transmission (1, 2). GPS signal uses BPSK (Binary phase shift key) phase modulation, in which signal shifted with a half circular phase shift over successive intervals. Each SV (satellite vehicle) have distinctive PRN (Pseudo Random Noise) sequence related with each SV and by a common navigation data. The fundamental frequency: of L1 is 10.23MHz, which is consist of two PRN Code the C/A code and P code where L2 consist of only one C/A code. Military GPS communication uses the P code. (3) Let's recall the basic equation of BPSK from (4).

\[ S(t) = \frac{\sqrt{P}}{T_b} \cos \left(2\pi f_c t + \pi(1 - n)\right), \quad n=0, 1 \]  

(1)

This produces two phases, 0 and π. In the specific procedure, binary data is often taken with the following signals:

\[ S_{0}(t) = \frac{\sqrt{P}}{T_b} \cos \left(2\pi f_c t + \pi\right), \quad \text{For binary 0} \]  

(2)

\[ S_{1}(t) = \frac{\sqrt{P}}{T_b} \cos \left(2\pi f_c t\right), \quad \text{For binary 1} \]  

(3)

Where carrier-wave's frequency is the fc. Hence, the signal-space can be represented the signal by single basis function.

\[ 0(t) = \frac{\sqrt{P}}{T_b} \cos \left(2\pi f_c t\right) \]  

(4)

[Fig.1. GPS signal generated in MATLAB]

From the above eq. (4) we generated the GPS's BPSK signal modulation in MATLAB simulation. In the above figure first signal is carrier signal. Second signal as message signal. And the third signal is Phase shifted key signal is combination of message and carrier signal.

2.2 Signal structure in LTE

The LTE is advancement of the requirement of the high speed rate of transmission. Multiple channel bandwidths provided by LTE (1.25-20 MHz). For achieving the speed and quality of service orthogonal frequency division multiplex (OFDM) for PHY layer, MIMO technology in LTE.

More than one narrow band sub-carriers used in wide channel bandwidth by OFDM technology. Inter symbol interference mitigate in the frequency domain which are mutually orthogonal in all sub-carriers shown in Figure (2).

[Fig.2: mitigate the internal symbol interference]
OFDMA has many advantages with and some disadvantages like high peak-to-average power ratio (PAPR) and high compassion to frequency offset and. PAPR is a result of the random constructive addition of sub-carriers and outcomes in spectral spreading of the signal which result at least as adjacent channel interference. To resolve the problem of PAPR add cyclic prefix on the uplink of Single Carrier FDMA (SC-FDMA). (6)

Let’s, recall QAM signal equation from (5),

\[
s(t) = \Re([l(t) + jQ(t)]e^{j2\pi f_0 t}) \\
= l(t)\cos(2\pi f_0 t) - Q(t)\sin(2\pi f_0 t)
\]

Where, \(i^2=-1\), \(l(t)\) and \(Q(t)\) are the modulating signals, \(f_0\) is the carrier frequency and \(\Re(\ )\) is the real part. At the receiver end cosine and sine signal received estimates of \(l(t)\) and \(Q(t)\) by demodulated using coherent demodulator.

It is possible to detect the modulation signals because of the orthogonality property. In most situations, one can demodulate \(l(t)\) just reproducing transmitted signal with a cosine signal:

\[
r(t) = s(t)\cos(2\pi f_0 t) \\
= l(t)\cos(2\pi f_0 t)\cos(2\pi f_0 t) - Q(t)\sin(2\pi f_0 t)\cos(2\pi f_0 t)
\]

Using standard trigonometric identities, we can write it as:

\[
r(t) = \frac{1}{2}l(t)[1 + \cos(4\pi f_0 t)] - \frac{1}{2}Q(t)\sin(4\pi f_0 t) \\
= \frac{1}{2}l(t) + \frac{1}{2}[l(t)\cos(4\pi f_0 t) - Q(t)\sin(4\pi f_0 t)]
\]
High frequency terms remove by Low-pass filtering. This filtered signal is natural by, the in-phase element can be received individually by the quadrature component. Likewise, one can reproduce with a sine wave and then low-pass filter to extract.

[Fig.3. Signal spectrum of signal for coding 8-QAM with SQRC]

From the above equation (7) we have created the 8QAM with square-root-cosine (SQRC) signal in MATLAB simulation.

**BER Measurement Results**

The bit error-rate expression of phase-shift keying (PSK) and 8-quadrature amplitude modulation (QAM) are gained in the presences of the phase error. One can examine the performance penalty by averaging over the date of the phase error, as a function of the phase error variance.

For BPSK, where erf(x) = 2√πx exp(-t^2)dt and 2b is defined as the signal-to-noise ratio (SNR) per bit; (7)

$$P_b(\Delta \theta) = \frac{1}{2} \left[ \frac{1}{2} \sin \left( \frac{\pi}{4} - \Delta \theta \right) \right] + \left( \frac{1}{2} \sin \left( \frac{\pi}{4} - \Delta \theta \right) \right)$$  (9)

[Fig.4: Bit Error Rate for BPSK simulation in MATLAB]

From the figure (4) of SNR we can deduce the bit error rate for BPSK modulation signal simulation and theoretical difference if the difference more, than modulation technique more of suspicious to the interference.

[Table 1: Bit rate error for BPSK]

The error probability of 8QAM symbol is obtained by the error probability of each branch (4-PAM) and is given by: (8)

$$P_e = 1 - \left( 1 - \frac{3\pi}{8} \left( \frac{\pi}{4} \right) \right)^2$$  (10)

[Fig.5: Bit Error Rate of 8QAM modulation]

From the above Graph of SNR (Eb/No) we can deduce the bit error rate for 8QAM modulation signal simulation and theoretical coded and theoretical encoded difference if the difference more, than the modulating technique of suspicion to the interference.

**CONCLUSION**

We have a GPS BPSK signal expression and LTE 8QAM signal expression and figure generated by MATLAB. We have a BER expression of 8QAM and BPSK with the phase error Δθ. As we can easily conclude GPS BPSK more differ in simulation as we assumed in theory and 8QAM have not much difference. On the above simulation and data of SNR, the BPSK as GPS signal and 8QAM as LTE signal we can find some fact that 8QAM is more secure than BPSK so GPS is easily victim of interference.
Fig. 1 GPS BPSK signal generated in MATLAB.

Fig. 2 Mitigate the internal symbol interference.

Fig. 3 LTE Signal spectrum of signal for 8-QAM
Fig 4 Bit Error Rate for BPSK simulation in MATLAB

Fig 5 Bit Error Rate for 8QAM modulation
Fig 4 Bit Error Rate for BPSK simulation in MATLAB

Fig 5 Bit Error Rate for of 8QAM modulation
### Tables

#### Table 1. Quantitative estimation of the Bit rate error for BPSK

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<th>SNR (dB)</th>
<th>Simulation</th>
<th>Theoretical</th>
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#### Table 2. Quantitative estimation of the Bit rate error for 8QAM

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Insert here (Reference format: www.sciencemag.org/about/authors/prep/res/refs.xhtml).
Interference between LTE and GPs measuring with Power Spectral Density

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Rajkot - India

ABSTRACT
In this paper we are focus over the Adjacent-channel interference (ACI), in which we are coined latest big Lightsquare mishap and other ACI problems to prove and also checking the Power spectral Density of the GPS signal over LTE signal as adjacent channel. By simulating two adjacent channels which consist of GPS signal and LTE signal in the MATLAB environment one can come up with conclusion after all.

Keywords:- LTE, PSD, Interference, GPS, ACI

I. INTRODUCTION
We can easily define Adjacent-channel interference (ACI), in which unnecessary power from a signal caused interference. ACI is not crosstalk. [1, 2] GPS signal increases its vulnerability to unwanted interference like out-of-band emissions. Same activity may be possible by telecommunication and electronic system that may be operating in adjacent bands.

Electromagnetic radiation lies behind everything from power full signal to visible light to slow signal. We have 30Hz to 300GHz bandwidth but we use only a portion of the spectrum for wireless communication. Range, antenna size and cost requirements compite with stringent government regulations to relegate most personal electronics to an even narrower range of frequencies. It consist of cell phones, GNSS, FM Radio, Microwave oven, Bluetooth, Wi-Fi like so many technology in small span. And with so many gadgets hanging around in such a narrow range of frequencies, things can get crowded. Signals can get crossed, literally. For decades, the FCC has tried to prevent this.

![Image: Figure 1: When gadgets talk to each other unintentionally, the results can be a wireless mess.]

Radio-frequency interference occurs when the signal emitted by one device gets unintentionally picked up by another—creating audible noise or a compromised connection. Some interference is due to badly shielded wires or components, but some is just the result of too many gadgets crowded into a limited spectrum. Placement also counts for a lot. When it comes to RF, a little distance can go a long way. [3]

II. ADJACENT CHANNEL INTERFERENCE

The adjacent-channel interference which GPS receiver experiences from a transmitter LTE is the sum of the power
that LTE emits into GPS’s channel—known as the “unwanted emission”, and represented by the ACLR (Adjacent Channel Leakage Ratio)—and the power that GPS picks up from LTE’s channel, which is represented by the ACS (Adjacent Channel Selectivity). LTE emitting power into GPS’s channel is called adjacent-channel leakage (unwanted emissions). It occurs for two reasons. First, because RF filters require a roll-off, and do not eliminate a signal completely. Second, due to intermodulation in LTE’s amplifiers, which cause the transmitted spectrum to spread beyond what was intended. As per over last paper we can state that GPS is more spacific to then LTE. Now we are here to simulate both technology as adjacent neighbour and simulate how much GPS is vulnerable by LTE [4].

III. POTENTIAL ISSUE OVER THE ADJACENT CHANNEL

As we conclude in previous paper GPS is more vulnerable to any random interference [8] now we focus here how much 4G LTE mobile communication technology affects as adjacent channel. Our motivation behind this research when FCC granted Lightsquare’s company to start LTE network that would use L-band spectrum adjacent to the L1 frequencies occupied by GPS. But Lightsquare’s company can’t prove that signals cause no interference to GPS.

Let’s see some brief case note of LightSquare & GPS. The LightSquared frequency plan has been presented in the 3GPP LTE Release downlink and uplink frequency ranges are 1525 MHz to 1559 MHz and 1626.5 MHz to 1660.5 MHz, respectively, and the band can accommodate both 5MHz and 10MHz RF channel bandwidths.

![Figure 2: LTE bands and neighbour signals to LTE and GPS L1](image)

Figure 2, illustrates the neighboring signals to GPS L1 and highlights the new potential interference source from LightSquared.

What has concerned the GNSS community especially is that until now the downlink band has been reserved for non-terrestrial Mobile Satellite Services (MSS) as shown in Figure 2, where spectral power densities in the typical operating environments for GPS are low. Current GPS receivers have not been designed with such a “noisy neighbour” to consider.

There are two types of interference that could be associated with these signals:

a) LightSquared signals at receiver receive with a power level up to -10 dBm and another side GPS receiver receive it with a power level can be low as -160 dBm. So these big differences in power levels at receiver create interference.

b) GPS interference can outcome from an unwanted response created by the collaborating of an LTE signal with the local oscillator (LO) of a GPS receiver. [6]

V. POWER SPECTRAL DENSITY CHARTS (PSD)

Power in band measures the total power within any specified frequency range or band. Power in band is characterized by the following equation:
Fourth Generation Wireless Network AND GPS Signal Measurement (Problem & Solution and new Application)

$\text{Power in Band} = \sum_{f} X(f)$

where $X$ is the input power spectrum from a specified band, $f_l$ is the low bound of the frequency band, and $f_h$ is the high bound of the frequency band. The low and high bounds of this band can be determined from the centre frequency. [8]

VI. PEAK SEARCH

A spectral peak search algorithm determines the levels and frequencies of peaks in a specified band. The algorithm uses interpolation to precisely locate frequency peaks in the amplitude or power spectrum in any units or scaling. You can also specify whether to locate a single maximum peak or multiple peaks that exceed a specified threshold.

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Power (dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-12.2</td>
</tr>
<tr>
<td>1</td>
<td>-12.7</td>
</tr>
<tr>
<td>2</td>
<td>-13.1</td>
</tr>
<tr>
<td>3</td>
<td>-13.5</td>
</tr>
<tr>
<td>4</td>
<td>-13.9</td>
</tr>
</tbody>
</table>

[Table 1: Power/Hz data when BPSK and 8QAM both adjacent]

From the above table we can check and deduce the interference at -0.6 dBm which is the lowest power/frequency getting interfere with each other. After this we have done some other iterative simulation to get some more result form that we can set the conclusion easily.

Adjacent channel power (ACP) measures the way a particular channel and its two adjacent channels distribute power. This measurement is performed by calculating the total power in the channel and also the total power in the surrounding upper and lower channels.

Figure 3 illustrates a typical ACP measurement and the centre frequency, bandwidth, and spacing that describe the channels.
VII. CONCLUSION

From the PSD simulation of LTE and GPS Signal as adjacent figure and Data and Real issue case study we can reach a conclusion LTE is really interference when GPS signal adjacent. After finding truth about interference, we have to move towards finding solution of interference by detecting, mitigating or avoiding.

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by Simulation." RK University’s First International Conference on Research & Entrepreneurship (ICRE 2016) (2016):

Simulation of notch filtering for GPS & LTE interference

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R. P. Bhadodia College, BCA Department, 
Manhar Patdi-7, Rajkot

Atul Gonsai  
Computer Science Department, 
Saurashtra University, Rajkot

Vishal sojitra

Abstract-Interference is present when GPS and LTE signals are adjacent after simulation and test results. First we get overview of pre and post different mitigation techniques. Detecting the interference and mitigate incoherence essential methods that can considerably improve the performance in interference scenario. In this paper we are focus on the interference mitigation technique in brief and getting brief of a best filtering approach. Using Matlab simulation we got adjacent interference filter result in chart form and data form.

Keywords: LTE, GPS,PSD,8QAM,BPSK, Interference, Simulation

I. INTRODUCTION

Examine the interference existence is one type of testing hypothesis question. One can resolve interference situation by mitigation process, in which remove the interfering signals. In this process of signal need to be “reconstructed” it is an estimation problem. Detection of interference and mitigation of interference situation are most of time applied collectively. GNSS signal use DSSS modulations: spreading as natural defence against interference.[1]

In the GNSS receiver Omni direction antenna work as primary and first external filter for interference of signal. Today’s most of GNSS receiver have no inbuilt best filter to protect against interference though big market for GNSS receiver. Some of the proficient GNSS receiver has antenna, which have a gain pattern capable to discard low elevation RF signals.[2]

Antenna array is the new generation feature by which new GNSS receivers can dynamically change the antenna’s parameter like antenna gain pattern and spatially filter for RF interference.[3]

Down-conversion and mixing specious and inter-modulation products. Quantization, generation of harmonics, ADC saturation are the impact of interference. Interfering signal is simulated using up down power of the quantization function Front-end captured by a strong interfering signal.

The front-end functionality is not straightforward in landscape. Non-linear special effects worse as the interference power increase.

Different level of mitigation technique overview.

TABLE I. BEFORE FILTER PUT ON : BPSK and SQAM PSD VALUE IN DIFFERENT FREQUENCY

<table>
<thead>
<tr>
<th>Frequency in MHz</th>
<th>BPSK Power/Frequency (dBHz)</th>
<th>SQAM Power/Frequency (dBHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>-114.8</td>
<td>-113.3</td>
</tr>
<tr>
<td>1</td>
<td>-120.9</td>
<td>-72.44</td>
</tr>
<tr>
<td>1.5</td>
<td>-114.8</td>
<td>-113.3</td>
</tr>
<tr>
<td>2</td>
<td>-120.9</td>
<td>-72.44</td>
</tr>
<tr>
<td>3</td>
<td>-114.8</td>
<td>-113.3</td>
</tr>
<tr>
<td>3.5</td>
<td>-120.9</td>
<td>-72.44</td>
</tr>
</tbody>
</table>

Process of mitigate the Radio frequency interference is called Mitigation and its objective to enable GNSS receiver to work in noisy environment.
Fourth Generation Wireless Network AND GPS Signal Measurement
(Problem & Solution and new Application)

Figure 1. PSD SQAM (LTE) and BPSK (GPS) interference simulation Graph[4]

After transmitting signal interference at receiver so receiver receive noise signal. Given above fig1 show at receiver side signal before filtration.

2 Pre-correlation methods: implemented before the correlation process used to remove impairments common to all GNSS signals Examples: notch filtering and pulse blanking

Conversely, a good filtering/amplification chain can reduce the interference impact.[5]

3 Filter Introduction

Filter are usually classified according to their frequency-domain characteristics as low pass, high pass and band stop or band-elimination filters. Another characteristic of an ideal filter is a linear phase response. A notch filter contains one or more notches or, ideally, perfect nulls in its frequency response characteristics. [9,10,11]

4.1 Notch filtering detail

A device which transfer strongly attenuates at single frequency and other signal modules should be delivered untouched. Parametric technique explicit for CWI, i.e., signals the power of which is concentrated around a single frequency.

Real Interference l[n]=Acos(2πfTnTs + θ)
Complex interference =Aexp(j2πfTnTs + Jθ)

One can easily remove considerably corrupting wideband GNSS signals by placing the notch of filter transfer function at interference frequency.[5]

3.2 At receiver side, using filter we can separate both signal or decrease an interference between both signals.

Figure 2. Pre-correlation base diagram

Figure 3. Basic diagram of remove impact of interference
Simulation of notch filtering for GPS & LTE interference

We got the result after the filter apply the following Matlab simulation.

![Power Spectral Density](image)

**TABLE II.** AFTER NOTCH FILTER PUT ON SQAM PSD VALUE IN DIFFERENT FREQUENCY

<table>
<thead>
<tr>
<th>Frequency in MHz</th>
<th>Power/Frequency(dB/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.5</td>
<td>-118.6</td>
</tr>
<tr>
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<td>-119.3</td>
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<td>-114.3</td>
</tr>
<tr>
<td>-1</td>
<td>-112.3</td>
</tr>
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<td>-0.5</td>
<td>-74.1</td>
</tr>
<tr>
<td>0</td>
<td>-72.1</td>
</tr>
<tr>
<td>0.5</td>
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<tr>
<td>1.5</td>
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<td>-118.5</td>
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<tr>
<td>3</td>
<td>-119.5</td>
</tr>
<tr>
<td>3.5</td>
<td>-118.5</td>
</tr>
</tbody>
</table>

**Fig. 5.** After notch filter: interference impact reduce to optimum level in BPSK simulation

**TABLE III.** AFTER FILTER put onBPSK PSD value in different FREQUENCY SIMULATION

<table>
<thead>
<tr>
<th>BPSK</th>
<th>Frequency in MHz</th>
<th>Power/Frequency(dB/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.5</td>
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<td>-129.2</td>
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<td>-2</td>
<td>-125.1</td>
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<td></td>
</tr>
<tr>
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<td>-114.3</td>
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<td>-81.4</td>
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<td></td>
</tr>
<tr>
<td>1.5</td>
<td>-128.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-125.1</td>
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<tr>
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<td>-129.4</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>-127</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: After filter put onBPSK PSD value in different frequency simulation

**III. CONCLUSION**

After simulation result graph and data we can deduce that filter can be used as post-processing interference mitigation as advancement tools. Notch filter can be implemented in any device which use different technology like mobile communication (LTE), GPS at time and adjacent band. But it can be more costly in form of a computation point of view signal transform. Filter have one more disadvantage over battery life-span of device. It would like
REFERENCES


Measurement (Data Mining) of Real Mobile Signals Data in Weka Tools for Interference Detection

International Conference on Information and Communication Technology for Intelligent Systems

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- Paresh Gami (1)

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Conference paper
First Online: 17 August 2017
Part of the Smart Innovation, Systems and Technologies book series (SIST, volume 84)

Abstract

In this paper we have collected the data from selected population of Rajkot city by the way of android and iPhone application after collecting all radio signals data like Wi-Fi signal power, GPS signal power, 4G signal power, 3G signal power, and Signal to noise ratio in different mobile device in different geographical location we can apply datamining technique by which can measure the different type of the scenario. After applying different method we can find hidden pattern and many insight to deal with interference situation.

Keywords
SNR, WIFI, GPS, LTE, WEKA

References


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Problem & Solution and new Application)


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Fourth Generation Wireless Network AND GPS Signal Measurement
(Problem & Solution and new Application)
Measurement (Data Mining) of Real Mobile Signals Data in Weka Tools for Interference Detection

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Abstract. In this paper we have collected the data from selected population of Rajkot city by the way of android and iPhone application after collecting all radio signals data like Wi-Fi signal power, GPS signal power, 4g signal power, 3g signal power, and Signal to noise ratio in different mobile device in different geographical location we can apply datamining technique by which can measure the different type of the scenario. After applying different method we can find hidden pattern and many insight to deal with interference situation.

Keywords: SNR · WIFI · GPS · LTE · WEKA

1 Introduction

In today’s world we are surrounding with many buzzing technologies like GPS, Wi-Fi, Bluetooth, GSM, 3GPP, CDMA, 4g LTE and all technologies based on Radio signals at different frequency and different type of modulation techniques and concepts. We are using all the technique simultaneously some time or many a time. Some research also try to create bridge between two more technologies to boost internet speed.

More often time simulation will not give exact idea of interference problem. But the real world problem may differ than simulation predefine situation. Many GPS receiver company find interfering by other radio signal in real world [1]. For the real world collection of data we here consider mobile devices are the best fit for our real world data collection tools in which android and IPhone mobile application are better, faster way to collect data from real world GPS, Wi-Fi, Bluetooth, GSM, CDMA, 4g LTE signal data and SNR data because all radio signal receiver are built in smart phone. By collecting all the device data from different cell of mobile towers, with WI-FI signal strength, GPS signal strength as row data of our measurement. The data collection process is voluntary how like to give feedback to our collection then simple install and wait for 5 min maximum in between our application collecting. After collecting the all the data from selected population we can measure in Datamining tools like WEKA by which we can measure some sort of classification and clusters.

The entire data collection period is significantly shortened, most of data collect within 3–4 days. But we can make best insight and classification and clustering by taking daily basis input from various mobile in which already installed.

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Systems and Technologies 84, DOI 10.1007/978-3-319-63645-0_73
2 Row Data Collection Procedures

For row data collection we have develop one android and iphone application based on angular js by which we can collect the signal data by just installing and make it open for just 3–5 s it will collect and submit to our server. So it is very easy to collect, not need to give more detail instruction to user for data collection. So data collection without user inference could give better data then user manual entry.

You could download from following links in google play store,


By Downloading installing following main screen will appear and after permission of user all GPS, WI-FI, mobile GSM, 4g sent to the webserver and server will fill the database [2, 3] (Fig. 1).

![Signal Measurement](image)

Fig. 1. Application transferrin the data to the server.

After filling the database we can see the area from data is coming by latitude and longitude got from user mobile. In following figure we can see google map balloon from we were got the data (Fig. 2).
Fig. 2. In admin panel we can find the balloons of samples who share the data of signals.

After collecting the data admin can visualize the each n every balloon with detail information by just clicking on balloon (Fig. 3).

Fig. 3. In admin panel we can also find the balloon wise detailing.

Admin can also visualize data real-time when anyone who installed the app and start at current time. So by just refreshing grid (Fig. 4).
3 Datamining Tools Setup and Configuration

Today’s generation datamining is the activity by which one can easily estimate, find pattern, classify data, and find clustered from Dataset. Here we set our data into MySQL database then we export the data into the excel sheet (CSV) comma separated file from where we have to convert the file in arff file extension. After conversion we can apply the data into the Waikato Environment for Knowledge Analysis (WEKA) “arff” file format [4, 5].

4 Measurement of Data and Results

From Fig. 5 we just classified how many different manufacturer include in datasheet right now, we have highest data of xiaomi, and least data of coolpad.

Figure 6 chart we just indicate the no of records of different carrier provider in datasheet right now, we have jio 4g and idea, Vodafone with sufficient data to analysis.
Fig. 5. Total android mobile from which we get the data manufacturer wise.

Fig. 6. Total mobile operator company from which we gather data company name wise.

Figure 7 provide comparison of 4g jio carrier robustness with different mobile’s data with different feature’s value by can deduce that how evdoECIO effect the GSM bit error rate.
**Fourth Generation Wireless Network AND GPS Signal Measurement**

Figure 7. Signal comparison combo chart of 4g jio mobile operator’s gsmBiterrorate, gsmSignal strength, evdoSnr, evdoECIO, cdmaECIO, ebDdbm.

Figure 8 provide comparison of Lenovo mobile data with different feature’s value by can deduce that how evdoECIO effect the GSM bit error rate.

![Chart Title](chart1.png)

![Chart Title](chart2.png)

**5 Weka Tool Base Datamining**

Weka tools Classify 59 rows with 7 attribute evdoDbm, evdoEcio, evdoSnr, gsmBitErrorrate, gsmSignalStrength, Carriername(BSNL3G), SNR
Fourth Generation Wireless Network AND GPS Signal Measurement
(Problem & Solution and new Application)
Likewise we can create “4g Jio” file to calculate regression and M5Rules to get idea out this data. We can also generate the file of “Lenovo mobile” Model data and check same classifier on it and deduce some pattern on real time data [6].

6 Conclusion

By this research we can identify mobile devices manufacturer problem or Mobile operator to improve the overall performance. On above data mining we can give how the bit error rate and signal strength makes conditional change. This also help in future to develop intelligent mobile communication system.

References

FILTER DESIGN FOR IMPROVEMENT OF INTERFERENCE ON ADJACENT FREQUENCY

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Dr. Atul Gonsai
Dr. Atul M. Gonsai, Computer Science Department,
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ABSTRACT

This paper is focus on the Radio signal’s interference mitigation solution by new general filter equation. Introduction of the basic of filtering and types of filters which are basic for any filter base research. We generate two adjacent signal of BPSK and 8bit QAM signal in MATLAB and generate interference between them. In this situation we have examined our general filter equation and get different results.

Key words: RSP, BPSK, QAM


1. INTRODUCTION

Nearly every electronic system have radio signal processing techniques via Bluetooth, Wi-Fi or mobile signal or GPS. The perfect filter, whether it is a low pass, high pass, or band pass filter will demonstration no loss within the pass band.

These techniques are rapidly developing day by day due to tremendous technological developments in high speed computers, integrated circuit fabrication and field programmable arrays (FPGA). With these, digital signal processing has now become more reliable and speed processing is almost near infinity [1-3].

RSP used in most of application as backbone to transmit data to one place to other such as telecommunication, bio-medical engineering, internet. Among all above application need as same time so filtering is the needed on any devices. Currently available filters such as High pass, Band Stop, Low pass, Band pass, and notch filters. Notch filters have two different two types, one is IIR and FIR.
Filter Design For Improvement of Interference on Adjacent Frequency

Purpose of filter design is to create frequency dependent modification of signal’s data array. All filters work on frequency-dependent techniques that process signals. The core concept of filter one can express by testing the frequency dependent environment of the impedance of capacitors and inductors. In filter is working as voltage divider where the diversion leg is a reactive sensitive for effective resistance. If frequency is altered, the charge value of the sensitive resistance changes, and the voltage divider ratio changes.

Filter used for stabilize amplifiers by rising and falling of the gain at higher frequencies where high phase shift may cause oscillations. Main use of filters are separate signals and attenuating the unwanted frequencies.

2. BASICS TYPES OF FILTER

![Figure 1 Basic type of Filters](image)

A band pass filter is the cascading the two filters, one is a high pass and second is a low pass.

The band pass will stop other frequency and simply allow in between frequency. A Model band pass filter is shown in Figure 1.1(C).

An exact opposite to the band pass filter is band stop or in other buzzing word is notch filter. Here stopping the frequency which is cover in between. Figure 1.1(D) shows a notch model.

The perfect filters for every situation is not yet built or we cannot built. Another problem with filter is to real time filtering. Filter must be able to stop or pass the frequency but should not affect the actual speed of transmission. [5-6]

3. THE 5 FUNCTIONAL PARAMETERS OF A PRACTICAL FILTER ARE DEFINED AS UNDER

FC cut-off frequency where filter response leaves the error band most of -3db. The frequency at which the minimum attenuation in the stop band is reached is called stop band frequency (Fs). The pass band ripple (max) is the difference (error band) and the minimum pass band attenuation (min) defines the minimum signal attenuation within the stop band. The order of filter (M) is defined by the sheerness where in the transfer function M represents the number of poles. In the transfer function a pole is considered as root of the denominator and equally, a zero is considered as root of the numerator.

http://www.iaeme.com/IECET/index.asp
Simulation of BPSK & 8QAM signal

The goal of filter design is to perform frequency dependent alteration of a data sequence. A possible requirement might be to remove noise above 30 Hz from a data sequence sampled at 100 Hz. A more rigorous specification might call for a specific amount of passband ripple, stopband attenuation, or transition width. A very precise specification could ask to achieve the performance goals with the minimum filter order, or it could call for an arbitrary magnitude shape, or it might require an FIR filter.

You can also use the parametric modelling or system identification functions to design IIR filters. These functions are discussed in Parametric Modelling.

This is a signal which is used in LTE with data. In LTE QAM (Quadrature Amplitude Modulation) 8-bit or 16-bit. This signal is a 8-bit QAM signal. Data of this signal is given below table.

This is a GPS Signal in this signal used BPSK (Binary Phase Shift Keying) Modulation. Data analysis of this signal is given in below table.

![Figure 2 8QAM and BPSK signal adjacent simulation with interference presence](image)

**Table 1** 8QAM and BPSK signal adjacent simulation with interference presence at -0.5 & 0.5

<table>
<thead>
<tr>
<th>Frequency in MHz</th>
<th>Power/Frequency(dB/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BPSK</td>
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<tr>
<td>-3.5</td>
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</tr>
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<td>-127</td>
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editor@iaeme.com
4. GENERAL FILTER EQUATION FOR INTERFERENCE

\[ K^* \frac{(s^2 + wo^2)}{(s^2 + B*s + wo^2)} \]  

Here \( K \) is a multiplier which is amplify a signal that is also known as a gain. Centre frequency is denoted by \( f_0 \), in Hz \( (f_0 = wo / (2 \pi)) \). Stopping Band Frequency width is denoted by \( f_b \) of the stopping band, in Hz \( (f_b = B / (2 \pi)) \)

5. SIMULATION OF GENERAL EQUATION AND RESULTS

5.1. Simulation result Signal after applying general filter

![Graph showing power spectral density](image)

**Figure 3** 8QAM and BPSK signal adjacent simulation with interference mitigation with general equation [2]

**Table 2** 8QAM and BPSK signal adjacent simulation with interference mitigation with general equation

<table>
<thead>
<tr>
<th></th>
<th>BPSK</th>
<th></th>
<th>QAM-8</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power/</td>
<td>Frequency in MHz</td>
<td>Power/</td>
<td>Frequency in MHz</td>
</tr>
<tr>
<td></td>
<td>Frequency (dB/Hz)</td>
<td></td>
<td>Frequency (dB/Hz)</td>
<td></td>
</tr>
<tr>
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<td>-125.3</td>
<td>-3.5</td>
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</tr>
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<td>3.5</td>
<td>-127</td>
<td>3.5</td>
<td>-118</td>
<td></td>
</tr>
</tbody>
</table>

Here we changed a sample of 8-QAM and according to changed data 8-QAM signal become minor wide. But after simulation we can find interference mitigate after equation filter -0.50 and 0.50.
4. GENERAL FILTER EQUATION FOR INTERFERENCE

\[ K^* (s^2 + \omega_0^2) / (s^4 + B^* s^2 + \omega_0^2) \]  

(1)

Here \( K \) is a multiplier which is amplify a signal that is also known as a gain. Centre frequency is denoted by \( f_0 \), in Hz \( (f_0 = \omega_0 / (2 \pi)) \). Stopping Band Frequency width is denoted by \( f_b \) of the stopping band, in Hz \( (f_b = B / (2 \pi)) \).

5. SIMULATION OF GENERAL EQUATION AND RESULTS

5.1. Simulation result Signal after applying general filter

![Power Spectral Density](image)

Figure 3 8QAM and BPSK signal adjacent simulation with interference mitigation with general equation]

<table>
<thead>
<tr>
<th>BPSK</th>
<th>QAM-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Power/</td>
</tr>
<tr>
<td>in MHz</td>
<td>Frequency</td>
</tr>
<tr>
<td></td>
<td>(dB/Hz)</td>
</tr>
<tr>
<td>-3.5</td>
<td>-125.3</td>
</tr>
<tr>
<td>-3</td>
<td>-129.2</td>
</tr>
<tr>
<td>-2</td>
<td>-125.1</td>
</tr>
<tr>
<td>-1.5</td>
<td>-128.5</td>
</tr>
<tr>
<td>-1</td>
<td>-114.3</td>
</tr>
<tr>
<td>-0.5</td>
<td>-91.73</td>
</tr>
<tr>
<td>0</td>
<td>-81.4</td>
</tr>
<tr>
<td>0.5</td>
<td>-91.71</td>
</tr>
<tr>
<td>1</td>
<td>-114.3</td>
</tr>
<tr>
<td>1.5</td>
<td>-128.5</td>
</tr>
<tr>
<td>2</td>
<td>-125.1</td>
</tr>
<tr>
<td>3</td>
<td>-129.4</td>
</tr>
<tr>
<td>3.5</td>
<td>-127</td>
</tr>
</tbody>
</table>

Here we changed a sample of 8-QAM and according to changed data 8-QAM signal become minor wide. But after simulation we can find interference mitigate after equation filter -0.50 and 0.50.

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Ravinjsinh S Vaghela and Dr. Atul Gonsai

Figure 4 8QAM and BPSK signal adjacent simulation with interference mitigation with general equation at point -0.25 and 0.25.

Table 3 8QAM and BPSK signal adjacent simulation with interference mitigation with general equation

<table>
<thead>
<tr>
<th>Frequency in MHz</th>
<th>Power/Frequency(dB/Hz) BPSK</th>
<th>Power/Frequency(dB/Hz) QAM-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.5</td>
<td>-122.5</td>
<td>-119.3</td>
</tr>
<tr>
<td>-3</td>
<td>-124.3</td>
<td>-119.6</td>
</tr>
<tr>
<td>-2</td>
<td>-122.7</td>
<td>-116</td>
</tr>
<tr>
<td>-1</td>
<td>-124.2</td>
<td>-77.01</td>
</tr>
<tr>
<td>-0.25</td>
<td>-72.1</td>
<td>-72.1</td>
</tr>
<tr>
<td>0</td>
<td>-83.5</td>
<td>-74.35</td>
</tr>
<tr>
<td>0.5</td>
<td>-72.1</td>
<td>-72.1</td>
</tr>
<tr>
<td>1</td>
<td>-124.2</td>
<td>-77.01</td>
</tr>
<tr>
<td>2</td>
<td>-122.2</td>
<td>-116</td>
</tr>
<tr>
<td>3</td>
<td>-124.3</td>
<td>-119.6</td>
</tr>
<tr>
<td>3.5</td>
<td>-122.5</td>
<td>-139.3</td>
</tr>
</tbody>
</table>

Here we changed a sample of 8-QAM and according to changed data 8-QAM signal become wide.

But after changing a data then also signal interfered in major lobe at point -0.25 and 0.25.

Figure 5 8QAM and BPSK signal adjacent simulation with different input frequency range interference mitigation with general equation

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Filter Design For Improvement of Interference on Adjacent Frequency

**Table 4** 8QAM and BPSK signal adjacent simulation with interference at point -0.5 and 0.5 mitigation with general equation

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Power/Frequency (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BPSK</td>
</tr>
<tr>
<td>-4</td>
<td>-138.6</td>
</tr>
<tr>
<td>-3</td>
<td>-131.1</td>
</tr>
<tr>
<td>-2</td>
<td>-133.9</td>
</tr>
<tr>
<td>-1</td>
<td>-119.7</td>
</tr>
<tr>
<td>-0.5</td>
<td>-81.02</td>
</tr>
<tr>
<td>0</td>
<td>-83.61</td>
</tr>
<tr>
<td>0.5</td>
<td>-81.02</td>
</tr>
<tr>
<td>1</td>
<td>-119.7</td>
</tr>
<tr>
<td>2</td>
<td>-133.9</td>
</tr>
<tr>
<td>3</td>
<td>-131.1</td>
</tr>
<tr>
<td>4</td>
<td>-138.6</td>
</tr>
</tbody>
</table>

In this signal we applied filter and a change a parameter of bpsk signal then after we getting an interference in major lobe at point -0.5 and 0.5.

**Figure 6** 8QAM and BPSK signal adjacent simulation with interference four time at point -3.5, -2.2 and 3.5 that mitigation with general equation

**Table 5** 8QAM and BPSK signal adjacent simulation with interference four time at point -3.5, -2.2 and 3.5 that mitigation with general equation

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Power/Frequency (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BPSK</td>
</tr>
<tr>
<td>-3.5</td>
<td>-120.5</td>
</tr>
<tr>
<td>-3</td>
<td>-115.6</td>
</tr>
<tr>
<td>-2</td>
<td>-120.7</td>
</tr>
<tr>
<td>-1</td>
<td>-116.2</td>
</tr>
<tr>
<td>0</td>
<td>-72.87</td>
</tr>
<tr>
<td>1</td>
<td>-116.2</td>
</tr>
<tr>
<td>2</td>
<td>-120.7</td>
</tr>
<tr>
<td>3</td>
<td>-115.6</td>
</tr>
<tr>
<td>3.5</td>
<td>-120.5</td>
</tr>
</tbody>
</table>

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In this after applying a filter we get a near to desire signal. In this signal major lobe is not interfere at any point but minor lobe is interfere four time at point -3.5, -2.2 and 3.5 that we can neglect not completely but partially. So last is more efficient compare to upper both signal.

6. CONCLUSION
Here, we have generate the generalize equation for filtering process. After simulating different frequency with different input in adjacent scenario of 8QAM and BPSK amplitude. We get near desire result but not in all the scenario. In futures we may have best filter equation.

REFERENCES