Vol II Issue VII Jan 2013

Impact Factor : 0.1870

ISSN No :2231-5063

Monthly Multidisciplinary Research Journal

Golden Research Thoughts

Chief Editor
Dr.Tukaram Narayan Shinde

Publisher
Mrs.Laxmi Ashok Yakkaldevi

Associate Editor
Dr.Rajani Dalvi

Honorary
Mr.Ashok Yakkaldevi

IMPACT FACTOR : 0.2105

Welcome to ISRJ

RNI MAHMUL/2011/38595 **ISSN No.2230-7850**

Indian Streams Research Journal is a multidisciplinary research journal, published monthly in English, Hindi & Marathi Language. All research papers submitted to the journal will be double - blind peer reviewed referred by members of the editorial Board readers will include investigator in universities, research institutes government and industry with research interest in the general subjects.

International Advisory Board

Flávio de São Pedro Filho
Federal University of Rondonia, Brazil

Kamani Perera
Regional Centre For Strategic Studies, Sri Lanka

Janaki Sinnasamy
Librarian, University of Malaya [Malaysia]

Romona Mihaila
Spiru Haret University, Romania

Delia Serbescu
Spiru Haret University, Bucharest, Romania

Anurag Misra
DBS College, Kanpur

Titus Pop

Mohammad Hailat
Dept. of Mathmatical Sciences,
University of South Carolina Aiken, Aiken SC 29801

Abdullah Sabbagh
Engineering Studies, Sydney

Catalina Neculai
University of Coventry, UK

Ecaterina Patrascu
Spiru Haret University, Bucharest

Loredana Bosca
Spiru Haret University, Romania

Fabricio Moraes de Almeida
Federal University of Rondonia, Brazil

George - Calin SERITAN
Postdoctoral Researcher

Hasan Baktir
English Language and Literature Department, Kayseri

Ghayoor Abbas Chotana
Department of Chemistry, Lahore University of Management Sciences [PK]
Anna Maria Constantinovici
AL. I. Cuza University, Romania

Horia Patrascu
Spiru Haret University, Bucharest, Romania

Ilie Pintea,
Spiru Haret University, Romania

Xiaohua Yang
PhD, USA
Nawab Ali Khan
College of Business Administration

Editorial Board

Pratap Vyamktrao Naikwade
ASP College Devrukh,Ratnagiri,MS India

R. R. Patil
Head Geology Department Solapur University, Solapur

Rama Bhosale
Prin. and Jt. Director Higher Education, Panvel

Salve R. N.
Department of Sociology, Shivaji University, Kolhapur

Govind P. Shinde
Bharati Vidyapeeth School of Distance Education Center, Navi Mumbai

Chakane Sanjay Dnyaneshwar
Arts, Science & Commerce College, Indapur, Pune

Awadhesh Kumar Shirotriya
Secretary, Play India Play (Trust),Meerut

Iresh Swami
Ex - VC. Solapur University, Solapur

N.S. Dhaygude
Ex. Prin. Dayanand College, Solapur

Narendra Kadu
Jt. Director Higher Education, Pune

K. M. Bhandarkar
Praful Patel College of Education, Gondia

Sonal Singh
Vikram University, Ujjain

G. P. Patankar
S. D. M. Degree College, Honavar, Karnataka

Maj. S. Bakhtiar Choudhary
Director,Hyderabad AP India.

S.Parvathi Devi
Ph.D.-University of Allahabad

Sonal Singh

Rajendra Shendge
Director, B.C.U.D. Solapur University, Solapur

R. R. Yalikar
Director Managment Institute, Solapur

Umesh Rajderkar
Head Humanities & Social Science YCMOU, Nashik

S. R. Pandya
Head Education Dept. Mumbai University, Mumbai

Alka Darshan Shrivastava
Shaskiya Snatkottar Mahavidyalaya, Dhar

Rahul Shriram Sudke
Devi Ahilya Vishwavidyalaya, Indore

S.KANNAN
Ph.D , Annamalai University,TN

Satish Kumar Kalhotra

Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.isrj.net

Golden Research Thoughts
Volume 2, Issue. 7, Jan. 2013
ISSN:-2231-5063

Available online at www.aygrt.net

ORIGINAL ARTICLE

SOURCES OF RADIO LINK INTERFERENCES AND THEIRMITIGATION TECHNIQUES

M.L.S.N. SWARAJYA LAKSHMI AND NIRANJAN PRASAD

K. L. University, Vijayawada; DLRL, Hyderabad

Abstract:

One of the primary tasks of the network planning engineer will be to manage interference issues in the design. This does not necessarily mean that at the end of the design process, there will be no interference anywhere in the network, but rather that the prevalence of interference is minimized and, if unavoidable, is placed where it will do the least harm (for those technologies that allow this to be done). There are a number of ways to do this. Of which the most effective way is proper frequency assignment. In this paper we have tried to explore different sources of interferences (i.e.,intra & inter)their schematic representations and mitigation techniques for reducing interference.

KEYWORDS:

interference;tetra;frequencyhopping;tracking;

INTRODUCTION:

The issues of intra-net interference in other words interference caused by othertransmitters in the same network. At the modeling of co-channel interference, where both the wanted system and the interferer are tuned to the same channel, and then extend this to look at interference from interferers tuned to other channels, and also at the composite effects of multiple interferers.

For most mobile networks, we will be examining uplink and downlink interference separately.

Interference is defined as unwanted contributions from other intended radio systems. This is distinct from noise, which is regarded as contributions from unintended radio frequency sources. We can split interference sources into different categories.

Intra-network interference, where interference is caused by other transmitters withinthe same network. In this case, we can assume that the interfering signal has the sameproperties as the victim system .

Inter-network interference from similar radio networks. This might be the case, forexample, where the coverage from two adjacent TETRA networks overlaps. Inter-network interference from dissimilar radio systems. In this case, we cannotassume that the interfering signal has the same characteristics as the victim system.

We split potential interferers in this way because we will use different techniques toassess the level of likely interference, particularly for the third case.

1. Interference in the Spectral Domain

DIFFERENT INTERFERENCE SCENARIOS:

On-channel interference (also known asco-channel interference).

Title : SOURCES OF RADIO LINK INTERFERENCES AND THEIRMITIGATION TECHNIQUES
Source:Golden Research Thoughts [2231-5063] M.L.S.N. SWARAJYA LAKSHMI AND NIRANJAN PRASAD yr:2013 vol:2 iss:7.

Adjacent channel and other offset interference.
Intereference between dissimilar systems
Multiple interferers

2 .INTERFERENCE IN THE TIME DOMAIN

1.1 Co-Channel interference:

The simplest case of interference is when both the wanted and the interferer are tunedto the same frequency, occupying the same frequency band with identical spectral characteristics. This can either be another transmitter in the same network or a different one. An illustration of the scenario for a point-to-point network is shown in Figure 1.

There are two things we affect of the interferer on the wanted link. The first is to establish the level of interference compared to the strength of the wanted signal that the system can tolerate. Secondly, we need to determine the received signal strengths from both the wanted transmitter and the inter ferer so we can compare their relative strengths to the interference characteristics(1).

For example, the co-channel rejection level is 19 dB. This means that to function according to the specification, the wanted signal must be 19 dB above a co-channelInterferer. In Figure 2, therefore for a TETRA receiver, the signal to interferer difference must be 19 dB or greater.

In the case of a system like TETRA or GSM.a mobile receiver or the transmission toa base station from a mobile embedded in clutter will typically be described byRayleigh fading. We need to take this into account when considering the level of inputfrom both wanted and interfering signal. If the interferer and wanted signal are not co-located,Then the fading characteristics are most likely to be de-correlated, meaningthat the variations at the receiver due to fading are entirely unrelated. when performingAnalysis, we may want to consider different levels of fade between wanted andInterfering signal.

A typical value may be 95% availability for the wanted link and 50%for the interferer. Thus, if the nominal (50%) signal strength at a receiver is -70 dBm,then using Rayleigh fading the signal exceed for 9 5 % of locations within the short sector is 12. 7 dB lower than this, which is -82. 5 dBm.

For an interferer with a nominal signal strength at the receiver of -90 dBm, the signal1evel exceeded for 50% of the time will be -90 dBm. The difference between the two is only 7. 5 dB, significantly less than the required 19 dB and therefore theinterference criteria cannot be met for this level of availability.

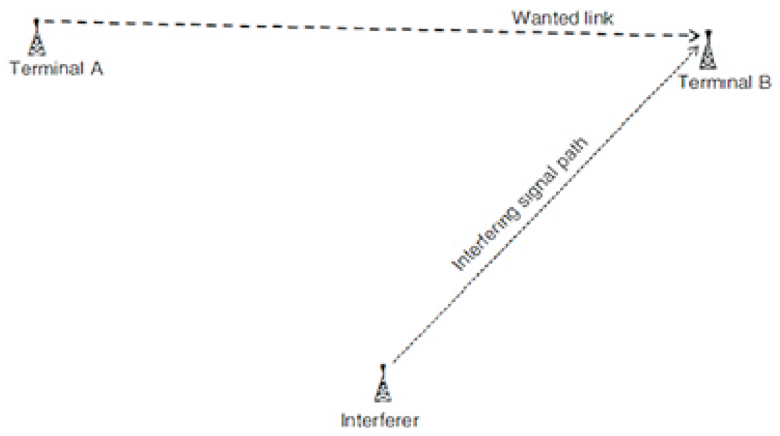

Figure. 1 Interference Scenario for a point to point link

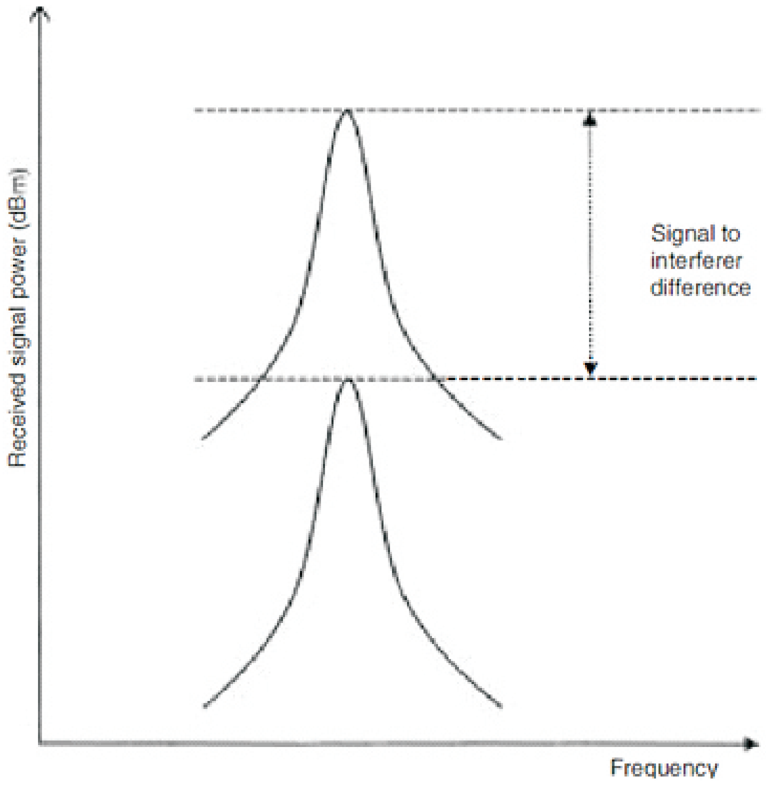

Figure 2:Co-channel signal to interferer level. For the example of TETRA, if the interferer is lessthan

19 dB lower than the wanted signal, then the wanted link will not function at the level prescribed bythe interferer.

In general, it is highly undesirable to have re-used frequencies within potentialinterference range and normally the system designers will use frequency re-use toprevent this occurring in practice.

Interference in this case is considered such that into a base station and not the mobilesubscribers to the network. Interference from base stations to mobiles is unlikely tohappen because normally the uplink and downlink frequencies will be separated infrequency. For example, in the UK Airwave network, the difference between paireduplinks and downlinks is 10 MHz, and there is at least 5 MHz difference between theclosest uplink and downlink channels. Interference between mobiles is less likely sinceeach mobile is less powerful and is likely to be embedded in clutter. However, the same process as described above can be carried out for mobile to mobile interference.

1.1 Adjacent and Other Channel Offset interference:

Interferers on other channelscan cause problems due to energy spilling over their channel into others. This is worstfor the immediate channel above and below the victim frequency. These channels areknown as 'adjacent channels'. To determine potential interference, we need to knowthe relative strength of energy in the adjacent channels and then proceed to determinethe effect of that energy.The adjacent channel situation is shown in Figure 3.

If we consider channeln asthe victim and channeln+ 1 as the interferer, it can be seen that although most of theenergy is within its own channel, there is still a skirt of energy overflowing into theadjacent channel and beyond. It is this energy that causes adjacent channel interference.Although the level of energy spilled into other bands is relatively low compared to themain channel, it must be remembered that the power transmitted is significantly higherthan the receive signal level and can still cause problems. This is particularly the casewhere transmitters and receivers are positioned in close proximity to one another.Most systems will give figures for the relative strength of interference into adjacentchannels.

For example, if the amount of energy radiated into the adjacent channel is50 dB down on the peak power in the wanted channel, then this can be accounted for inthe adjacent channel interference analysis.

For example, assume that the received signal strength for 50% availability is-50 dBm in the interferer's intended channel. This is a strong signal and it wouldbe likely to occur close to the transmitter. The power in the adjacent channel

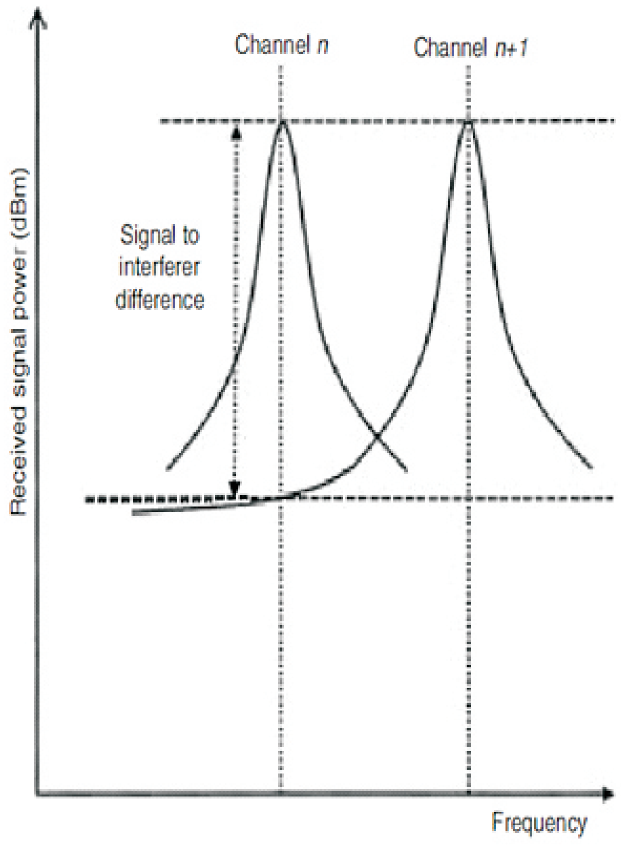

Figure.3 Diagram showing energy from an interferer (tuned to channeln + 1) spreading into a victimreceiver tuned to channeln. Energy from a transmission, even if filtered at the transmitter, will still bepresent outside of the tuned band. This can cause interference to the adjacent channel as shown or evenreceivers many channels away(2).

would be -100 dBm, assuming the 50-dB adjacent channel figure quoted above. If thewanted signal strength for another receiver operating in the adjacent channel is-90 dBm, then the difference between the wanted and interfering signal is only10 dB below the wanted signal. We would need to compare this to the co-channel interferencerejection figure to determine whether interference would be present in this scenario.

We can also apply the same corrections to account for fading of boththe wanted and interfering signal to determine its performance at the required levelsof availability.

Interference does not stop at the adjacent channels, but may continue over a widerange. An illustration of wider transmit spectral power is shown in Figure 4.The level of energy received in these other bands can be described in the manner shown on Table 1.

Table 1 can be interpreted in the following manner. For co-channel interference, the wanted power must be 12 dB higher than any interferer. For the adjacent channels above and below the wanted channel, the signal can tolerate an interferer as powerful as the wanted channel. For interferers four channels away, the interference power at its own tuned frequency can be 30 dB higher than the wanted signal.

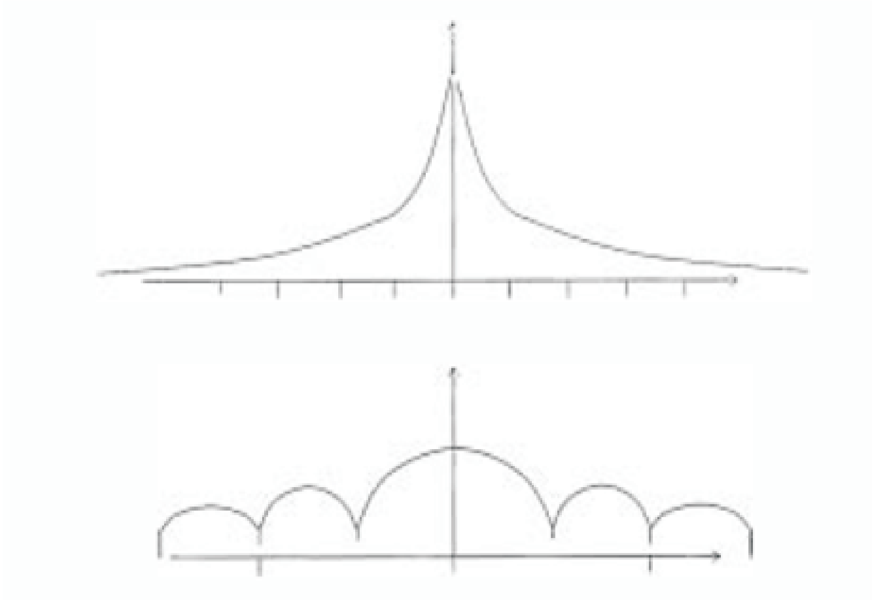

Figure .4 Illustration of energy radiated from a narrowband transmission (top) and a widebandtransmission (bottom) These Images are indicative only, but they show how energy is present outside ofthe tuned frequency) and can extend a wide range beyond the nominal bandwidth.

Specifications for radio transmitters for a particular service can include a spectrum Mask. This is not anexact description of the actual transmitted power spectral density, but is a definition of maximum values that cannot be exceeded. An example is shown inFigure 5.for TETRA and for the TETRA Advanced Packet Service (TAPS). The frequency offset values are in MHz and the lines for spurious levels in the TETRA bandwidth are shown in dB. Note that the frequency offset is applicable both above and below the tuned frequency.

Channel Offset(No. of channels)	**C/I (dB)**
0	12
1	0
2	-6
3	-12
4	-30
5	-40

Table .1 Hypothetical C/I figures for a radio system. The channel offsetfigures are valid for channels above and below the tuned frequency, which ischannel offset = 0

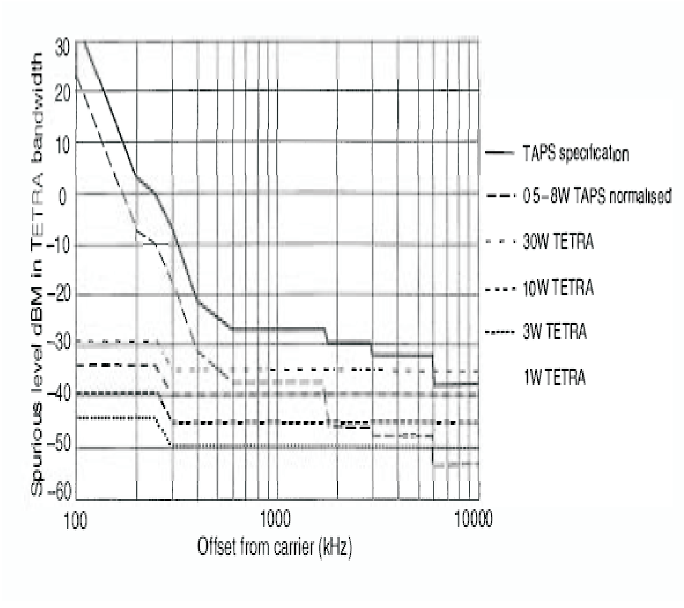

Figure.5. TAPS and TETRA spectrum mash.

1.3 Interference between Dissimilar Systems:

Management of interference between dissimilar systems is complicated by thedifferences between the spectral characteristics of the interfering transmitter andthe type of signal the receiver is designed to capture. We need a generic method of determining how these different systems interact.

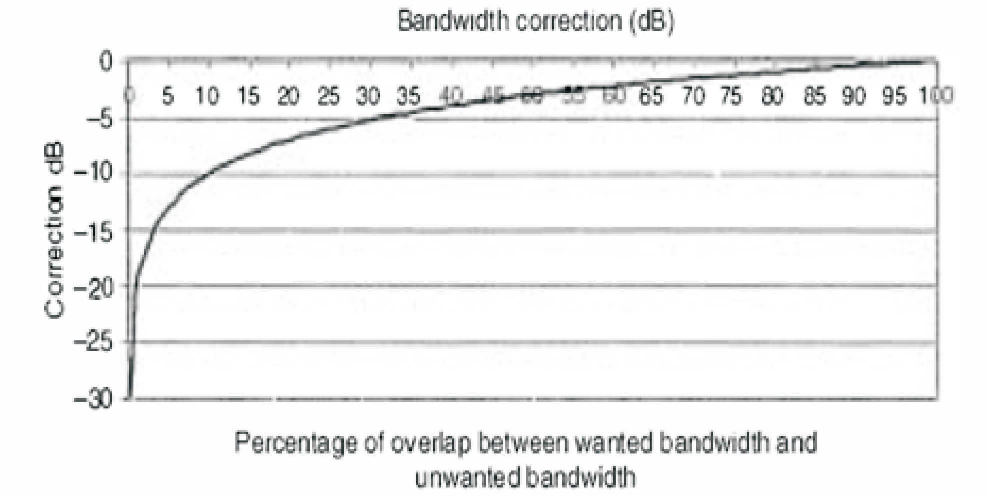

Figure .6 Bandwidth correction in dB compared to the percentage overlap

One possible way of achieving this isto perform actual measurements on the test bench using test gear that as far as possiblereproduces the transmit characteristics, the propagation channel and the receiveinterference rejection characteristics against the interfering signal type.

If this is donecorrectly, then very useful metrics can be derived for use in system design. However,this process is time-consuming and can be expensive and even if it is carried out, theresults may not be made publicly available. This is of course particularly true formilitary systems, where security classification may preclude release of the data(3).

Another method is to calculate the RF power injected into the receiver from aninterfering transmitter. This is a complicated process that needs to consider the energy not just arriving at the victim antenna but also the energy passed through the receiverfilters into the input of the discriminator. This is illustrated in Figure 7.

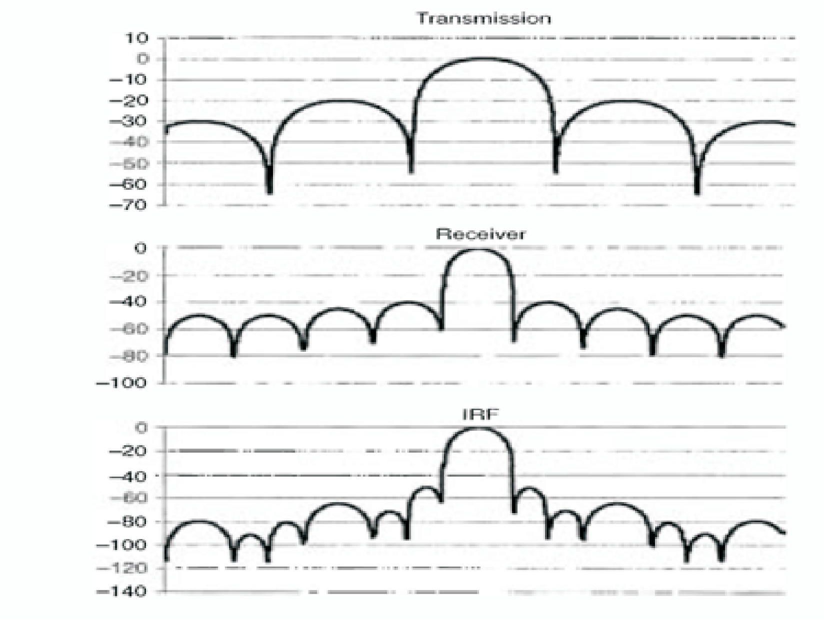

Figure .7Theenergy transmitted by a co-channel interferer is affected by the receiver response,including filters designed to reject interference. The Interference Rejection Factor is the convolutionof the two.

The top diagram shows the transmitted energy from an interferer. The receiver inputrejection filter response. (IRF) is shown in thebottom diagram. This is the convolution of the input energy and receiver response. Theresponse shown is for a co-channel interferer. This shows the importance of bothtransmitter and receiver filters to reduce the potential effects of interference.

The sumof the energy input into the receiver discrimination circuits determines how muchthe interferer will disrupt the victim receiver. The lower the unwanted energy, the betterthe receiver will work.This process also works for interferers that are not co-channel as illustrated inFigure 8. The rejection response is again shown at the bottom. In this case, it is morecomplex in nature. The important aspect is the sum of energy injected into the receiverafter filtering.

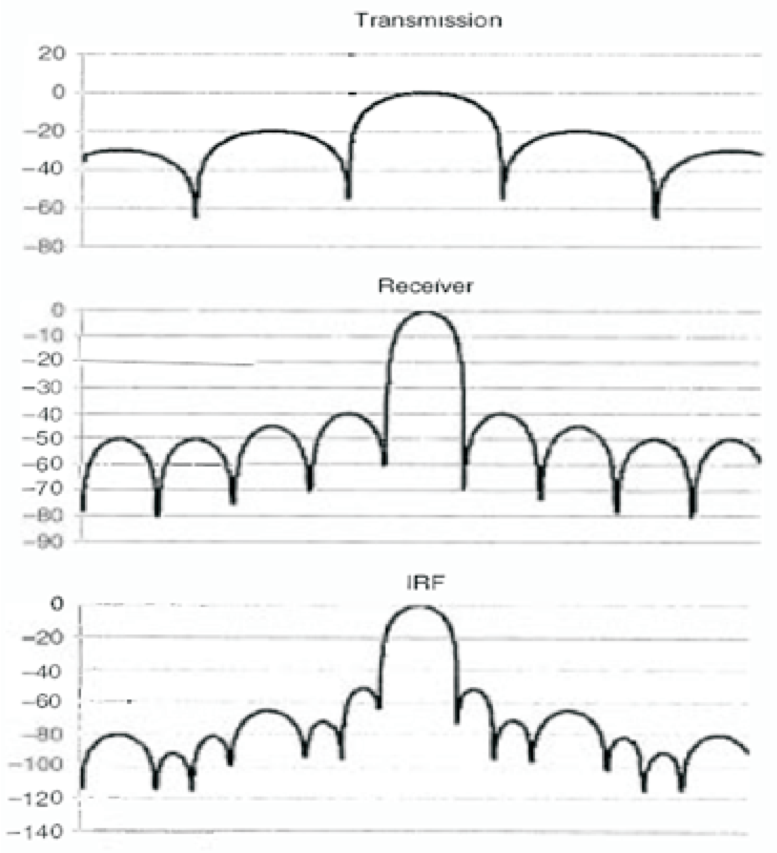

Figure 8 Interference Rejection Factor(lRF)can alsobe determined for off-channel interferers as shown.

The Interference Rejection Factor (IRF)response shown in Figures 7 and 8 can be resolved into a numeric value for interference rejection for a given type of transmission and receiver, and for a givenfrequency offset. The overall response is likely to be along the lines of the response shown in Figure .5.for the TAPS/TETRA case.

1.4 Multiple interferers:

So far in this section we have only considered a single interferer. However, in somecases there may be many interferers, each providing a component of energy to the totalinterference. We will look at two methods of assessing interference from multipleinterferers; the Power Sum Method and the Simplified Multiplication Method (SMM)(4).

1.4.1 Power Sum Method:

The power sum method can be used for multiple interferers when they are of the sametype as the victim signal. The formula for the power sum method is:

P_I=10 log_10 ($\Sigma (1 /) 10)$ eq(1)

Where

P_I isthe calculated total interference.
Iis the interfering power level of each interferer (dBm).

We can illustrate the use of this by examples. First, consider two interferers each with a power level in the receiver channel of -100 dBm. Thus, the equation becomes

$$P_I=10\log_{10}\left(10^{(-100)/10}+10^{(-100)/10}\right) \quad \text{eq(2)}$$

This evaluates to -96.9897 dB, or approximately -97 dBm. Consideration of this will show that in the case of two de-correlated interference sources of the same power,the total power is 3 dB above the level of each. Since 3 dB equates to double the power,this is logical. However, the process also works for any combination of interferers withany individual power contribution.As another example, consider the four interferers:

I, = -I03dBm.
I2 = -97 dBm.
I3 = -105 dBm.
I4 = -120dBm.

Applying this to the formula gives:

$$P_I=10\log_{10}\left(10^{-10.3}+10^{-9.7}+10^{-10.5}+10^{-12.0}\right) \quad \text{eq(3)}$$

Evaluating this gives a result of PI = -95.49 dBm

1.4..2 Simplified Multiplication Method:

The Simplified Multiplication Method (SMM) is one of the most popularmethod for assessing interference from multiple interferers. The method is based on the following assumptions:

There is no correlation between the interferers.
There is one dominant interferer.
Time dispersion can be ignored.
Noise is negligible compared to the interferers.

The SMM is based on using the CDF of the normal distribution. The method isdescribed by an example shown below. The process is iterative.

Assume there are four interferers as in the example for the power sum method:

I1= -103 dBm.
I2 = -97dBm.
I3 = -105 dBm.
I4 = -120dBm.

The SMM process starts by choosing a seed value to begin the calculation. This ischosen as 6 dB above the highest interferer, which in this case is -97 + 6 = -91 dBm.Each of the interferers are compared to this value, giving a difference value ZI. .After this, the normal distribution is normalized for each interferer by the expression:

$$X_I=Z^i/(S^d\sqrt{2}$$

whereSd is the standard deviation due to fading, which at VHF is approximately due to fading, which at VHF is approximately 8.3dB, or approximately 9.5 dB for UHF. In this case, we will use the VHF value. For each interferer we determine the normal distribution CDF for Xi. We then multiply the CDF values for each interferer together and finally produce the delta value that wewill use to modify the seed value for the next step. The delta value is calculated according to:

Δ=(0.5-CDF product)/0.05

where the value of 0.05 has been shown to be the best correction to allow the sequence to converge quickly. The delta value is added to the seed value to give an improved value, which in this case is -91 - 0.3335 = -91.3335 dB.The step 2 seed value is modified by the deltavaluegive a value = -91.37 dB.The process can be continued to refine the value, but improvements will be negligible

Table 2: Step one in the SMM method with seed value = -91 dB

Interferer	**Level**	**Z_I**	**X_I**	**CDF**
I1	-103	11.6665	0.9939	0.8399
I2	-97	6.6665	0.4828	0.6854
I3	-105	13.6665	1.1643	0.8778
I4	-120	28.6665	2.4422	0.9927
Product of CDF Values	-	-	-	0.5016
Delta	-	-	-	-0.0323

Interferer	**Level**	**Z_I**	**X_I**	**CDF**
I1	-103	12	1.0223	0.8467
I2	-97	6	0.5112	0.6954
I3	-105	14	1.1927	0.8835
I4	-120	29	2.4706	0.9933
Product of CDF Values	-	-	-	0.5167
Delta	-	-	-	-0.3335 dB

Table 3: Step two in the SMM method with seed value = -91.3335 dBm

The SMM is the accurate method of assessing interference from multiple interferers; there are others based on modifying the SMM or via other routes. Often these have been designed to deal with specific circumstances. The processes involved in this process are illustrated in Tables 2 and 3.

1.5Interference in the Time Domain

1.5.1 Time Slots, Frequency Hopping Systems and Activity Ratios:

Interference is not just dependent on spectrum considerations, but it can also havetime-varying characteristics due to a number of factors. Some of these are technologydriven and others due to variable atmospheric effects over time. Technologies based onTime Division Duplexing (TDD) use time slots to multiplex several radio channelsonto a single channel as shown in Figure 9

These time slots help to preventinterference and they also mean that one individual channel is working only in 1/n of thetime, where n is the number of slots. TETRA, for example, uses four time slots in asingle carrier.

Timing is vital for the receiver to function properly. The relative time that a signal is active is called the "activity ratio". A continuouslytransmittingsignal has an activity ratio of 1.0, and a signal that is active only 1 % of thetime has an activity ratio of 0.01. When considering interference effects of signals with intermittent transmission, this must be included in interference calculations. Theprecise method of evaluating interference depends on the statistics describing theprobability of the wanted and unwanted signals being present at the same instant.

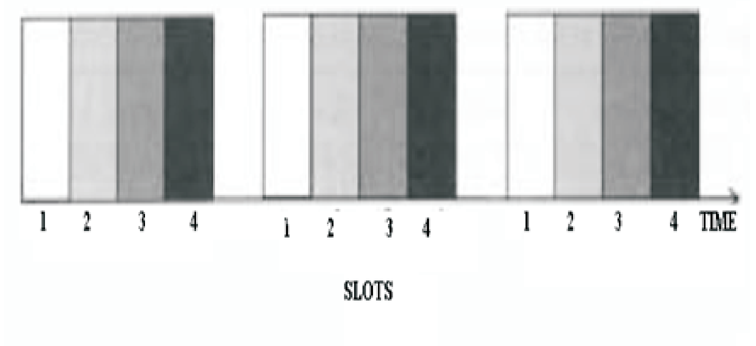

Figure .9 Time slots in a TDD system, with a gap for synchronization and system management.

Thisis described in Figure10, whichshowswanted andunwante drandomly distributed transmissions occurring at an activity level of 0.2. The relative locationsofthe two transmission sources are not considered at present, but we will be looking at this aspectshortly. We are also assuming that the receiver for the wanted transmitter is looking fora signal during the same time slot.

The clashes can be seen from the figure10. These are where both systems are using thesame part of spectrum at the same time, and thus where interference can occur. If the two transmissions are truly random, then classic Erlang-B calculations can be used to determine the probability of interference occurring based on common use of the same channel at the same time.

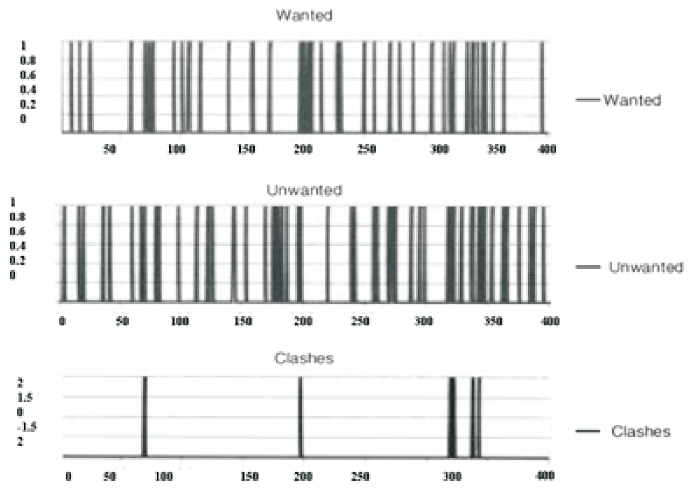

Figure 10Example of two systems operating independently with occasional time clashes.

However, it pays to be careful about applying Erlang-B without considering thescenario to be modeled. Erlang-B requires randomness for the statistics to be valid(technically, this is called a poisson process), but there can be many conditions thatprohibit this from being the case. These include:

Systems where one transmission will trigger another one. This might be the relayof orders from higher to lower echelons, a sensor network where communicationsare used to relay information about intercepts or other tactical information, orsystems based on timing (where, for example, transmissions are made at the sametime each day).

In this case, the transmissions are not truly random. Although thetriggering event may be random, once the process has started it follows nonrandombehaviour.

Systems where the use of spectrum is correlated between wanted and victim.This may include two frequency hopping systems using the same or similar hop sets. Thus the two systems are linked and not therefore random.

A tracking system, such as a follower jammer, which will attempt to jam the portionof the link present during a time slot period. Again, the two systems are linked andnot truly random.

These cases, which are not poisson processes, cannot be solved using Erlang'sequations. Without calculating the mathematics from scratch, one possible approach isto simulate the network performance to gather the metrics necessary to determineinterference probability.

1.5.3Non-Continuous Interference:

Interference is not always a constant effect. In particular, signals that propagate a long wayare subject to changes in atmospheric conditions. This includes variation in thek-factor due to changes in the vertical atmospheric column, ducting and increases introposcatter. These can be modeled over long periods to produce special propagation prediction models that account for differences in propagation over time(3). Such models normally include results for different percentages of time; 50%, 10%, 5% and 1 % are commonly quoted in such models.

1.6 Interference Mitigation Techniques:

There are several ways of mitigating against interference. These include:

Power management of the interferer.

Antenna height of both interferer and victim.

Antenna tilt of both interferer and victim: sectored antennas or null steering for both interferer and victim.

Frequency re-assignment for either interferer or victim.

The selection of which mitigation method is applied is usually based on theamountofinterference and the implications of the potential changes. Some typical considerations include:

Power management: one approach is to reduce the power of the interferer, to benefitfrom the change in relative signal strength. However, reducing the power of theinterferer will also reduce its service area and this will have an effect on networkcoverage and capacity in the region around the interfering base station.

Antenna height: the antenna heights of either the interferer or victim can be reduced(or both).This will have the effect of reducing the range of the interferer if its antenna height is reduced (again this may have a knock-on effect to the overall networkcoverage and local capacity). The victim antenna height can also be reduced. This can help in the situation where the reduction in height will result in benefits from terrain or clutter shielding.

Again, of course, the coverage area of the victim will be reduced in this case.

Antenna tilting: for antennas that have vertical directivity, it is possible to orient antennas used for paths within the horizon such that the energy radiated towards the horizon is reduced. This will have the effect of maintaining the coverage in the wanted area but reducing interference outside of it.

Sectored antennas and null steering: antennas with directional patterns in the horizontal plane can be used to minimize interference in the direction of the victim or interferer (as required).

Antennas that have a null (very low response in a particular direction) can be used to spatially filter out particular interferers(5). This approach can only be used when the direction of the interfering energy is known, and thus it is applicable to the condition of base station to base station interference.

Frequency Assignment: either the victim or interfering system can have theirfrequencies changed to prevent interference between them. This of course maycause interference with other spectrum users and thus should only be done with care,and with checks to identify any potential problems that may be caused by the change.

CONCLUSION:

Interference is a phenomenon which we cannot be completely destroyed i.e.,unavoidable.But there are number of techniques for reducing its harmness to the network. In this paper we have tried to explore the different souces of interference and some of the mitigation techniques for reducing its malicious effects to the communication networks.Further more research has to be carried out to determine most effective and advantageous techniques for reducing interference there by increasing the performance of the networks.

REFERENCES:

1. ADJACENT BAND COMPATIBILITY BETWEEN TETRATAPSMOBILESERVICES AT 870 MHz, . International Journal of advance science and technology Vol. 5, Issue4,september-october 2012,
2.. "Method for the Assessment of Multiple Intereference ". International Journal of Engineering Research and ApplicationsSecurity Solutions for Wireless Sensor NetworksDirk WESTHOFF, Joao GIRAO, Amardeo SARMA (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue4, July-August 2012,
3.,Antennas and Propagation for Wireless Communications Systems, WileyBlackwell,ISBN journal.) ISSN:2448-2770.www.ISBN.com vol.3 september-october
4.Radio Interference Suppression of Switch Mode ... - Schmidt-Walter