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AUTOMATIC REMOTE MONITORING STATIONS FOR GNSS INTERFERENCE MONITORING

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ABSTRACT: Interference is an actual problem for Global Navigation Satellite System (GNSS) receivers. Interferences present a serious intimidation to GNSS reference stations because unobserved degradations in reference station measurements potentially impact the quality of the information provided via the navigation service messages, which in turn can affect the whole user community. A lot of ISM band terrestrial interference was also observed when the signals were received by Global Navigation Satellite System (GNSS) User Receiver's near Omni-directional antenna. The terrestrial interference was observed within the GNSS S-band bandwidth of 2492.028 ± 16.5 MHz. It was also observed that the terrestrial interference is time varying and location specific. Additionally, since the user receiver antenna is generally Omni-directional so it picked up signals from all visible satellites it was difficult to characterize the interference from each of the GNSS satellite. So it was decided to estimate the interference levels from the individual satellites using a better gain antenna like antenna diameter 2.4m and above. So to know the interference level at reference unmanned station, this paper gives a low cost LabVIEW based system with Spectrum Analyzer which can forecast that the interferences on the navigation signals are due to the terrestrial interferences or other GNSS satellite interferences at those reference stations. The proposed software has the ability to automatically record.

Index terms: Global Navigation Satellite System (GNSS), GNSS interferences, terrestrial Interference, Data acquisition, Spectrum Analyzer, LabVIEW.

I. INTRODUCTION

Interference presents a serious threat for users and operators of satellite navigation systems and also the development and modernization of the Global Navigation Satellite System (GNSS), more and more navigation signals are occupying the same frequency band. Due to this, interferences on the navigation signals are increased. Efforts were made initially to characterize interference from interfering GNSS satellites by using User Receiver's active antenna (survey grade antenna).

However, it was difficult to characterize the interference because of the presence of terrestrial interference in the same frequency band. Since the user receiver antenna has nearly Omni-directional radiation pattern, it picked up not only GNSS interference but also the terrestrial interference. So when navigation signals are received, it was mixture of GNSS signal, GNSS interferences and Terrestrial interferences. It was also noted that there is considerable interference in S Band from the terrestrial sources. Hence it was necessary to establish mobile interference monitoring stations at different locations to evaluate the level of interference from satellite and local terrestrial sources.

In order to mitigate this threat, it is necessary to monitor the interference environment at these reference stations, which generates situational awareness of possible measurement quality deteriorations. As mentioned in introduction the terrestrial interferences are location specific, which means terrestrial interference is different at different places. So by knowing the interferences at different reference stations how interferences affect the navigation signals can be predicted.

A. Related work done

Different studies have been made on GNSS interferences monitoring.[1] gives the interference monitoring system prototype specifically designed for interference monitoring purpose, offering an extensive interference detection, characterization, and impact prediction without any operator intervention required. [2] gives a method based on the Chi-square Goodness-of-Fit test and can be applied to all types of interfacing signals with moderate complexity.

B. Proposed work

This paper has proposed a LabVIEW based system with handheld Spectrum Analyzer which can quantify the level of interference both from terrestrial and satellite sources and gives a quantitative analysis of the level of degradation caused due to interference on the navigation signals.

C. Organization of rest of the paper

Section II describes about the whole system and how it works as well system features and software features in particular. Section III describes the method of monitoring, analyzing, and evaluating the interference levels and degradation assessment. Flowchart of system as well front panels of both, 'set the parameters' and 'getting the EIRP' Vis are also given. Section IV concludes the paper.

II. LabVIEW BASED INTERFERENCE MONITORING SYSTEM

Fig. 1 General block diagram of system used to acquire and analyze the data.

The block diagram of the monitoring station is given in figure 1. It consists of a narrow beam antenna (typically 2.4m parabolic antenna) to receive the RF signal from a particular GNSS satellite by pointing the antenna to the designated Azimuth and elevation angle of the satellite. This will ensure the signal reception from a single satellite unlike in filed grade antenna (user antenna) which is receiving the signals FROM all satellites. The signal is amplified in a low noise amplifier and fed to a handheld spectrum analyzer (MS2724C Anritsu Spectrum Master). The software running on a LabVIEW installed PC is connected to the spectrum analyzer through an Ethernet cable and enables data transfer between Spectrum Analyzer and LabVIEW installed PC. For analyzing the same data at the control room the software that allows accessing the PC at reference station from the PC at the control room can be used. There are many types of software available in the market that provides this kind of facilities, e.g. Team Viewer is one that allows accessing the PC at remote station through internet. By using this type of any software the acquired value that is coming from the spectrum analyzer to the PC with LabVIEW at reference station from the PC at control room can be seen by operator.
The description of the software is given below
Features of interference monitoring software and interference monitoring system:
The main features of interference monitoring software are

- Set the values in Spectrum Analyzer by entering in PC.
- Retrieve the values of the Spectrum Analyzer into the PC.
- Provides graph of Channel power and C/N0 for continuous monitoring.
- Provides value of EIRP of the monitoring satellite by doing necessary calculation.
- Continuously monitors the communication between Spectrum Analyzer and PC, and gives indication if any problem is there in connection.
- Access the interference power ratios if the user asks the channel power in the bandwidth of interest.

The main features of interference monitoring system are

- It is a Low cost interference monitoring system as compared to large antenna monitoring stations.
- It can be easily operated.
- It provides unmanned interference monitoring system at reference station with the help of Team Viewer software.
- It access the EIRP of interfering satellites

III. INTERFERENCE MONITORING, ANALYSING AND EVALUATING METHODOLOGY

Fig. 2 shows the Flow chart of the system for analyze and acquire the data. There are two files of LabVIEW called VIs. First one is for setting the parameters into the spectrum analyzer named 'set the parameters' and other one is for

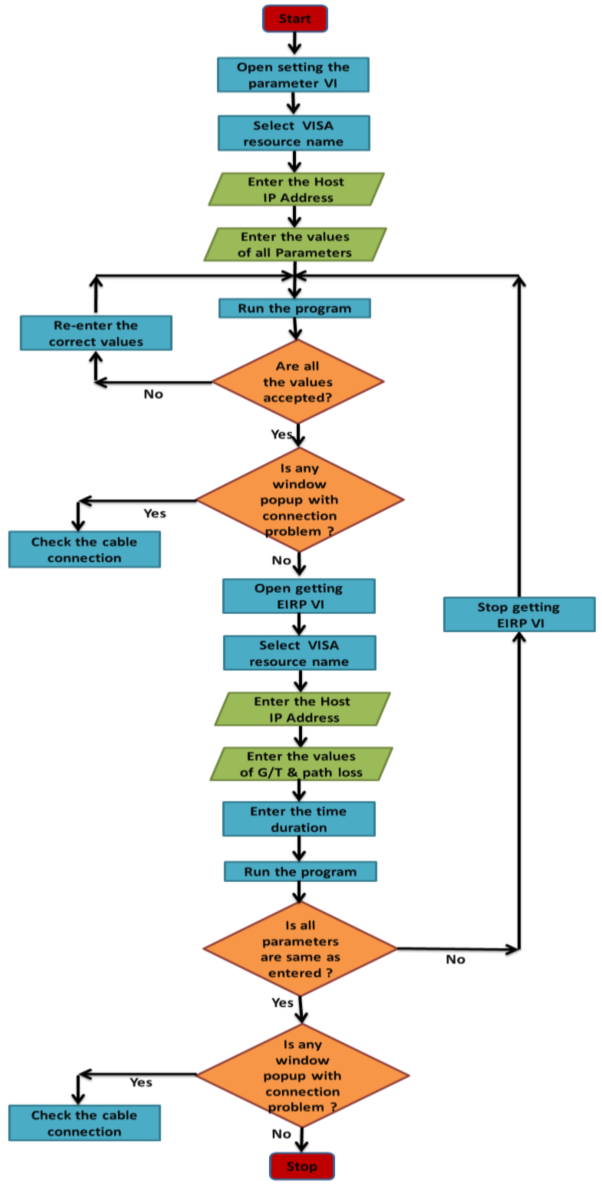

Fig. 2 Flowchart of the system for analyses and acquire the data

fetching the data from the spectrum analyzer named ‘getting the EIRP’. For operating the software ‘set the parameters ’VI is opened first. In which there are numbers of blocks to put the values of certain parameters like Centre Frequency, Frequency Span, RBW (Resolution Bandwidth), VBW (Video Bandwidth), Input Attenuation, Reference level, Channel Power Width, Marker frequency etc. after putting these values when the VI runs, it will set these parameters into the spectrum analyzer. Once these parameters are set in the spectrum Analyzer, the second VI ‘getting the EIRP’ retrieves the values of channel power, Noise power etc. After knowing Channel power and Noise power, the C/N0 of the transmitted GNSS signal is calculated in VI and displayed. Equation of finding the C/N0 of receiving GNSS signal:

C/N0 = EIRP - Path loss + G/T – k. . . . . . . (1)

Where,

- EIRP(Effective isotropic radiated power) = Transmitted Power x Transmitted Gain
- Transmission Path Loss
- Path loss = $(\lambda /4 \Pi R)^2$, R = Distance from satellite, λ = wavelength
- Antenna Gain (G) = $\eta \times (\Pi d / \lambda)^2$,
- η = Efficiency of antenna, d = Diameter of antenna
- Antenna Temperature (T) = A parameter that describes how much noise an antenna produce in given environment
- k = Boltzmann constant = (1.3806 x 10-23 J K-1)

The values above thus obtained are used to calculate the EIRP. Now the value of C/N0 of signal, the value of Path Loss in between transmitting GNSS satellite and receiving antenna on the reference station, G/T of receiving antenna and value of Boltzmann constant (k) = 1.3806 x 10-23 J K-1 is known. But for the value of Boltzmann constant the logarithm of k (Boltzmann constant) is taken and multiply it with 10, i.e. 10*log(k).

So by using Eqn. 1 the EIRP (Effective Isotropic radiated Power) of the transmitting satellite is calculated. Now for knowing about the interference on receiving GNSS signal antenna is located on nearby satellite and by running both of the Vis, the EIRP of that satellite can be found. A term ‘excess EIRP’, which is defined as the amount by which the interfering satellite EIRP is equal or higher than required GNSS received signal EIRP in dB measured in S-band is to be estimated. Based on the EIRP estimates from the interfering satellites, the impairment in C/No of the user receiver can be calculated.

If excess EIRP value is zero or positive then other GNSS satellite signal will definitely interfere to our GNSS satellite signal. Because of this interference of nearby satellite impairment in C/N0 is there. Fig. 3 shows Front panel of ‘set the parameters’ VI. This VI is used to set the parameters into the Spectrum Analyzer by PC. In this VI VISA resource name, i.e. Anritsu Spectrum Master is to be selected, it is a name given to the spectrum analyzer which means PC

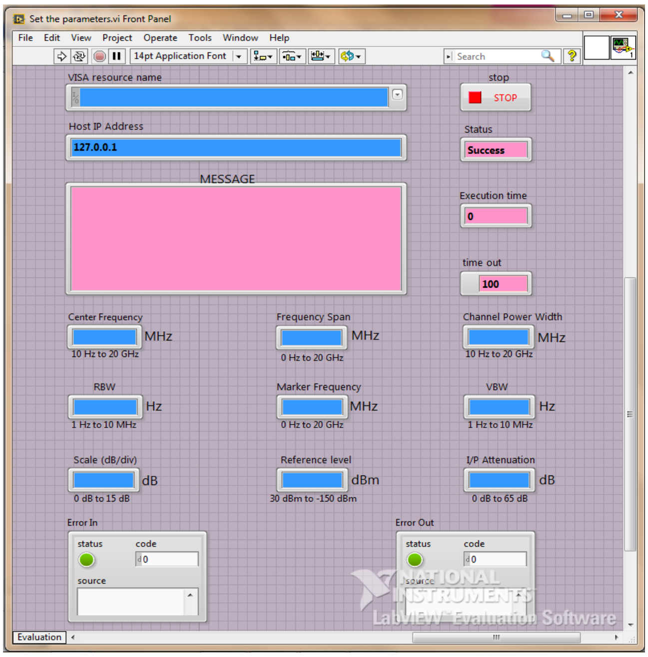

Fig. 3 Front panel of set the parameters VI

Is communicating with that device. Then after there is a block of host (Spectrum Analyzer) IP address in which the IP of Spectrum Analyzer is to be entered, which is used to check the communication between PC and Spectrum Analyzer. Front panel also contains parameters like Centre Frequency, Frequency Span, RBW (Resolution Bandwidth), VBW (Video Bandwidth), Input Attenuation, Reference level,

Fig. 4 Front panel of getting the EIRP VI

Channel Power Width, Marker frequency etc. the appropriate values are entered in each of the blocks. After entering all the values when VI is run, if all values are acceptable, it will set all the parameters of Spectrum Analyzer equal to the entered values in the ‘set the parameters’ VI and if not then it will display that entered value of parameter is not acceptable. The Spectrum Analyzer is calibrated with the reference satellite signal. Fig. 4shows the Front panel of ‘getting the EIRP’ VI. As the process has done in ‘set the parameters’ VI, the VISA resource name and IP address of the Spectrum Analyzer is entered in 'getting the EIRP' VI. Additionally the amount of time for which the VI will run can also be set. As well Front panel also shows values of all the parameters of Spectrum Analyzer. There are also two blocks for G/T and Path Loss in 'gsetting the EIRP' VI. Both of these values are known for receiving antenna at reference station. When both these values are entered, VI will give the value of EIRP by calculating according to Eq. 1. There are two graphs of Channel Power and C/N0 that is continuously plotting the values of Channel Power and C/N0. These graphs will help to continuously monitor the Channel Power and C/N0. This VI also stores the values of Channel Power, Noise Power, C/N0 and EIRP per every 3 seconds in text file and excel file. These text file and excel file will help when the values of parameters for previous days is needed for analysis.

IV. CONCLUSION

Interference monitoring has always been considered one of the key issues in many GNSS based applications. In this paper, a low cost LabVIEW based interference monitoring system for GNSS received signal at reference station is proposed. LabVIEW code is generated that sets the parameters in Spectrum Analyzer and also retrieves the Channel Power, Noise Power and C/N0. From this the EIRP of GNSS satellite calculated. By getting the EIRP of nearby satellite the interferences on navigation signals are due to the terrestrial interferences or other GNSS satellite interferences at reference stations can be anticipated. By knowing the interference at reference station, prediction can be made that how interference affects the GNSS signals.

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