Network Operators Improve Bandwidth Management Using Long Duration Spectrum Recordings and Signal Analysis

X-COM Systems

Introduction

X-COM provides a unique set of capabilities that can simplify a wide variety of Spectrum Management tasks. The combination of a high performance Signal Analyzer and the X-COM IQC-2110 enables the recording of broad swaths of spectrum over periods of time as long as days. Using the X-COM suite of software analysis tools, a user can search for carriers of interest and identify bandwidth allocation or power level violations within a network operator's bandwidth. Once identified, errant carriers can be traced to an earth station and its operator through the network management system.

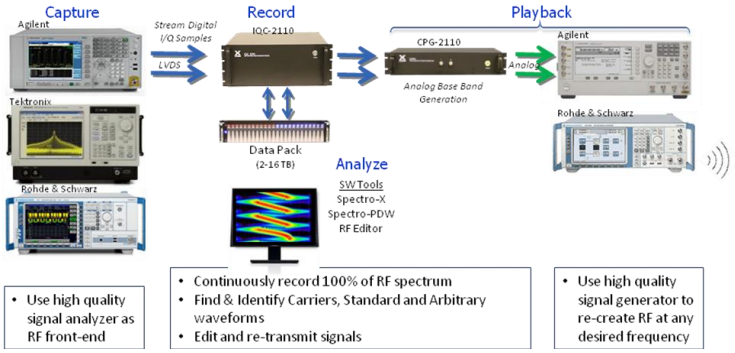
Spectrum Management to Maximize your Bandwidth ROI

Bandwidth is the currency of data and voice communications. Operators of a communications satellite allocate and charge for bandwidth based on duration of access and transmission spectral efficiency. Terrestrial, wireless service providers obtain revenue using similar formulas and many times due to antenna constraints, must also understand geographic radiation patterns as they can dramatically impact CapEx.

Independent of whether a satellite transponder will be shared using time, frequency or code division multiple access techniques, users must adhere to strict spectral masks so that the operator can accurately predict usage, and allocate and charge for capacity. Often, transponder access is random in frequency and time, as in the case of FDMA telephony systems or random in time as in the case of TDMA transaction processing systems. Therefore, a random snapshot of a segment of the transponder from a short-capture memory, signal analyzer may easily miss a user whose; transmitted spectrum does not roll off steep enough, whose power level is causing adjacent channel interference or who is either accessing a slot at the wrong time or not authorized at all. Even with mask triggered signal analyzers, there would be a distinct advantage in being able to view a portion of the transponder bandwidth for more than a few seconds.

Typical Solution Description

A typical system configuration for spectrum recording and analysis is shown below.



The X-COM IQC-2110 is plug compatible with signal analyzers from Agilent (PXA, MXA, EXA Series), Rhode & Schwarz (FSV Series) and Tektronix (RSA 6000A or RSA 5000A). The signal analyzer acts as the microwave or RF front end, pre-selector and down converter, presenting digital I & Q sample streams to the X-COM IQC-2110. The SA's superior noise floor, SFDR, amplitude and phase flatness over the span bandwidth ensures a very high fidelity signal which the IQC-2110 stores in a RAID5 disk array. The result is a, gap-free, long duration recording of the spectrum with storage redundancy.

The X-COM IQC-2110 can capture and record across a 150 MHz bandwidth although this is often limited by the span of the signal analyzer. In addition, the X-COM IQC control software can implement Stop & Stare functionality. Here, an SA center frequency is set by the IQC software and the spectrum is recorded across the span for a user defined period of time. The SA is then set to the next frequency in the transponder and the capture continues. In this manner, using for example a span of 110MHz, the transponder bandwidth of 500 MHz can be recorded in five steps.

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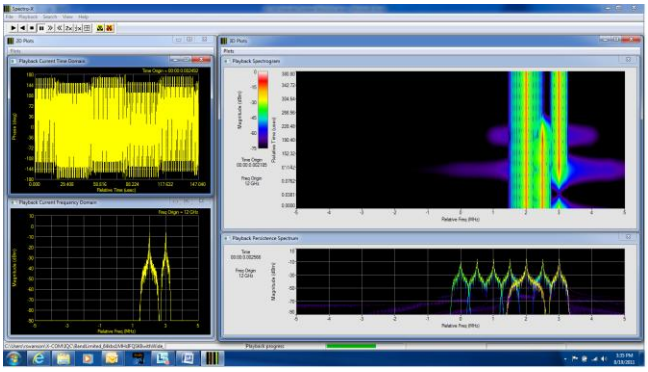
The time period over which the capture bandwidth is recorded is only dependent on the size of the disk array connected to the IQC-2110. Using a 12TB disk array, 60 hours of capture time is possible at a 10MHz bandwidth and over 5 hours at a 110 MHz capture bandwidth. Captured files would be transferred to an X-COM SigAnalyst work station with a comparable amount of RAID5 disk storage for post processing. In a satellite transponder monitoring scenario, the X-COM equipment would be located at the network control center.

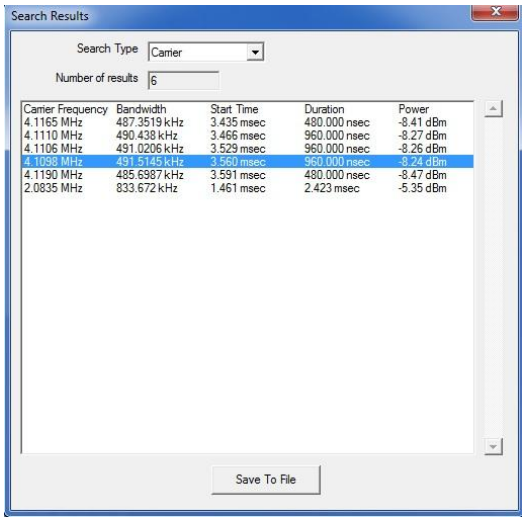
The image below is a typical example of what a satellite operator might see using the X-COM Spectro-X software program to visualize a captured data file. Playback speed through the file can be set by the operator. Here, it has been paused and shows a time slice through the file. The top left plot is phase vs. time. The bottom left is magnitude vs frequency. Additional windows can provide other views simultaneously such as I & Q vs. time or power historgrams in the time and frequency domain.

This particular file was of a portion of a transponder shared by QPSK modulated carriers utilizing an FDMA access scheme.

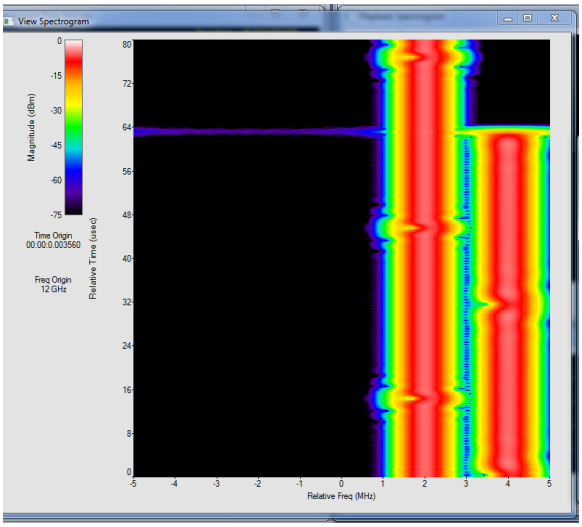


The carriers are only present for the duration of a phone call or data transfer and are randomly assigned frequency slots as they become available. Of interest are the two right hand images. The top one is a spectrogram that is color coded to indicate power vs frequency, scrolling vertically in time. Note the carrier 2 MHz to the right of the 12GHz center frequency. Its occupied BW seems much larger than the two carriers adjacent and higher in frequency even though all carriers are supposed to comply with the same spectral mask. The bottom plot is even more telling. It is a persistence spectrum plot so a ghosting of all carriers that access the transponder, independent of when in time they do so, is visually present. It is clear that one station has not properly band-limited its transmissions and is in violation of the spectral mask. Since in this case, carriers are assigned to the next available frequency slot as they request access, in turn driven by the random nature of telephone calls being placed in time, it would only be a matter of luck to see such an errant carrier without being able to capture long duration views of the transponder accesses.

Now that the satellite operator is aware of an errant transmitting station, Spectro-X provides additional tool to further investigate. To specifically identify which earth station is violating the spectral mask, the carrier search feature of Spectro-X was used. Enlarging the lower left plot and using markers, the bandwidth of a “legal” carrier at a power level of -40dBm was measured to be 347 KHz. The bandwidth of the one at 12.002 GHz, at the same power level, was measured to occupy 730 KHz. So, an automated search was set up to look through the entire capture file, which might represent a time span of tens of hours, at the -40dBm power level for all carriers with a bandwidth near or exceeding 500 KHz. This was accomplished by setting the RBW of the search to that bandwidth.



The results show a single occurrence of the “illegal” carrier and several other occurrences just above 12.004 GHz. However, by clicking on one of those search results at, for example, 4.1098 MHz (offset relative to a 12 GHz center frequency), Spectro-X displays a spectrogram exactly at that time point in the captured file. Note the blue coloring just at the 3 MHz relative frequency point. This indicates a point in the frequency domain with power levels down around -50 to -70dBm and so one can conclude that this was just two adjacent legal carriers close enough that the search routine thought they might be a single carrier. The spectrogram provides the operator a quick visual verification that this search result can be discarded.



So, the errant carrier has been captured with an exact start of transmission time of 1.461 mSec from the start time of the capture and with duration of 2.423 mSec. Since the beginning of IQC-2110 capture files are time stamped (UTC), a search of the call request records which are part of the network control system logs at the network control center could identify which earth station requested, and accessed the transponder at that time. The station operator could be contacted and the problem resolved.

The superior RF performance of industry leading signal analyzers are the perfect complement to the high fidelity, 16 bit dynamic range and long duration recording capabilities of the X-COM IQC-2110. With the signal visualization and search capabilities of Spectro-X, they provide the operators of satellite or terrestrial wireless networks an unsurpassed set of tools to manage access to their network and maximize revenue generation from their bandwidth investment.