A New Challenge for Digital Television Broadcasters: Useful Measurements of DTV Signal Coverage

Z Technology Application Note No: 10

Background

Until recently station owners and managers had few reasons to actually measure signals from terrestrial television broadcast transmitters. For many years, the world of over-the-air broadcasting was relatively stable. If a coverage problem did occur it was usually caused by a major event such as lose of the transmitter or damage to the antenna system. Such events usually became apparent quickly. The solution: repair the damaged hardware (sometimes easier said than done) and coverage was back to the same footprint as usual. A broadcaster seldom needed to consider measuring actual signal coverage.

With the roll out of terrestrial digital broadcasting, this has changed. We are now fully involved in the transition process to digital television broadcasting. Signals from new digital transmitters are being overlaid onto existing analog footprints. Chief Engineers find themselves faced with the challenge of turning on a *new* DTV transmitter on a *new* tower with a *new* antenna. To make matters more unsettled, old channel taboos are no longer valid. An engineer may be required to bring up a UHF DTV signal with the added difficulty of replicating the footprint of his existing analog VHF signal. The task will be even more challenging for the many broadcasters faced with a stepping stone build-out process. For these CEs the next few years will consist of sequentially stepping through several interim stages before finally getting to their permanent assigned DTV channel with full power on the proper tower using the final antenna array.

There are other factors adding complexity to the situation. The broadcaster, who wants protection of the new DTV signal over the same footprint he now enjoys, must demonstrate that his new signal pattern is the same as the old NTSC one. According to the FCC, sufficient and proper DTV coverage is required before the end of 2003 for commercial stations and by December 2004 for public stations.

It is important to understand a broadcaster's DTV signal coverage during each of the rollout steps for terrestrial digital television. This is a dynamic and changing situation and will continue to be so for the next several years. Perhaps the best way to state the requirements for the new DTV signal is to boil it all down to one real-world question: "Are you actually delivering a usable (decodable) 8VSB signal to people with digital television sets, DTV set-top boxes and PCs equipped with wireless data receivers?"

It is reasonable and responsible to take immediate steps to answer this question. It is also apparent that it is insufficient to simply rely on past signal coverage records or even to use computer predictions of theoretical but unproven DTV signal coverage.

Now is the time for old-fashioned in-the-field measurement work. However, some care and a few new measurement techniques are required in order to properly carry out this important task.

DTV Coverage Measurements

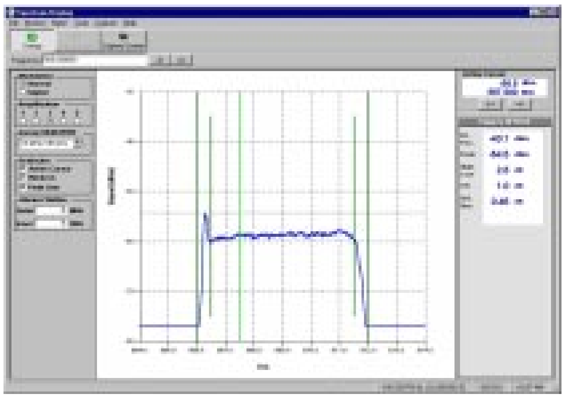
Fortunately, an engineer can now make useful digital television signal coverage measurements in a modern, rapid and automatic way. With a little understanding of some useful measurement parameters, a broadcaster can gain a good understanding of the quality and effectiveness of DTV signal delivered to the market.

To help in this effort, Z Technology has create a Signal Coverage Drive Test Measuring and Mapping System called the DSS5800. It is especially designed for new digital television terrestrial transmission measurements. Z Technology has created a unique tool and unique new measurement parameters for the DTV coverage analysis world. These include parameters or values to be collected that directly correlate with the ability to receive, decode and utilize the data being transmitted.

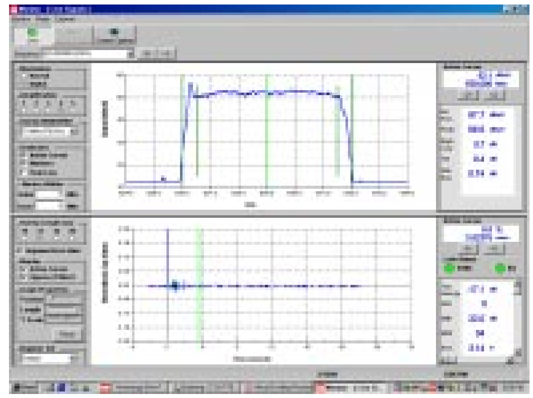
These parameters can be divided into two separate measurement groups: 1) RF spectrum measurements and 2) baseband (decoded) measurements. The first set of parameters include values collected from DTV signals and referenced to the RF spectrum of the off-air received signal. The simplest of these is received channel power or "Integrated Power." The FCC specifies this value and the broadcaster is required to meet minimum Field Intensity Levels within the coverage area. (41dBuV/Meter and 47dBuV/Meter.) Additional RF parameters have been defined and can be tracked. They include several values giving the user-added clues as to the "receivability" a DTV signal. For example, a received signal can be quite strong but have one or more large notches in its spectrum. This could make decoding impossible. Therefore, in addition to measuring and recording RF Field Intensity Levels, it is useful to track and record Notches in the 6MHz received spectrum, Tilt across the channel and Peak Power within the bandpass. All these parameters are useful in characterizing DTV transmitted signals and in gaining confidence while delivering acceptable and receivable signals. A Table of these useful RF parameters is shown below.

RF SPECTRUM PARAMETERS USED TO CHARACTERIZE DTV SIGNALS			
Abbreviation	**RF Parameter**	**Ideal Value & units used**	**Comments**
Int Pwr	Integrates Total Power of energy within Bandpass	>41dBuV/m (dBuV/m)	This parameter is the "sum" of all the power being received within the 6 MHz Channel.
Peak	Peak Power within Bandpass	Large (dBuV/m)	The max. signal strength being received at the highest point within the Channel.
Tilt	Tilt across Bandpass	0 (dB)	A perfect signal will be flat over the Channel bandpass
High-Low	In-Band <u>Notches (</u>The	0 (dB)	This parameter is a measure

Diff	difference between the highest & lowest point in the Bandpass.)		of the deepest notch within the spectrum over the Channel Bandpass.
Std Dev	Standard Deviation	0(units of σ, In dB)	Mathematical Definition of Standard Deviation for a signal within the Channel Bandpass



DTV RF Spectrum Showing RF Parameter Measurements



DTV Display Showing RF and Decoder Parameters

A further set of parameters worth measuring within your service area can be obtained by decoding the 8VSB transmitted signal. Several decoder parameters can be used to determine what "margin" a signal has before reception fails. Signal to noise ratio (SNR), segment error rate (SER), sync lock and equalizer lock are all important. In addition, multipath performance can be studied by recording tap energy values as well as total tap energy being captured at the received site. All of these decoded parameters are good quality indicators and well worth tracking over time and across the coverage area. A summary Table of decoded parameters is shown below.

DECODED PARAMETERS USED TO CHARACTERIZES DTV SIGNALS			
Abbreviation	**Parameter**	**Ideal value & units used.**	**Comments**
SYNC Lock	Synchronizer Lock (Sync circuits locked onto signal)	Yes (1/0)	The most fundamental and the first step necessary before a System can decode the signal.
EQ Lock	Equalizer Lock (Equalizer locked on signal & producing decoded data)	Yes (1/0)	After Sync Lock, the next step required for decoding an 8VSB signal is to affirm equalizer lock.
Tap Energy	Tap energy received from reflected signals	**-** infinity (dB)	Energy the decoder equalizer sees from linear distortions. That is, the sum of energy received at the decoder due to reflections or echoes.

Main Tap	Energy in the Main Tap (This is a number ranging from 0 – 100)	100	A measure of the amount of the signal arriving at the decoder via the main signal path. When there are no echoes, all energy is received through the one and only main signal path. This causes the Main Tap number to = 100.
SNR	Signal to Noise Ratio	15.2 (dB) or better	The SNR must be at least 15.2 dB to decode any part of the signal.
MSE	Mean Square Error	0 (dB)	This is a value used to calculate SNR. The smaller it is the better.
SER	Segment Error Rate Number of Segments found in error per second in decoded data stream	**<** 3 (segment errors per sec)	The digital signal is encoded into segments. The SER count keeps track of segment errors per second. The industry has defined 3 as the Threshold of Visibility of segment errors.

Summary

In summary, by measuring received signal strength power over a service area and also by determining other RF and Decoded Parameter values an operator can properly gauge signal receivability. This allows the engineer to move from a guessing-game scenario to the reality of having useful measured data from a transmitted DTV signal for review and analysis.

Z Technology has a series of products and systems available for these measurement needs. The testing procedures and resulting parameters discussed above are all available from the DSS5800 Digital Television Signal Coverage Analysis System. Another Z Technology product, the R507 Field Strength Meter with Spectrum Display, offers some of these same critical measurements indicators and can be used to analyze DTV signals.

Both of these products can be used to produce a signal coverage area plot showing the extent and the quality of received digital television signals. The DSS5800 allows users to plot signal parameter data against gps location information. They are plotted over street level maps. The added convenience of the resulting spatial presentation for RF and Decoded Parameters is quit useful and revealing.

Z Technology also manufactures similar products for other digital television modulation standards. Please contact us for more information.

DSS5800 Drive Test System by Z Technology, Inc.