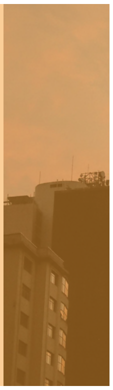
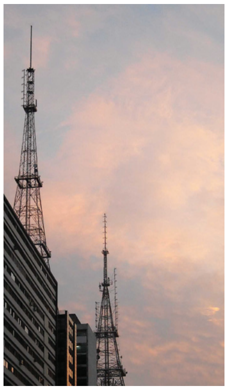


Predict your TV viewing quality with ISDB-Tb RF Monitoring

Application Note

Ensuring excellent quality of ISDB-Tb broadcast signals and its contents requires much more than simply watching a TV program. Watching the program does tell you that the transmitter is on-air, but what about the other TV programs in the multiplex? What about the one-segment program for mobile handset users? Is the RF signal quality good, or are you near the edge of the “digital-cliff” and about ready to lose the signal completely? If an error or noticeable artifact is seen or heard within the TV program, how easily can it be pin-pointed to a piece of broadcast equipment, or maybe even the content provider? All of these questions go on daily in the life of a broadcast engineer. Being able to answer these questions makes the difference between proving good quality and excellent quality. This Application Note will answer these questions and show how to develop an RF network monitoring strategy with the Tektronix RFM220 ISDB-Tb Measurement Demodulator.

Tektronix®

Signal Quality		
Channel Level	-42.9	dBm
Full Band Level	-43.7	dBm
Carrier Frequency Offset	-1199	Hz
Mean SNR	23.7	dB
Coarse MER	22.4	dB
Layer A MER	30.7	dB
Layer B MER	30.7	dB
Layer C MER	30.7	dB
BER	0	Parts Per Billion
PER	0	Parts Per Billion
Right Shoulder	47.6	dB
Left Shoulder	49.5	dB

Figure 1. Real-time display of RF measurements along with Green/Red LED indicators of Pass/Fail conditions.

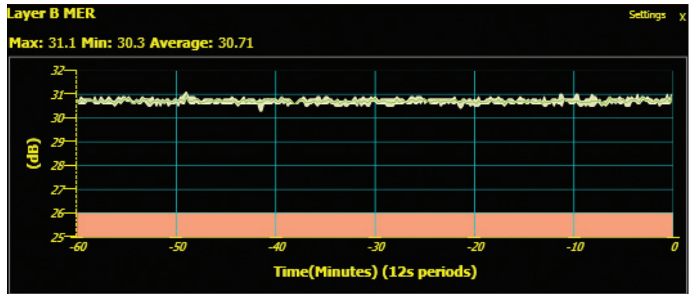

Figure 2. Layer B MER over the last 60 minutes.

Monitoring ISDB-Tb Signals

Every broadcast station needs some means to determine if their programming is being received by viewers at home, as well as those traveling about the city. Monitoring the previous NTSC and PAL transmission was often performed by inserting a special test pattern into a vertical interval line of a frame (VITS) that was not seen by the viewer. Impairments and non-linearity seen on this received signal could easily determine the impact to the rest of the active video signal seen by the viewer. Today, we no longer have that luxury as only the active video lines are sent, and in a compressed form making it more difficult to determine how RF impairments affect the video quality.

Determining the optimum monitoring solution can be quite involved today. The basis for this new ISDB-Tb digital broadcast standard is the suite of documents from ABNT NBR. This standard is derived from the Japanese ISDB-T standard, along with a few additions (such as H.264 video) making it relevant for most of South America. The primary standard is ABNT NBR 15601 for modulation and transmission, but many more exist for compression (15602), multiplexing (15603), as well as many other standards.

Objective Monitoring

The most important part of a broadcast engineer's job is to ensure that the broadcast content (TV program) can be faithfully transmitted from the tower to the viewer without impairments or interference.

One method of ensuring this is to place a tap on the transmitter's High Power Amplifier output and monitor the live signal. This is a good method, but does not take into account potential antenna issues, or external interference.

A better method is to place an antenna somewhere within the city (e.g., TV studio roof) and monitor the signal at this point. This will be representative of the signal that a viewer sees. At this point, the most important measurements should be:

- Signal Strength
- Signal Noise (MER) on each layer
- Multipath Reflections (or Delay Profile)

The Tektronix RFM220 ISDB-Tb Measurement Demodulator provides these key measurements, along with a host of additional RF measurements as shown in Figure 1.

As RF measurements are affected by environmental conditions, a true measure can only be made by making RF measurements over time. In the RFM220, each measurement is logged into a database which provides a Max/Min/Average over the last seven days. Figure 2 shows the Layer B Modulation Error Ratio over the last 60 minutes. The red band indicates the level at which the MER will raise an alarm and an SNMP trap.

Figure 3. MPEG slice and block errors due to RF impairments.

When the Signal strength level or MER level drops into the red band of the graph, this would be a call-to-action for engineering as the signal is beginning to approach the cliff-effect. This is the point at which a digital TV signal changes rapidly between a perfect TV program, and no program, or somewhere in between, where the picture is occasionally blocky, or several slices or rows have been distorted as seen in Figure 3.

Using the RFM220 provides a reliable method to know what type is signal is really being delivered to the viewers. Any time that the signal strays beyond the levels set by engineering, the monitor will indicate the error, trip an alarm condition, and notify the appropriate server that a major violation has occurred.

Subjective Monitoring

An alternative method to buying test equipment is to simply put an antenna on the roof of the studio and run its cable down to a Digital Converter and then watch the TV program. The problem with this basic solution is that:

- The Digital Converter will not be able to provide an accurate readout of its given signal strength. Therefore, it will be impossible to know when the cliff-effect is being approached.
- Each TV viewer is likely to have a different Digital Converter making it difficult or impossible to know when interoperability issues are occurring.
- Some viewers may be watching one TV program within a multiplex while other viewers are watching a different TV program within the same multiplex. It is difficult for broadcast operators to reliably watch more than one program at a time.

Previous monitoring methods would simply demodulate the signal and view the VITS line for impairments and non-linearity. But in MPEG transmission, these possibilities no longer exist.

Therefore, the broadcaster needs some method to ensure that all viewers are receiving an adequate amount of signal strength, and that all programs are viewable.

Tradeoffs

Both objective and subjective approaches let you know if you are on-air, but the subjective method lacks a way to let you know if you are:

- Being received by the entire city
- Near the digital cliff
- Able to quantify the quality of the RF signal

Therefore, it would never be advisable to use a Digital Converter within the studio to determine the signal quality that the general population is receiving from the transmitter. The RFM220 would provide the most accurate and reliable method to monitor a live broadcast ISDB-Tb signal.

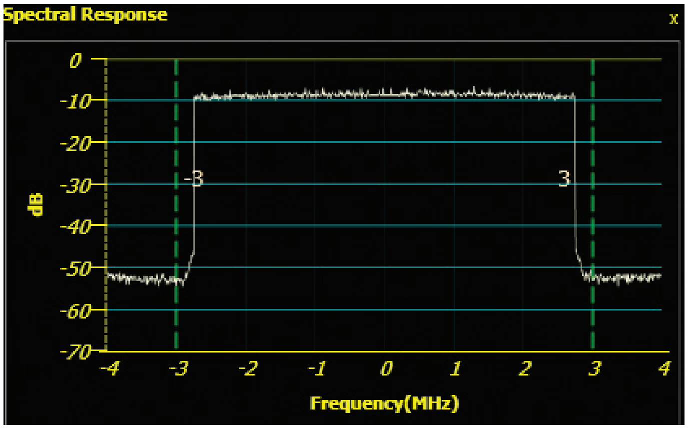

Figure 4. ISDB-Tb signal with good frequency response (no adjacent carriers).

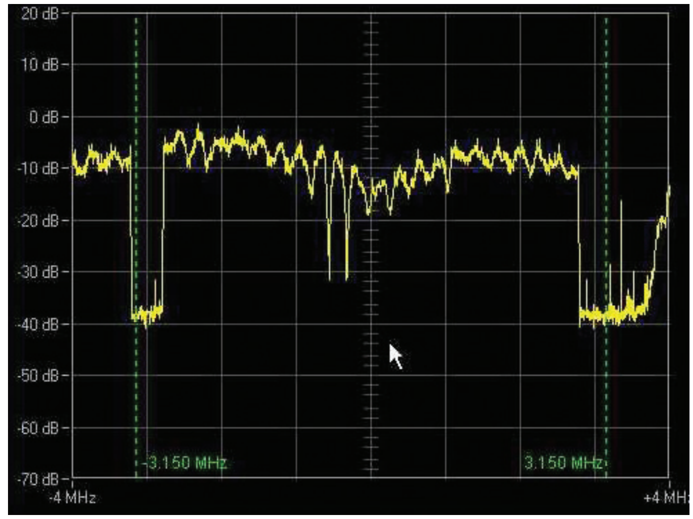

Figure 5. ISDB-Tb signal with poor frequency response. This signal has a digital carrier one channel below and a PAL signal one channel above.

Diagnostics and Troubleshooting ISDB-Tb signals

What to do when good levels and MER are not enough. Occasionally, things go wrong rather abruptly. This could be after performing a firmware upgrade with a piece of broadcast equipment, when a content provider makes a codec change, or when another broadcaster begins to impair your signal with excessive power levels. These somewhat isolated incidents may or may not have an impact on the transmission of your RF signal. But to the rest of the city watching your TV program, it could be the difference between a perfect program and no program at all.

When one or more viewers call in with TV program quality complaints, additional measurements beyond signal strength and MER need to be checked. If the one or more TV sets in the studio still look and sound fine even though complaints are still coming in, then the following list is well worth pursuing as not all Digital Converters will act alike when faced with RF or MPEG impairments.

- Spectral Plot
- Multipath Plot (Delay Profile)
- ISO/IEC 13818-1 MPEG-2 Transport Stream Compliance
- ABNT NBR 15603 Multiplex SI/EPG Compliance
- Video Quality of Experience
- Audio Loudness
- ABNT NBR 15602 codec compliance

Some Digital Converters are simply better at hiding errors, while other Digital Converters completely fail at the slightest RF or MPEG problem. Keep in mind that Digital Converters are not required to perform well in the presence of a bad signal or MPEG stream. Therefore, a broadcaster should verify much more that the basic RF transmission parameters.

Preferred Solutions

Spectral Plot

Each broadcast signal consumes 6 MHz of bandwidth around a center carrier. Each signal should occupy just that 6 MHz region without any harmonics or aberrations leaking into the adjacent channel. Any leakage, drift, or abnormal harmonics could easily cause serious harm to the adjacent signal. Excessive adjacent channel interference can cause enough distortion to completely destroy the adjacent channel. Occasionally, the transmitted signal, composed of thousands of low bandwidth carriers (as defined by DVB COFDM), may become impaired on just a small percentage of these carriers. One simple method is to review the health of the 6 MHz ISDB-Tb signal by using the Spectral plot from the RFM220. A clean ISDB-Tb signal should be flat and without deformity. It should not leak outside its 6 MHz boundaries, and the adjacent channels should do the same. Figure 4 shows a clean ISDB-Tb signal, while Figure 5 shows a signal with non-linearity.

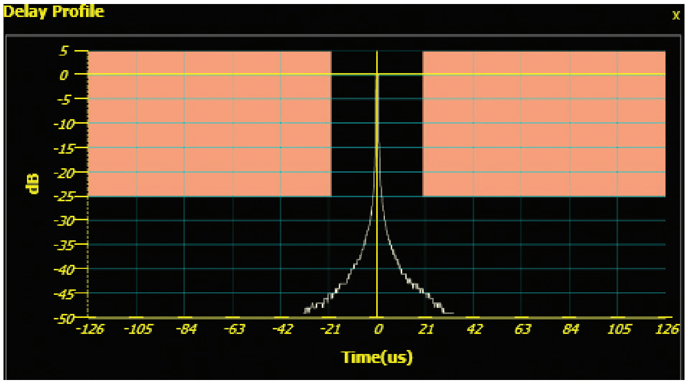

Figure 6. ISDB-Tb signal with no multipath or reflections.

Multipath Plot

Many broadcasters use a single high powered transmitter to deliver their programming across the city and neighboring areas. When the region is too large, or hills and valleys make it impossible for one transmitter to reach every home, then a series of synchronized transmitters (all on the same frequency - SFN) run in parallel to deliver one highly reliable signal to all viewers. If any one of these transmitters fails to stay synchronized, then a Digital Converter may not be able to faithfully recover the digital TV program. Also, if enough of a strong signal is reflected off of one or more tall buildings or hillsides, then the Digital Converter may end up seeing two different signals, or a slight delay between the two. ISDB-Tb Digital Converters are capable of coping with small delays between one or more identical signals, but at some point, they become unmanageable. Therefore, it is important to monitor all transmissions and reflections of a known frequency to ensure that the amplitude and delay between them is kept to a manageable level. The RFM220 provides a plot showing the amplitude of all carriers using the same frequency. The red bands identify the region that the lower powered carriers need to avoid. Figure 6 shows a multipath plot with no additional carriers.

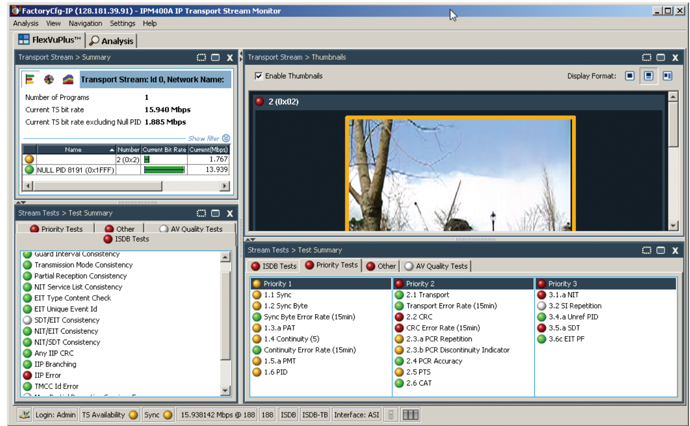

Figure 7. MTM400A measuring transport compliance from the ASI output of an RFM220.

ISO/IEC 13818-1 MPEG-2 Transport Stream Compliance

Many Digital Converters fail when some of the MPEG-2 transport requirements are not met. These range from PAT and PMT section/table problems, to PCR and DTS/PTS timing issues. When these problems are detected by the Digital Converter, it may fail in any number of ways, or maybe not at all. To make things more difficult, one error may cause one Digital Converter to fail, while a different Digital Converter ignores the error. The only true method to determine Digital Converter interoperability is to ensure compliance to ETSI TR 101 290. The RFM220 works together with the Tektronix MTM400A Transport Stream Monitor to demodulate and monitor Transport Stream compliance. Figure 7 shows an MTM400A monitoring an ISDB-Tb Transport Stream. This example includes a history of several errors (orange LEDs), and a few current sections errors (red LEDs). The CRC errors are indicative of a checksum problem in one or more of the tables.

Figure 8. VQS1000 Blockiness graph peaking at 100% during a fast-action scene.

Figure 9. VQS1000 measuring Short term audio loudness.

ABNT NBR 15603 Multiplex SI/EPG Compliance

Another powerful reason to use the MTM400A to is to ensure that the ASI stream feeding the RF modulator does indeed include the correct ISDB-Tb IIP and TMCC tables. Failure to do so often causes disastrous results as the modulator/up-convertor looks to the tables and related transport trailer bytes to determine which packets go into which layers of the ISDB-Tb QPSK and QAM signals. Any mix-up in the tables and the resulting channel may become useless. Any time that the multiplex is changed (e.g., adding a new SD channel to the lineup), it is advisable to validate the structure of the new stream in order to guarantee that the Digital Converter will be able to decode the newly modified stream. Figure 7 also shows a test of the IIP and TMCC tables associated with the transport stream. In this case the TMCC tables are correct, but the IIP table is in error. A bad or lacking IIP table means that the modulator may not know which modulation scheme or FEC to perform on each transport packet.

Video Quality of Experience

Sometimes the RF or transport errors cause the video Quality of Experience (QoE) to degrade. There are also times in which the RF and transport stream are perfect, but the video QoE still has problems (e.g., frozen, blocky, slice errors). In this case, the QoE problems in the content were present in the ingested content. It is assumed that this incoming content is error free. For those times in which the video QoE is questionable, the Tektronix VQS1000 Video and Audio Quality Analyzer is a great tool for decoding to baseband and then observing the video. The video processing is performed by taking the RFM220 ASI output signal and passing it through the MTM400A for real-time processing in a PC or server. The resulting measurements alert the operator to any large amounts of black, frozen or blocky frames. These results can be gated over a series of frames or seconds as it is common to have black or still frames for a short period of time. Also, given that encoders commonly use constant bandwidth with variable quality, we occasionally have fast-action scenes in which a normal encoder over compresses a few frames while trying to keep up with the action. Figure 8 shows a blockiness graph over the last 60 seconds with the last few seconds peaking at 100% during a fast-action video segment.

Audio Loudness

Ensuring a consistent quality of audio level can be difficult on a compressed stream. As with the video QoS being measured from the RFM220 and MTM400A, so can the audio quality (QoE) be measured from the VQS1000. The most important point is to ensure a constant level over time using audio loudness standards such as ITU 1770. The VQS1000 software can measure Dial Norm delta, True Peak, Short term loudness, and Long term loudness. Figure 9 shows the VQS1000 measuring Short term loudness in LKFS unit over time, along with the ballistics meters and waveform displays.

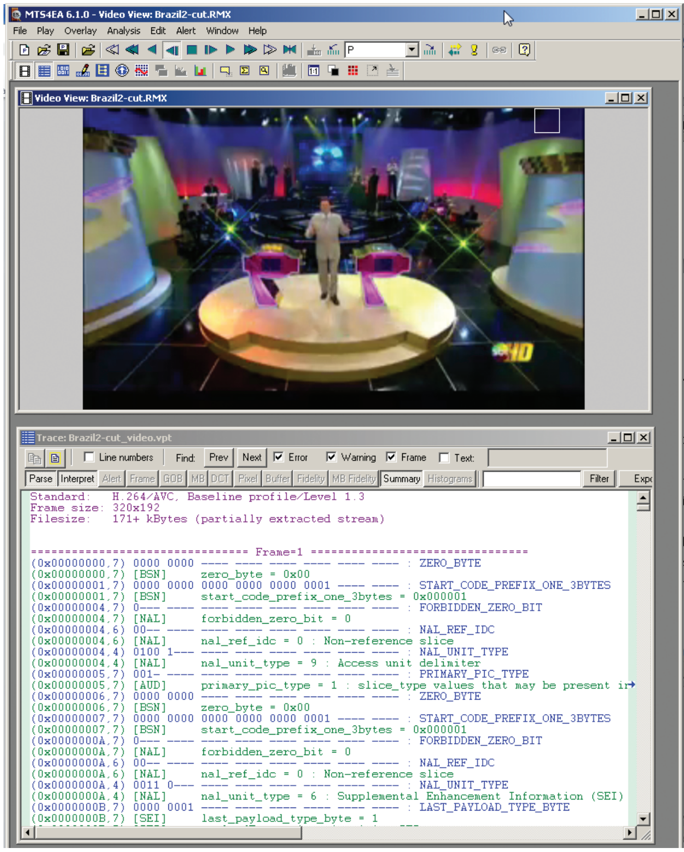

Figure 10. MTS4EA validating the H.264 codec protocol.

ABNT NBR 15602 codec compliance

MPEG-2 and H.264 video encoders are carefully reviewed after each firmware release so that they rarely have encoding protocol issues. But, when they do, they are hard to find. The problem is that so many Digital Converters tend to hide problems in video and audio streams. This can be extremely confusing as many different Digital Converters show a valid program while one or two other Digital Converters determine that a signal is not useable. When this happens, and all previously mentioned tests continue to pass, it is time to take a stream capture of the live program from the MTM400A and analyze it with an Elementary Stream Analyzer like the Tektronix MTS4EA. This application software will test every single command in the video elementary stream and indicate any incorrect commands or parameters. Figure 10 shows the MTS4EA validating the H.264 protocol syntax and semantics from an ISDB-Tb transport stream.

Alternative Solutions

There are alternative methods to achieve some of the same results, but they will not be the most cost effective solutions. If you happen to have an available spectrum analyzer at each broadcast station, then you will probably be OK with its results, but to outfit each broadcast station with its own spectrum analyzer would be cost prohibitive.

As well for multipath reflections, there are instruments that can measure SFN delay or multipath, but the results will be similar and the application is already built into each RFM220.

The RFM220 ASI output can be measured by other devices that comply with ETSI TR 101 290, but pay close attention to how much additional capability is provided for IIP and TMCC testing which is crucial for maintaining an accurate ISDB-Tb network. Also, using the MTM400A provides the added ability to leverage the VQS1000 for both video and audio QoE testing.

When it comes to codec compliance testing, make sure that you have a means to acquire or record the stream to disk before processing.

Tradeoffs

All in all, there are a variety of solutions available for diagnostics and troubleshooting ISDB-Tb signals, and Tektronix has the most affordable and complete offering from satellite to IP ingest, to ISDB-Tb IIP and TMCC testing, to RF monitoring, and back to baseband QoE. Tektronix covers ISDB-Tb from End to End.

Summary

For day to day RF monitoring of ISDB-Tb signals, the RFM220 is perfectly equipped to provide and log all of the critical measurement results. Additional measurements are available as well visualizing the QPSK and QAM constellations as well as spectral and delay plots.

For more difficult issues like transport, codec, and QoE support, additional tools in support of the RFM220 will complete the task of detecting and resolving virtually any ISDB-Tb problem that arises.

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Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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