Measurements on MPEG2 and DVB-T signals (1)

With the expansion of multi-frequency networks (MFNs) and single-frequency networks (SFNs) for DVB-T*, there is a growing demand for measuring instruments and techniques for this modern transmission method. The instruments used for analog TV are not suitable for DVB apart from a few exceptions like spectrum analyzers and thermal power meters.

Not only do the measuring instruments for the three DVB systems, i.e.
- DVB-C for cable transmission,
- DVB-S for satellite transmission
- DVB-T for terrestrial transmission

differ considerably from the conventional technology, but the test parameters and associated test methods as well. This refresher topic, which is to be continued over several issues, presents measuring instruments and techniques from Rohde & Schwarz specially designed for DVB-T. After a brief description of the signal feed and transmitters for DVB-T, which explains the special features of the system, test parameters, methods and instruments are described.

In the studio: from programs to transport streams

In the studio, the video data are coded to ITU-R BT.601 and the audio data to AES/EBU in compliance with the MPEG2 guidelines. Data containers for general data such as teletext are

* Abbreviations in italics: explanation in “Glossary” box on page 33.
Protocol analysis with enhanced functionality

Video quality analysis to MPEG2; decoding with enhanced functionality

Test sequence control from PC

Refresher topic
adds, as well as the indispensable tables to PSI and SI specifications. The result is a multiplexed, packetized transport stream (TS) that can contain a large number of TV programs. For terrestrial transmission in single-frequency networks, the sync information for the individual transmitters must still be added. Based on GPS, the MIP inserter introduces all important sync data into the TS, which is then sent to all transmitters in the network (FIG 1). There are a number of ways of doing this:

- Radio-relay or satellite links with QPSK modulation
- Cable over very short distances or fiber-optic links with ATM and SDH/PDH protocols

In the transmitter: from transport stream to DVB-T symbol

The DVB-T transmitter uses COFDM for data modulation. “C” for “coded” stands for a variety of error control measures such as energy dispersal, Reed-Solomon and Viterbi forward error correction, which are enhanced by the convolutional interleaver and the bit and symbol interleaver. After insertion of the TPS carriers and the pilots for channel correction in the receiver, OFDM proper is carried out. The DVB-T symbol is generated together with the guard interval, which precedes the symbol. Then follows D/A conversion and boosting of the signal to the desired output power by means of liquid-cooled solid-state amplifiers. Several transistorized amplifiers are connected in parallel to give output powers in the kilowatt range.

Key measurements in the studio

What measurements on MPEG2 and DVB signals used for digital TV are necessary and sensible?

The output signals produced in digital studios are, except for a few minor differences, the same for the three DVB systems. In the studio, several transport streams are coded – one for each program. This is the critical stage to ensure that the transport streams actually intended for transmission have been combined, as signals may be misrouted by the digital crossbars ahead of the last TS multiplexer allowing unwanted transport streams to pass.

Realtime monitoring of the TS protocol at the studio output is therefore essential.

Monitoring parameters PAT and PMT

Apart from the data rates of the programs and their elements, the PAT and the PMT to which reference is made in the PATs, are the main parameters to be monitored. The PAT is a list of all programs in a TS, whereas PMTs contain the associated program elements. The European Guideline ETR290 [1] defines all parameters which a monitoring system must handle. An ideal instrument for this is MPEG2 Measurement Decoder DVMD from Rohde & Schwarz (FIG 2), which complies with all ETR290 requirements.

A few monitoring examples, a PMT (FIG 3), three-priority error statistics (FIG 4) and an error report (FIG 5) as proposed by the standard are shown as on-screen displays. The program that is currently being decoded is available at the DVMD’s CCVS output.

In-depth measurements with Stream Explorer™

The repetition rates for PSI and SI tables are to be defined with the settings in ETR290 for DVB, or with the time references to ISO/IEC13818 for MPEG2. Incorrect program switching is therefore detected immediately and compliance with the MPEG2 protocol is guaranteed. More in-depth measurements are possible with Stream Explorer™ DVMD-B1, an option which allows the user to look at the tables.

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**Table:**

<table>
<thead>
<tr>
<th>PID</th>
<th>Type</th>
<th>Code</th>
<th>CA</th>
<th>PID</th>
<th>Mbs/NET</th>
</tr>
</thead>
<tbody>
<tr>
<td>0200</td>
<td>PAT</td>
<td>0000</td>
<td>002</td>
<td>4.830</td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td>PCR</td>
<td>0001</td>
<td>002</td>
<td>0.132</td>
<td></td>
</tr>
<tr>
<td>3002</td>
<td>DATA</td>
<td>002</td>
<td>0.020</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FIG 3** Program map table output by MPEG2 Measurement Decoder DVMD

**FIG 2** MPEG2 Measurement Decoder DVMD [3]

Data sheet PD 757.2744

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in plain text and at the data in the TS packets. The table contents can be checked for compliance with the DVB system in question. The NIT in particular contains different entries for the three different DVB systems. The plain-text NIT prevents misinterpretations.

**Reference TS in endless loop**
Repeatability protocol measurements should always be possible – at least for the tests performed when setting up a studio. A TS with a live program does not fulfill this requirement: its contents vary constantly giving different, but not widely varying, results at different times. A reference TS is therefore desirable for such measurements.

MPEG2 Measurement Generator DVG (FIG 6), designed for this purpose, has internationally standardized, MPEG2 test sequences for video, audio, data and tables. These sequences are in the form of endless loops and so can be repeated any number of times.

Exceptional conditions sometimes require exceptional signals: the optional Stream Combiner™ DVG-B1 generates the right data stream for any kind of measurement, no matter how unusual it may be.

**Picture quality monitoring using SSCQE**
Not only the MPEG2 protocol has to be monitored but also picture quality after MPEG2 coding at the studio output. The viewers at home expect constantly high picture quality despite the high data compression. As the original picture is usually not available at the studio output for comparison with the decoded MPEG2 picture, a method of measuring picture quality without a reference picture has been deve-
Digital Video Quality Analyzer DVQ (FIG 7) uses an objective version of the SSCQE method described in ITU-R BT.500 [2] to measure the quality of the MPEG2-coded and decoded video signals. Picture quality can also be monitored via the CCVS output on the on-screen display of the video monitor.

Particularly important additional information is derived from long-term picture quality monitoring with display of the data rate of the measured program and the TA and SA, which is offered by option DVQ-B1. This option has two components. The Quality Monitor triggers an alarm if picture quality drops below a certain limit. If the alarm occurs more frequently or over extended periods of time, the settings of the MPEG2 coder and the multiplex equipment must be checked — especially if statistical multiplex coding is used. Only in this way can constantly high picture quality be guaranteed. The second component of the option, the elementary stream analyzer, provides access to the pixel and macro-block level and to the I, P and B coding level of single pictures.

**MIP monitoring**

The MIP inserter is the last point in the TS transmission chain (FIG 1) before program distribution to the transmitters of the SFN. The TS packet with the fixed PID 0x0015 contains GPS time information for synchronizing the complete SFN. If this information is incomplete or errored, transmission in the network may collapse. Monitoring the MIP contents is therefore a priority task and implemented in TS monitoring by MPEG2 Measurement Decoder DVMD (see also article on right).

Three instruments cover all measurements

Complete TS monitoring can be effected with just three measuring instruments from Rohde & Schwarz:
- MPEG2 Measurement Decoder DVMD,
- Digital Video Quality Analyzer DVQ,
- MPEG2 Measurement Generator DVG with appropriate options for repeatable measurements.

Sigmar Grunwald

(to be continued)