1.12 Video Quality Analysis

Any programs broadcast must meet defined video quality standards when they leave the studio. These standards are specified by the program providers to ensure a minimum acceptable video quality for the programs received by TV viewers at home. Therefore, in addition to MPEG2 protocol analysis with DVMD MPEG2 MEASUREMENT DECODER or DVRM MPEG2 REALTIME MONITOR, the quality of MPEG2 coding is to be measured at the studio output.

ITU-R BT.500 describes two methods of subjective video quality assessment.
The first method is based on the direct comparison with a reference picture to determine the quality of a processed picture with high accuracy. This method is known as DSCQS (double stimulus continuous quality scale). It supplies very accurate results in the off-line mode but cannot be employed during the active (running) program.
The second method determines video quality directly from the processed picture during the active program. A reference picture is not needed. This method is referred to as SSCQE (single stimulus continuous quality evaluation). It is optimal for quality monitoring, for example at the studio output, where only the MPEG2-coded, packetized picture is available, but no reference picture.

ITU-R BT.500 has defined a five-level rating scale for the video quality:
excellent, good, fair, poor and bad.
The five quality levels are also displayed on a numerical scale ranging from 100 to 0.

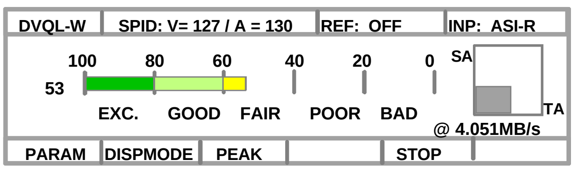


Fig. 1.18 Quality rating scale to ITU-R BT.500

A method has therefore to be found that simulates, based on the decoded MPEG2 data, the subjective perception of an average human eye and the processing of information conveyed by the optic nerve to the brain. This is done by means of a weighting equation, from which the objective picture quality is calculated.

Important parameters of this equation are, for example:

TA	temporal activity and
SA	spatial activity

TA describes the instantaneous motion (i.e. the variation of the picture contents versus time) of a decoded picture, whereas SA reflects the structural complexity of the picture. Both parameters have an impact on picture quality after MPEG2 coding.

The perception of information by an average human eye and the processing of this information in the brain are such that coding errors occurring during fast movements (i.e. with high TA) are usually masked. While with widely splashing water, for example, where picture contents are very close to white noise (high SA), a high degree of blocking effects will be measured objectively, the weighted picture quality will still be adequate. However, if TA is so high that practically no correlation can be established from frame to frame in MPEG2 coding (frame-to-frame coding being the common method used), picture quality at those instants will be low. An example of this is shown in Fig. 1.20.

DIGITAL VIDEO QUALITY ANALYZER DVQ uses a patented method of video quality assessment. This is based on objectively measurable MPEG2 artefacts obtained after coding and decoding. It can be demonstrated that the amplitude differences between neighbouring pixels located within a pixel block remain within narrow tolerance limits and are smaller than the amplitude differences between neighbouring pixels extending across pixel block or macroblock boundaries.

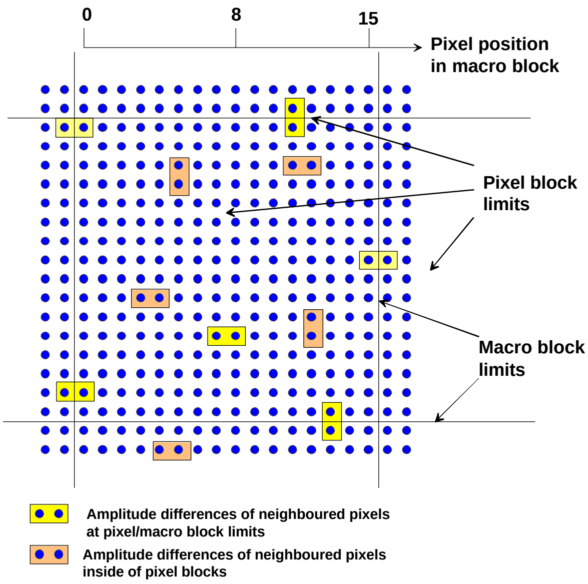


Fig. 1.19 Amplitude difference between neighbouring pixels

The above effect results from the quantization of the DC coefficients during MPEG2 coding. Substantial amplitude differences at the block boundaries make themselves felt as "blocking", which strongly affects picture quality.

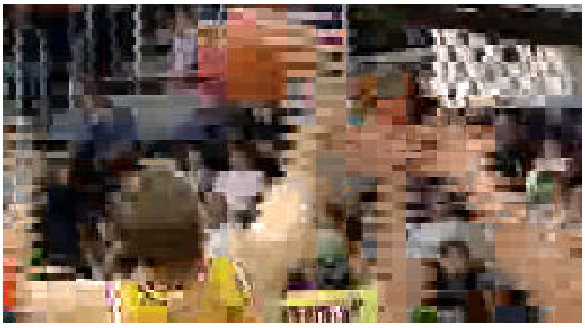
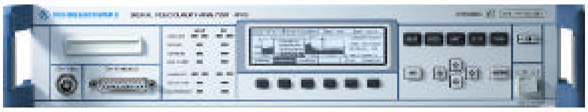


Fig. 1.20 Strong blocking effects

Such poor coding results are reliably detected with DIGITAL VIDEO QUALITY ANALYZER DVQ. The analyzer outputs an alarm if video quality falls below specified tolerance limits, so guaranteeing at any time a minimum acceptable picture quality for the programs received by TV viewers.



Condensed data
DIGITAL VIDEO QUALITY ANALYZER DVQ

Signal inputs	ASI SPI ITU-R BT.601 and AES/EBU
Coding formats Video	 MPEG2 MP@ML, MPEG2 4:2:2P@ML
Audio	MPEG1 layers 1 and 2 Dolby® AC-3
Events recorded in REPORT (and signalled by LEDs)	picture loss, picture freeze, quality below threshold, sound loss left, sound loss right
Measurements	temporal activity (TA), spatial activity (SA), unweighted video quality, weighted video quality
Alarm outputs	12 floating relay contacts
Decoder outputs Video	 1x CCVS, 1x ITU-R BT.601
Audio	2x analog audio R/L, 1x AES/EBU
Interfaces	RS232C, Ethernet 10baseT

1.12.1 Measurements with DVQ and DVQM

The SCAN function of DIGITAL VIDEO QUALITY ANALYZER DVQ allows the consecutive quality analysis of all programs contained in a TS. This method is suitable as long as only two or three programs are to be monitored. With a measurement time of only 10 s per program, a test cycle will be completed after about 20 s. However, if a larger number of programs is to be analyzed, a test cycle may well take up to two minutes, which is not acceptable for monitoring purposes. For such applications, parallel monitoring of all programs of a TS is mandatory.

To refresh you memory: Data rates in the 8 MHz UHF DVCB-C channel and the 33 (36) MHz DVB-S transponder are about 38 Mbit/s, which corresponds to seven to ten programs in a transport stream.

The solution to this problem is MULTICHANNEL QUALITY ANALYZER DVQM, which allows the simultaneous monitoring of up to 12 programs of a transport stream. DVQM accommodates up to 12 DVQ measurement boards in a 19" rack. If a TS contains encrypted (scrambled) programs, these can be decrypted and analyzed by means of the descrambling options. With these options fitted, the number of encrypted programs that can be monitored with DVQM is reduced to six (see also condensed data of DVQM).

DVQM provides straightforward status indication for all of the 12 programs monitored by means of an LED field on the front panel.
The DTV NetView software supplied as standard enables remote query of all quality parameters (DVQL as an option).

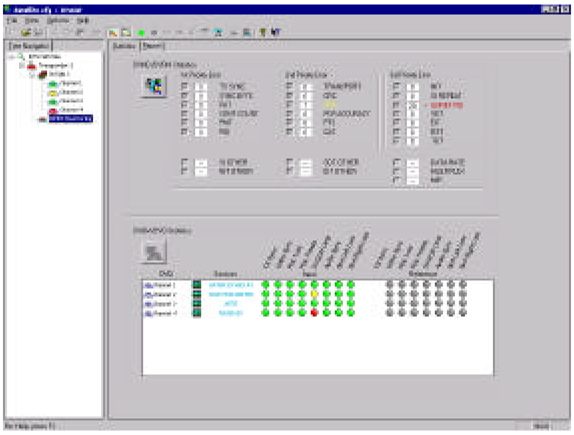


Fig. 1.21 DTV NetView menu for parallel channel monitoring

Moreover, the QUALITY MONITOR software is available on the Rohde & Schwarz homepage. This software, which can be used with DVQ and DVQM, allows long-term monitoring of the following parameters:

DVQL-W digital video quality level weighted
(optional with DVQM)
TA temporal activity
SA spatial activity
Bit rate

This function can be performed on all programs, irrespective of whether the transport stream is coded with constant bit rate (CBR) or variable bit rate (VBR) in the statistical multiplex.

QUALITY MONITOR with CBR-coded TS

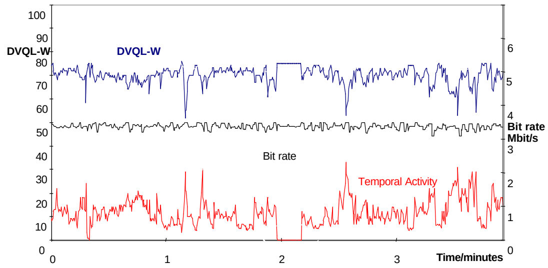


Fig. 1.22 Long-term monitoring of CBR-coded TS with QUALITY MONITOR

There is an obvious relationship between short-term TA peaks and short-term low video quality, as occurs in abrupt changes of scene. Another remarkable point is at TA = 0 (at 2 min), where maximum video quality is obtained with constant, specified data rate.

QUALITY MONITOR with VBR-coded TS

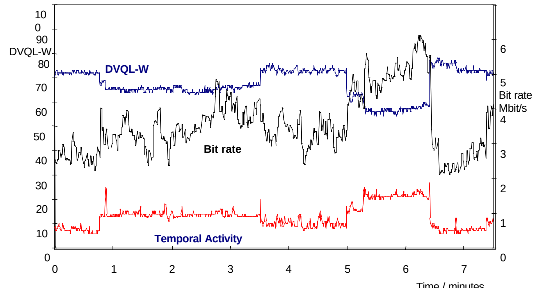


Fig. 1.23 Long-term monitoring of VBR-coded TS (statistical multiplex) with QUALITY MONITOR

With low TA, video quality is high. As TA increases, video quality decreases (see intervals from 40 s to 3 min 30 s and 5 min to 6 min 30 s). In the above example it is attempted to improve video quality by using higher data rates in the statistical multiplex, which however fails.

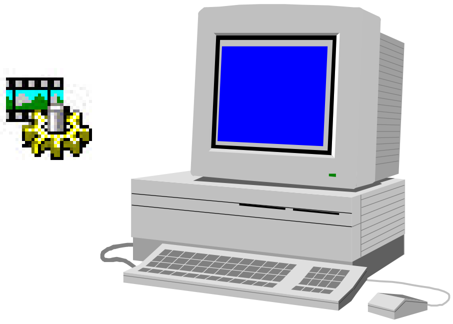
The data rate is changed in this process from approx. 2 Mbit/s to approx. 6 Mbit/s.

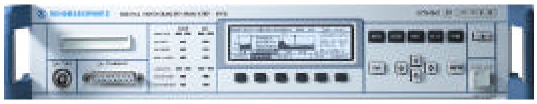
MULTICHANNEL QUALITY ANALYZER DVQM

Condensed data
MULTICHANNEL QUALITY ANALYZER DVQM

Signal inputs, signal outputs coding formats, etc	same as DVQ
Measurements	same as DVQ, optionally: weighted video quality
Signal processing	DVB and ATSC standard
Descrambler system (optional)	Conax, NagraVision or Viaccess, Irdeto, Mediaguard
Decoder outputs	
Video	1x CCVS 1x ITU-R BT.601,
Audio	2x analog audio R/L 1x AES/EBU
Interfaces	RS232C Ethernet 10baseT SNMP

1.12.2 QUALITY EXPLORER® DVQ-B1





The QUALITY MONITOR software, which is available on the Rohde & Schwarz homepage, monitors video quality after MPEG2 coding as well as the data rate, the rate of change of the picture contents (temporal activity, TA), and the structural complexity of the picture (spatial activity, SA). To analyze the structure of sequences, GOPs and macroblocks, and to check header assignment for these picture elements, QUALITY EXPLORER® DVQ-B1 with ELEMENTARY STREAM ANALYZER ESA is available.

DVQ stores a selectable number of TS packets, e.g. 4000. These packets are transferred to a PC via the RS232C or the Ethernet interface for evaluation. In the following example, somewhat more than three sequences (GOPs) with a length of 12 pictures are obtained for 4000 TS packets.

In the following, the headers of sequences, GOPs and I, P and B pictures can be called from the "Diver" transport stream stored in DVG or DVRG.

The first figure shows the interpreted header of a sequence.

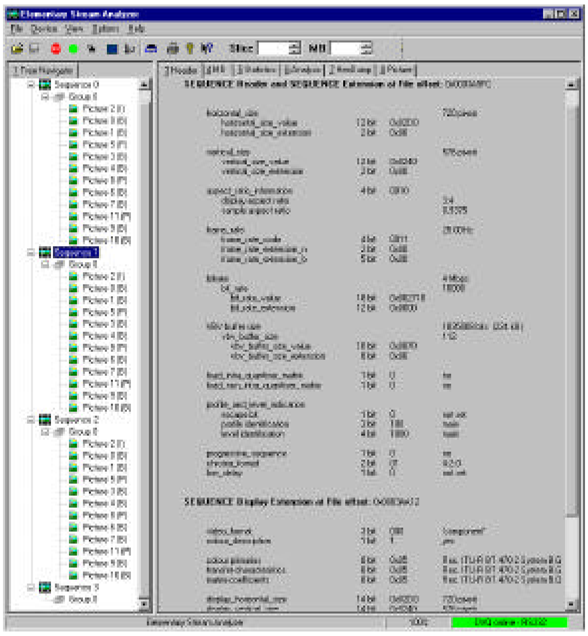


Fig. 1.24 Sequence header

The second figure shows the interpreted header of a GOP (group of pictures).

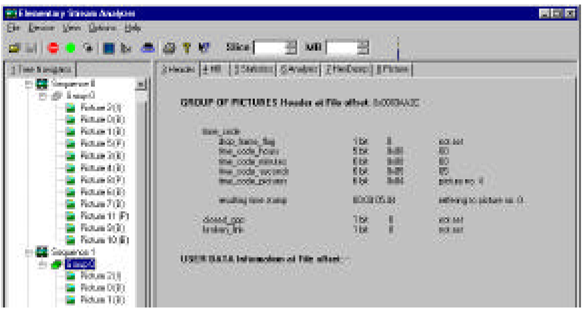


Fig. 1.25 GOP header

The third figure shows the interpreted header of an intraframe-coded picture.

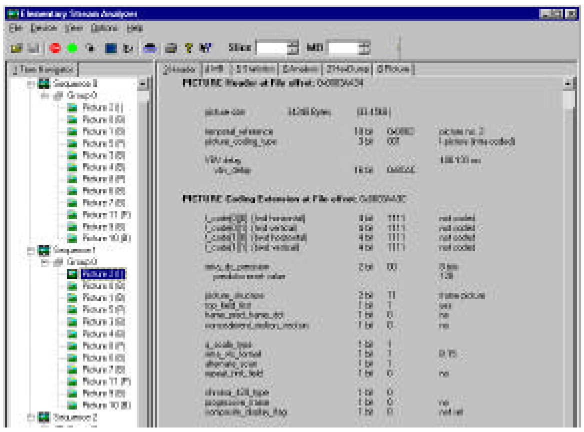


Fig. 1.26 Header of an intraframe-coded picture

Another display shows the tree structure of the GOPs and pictures of a TS as well as a selected picture analyzed according to macroblock types of the "Flower garden" test TS.

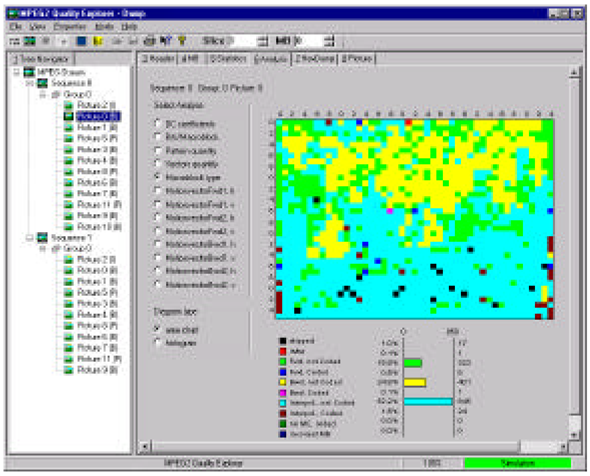


Fig. 1.27 Tree structure of GOP and analysis of B picture according to macroblock types
(GOP: group of pictures,
B picture: bidirectional predicted picture)

In the above figure it can be seen that not all macroblocks of the B picture bidirectionally coded. P and I coded macroblocks exist too. Some macroblocks are skipped because the information they carry has been transmitted before or can be obtained by way of calculation.

Not only the macroblock type is of interest but also the distribution of the numerical DCT coefficients in a macroblock.
In addition to other important information regarding macroblock structure, the DCT coefficients can be displayed in various modes:

QFS (n) Display of DCT coefficients after zigzag scanning
QF (v)(u) Display of DCT coefficients before zigzag scanning
F (v)(u) Display of DCT coefficients after quantization and before zigzag scanning

The decoded pixel values of a pixel block can be displayed too:

f (y)(x) Spatial representation of pixels

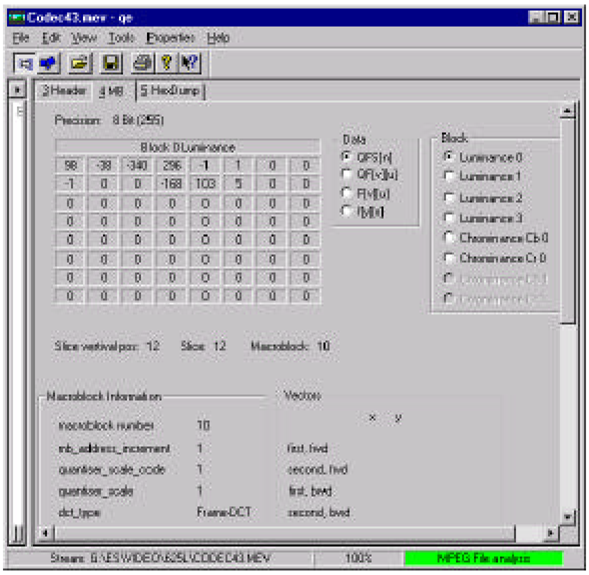


Fig. 1.28 Macroblock analysis

Further important information on video quality is obtained from the distribution of the DC coefficients of the macroblocks in intraframe-coded pictures (I pictures), for example in the "CODEC 4:3" test TS.

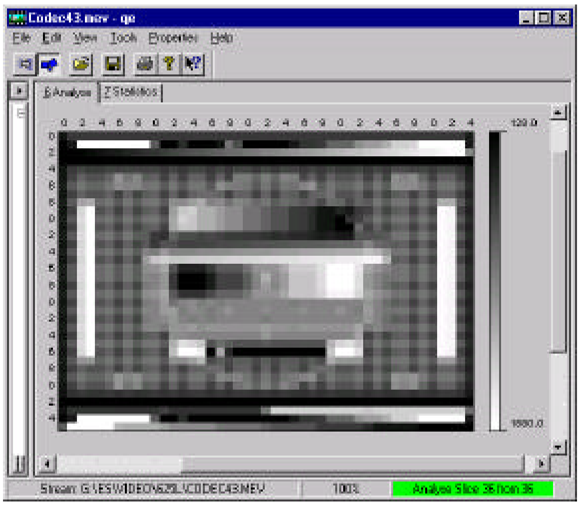


Fig. 1.29 Distribution of DC coefficients in I picture

Another important criterion for video quality assessment are the different macroblock types encountered in forward predicted (P) pictures and bidirectional predicted (B) pictures.

The prevailing type (yellow, backwards, not coded) cannot be used in the lower part of the picture (as can be seen in the example in Fig. 1.27) because there exists no correlation between consecutive pictures (brown, interpolated, coded).

In this picture area of the "DVTS" MPEG2 test TS stored in DVG/DVRG there is white noise.

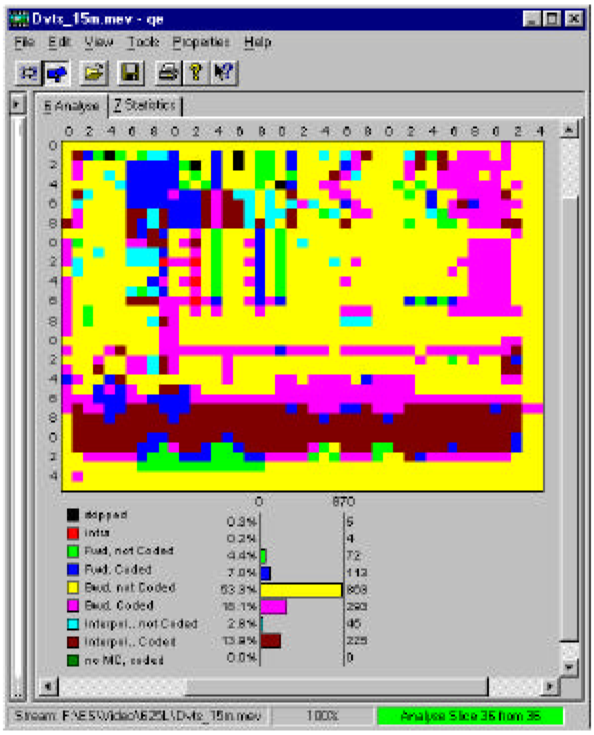


Fig. 1.30 Macroblock types in B pictures

The "HexDump" function provides information on the data volume carried in a macroblock. Fig. 1.31 shows the contents of the header of the first P picture of sequence 1 as well as the contents of macroblock 35 of slice 4.

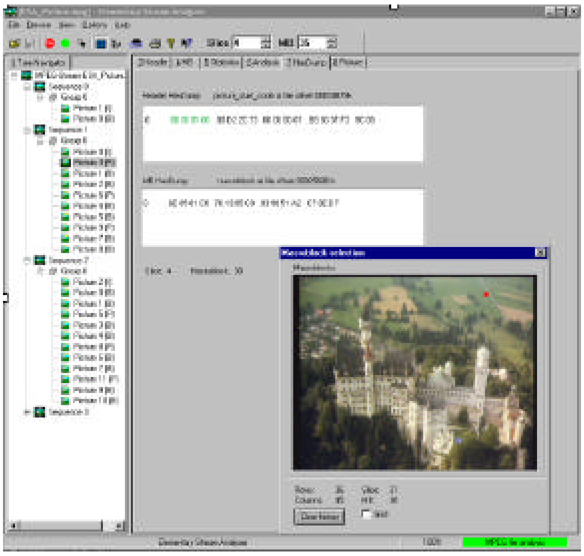


Fig. 1.31 Data within macroblock marked red shown as hex dump

In the "Picture" mode, Elementary Stream Analyzer ESA displays a selected decoded picture of a stored sequence. This display allows the most accurate analysis of errors occurring in MPEG2 coding and subsequent decoding, for example of pronounced blocking effects in the central area of a picture of the "Squirrel" sequence.

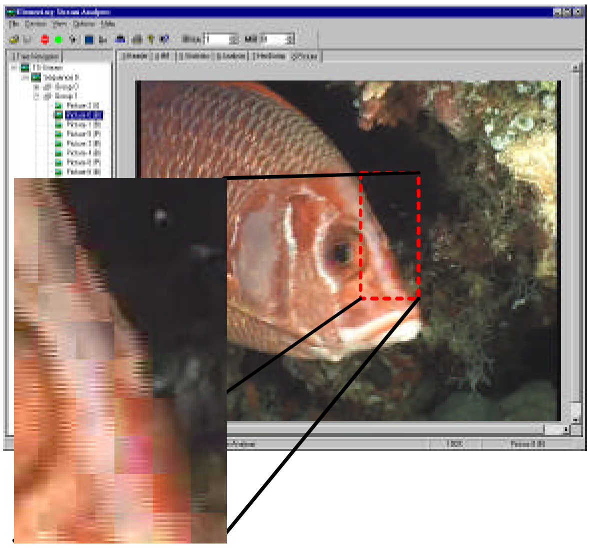


Fig. 1.32 B picture of the "Squirrel" sequence showing strong blocking effects

QUALITY EXPLORER® DVQ-B1 enables detailed protocol analysis of all elementary streams as well as analysis of the picture contents at macroblock level, including the evaluation of DCT coefficients, and additionally furnishes a representation of the decoded pixel blocks. It is ideal for checking MPEG2 encoder functionality.