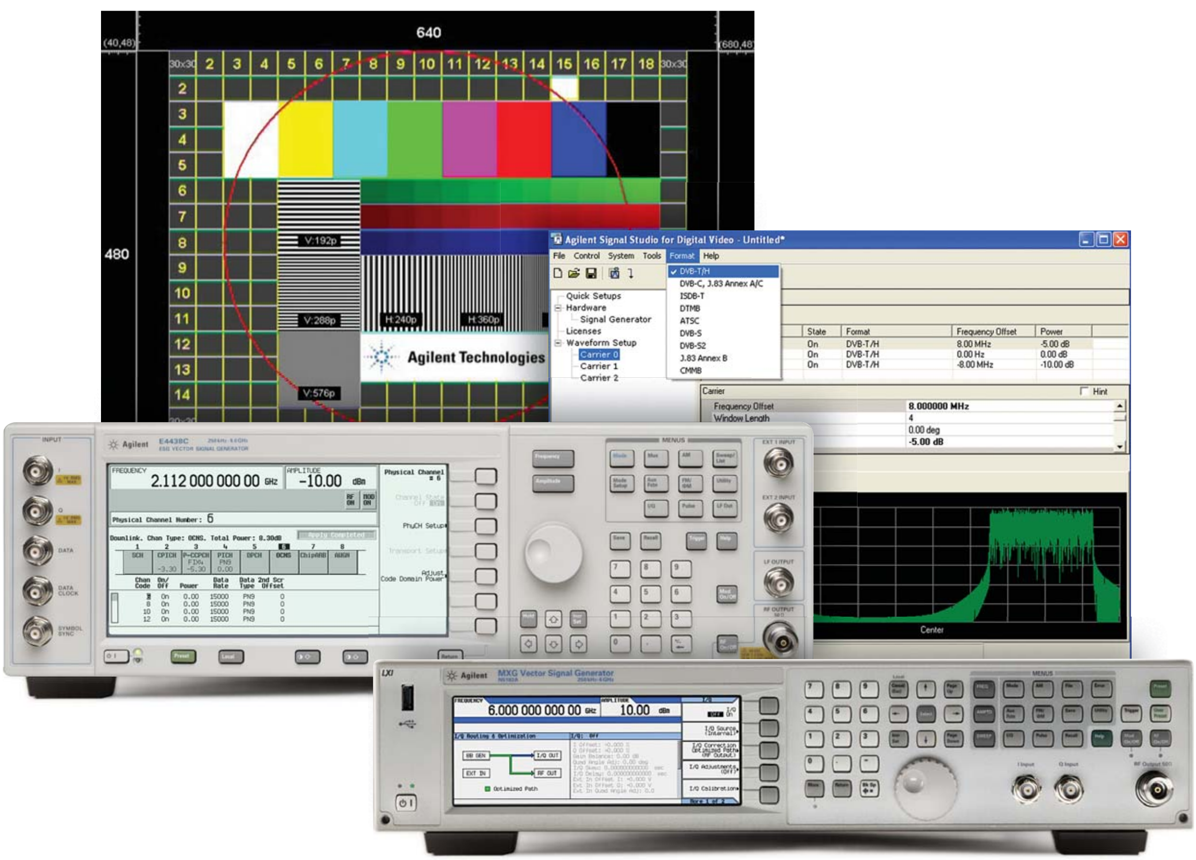
BER and Subjective Evaluation for DVB-T/H Receiver Test

Application Note



An optimized solution for pre-production R&D and manufacturing

Agilent Technologies

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Introduction and Abbreviations

Agilent Technologies N7623B Signal Studio for digital video is software designed to simulate multiple formats of video broadcast ARB waveforms including: DVB-T/H/C/S, ISDB-T/T_{SB}/T_B, DTMB, ATSC, T-DMB, S-DMB, CMMB, and J.83 Annex A/B/C. Agilent's PSG/ESG/MXG vector signal generators are optimized for all in one mobile receiver test including video, cellular communication and wireless connection applications. This application notes focuses on DVB-T/H receiver test.

Abbreviations

ARB	Arbitrary waveform
ATSC	Advanced Television System Committee
BER	Bit error ratio
CIF	Common intermediate format
C/N (C/I)	Carrier to noise (interference) ratio
DRM	Digital rights management
DSM-CC	Digital storage media - command and control
DTMB	Digital terrestrial multimedia broadcast
DVB	Digital video broadcasting
DVB-H	Digital video broadcasting – handheld
DVB-T	Digital video broadcasting – terrestrial
EN	European normative
FEC	Forward error correction
GSM	Global system for mobile communication
I_MT	Interface of mobile terminal
INT	IP/MAC notification table
IP	Internet protocol
ISDB-T/T_{SB}/T_B	Integrated services digital broadcasting-terrestrial (TSB for Japan sound broadcast , TB for Brazil)
ISO	International Standardization Organization
MBRAI	Mobile and portable DVB-T/H radio access interface
MER	Modulation error ratio
MPE	Multi-protocol encapsulation
MPE-FEC	Multi-protocol encapsulation forward error correction
NIT	Network information table
QEF	Quasi error free
OFDM	Orthogonal frequency division multiplexing
QAM	Quadrate amplitude modulation
PRBS	Pseudo random binary sequence
PID	Packet ID
RS	Reed Solomon
SNR	Signal to noise ratio
TPS	Transport parameter signaling
TV	Television
UMTS	Universal mobile telecommunication system

1. Overview

Video broadcasting is moving towards all digital technology as higher quality video and more bandwidth efficiency become available in digital broadcast systems (although the analog TV systems will co-exist with digital TV systems for years to come). There are many different digital TV standards across the world, categorized as cable, satellite, terrestrial or mobile TV. More and more, set-top boxes (STB) and TV sets require integration of multiple digital broadcast standards such as DVB-T/H, ISDB-T, DTMB and ATSC for worldwide markets. And mobile TV is hot. Developers and manufacturers of mobile phones nowadays are faced with integrating DVB-H and ISDB-T mobile TV broadcasting technology into their devices. This requires test equipment and test procedures different from those required for mobile cellular communications.

Objective BER measurement and subjective video clips are necessary for video receiver evaluation. ARB waveforms that contain repeatable transport stream (TS) short video playback are a cost-effective solution for integrated module design and final subjective evaluation.

This application note describes how to use N7623B Signal Studio for digital video software with the N5182A MXG, N5162A MXG ATE, and E4438C ESG vector signal generators to generate standard-compliant digital video test signals for video receiver and component test. Typical test cases for digital video set-top boxes, TV receivers and handset receivers are covered.

The International Electrotechnical Commission (IEC) created the MBRAI specifications, which call for strict conformance tests that ensure the proper functionality of mobile receiver terminals for DVB-T/H transmissions. MBRAI is a common abbreviation of the IEC 62002 standard and stands for “mobile and portable DVB-T/H radio access interface”. The examples in this application note follow IEC MBRAI test requirements.

2. About DVB-T and DVB-H Technologies

2.1 DVB-T

Digital video broadcasting terrestrial (DVB-T), compliant with the ETSI EN 300 744 standard, is the most popular digital terrestrial transmission system in the world. It has been successfully deployed in the UK, Germany, Sweden, Finland, Spain, Italy, Netherlands, Switzerland, Singapore and Australia. DVB-T trials are currently taking place in China, Malaysia, Thailand, Vietnam, Ukraine, Azerbaijan, Croatia, South Africa and other countries.

DVB-T is the youngest of the three core DVB systems (DVB-C for cable and DVB-S for satellite are the other two). Based on coded orthogonal frequency divisional multiplexing (COFDM) and QPSK, 16 QAM and 64 QAM modulations, it is the most sophisticated and flexible digital terrestrial transmission system available today. DVB-T allows service providers to match, and even improve on, analog coverage - for a fraction of the power. It extends the scope of digital terrestrial television to the mobile field, which was simply not possible before, or with other digital systems.

2.2 DVB-H

Digital video broadcasting handheld (DVB-H) is an extension of DVB-T, which is suitable for small screens, handheld portable devices and mobile reception. Despite the success of mobile DVB-T reception, the major concern with any handheld device is battery life. The power consumption of DVB-T front-end receivers is too high to support handheld receivers that are expected to last from one to several days on a single charge. The new DVB-H standard addresses this requirement for broadcasting to handheld devices. A time-slicing mechanism allows receivers to switch off for inactive periods, leading to power savings of approximately 90 percent. The other major requirements for DVB-H are an ability to receive 15 Mbits per second in an 8 MHz channel and in a wide-area single frequency network (SFN). In order to meet the above requirements, the DVB-H specification includes the following:

- **Time-slicing:** Rather than continuous data transmission as in DVB-T, DVB-H employs a mechanism where bursts of data are received at a time – an IP datacast carousel. This means that the receiver is inactive for much of the time, and can thus, by means of clever control signaling, be "switched off". The result is a power saving of approximately 90 percent and more in some cases.
- **4K-mode:** 4K mode has been added by some 3409 active carriers, DVB-H benefits from the compromise between the high-speed small-area SFN capability of 2K DVB-T and the lower speed but larger area SFN of 8K DVB-T. In addition, with the aid of enhanced in-depth interleavers in the 2K and 4K modes, DVB-H has even better immunity to ignition interference.
- **MPE-FEC:** The addition of an optional, multiplexer level, forward error correction scheme means that DVB-H transmissions can be even more robust. This is advantageous when considering the hostile environments and poor antenna designs typical of handheld receivers.

2.3 Compatibility between DVB-T and DVB-H

Like DVB-T, DVB-H can be used in 6, 7 and 8 MHz channel environments. However, a 5 MHz option is also specified for use in non-broadcast environments. A key initial requirement, and a significant feature of DVB-H, is that it can co-exist with DVB-T in the same multiplex. Thus, you can choose to have 2 DVB-T services and one DVB-H service in the same overall DVB-T multiplex.

3. Receiver Test: BER vs. Subjective Video Evaluation

3.1 Degredation criteria and resynchronization

Four different degradation criteria are used.

a) Reference BER, defined as BER = 2×10^{-4} after Viterbi decoding
b) Picture failure point (PFP)
c) Subjective failure point (SFP) in mobile reception
d) DVB-H error criterion MFER and FER

The criteria a) and b) are used in the non-mobile cases for DVB-T. Criterion c) is for mobile reception in DVB-T and criterion d for DVB-H reception. A receiver must be able to acquire a degraded signal and pass a resynchronization test that ensures the C/N or C/I value is valid. Once the degradation criterion is achieved, all receiver input signals are removed for a period of 5 seconds and then re-applied. The same degradation criterion must be achieved within 5 seconds. The BER criterion is suitable in R&D and production quality assurance (QA) where in-chip reports of BER measurement can be accessed. Subjective criteria are adopted in production and anywhere a BER report is not available.

3.2 BER test points in DVB-T/H systems

Bit error ratio measurement is a general objective test for digital communication systems. For video broadcast systems, BER is defined at several points on the receiver link, as shown in Figure 1. There are 3 types of BER tests in video receiver performance evaluation:

1) BER before Viterbi (inner) decoder, implemented as shown in comparison 1, Figure 3.
2) BER before RS (outer) decoder, implemented as shown in comparison 2, Figure 3.
3) BER after RS (outer) decoder, implemented as shown in comparison 3, Figure 3.

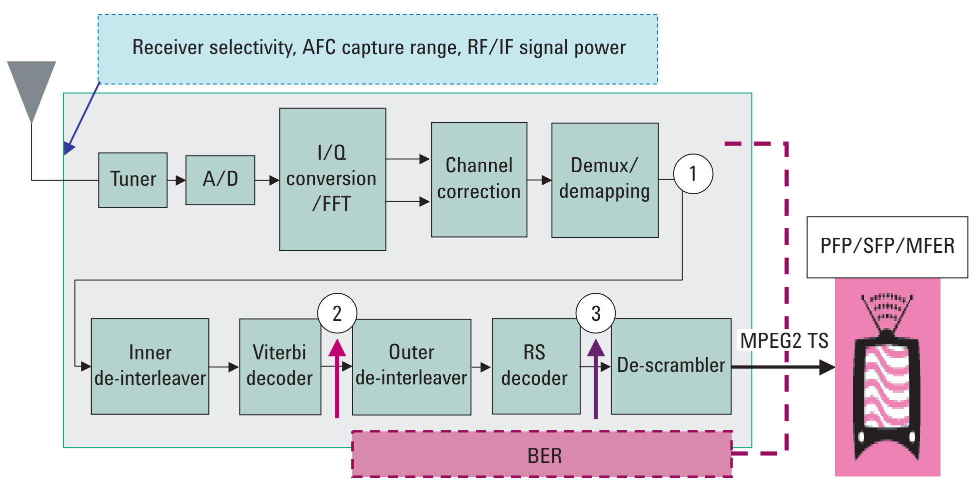

Figure 1. DVB-T/H BER measurement points

A reference BER is defined in a DVB system after Viterbi decoding as:

[b1] Common definition: $BER = \frac{erroneous\_bits}{Total\_number\_of\_bits}$

The reference BER = 2 X 10^{-4} after Viterbi decoding for a DVB-T system is normally 1000 errors counted to ensure a meaning BER rate at 2 X 10^{-4}. The quasi error-free (QEF) criterion defined by the DVB-T standard corresponds to the reference BER.

In a DVB-T/H system, a fixed pattern or pseudo random binary sequence (PRBS) random data is used to test BER after Viterbi decoding (the reference BER). The reference BER measurement is more convenient in engineering as it is easy and quick to achieve the BER of 10e–4 scales.

3.3 BET test with user defined patterns or PN23

BER measurement is an important objective criterion in receiver evaluation, either in an AWGN or fading environment. It can be for a physical (PHY) stream layer or TS layer. The payload can be PRBS ($2e^{23}$–1, $2e^{15}$–1), all one, all zero or used-defined patterns.

3.3.1 PHY stream layer measurements

The basic serial BER stream can be a PRBS, all ones or all zeros. The PRBS, in compliance with ITU-T O.151, is based on the generator polynomial, $2e^{23}$–1 or $2e^{15}$–1. Figure 2 shows the menu on which the payload of the test stream can be selected.

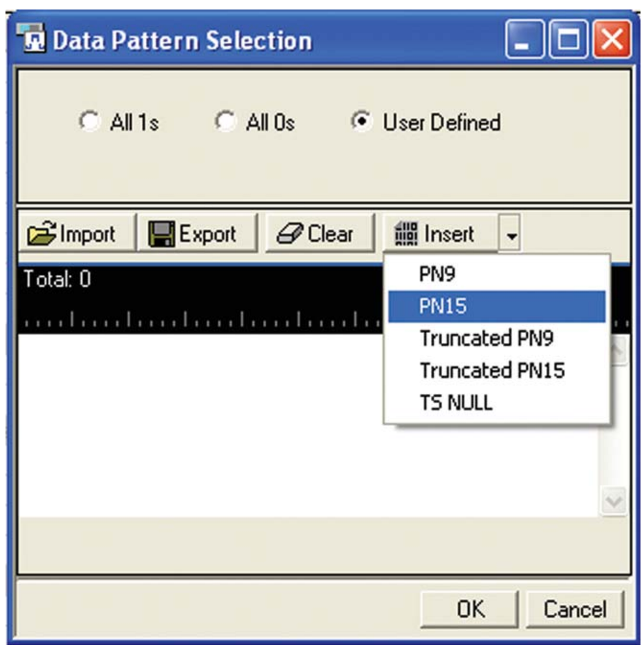

Figure 2. Data pattern selection for BER test in N7623B

When the payload is selected as “Test Pattern”, the test signal is a stream of pure PRBS without any TS framing structure.

There are two methods to calculate BER. The first method compares the received data after the Viterbi decoder with that of known send data in the signal. In this way the receiver determines the payload of the received signal, or if it is a continuous PRBS signal, it can be decoded using its digital signature (PRBS polynomial). It is advantageous to use continuous PRBS as test payload.

The second method to calculate BER is to recode the received data after it goes through the TS decoder (where it is believed to be quasi error free), and then compare the recoded data to received data after Viterbi. If you use this method, you don’t need to know the payload information and you can use any data as payload. The limitation is that the BER needs to be well above 10e-2 in order to get quasi-free data after TS.

Figure 3 shows a BER measurement of a test system. Comparison 1, 2, 3 are measurement types 1, 2 and 3 respectively. Usually comparison 3 is implemented in a receiver chipset to measure BER after Viterbi decoding as recommended by MBRAI. In this case no matter what the payload is in the received signal, the chip set can report the BER measurement automatically.

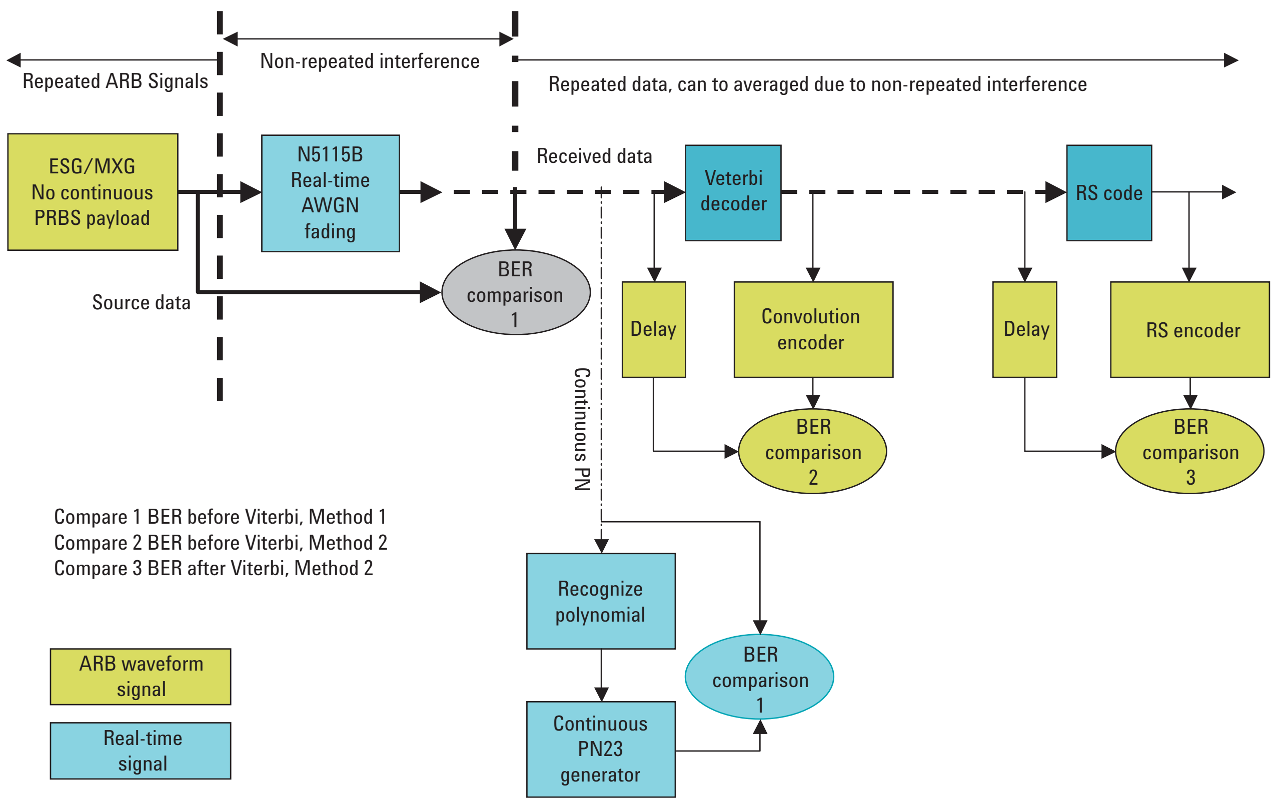

Figure 3. BER test analysis: ARB waveform and real-time continuous PN signal

3.3.2 MPEG-2 TS measurements

The N7623B software can use TS input created by other TS complier tools as the PHY layer payload. See Figure 4.

Important tip: N7623B software is transparent to the TS layer setting, so DVB-T/H signal information embedded in the TS stream can be transmitted to all the required situations defined in the MBRAI test items by properly setting the physical layer parameter. This application note does not go into detail on TS or PHY layer test for DVB-T/H.

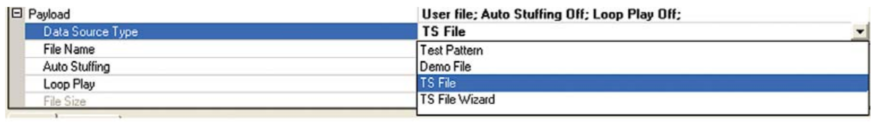

Figure 4. TS as payload in N7623B

Table 1 shows the 3 types of packet streams available for the MPEG-2 TS input. As the PHY layer coding is transparent to MPEG-2 TS frames, the receiver needs to compare the transmitted MPEG II-TS packets to the received MPEG-2 TS packets.

Table 1. Types of MPEG 2-TS packets

Selection	Remarks
HEAD 184 payload	TS 4-bytes header + 184 bytes filled with payload packet ID (PID is not evaluated)
SYNC 187 payload	0x47+187 bytes filled with payload (PID is not used)
Stuffing packet	TS 4-bytes header +184 null bytes filled with payload (PID 0x1FFF is evaluated)

There are certain relationships of BER and subjective evaluation according to MBRAI standards, the receiver video quality can be evaluated with subjective criteria, especially for integration and production. This is shown in the next example.

3.4 Subjective evaluation and seamless TS video playback

In addition to objective BER measurements, subjective evaluation criteria PFP (picture failure point, DVB-T fixed), SFP (subjective failure point in mobile reception for mobile DVB-T receivers) and MFER (MPE-FEC frame error rate for DVB-H) are also defined in video broadcast systems for video quality evaluation. These tests depend on subjective evaluation of the receiver's final output – that is, a continuous video. So for receiver evaluation a continuous video source with 10 seconds (PFP) to 20 seconds (SFP) is required by ESR5 (5% OF Error Seconds Ratio) in MBRAI.

3.4.1 Compile a TS stream to match the physical channel

In most cases, subjective evaluation criteria is used for receiver evaluation instead of BER testing. Continuous repeatable video signals with AWGN noises or fading impairments are the references used to test the item list in Section 6, which shows some typical DVB-T/H receiver test examples. N7623B Signal Studio software has an IP-patent (pending) for a TS complier wizard that lets you input any TS file (or multiple TS files) as payload to the PHY layer. Using the wizard you can stuff, truncate and loop TS video for smooth playback on MXG/ESG signal generators without any mosaics, glitches or pauses.

3.4.2 Real environment simulation: short video file with real-time AWGN and fading

Depending on transmission format, bandwidth and modulation, the typical short video playback time is 5 to 40 seconds on the MXG signal generator. Even if the video repeated is less than 5 seconds, (please refer back to the Figure 3. BER test diagram) the AWGN and fading channel impairment is real-time and not repeated. Watch the error point or frame on the video output from the receiver for PFP, SFP or MFER test noted in Section 3, *"Subjective evaluation and seamless TS video playback"*.

A typical color bar used for subjective evaluation is embedded in N7623B Signal Studio software, shown in Figure 5.

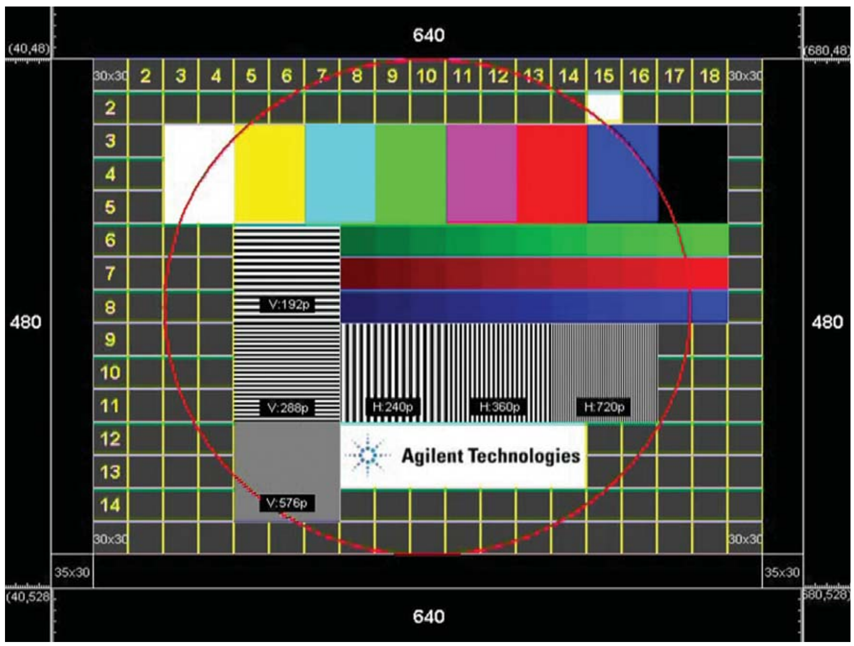

Figure 5. Seamless repeated color bar test stream embedded in N7623B

3.5 Relationship between objective and subjective video evaluation

There are fixed relationships between BER criteria and subjective evaluation criteria. Table 2 shows an example of the relationship between the picture failure point (PFP) and reference BER.

Table 2. Delta values between the picture failure point and reference BER

Measurement	Delta [dB]
C/N in Gaussian channel	1.3
Minimum input level	1.3
Immunity to other channels	2.0
Immunity to co-channels	2.0
C/N in portable channels	2.3

Please refer to the MBRAI standard for more details. Usually a subjective evaluation of a motion picture, such as a color bar with a moving lock, is used in a production evaluation instead of a BER test.

4. General Test Diagram Introduction

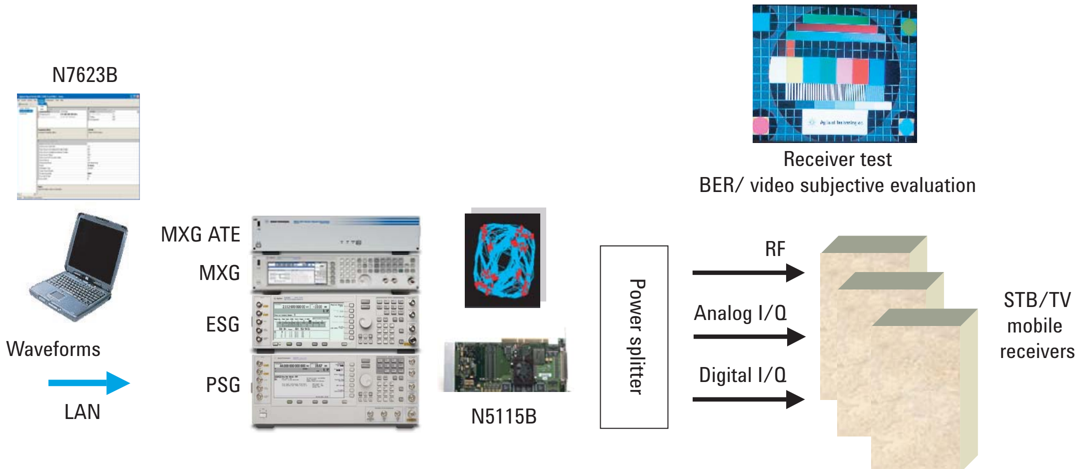

Figure 6. Agilent DVB-T/H receiver test system

Figure 6 shows a typical video receiver test system. Detailed descriptions of the test equipment follow.

4.1 N7623B Signal Studio for digital video software

N7623B Signal Studio for digital video (Figure 7) is a versatile software tool that simplifies the creation of arbitrary waveforms for most digital video standards. This includes formats such as DVB-T/C/H/S/S2, ISDB-T/T_{SB}/T_B, ATSC, J.83 Annex A/B/C, DTMB and CMMB. The N7623B software enhances support for MPEG transport streams that fit into 64 MSamples [DF2] memory. Play back fully channel-coded digital video waveforms using E4438C ESG, N5182A MXG, N5162A MXG ATE and E8267D PSG vector signal generators, high-performance platforms that support a wide range of applications including cellular and wireless connectivity communications.

In each broadcast standard, modulation types (QAM, QPSK or VSB), OFDM parameters (subcarrier numbers guard the period length or FFT size) and burst frames in DVB-H, are parameters that need to be considered when creating RF waveforms.

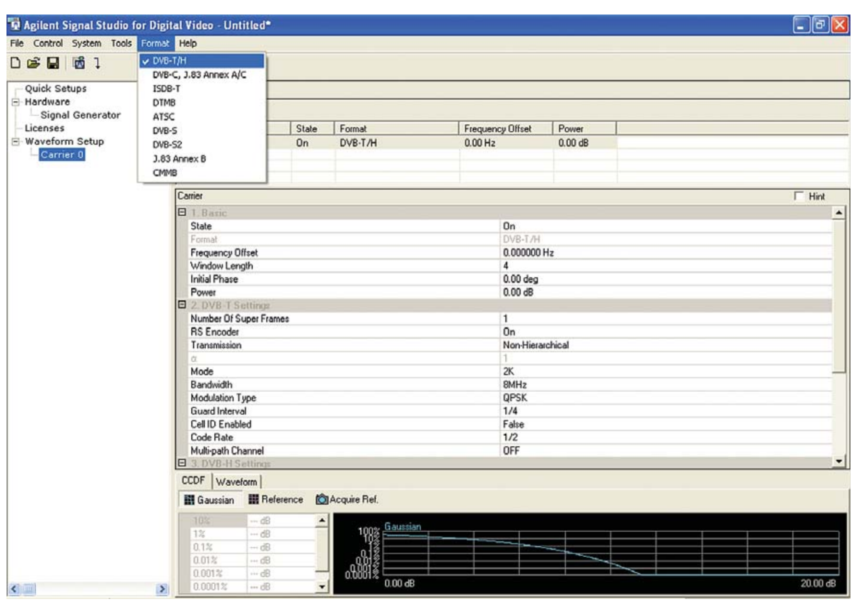

Figure 7. N7623B Signal Studio for digital video interface

4.2 Signal generator platforms

4.2.1 N5182A MXG and N5162A MXG ATE vector signal generators

Figure 8a. N5182A MXG vector signal generator

Figure 8b. N5162A MXG ATE vector signal generator

The N5182A MXG (Figure 8a) offers the industry-best adjacent-channel power (ACPR), accurate frequency amplitude levels, switching speeds and operation reliability making it ideal for the characterization and evaluation of single and multiple carrier tuner, mixer and power amplifiers in large scale manufacture. The typical uncertainty of the N5182A is ±0.6 dB at +7 dBm to –60 dBm when carrier frequency under 1 GHz. The typical single side band (SSB) phase noise of N5182A is 500 MHz –126 dBc/Hz with 20 KHz offset at 500 MHz and –121 dBc/Hz with 20 KHz offset at 1GHz. N5162A MXG ATE (Figure 8b) is streamlined for automated test equipment (ATE) needs with removal of front panel and and all connectors relocated to the rear panel for convenient and secure rack configurations. The MXG ATE delivers fast switching speeds, high power, and low distortion performance. For details please refer to the *N5182A MXG and N5162A MXG ATE Vector Signal Generators Data Sheet*, 5989-5261EN.

4.2.2 E4438C ESG vector signal generator

Figure 9. E4438C ESG vector signal generator

The E4438C ESG (Figure 9) provides lower phase noise, industry-leading modulation error ratio (MER) performance, excellent level accuracy, fading capabilities, and digital I/Q inputs and outputs making it better suited for early R&D receiver or component test. The digital I/Q input and output interface to N5115B Baseband Studio for fading, makes it an ideal platform for conformance test in R&D.

4.2.3 E8267D PSG vector signal generator

Figure 10. E8267D PSD vector signal generator

The E8267D PSG (Figure 10) provides the highest performance for your microwave test applications such as satellite communication application.

4.3 N5115B Baseband Studio for fading and N5102A digital interface

N5115B Baseband Studio for fading (Figure 11) is a powerful tool for verifying your cellular communications, WLAN, or satellite communications receiver designs. You can achieve realistic channel simulation using multipath fading and AWGN, or simulate diverse or multiple antennas or interfering signals by adding a second channel. Preconfigured fading profiles simplify initial setup, or you can create user-defined fading profiles to meet your specific test needs.

N5115B Baseband Studio for fading also provides support for digital input or output using an N5102A digital signal interface module, enabling you to connect directly to your device's digital subsystem for added power and flexibility.

Figure 11 N5115B Baseband Studio for fading

5. MBRAI Receiver Case Analysis

The test cases for the MBRAI standard can be divided into seven parts: C/N performance, input signal levels, immunity to analog and/or digital signals in other channels, immunity to co-channel interference, multipath reception within the guard interval, multipath reception outside the guard interval and impulsive noise.

5.1 Receiver minimum and maximum input signal levels (Chapter 6. or IEC 62002-2)

This test determines the minimum and maximum input levels of the DUT, as shown in Figure 12. For this purpose, MBRAI has or uses input level tests for different channels. The amplitude accuracy of the DTV signal is important because the trans region area between a good picture and "total blurred" ("cliff" effect) is small leaving little room for error. The typical "cliff" region for DVB-T is only 0.6 dB.

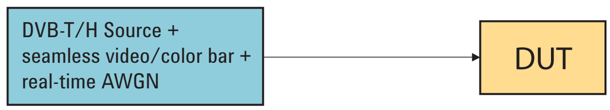

Figure 12. Example of a possible measurement setup for a minimum and maximum receiver input test

Look at Figure 13 to see how reducing accuracy uncertainty reduces the possibility of errors on receiver sensitivity measurements. For example, if the wanted sensitivity level of the DVBT receiver is –90 dBm and the signal generator has level uncertainty of ±2 dBm, the you may pick a receiver that only has a –88 dBm sensitivity level because the test source has an output of +2.0 dB uncertainty. Or you may throw away some receivers when the test signals are –2.0 dB from the wanted reference of –90 dBm, even though the receiver really has sensitivity of –90.0 dBm, not –92.0 dBm. The MXG has ±0.6 dB absolute amplitude accuracy and 0.01 dBm resolution when the output frequency is below 1 GHz.

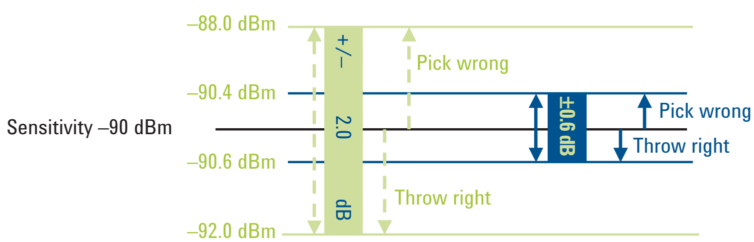

Figure 13 Sensitivity measurements: range of errors (pick "wrong" and throw "right")

5.2 Channel simulation: fading and AWGN

Channel simulation is an essential part of the design and verification process: this ensures the receiver is robust enough to provide reliable communication under fading conditions. See Figure 14.

There are two methods of simulating the fading effect using the Agilent DTV test system

- **ARB fading** covers up to 20 paths, but doesn't include mobile fading (no Doppler fading)
- **N5115B Baseband Studio for fading** covers all fading requirements in MBRAI and provides Doppler fading (Jake's method)

Baseband Studio for fading software provides the capability to change fading parameters for large- and small-scale fading scenarios with wide signal bandwidths. There is a real-time AWGN generator that can add real-time noise on repeatable video signal based on ARB waveforms. The total effect of the RF signal is a kind of real-time signal, called a pseudo real-time signal for video performance test.

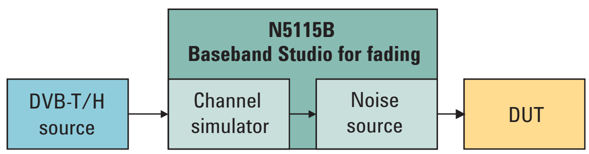

Figure 14. Example of a possible measurement setup for MBRAI tests: C/N performance (Chapter 5), echo within (Chapter 9) and outside channel (Chapter 10) mobile SFN channel (Chapter 13)

- **Carrier-to-noise (C/N) performance**
  (Chapter 5 of IEC 62002-2)

This test measures the carrier-to-noise ratio required to reach the appropriate failure point criteria.

In order to determine the C/N performance of the DUT, different channel types are used:

- Gaussian: ideal channel conditions
- Portable: multipath channel without a direct path
- Portable indoor (PI) and portable outdoor (PO)
- Mobile: terminal is moving in a car

- **Guard interval utilization: echoes within or outside the guard interval**
  (Chapter 9/10 of IEC 62002-2)

The performance of a receiver is determined while echoes within and outside the guard interval occur. The receiver should be able to handle two static echo paths in the channel when the echoes are within the guard interval. During the test, various delayed echoes are applied to the useful signal for echoes outside the guard interval.

- **Mobile single frequency noise channel test**
  (Chapter 13 of IEC 62002-2)

The SFN channel tests verify that the receiver synchronization works correctly in the mobile SFN environment. The mobile performance should remain within a specified level. The requirements and this test apply to DVB-H receivers.

5.3 Interference and immunity tests (Chapter 7, 8 & 11 of IEC 62002-2)

There are four types of interference tests in digital TV receiver test:

Chapter 7 – immunity to analog and/or digital signals in adjacent channels
Chapter 8 – immunity to co-channel interference from analog TV signals
Chapter 11 – tolerance to impulse interference

Typically more than one signal generator is necessary for this measurement set as shown in Figure 15.

- Analog TV signal in adjacent channels[1]
- Digital TV signal in adjacent channels
- Analog TV signal in co-channel[1]
- Impulsive interference signals[1]

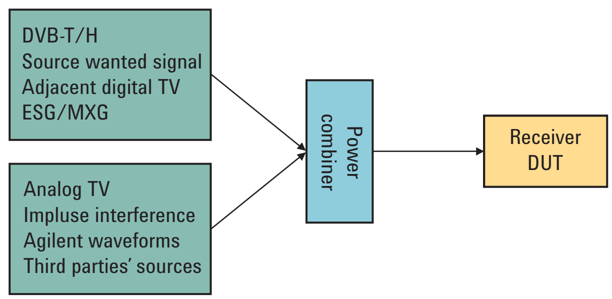

Figure 15. Example of measurement setup for immunity to analog and digital signals (Chapter 7), co-channel analog TV signals (Chapter 8) and impulsive interference (Chapter 11) tests

1 Agilent provides recorded analog PAL or SECAM TV waveforms as interference signals to configure the S1, S2, L1, L2, L3 and L4 test patterns defined in Chapter 7 and Chapter 8 of MBRAI. The same waveforms are used for impulse interference signal defined in Chapter 11 of MBRAI. Agilent provides some example waveforms for impulse interference testing in MXG/ESG playable waveforms. These waveform can be recorded using the RF signal recording tools of the N89601A software on PSA or MXA spectrum analyzer.

- **Immunity to analog and/or digital signals in adjacent channels**
  (Chapter 7 of IEC 62002-2)

This scenario determines the performance of a receiver device in the presence of analog and/or digital signals in adjacent channels. Different test scenarios are specified. The S1 and S2 patterns, contain only one analog or digital interferer. The test patterns L1, L2, L3 and L4 show two interferer signals (analog; digital).

- **Immunity to co-channel interference from analog TV signals**
  (Chapter 8 of IEC 62002-2)

The co-channel interference test simulates an analog TV signal interfering with the actual useful signal in the same channel. PAL I1, B/G and SECAM signals (depending on the area of operation) are overlaid on the useful signal.

- **Tolerance to impulse interference**
  (Chapter 11 of IEC 62002-2)

This test determines the performance of receivers when impulsive noise interference is present. The carrier-to-noise value for the impulsive interference is decreased for various noise conditions in one channel.

5.4 GSM900 TX signal blocking test

N7624B Signal Studio can easily create a GSM900 TX signal on the MXG or ESG which simulates the block condition in DVB-T/H receiver test defined in Chapter 11 of MBRAI. With a second MXG or ESG signal generator for GSM900 signals the blocking test can be conducted as shown in the diagram of Figure 16.

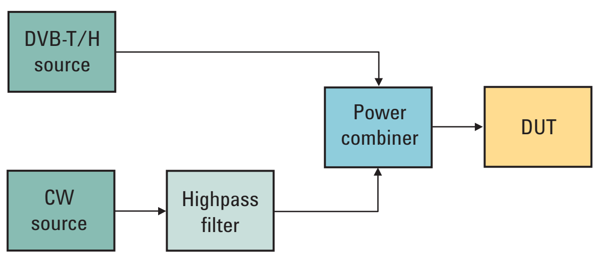

Figure 16. Example of a measurement setup for a GSM900 TX signal blocking test; a continuous wave (CW) source provides a GSM modulated interference signal

GSM900 TX signal blocking test (Chapter 12 of IEC 62002-2)

The blocking test should verify that the receiver sensitivity does not degrade too heavily when a GSM900 TX blocking signal is present at the receiver input. An alternative method is to use a FM modulated carrier to simulate the worst interferences that come from GSM. This is shown in Figure 16.

6. Examples of Typical DVB-T/H Receiver Tests

Table 2. Supported frequency ranges and mobility

Terminal category		Mobile	VHF III	UHF IV	UHF V
a	Integrated car terminals	Yes	Yes, in areas where VHF is used for DVB-T.	Yes	Yes
b1	Portable digital TV-sets	No	Yes, in areas where VHF is used for DVB-T.	Yes	Yes
b2	Pocketable TV-sets	Yes	Optional	Yes	Yes
c	Convergence terminals	Yes	No	Yes	Yes / up to 55 channels (746 MHz)

The receiver performance figures are all specified at the reference point (Figure 17), which is the input of the receiver. All conformance testing is performed at the same point. In a case where the GSM rejection filter is included (terminal category c), the measurements will be carried out at the front of the GSM rejection filter.

In the case of a DVB-H receiver, manufacturers shall provide the specified test mode in which the following parameters can be monitored:

- TS-BER after Viterbi decoder
- TS-PER (picture error rate)
- MPE FER *(FER)* (frame error rate before MPE-FEC)
- MPE-FEC *FER (MFER)* (frame error rate after MPE-FEC)

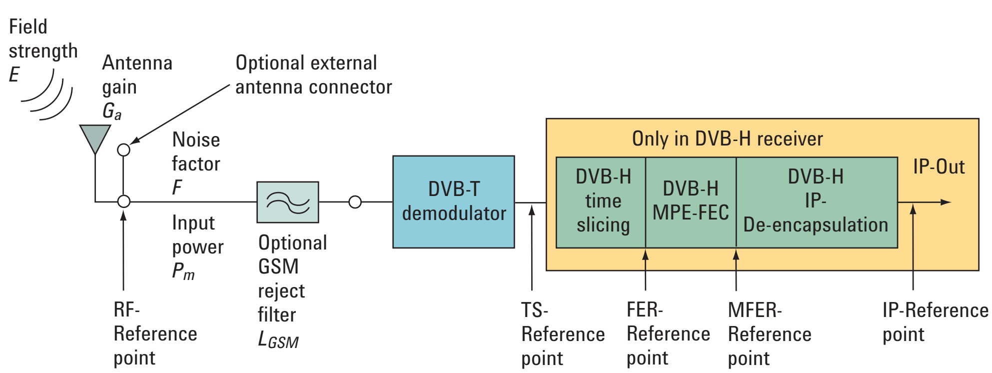

Figure 17. DVB-T/H test reference model, from page 18 of MBRAI part I specs (V2.1.0)

6.1 Minimum and maximum receiver input signal levels

In a case of QPSK modulated signals (DVB-T) with a code rate 1/2 in an 8 MHz channel (Channel 45), the following requirements need to be met (Figure 18):

- Minimum input level: –94.6 dBm
- Maximum input level (terminal category b, c): –28 dBm or higher
- Payload–>Data source type: Demo file; PAL or NTSC (depending on the TS decoder output)

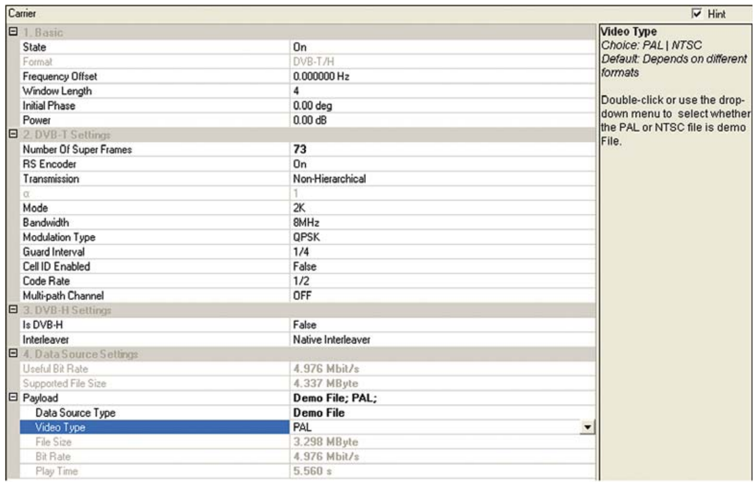

Figure 18. Easy configuration of a sensitivity test signal using the N7623B

Generate and download the waveform to the MXG. It will take about 8 minutes to complete the download because the waveform is so large. Fortunately the waveform can be saved on MXG so you won't need to download it every time. *Tip: Ftp will be the fastest way to download the file; then you can download the waveform directly using buttons on N7623B's GUI.*

Minimum input levels

Adjust the DVB-T/H signal source power level until the receiver reaches the reference BER criterion 2×10^{-4} after the Viterbi decoder (failure criterion a). Alternatively, the picture failure point (PFP) criterion (failure criterion b) may be used. For DVB-H receivers a 5% MFER criterion is used. Measure the power level at the terminal reference point. Once the reference failure criterion is reached, the re-synchronization needs to be achieved.

Try to adjust the amplitude by 0.1 dBm when the signal approaches the minimum level as the BER measurement result will change dramatically due to the "cliff effect" at the receiver sensitivity point.

Maximum input level

Adjust the DVB-T/H signal source power level to the defined maximum value. Measure the reference BER after the Viterbi decoder (failure criterion a). Alternatively, the picture failure point (PFP) criterion (failure criterion b) may be used. For DVB-H receivers a 5% *MFER* criterion is used. Once the reference failure criterion is reached, the re-synchronization needs to be achieved.

PFP criterion of a receiver is used in this example.

6.2 C/N performance

This test determines the point TP4 (characterization point for C/N versus Doppler) in IEC 62002-1 for DVB-H receivers. See item 3 of Table 6.

N7623B Signal Studio for digital video:
Frequency: 666 MHz
Level: –50 dBm
FFT: 8k; constellation: 16QAM; guard interval: 1/4; code rate: 1/2;
MPE-FEC CR: 3/4; embedded in DVB-H TS stream defined by user
(Not a physical layer parameter)

N5115B Baseband Studio for Fading:
Doppler Shift: 10 Hz

Figure 19. Set 10 Hz Doppler shift in N5115B

Note: For C/N test in other fading environments (no mobile movement), the N7623B provides faded ARB waveform creation capability, so a separate baseband fader is not needed for most of fading test cases (Figure 20).

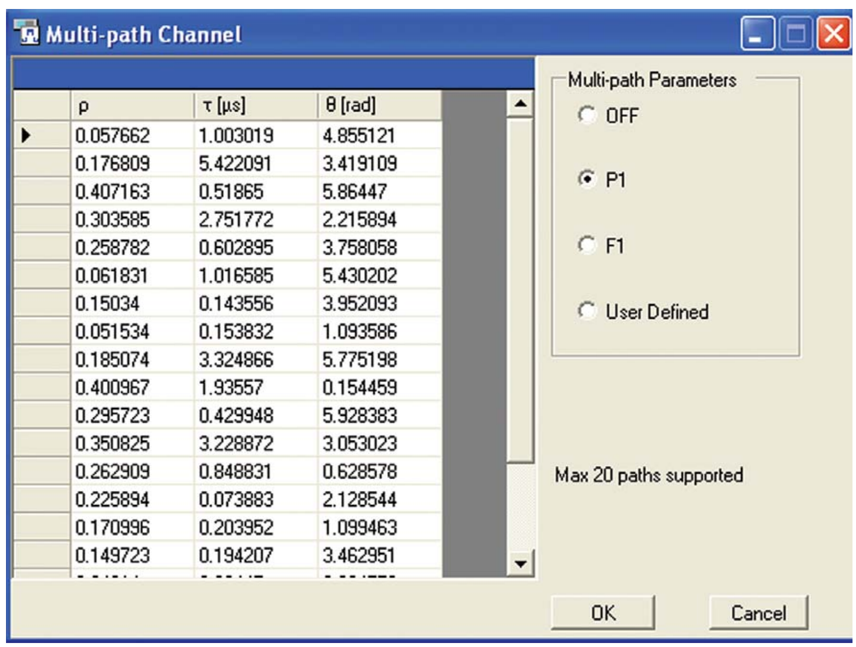

Figure 20. Static fading setting embedded in the N7623B

6.3 Immunity to analog and/or digital signals in adjacent channels

As part of this example, test pattern L1 includes an analog and a digital interferer signal with the following characteristics (Figure 21):

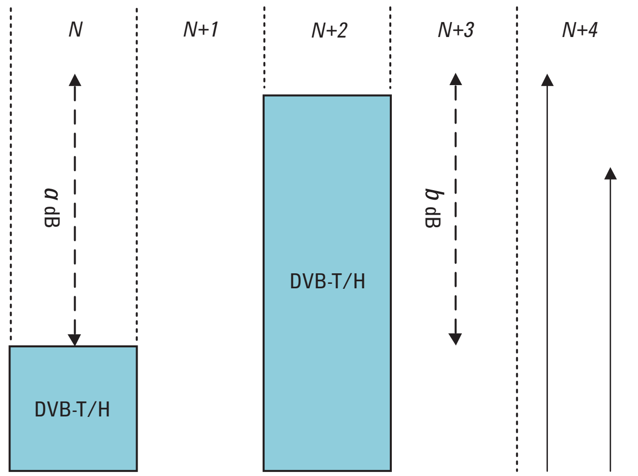

Figure 21. Adjacent digital/analog TV channel interference, (from page 41 of MBRAI part I)

The interferers are set to the maximum allowable level.
For terminal categories a and b1:
Analog interferer –25 dB (mW), digital interferer –30 dB (mW)
For terminal categories b2 and c:
Analog interferer –35 dB (mW), digital interferer –40 dB (mW)

Step 1. The useful DVB-T signal in the example above for channel N=45 (666 MHz) has the following characteristics.
N7623B Signal Studio for digital video for the wanted signal:

- FFT: 8k
- Constellation: 16QAM
- Code rate = 2/3
- Guard interval = 1/8

N7623B Signal Studio for digital video for the wanted interference signals:
The DVB-T interferer signal needs to be compliant with ETSI EN 300 744. In this example, it is same as the wanted signal with proper amplitude and frequency.

Step 2. The analog PAL B/G interferer needs to meet following requirements:

- Modulating signals: 75 % color bar, 1 kHz FM sound with ±50 Hz deviation, any NICAM modulation
- Level ratio vision carrier/FM carrier: 13 dB
- Level ratio vision carrier/NICAM carrier: 20 dB
- Filter roll off factor: 40 %

Download the waveform name "L1 Pattern PAL B-G" (or use a third party analog TV signal generator) and set the frequency (696 MHz), amplitude (–25 dBm) on the second MXG, suppose the DUT is category a) or b1).

Step 3. Generate the digital interference channel with same configuration as the wanted signal on the third MXG and set the amplitude to –30 dBm and the frequency to 682 MHz.

Adjust the amplitude of wanted signal to calculate the PFP out on the receiver screen at 666 MHz (Channel 45). The difference shall be higher than the requirement in Table 3.

Table 3. Adjacent interference tolerances defined in MBRAI

Mode	a[N+2]	b[N+4]
2k/8k 16-QAM CR=1/2 GI=1/8	40 dB	45 dB
2k/8k 16-QAM CR=2/3 GI=1/8	40 dB	45 dB
2k/8k 16-QAM CR=3/4 GI=1/8	36 dB	41 dB
2k/8k 64-QAM CR=2/3 GI=1/8	32 dB	37 dB

6.4 Guard interval utilization: echoes within the guard interval

The following parameters are used for the test.

N7623B Signal Studio for digital video (Figure 22):

- Channel 45 (666 MHz)
- Level: –40 dBm
- FFT: 8k; constellation: 64QAM; code rate = 2/3; guard interval = 1/8

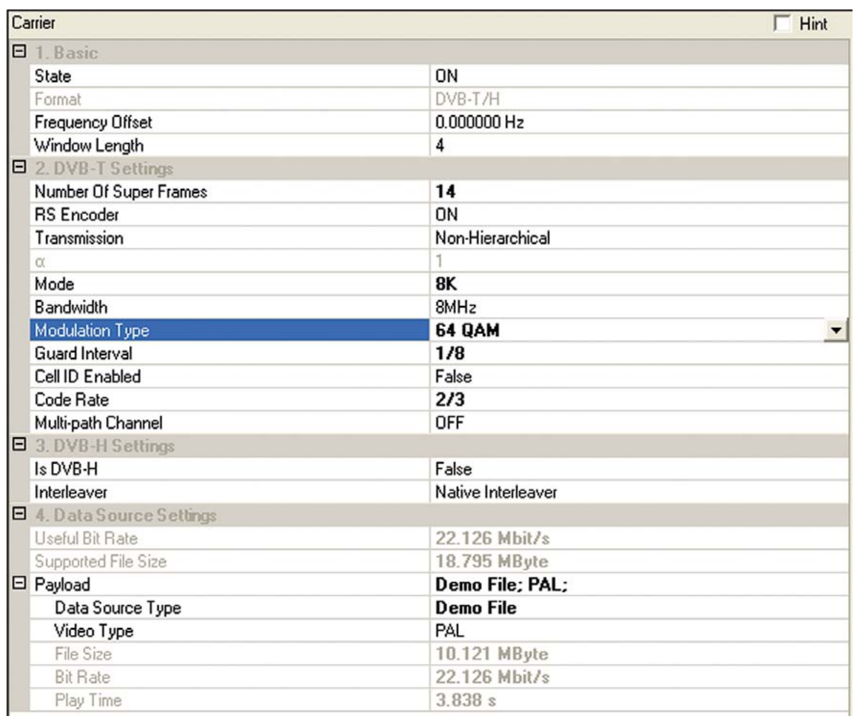

Figure 22. DTV signal test setup in N7623B

N7623B Signal Studio for digital video. (Figure 23):

- Real-time Noise: ON
- Carrier to Noise Ratio: 26.2 dB
- Carrier bandwidth: 8.0 MHz
- Noise Bandwidth Factor: 2

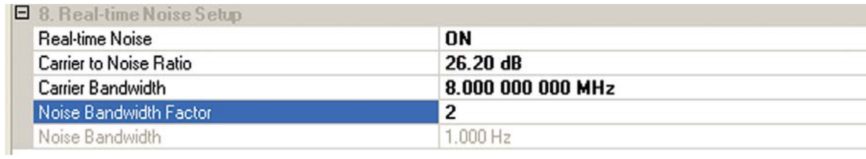

Figure. 23 Real-time AWGN setup in N7623B

N5115B Baseband studio for fading (Figure 24):

Echoes

- Path 1: Attenuation = 0 dB, delay = 0 s
- Path 2: Attenuation = 0 dB, delay = 100.8 Ys
- Path 3: Attenuation = –1 dB, delay = 100.8 Ys, Doppler shift = 0.2 Hz

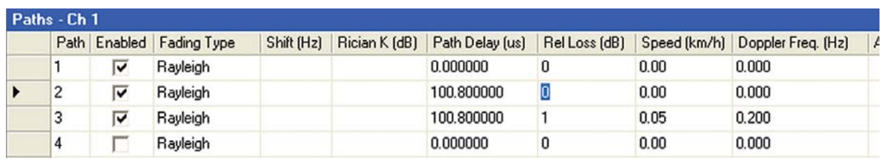

Figure 24. Echo path setup in N5115B

The minimum echo requirements are presented in Table 4.

Table 4. Performance with echoes within the guard interval, from MBRAI

Mode	C/N	BER
8K, 16-QAM, CR=1/2, GI=1/8	16.3 dB	< 2x10E–4
8K, 16-QAM, CR=2/3, GI=1/8	26.2 dB	< 2x10E–4

6.5 Mobile SFN channel test

In order to ensure that the receiver synchronization also works correctly in a mobile SFN environment, three mobile SFN channel models (weak long echo, strong long echo, strong short echo) are checked.

The useful DVB-H signal needs to show following characteristics:
N7623B Signal Studio for digital video:

- Channel 45: 666 MHz
- FFT: 8K; constellation: 16QAM; code rate = 1/2; guard interval = 1/4; MPE-FEC = 3/4;

The payload is a user-defined TS video file that is compliant to DVB-H standards with time slice enabled.

N5115B Baseband Studio for fading (Figure 25)
For this example, the weak long echo channel is chosen. There are twelve Rayleigh paths, defined as follows: (Delay/us, Power/dB): (0.0/–3), (0.2/0), (0.5/–2), (1.6/–6), (2.3/–8), (5.0/–10), (179.2/–13.6), (179.4/–10.6), (179.9/–12.6), (180.8/–16.6), (181.5/–18.6), (184.2/–20.6).

Paths - Ch 1

Path	Enabled	Fading Type	Shift (Hz)	Rician K (dB)	Path Delay (us)	Rel Loss (dB)	Speed (km/h)	Doppler Freq. (Hz)
1	☑	Rayleigh			0.000000	3	0.00	0.000
2	☑	Rayleigh			0.200000	0	0.00	0.000
3	☑	Rayleigh			0.500000	2	0.00	0.000
4	☑	Rayleigh			1.600000	6	0.00	0.000
5	☑	Rayleigh			2.300000	8	0.00	0.000
6	☑	Rayleigh			5.000000	10	0.00	0.000
7	☑	Rayleigh			179.200000	13.6	0.00	0.000
8	☑	Rayleigh			179.400000	10.6	0.00	0.000
9	☑	Rayleigh			179.900000	12.6	0.00	0.000
10	☑	Rayleigh			180.800000	16.6	0.00	0.000
11	☑	Rayleigh			181.500000	18.6	0.00	0.000
12	☑	Rayleigh			184.200000	20.6	0.00	0.000

Figure 25. Mobile SFN fading (no Doppler shifting) in N5115B Baseband Studio for fading

Additionally apply a Doppler shift of 10 Hz at the primary path (Figure 26). With this setting, the C/N value can be varied until C/Nmin is met. With this value, you can vary the Doppler shift setting to check for MBRAI compliance.

Paths - Ch 1

Path	Enabled	Fading Type	Rician K (dB)	Path Delay (us)	Rel Loss (dB)	Speed (km/h)	Doppler Freq. (Hz)
1	☑	Rayleigh		0.000000	3	2.70	10.000
2	☑	Rayleigh		0.200000	0	2.70	10.000
3	☑	Rayleigh		0.500000	2	2.70	10.000
4	☑	Rayleigh		1.600000	6	2.70	10.000
5	☑	Rayleigh		2.300000	8	2.70	10.000
6	☑	Rayleigh		5.000000	10	2.70	10.000
7	☑	Rayleigh		179.200000	13.6	2.70	10.000
8	☑	Rayleigh		179.400000	10.6	2.70	10.000
9	☑	Rayleigh		179.900000	12.6	2.70	10.000
10	☑	Rayleigh		180.800000	16.6	2.70	10.000
11	☑	Rayleigh		181.500000	18.6	2.70	10.000
12	☑	Rayleigh		184.200000	20.6	2.70	10.000

Figure 26. Mobile SFN fading setting (with a 10 Hz Doppler shift) in N5115B Baseband Studio for fading

The first Doppler frequency in the channel simulator is set to 10 Hz and the C/N value is adjusted by changing the noise source signal level until the receiver reaches 5% MFER criterion. The resulting C/N ratio is the C/Nmin. Next the C/N ratio is increased by 3 dB from the specified C/Nmin. The Doppler frequency is then adjusted until the receiver reaches 5% MFER for the DVB-H receiver. The resulting Doppler frequency is Fd3dB (Table 5).

Table 5. C/N (dB) for MFER 5% for DVB-H

Guard interval = 1/4			**8k**		**Speed at Fd3dB km/h**	
Modulation	Code rate	MPE-FEC CR	C/N_{min} dB	Fd3dB Hz	474 MHz	746 MHz
16-QAM	1/2	3/4	15.5	100	228	145

7. Receiver Production Recommendation

7.1 Application programming interface (API)

The Microsoft® .NET-based application programming interface (API) is provided to enable systematic and efficient configuration of complex digital video waveforms. It allows programmatic setting of signal parameters by importing custom data sets or using programming loops and mathematical functions rather than manually entering data in the Signal Studio graphical user interface. The entire signal configuration and playback process can easily be automated in your own programming environment using the API. Included with the software is a full API. Use the API to set parameters either programmatically or by using an API graphical user interface. The API's built-in Help System provides programming examples that you can easily fellow.

7.2 Recommended MBRAI test items

Table 6. Summary of receiver test items from MBRAI

Clause	Conditions	Terminal category a car terminals	Terminal category b1 portable TVs	Terminal category b2 pocketable TVs	Terminal category c hand-held convergence terminals	N7623B = S PAL/SECAM/Pulse = A	Signal generators M = MXG / E = ESG	Baseband Studio for fading = B	Pre Production	Large Volume Manufacture
5. C/N performance		Ch 45								
	Gaussian	All modulations, 2k/4k/8k				S	M/E		X	X
	Portable	All modulations, 2k/4k/8k				S	M/E		X	
	PI / PO	16-QAM 2/3, 3/4, 64-QAM 2/3, GI 1/4, 8k			QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, MPE-FEC 3/4, GI 1/4, 8k	S			X	
	Mobile	QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, 64-QAM 2/3 GI 1/4, 8k			QPSK 1/2, 2/3 16-QAM 1/2, 2/3, MPE-FEC 3/4, GI 1/4, 8k	S	E	B	X	
6. Receiver minimum and maximum input signal levels	Minimum and maximum input levels	Ch 21, 45, 64 (UHF), Ch 8, 12 (VHF)								
		QPSK 1/2				S	M/E		X	X
7. Immunity to analog and/or digital signals in other channels	S1	N±1: Ch 45 (UHF), Ch 8 (VHF) with 64-QAM 2/3 additionally Ch 21, 64 (UHF), Ch 5, 12 (VHF). *N±2*: Ch 45 (UHF), Ch 8 (VHF)				S A	3M/E		X	X
		16-QAM 3/4 , 16-QAM 2/3, 16-QAM 1/2 , 64-QAM 3/4 , 64-QAM 2/3, GI 1/8								
	S2	Ch 45 (UHF), Ch 8 (VHF)				S A	3M/E		X	
		QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, 3/4, 64-QAM 2/3, 3/4, GI 1/8								
	L1-L3	Ch 21, 45, 64 (UHF), Ch 8 (VHF)				S A	3M/E		X	X
		16-QAM 1/2, 2/3, 3/4, 64-QAM 2/3, GI 1/8, 8k	16-QAM 1/2, 2/3, 3/4, 64-QAM 2/3, GI 1/8, 8k	16-QAM 1/2, 2/3, 3/4, 64-QAM 2/3, GI 1/8, 8k	QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, GI 1/8, 8k					
	L4	Ch 43				S	3M/E		X	
		QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, GI 1/8, 8k	QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, GI 1/8, 8k	QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, GI 1/8, 8k	QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, GI 1/8, 8k					
8. Immunity to co-channel interference from analog TV signals		Ch 45 (UHF)				S A	2M/E		X	
		16-QAM 1/2, 2/3, 3/4, 64-QAM 2/3, 3/4, GI 1/8			QPSK 1/2, 2/3, 16-QAM 1/2, 2/3, MPE-FEC 3/4, GI 1/4, 8k					
9/10. Guard interval utilization: echoes within/outside guard interval		Ch 45 (UHF)				S	E	B	X	
		8k, 64-QAM 2/3, GI 1/8 8k, 16-QAM 1/2, GI 1/8								
11. Tolerance to impulse interference		Ch 45 (UHF)				S A	2M/E		X	
		8k, 64-QAM 2/3, GI 1/8 8k, 16-QAM 1/2, GI 1/8 8k, 16-QAM 2/3, GI 1/8								
12. GSM900 TX signal blocking test					8k, GI 1/4, QPSK 1/2CR MPE-FEC 3/4, C55	S	2M/E		X	X
13. Mobile SFN channel test					8k, GI 1/4, 16-QAM 1/2 MPE-FEC 3/4, C45	S	M/E	B	X	

Reference

- DVB-T standard: ETSI 300 744: Digital Video Broadcasting (DVB): Framing structure channel coding and modulation for digital terrestrial television
- DVB-H standard: ETSI 302 304: Digital Video Broadcasting (DVB): Transmission System for Handheld Terminals (DVB-H)
- EICTA MBRAI 2.0 MOBILE AND PORTABLE DVB-T/H RADIO ACCESS: (Part 1: Interface specification)
- EICTA MBRAI 2.0 MOBILE AND PORTABLE DVB-T/H RADIO ACCESS: (Part 2: Interface conformance testing)
- ETSI EN 300 744 Final draft, "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television", V1.5.1, June, 2004
- ETSI EN 300 429, "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems", V1.2.1, April, 1998.
- ETR 290, "Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems", May 1997
- DTG RF Sub-Group document No.67, part 11, "UHF Transmission and Reception"

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