DVB-T and DVB-T2 Receiver Test Challenges

Application Note

Introduction

Over the past 10 years, DVB-T has become the most widely adopted and deployed terrestrial digital video standard. It is now well established and the prices of DVB receivers have dropped over time as the technology has matured. Due to its successful development and deployment, DVB-T has come to serve as a sort of benchmark for the development of other terrestrial digital video standards.

Due to increasing scarcity of spectrum and requirements for high transmission capacity in recent years, an updated standard with more spectral efficiency is required to replace DVB-T. The DVB-T2 system is capable of meeting these requirements, due to its increased capacity, robustness, and the ability to reuse existing reception antennas. The regions which previously adopted DVB-T systems, primarily countries in Europe and Asia, will be migrating to DVB-T2, while many new countries and regions began the process of adopting DVB-T2 directly since the first version of the standard was published in 2009.

With the advanced technologies used in DVB-T2 to achieve high performance, new measurement challenges are facing both transmitter and receiver developers. In this application note, we will focus on the measurement challenges for developers of receivers such as set-top-boxes.

Overview of DVB-T and DVB-T2 Systems

Both DVB-T and DVB-T2 use the OFDM modulation scheme, which provides various options for bandwidth, modulation, FEC (forward error correction) rates, number of carriers, and guard intervals, making it flexible enough to meet the needs of different transmission environments and operators.

DVB-T2 is an ideal choice for the replacement of the DVB-T system because a number of the elements of the DVB-T2 system align with the system requirements put forth by the standards bodies. The key requirements and the corresponding DVB-T2 technology components are listed in Table 1.

Table 1. Key requirements of DVB-T replacement system and corresponding DVB-T2 system components

Key requirements of the DVB-T replacement system	Key DVB-T2 technology components
Provide a minimum of a 30% capacity increase over DVB-T	• A more powerful channel coding scheme • Extended interleaving • High order modulation with constellation rotation for additional robustness • More options for carrier numbers, guard interval sizes and pilot signal for overhead optimization
Service-specific robustness provision mechanism	Multiple Physical Layer Pipes (PLPs) allow for individual robustness adjustments for each of the services within a channel, in order to meet the required reception conditions.
Improved SFN performance	• More options for carrier numbers, guard interval sizes and pilot signals • The Alamouti coding transmitter diversity method improves coverage in small-scale single-frequency networks
Ability to reduce peak-to-average power ratio	PAPR reduction schemes: • ACE (Active Constellation Extension) • TR (Tone Reservation)

Key features

Table 2 provides a side-by-side comparison of the DVB-T and DVB-T2 system features. The combination of these features can result in numerous test cases. DVB-T2 provides more options than DVB-T, resulting in higher efficiency and flexibility. It also supports more advanced technologies, such as multiple PLPs, LDPC coding, and MISO, which results in increased signal and test complexity, especially for a MISO configuration. Overall, while there are similarities between the two systems, the broader set of features in the DVB-T2 system allows it to offer both a much higher data rate than DVB-T and a much more robust signal.

Table 2. Comparison of the key features of the DVB-T and DVB-T2 systems

Features	DVB-T	DVB-T2
FEC	Convolutional coding + RS: 1/2, 2/3, 3/4, 5/6, 7/8	LDPC + BCH: 1/2, 3/5, 2/3, 3/4, 4/5, 5/6
Modulation	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM, 256QAM with constellation rotation
Guard interval	1/4, 1/8, 1/16, 1/32	1/4, 19/128, 1/8, 19/256, 1/16, 1/32, 1/128
FFT size	2 k, 4 k, 8 k	1 k, 2 k, 4 k, 8 k, 16 k, 32 k
Scattered pilots	8% of total	1%, 2%, 4%, 8% of total
Continual pilots	2.0% of total	0.4% – 2.4%
Bandwidth	5, 6, 7, 8 MHz	1.7, 5, 6, 7, 8, 10 MHz
Typical data rate	24 Mbit/s	40 Mbit/s
Max. data rate (@ 20 dB C/N)	31.7 Mbit/s	45.5 Mbit/s

MISO in the DVB-T2 system

Using multiple antennas is a promising performance improvement technology. As such, the DVB-T2 system has adopted MISO to achieve performance gains via transmitter diversity. An example of this transceiver system is shown in Figure 1.

While MISO and MIMO both offer new broadcasting techniques, further investigation is required in order to evaluate the system performance improvements they provide, especially for channel profiles for multiple antennas. This type of investigation necessitates the presence of an efficient measurement scheme, such as a MIMO channel emulator to simulate the transmission environment of multiple antennas.

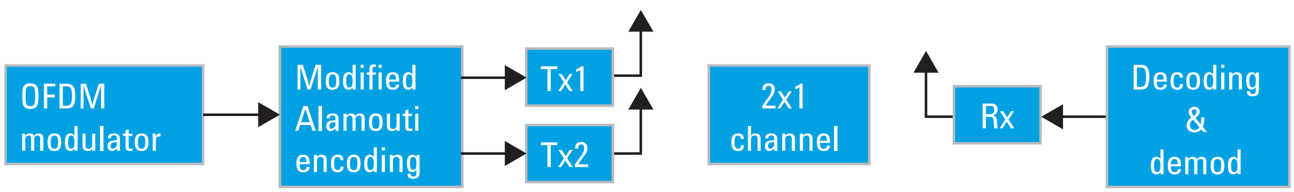

Figure 1. MISO transceiver system.

Receiver structure

Receiver testing requires that measurements be made at various interfaces within the receiver. Understanding the structure of a receiver is therefore important for both testing and troubleshooting, especially in receiver design and development. The block diagrams in Figures 2 and 3, respectively, show the receiver structures for DVB-T and DVB-T2 and point out the locations of the test interfaces.

BER is the primary parameter for receiver test. In the block diagrams in Figures 2 and 3, the BER and FER at different interfaces are marked as test points, as defined in the measurement guidelines[1][2].

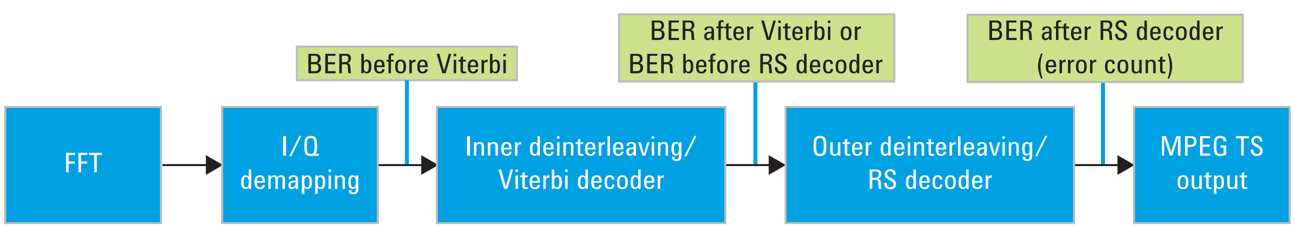

Figure 2. Simplified block diagram of a DVB-T receiver.

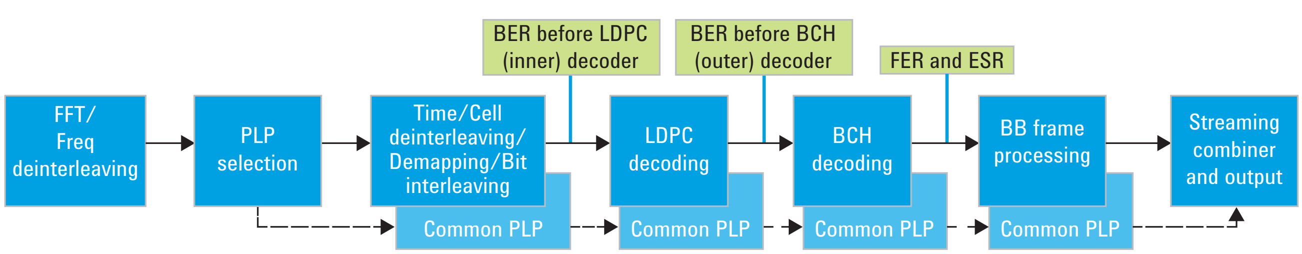

Figure 3. Simplified block diagram of a DVB-T2 receiver.

DVB-T and DVB-T2 Tests

Because DVB-T2 was developed as an evolution of DVB-T which will eventually replace DVB-T, DVB-T2 basically follows the same measurement criteria as DVB-T and the performance measurement scenarios are similar for both systems. The test challenges discussed in this section apply to both systems.

Performance evaluation

There are two test schemes for performance evaluation. One is reference BER, which is an objective test, and the other is picture failure point, which is a subjective test that provides results which can be observed by viewing the video display. The measured results of these two tests can be converted from one to the other according to the measurement guidelines[1].

Reference BER

BER can be measured at various interfaces, as shown in Figures 2 and 3, to evaluate the performance quality of the various modules in a receiver. Reference BER is defined as BER = $2x10^{-4}$ after Viterbi decoding (Inner decoding) for DVB-T, and as 10^{-7} after LDPC decoding (Inner decoding) for DVB-T2. This criteria corresponds to the DVB-T standard's quasi error free (QEF) criteria, which indicates that there be "less than one uncorrected error event per hour". Since making the BER = 10^{-7} measurement is time-consuming, the BER after LDPC = 10^{-4} is used instead and the associated Carrier-to-Noise (C/N) ratio value is increased by 0.2 dB.

Picture failure point

The picture failure point is defined as the C/N or Carrier-to-Interference (C/I) value where visible picture errors start to appear on the screen. This test is more convenient for some of the measurements than the normal reference BER test, which it might not be possible to perform, which might be the case if, for example, the DUT doesn't provide an interface for a BER test, such as in the case of a commercial receiver. A more objective analysis can be performed using the ESR5 (erroneous second ratio 5%) criteria, which allows one erroneous second within the 20s observation period in the transport stream (TS).

For objective BER measurements, two alternative methods are available. One is for an "Out of Service" scenario and the other is for an "In Service" scenario.

The basic principle of the "Out of Service" measurement is to generate, within the channel encoder, a known, fixed, repeating sequence of bits, essentially of a pseudo-random nature. In order to do this the data entering the sync-inversion/randomization function is a continuous repetition of one fixed TS packet. After performing this measurement, the BER can be measured within the receiver with the known bit pattern.

The basic assumption made with the "In Service" measurement method is that the decoder will correct all errors and produce an error-free TS packet under normal operating circumstances. The number of erroneous bits within a TS packet will be estimated by comparing the bit pattern of this TS packet before and after decoding. If the measured BER value is too high, for example if it exceeds 10^{-3} for DVB-T, the measurement should be regarded as unreliable due to the limits of the decoding algorithm. Figure 4 contains this measurement scheme for reference BER.

If a subjective test is desired, the "In Service" test should be used with the TS with real video program, resulting in video that is visible on the display in the receiver test setup.

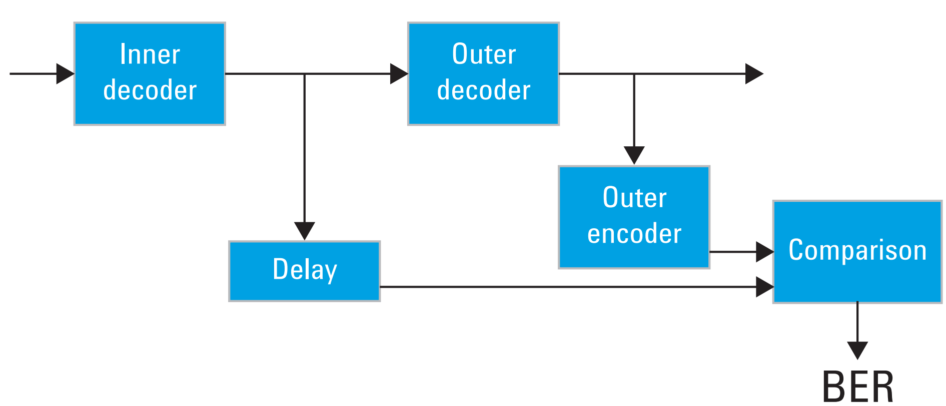

Figure 4. BER measurement before outer decoding.

Receiver performance test challenges

Performance tests for a receiver can be summarized as receiver sensitivity/dynamic range, C/N performance under different channel environments, and interference immunity, but numerous test cases with different parameter configurations will also be needed, especially for DVB-T2 with single PLP and multiple PLP modes. The test system just described is shown in Figure 5.

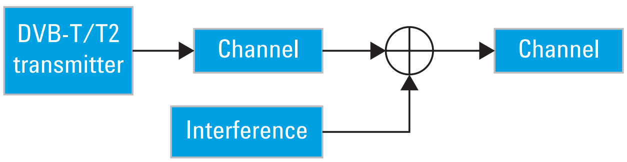

Figure 5. Receiver performance test system.

Challenge #1: Testing receiver sensitivity/dynamic range

For network planning purposes, the minimum and maximum input powers for normal operation of a receiver have to be determined, as do the minimum and maximum input power thresholds for QEF reception (indicated by reference BER). For these measurements, the channel module shown in Figure 5 will be by-passed and no interference signal will be added. The signal sent out by the transmitter will feed into the receiver directly and the power of the transmitter will be adjusted.

This measurement scenario offers one of the simplest measurement cases because no interference signal, nor complicated channel simulations, are needed. But it is a very important measurement for ensuring that all of the functionalities of the system are operational under normal conditions. There are numerous choices for test system configurations, but the challenge is to ensure that the transmitter test setup is quick and easy so that all test cases can be covered. In each configuration a signal generator is used to emulate a DVB-T or DVB-T2 transmitter.

Challenge #2: C/N performance testing

In different channel environments, when noise is applied to the wanted carrier, the receiver should meet the C/N requirements for reference BER for different modulation and channel coding schemes.

The channel conditions include

- Gaussian channel: AWGN will be added to the wanted signal. The channel module in Figure 5 is an AWGN generator with settable calibrated C/N.
- Multipath fading channel: Different channel profiles are defined in the test specs, including Rayleigh, portable indoor (PI), portable outdoor (PO), mobile channel with Doppler frequency, and SFN with long or short echoes. For DVB-T2, 2x1 MISO channel profiles are defined and simulated when transmit diversity is used. The channel module in Figure 5 is a channel simulator which can generate different channel environments according to the channel profiles with calibrated AWGN.

In this test, no interference signal will be added to the setup shown in Figure 5. With this scenario, the complexity and the cost of the measurements is increased because the different channel environments must be simulated and a multipath fading simulator is always expensive and difficult to verify, especially when MISO is used. It is particularly useful to have a professional and cost-efficient channel simulator that can generate all of the required channel profiles to reduce test time and ensure consistent measurement results.

Challenge #3: Interference immunity testing

This test is used to identify the capability of the receiver to reject out-of-channel and co-channel interference, interoperability with other radio systems, and tolerance to impulse interference.

Types of interference signals:

- DVB-T or DVB-T2 digital video: The interference DVB-T or DVB-T2 signal exists on a few adjacent carriers. The power level of the interference signal on an adjacent channel is much higher than the wanted signal.
- Analog TV: The analog TV signal can be PAL, NTSC or SECAM, corresponding to the analog TV formats used in the respective countries. There are cases where adjacent channels carry analog TV or digital TV signals only, or where some adjacent channels carry analog TV and some carry digital TV signals. Also, there are cases where analog TV signals co-exist with wanted DVB-T and DVB-T2 signals in the same carrier channel.
- Impulse interference: Impulse interference is generated in short bursts. Sources include car ignition systems and domestic appliances such as switches and electric

motors. Impulse interference reaches the receiver directly through the antenna. The damage this interference can cause is potentially serious because a single impulse burst can destroy a complete symbol's worth of data. Patterns of impulse interference are defined by specs compiled through extensive studies. An AWGN generator with burst gates can be used to simulate impulse interference.

- Other Radio signals: A cellular radio can be GSM/EDGE, WCDMA, LTE or a combination of these. The interference immunity test is especially important for mobile applications. The co-existence, and especially the simultaneous operation, of several radios in small-sized handheld terminals results in several design challenges. The GSM signal can be emulated with filtered and FM modulated CW signals. With a vector signal generator, it is also very easy to emulate a spectrally correct cellular radio signal as the interference signal.

An additional signal generator is used to generate the interference signal, then combine it with the wanted signal and feed it to the receiver. We can use a signal analyzer to check the power difference and frequency relationship of the interference and wanted signals after they are combined. No additional noise is added in the channel for this test.

With so many possible sources of interference, interference immunity testing is the most complex of the receiver measurements. Having both an appropriate signal generator and signal analyzer will make this series of tests more manageable. A high performance general purpose signal generator offers the most efficient and flexible testing capability because all of these interference signals can be generated by this one box, which simplifies test system setup.

Conclusion

Performing tests and measurements on terrestrial digital video receivers is more challenging than testing any other digital video device because of the variable transmission environment. The current technology transition taking place, along with pressure to reduce costs, have resulted in the challenges discussed in this application note, including numerous test cases required for basic sensitivity and dynamic range testing, managing the complexity and the cost of C/N performance testing under AWGN and fading environments, and reducing the complexity of interference immunity testing where there are multiple sources and types of interference. Comprehensive testing of receivers is critical in the development and deployment of the new DVB-T2 system, just as it was for DVB-T, and will help to minimize the test costs for manufacturing DVB-T2 devices.

Reference

[1] ETSI TR 101 290 V1.2.1, "Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems", 2001-05.

[2] DVB Document A14-2, "Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems; Amendment for DVB-T2 System", July 2012.

[3] EICTA MBRAI, "Mobile and Portable DVB-T/H Radio Access; Part 1: Interface specification".

Web

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Related Literature

Addressing the Challenges of Deploying Single Frequency Networks DVB-T & DVB-T2, Application Note, Literature Number 5991-1362EN

Conduct DVB-T/H Conformance Tests with Agilent's Real-Time DVB-T/H Digital Video Solution, Literature Number 5990-5722EN

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