Ready for takeoff: test signals for DVB-T2, the coming generation of digital TV

Equipped with the R&S®SFU-K16 realtime coder option, the R&S®SFU broadcast test system is the first full-fledged DVB-T2 signal generator in the world.

HDTV via terrestrial channels

Flat-screen television sets have completely replaced cathode ray tube (CTR) TVs in the last few years, and the diagonal screen size is steadily increasing. The 720 × 576 pixels of the current DVB-T standard are no longer sufficient, and the image looks coarse and "pixellated". The 720 or even 1080 lines of the state-of-the-art flat screens are not optimally used. This is why HDTV programs are in demand – not only via cable or satellite but most recently also via the terrestrial VHF/UHF TV channels. With DVB-T2, a transmission system that is tailor-made for these requirements has now been standardized for the first time.

The definition of DVB-T2 began with a study conducted by the DVB organization in 2006. The organization stipulated several conditions for the DVB-T2 standard in comparison with DVB-T, including the following:

- At least 30 % higher transmission capacity
- Program-specific error protection mechanism
- Continued usability of the existing DVB-T private antennas and transmitter sites
- More efficient single-frequency networks
- Optional procedures to reduce the crest factor and thereby the transmitter operating costs

The results of the specification of the DVB-T2 standard were published as DVB Bluebook A122 at the end of June 2008 and submitted to the ETSI in order to be formally standardized [1]. This standardization is expected to be completed by the end of 2009.

FIG 1 shows the block diagram of a DVB-T2 modulator. The programs to be transmitted are fed as transport streams (MPEG-2 or generic streams). In a first block (mode adaption and stream adaption), the data packets are preprocessed and temporally arranged before they reach the actual modulator via the modulator interface (T2-MI). At the modulator, the "byte interleaving, coding and modulation" functional unit inserts the error protection. The third block (frame builder and OFDM generation) finally generates the OFDM symbols and converts the signals to the transmit frequency. FIG 1 also illustrates the functionality of the new R&S®SFU-K16 DVB-T2 realtime coder option.

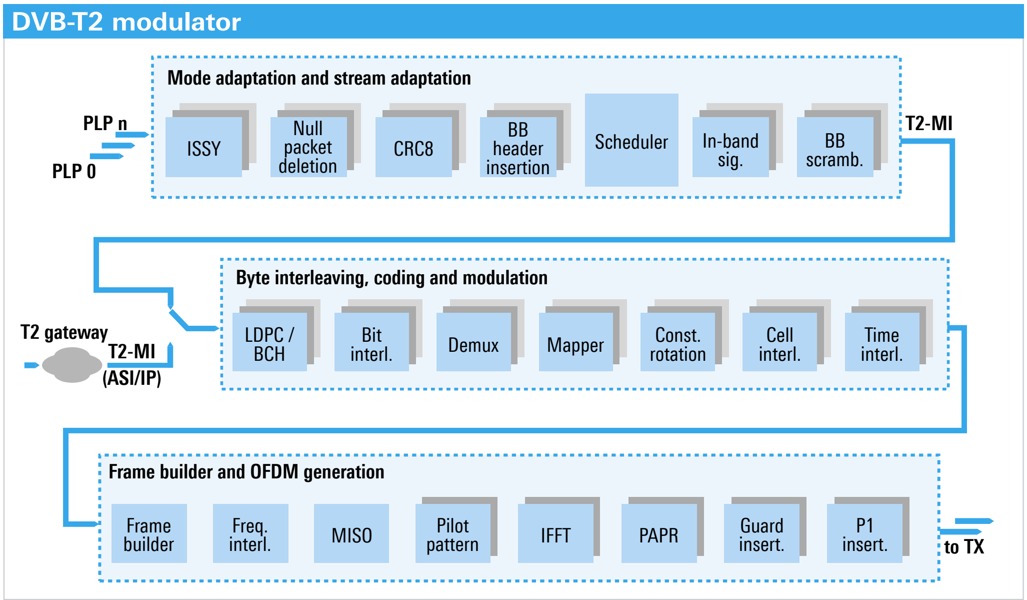

FIG 1 Block diagram of a DVB-T2 modulator. Its functionality is basically the same as that of the new R&S®SFU-K16 realtime coder option.

The R&S®SFU broadcast test system has firmly established itself in the consumer electronics industry as the reference signal source for broadcasting standards. The selection of transmission standards is continuously being expanded: Two new coder options appeared in 2008 for the CMMB and DVB-SH standards [2]; equipped with the R&S®SFU-K16 realtime coder option, the R&S®SFU is now the first full-fledged DVB-T2 signal generator in the world.

Combination of innovative and tried-and-tested technologies

Of course, not all the functional blocks had to be redefined for the DVB-T2 standard. The technologies utilized for DVB-T2 can be classified in three categories. Firstly, the technologies used for DVB-T were consistently enhanced. Like almost all digital terrestrial TV systems, DVB-T2 uses OFMD modulation. In comparison with DVB-T, a 256QAM constellation and the longer FFT modes 16k and 32k have been additionally introduced. This increases the data rate and, if the guard interval length remains constant, reduces the overhead. The R&S®SFU-K16 DVB-T2 option supports the 256QAM constellation as well as the longer FFT modes. Besides tried-and-tested concepts from DVB-T, DVB-T2 also uses technologies from other DVB standards. These include primarily error protection by means of LDPC coding, which was specified originally for DVB-S2, as well as the use of baseband frames. The R&S®SFU-K16 DVB-T2 option can generate all LDPC code rates of the DVB-T2 standard.

Furthermore, DVB-T2 uses not only known and advanced technologies but also some brand-new concepts in broadcasting. DVB-T2 makes program-specific error protection possible for the first time. This means that an operator can choose between data rate and transmission security individually for each program to be transmitted. For this purpose, the encoder assigns the programs to physical layer pipes (PLP) whose coding parameters can be individually defined. For example, SDTV programs can be provided with strong error protection for basic coverage, while HDTV programs with a high date rate can be transmitted with weaker error protection in the same RF channel.

This principle is shown in FIG 2. The receiver only decodes the content of the desired PLP and ignores all other PLPs. The R&S®SFU-K16 DVB-T2 option currently allows the modulation of one PLP (single PLP mode, FIG 3). The option will be expanded to multi-PLP mode in future firmware.

Reduced crest factor and rotated constellations

OFDM signals normally have a high crest factor. This reduces the transmitter's efficiency and thus ultimately increases its operating costs, as the transmitter must be designed to handle the peak power of the signal. The DVB-T2 standard defines two entirely new techniques for reducing the crest factor of the transmit signal. For this purpose, the DVB-T2 modulator can change the DVB-T2 signal by suitably modulating unused OFDM carriers (reserved tones) or by shifting the points of the constellation diagram (adaptive constellation extension) so that lower peak values occur. As these two methods require relatively high computing effort, they are defined as optional in the DVB-T2 standard. The R&S®SFU-K16 DVB-T2 option can simulate the reserved tones method. Another brand-new

Assigning the services to PLPs

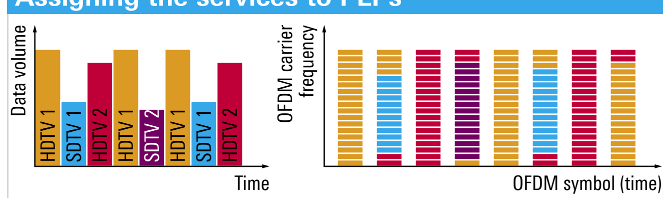

FIG 2 The receiver decodes only the content of the desired PLP and ignores all other PLPs.

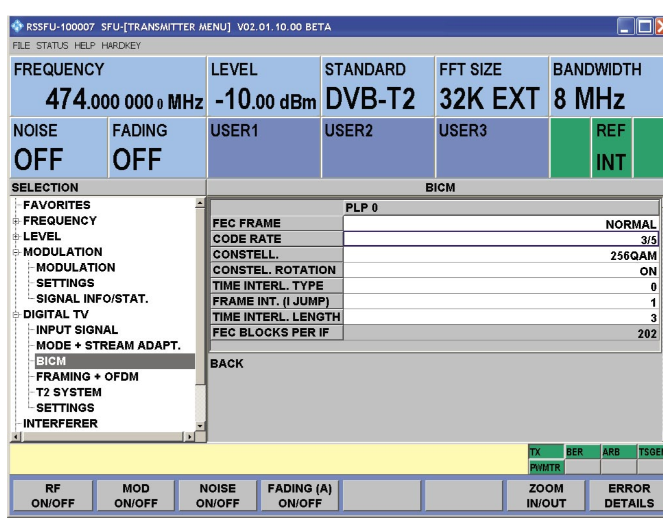

FIG 3 Single PLP coding and modulation menu of the R&S®SFU-K16 DVB-T2 realtime coder option.

technology, which is utilized in DVB-T2 for the first time, uses rotated constellations. The modulator rotates the constellation diagram by a defined angle relative to the I/Q coordinate system (FIG 4). In this way, part of the I information is mapped onto the Q-axis and vice versa. In addition, the Q information to be transmitted is delayed by several symbol lengths compared to the I information. As a result, related I and Q values are not transmitted in the same symbol and thus not on the same OFDM carrier. By combining these two measures (Q-delayed rotated constellation), a symbol can be reconstructed even if the related OFDM carrier has been completely impaired. This significantly increases transmission security in the selective channel. The R&S®SFU-K16 DVB-T2 option supports optional rotation for all constellations of the DVB-T2 standard.

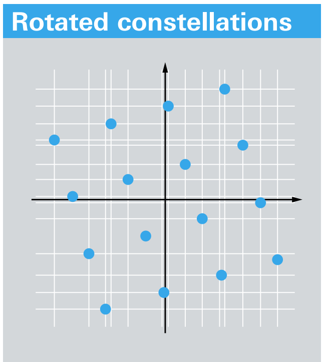

FIG 4 Rotated constellation diagram for 16QAM: The modulator rotates the diagram by a defined angle relative to the I/Q coordinate system.

Development of DVB-T2 receivers with the R&S®SFU broadcast test system

DVB-T2 is a standard that makes efficient terrestrial HDTV transmission possible. Along with the broadcast network operators, the consumer electronics industry must now act so that fully developed DVB-T2 receivers are launched on the market in time. The first receivers will probably be set-top boxes that convert DVB-T2 signals for existing TV sets. As in the case of DVB-T and DVB-C, DVB-T2 tuners will, however, increasingly be permanently integrated into TV sets as the DVB-T2 standard becomes more widespread and manufacturing costs decline. Equipped with the new R&S®SFU-K16 realtime coder option, the R&S®SFU broadcast test system is the perfect solution for developing and testing DVB-T2 receivers. Its integrated fading simulator, noise generator and simulator of adjacent channel interference make it an indispensable tool for the development of digital TV receivers as well as for signal generation. The simulation functions in particular are the R&S®SFU broadcast test system's main strength. The 40-path fading option and the interferer management option are able to simulate virtually all conceivable channel conditions in a reproducible way. The noise generator options generate not only white noise, but also pulse-like noise and phase noise. Especially phase noise is a critical parameter for the new 32k FFT mode and the 256QAM constellation of DVB-T2. The R&S®SFU broadcast test system has all the functions required for developing and testing DVB-T2 receivers.

Peter Lampel

References
[1] DVB Document A122: Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2).
[2] Test signals for the new CMMB and DVB-SH mobile TV systems. News from Rohde&Schwarz (2008) No. 198, pp. 65–69.

First regular DVB-T2 operation in England

As with the introduction of DVB-T a number of years ago, the British Broadcasting Corporation (BBC) is again playing a leading role with DVB-T2. At the end of 2009, the first regular DVB-T2 operation in the world will start in northwestern England in the region around Manchester, Liverpool and Preston. A multiplex with three HDTV programs from the BBC, ITV and Channel 4 is going to be broadcast from the Winter Hill transmitter in Lancashire. Other regions will follow, up until the 2010 Soccer World Cup. The operator needs a high data throughput for the HDTV package. FIG 5 shows an overview of the intended coding parameters, which are consistently designed for high data throughput. With these settings, DVB-T2 achieves an impressive increase of almost 50 percent in data throughput compared with DVB-T. The use of a powerful source coding with H.264 and HE-AAC increases the information data rate even more.

Parameter	DVB-T	DVB-T2
Modulation	64QAM	256QAM
FFT size	2k	32k
Guard interval	1/32	1/128
FEC	2/3 CC + RS	3/5 LDPC + BCH
Scattered pilots	8.3 %	1.0 %
Continual pilots	2.0 %	0.53 %
L1 overhead	1.0 %	0.53 %
Carrier mode	standard	extended
Capacity	24.1 Mbit/s	36.1 Mbit/s

FIG 5 Overview of the DVB-T and DVB-T2 coding parameters used in the United Kingdom.