New Method Enables Test for Satellite TV Tuners, LNBs

AS DIGITAL TECHNOLOGY INCREASINGLY REPLACES ANALOG CIRCUITRY, NEW TEST STRATEGIES ARE NEEDED TO KEEP PACE WITH THE SHIFT TO BROADBAND A/D CONVERTER FRONTENDS. SATELLITE OPERATOR ECHOSTAR PLANS TO USE LOAD PROFILES TO TEST SET-TOP BOXES AND LOW-NOISE BLOCK CONVERTERS (LNBS), WHERE ROHDE & SCHWARZ'S DIGITAL MULTICHANNEL SIGNAL GENERATORS OFFER AN EFFICIENT SOLUTION.

For as long as satellite TV has existed, low-noise block (LNBs) converters and satellite tuners have been designed as superheterodyne receivers. The LNB converts the downlink signal from the Ku band to the L band. The satellite tuner in the TV or set-top box then converts the L band signal to a lower intermediate frequency where the desired channel is selected and decoded.

Testing of such receivers worked perfectly well with the standard RF measuring instruments: a network analyzer to measure the gain and matching, a spectrum analyzer to test the image frequency rejection and third-order intercept and to detect spurious responses, and a noise source to measure the noise factor. Continuous waveform (CW) carriers were used as test signals. A modulated carrier from a signal generator was required only to test the decoder. Simulation of a fully loaded band was not practical due to cost constraints because a separate modulator with L-Band upconverter would have been required for each channel.

Fast A/D Converter Replaces Analog Tuner

At present, however, the situation is changing in a fundamental way. In next-generation set-top boxes and outdoor units (ODU), the superheterodyne frontend is replaced by an A/D converter for direct sampling of the satellite interface (IF) signal. The satellite IF signal is normally in the 950 to 2150MHz range, that is, in the L band. However, there are cases where the signal can begin at 250MHz and extend all the way to 3000MHz. The new receivers digitize a wide subrange that can span 1000MHz, for example. This is also known as full-band capture technology. The channel to be decoded is selected based on digital signal processing (Fig. 1). The advantages of such architecture are obvious: less analog circuit technology means fewer tolerances, less alignment, and less space is needed on the printed board. Because fast A/D converters are commercially available, this approach is also more cost effective.

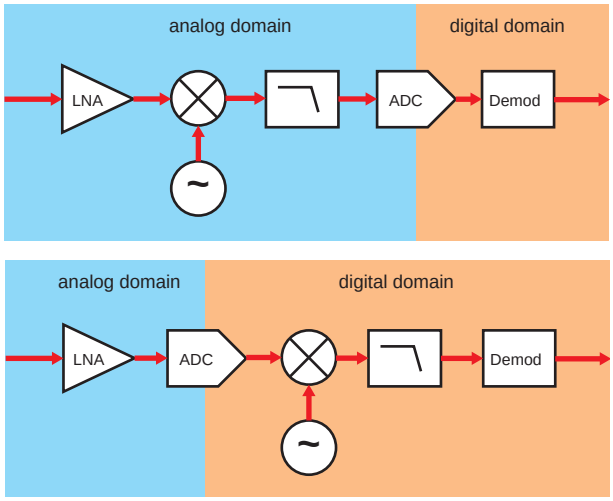

Fig. 1: Conventional satellite tuner with superheterodyne receiver (top) compared with a next-generation satellite tuner with full-band capture (bottom)

However, these new, direct-sampling receivers require a different test and measurement approach. Analog test equipment can no longer access the IF signal processing chain. Therefore, parameters such as the gain may have to be derived from other measurements. For an A/D converter, it is crucial to optimize the functionality over the entire expected dynamic range of the input signal. Measurements with a single CW signal or a carrier that has a narrowband profile compared to the receive bandwidth are not adequate. Instead, the receiver must be tested with full transponder load in order to simulate the real-world satellite signal as closely as possible. Previous methods making use of a single carrier at a simulated total aggregate power will yield different or undesired results in the A/D section.

Simulated Transponder Loads

Network operators use a large number of different transponder loads. Due to spot beams, these can have a wide dynamic range. To test LNBs and set-top boxes, EchoStar Corporation has developed a new test strategy based on simulated transponder loads. The tests are executed with a series of load profiles in order to simulate the different transponder loads in a real-world satellite TV network (Figs. 2 to 4). Load profiles are chosen that will stress the A/D converter in various ways to ensure that the LNBs and set-top boxes do not degrade the reception signal under real conditions, guaranteeing best modulation error ratio (MER) and a low bit error rate. EchoStar

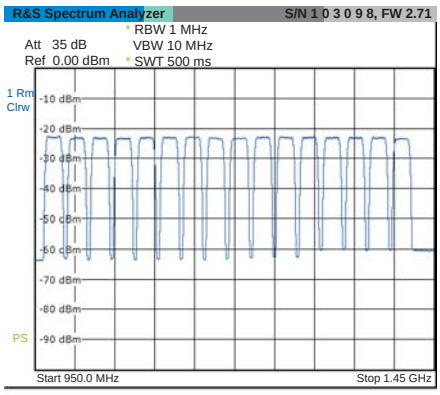

Fig. 2: Load profile with 16 CONUS transponders

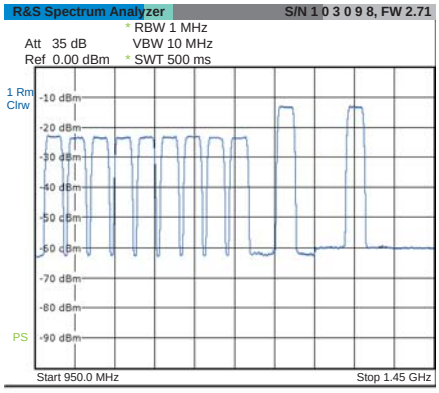

Fig. 3: Load profile with 9 CONUS transponders and 2 spot beams

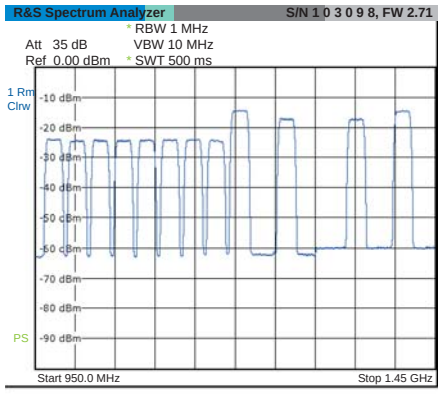

Fig. 4: Load profile with 8 CONUS transponders and two higher level spot beams for the target region. The two lower level spot beams between the two higher level carriers are from an adjacent target region. Although the set-top box cannot decode them through program access control, their energy needs to be taken into account as a load on the A/D converter.

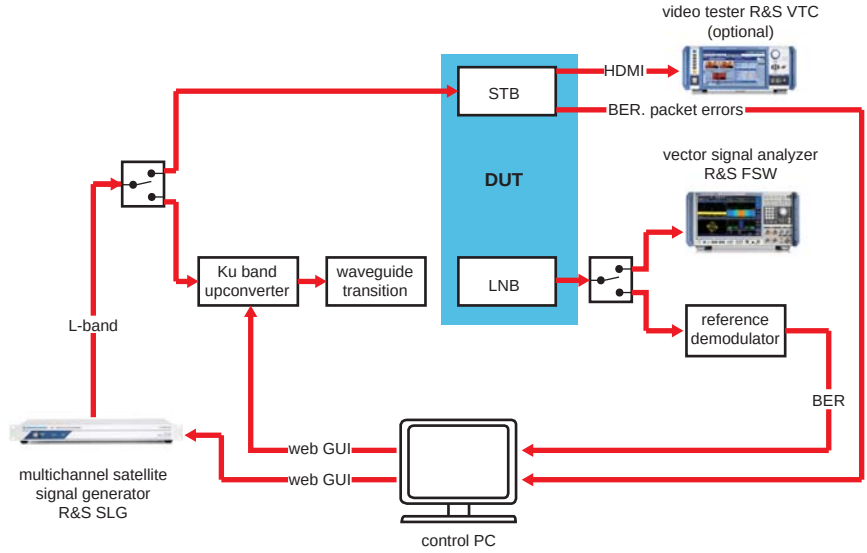

Fig. 5: System for testing set-top boxes (STB) or LNBs with load profiles

is adopting this test strategy for the latest generation of LNBs and set-top boxes for the first time. It is expected that manufacturers will also increasingly test with load profiles in the future.

For the test and measurement equipment, the greatest challenge associated with this test strategy is generating a sufficient number of modulated transponder signals. Until now, two different approaches were available, each with specific technical or economic drawbacks. One approach involves using a number of satellite TV modulators, as they are typically used in the uplink, and aggregating their output signals. However, such a setup is complicated to configure and calibrate and requires a great deal of space and power. It is also relatively costly due to the large number of modulators.

Alternatively, an arbitrary waveform generator with sufficient bandwidth can be used. However, it is no easy task to generate a suitable I/Q waveform file for multiple satellite TV transponders. Even minor changes to the configuration require the creation of a new waveform file, which makes this approach rather inflexible. The R&S SLG multichannel satellite load generator from Rohde & Schwarz greatly simplifies this job by simultaneously generating up to 32 satellite transponder signals. The symbol rate, FEC, frequency and level can be individually set for each transponder. Up to 16 transponders can transmit live video signals.

Automatic Test System

Fig. 5 illustrates the test system in use at EchoStar. An R&S SLG generates the modulated signals in the frequency range from 250 to 3000MHz. The different load profiles are stored on the instrument as configurations and then called up in sequence. When testing a set-top box, the generator's output signal is fed directly to the DUT input. The R&S SLG basically simulates the output of an LNB. The set-top box supplies the bit error ratio or the number of uncorrected FEC packets per time unit. Alternatively, the picture quality of the HDMI output signal from the set-top box can be analyzed, for example, with the R&S VTC video tester. To test an LNB, the SLG load profile is first converted with an upconverter to the Ku band and then passed to the DUT input. The DUT supplies a satellite IF signal, which is either measured with an R&S FSW vector signal analyzer or decoded with a reference receiver. The reference receiver outputs the BER along with a number of other parameters for the demodulated signal. A personal computer controls the different instruments and stores the results.

Selective Degradation of Signal Quality

The R&S SLG multichannel signal generator is a very useful signal source for this test system because it requires much less space and power and generates less heat and noise than 16 indi-

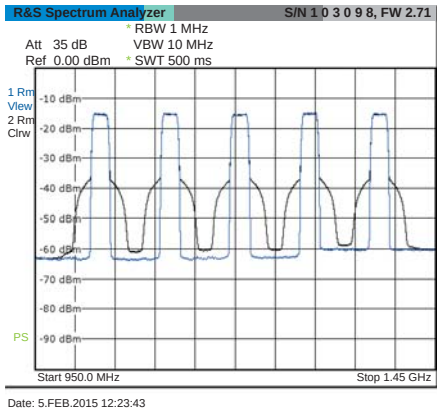

Fig 6: Selective degradation of the signal quality in a transponder occupancy with phase noise. To highlight the effect, only every third transponder was activated.

vidual modulators. It is controlled over an Ethernet interface for ease of local or remote control. Stored load profiles can be easily recalled for subsequent usage. In addition, the signal can be selectively degraded with additive white Gaussian noise (AWGN) and phase noise. The phase noise generator is especially attractive to EchoStar (Fig. 6). The company intends to use it to obtain deeper insights into the performance limits of the new direct-sampling tuners. EchoStar previously found it nearly impossible to develop and verify a specification for the phase noise.

The next generation of direct-sampling frontends is revolutionizing the design of satellite receivers. Digital multichannel signal generators allow users to keep pace with this technological advancement and test the new receivers as thoroughly as classic superheterodyne receivers were tested in the past.

About This Article:

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