

## Vector Signal Generator SMIQ02W / SMIQ03W

# Test signals for digital WorldSpace satellite sound broadcasting

WorldSpace of Washington is currently setting up a digital satellite system to provide a wide range of programs to countries with inadequate broadcasting infrastructure. The planned, portable sound receivers have a built-in patch antenna for direct satellite reception. Rohde & Schwarz supplies the test equipment for use in the production of such receivers.

channel assignment any time, it may for example transmit news on one program channel simultaneously in eight languages and then music in CD quality on all eight channels. Additional information such as station identification, currently transmitted language or program type sent along with the program make it easier for listeners to find the station they want. Broadcasters can also encrypt their programs so that they may only be received after entry of a code (pay audio).

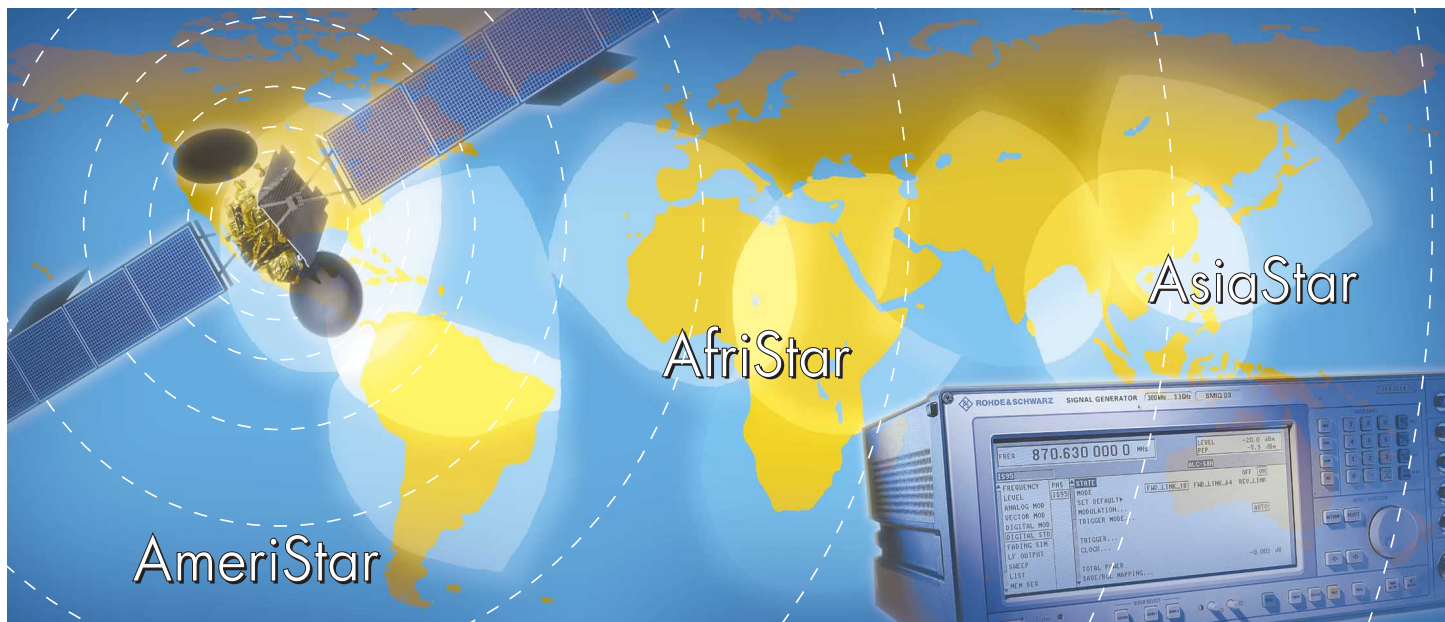


FIG 1 Three satellites of US provider WorldSpace will soon be broadcasting programs to more than 4.6 billion listeners. Vector Signal Generator SMIQ simulates real signals for tests in receiver production.

In its final configuration, the WorldSpace broadcast system will comprise three geostationary satellites. The first satellite is being brought into position above Africa in autumn 1998, the second one is to go into operation a few months later to provide coverage for the whole of South Asia, the third one is planned for South and Central America (FIG 1). According to WorldSpace, around 4.6 billion people will then be able to receive the satellite programs. The resulting demand for

WorldSpace receivers is estimated to be 15 million per year!

Each satellite has three partly overlapping beams. Up to 96 program channels can be broadcast per beam, which means that one satellite is capable of transmitting up to 288 programs at a data rate of 16 kbit/s each. To enable transmission of audio signals at such a low data rate, they are first compressed in an elaborate data-reduction process (MPEG layer 3). Depending on the desired signal quality, the compressed audio signal will occupy between a half and max. eight channels. Quality categories range from "AM quality (mono)" to "CD quality (stereo)". Since a broadcasting station can change its

Broadcasters lease their channels from WorldSpace and send the programs ready compressed in frequency-division multiplex at 7 GHz via a parabolic antenna direct to the satellite. The satellite receives the programs of all broadcasters, assigns them to the corresponding transmit beams and converts them to TDM (time-division multiplex) signals. As a result, the 96 channels of a transmit beam form a single serial bit stream. Complex error control is employed (Reed-Solomon encoding, interleaving and Viterbi convolutional encoding) to prevent transmission errors. The downlink is in the L band (1.5 MHz) with a polarized QPSK signal.

## Measurement task

For measurements in the production of receivers it is necessary to simulate real receive conditions as closely as possible to ensure that each receiver leaving the factory will function properly for its user. Testing should not take too long, of course, because of the high-volume production that is envisaged. For this measurement application, Rohde & Schwarz has developed two further models of Vector Signal Generator SMIQ [1]: SMIQ02W (300 kHz to 2.2 GHz) and SMIQ03W (300 kHz to 3.3 GHz). The complete TDM signal of a transmit beam including all audio contents is calculated by means of PC program SMIQ-K3 and then loaded into the data memory of SMIQ via the IEC/IEEE bus. From the calculated signal, SMIQ generates the RF signal which is applied via a cable or an antenna to the receiver under test. Receiver functions are tested by an audio analyzer, for example UPL [2]. Nothing else – no extra encoders or data sources – is required to conduct the measurements.

## Signal calculation

The first thing needed to generate a complete TDM test signal is program contents, ie audio signals. The wavfile generator of the SMIQ-K3 software

can produce various audio test signals such as sine, multisine, sine sweeps and noise in mono or stereo. The sampling rate and length of the signal are selectable. The memory of SMIQ..W can hold signals up to a length of 20 s. Continuous signals are generated by repetitive output of the stored signal. The frequency of the individual audio signals is adjusted automatically so that the waveform exactly matches the TDM frame structure of 9.936 s and there is no signal discontinuity on the transition from the end to the beginning of the file. The calculated signal can be displayed in the form of a spectrum or as a waveform (FIG 2) and even monitored by means of a PC sound card. Of course, any other audio files (name.wav) can be integrated, for example an extract from Mozart's Little Serenade.

The customer can create a set of audio files and organize it with the Audio Source Manager. All files are converted to MPEG layer 3 format in a compiler. Here it is necessary to select the bit rate to which the original signal is to be compressed, depending on desired signal quality or available channel capacity.

The individual "sound broadcast programs" are generated in the TDM encoder. This is done by selecting the required audio signal and entering

additional information such as program type (eg news), language, signal length or encryption mark. One or more programs of a station are combined into a broadcast channel. Extra information can be added to this channel too, ranging from codes for the decryption of pay-audio programs through to messages for display as scrolling text on the receiver panel. Calculation of the TDM bit stream includes distribution of programs to the various 16 kbit/s transmission channels, encryption of pay-audio programs, calculation of multilevel error control, multiplexing of channels to generate a serial data stream, and scrambling of the overall signal.

## Signal generation

Modulation of the calculated data stream onto the downlink carrier is performed by Vector Signal Generator SMIQ02W or SMIQ03W. The data record is transferred on the IEC/IEEE bus from the PC to the SMIQ modulation data memory. SMIQ is set up in line with WorldSpace system specifications (QPSK modulation, 1.84 MHz symbol rate, square root cosine filtering), and finally the RF level and frequency are selected. Once the receiver under test has synchronized to the signal applied, the signal of the selected program can be measured or aurally monitored at its output.

Data records transferred to SMIQ remain stored in its memory, so the PC is only needed to calculate new records. SMIQ comes ready with a sample data record containing various test signals and pieces of music.

As already mentioned, actual receive conditions should be simulated as accurately as possible in receiver tests. But QPSK signals from a satellite are not as ideal as those produced by a signal generator, they are strongly distorted by the transmitter tube because this is driven at high power to increase efficiency of the satellite transmitter. This results in amplitude and phase distortion

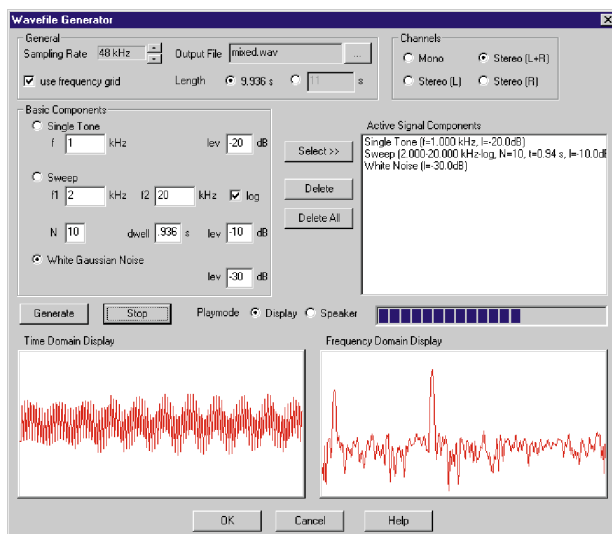


FIG 2  
Wavefile generator  
menu for calculating  
audio test signals

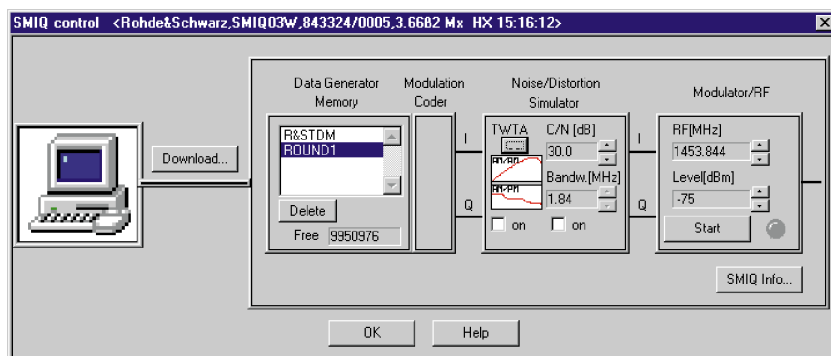


FIG 3 SMIQ control menu for downloading calculated TDM data and operating Signal Generator SMIQ02W/03W from PC

(up to 45°), a disadvantage that is accepted and taken into account in the design of sound broadcast receivers. SMIQ02W/03W is capable of simulating this type of distortion. For example, 30 points are entered for the AM/AM as well as the AM/PM characteristic to be simulated. Based on these values, the instrument calculates the complete waveforms by spline interpolation and then determines the I and Q correction characteristics. The I/Q signal from the modulation coder is corrected accordingly and the RF signal is thus output with the wanted distortion. The distortion characteristic for the WorldSpace satellite is implemented as standard. Comparisons of SMIQ output signals with actual satellite-transmitted signals have not revealed any perceptible differences. The TWTA (travelling wave tube amplifier) simulation used here is also employed in receiver circuitry design.

The generator's output signal has to be matched to real receive conditions on one more count, i.e. the satellite signal carries a lot of noise, whereas a signal generator normally supplies noise-free signals. Since specifications stipulate that receivers should operate properly even at a carrier/noise (C/N) ratio of about 4 dB, the generator too must be capable of producing a signal as poor as this to simulate real receive condi-

tions. SMIQ02W/03W therefore offers the possibility of superimposing white noise of different bandwidths on the output signal. The C/N ratio can be varied between -5 and 30 dB in 0.1 dB increments. This high resolution plus the high accuracy of the C/N setting (error <0.2 dB) are necessary since, due to the complex error control mechanisms, even comparatively slight variations of C/N ratio may be deci-

sive as to whether reception is possible or not. In production, reception quality at a defined C/N ratio decides whether or not a receiver meets specifications and can be supplied to the customer. SMIQ..W is the only instrument on the market that is capable of simulating defined modulation distortion in this way and supplying an output signal with defined noise.

Wolfgang Kernchen

#### REFERENCES

- [1] Klier, J.: Signal Generator SMIQ – High-quality digital modulation up to 3.3 GHz. News from Rohde & Schwarz (1997) No. 154, pp 4–6
- [2] Kernchen, W.: Audio Analyzer UPL – Audio analysis today and tomorrow. News from Rohde & Schwarz (1996) No. 151, pp 4–6

#### Condensed data of Vector Signal Generator SMIQ02W / SMIQ03W

Frequency range 02W / 03W	300 kHz to 2.2 GHz / 3.3 GHz
Distortion simulator	AM/AM and AM/PM distortion of output signal, programmable characteristic
Noise generator	
Distribution	AWGN (additive white Gaussian noise)
C/N	-5 to 30 dB, resolution 0.1 dB, error <0.2 dB

Reader service card 160/02