R&S®SMBV100A vector signal generator – allrounder and specialist at the same time

The attractively priced R&S®SMBV100A offers performance that was previously available only in considerably more expensive instruments. It provides an output level of typ. +24 dBm up to 6 GHz and a maximum RF bandwidth of 528 MHz. Digital standards such as WiMAX™, 3GPP FDD, HSPA and LTE can be configured directly on the instrument via its intuitive user interface. An integrated modulation generator produces baseband signals internally, eliminating the need for a PC.

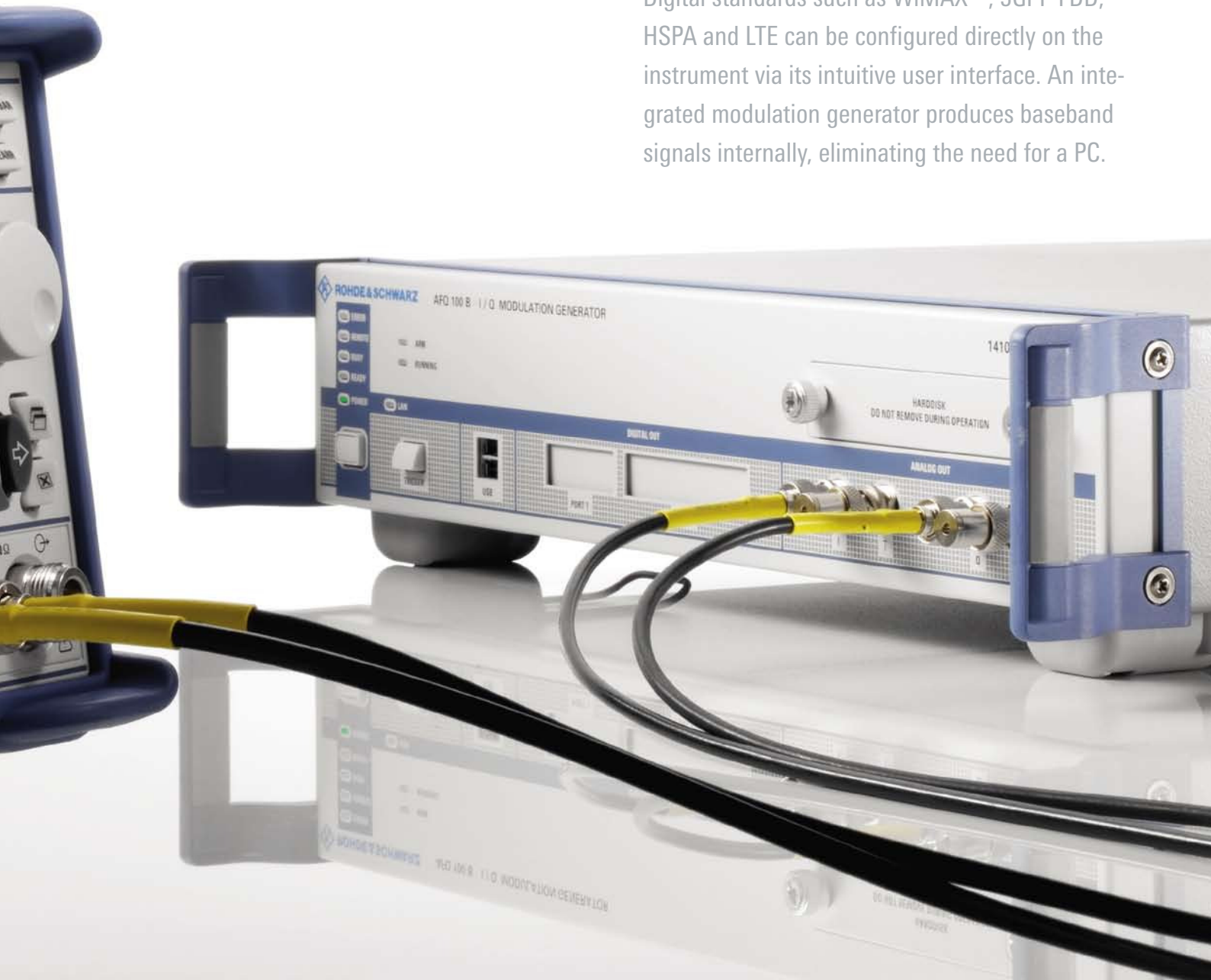


FIG 1 Developing digital RF modules, producing RF receivers or researching in the field of complex radar applications: Whatever the task, the R&S®SMBV100A can be adapted to meet the requirements. With its baseband bandwidth of 264 MHz and the resulting RF bandwidth of 528 MHz, it is suitable not only as an RF converter for UWB signals but also for complex pulsed signals as can be generated using the new R&S®AFQ100B generator (right) and the R&S®AFQ-K6 pulse sequencer software.

Signals for today and tomorrow

Testing as many different digital communications standards as possible by means of a single instrument – this is the requirement modern test equipment must fulfill, in a world where digital standards are diversifying more and more. In addition to established digital standards such as WCDMA and GSM, new ones such as LTE, WiMAX™ and WLAN IEEE 802.11n have been created, resulting in new and more stringent requirements regarding transmission rate and bandwidth. For example, LTE defines data rates of 100 Mbit/s, and IEEE 802.11n specifies bandwidths of up to 40 MHz. Likewise running in high gear is the development of mobile phones, these modern jack-of-all-trades that can also handle sound and TV broadcasting standards such as FM and DVB-T/-H and provide mobile navigation via GPS.

The R&S®SMBV100A vector signal generator (FIG 1) has been designed for this dynamic background: As a platform that is also ready for future applications, it combines the powerful RF technology of the R&S®SMB100A* generator with the innovative operating concept (FIG 2) and the flexible baseband generation of the R&S®SMx generator family. In its standard configuration, it is a purely analog vector signal generator that converts analog I/Q signals from a baseband source to the RF with an RF bandwidth up to 528 MHz. Depending on the options installed, it generates frequencies up to 3.2 GHz or 6 GHz and provides signals of high power (24 dBm), excellent spectral characteristics and very low error vector magnitude.

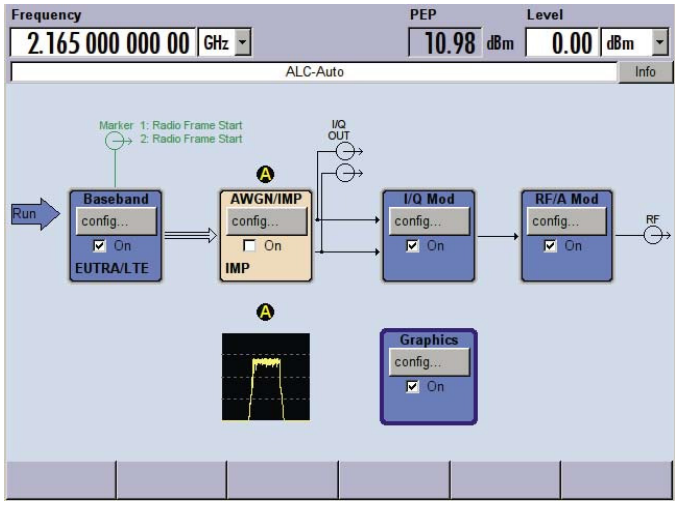


FIG 2 The user interface shows the signal flow through the relevant signal processing blocks, starting from generation of the baseband signal up to the RF. Clicking the blocks will open configuration menus for the individual functional units. The display responds to changes in the signal flow and indicates the most important settings and status messages at a glance. The graphic display provides, for example, the I/Q representation and the power spectrum as display modes for checking the signal currently output.

* R&S®SMB100A Signal Generator: Whether broadcast, ærospace and defense, or EMC: analog signals for every application. News from Rohde&Schwarz (2007) No. 194, pp 18–23.

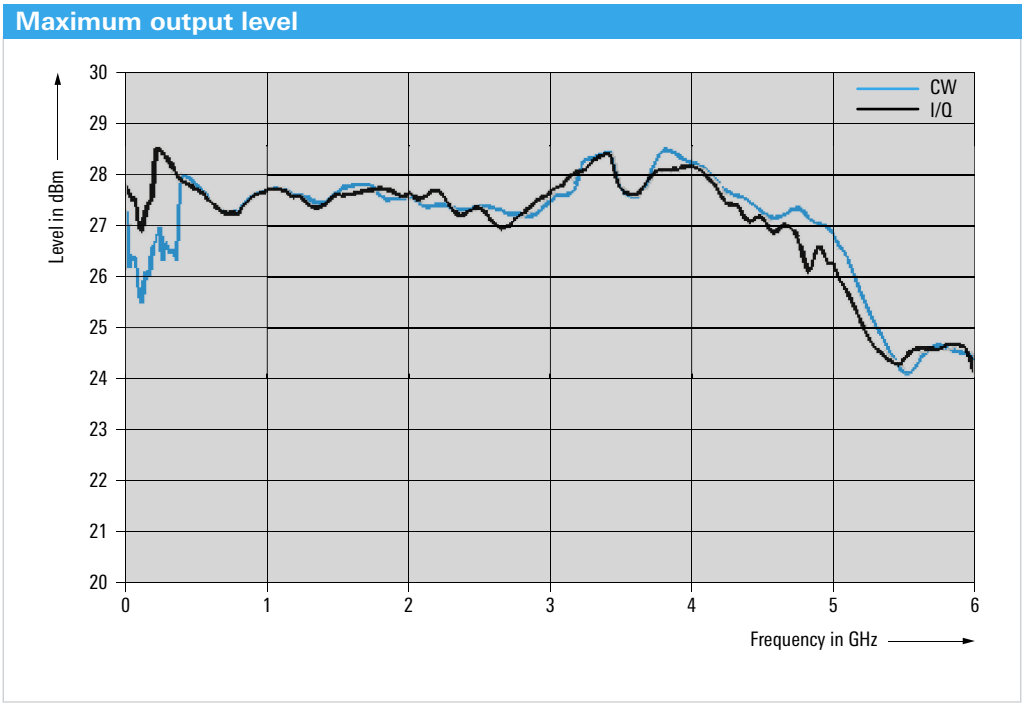


FIG 3 Measured maximum output level in the CW and I/Q modulation modes.

The R&S®SMBV100A is the only signal generator in its class that can be equipped either with an arbitrary waveform generator (ARB generator) or a realtime baseband coder. The ARB generator is scalable in terms of bandwidth (60 MHz or 120 MHz) and memory depth, allowing the R&S®SMBV100A to be optimally adapted to the task at hand.

Due to its compact size (3 HU, ¾ 19"), it is moreover the first vector signal generator that can deliver cutting-edge modulation signals in minimum time as a powerful standalone unit and still fits into tight spaces.

Highest RF output level in its class

The R&S®SMBV100A offers an RF frequency range of 9 kHz to 6 GHz as well as analog modulation modes including AM, FM, φM and fast pulse modulation. It also features excellent spectral characteristics and a powerful output stage, enabling high output levels of typically +24 dBm to be achieved over the entire frequency range up to 6 GHz (FIG 3).

Low adjacent channel power

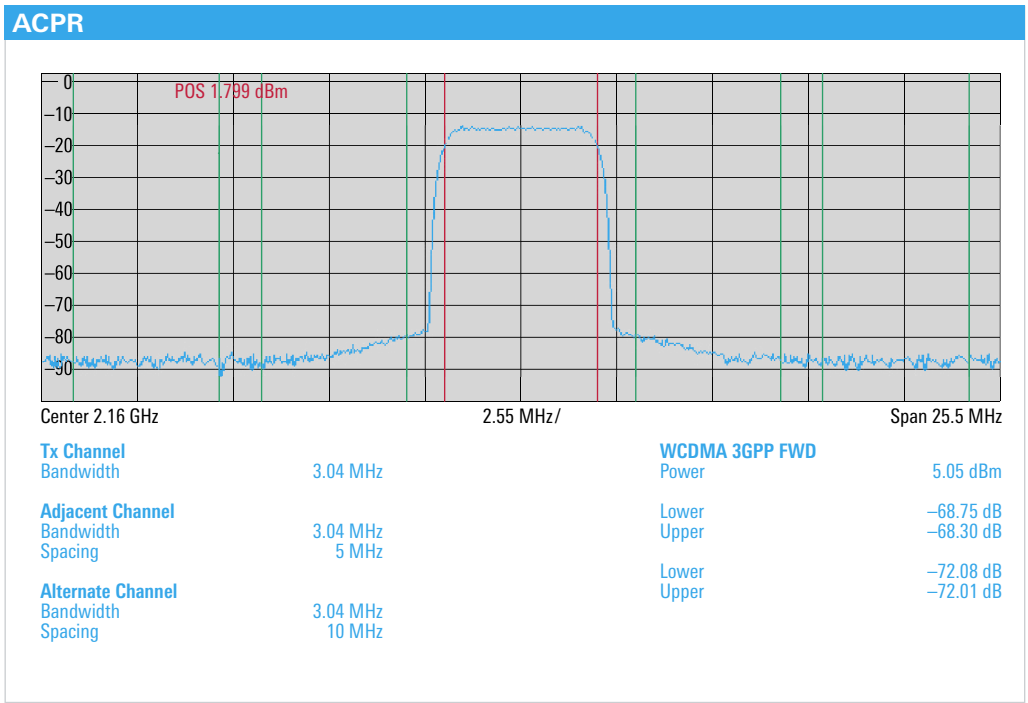
The adjacent channel power ratio (ACPR) is a measure of the linearity and the wideband noise of a signal generator with I/Q modulation. Featuring an excellent ACPR of typically –68 dBc for a 3GPP signal (test model 1-64) at 2 GHz (FIG 4), the R&S®SMBV100A not only has ample margin for testing receivers but is also suited for testing power amplifiers.

Due to the RF module's high level margin, the RF chain operates at very low distortion, and high adjacent channel power suppression is achieved for the first adjacent channel up to high output levels. Based on an internal level algorithm, the generator thus attains an ACPR value of typically –68 dBc for a 3GPP signal (test model 1-64) with a crest factor of 10.55 dB over a very wide level range up to +5 dBm channel power (FIG 5).

RF bandwidths up to 528 MHz

The input circuit of the R&S®SMBV100A is optimized for high bandwidths, making the instrument extremely future-ready. With its baseband bandwidth of 264 MHz and the resulting RF bandwidth of 528 MHz, it is suitable not only as an RF converter for UWB signals but also for complex pulsed signals, such as can be generated with the new R&S®AFQ100B UWB signal and I/Q modulation generator (page 50) using the R&S®AFQ-K6 pulse sequencer software. This is made possible by the newly developed vector board, which has as its core an ASIC with a wideband, highly linear and low-noise I/Q modulator.

FIG 4 ACPR of an R&S®SMBV100A vector signal generator at 2.16 GHz.



Low error vector magnitude

The error vector magnitude (EVM) of a signal generator results from the static vector error of the I/Q modulator (quadrature offset, I/Q imbalance and carrier leakage), the modulation frequency response and the phase noise of the modulated signal. The static vector errors are internally compensated in the R&S®SMBV100A. Together with the low modulation frequency response and phase noise of the RF module, the generator thus achieves excellent EVM values. For 3GPP test signals, the EVM is typically 0.4 % at 2.1 GHz; for GSM EDGE, it is typically 0.2 % at 910 MHz.

Scalable baseband signal generation

For applications in which precalculated signals have to be generated, e.g. for production tests, an ARB generator module (FIG 6) with outstanding characteristics is available. FIG 7 shows possible applications in which the functional diversity of the R&S®SMBV100A with a built-in ARB board becomes clear.

ACPR for 3GPP test model 1-64

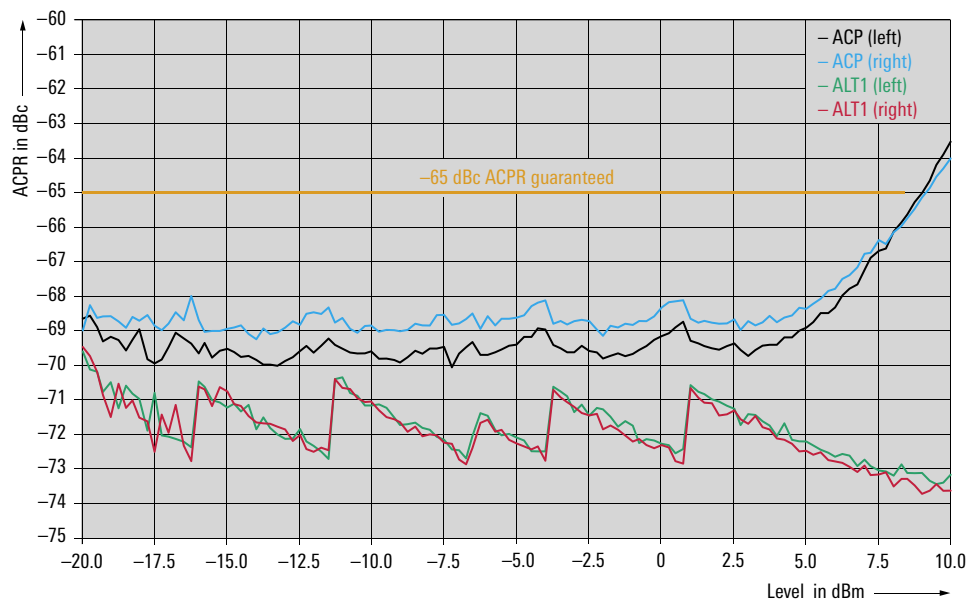


FIG 5 Measured ACPR for the 3GPP test model 1-64 at 2 GHz as a function of the output level.

Signal flow on ARB board

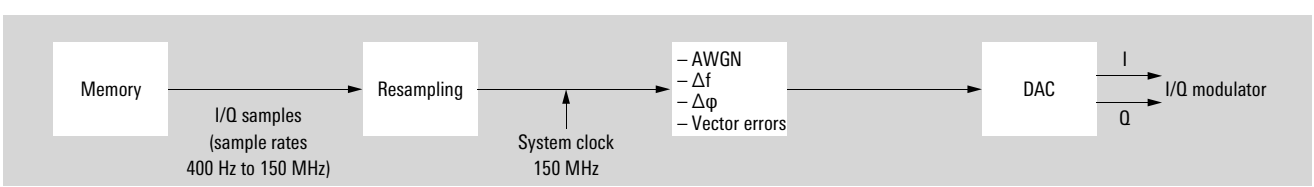


FIG 6 The I/Q data is first written from a file to the memory. The minimum required sample rate for a specific signal bandwidth can be used, i.e. the sample rate need not be synchronized to the system clock, which helps ensure efficient memory utilization. With the set sample rate, the samples are passed on from the memory to the resampler, which upconverts the sample rate to the system clock of 150 MHz. The subsequent block inserts, if desired, vector errors into the signal or superimposes noise on it. The signal is then converted from digital to analog and finally fed to the I/Q modulator, which modulates it to the desired carrier frequency.

Typical application	Feature	Description
Playback of waveforms of common digital standards such as LTE, WiMAX™ or WLAN	60 MHz RF bandwidth	ARB baseband generator (R&S®SMBV-B50 option)
Playback of waveforms of high bandwidth, to be expected with future standards such as LTE Advanced	120 MHz RF bandwidth	ARB baseband generator (R&S®SMBV-B51 option)
Playback of short waveforms, e. g. for ACP amplifier tests	32 Msample memory depth	Standard with the above ARB baseband generators
Playback of long waveforms, e. g. for broadcast standards	256 Msample memory depth	Memory extension (R&S®SMBV-B55 option)
High-speed tests using different signals	Multisegment waveform mode	Generation of different waveforms; switchover between these waveforms within a few milliseconds
Testing receivers in the presence of interference from signals on adjacent channels	Multicarrier mode	Different modulated ARB signals can be arbitrarily positioned in the spectrum within the RF bandwidth of the ARB generator
Chip tests on digital interfaces	Digital baseband output	Output of different digital protocols via the R&S®EX-IQ-Box option
Upconversion of a digital baseband signal to the RF	Digital baseband input	For example, RF modulator for the R&S®AMU200A baseband generator
Testing receiver performance with a faulty transmitter or channel	Defined signal impairment	Variation of gain, offset and quadrature as well as skew and delay
Testing receiver performance with noisy signal	AWGN	Addition of noise to the signal or pure noise (R&S®SMBV-K62 option)
Alignment of RF phase	Phase offset	Used for measurements requiring phase coherence in sync mode

FIG 7 The R&S®SMBV100A vector signal generator offers a variety of applications with the optional ARB board.

Short setting times – ideal for production

For tests in production applications, low purchase costs and, above all, the setting speed are primary considerations. A generator must therefore be able to rapidly deliver a wide variety of different test signals one after the other. The ARB generator in the R&S®SMBV100A can output precalculated signals seamlessly one after the other in multisegment waveform mode. In addition, the list mode allows level and frequency hops in less than one millisecond. In this mode, first a list containing up to two thousand level and frequency points is created, and then in a learning phase the module settings required for these list elements are calculated and saved. The elements of the list can then be called sequentially.

Multistandard realtime baseband coder

When equipped with the realtime baseband coder, the R&S®SMBV100A delivers its maximum performance, particularly in research and development. In addition to all the functions offered by the ARB board, signals of all established and future-oriented wireless communications standards can be generated and configured on the instrument. This is conveniently done in the straightforward menus on the familiar, tried-and-tested graphical user interface known from the R&S®SMx family. Precalculating signals on an external PC and transferring them to the instrument is therefore not necessary.

The range of digital standards leaves no wishes open:

- Latest 4G standards such as LTE (long term evolution) and WiMAX™
- Proven standards such as 3GPP with the HSUPA and HSPA+ enhancements, CDMA2000® and, of course, GSM
- Virtually all important sound broadcasting standards such as FM stereo (with RDS), DAB, Sirius and XM (satellite radio) will be available in the near future
- Custom digital modulation with all common modulation modes, codings and flexible settings

The advantage of generating signals in realtime (FIG 8) is that you can quickly modify parameters and immediately check the results. In addition, signals are not cyclically repeated; instead, they can potentially be infinitely long. Future standards (for realtime operation) will be added to the R&S®SMBV100A.

Frequency offset

Each of the signals set in the baseband block can be assigned a frequency offset and also be phase-adjusted. This makes it very easy to create a single-sideband signal from any signal – with the R&S®SMBV100A featuring a sideband suppression of 40 dB at a frequency offset of 60 MHz.

Ready for MIMO

Advanced mobile radio standards such as LTE offer modes with the transmitter sending different signals on multiple antennas and the receiver receiving them on multiple antennas. This technology, which is referred to as multiple input multiple output (MIMO) and is often used in conjunction with beamforming, places high requirements on the particular simulation environment: To generate the signals, you normally need a signal generator for each antenna. The generators must be phased-locked both at the RF and in the baseband, as if a single transmitter were generating the signals. When switched to sync mode, the R&S®SMBV100A provides high-precision phase-locking in the baseband and at the RF for multiple series-connected instruments (FIG 9). The basebands of phase-locked instruments are automatically synchronized, wich keeps the delay between the signals to below one nanosecond. The RF output signals are phase-locked by feeding a common LO signal to all I/Q modulators. Phase differences between the RF output signals are compensated by introducing a phase offset in the baseband signal. The overall configuration requires no extra equipment but merely two additional cables.

Impairments and AWGN

The generated signal can be influenced in the digital domain in various ways by means of the R&S®SMBV100A, either to simulate transmitter errors or to compensate for unwanted effects of the receiver. Besides the familiar gain, offset and quadrature parameters known from the R&S®SMx family, the signal can also be influenced using the skew and delay parameters. It is thus possible to shift I relative to Q in time (skew) or to shift both channels together back or forward in time (delay). Digital signal processing allows fine tuning down to one picosecond. In sync mode, the baseband of one signal generator can thus be time-adjusted with utmost precision relative to that of another signal generator (FIG 9).

To test how receivers behave if channels are noisy, the R&S®SMBV100A allows users to generate Gaussian white noise (GWN). This can be either added to the useful signal as additive GWN (AWGN) or generated as noise without a useful signal. Both the noise bandwidth and the desired signal-to-noise ratio are adjustable.

Continued on page 43 after the "75 Years of Rohde & Schwarz" extra section.

Signal flow on realtime board

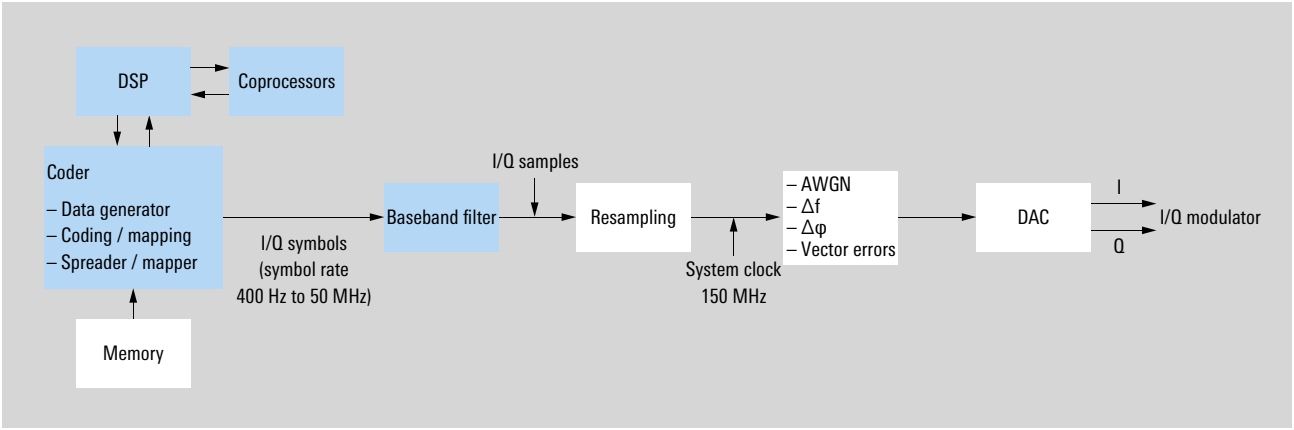
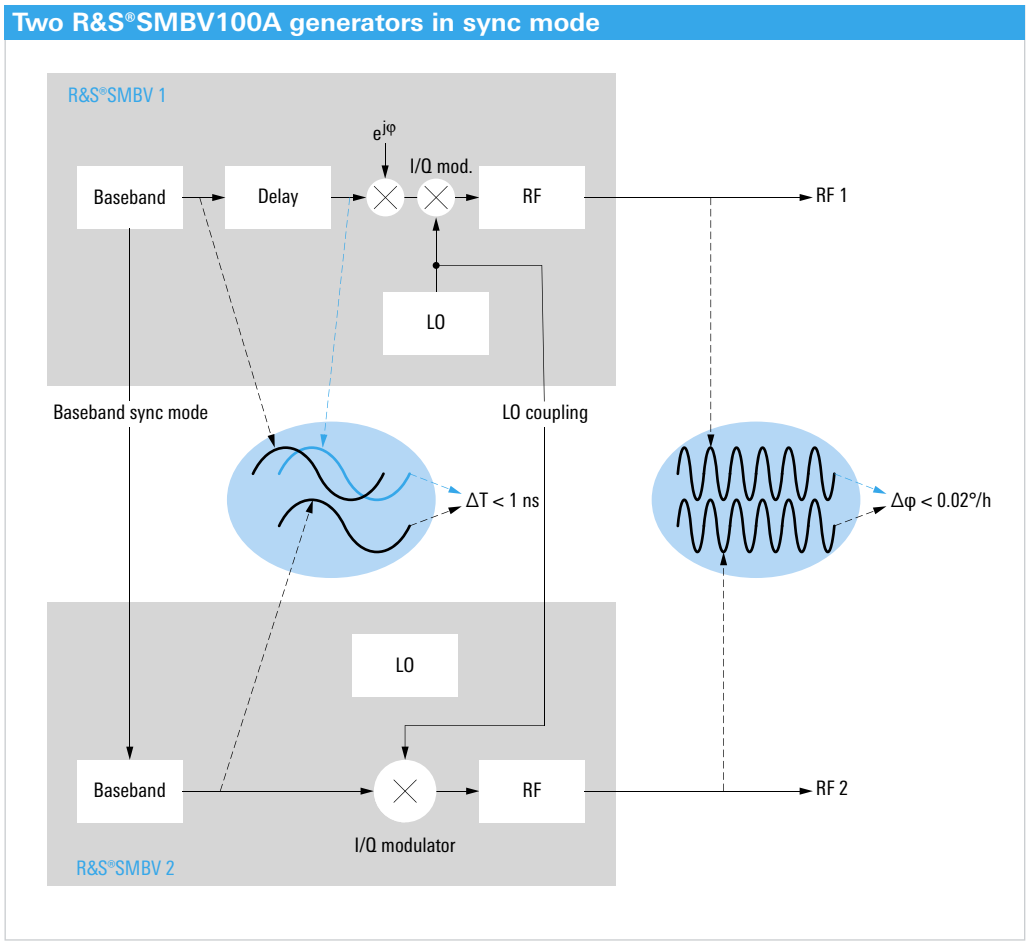


FIG 8 The data to be transmitted (e.g. for WCDMA channels) is initially in the memory in the form of a data list or is generated directly in the coder. It is then spread and channel-coded in the coder, if necessary, and mapped onto symbols. During these processes, special operations such as framing are executed on a DSP that in turn can use fast coprocessor functions. The I/Q symbols thus generated undergo pulse shaping and oversampling in the filter. The resulting samples are then put through the process already described for the ARB board (FIG 6).

FIG 9 Synchronization of two R&S®SMBV100A vector signal generators.



Continued from page 42

User-friendly service concept

As in the development of the tried-and-tested modules of the R&S®SMB100A generator, high reliability was made a top priority also for the new modules. Designed to meet tough requirements (temperature range 0 °C to 55 °C, altitude up to 4600 m), the R&S®SMBV100A offers a long life in production or lab applications and has low failure rates. Nevertheless, if a module does fail, repair is no problem, for the module can be replaced on site.

The defective module is easily located by using the precise diagnostic functions on the instrument and following the detailed troubleshooting instructions in the service manual. The video sequences integrated in the service manual, which show all the required worksteps in detail, make it easy to replace the module. After a replacement of the RF board, the level correction values can be re-recorded and saved in the R&S®SMBV100A on site automatically and independently by using an R&S®NRP-Z91 or R&S®NRP-Z92 power sensor. This reduces downtimes considerably.

Summary

The R&S®SMBV100A is the first vector signal generator in its class that not only offers excellent RF characteristics but, in particular, also features future-oriented internal baseband generation. Offering high versatility and scalability, it is a truly all-purpose instrument. Due to its powerful digital hardware, the baseband coder can calculate even complex digital modulation modes in realtime. Plus, parameters can easily be modified on the intuitive graphical user interface. These features combine to make the generator an ideal measuring instrument for lab applications. It is also highly suitable for use in production, owing to its fast setting times and its ability to switch very fast between stored waveforms.

Dr. Joachim Danz; Eckhard Hammer; Volker Ohlen