An outstanding achievement: The R&S® SMU200A as the follow-up instrument to the successful Signal Generator R&S® SMIQ excels at flexibility and performance. It is the first high-end generator able to offer two complete signal generators with digital modulation capability in a single instrument.

Modular design for user-friendly solutions

The new Vector Signal Generator R&S® SMU200A is based on a powerful system platform with a fast processor and SVGA colour display (800 × 600 pixels). Occupying only four height units, it offers space for up to two RF paths – and the user is able to choose from four different frequency options (upper frequency limit 2.2/3/4/6 GHz) for the first RF path. In addition, a second RF path with an upper frequency limit of up to 2.2 GHz or 3 GHz can be installed. The lower frequency limit is 100 kHz for all options. Both RF paths have I/Q modulation capability via the internal baseband section of the generator. The first RF path can also be modulated with external analog I/Q signals.

The baseband section of the R&S®SMU is completely digital and can accommodate up to two I/Q baseband generators. Their output signals can be provided with a frequency offset in the baseband and added as well.

FIG 1 Visionary: The new Vector Signal Generator R&S® SMU200A offers two complete signal generators with digital modulation capability in a single instrument and facilitates the overview due to a novel operating concept.
Application examples: The R&S® SMU 200A with two paths

FIG 2
The block diagram on the R&S® SMU display is of key importance to the operating concept. Left, the example of 3GPP transmit diversity, where a base station transmits differently coded signals via two transmitting antennas. An R&S® SMU with two baseband generators is able to simulate this, for example to test the receiver of a mobile phone. Baseband A generates the signal of antenna 1, baseband B that of antenna 2 (each in realtime with channel coding). Since both signals are transmitted on the same RF frequency, only one RF path is required. The yellow/red signal flow in the block diagram of the generator was subsequently added to these examples for clarification purposes.

FIG 3
Simulation of the multicarrier signal of a 3GPP base station for receiver tests on mobile stations, where baseband A generates in realtime the wanted signal to be demodulated by the receiver. Baseband B generates a matching multicarrier signal as the background signal by means of its arbitrary waveform generator.

FIG 4
With two RF and two baseband paths, the R&S® SMU simultaneously generates wanted and interfering signals of receiver tests; the interfering signal can, of course, also be modulated. Thus, tests such as adjacent channel selectivity or blocking are feasible with only one instrument.
The flexible concept with diverse options allows nearly all conceivable versions: from the vector signal generator with external modulation capability with one RF path through to the fully-fledged device with two RF paths. Moreover, most options (e.g., digital mobile radio standards) are software options and easily upgradeable. Users can thus configure devices that are tailored to meet their specific applications and only buy what they really need.

Two baseband/RF paths open up new applications

Two signal generators in one – a design that saves 50% in space. Both paths open up applications to the R&S® SMU that were so far only feasible with several signal generators, involving enormous effort. If two baseband generators are installed, their output signals can be digitally added and applied to the I/O modulator of an RF path – if necessary weighted and with an application-specific frequency offset. Owing to an innovative resampling concept, the entire baseband section runs using a common clock, and synchronization is child’s play. One baseband generator can also trigger the other one, allowing a defined time offset between the signals. It is thus possible to create complex scenarios that will be far only feasible in mobile radio in the future by using just one RF path (for examples, see left page). The maximum bandwidth of the overall signal of 80 MHz is more than sufficient for nearly all applications.

With two RF and two baseband paths, there is almost nothing left to be desired. The generator can also generate signal combinations that largely differ in power and frequency offset, for example a wanted signal and modulated interfering signal for receiver tests. Modulation signals of up to 80 MHz are now possible on each path.

Ready for 3G and more

The core of an R&S® SMU baseband generator (option R&S® SMU-B10) is a universal coder with DSP and FPGA coprocessor for calculating complex signals in real-time. The generator is thus basically able to generate signals for all common mobile radio standards. The universal coder features ASK, FSK (incl. MSK), PSK (incl. 8PSK EDGE) and QAM (up to 1024QAM) as modulation modes plus all standard baseband filters and coding types. Different PRBS types, user-specific patterns and data lists are provided as internal data sources. It is also possible to apply external data in real-time via the USB interface, the serial or the parallel port.

Moreover, each R&S® SMU baseband generator contains an arbitrary waveform generator (ARB) with a 56 Msample memory depth, thus surpassing even the trustworthy I/Q Modulation Generator R&S® AMIQ from Rohde & Schwarz. Plus, lower oversampling values can be used with each of these ARBs because of the built-in hardware interpolation filter, which again increases the effective memory depth.

Of course, the tried-and-tested Simulation Software R&S® WinIQSIM™ supports the R&S® SMU, too. All standards that can be generated with this software, including WLAN 802.11 (a, b and g), cdma2000 and 3GPP TDD low rate (TD-SCDMA) and high rate, are thus available to users right from the start.

Furthermore, the generator internally provides software options that are tailored to meet important mobile radio standards. To begin with, the 3GPP FDD und GSM/EDGE options are available. Another available option generates CW multicarrier signals as are often required for amplifier tests.

The GSM/EDGE option allows the R&S® SMU to change modulation between GMSK and 8PSK EDGE in real-time and offers all burst types defined in the standard. Plus, in the new framed (double) mode, two different frames can be generated. The number of repetitions of a frame prior to changing to another frame can be set. The generator is thus able to simulate multiframe scenarios, for example an idle burst every 26 frames, or a change of modulation as a function of time in a defined timeslot.

In the digital standard 3GPP, the real-time capabilities and the ARB of a baseband generator are combined so that the generator provides an impressive functionality portfolio. In downlink mode, up to four code channels can be generated in real-time, including channel coding (PCCPCH and up to three DPCHs). All in all, the R&S® SMU simulates up to four base stations with 128 DPCHs each (with control channels). All conceivable scenarios are thus possible, ranging from the standard-conformant reference measurement channel to the simulation of a base station under full load.

The orthogonal channel noise simulation (OCNS) defined in the standard is, of course, also available. In uplink mode, the three modes PRACH, PCPCH and DPCCH with DPDCH can be selected, for mobile station 1 all in real-time and with channel coding. Thus, receiver tests on 3GPP base stations according to TS 25.141 are possible. For more complex scenarios, the generator can simulate up to 67 additional mobile stations. Numerous other functions and comprehensive graphical possibilities such as code domain (FIG 5) or channel graph complement the picture.
FIG 5
Left: The code domain display of the 3GPP FDD system in the R&S® SMU.
Below: For comparison, the same signal measured by using the 3GPP option in the Signal Analyzer R&S® FSQ.

FIG 6 With a 3GPP signal with four carriers, the R&S® SMU achieves ACLR values of typically 64 dB in the adjacent channel, typically 65 dB in the alternate channel.

FIG 7 SSB phase noise of the R&S® SMU for important carrier frequencies (typical values).
If required, additive white Gaussian noise (AWGN) or artificial I/Q impairments can be added to the I/Q signals thus generated. For test purposes, a single noise signal can be generated. Modern 16-bit DACs carry out the D/A conversion.

**Outstanding signal quality**

Needless to say, the signal quality of the R&S ® SMU – a criterion that is still of paramount importance in many applications – is just as impressive. Especially measurements on RF components such as power amplifiers for 3GPP base stations place highly stringent requirements on the T&M equipment used (FIG 8). Here as well, the generator wins out. With a 3GPP test model 1, 64 DPCHs, it achieves ACLR values of typically 70 dB in the adjacent channel and typically 75 dB in the alternate channel. With a 3GPP four-carrier signal, as shown in FIG 6, the generator typically achieves 64 dB in the adjacent channel and typically 65 dB in the alternate channel, thus offering maximum performance for any conceivable signal configurations. At the same time, the vector error of the generated signals is extremely small (for 3GPP typ. 0.3% with 1 DPCH, rms value).

Another important parameter is the SSB phase noise (FIG 7). In this case, the generator typically achieves –135 dBc at 1 GHz (20 kHz offset, 1 Hz measurement bandwidth); to achieve such a value, conventional devices require expensive options. This achieves not only exceptionally small modulation errors with narrowband standards but makes the R&S ® SMU ideal for use as an interferer with blocking measurements.

The I/Q modulator used in the generator exhibits an RF modulation bandwidth of 200 MHz which can be fully exploited in the external wideband I/Q mode with external analog I/Q signals.

If the internal baseband section is used, an RF modulation bandwidth of 80 MHz (per installed path) is available. The R&S ® SMU is thus ideally prepared for the broadband systems of the future.

A new digital level control ensures high level linearity and accurate repeatability, both important parameters for numerous measurements. With the latter, the generator typically achieves an excellent value of 0.05 dB – even with modulated signals such as for 3GPP. The overall level uncertainty is less than 0.5 dB.

An electronic attenuator ensures wear-free switching in the entire level range. The generator features up to +13 dBm (PEP) in its standard version. By means of the high-power option, the output power can be increased up to +19 dBm (up to +26 dBm in overrange). The option is installed in parallel with the electronic attenuator so that the latter can still be used in the normal level range.

**Modern intuitive operating concept**

The third-generation mobile radio places high demands on the functionality of signal generators. Complex signals, partially with channel coding, must be generated for standard-conformant measurements on base stations or mobile phones. For this reason, Rohde & Schwarz has developed a state-of-the-art operating concept with a graphical user interface for the R&S ® SMU. The main element of this concept is the block diagram that visualizes the entire signal flow from baseband.
FIG 9 The R&S® SMU is able to display the generated baseband signal in realtime.

FIG 10 The context-sensitive help includes the entire operating manual and offers full-text search.
to RF output (FIG 2 to FIG 4) with each block representing a functional unit in the device. The graphical display helps the user to recognize at any time both the active blocks and the point in the signal flow at which a specific parameter is effective. The block diagram also shows other active control signals such as trigger or marker. Submenus are displayed in individual windows, similar to PC programs. The generator can be controlled via the front panel as well as with keyboard and mouse.

The block diagram and in particular its graphical functions are convincing. Owing to its built-in transients recorder, it can display the generated baseband signal in realtime in all common display modes: I(t), Q(t), vector diagram, constellation diagram, frequency spectrum, etc (FIG 9). It is thus easy to verify if the required signal is generated; moreover, an oscilloscope or a signal analyzer to check the I/Q signal becomes superfluous. This concept makes even the generation of the most complex signals child’s play – and it’s fun to operate the R&S®SMU.

And should the user really need some help, this is also no problem. A simple click on the help key opens the context-sensitive help system with explanations of the selected parameter (FIG 10). It contains the entire operating manual of the generator and offers numerous possible navigations including full-text search, as known from Internet browsers.

Dr René Desquiotz

The main characteristics of the Vector Signal Generator R&S®SMU200A
- Two signal generators in one
- First RF path up to 2.2/3/4 GHz or 6 GHz
- Second RF path up to 2.2 GHz or 3 GHz
- Up to two I/Q baseband generators can be installed
- Baseband signals can be added digitally, also with frequency offset
- Baseband generator with universal coder for realtime signals and arbitrary waveform generator with 56 Msample for I and Q and four marker bits per sample (256 Mbyte)
- I/Q modulator with 200 MHz bandwidth
- Very low SSB phase noise of typically –135 dBc (f = 1 GHz, 20 kHz carrier offset, 1 Hz measurement bandwidth)
- Outstanding ACLR values of typically 70 dB (3GPP test model 1, 64 DPCHs, adjacent channel)
- Very short frequency setting times of <3 ms (<450 µs in List mode)
- Electronic attenuator up to 6 GHz
- High output level up to +19 dBm (+26 dBm in overrange) with high-power option
- Intuitive operating concept with graphical display of the signal flow (block diagram)