I/Q Modulation Generator R&S AMIQ

New approaches in the generation of complex I/Q signals

- 14-bit resolution
- 16 000 000 sample memory depth
- 100 MHz sample rate
- 78 dB ACP dynamic range (typical of 3GPP FDD)
- Integrated hard disk and floppy disk drive
- Optional BER measurement (R&S AMIQ-B1)
- Optional differential I/Q outputs (R&S AMIQ-B2)
- Optional digital I/Q output (R&S AMIQ-B3)

ROHDE&SCHWARZ

The ultimate in I/Q signals

Modulation Generator R&S AMIQ

- 100 MHz clock rate per channel
- Up to 16000000 samples per channel
- Generation of broadband digital communication signals (e.g. WCDMA, HIPERLAN2 and IEEE802.11a)
- Built-in hard disk for storage of calculated signals
- Downloading of calculated waveforms and signals also from integrated floppy disk drive
- Antialiasing filter featuring excellent frequency response and group delay
- Auto-alignment and additional user correction of amplitude and offset
- Fine adjustment of I/Q skew
- Wide dynamic range through the use of 14-bit D/A converter, ideal for multicarrier applications
- Excellent ACP (adjacent-channel power) values with WCDMA 3GPP FDD signals of typically –78 dBc for test model 1 with 64 channels

An ideal pair: R&S AMIQ and R&S WinIQSIM™

The number of systems based on complex digital modulation methods has dramatically increased in every field of communications. I/Q modulation is therefore gaining importance for the development of such modulation methods. The Modulation Generator R&S AMIQ and the Simulation Software R&S WinIQSIM™, which is described in a separate data sheet (PD 0757.6940), open up new dimensions for the generation of I/Q signals.

The R&S AMIQ is a dual-channel modulation generator that has especially been designed for use as an I/Q source. It is programmed and set with R&S WinIQSIM™. Alternatively, the R&S AMIQ can be operated from the Vector Signal Generator R&S SMIQ.

Of course, the R&S AMIQ features full remote-control capabilities via the GPIB/IEEE and RS-232-C interfaces.

Each channel can store up to 16 000000 samples. Sequences of sufficient length can thus be generated even at high symbol rates. Featuring clock frequencies of up to 100 Msample/s and a high amplitude resolution of 14 bit at the analog signal output and up to 16 bit at the digital signal output, the R&S AMIQ is the ideal source for any digital modulation signal.

An automatic amplitude/offset alignment as well as fine adjustment of the skew provide excellent symmetry of the two channels which previously was extremely difficult to attain with dual-channel ARB generators. The error vector is thus minimized.

The filters have been optimized regarding group delay, frequency response and matching between the two channels for use as an I/Q modulation source.

Typical applications of the R&S AMIQ and R&S WinIQSIM™ not only include driving the I/Q inputs of a vector signal generator; the combination is also ideal for direct applications in the baseband, such as testing I/Q modulators/demodulators.

The digital signal output (option R&S AMIQ-B3) opens up further applications in the baseband: digital/analog converters (DACs) or digital input base stations can be tested, for example.

Simulation Software R&S WinIQSIM™[1]

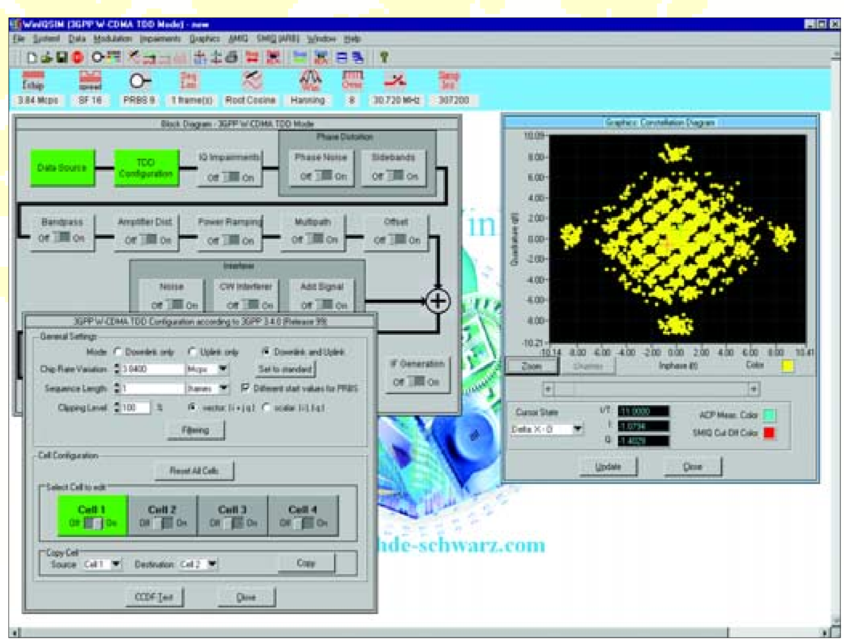
- Single-carrier signals
- Multicarrier signals (up to 512 modulated or unmodulated carriers)
- Multicarrier mixed signals (up to 32 differently modulated carriers)
- User-defined CDMA signal scenarios
- Addition of impairments
- Data editor for creating any TDMA frame configuration
- Predefined files for TDMA mobile radio standards (GSM, GSM-EDGE, DECT, NADC (IS 54C/IS 136), PDC, and test models 1 to 4 for WCDMA 3GPP FDD)
- IF signal calculation
- Graphic display of calculated signals (constellation diagram, vector diagram, i(t)/q(t), magnitude and phase, eye pattern, spectrum, etc)
- Remote control of the R&S AMIQ
- The import system allows data from other software programs to be read in via the TCP/IP and DDE interfaces

[1] For more details see data sheet PD 0757.6940.

Versatile to the last detail

R&S WinIQSIM™ is a Windows software program for calculating I and Q baseband signals. Its functionality ranges from single-carrier modulation, generation of multicarrier, CDMA and WCDMA signals through to TDMA frame configuration with the help of a convenient data editor. All modulation parameters and impairments can be simulated for single-carrier, multicarrier as well as for CDMA signals. To put it in a nutshell: R&S WinIQSIM™ is an indispensable tool for anyone engaged in modern digital modulation.

This Windows software enables the R&S AMIQ to simply generate complex modulation signals. This includes modulation signals for WCDMA 3GPP, which is similar to QPSK, or 8PSK EDGE modulation with $3\pi/8$ shifting for the EDGE enhancement in the GSM standard. OFDM, which is used for HIPERLAN/2, and where a data stream is transferred via a large number of carriers, is a special modulation format. For generating this type of signal, the R&S WinIQOFDM software (see www.rohde-schwarz.com) is used.



One modulation generator ...

Outstanding quality

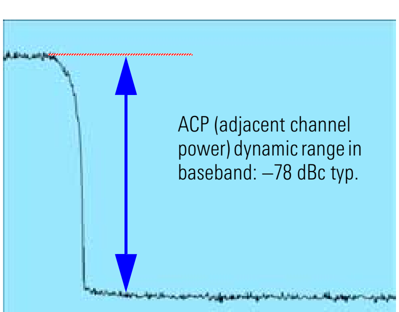
In addition to the great memory depth of up to 16000000 samples, the R&S AMIQ is outstanding especially for its wide dynamic range and excellent spectral purity. For WCDMA signals, low adjacent-channel power (ACP) in the baseband is thus ensured. The built-in filters are designed for flat frequency response and constant group delay.

Two identical channels

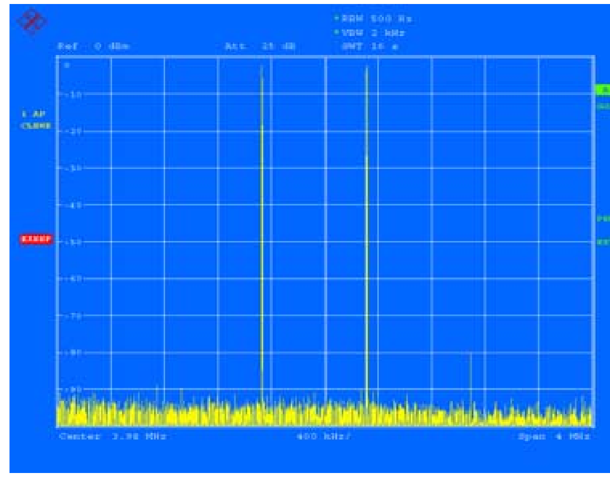
For an I/Q source, it is especially important for the two channels to be identical since any difference would inevitably cause an additional modulation error.

Automatic internal alignment of offset and amplitude of the I and Q channels guarantees high performance. Small amplitude or offset errors of the connected device under test can be user-corrected for overall system alignment. This user correction is independent of the automatic internal alignment.

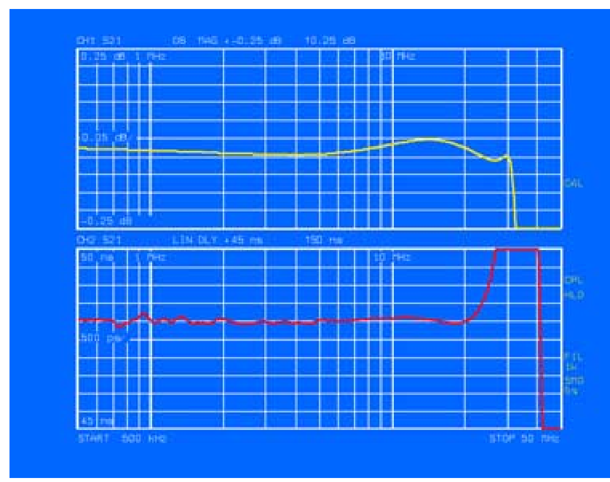
Skews between the I and Q channels, which may be caused, for example, by slight differences in the connecting cables between the R&S AMIQ and the vector signal generator, can be compensated with a resolution of approx. 10 ps.



Intermodulation characteristic of the R&S AMIQ at 50 MHz clock rate



Frequency response and group delay of 25 MHz output filter



All these features are the basis for the outstanding modulation performance of the R&S AMIQ.

Synchronization capabilities

The signal output can be externally controlled. The clock rate of the I/Q output can be adapted to the device under test by means of an external clock. Four user-programmable marker outputs can be synchronized to the desired sample and used, for example, to generate sync pulses at the beginning of a timeslot or to drive the power ramping input of an RF signal generator.

BER measurement

Measuring the bit error rate has become a frequently used method for the verification of digital communication systems (e.g. measuring the sensitivity or selectivity of receivers, subsystems and components). The **option R&S AMIQ-B1** allows the R&S AMIQ to be used for BER (bit error rate) measurements. The device under test (DUT) must deliver the data to be tested and the associated clock. If the DUT does not have its own clock, the clock can be generated by the R&S AMIQ and output via one of the four user-programmable marker channels. The built-in BER tester compares the data with the

... satisfying all requirements

nominal data and calculates the bit error rate. The result of the BER measurement is available via the remote-control interface. Various standard PRBS sequences (PN9, PN15, etc) are used as nominal data.

The BER measurement has an integrating function, i.e. at the wrap-around point of a PRBS sequence the bit error measurement is stopped and restarted by a control signal at the restart input without the previous result being cleared. All partial results are added until the predefined total number of data bits or error bits is attained. Irrelevant data sequences (e.g. preambles) are blanked, if necessary, by means of the control signal at the data enable input so that they do not invalidate the BER measurement. The PRBS sequence and the two control signals (at the marker outputs of the R&S AMIQ) are generated by means of R&S WinIQSIM™.

Differential outputs

The **option R&S AMIQ-B2** enhances the existing I and Q outputs by providing the inverted $\bar{I}$ and $\bar{Q}$ signal outputs.

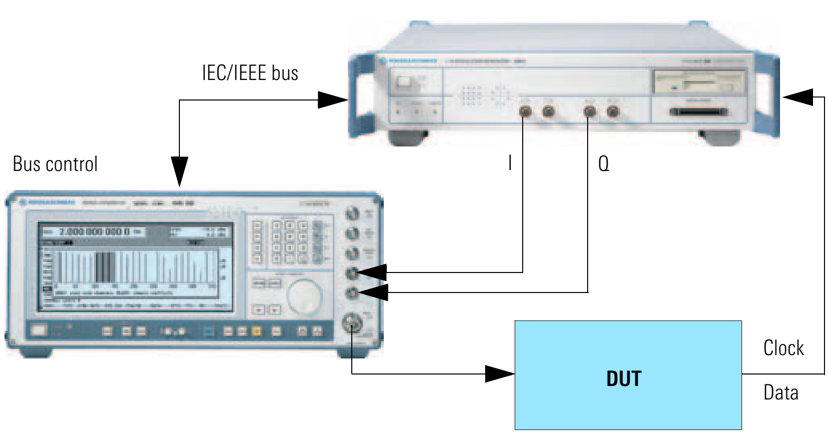
To meet all requirements, the option R&S AMIQ-B2 allows a DC (bias) voltage to be superimposed on the balanced modulation signal (e.g. for setting the operating point). This bias voltage can be set separately for the I and Q channels with high resolution.

Using the R&S AMIQ-B2, unbalanced signals can be converted to balanced signals without requiring an external circuit.

Digital output

The **option R&S AMIQ-B3** provides the digital I and Q waveform data for each channel at a 68-pin SCSI connector on the front panel. A resolution from 8 bits to 16 bits can be selected for the output signals. So it is possible, for example, to drive digital/analog converters (DACs) with different word lengths. By matching the word length, clock and level of the output data to the requirements of the DUT, the R&S AMIQ provides TTL-similar digital signals that are optimally suited for testing digital modules.

Example of bit error rate test



Use in development

The R&S AMIQ considerably enhances the variety of applications of a vector signal generator. It takes over where the internal modulation capabilities of a vector signal generator reach their limits. For example, signals can be generated with a bit rate higher than that which can be processed by the internal modulation coder of an RF generator. The variation capability of any modulation parameter including the superposition of impairments and the generation of IF signals with the aid of R&S WinIQSIM™ is far beyond the facilities of a conventional signal generator. IQWizard[1)] allows the conversion of existing signal data that was generated with the aid of mathematical programs, for example.

Use in production

For use in production environments, measuring instruments have to satisfy versatile requirements. One of the main points of interest is the space they require. Since the R&S AMIQ has no built-in display, it is low in height which makes it especially suited for rackmounting in ATE (Automatic Test Equipment) systems. The R&S AMIQ and R&S WinIQSIM™ were designed for high-speed remote control via the IEC/IEEE bus. Predefined signals can be stored on the internal hard disk and quickly downloaded into the output memory.

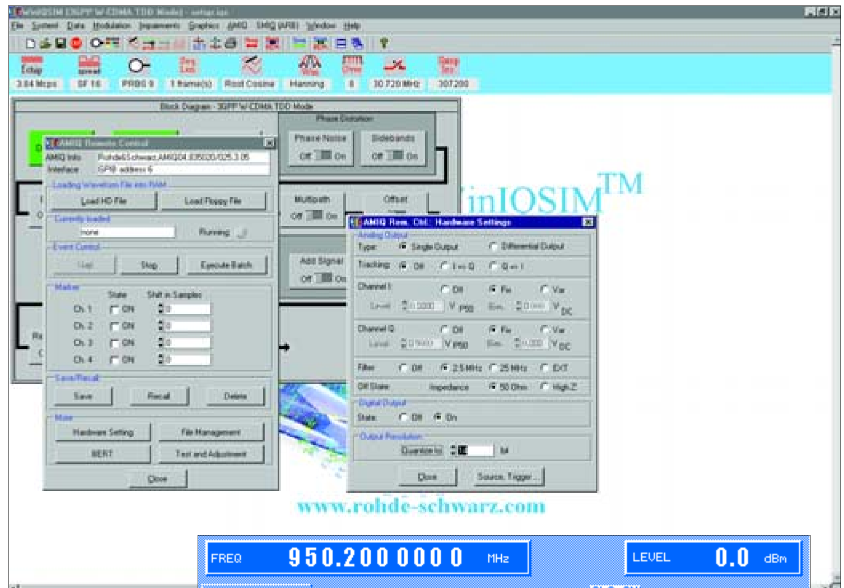
3-year calibration cycle

Another benefit of the R&S AMIQ is its 3-year calibration interval: it reduces costs and increases availability.

1) Can be downloaded from www.rohde-schwarz.com (Application Note 1MA28).

Operation

User interface for controlling the R&S AMIQ with R&S WinIQSIM™



Menu for controlling the R&S AMIQ with the R&S SMIQ

R&S AMIQ, R&S WinIQSIM™ and R&S SMIQ – a perfect team

The R&S AMIQ is a black box without any control and display elements. There are several choices for operating the R&S AMIQ:

Operation via R&S WinIQSIM™
With R&S WinIQSIM™, calculated signals are downloaded to the R&S AMIQ hard disk or directly into the RAM of the R&S AMIQ via IEC/IEEE bus or RS-232-C interface. In addition, all R&S AMIQ functions can be set in a menu under R&S WinIQSIM™.

Operation from R&S SMIQ
A PC with R&S WinIQSIM™ is only required if new waveforms are to be calculated, since the once calculated signals can be stored on the hard disk of the R&S AMIQ. In conjunction with the Vector Signal Generator R&S SMIQ, it is possible to select waveforms stored on hard disk or floppy and change the R&S AMIQ parameters via a special menu. In this mode, the R&S AMIQ acts as if it were an option to the R&S SMIQ.

Operation in ATE systems
As with any other remotely controlled instrument, all functions of the R&S AMIQ, e.g. downloading predefined waveforms from the integrated hard disk, can be controlled via the remote-control interface. In this operating mode, neither R&S WinIQSIM™ nor an R&S SMIQ is required.

Flexible generation of digitally modulated signals with the R&S AMIQ and the R&S SMIQ

Applications

Verification/conformance testing

For the verification and conformance testing of mobile phones and base stations, signal generators are used for testing subsystems such as receivers, modulators and amplifiers. Due to its versatility and signal quality, the R&S AMIQ is the ideal baseband source to handle these tasks. Preprogrammed standard settings in R&S WinIQSIM™ provides frame structures for all primary mobile radio standards. Thus, it is not only possible to generate signals to standards such as GSM and IS-95, but also to the new WCDMA standards such as 3GPP FDD and TDD, TD-SCDMA and CDMA2000. For some of these standards, a special option is required for output of the signals by the R&S AMIQ.

Development of new communication systems

The comprehensive setting facilities provided in R&S WinIQSIM™ allow future systems to be developed with the R&S AMIQ. The programmable data generator contributes to the easy definition of new TDMA (time division multiple access) systems.

Use of the additional R&S WinIQOFDM software provides the R&S AMIQ with the capability of generating OFDM (orthogonal frequency division multiplexing) signals such as HIPERLAN/2 and IEEE802.11a.

Use in automatic test equipment (ATE) systems

In test systems, space is usually limited. Due to its low height, the R&S AMIQ is an ideal choice for use as a baseband or IF signal source. For this application, the R&S AMIQ certainly benefits from its black box design with an IEC/IEEE bus optimized for high transfer rate, and the integrated hard disk for saving the calculated signals.

In addition to size, the time required is also a crucial factor in ATE systems. Fast switchover between different signal sequences is a very important aspect. The R&S AMIQ provides the possibility of combining up to 30 different sequences with fast switchover. The resulting multisegment waveforms can be stored on the internal hard disk like individual sequences and reloaded into the memory for output.

Tolerance tests

In addition to ideal signals, the R&S WinIQSIM™/R&S AMIQ combination also allows the generation of defined signal impairments and additive interfering signals. Variation of bit rates and filtering are used to determine tolerance limits and to detect potential critical spots in new systems. By using the Vector Signal Generator R&S SMIQ, fading and additive noise can be added to the complex signals provided by the R&S AMIQ. In particular, the R&S SMIQ meets the dynamic fading scenarios prescribed by the 3GPP standard.

Adjustment of I/Q modulators

More and more ICs and modules are equipped with differential I/Q inputs. In the case of DC coupling between the R&S AMIQ and a modulator chip, for example, the I/Q signal can be superimposed by a DC (bias) voltage for setting the operating point (option R&S AMIQ-B2 required). This DC voltage can be set separately for the I and Q channel. By superimposing a small offset voltage (user correction) in addition to this bias voltage, the RF carrier leakage in the modulator is minimized to obtain optimum data for the I/Q signal at the RF.

Digital components

The R&S AMIQ's digital signal output (option R&S AMIQ-B3) allows signals to be directly fed to baseband components with digital inputs.

The digital signal output is also optimal for testing digital/analog converters. Due to the selectable word length (8 bits to 16 bits), the test signal can be adapted to the specific requirements.

Specifications

Output memory	
Waveform length (data and markers) Clock rate – Slow mode (10 Hz to 4 MHz) Clock rate– Fast mode (2 MHz to 100 MHz)	 24 to 16 000 000 in steps of one 24 to 16 000 000 in steps of four
Amplitude resolution of data words	selectable word length 8 bit to 14 bit; up to 16 bit at digital output
Marker channels Number	can be used as marker or trigger outputs (for word lengths up to 14 bit) 4
Multisegment waveform Segment changeover time without clock change with clock change	max. 30 segments 4 ms typ. 12 ms typ.
Clock generation	
Clock range	10 Hz to 100 MHz
Setting range	10 Hz to 105 MHz[1]
Resolution	1×10^{-7}
External clock input Clock rate	 10 Hz to 4 MHz (slow mode) 2 MHz to 100 MHz (fast mode)
Reference frequency	
Internal reference output Frequency Aging (after 30 days of operation) Temperature effect (0 °C to 45 °C) Level, rms Frequency adjustment	 10 MHz 1×10^{-5}/year $<2 \times 10^{-6}$/°C 0.5 V (into 50 Ω) electronic
External reference input Frequency Level, rms Input impedance	 10 MHz 0.1 V to 2 V 50 Ω
Signal output	
Outputs	I and Q[2]
Output impedance	50 Ω
Output voltage (V_p into 50 Ω) Fix mode Amplitude fine variation Resolution Level difference between the two channels Residual DC offset DC fine variation Resolution SFDR[3] (sinewave/clockrate) 1 MHz/10 MHz 5 MHz/50 MHz Variable mode Resolution Residual DC offset DC fine variation Resolution SFDR[3] (sinewave 1 MHz, clock rate 10 MHz)	 0.5 V, same for both channels ±10%, separately for each channel 0.01% <0.2% (at 1 kHz, after auto-alignment) <0.5 mV, 0.1 mV typ. (after auto-alignment) ±30 mV typ. 30 µV >70 dB, 80 dB typ. >60 dB, 75 dB typ. 0 V to 1 V, separately adjustable for each channel 3 digits <5 mV, 1 mV typ. (after auto-alignment) ±70 mV typ. 70 µV >50 dB (level >0.1 V), 70 dB typ. (level >0.5 V)
Skew between I and Q channel (filter off, clock rate 10 MHz, fix mode) Fine variation Resolution	 ±1 ns typ. <10 ps
Rise time	5 ns typ.

Adjacent-channel power	
WCDMA 3GPP FDD Test model 1 (64 DPCH channels) Offset 5 MHz Offset 10 MHz	 –78 dBc typ. –78 dBc typ.
Error vector	
IS-95 (QPSK)	0.35% typ. EVM (rms)
GSM (GMSK)	0.2° typ. phase error (rms)
DECT (2-FSK)	0.9% typ. FSK error
NADC, PHS (π/4 DQPSK)	0.3% typ. EVM (rms)
Filters	
Operating modes	off (no filter), internal or external filter
Internal filters 25 MHz Freq. response Amplitude Group delay I/Q imbalance Amplitude Group delay Stopband attenuation 2.5 MHz Freq. response Amplitude Group delay I/Q imbalance Amplitude Group delay Stopband attenuation	 elliptic, 7th order + delay equalizer 0.15 dB typ. up to 25 MHz 500 ps typ. up to 20 MHz 0.05 dB typ. up to 25 MHz 200 ps typ. up to 20 MHz 70 dB from 75 MHz elliptic, 7th order + delay equalizer 0.15 dB typ. up to 2.5 MHz 5 ns typ. up to 2 MHz 0.05 dB typ. up to 2.5 MHz 1 ns typ. up to 2 MHz 70 dB from 7.5 MHz
External filters Impedance	one filter can be connected for each channel, BNC connectors on rear panel 50 Ω
Trigger	
CONT mode	repetitive output of loaded waveform after occurrence of trigger
SINGLE mode	single output of loaded waveform after occurrence of trigger
GATED mode	start of (repetitive) waveform output after occurrence of trigger until end of trigger event
Trigger signal	via remote control or trigger input
Trigger input Input level Max. permissible input voltage Pulse width (clock rate –slow mode) Pulse width (clock rate – fast mode) Delay between trigger input and output of first data word Slow mode Fast mode	BNC connector, selectable polarity TTL –0.5 V to 6 V min. 200 ns + 1 sample min. 11 samples 220 ns + (1 sample + 20 ns) jitter 21 samples + 1 sample jitter
Marker outputs	
Number of outputs	4, BNC connectors
Level	TTL, can be terminated into 50 Ω, (high >2 V)
BER measurement (option R&S AMIQ-B1)	
Data supplied by the DUT can be compared with a nominal random bit sequence; the results are transferred to the host computer (via the currently used remote control); the BER measurement can be controlled from R&S WinIQSIM™ and R&S SMIQ.	
Pseudo random bit sequences	2^9-1, $2^{11}-1$, $2^{15}-1$, $2^{16}-1$, $2^{20}-1$, $2^{21}-1$, $2^{23}-1$
Clock rate	max. 20 MHz

Clock source	each valid bit requires a clock, which is supplied by the DUT or the R&S AMIQ
Sync period	24 clocks
Interface	9-pin D-SUB connector, D-SUB BNC cable supplied in addition
Data	TTL
Data enable	TTL
Clock	TTL
Restart	TTL
Setup time	10 ns
Hold time	2 ns
Polarity	normal and inverted (data, clock, data enable)
Measurement time	selectable through max. number of data or error bits (max. 2^{31} bit), continuous measurement
Measurement results	BER in ppm (when set number of data or error bits is attained), not synchronized, no clock from DUT
Differential I/Q outputs (option R&S AMIQ-B2)[4]	
Provides the inverted $\bar{I}$ and $\bar{Q}$ signals and allows a DC voltage to be simultaneously superimposed on the output signal.	
Outputs	I, $\bar{I}$, Q and $\bar{Q}$
Operating mode	single/differential, selectable
Output impedance	50 Ω when on, 50 Ω or high Z when off
Bias voltage (EMF, to ground)	–2.5 V to +2.5 V (±10 mV) for both I and Q channels separate, common setting for I and $\bar{I}$ or Q and $\bar{Q}$
Resolution	<1.5 mV
Difference between I and $\bar{I}$ or Q and $\bar{Q}$	<0.5% + 1.5 mV
Output voltage (differential EMF between the I and $\bar{I}$ or Q and $\bar{Q}$ outputs, unless otherwise specified, V_p)	
Fix mode	2 V, same for both I and Q channels
Level difference I ↔ Q	<0.5% (at 1 kHz, after auto-alignment)
I ↔ $\bar{I}$ (Q ↔ $\bar{Q}$)	<0.5% (at 1 kHz, after auto-alignment)
Residual DC offset	<1 mV (to ground, after auto-alignment)
DC fine variation	±120 mV typ.
Resolution	120 µV
Variable mode	0 V to 4 V, separately adjustable for I and Q channels
Resolution	3 digits
DC fine variation	±280 mV typ.
Resolution	280 µV
Digital I/Q output (option R&S AMIQ-B3)	
Output	68-pin SCSI connector (mini D-SUB, half pitch)
Channels	I and Q
Resolution	8 bit to 16 bit (selectable, no marker output for word lengths >14 bit)
Max. clock frequency	100 MHz (if an external clock is used, the internal delay time from 20 ns to 25 ns between the input clock and the output data has to be taken into account above 40 MHz)
Output impedance	30 Ω to 50 Ω typ., high impedance with low level at pin 66
Output level	LVT or ABT level (data, marker and clock); the high level of the data, marker and clock signals is automatically adapted to the selected supply voltage for external circuits
V_{cc} output	+3.3 V or +5 V
Remote control and memory	via IEC 60625 (IEEE 488) and RS-232-C
Command set	SCPI 1996.0 with extensions
IEC/IEEE interface functions	SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0
Mass memory	floppy disk drive (3.5", 1.44 MB), hard disk 8 GB
Download time (4 000 000 I/Q samples from built-in hard disk)	27 s
General data	
Operating temperature range	+5 °C to +45 °C; meets EN 60068-2-1, Edition: 1995-03 and EN 60068-2-2, Edition: 1994-08
Storage temperature range	–20 °C to +60 °C
Damp heat	80% relative humidity at +30 °C
Vibration, sinusoidal	5 Hz to 150 Hz, max. 2 g at 55 Hz, 0.5 g const. 55 Hz to 150 Hz, meets EN 60068-2-6, Edition: 1996-05, EN 61010-1 and MIL-T-28800D class 5
Electromagnetic compatibility	meets EN 61000-6-3 and EN 61000-6-4 (EMC Directive of EU)
Immunity to RFI	10 V/m
Power supply	100 V to 120 V ± 10%, 50 Hz to 400 Hz, 200 V to 240 V ± 10%, 50 Hz to 60 Hz, autoranging, 150 VA
Safety	meets EN 61010-1, Edition: 1994-03 CAN/CSA-C22.2 No. 1010.1-92 UL Std. No. 3111-1
Dimensions (W × H × D)	427 mm × 88 mm × 450 mm
Weight	8.7 kg

1) Specs at clock >100 MHz not guaranteed, max. ambient temperature +35 °C.
2) $\bar{I}$ and $\bar{Q}$ in addition when option R&S AMIQ-B2 is used.
3) Spurious-free dynamic range.
4) All data not specified here are identical to those of the R&S AMIQ without option R&S AMIQ-B2 (I and Q only).

Ordering information

I/Q Modulation Generator 16 Msamples	R&S AMIQ	1110.2003.04
Accessories supplied		
R&S WinIQSIM™ version for Windows 95/98/NT/2000 on CD-ROM; manual, power cable, R&S AMIQ operating manual		
Options		
BER Measurement	R&S AMIQ-B1	1110.3500.02
Differential I/Q Outputs	R&S AMIQ-B2	1110.3700.03
Digital I/Q Output	R&S AMIQ-B3	1122.2103.02
Rear I/Q Outputs	R&S AMIQ-B19 [1)]	1110.3400.02
Digital Standards		
IS-95	R&S AMIQK11	1122.2003.02
CDMA2000	R&S AMIQK12	1122.2503.02
WCDMA TDD Mode (3GPP)	R&S AMIQK13	1122.2603.02
TD-SCDMA	R&S AMIQK14	1122.2703.02
1×EV-DO	R&S AMIQK17	1122.3000.02
IEEE802.11	R&S AMIQK19	1122.3200.02
3GPP FDD incl. HSDPA	R&S AMIQK20	1400.5354.02
OFDM Signal Generation	R&S AMIQK15	1122.2803.02
Recommended extras		
19" Rack Adapter	R&S ZZA-211	1096.3260.00

1) Not with option R&S AMIQ-B2. Marker outputs 3 and 4 not provided when this option is fitted.

PD 0757.3970.24 · I/Q Modulation Generator R&S AMIQ · Trade names are trademarks of the owners · Subject to change · Data without tolerances: typical values
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