I/Q Modulation Generator AMIQ

New approaches in the generation of complex I/Q signals

- 14-bit resolution
- 4 000 000/16 000 000 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 (AMIQ-B1)
- Optional differential I/Q outputs (AMIQ-B2)
- Optional digital I/Q output (AMIQ-B3)

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The ultimate in I/Q signals

Modulation Generator 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: AMIQ and 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 AMIQ and the Simulation Software WinIQSIM™, which is described in a separate data sheet (PD 0757.6940), open up new dimensions for the generation of I/Q signals.

The 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 WinIQSIM™. Alternatively, the AMIQ can be operated from the Vector Signal Generator SMIQ.

Of course, the 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 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 AMIQ and 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 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 WinIQSIM™ *)

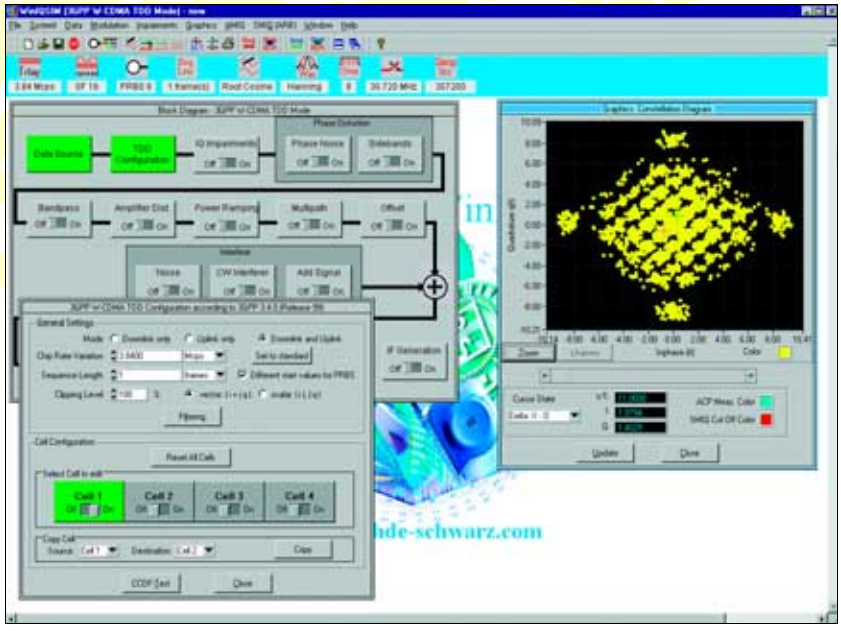
- Single-carrier signals
- Multicarrier signals (up to 512 modulated or unmodulated carriers)
- Multicarrier mixed signals (up to 32 differently modulated carriers)
- User-defined CDMA signal scenarios
- Addition of impairments
- Data editor for creating any TDMA frame configuration
- Predefined files 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 AMIQ
- The import system allows data from other software programs to be read in via the TCP/IP and DDE interfaces

*) For more details see data sheet PD 0757.6940.

Versatile to the last detail

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: WinIQSIM™ is an indispensable tool for anyone engaged in modern digital modulation.

This Windows software enables the 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 WinIQOFDM software (see www.rohde-schwarz.com) is used.

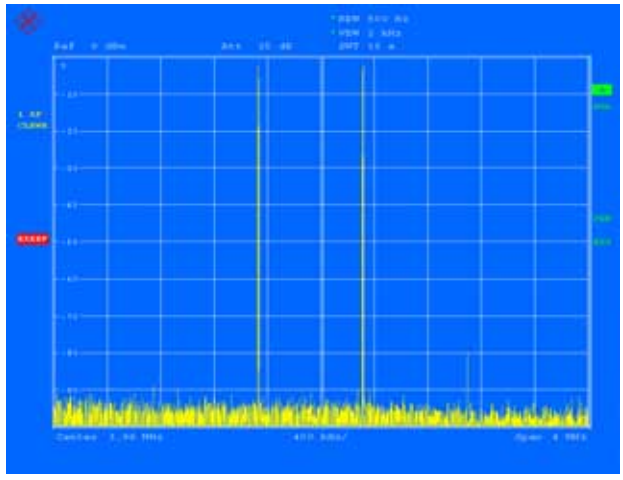


One modulation generator ...

Outstanding quality

In addition to the great memory depth of up to 16000000 samples, the 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.

Intermodulation characteristic of the AMIQ at 50 MHz clock rate



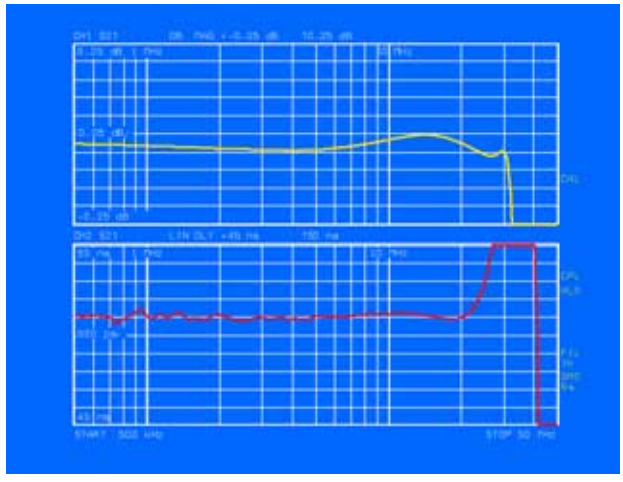
Two identical channels

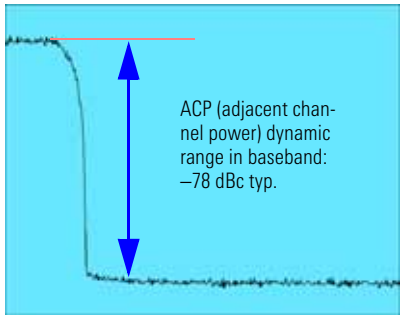
For an I/Q source, it is especially important for the two channels to be identical since any difference would inevitably cause an additional modulation error.

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 AMIQ and the vector signal generator, can be compensated with a resolution of approx. 10 ps.

Frequency response and group delay of 25 MHz output filter





All these features are the basis for the outstanding modulation performance of the 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 AMIQ-B1** allows the 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 AMIQ and output via one of the four user-programmable marker channels. The built-in BER tester compares the data with the nominal data

... satisfying all requirements

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 AMIQ) are generated by means of WinIQSIM™.

Differential outputs

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

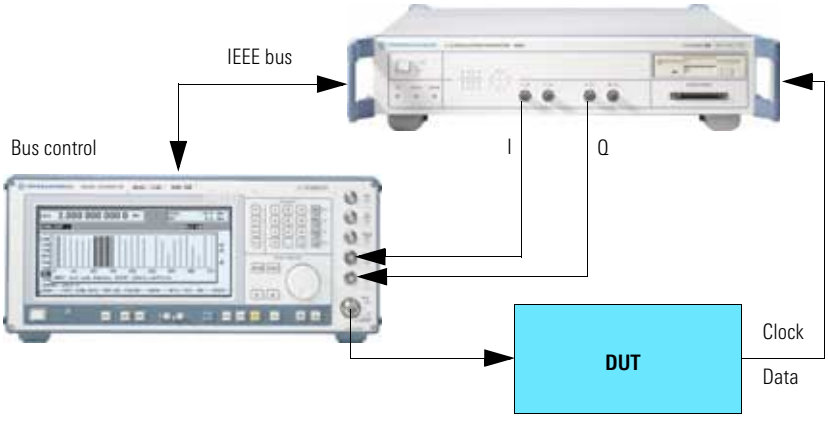
To meet all requirements, the option AMIQ-B2 allows a DC (bias) voltage to be superimposed on the balanced modulation signal (e.g. for setting the operating point). This bias voltage can be set separately for the I and Q channels with high resolution.

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

Digital output

The **option 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 AMIQ provides TTL-similar digital signals that are optimally suited for testing digital modules.

Example of bit error rate test



Use in development

The 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 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 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 AMIQ and 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.

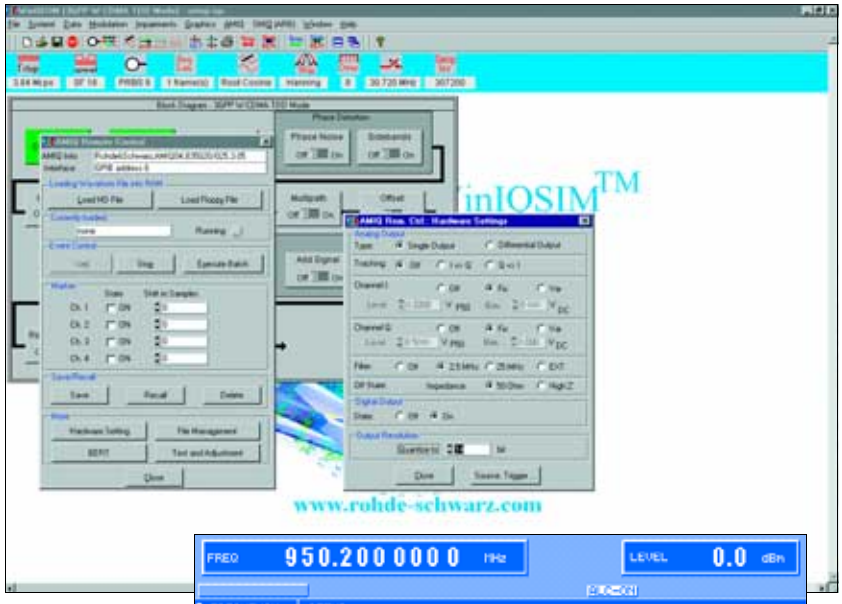
3-year calibration cycle

Another benefit of the 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 AMIQ with WinIQSIM™



AMIQ, WinIQSIM™ and SMIQ – a perfect team

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

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

Operation from SMIQ
A PC with 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 AMIQ. In conjunction with the Vector Signal Generator SMIQ from Rohde&Schwarz, it is possible to select waveforms stored on hard disk or floppy and change the AMIQ parameters via a special menu. In this mode, the AMIQ acts as if it were an option to the SMIQ.

Menu for controlling the AMIQ with the SMIQ

Flexible generation of digitally modulated signals with the AMIQ and the SMIQ

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

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 AMIQ is the ideal baseband source to handle these tasks. Preprogrammed standard settings in 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 AMIQ.

Development of new communication systems

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

Use of the additional WinIQOFDM software provides the AMIQ with the capability of generating OFDM (orthogonal frequency division multiplexing) signals such as HIPERLAN/2 and IEEE 802.11a.

Use in automatic test equipment (ATE) systems

In test systems, space is usually limited. Due to its low height, the AMIQ is an ideal choice for use as a baseband or IF signal source. For this application, the 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 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 WinIQSIM™/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 SMIQ, fading and additive noise can be added to the complex signals provided by the AMIQ. In particular, the 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 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 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 AMIQ's digital signal output (option 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.

Certified Quality System
ISO 9001
DQS REG. NO 1954

Certified Environmental System
ISO 14001
REG. NO 1954

Specifications

Output memory	
Waveform length (data and markers)	
Clock rate – Slow mode (10 Hz to 4 MHz)	24 to 4000000/16000000 in steps of one
Clock rate– Fast mode (2 MHz to 100 MHz)	24 to 4000000/16000000 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	can be used as marker or trigger outputs (for word lengths up to 14 bit)
Number	4
Multisegment waveform	max. 30 segments
Segment changeover time	
without clock change	4 ms typ.
with clock change	12 ms typ.
Clock generation	
Clock range	10 Hz to 100 MHz
Setting range	10 Hz to 105 MHz[1]
Resolution	1 x 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	10 MHz
Aging (after 30 days of operation)	1 x 10^{-5}/year
Temperature effect (0 °C to 45 °C)	<2 x 10^{-6}/°C
Level, rms	0.5 V (into 50 Ω)
Frequency adjustment	electronic
External reference input	
Frequency	10 MHz
Level, rms	0.1 V to 2 V
Input impedance	50 Ω
Signal output	
Outputs	I and Q[2]
Output impedance	50 Ω
Output voltage (V_p into 50 Ω)	
Fix mode	0.5 V, same for both channels
Amplitude fine variation	±10%, separately for each channel
Resolution	0.01%
Level difference between the two channels	<0.2% (at 1 kHz, after auto-alignment)
Residual DC offset	<0.5 mV, 0.1 mV typ. (after auto-alignment)
DC fine variation	±30 mV typ.
Resolution	30 µV
SFDR[3] (sinewave 1 MHz, clock rate 10 MHz)	>70 dB, 80 dB typ.
Variable mode	0 V to 1 V, separately adjustable for each channel
Resolution	3 digits
Residual DC offset	<5 mV, 1 mV typ. (after auto-alignment)
DC fine variation	±70 mV typ.
Resolution	70 µV
SFDR[3] (sinewave 1 MHz, clock rate 10 MHz)	>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		±1 ns typ.
Resolution		<10 ps
Rise time		5 ns typ.
Adjacent-channel power		
WCDMA 3GPP FDD		
Test model 1 (64 DPCH channels)		
Offset 5 MHz		–78 dBc typ.
Offset 10 MHz		–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/4DQPSK)		0.3% typ. EVM (rms)
Filters		
Operating modes		off (no filter), internal or external filter
Internal filters		
25 MHz		elliptic, 7th order + delay equalizer
Freq. response	Amplitude	0.15 dB typ. up to 25 MHz
	Group delay	500 ps typ. up to 20 MHz
I/Q imbalance	Amplitude	0.05 dB typ. up to 25 MHz
	Group delay	200 ps typ. up to 20 MHz
Stopband attenuation		70 dB from 75 MHz
2.5 MHz		elliptic, 7th order + delay equalizer
Freq. response	Amplitude	0.15 dB typ. up to 2.5 MHz
	Group delay	5 ns typ. up to 2 MHz
I/Q imbalance	Amplitude	0.05 dB typ. up to 2.5 MHz
	Group delay	1 ns typ. up to 2 MHz
Stopband attenuation		70 dB from 7.5 MHz
External filters		one filter can be connected for each channel, BNC connectors on rear panel
Impedance		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		BNC connector, selectable polarity
Input level		TTL
Max. permissible input voltage		–0.5 V to 6 V
Pulse width (clock rate –slow mode)		min. 200 ns + 1 sample
Pulse width (clock rate – fast mode)		min. 11 samples
Delay between trigger input and output of first data word		
Slow mode		220 ns + (1 sample + 20 ns) jitter
Fast mode		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 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 WinIQSIM™ and 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 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 AMIQ-B2)[4]	
Provides the inverted $\overline{I}$ and $\overline{Q}$ signals and allows a DC voltage to be simultaneously superimposed on the output signal.	
Outputs	I, $\overline{I}$, Q and $\overline{Q}$
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 $\overline{I}$ or Q and $\overline{Q}$
Resolution	<1.5 mV
Difference between I and $\overline{I}$ or Q and $\overline{Q}$	<0.5% + 1.5 mV
Output voltage (differential EMF between the I and $\overline{I}$ or Q and $\overline{Q}$ 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 ↔ $\overline{I}$ (Q ↔ $\overline{Q}$)	<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
Max. output voltage (V_{signal} + $V_{voltage}$)	<2.5 V (to ground)

Digital I/Q output (option 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 IEC625-2 (IEEE488) 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 3 GB/6 GB (AMIQ03/04)
Download time (4000000 I/Q samples from built-in hard disk)	27 s
General data	
Nominal temperature range	0 °C to +45 °C; meets IEC68-2-1 and IEC68-2-2
Storage temperature range	–40 °C to +70 °C
Damp heat	95% relative humidity at +40 °C; meets IEC68-2-3
Vibration, sinusoidal	5 Hz to 150 Hz, max. 2 g at 55 Hz, 0.5 g const. 55 Hz to 150 Hz, meets IEC68-2-6, IEC1010-1 and MIL-T-28800D class 5
Electromagnetic compatibility	meets EN50081-1 and EN50082-1 (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 DIN EN 61010-1, 1994-03 CAN/CSA-C22.2 No. 1010.1-92 UL Std. No. 3111-1 IEC61010-1
Dimensions (W x H x D)	427 mm x 88 mm x 450 mm
Weight	8.7 kg

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

Ordering information

I/Q Modulation Generator	AMIQ	
4 Msamples		1110.2003.03
16 Msamples		1110.2003.04
Accessories supplied		
WinIQSIM™ version for Windows 95/98/NT/2000 on CD-ROM; manual, power cable, AMIQ operating manual		
Options		
BER Measurement	AMIQ-B1	1110.3500.02
Differential I/Q Outputs	AMIQ-B2	1110.3700.02
Digital I/Q Output	AMIQ-B3	1122.2103.02
Rear I/Q Outputs	AMIQB19 [1]	1110.3400.02
Digital Standards		
IS-95	AMIQK11	1122.2003.02
CDMA2000	AMIQK12	1122.2503.02
WCDMA TDD Mode (3GPP)	AMIQK13	1122.2603.02
TD-SCDMA	AMIQK14	1122.2703.02
OFDM Signal Generation	AMIQK15	1122.2803.02
Recommended extras		
19" Rack Adapter	ZZA-211	1096.3260.00

[1] Not with option AMIQ-B2. Marker outputs 3 and 4 not provided when this option is fitted.

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ROHDE&SCHWARZ

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