IZT S1000
Signal Generator Platform

Innovationszentrum Telekommunikations-
technik GmbH

- 31 Virtual Signal Generators
- Dual RF Outputs
- Phase Synchronous Outputs for Diversity and MIMO Testing
- Real-time Impairment Simulation
- Modulators for DAB, DAB+, XM, Sirius, HD Radio™ and DVB-T
- Universal ARB Function
- Easy-to-use Compact Setup

IZT S1000
Signal Generator Platform

The IZT S1000 Signal Generator Platform enables the user to consolidate multiple conventional RF generators into one compact, cost effective, flexible and easy-to-use RF test source.

Modern radio receivers no longer gather information from a single modulated carrier, but often from multiple sources simultaneously. The multiple signals can be from more than one antenna, with independent carriers and different modulation formats.

With multiple technologies, modulations and frequencies combined in a single receiver, the IZT S1000 can combine these as well to match the receiver test requirements without a costly batch of standard RF generators. The IZT S1000 with its revolutionary architecture and IZT's patented signal processing algorithm combines multiple technologies into a single piece of test equipment for today's acceptance testing requirements.

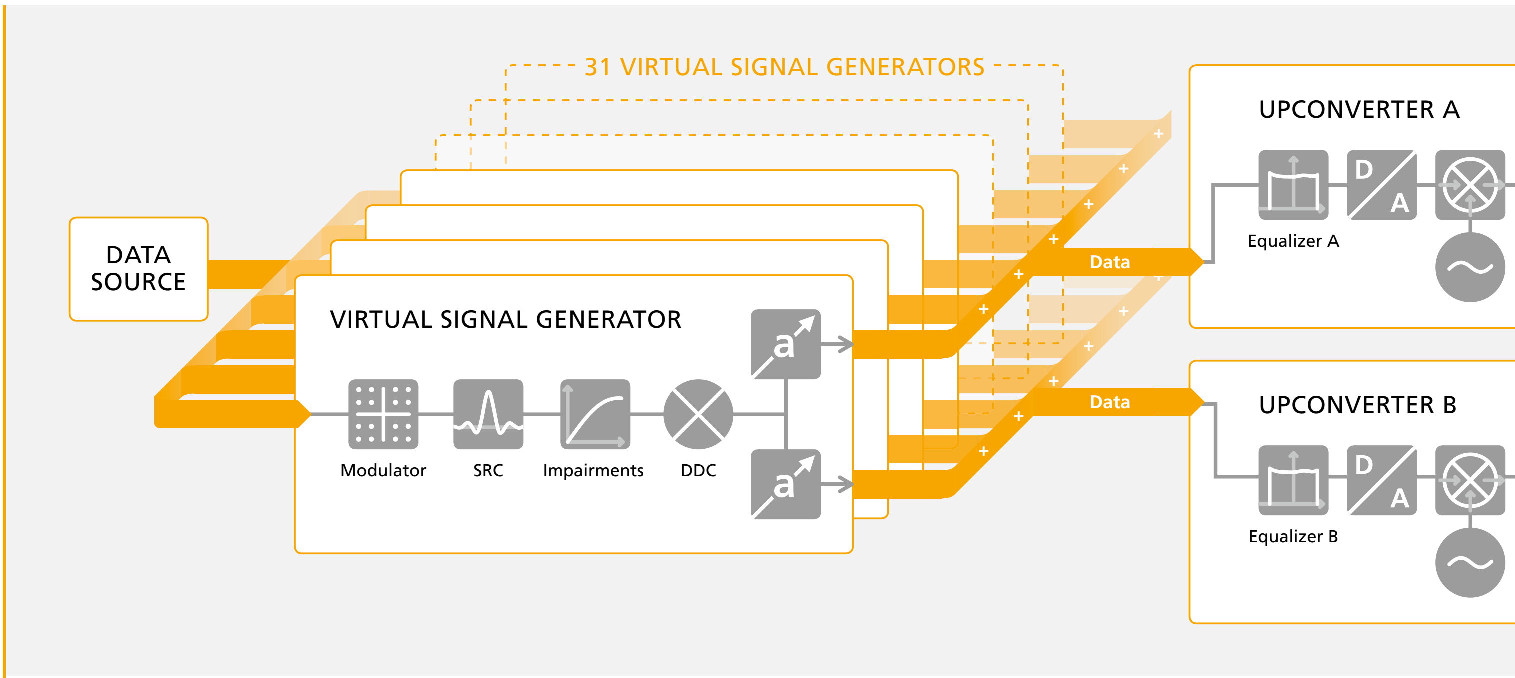


figure 1: IZT S1000 structure

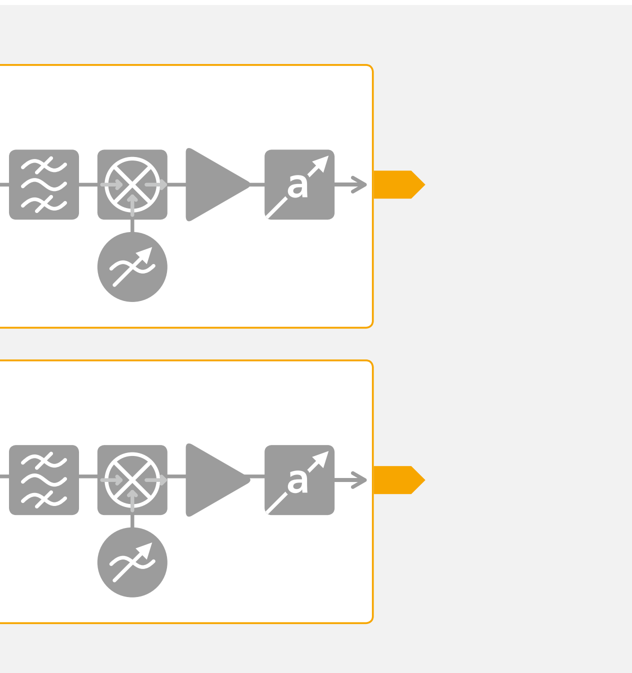
1. One Unit – 31 Signal Generators

The IZT S1000 generates a composite signal output comprised of up to 31 signal carriers in two independent 120 MHz wide blocks settable within the frequency range up to 3 GHz.

For each virtual signal generator, the user assigns

- content
- real-time modulation or plain I/Q data for VSG channels
- interpolation rate
- launch delay
- impairments
- center frequency
- RF power

The output signals of all active virtual signal generators are combined and distributed to the two RF outputs.



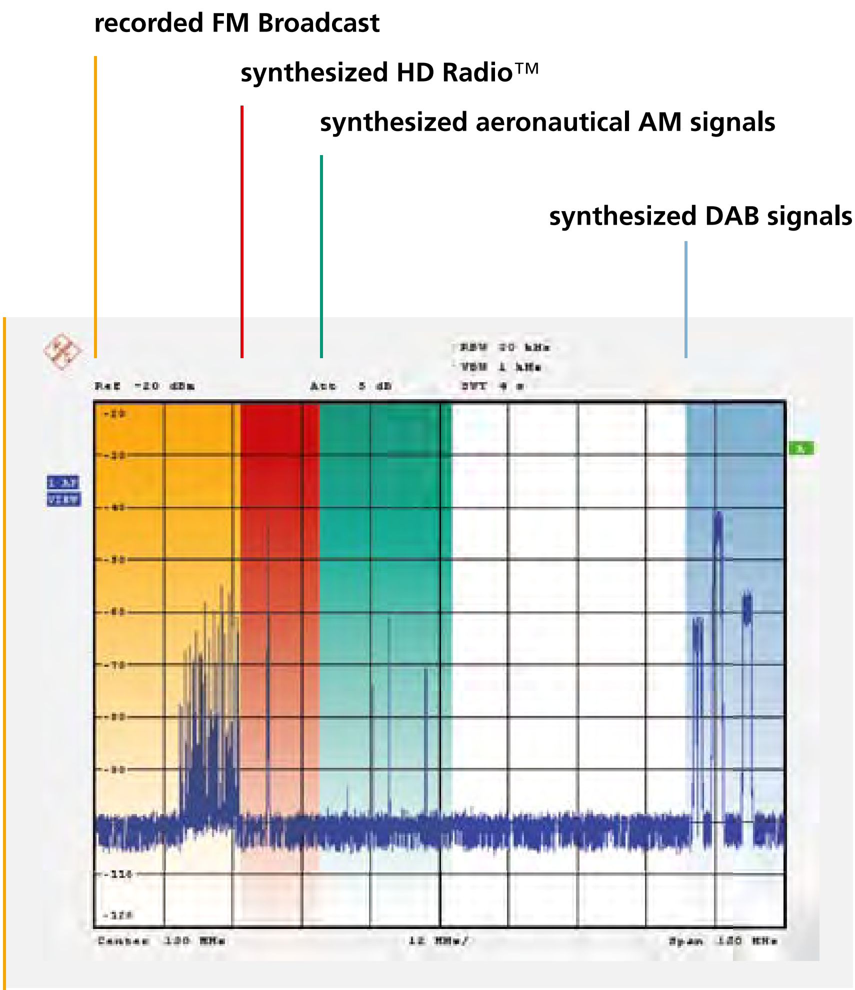


figure 2: Synthesizing a spectrum with the IZT S1000 over its full bandwidth

2. Hardware Platform

Chassis

The IZT S1000 comes in a compact 2U form factor chassis with high-resolution display and front panel keyboard.

The chassis contains all digital processing hardware, synthesizers and RF sections. It is configured as required for different customer applications.

State-of-the-Art Digital Processing

The IZT S1000 uses a patented time/frequency domain approach for efficiently processing and combining a large number of signals. The cumulative bandwidth of these signals can support up to 320 MSamples/s.

Eight Gigabyte RAM

The IZT S1000 has four gigabyte of fast RAM available as one place for storing and reading out waveform data with up to 320 MSamples/s total bandwidth. It can be loaded from the internal hard drive or from a streaming server. Eight gigabyte of memory is available as an option.

Two Independent RF Outputs

The IZT S1000 contains two independent RF sections, each settable within 9 kHz to 3 GHz with an instantaneous bandwidth of 120 MHz. Their linearity and dynamic range are designed to meet the demanding operating conditions created by multiple RF signals.

When equipped with dual synthesizers, the center frequencies of the outputs can be tuned independently over the entire band.

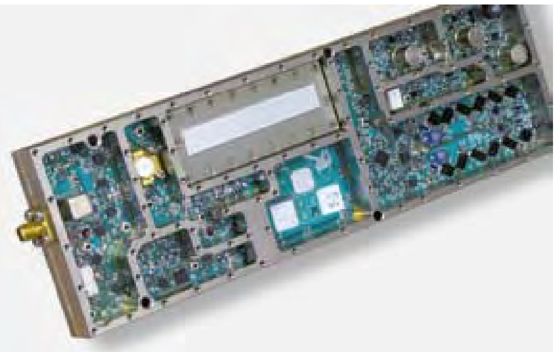


figure 3: RF section of the IZT S1000

Absolute Timing Accuracy for Antenna Diversity and MIMO

The IZT S1000 provides accurate frequency and time synchronization. All relevant clocks and local oscillators in the IZT S1000 are also accessible to the user. This allows absolute launch timings and phase-locked frequencies within a single IZT S1000 or with multiple IZT S1000 when they are combined into a larger test setup.

Receivers with multiple antennas can be fed with a combination of signals from multiple RF outputs with controlled delay, frequency and phase relationship with identical or different content. This makes the IZT S1000 the ultimate signal source for over-the-air and MIMO testing.

DC Supply and Control Signals for External Equipment

The IZT S1000 offers an electronically adjustable DC output from 1 to 12 VDC at 1 A. This is useful for supplying power to an external amplifier, a switch matrix or similar equipment. In addition, eight bi-directional digital I/O-signals are available to control and monitor this equipment. The state of the I/O's and the supply voltage can be fully remote controlled.

eSATA Interface

The internal HDD of the IZT S1000 has 320 GB capacity. If required, it can be complemented with an external HDD via the eSATA interface. The additional storage capacity is available for additional bitstreams or for rapid upload of data to the IZT S1000's internal storage.

Full Remote Control via Ethernet, Serial Port and GPIB

Labview applications and drivers are available in the option S1000-LBV for easy integration of the IZT S1000 into automated test setups. The „SingleCommandSender" can send S1000 commands on all available interface to the IZT S1000 and is capable extracting SCPI commands into SCPI command files for automatic replay. The „Multiple Command Center" can replay SCPI command files for automated test routines either in single loop or continuously.

figure 4: Labview for automated test setups

Dual Gigabit LAN Port for Streaming

The IZT S1000 can receive data from a streaming server directly into the FPGA via two Gbit Ethernet ports. Each port can handle up to 24 MSamples/s at 16 bit resolution. Two ports in parallel can handle as much as 48 MSamples/s which equals to 41 MHz bandwidth of digitized signals, to support replay of a two-channel diversity recording of the FM broadcast band for example.

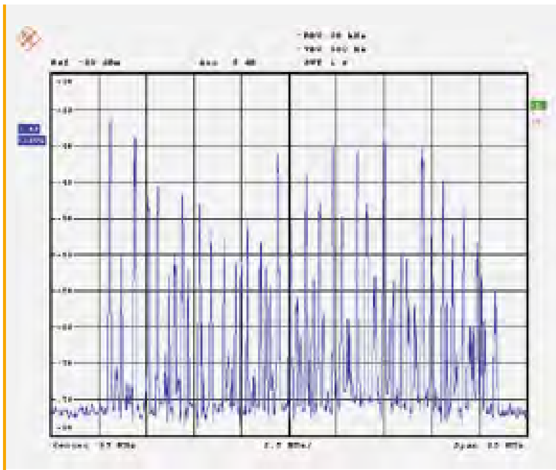


figure 5: Recorded FM broadcast spectrum

3. Signal Processing

Data Sources

The data source supplies all virtual signal generators with their required inputs

- raw I/Q data with 12 or 16 bit resolution for arbitrary or pre-encoded signals
- bitstreams for real-time modulators
- data for frequency, delay and power profiles
- R3301 recordings in any samplerate and 16 or 32 bit resolution
- data from standard third party measurement equipment

Internal Memory

Data can be taken from the onboard DDR2 RAM, which is up to 8 GBytes large with 4 GBytes standard. Conventional signal generators, lacking the sophisticated processing of the IZT S1000, hold only a few seconds of content, while the IZT S1000 can support many minutes of continuous signal out of internal memory until the signal wraps. The signals are repeated seamlessly in a loop without interruption.

Internal HDD

For low to medium data rates (e.g. satellite radio) content can be streamed in real time from the internal hard drive. The HDD has a capacity of 320 GByte and can be complemented with an external disk via the eSATA interface.

External Server

For the most demanding applications, up to 2 x 24 MSamples/s of data can be streamed via two Gbit Ethernet interfaces from an external server directly to the FPGA.

Variable Sample Rate Converters

Each of the 31 virtual signal generators contains independently variable sample rate converters with 120 dB SFDR and sub-Hertz frequency resolution.

These allow the user to easily combine signals from different standards with their specific sample rate without time consuming pre-processing.

Fading Channel Simulation

The fading channel simulation of the IZT S1000 offers a pool of up to 64 fading paths that can be allocated freely to the virtual signal generators and the RF outputs. The user takes advantage of the full flexibility on both ends of the channel simulator block. For example, two virtual signal generators can be distributed to a total of 64 paths, sixteen of which go to RF output 1 and sixteen of which go to RF output 2.

All paths can simulate 'moving', i.e. support a time variant delay. The doppler spread can be as high as 40 kilohertz. The complex gains of all paths are either streamed from a file or calculated in real-time by the IZT S1000 software. When read from a file, the known timing between fading coefficients allows signal support testing of receivers with antenna diversity or the analysis of difficult fading scenarios in a perfectly controlled environment.

figure 6: Screenshot of fading channel simulation

Profiles

The IZT S1000 supports a number of time variant signals called 'profiles' to simulate large scale variations of signal properties:

- propagation delay
- center frequency
- power levels

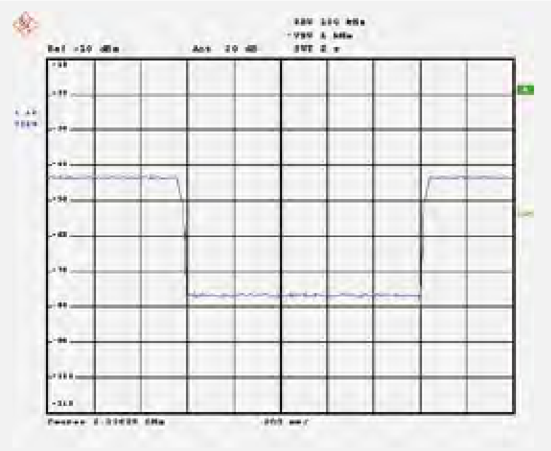


figure 7: Power level profile

These parameters can be changed independently for each virtual signal generator without affecting signal quality and with a timing resolution of twelve microseconds. Typical applications are large scale fading or shadowing effects, delay variations caused by moving satellites or emulating a fast frequency hopper.

Shaped Noise Source

The IZT S1000 contains one noise source per RF output which sets the carrier to noise ratio to a user defined level. The individual power of the signals and the noise are controlled and combined digitally, so the carrier to noise ratio is extremely accurate.

In addition to carrier to noise settings, the IZT S1000 allows the user to shape the noise floor. This is very important for wideband multi-standard signal generation to simulate frequency dependent background noise, antenna and LNA performance in the different frequency bands. Further, this feature reduces total output power, as only those bands which are relevant to the receiver are subject to an elevated noise floor.

Nonlinearity and Filter Simulation

Like the IZT S2000 product offering, the IZT S1000 offers a very realistic simulation of the nonlinear distortion created in the power amplifier of a transmitter. First, the signal is subject to a memoryless distorter, which models the AM/AM and AM/PM characteristics of the power amplifier. Secondly, a model of the output filter of the actual transmitter is applied to emulate realistic results. The output filter emulation and nonlinearities can be activated independently.

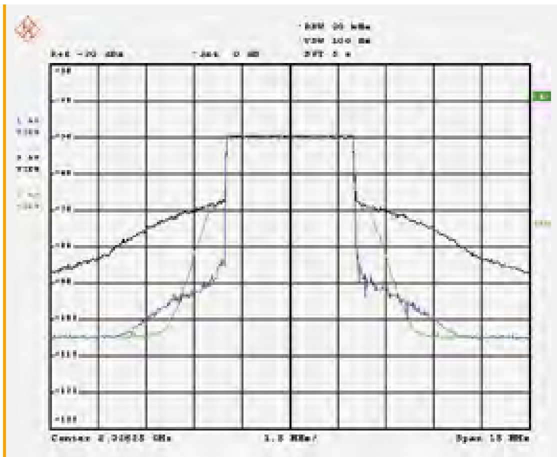


figure 8: Distorted signal before (black), after the filter simulation (green) and after filter simulation with alternative filter settings (blue).

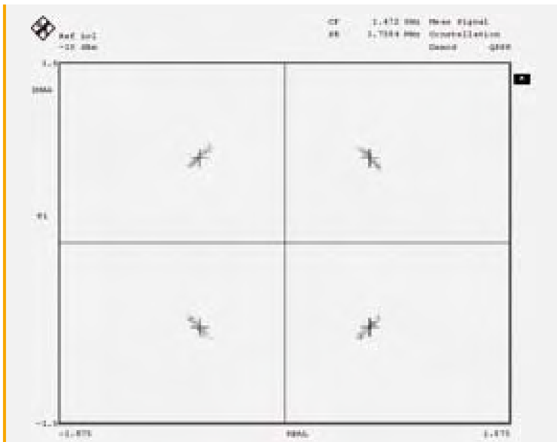


figure 9: QPSK constellation affected by phase noise

Phase Noise

The IZT S1000 can apply phase noise to the modulated signals for system validation or troubleshooting of carrier tracking loops. The user simply selects the desired frequency profile and sets the RMS phase error. Additional frequency profiles can be generated and installed on the IZT S1000.

Frequency Hopping Module

The Frequency Hopping Module IZT S1000-FHS utilizes the profile functionality of the IZT S1000 to generate a hopping network in a very efficient manner. The content can be generated by a analogue modulation tool or from the user as narrow band I/Q data. One hopper requires one VSG (two VSGs with 240MHz spread). Additional hoppers can be added with option IZT S1000-FSC.

Spread	up to 120MHz / 240MHz
Hop rate	> 2000 hops/sec.
Channel spacing	user settable
Hopper pattern	regular or random within user-defined channel list
	regular or random within sequence of channels or user defined frequencies
Number of hoppers	up to 31; one hopper requires one IZT-S1000-110
	one hopper requires two IZT-S1000-110 with 240MHz spread
Content	Narrow band I/Q-Data < 5 MSamples/s when number of hoppers is 31

4. Modulation Formats

Plain I/Q Data and RF Recordings

The IZT S1000 replays recorded or simulated signals with up to 40 MSamples/s at 12 or 16 bits complex resolution. This sample rate is sufficient for 34.4 MHz of bandwidth.

At this data rate, the internal memory will support sequences with more than one minute duration before they loop. When used with an external server, hours of recorded and continuous signals can be replayed. Recordings can be made with IZT R3000 monitoring receivers and RF recorder IZT R3301. The IZT R3301 and the IZT S1000 support diversity setups with multiple antennas.

Instead of recording a signal, the user can generate plain I/Q data from any other sources for a system simulation. The variable sample rate converters built into the IZT S1000 avoid time consuming offline resampling of the test data.

Multiple virtual signal generators create complex signal environments with uncorrelated or identical content. Each virtual signal generator is assigned specific signal power and center frequency in real-time via the GUI or remote control.

DAB and DAB+

The IZT S1000 is offered with an offline tool to generate ETI-streams for DAB and DAB+. These ETI streams can contain many different services in one DAB ensemble to simulate realistic or worst case environments. The ETI streams are COFDM modulated and either loaded to the internal memory or streamed from external server to the Gbit Ethernet ports. ETI files from different sources can also be used.

DVB-T

The IZT S1000 is offered with an offline tool to generate digitally modulated I/Q files from transport stream files.

These TS files are COFDM modulated and either loaded to the internal memory or streamed from external server to the Gbit Ethernet ports.

The modulator supports all specified levels of QAM modulation and inner code rates. Two-level hierarchical channel coding and modulation, including uniform and multi-resolution constellations are possible.

DVB-T Waveform	
Waveform	COFDM with QPSK or 4QAM, 16QAM, 64QAM
Transmission Mode	2K, 4K or 8K
Guard Interval	1/4, 1/8, 1/16, 1/32
Coderate	1/2, 2/3, 3/4, 5/6, 7/8
Bandwidth (MHz)	8, 7, 6, 5

HD Radio™

The IZT S1000 is the perfect signal source for development and test of HD Radio™ receivers. It handles all test vectors as they are supplied by iBiquity without prior conversion. Multiple virtual signal generators simulate RF environments with as many as 31 signals in real time for comprehensive receiver testing. By utilizing its dual RF section, the IZT S1000 generates AM and FM signals simultaneously.

DRM/DRM+

The DRM/DRM+ generator is a realtime software modulator for DRM and DRM+. It combines DRM content server and modulator capabilities in one software defined radio (SDR) application. Along with the software, a graphical user interface is provided for setting up the DRM signal parameters (e.g. audio bit rate, transmission mode and spectrum occupancy), the stream sources, destinations and the service information (e.g. station label).

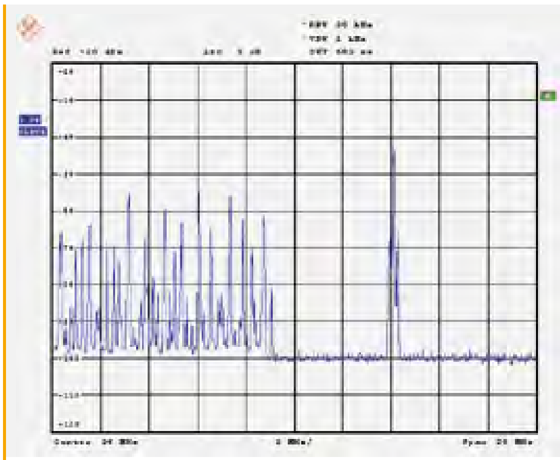


figure 10: Recorded FM broadcast spectrum combined with one HD Radio signal

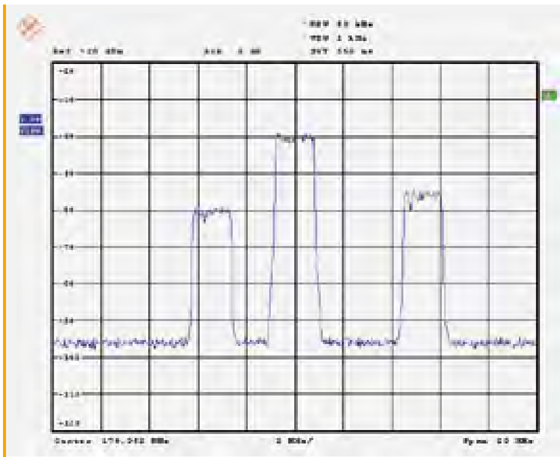


figure 11: Three DAB ensembles

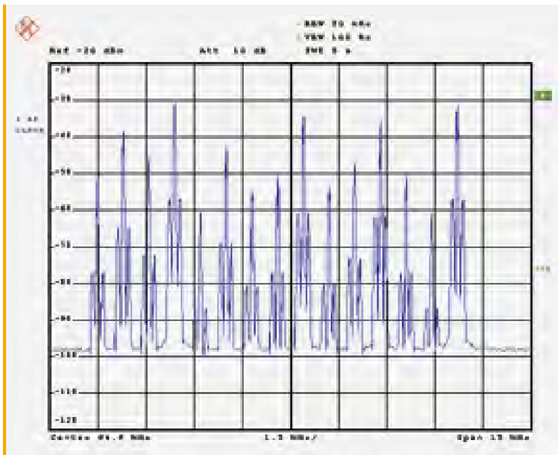


figure 12: Fifteen HD Radio signals

Sirius XM Satellite Radio

Like the IZT S2000 and S800E products, the IZT S1000 offers real time modulation for all Sirius XM signals, including overlay waveforms.

Compared to an ordinary arbitrary waveform generator, real time modulation results in much more compact data files and – most importantly – allows the modification of all signal properties in real time. The time consuming process of generating and loading new streams into the generators is eliminated.

Real time modulation allows many hours of continuous content and makes the IZT S1000 suitable for all aspects of type acceptance testing of Sirius XM receivers. The necessary bit streams are stored on the internal HDD and streamed to the modulator, which then turns them into a total of nine individual signals: four QPSK carriers and two COFDM carriers for XM and two QPSK carriers and one COFDM carrier for Sirius.

If required, additional virtual signal generators can generate out-of-band or adjacent channel interferers. Routing these to the second RF section will facilitate the insertion of filters and allows independent tuning of their center frequency over a large bandwidth.

In a fully automated test setup, the IZT S1000's multipurpose I/Os can control an external RF matrix/filter assembly. The adjustable voltage output can supply power to an external amplifier.

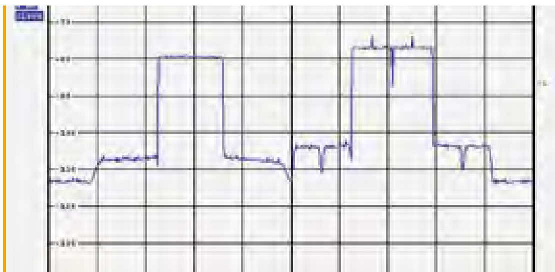


figure 13: Full Sirius XM Radio signal using eight virtual signal generators

5. User Interface and Remote Control

Grafical User Interface

The IZT S1000's front panel and graphical user interface have been specially designed for rapid user-friendly control of multiple signals. The parameters of the virtual signal generators are organized in a grid layout with a minimum number of layers. The front panel allows quick navigation through the grid and quick access keys take the user right to those parameters which are changed most frequently during operation. The GUI provides optimum support for the user by checking settings for inconsistencies and giving hints about how to resolve them.

figure 14: Screenshot of the graphical user interface

The IZT S1000 is fully remote controlled through SCPI commands received via RS-232, LAN or GPIB. The GUI will automatically reflect the settings received. A convenient XML-based save and recall mechanism simplifies handling of large configuration scenarios. Saved scenarios can be transferred to external devices for documentation purposes and copied to other IZT S1000 to replicate setups.

6. Optional Hardware

External Calibration Unit

The calibration kit is needed to calibrate the IZT S1000 and the connected peripheral cables up to the point where the DUT is receiving the signals. It includes software which resides on the IZT S1000 or on the streaming server. The calibration kit for the IZT S1000 is needed if highest possible accuracy of absolute phase correlation is required.

Frequency Range	CAL	100 kHz ... 3.0 GHz
RF Inputs	CAL	SMA (f), 50 Ω
Maximum Input Level	CAL	+15 dBm
VSWR (Input / Output)	CAL	< 1.20:1
Power Detection Range	CAL	-70 … 0 dBm
DC Input		9 … 30 V
Short Current Limit		3 A
LED Display	Status	Red (Error) / Flashing (Calibration) / OFF (No Action)
	DC Power	Green (Power On) / Off (Power Off)
Mechanical Dimensions		115 x 74 x 235 mm (W x L x H)

RF Switch Matrix

The IZT S1000-MTX is an external 2:4 RF switch matrix for the IZT S1000 signal generator. It can be used for test setups in DUT environment and laboratory. The IZT S1000-MTX is capable of simulating Bias Tee current sinks, e.g. for active antennas. The switching behaviour is controlled from the IZT S1000 GUI and can also be controlled from the remote interface.

Frequency Range	RF IN 1,2	100 kHz … 3000 MHz
	RF OUT 1-4	100 kHz … 3000 MHz
RF Inputs	RF IN 1,2	SMA (f), 50 Ω
RF Outputs	RF OUT 1-4	SMA (f), 50 Ω
Maximum Input Level	RF IN 1,2	+10 dBm
	RF OUT 1-4	16V DC / 100 mA
VSWR (Input / Output)	RF IN 1,2	< 1.6:1
	RF OUT 1-4	< 1.6:1 (typ. <1.25:1 @ 1 GHz, < 1.35:1 @ 2 GHz)
Insertion Loss		< 4 dB (typ. 1 dB @ 1 GHz, 2.5 dB @ 2 GHz)
DC Input	GPIO S1000	V_{SUPPLY} = 11 … 13 V
	RF OUT 1-4	V_{BIAS} = 6 ... 15 V, IBIAS = 0 … 95 mA
LED Status Display	LED 1	Green ($V_{in} \geq 11.0$ V) / Green ($V_{in} < 11.0$ V) / Off ($V_{in} < 5.5$ V)
	LED 2	Green (Current Mode: GPIO) / Red (Current Mode: Poti)
	LED 3	Green (RF Amps On) / Off (RF Amps Off)
LED RF OUT Display	RF IN 1	Green (RF IN 1 active) / Off (RF IN 1 terminated)
	RF IN 2	Green (RF IN 2 active) / Off (RF IN 2 terminated)
	BIAS ACTIVE	Orange ($I_{BIAS} \geq 10$ mA) / Off ($I_{BIAS} < 10$ mA)
Mechanical Dimensions		443 x 430 x 41.6 mm (W x L x H)

Specification subject to change without further notice.

7. Performance Specifications IZT S1000

RF characteristics		
Frequency	Range	9 kHz to 3 GHz
	Resolution	0.001 Hz
Instantaneous bandwidth	9 kHz to 30 MHz	30 MHz
	90 MHz to 2940 MHz	120 MHz
Reference	Accuracy	OCXO
	Aging	$\pm 5 \cdot 10^{-8}$ per year
	Temperature stability	$< \pm 1 \cdot 10^{-8}$
	Warm-up time	10 min
Power level	Maximum output power	+20 dBm (typ.)
	Resolution	0.1 dB
	Uncertainty	±0.5 dB from +10dBm to -50dBm; ±1.0 dB below -50dBm
Spectral purity	Harmonics	< -30 dBc at +10 dBm
	SSB phase noise non harmonics	< -70 dBc (typ.)

Signal generation		
Integrated hard disk	Size	320 GB
Internal memory	Size	4 GB, 8 GB (optional)
External LAN	Connection	2x1000 BaseT UDP/TCP
Channels	Number of	up to 31
Data representation	Data format	12/16 bit I / Q
	Input sample rate	variable up to 40 MSamples/s

Digital standards		
Sirius Satellite Radio	Supported channels	satellite 1, terrestrial, satellite 2
	Source	encrypted TE1 files provided by Sirius, sample file preinstalled
XM Satellite Radio	Supported channels	satellite 1A, 2A, 2B, 1B; terrestrial A & B
	Source	TDM meta files provided by XM, sample file preinstalled
HD Radio	Supported channels	multiple radio stations possible
	Source	iBiquity test vectors, all preinstalled
AM	Source	I/Q files generated from audio files with offline tool
FM	Source	I/Q files generated from audio files with offline tool
	RDS	included in I/Q files
DAB	Supported channels	up to 31
	Source	I/Q files generated by offline tool from music files
DAB+	Supported channels	up to 31
	Source	I/Q files generated by offline tool from music files
DVB-T	Supported channels	up to 16
	Source	I/Q files generated by offline tool from TS files
DRM/DRM+	Supported channels	up to 31
	Source	I/Q files generated by offline tool from music files

General data	
Power supply, nominal values	Input voltage range: 100 V to 240 V (AC)
	AC supply frequency: 50 Hz to 60 Hz
	Max. input current: 1.4 A (100 V) to 0.6 A (240 V)
EMC	Meets EN 55022, class B, QP, AV
Environmental conditions	Operating temperature: 0°C t o 55°C
	Storage temperature: -40°C to +70°C
Dimensions	19“, 2 U, depth 570 mm
Weight	< 12 kg
Recommended calibration interval	2 years

Ordering Guide		
Hardware options	IZT S1000-CHS	Chassis and all digital hardware. Including graphical user interface.
	IZT S1000-RF3	RF section 9 kHz-3 GHz. The IZT S1000 can be equipped with one or two RF outputs. Requires at least one synthesizer RFS3.
	IZT S1000-RFS3	RF Synthesizer 3 GHz
	IZT S1000-eSATA	eSATA interface to connect an external HDD to the internal processor.
	IZT S1000-8GB	8 GB high speed memory. Increases the internal memory from 4 GB to 8 GB.
	IZT S1000-GPIB	Adds the physical interface "GPIB" for remote control.
	IZT S1000-CAL	Calibration kit for diversity channels with exact phase correlation.
	IZT S1000-MTX	RF Switching Matrix
	IZT S1000-LBV	Labview Driver
	IZT S1000-FHS	Frequency Hopping Module
	IZT S1000-FHC	Additional Frequency Hopping Channel
Software options	IZT S1000-110	One Virtual Signal Generator. Up to 31 are possible.
	IZT S1000-120	Highspeed LAN, two Gbit ports for streaming data
	IZT S1000-201	Sirius Legacy: Modulator for "legacy" Sirius Satellite Radio signals. Requires three IZT S1000-110.
	IZT S1000-201a	Sirius Overlay: Modulator for Sirius overlay waveform. Requires IZT S1000-201.
	IZT S1000-201b	Sirius Spectral Representation
	IZT S1000-202	XM: Modulator for XM Satellite Radio signals. Requires five IZT S1000-110.
	IZT S1000-202a	XM Overlay: Modulator for XM overlay waveform. Requires IZT S1000-202.
	IZT S1000-202b	XM spectral representation
	IZT S1000-220	HD Radio™ license to play digital HD AM and FM files. Requires at least one IZT S1000-110.
	IZT S1000-230	IZT S1000 internal HDD streaming
	IZT S1000-301	Phase noise simulation
	IZT S1000-302	Nonlinearity simulation and Output Filter Simulation
	IZT S1000-304	Fading channel simulator with fixed delays.
	IZT S1000-305	Power level profiles
	IZT S1000-306	Frequency Profile / Delay Profile
	IZT S1000-307	Shaped Noise
	IZT S1000-402	FM RDS: Generation of AM and FM signals from audio waveform files. Includes RDS coder. Requires at least one IZT S1000-110.
	IZT S1000-403	DAB waveform
	IZT S1000-404	DAB MUX GUI
	IZT S1000-405	DAB+ MUX GUI
	IZT S1000-408	DVB-T: Generation of DVB-T waveform
	IZT S1000-409	DRM GUI and modulation
	IZT S1000-410	DRM+ GUI and modulation
Service	IZT S1000-CLC	Calibration recommended in a cycle of 2 years, certificate included.
	IZT S1000-WE2	Warranty Extension to 2 Years: Extension of the standard 1 year warranty to 2 years.
	IZT S1000-WE3	Warranty Extension to 3 Years: Extension of the standard 1 year warranty to 3 years.

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About IZT

The Innovationszentrum fuer Telekommunikationstechnik GmbH IZT specializes in the most advanced digital signal processing and field programmable gate array (FPGA) designs in combination with high frequency and microwave technology.

The product portfolio includes equipment for signal generation, receivers for signal monitoring and recording, transmitters for digital broadcast, digital radio systems, and channel simulators. IZT offers powerful platforms and customized solutions for high signal bandwidth and real-time signal processing applications. The product and project business is managed from the principal office located in Erlangen/Germany.

IZT distributes its products worldwide together with its international strategic partners. The customers are civil companies, governmental agencies and armed forces.

The IZT quality management system is ISO 9001:2000 certified.