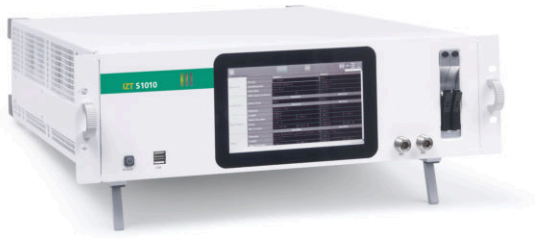
IZT S1000 / IZT S1010
High-Performance Signal Generator

Product Information

- One device – 31 Virtual Signal Generators of highest RF quality
- Two phase-synchronous RF outputs for diversity testing
- Versatile real-time impairment simulation
- Modulators for Digital Radio and TV Standards
- GNSS Constellation Simulator
- Universal ARB function
- Automated testing for development and production



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Overview

The IZT S1000 offers a compact multi-channel high performance platform for complex and versatile testing in one device. Its unique 31 signal generator technology makes it possible to simultaneously simulate a test environment with multiple sources and to replace extensive setups while reducing time and cost.

The IZT S1000 generates, encodes and modulates RF signals for important global digital standards and simulates real-time impairments using its multi-channel, multi-standard functionality. It can be used to meet a wide range of challenging test requirements as well as to perform integrated automated sequences to reduce time to market.

The IZT S1010 integrates a high speed streaming capability in a compact unit to address the most demanding applications. Due to the very fast and high capacity SSDs it is possible to stream multiple signals in parallel.

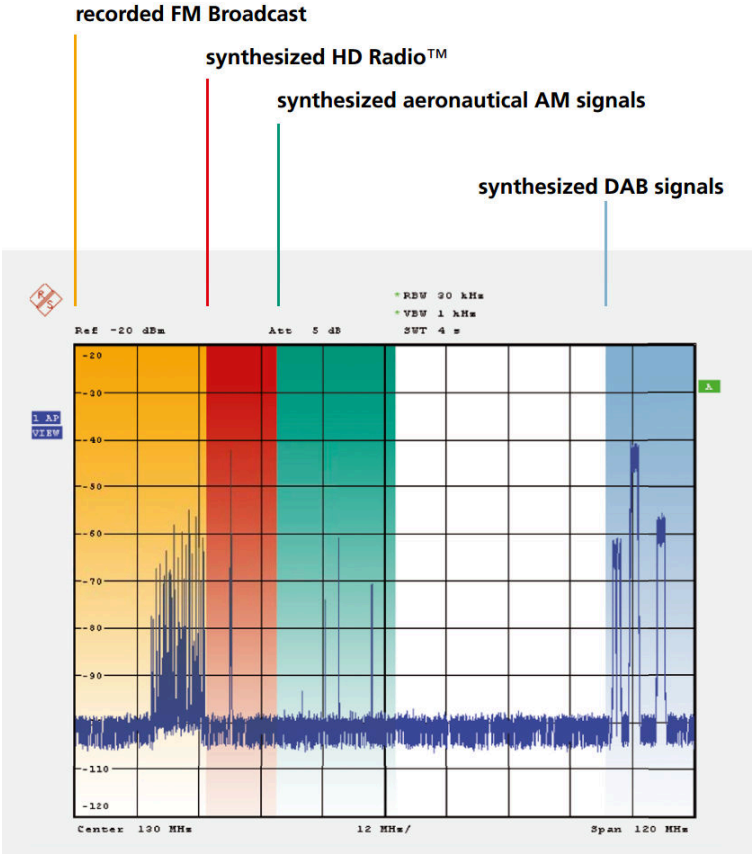

Figure 1: SYNTHESIZED 120 MHZ SPECTRUM CONSISTING OF DIFFERENT SIGNAL TYPES

Key Features

OUTSTANDING TECHNOLOGY FOR SIGNAL PROCESSING

State-of-the-art digital processing

High performance test equipment has to be designed for today's exceptionally complex testing environment. Due to IZT's patented approach for signal synthesis, the IZT S1000 is capable of processing and combining a high number of signals in a very eff cient manner. The cumulative bandwidth of these signals can go up to 320 MS/s.

One device – 31 Virtual Signal Generators (VSG)

The IZT S1000 generates a 120 MHz wide composite output signal from up to 31 individual signal carriers (Figure 1). Each signal can be set in two independent 120 MHz blocks within the frequency range up to 3 GHz. Figure 1 shows the block diagram of the IZT S1000.

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 two RF outputs.

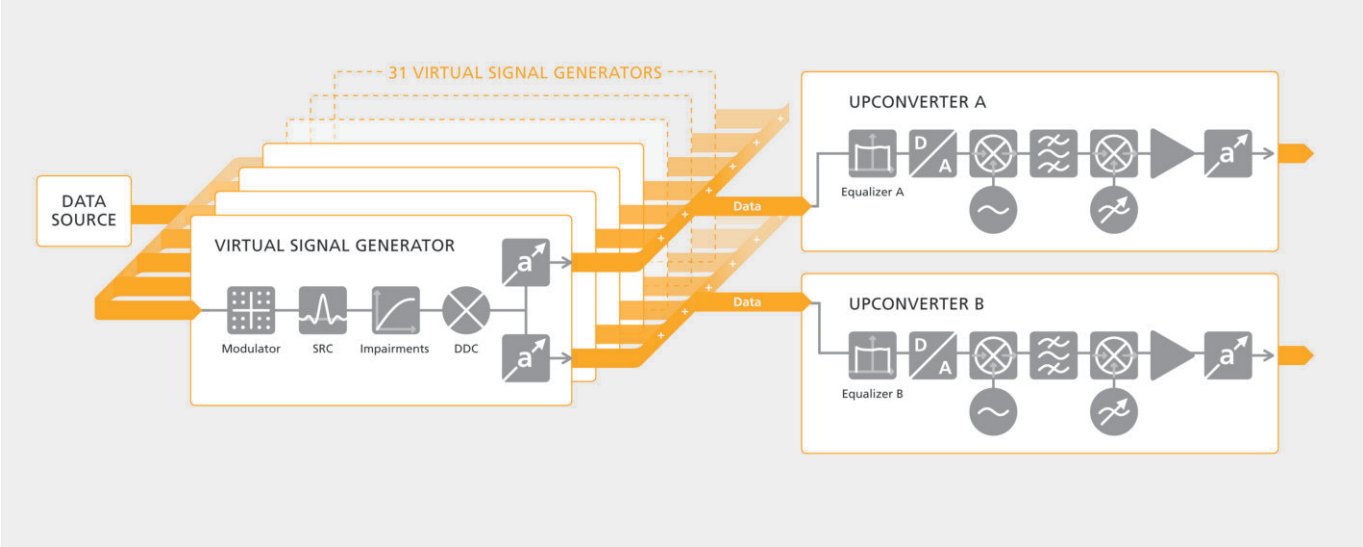

Figure 2: IZT S1000 BLOCK DIAGRAM

TWO INDEPENDENT RF OUTPUTS

The IZT S1000 contains two independent RF sections (Figure 3), each of which can be set 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.

The center frequencies can be modif ed during signal generation. This allows the user to move the signals seamlessly in the 3 GHz span. This feature enables a broad range of additional applications such as testing receivers at multiple frequencies or superimposing an interferer moving over a frequency span of 3 GHz. In test setups like the XM TA2, it saves an additional signal generator.

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

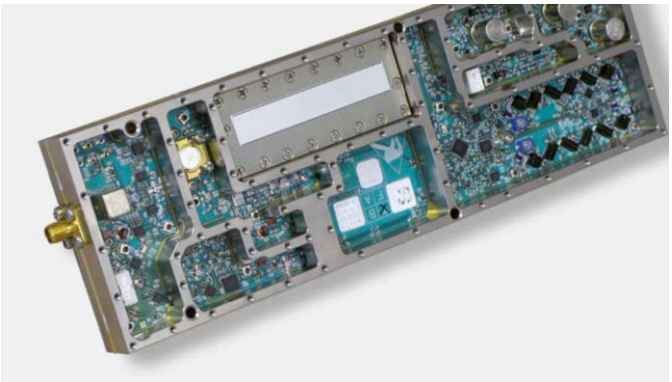

Figure 3: RF SECTION OF THE IZT S1000

REPLAYING RF SIGNALS

The IZT S1000 replays recorded or simulated signals with up to 40 MS/s at 12- or 16-bit complex resolution. This sample rate is sufficient for an individual signal bandwidth of 34.4 MHz.

The internal memory supports sequences with more than one minute duration before they loop at the highest bandwidth. When using lower bandwidths, this looping length is scaled up linearly. When used with an external Memory Extension (Figure 4), which is available in two hardware configurations, hours of recorded signals can be replayed continuously.

Signal sequences can be recorded with IZT receivers. This can be done for a single antenna, whereas when using the IZT R3301, diversity setups with multiple antennas are supported.

Instead of recording a signal, the user can generate plain I/Q data using system simulations from Matlab, LabVIEW etc. The variable sample rate converters built into the IZT S1000 avoid time-consuming offline resampling of the test data.

Due to its multi-channel functionality, IZT S1000 is able to replay or simulate complex signal environments with uncorrelated or identical content. A specific signal power and center frequency can be assigned to each VSG in real-time via the GUI or remote control.

Figure 4: IZT S1000 WITH EXTERNAL MEMORY EXTENSION

VARIABLE SAMPLE RATE CONVERTERS

Each of the 31 Virtual Signal Generators contains independent variable sample rate converters with 120 dB SFDR and sub-Hertz frequency resolution. They allow the user to easily combine signals from different standards and origin with their specific sample rate without time-consuming pre-processing.

PSI MODE PERMITS UP TO 100 MHZ BANDWIDTH

The PSI mode option allows the generation of wideband signals of up to 100 MHz bandwidth. Individual wideband signals, which are absolutely synchronous in phase, delay and time, are seamlessly combined in the frequency band. With 8 GB internal memory, the user can realize a 100 MHz spectrum with a repeat length of more than 10 seconds.

ABSOLUTE TIMING ACCURACY FOR ANTENNA DIVERSITY AND MIMO

The IZT S1000 provides accurate frequency and time synchronization. All relevant clocks and local oscillators are accessible to the user. This allows absolute launch timing and phase-locked frequencies within a single IZT S1000 or across multiple synchronized IZT S1000 in a complex test setup.

Receivers with several 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.

VARIABLE SIGNAL EMISSION AT DEFINED TIMESLOTS

For more flexibility in testing, IZT S1000 supports “advanced streaming”, which allows individual emissions to be sent at defined time slots (Figure 5). In each emission, the most important signal parameters can be configured even during run-time:

- Start/stop time
- Frequency
- Bandwidth
- Source (I/Q File, ARB12, ABR16, IZT R3000, NI)
- Time-variant prof les
- Hopping sequence
- Up to 31 signal streams from the IZT S1000 Memory Extension

For complex scenarios, the following parameters can be configured:

- RF frequency of RF1/RF2
- Noise generation
- Shaped noise

SMOOTH EXTERNAL SYNCHRONIZATION

If a setup with several signal generators is necessary, an option for external synchronization is available. IZT S1000 is prepared such that the IZT devices can be used absolutely phase-synchronously together. One of the devices will take the role of the master and the other will take the role of the slave. A central clock and LO signals are distributed among the signal generators. If there are more than two signal generators, an additional clock/LO distribution unit is available.

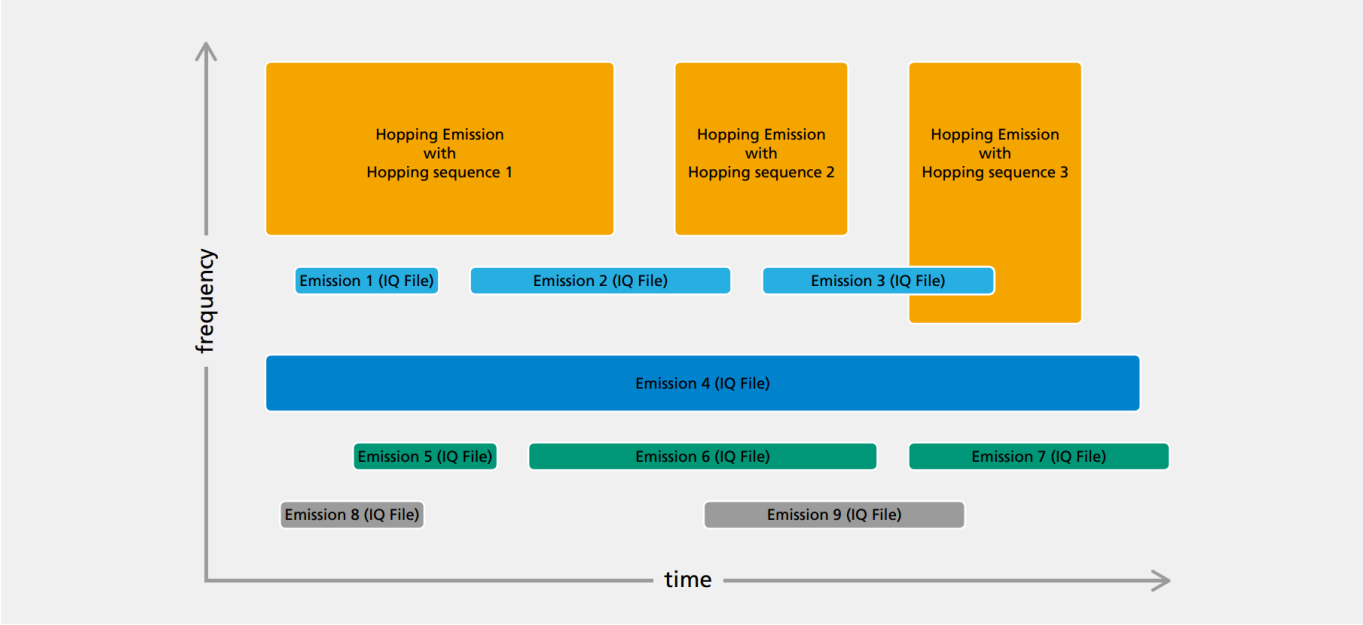

Figure 5: SCENARIO SIMULATION WITH CHANGING CONTENT OVER TIME

Real-time Impairment Simulation

As a versatile and comprehensive testing platform, IZT S1000 can be equipped with a wide range of simulation tools. Many configurations are possible – the specific application will be customised with the exact software option as required. Most of the software options can be easily upgraded by option keys.

Fading Channel Simulation

Figure 6 shows the fading channel simulation of the IZT S1000, which offers a pool of up to 32 fading paths that can be allocated freely to the VSGs and the RF outputs. The user takes advantage of the full flexibility at both ends of the channel simulator block. For example, two VSGs can be distributed to over 32 paths in total, sixteen of which go to RF output 1 and sixteen of which go to RF output 2.

All paths can simulate a “moving path”, that is the support of a time-variant delay. The Doppler spread can be as high as 10 kHz. The complex gains of all paths are either streamed from a file or calculated in real-time by the IZT S1000 software. The fading channel simulation has the ability to generate scenarios for testing receivers with antenna diversity. Each scenario is reproducible in a perfectly controlled way.

Different fading models such as Rayleyh, Rice, LOS, GAUSS are supported to easily simulate scenarios as def ned in receiver test procedures.

Fading models for TU4 / RA6 / TU6 / TU12 / SFN are provided as predef ned scenarios, which can be recalled. During product support, these fading models will be continuously enhanced and upgraded.

The IZT S1000 can be used for Maximal Ratio Combining (MRC) receiver testing. The powerful fading simulation and two RF outputs provide a simple and effective way to test MRC. MRC is a variant of diversity combining, that is a method to combine two or more received signals in order to improve the quality of the resulting signal.

Figure 6: SCREENSHOT OF FADING CHANNEL SIMULATION

Time Variant Signal Profiles

The IZT S1000 supports a number of time-variant signals called “profiles” to simulate large-scale variations of signal properties (Figure 7):

- Propagation delay
- Signal frequency
- Power levels

These parameters can be modified independently for each VSG without affecting signal quality and with a timing resolution as low as 12 µs. Typical applications are large-scale fading or shadowing effects, delay variations caused by moving satellites or emulating a fast frequency hopper.

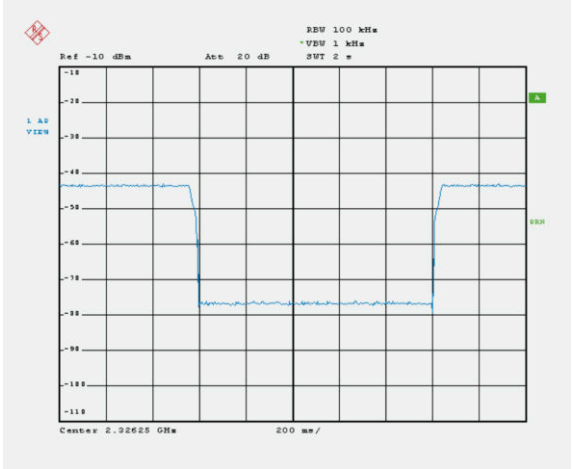

Figure 7: POWER LEVEL PROFILE

Shaped Noise Source

The IZT S1000 contains one incoherent 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. In consequence, 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 because only bands relevant to the receiver are subject to an elevated noise floor.

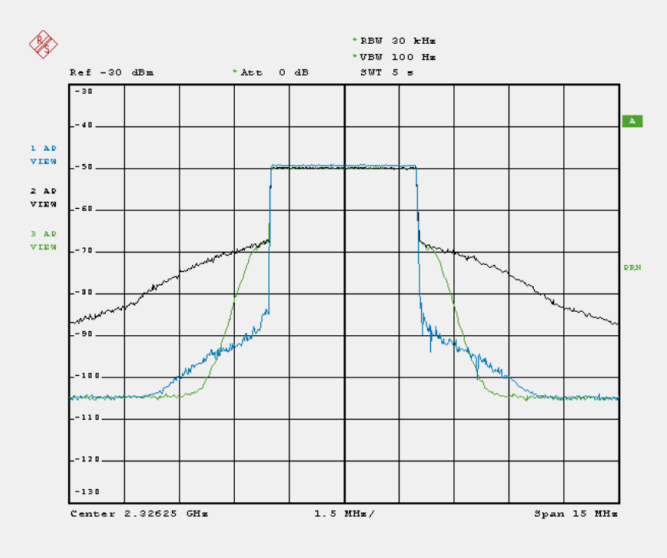

Figure 8: DISTORTED SIGNAL BEFORE (BLACK), AFTER THE FILTER SIMULATION (GREEN) AND AFTER FILTER SIMULATION WITH ALTERNATIVE FILTER SETTINGS (BLUE)

Nonlinearity and Filter Simulation

The IZT S1000 offers a very realistic simulation of the nonlinear distortion created in the power amplif er of a transmitter (Figure 8). First, the signal is subjected to a memoryless distorter, which models the AM/AM and AM/PM characteristics of a power amplifier. In the second stage, an output filter model of the actual transmitter is applied to emulate realistic results. The output filter emulation and nonlinearities can be activated independently.

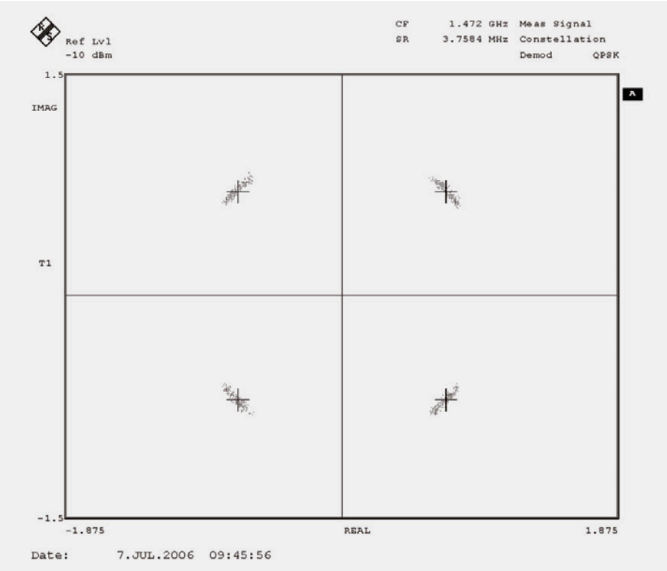

Figure 9: QPSK CONSTELLATION AFFECTED BY PHASE NOISE

Phase Noise

The IZT S1000 can simulate phase noise to the modulated signals for system validation or troubleshooting of carrier tracking loops. The user simply selects the desired phase noise mask and gain and the IZT S1000 generates the phase noise exactly as specified (Figure 10).

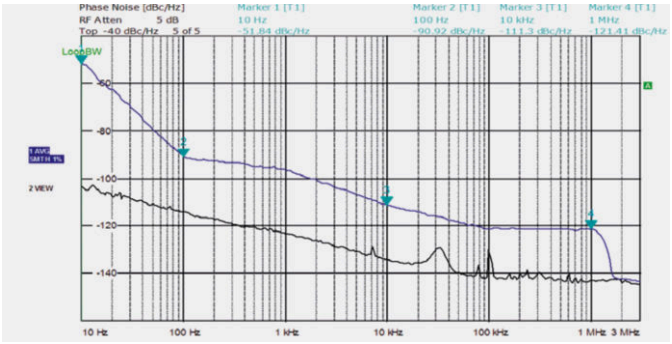

Figure 10: PHASE NOISE SIMULATION FOR HD RADIO AM

Injection	Before fading
Profiles	Pre-def ned phase noise masks from library User-def ned phase noise masks Settable on Graphical User Interface
Format	ASCII text f les, editable
Graphical User Interface	31 independent points 31 independent frequency offset values Internal calculation
Max phase angle	±180°
Density distribution function	Gaussian
Phase noise uncertainty	±0.5 dBc/Hz typical
Frequency offset range from carrier	1 Hz – 2.5 MHz

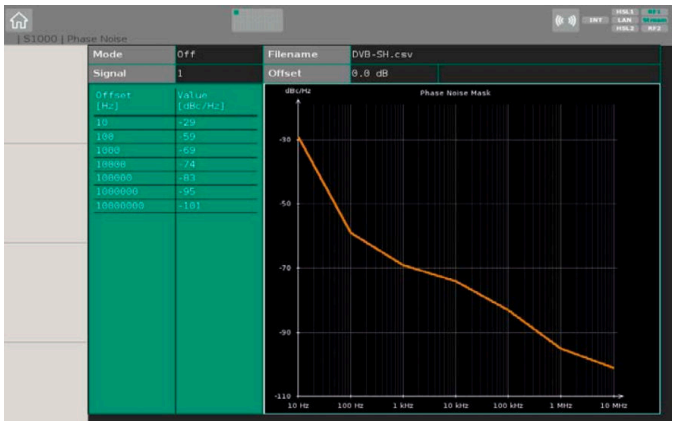

Figure 11: SCREENSHOT OF PHASE NOISE CONFIGURATION

Your Benefits

Upgradeable Hardware for Powerful Testing

Figure 12: IZT S1000 SIGNAL GENERATOR

The IZT S1000 addresses a wide range of different customer applications. The customer benefits from its compact 2U form factor chassis with high resolution display and front panel keyboard. The chassis contains all digital processing hardware, synthesizers and RF sections.

As a versatile and comprehensive testing platform it is offered with a broad choice of available hardware options. For a specific customer application, a single device or extensive setup can be equipped with the exact hardware as required.

Internal Memory

The internal memory 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
- Bit streams from real-time modulators
- Data for frequency, delay and power profiles
- RF recordings from R3000 at any sample rate and 16- or 32-bit resolution
- Data from third party measurement equipment

The Virtual Signal Generators share the data of the onboard sample memory. Conventional signal generators, lacking the sophisticated processing of the IZT S1000, hold only a few seconds of content, while the IZT S1000 can support minutes of continuous signal out of internal memory until the signal wraps. The signals are repeated seamlessly in a loop without interruption.

The IZT S1000 has four GB of fast sample memory available for storing and reading out I/Q data. Eight GB memory is available as an option.

The signals can be loaded from the internal hard drive or streamed from an external IZT Memory Extension unit.

Internal HDD and eSATA Interface

For low to medium data rates (for example satellite radio), content can be streamed in real-time from the internal hard drive. The HDD has a capacity of 500 GB and can be complemented with an external disk via the eSATA interface. The additional storage capacity is available for additional bit streams or for rapid upload of data to the IZT S1000's internal storage.

Data Streaming from External Memory Extension

For the most demanding applications, data can be streamed from an external Memory Extension directly into the FPGA via dual Gbit LAN or via 10 Gbit optical LAN interface (Figure 14).

All kinds of signals for radio testing and any I/Q signals of variable sample rate as well as multiple signals, can be streamed at the same time to the signal source.

Dedicated Ethernet connections via the dual Gbit Ethernet port make it possible to stream up to 225 MB/s. The available streaming resources can be shared among all streamed Virtual Signal Generators. Also the direct replay of a two-channel diversity recording of the complete FM broadcast band is possible (Figure 13).

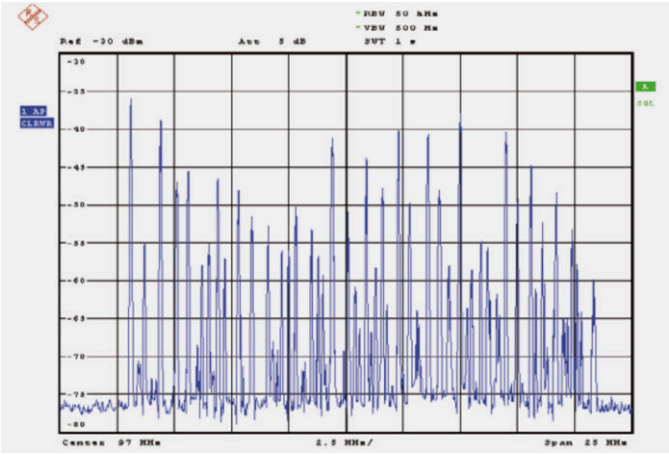

Figure 13: RECORDED FM BROADCAST SPECTRUM

The external Memory Extension is available in two different configurations:

- to extend the capabilities of the signal generator with 2 x 12 TB
- to extend the capabilities of the signal generator with 2 x 9 TB with fault tolerance

Figure 14: BACK PLANE OF THE IZT S1000 INCLUDING 10 GBIT INTERFACE

Wideband Streaming

The S1000 and S1010 can be reconfigured with an alternative Software and Firmware which enables the wideband streaming functionality. The WBS-GUI controls the S1000 and streams one or two wideband signals from the internal S1010 or from the connected S1000-MemoryExtension-WBS.

One 120 MHz bandwidth stream can be provided from an S1000-MemoryExtension-WBS or two times 60 MHz. The IZT S1010 in combination with the S1010-SDD option provides the data on the optical 10G interface and is then prolonged to the fast FPGA based processing board. IZT S1000 is capable of sharing the available streaming resources among wideband signals. These signals can of course be fully synchronous.

The various options enable also trigger functionality for starting signals and a marker functionality which is a digital pulse that can be generate at specific points within a waveform generation.

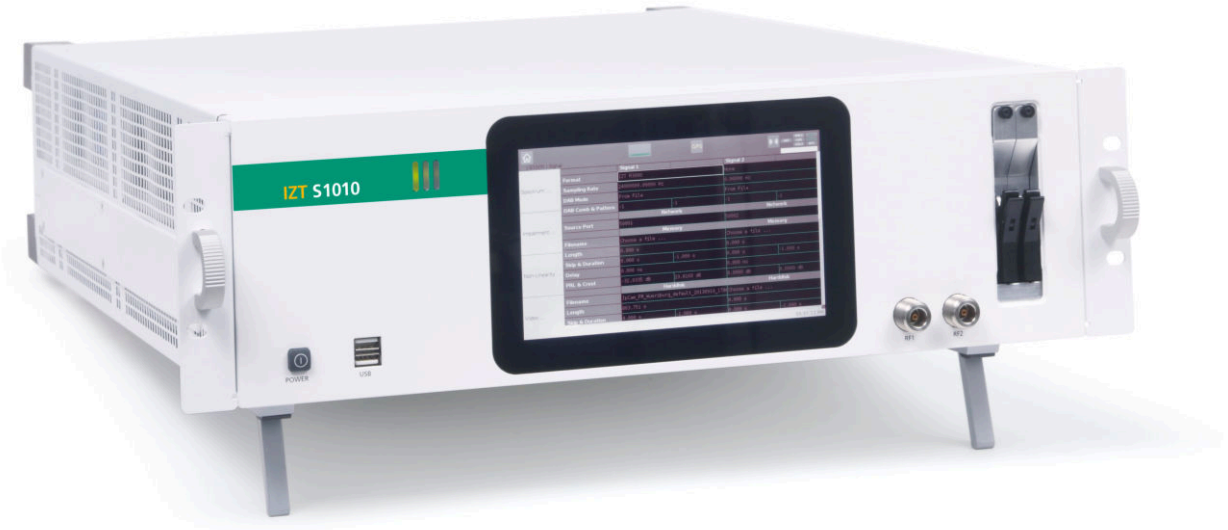

Figure 15: IZT S1010 SIGNAL GENERATOR

High Speed Streaming Directly from the IZT S1010 Signal Generator

For the most demanding applications which require extensive data streaming, but are limited in rack space the IZT S1010 is the ideal solution. The main difference to the IZT S1000 Signal Generator is that the streaming capabilities, as available with an external Memory Extension, are included in the IZT S1010. Due to the very fast SSDs it is possible to stream many VSGs parallel. Adding RF and software options allows to configure the IZT S1010 to the specific needs (Figure 15).

IZT S1010 comprises all digital processing and is equipped with 4 x 1 TB SSD (optional) and a 250 GB SSD system disk. These disks are available from outside with robust HDD trays and are used to store and stream the test vectors in high speed. As there are no moving parts for the SSD the IZT S1010 is very robust and can be used in rough environments and high elevation.

The IZT S1010 is provided with the user-friendly Graphical User Interface. The internal TFT has a built in multitouch controller. The unit can be controlled from the internal TFT or at an external connected TFT-display or projector. For the IZT S1010 Signal Generator an optional rack mount slide mechanism is available which helps to install the S1010 easily in a 19" rack and access it from the rear side. An optional DC supply can be installed instead of the AC redundant supply.

DC Supply and Control Signals from External Equipment

The IZT S1000 provides 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 for controlling and monitoring this equipment. The state of the I/Os and the supply voltage can be fully remote-controlled.

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 an analogue modulation tool or from the user as narrow band I/Q data. One hopper requires one VSG only (two VSGs with 240 MHz spread). Additional hoppers can be added with the option IZT S1000-FHC.

Figure 16: BACK PLANE OF THE IZT S1010

Figure 17: IZT S1000-MTX

Spread	Up to 120 MHz / 240 MHz
Hop rate	> 2000 hops/s
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 240 MHz spread
Content	Narrow band I/Q-data < 5 MS/s when number of hoppers is 31

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 a DUT environment and laboratory. The IZT S1000-MTX is capable of simulating bias tee current sinks, for example for active antennas. The switching behavior is controlled from the IZT S1000 GUI and can also be controlled from the remote interface.

Frequency range	RF IN 1,2	100 kHz – 3 GHz
	RF OUT 1-4	100 kHz – 3 GHz
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	16 V DC / 100 mA
VSWR (input/output)	RF IN 1,2	< 1.6:1
	RF OUT 1-4	< 1.6:1 (typical < 1.25:1 @ 1 GHz, < 1.35:1 @ 2 GHz)
Insertion loss		< 4 dB (typical 1 dB @ 1 GHz, 2.5 dB @ 2 GHz)
DC input	GPIO S1000	V_{SUPPLY} = 11 V – 13 V
	RF OUT 1-4	VBIAS = 6 V – 15 V, IBIAS = 0 mA – 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)
Dimensions (W x H x D)		443 mm x 41.6 mm x 430 mm

SUPPORT FOR GLOBAL MODULATION FORMATS

The IZT S1000/ IZT S1010 supports a great number of modulation standards. This enables users to rapidly develop custom applications for research, design, characterization, validation and testing communication systems and components that modulate or demodulate signals.

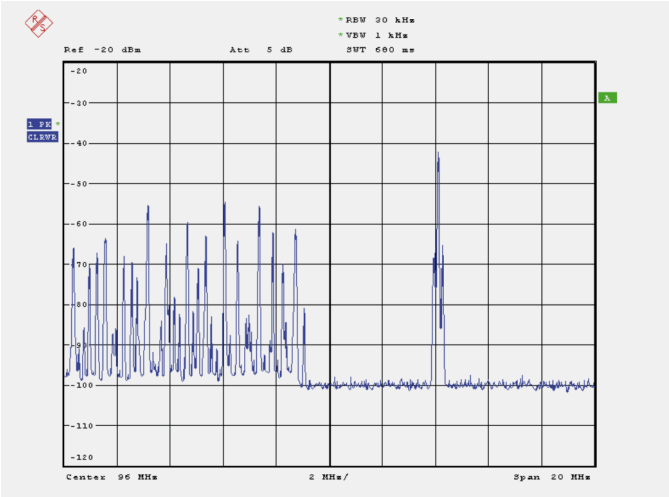

Figure 18: RECORDED FM BROADCAST SPECTRUM COMBINED WITH ONE HD RADIO SIGNAL

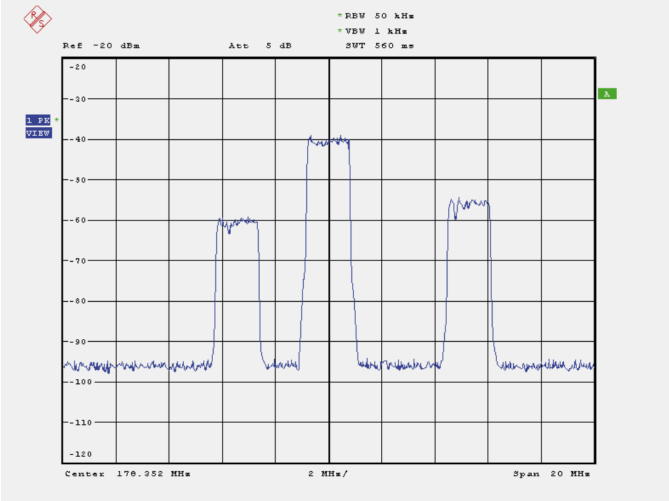

Figure 19: THREE DAB ENSEMBLES

DAB / DAB+ / DMB

The IZT S1000 modulates DAB and DAB+ signals from ETI or EDI. With the DAB modulator option S1000-403, the streams are COFDM modulated and can be either loaded to the internal memory or streamed from the external Memory Extension.

The DAB real-time modulator S1000-203 can use ETI or EDI files directly as input and can be configured multiple times in different VSGs. The DAB real-time modulator is capable of full ETI reconfigurations.

The IZT DAB ContentServer can be used to generate ETI files or EDI/ETI streams for DAB and DAB+ and DMB. Combining its functionality with the IZT S1000, provides a versatile laboratory setup. The DAB real-time modulator option and live EDI input option for the IZT S1000/ IZT S1010 allow a direct link between the IZT DAB ContentServer and the IZT S1000/ IZT S1010 with the EDI protocol. Reconfigurations can be tested effectively.

The IZT DAB ContentServer Embedded Edition allows basic testing of DAB receivers and is exclusively available to be combined with the IZT S1000/ IZT S1010. To test the full feature set of the DAB standard family, the IZT DAB ContentServer Developer Edition is recommended. It provides the complete functionality – including all standardized and broadcaster-specific data services, reconfigurations and signaling options.

DVB-T / DVB-T2 / ISDB-T

The IZT S1000/ IZT S1010 is offered with a modulation tool to generate digitally modulated signals from Transport Stream (TS) files. The TS files are COFDM modulated and are either loaded to the internal memory or streamed from external memory extension to the IZT S1000 or directly with the IZT S1010.

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

HD RADIO™

The IZT S1000/ IZT S1010 is the perfect signal source for the development and testing of HD Radio™ receivers (Figure 20). 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/ IZT S1010 generates AM and FM signals simultaneously (Figure 21).

Figure 20: HD RADIO RECEIVER

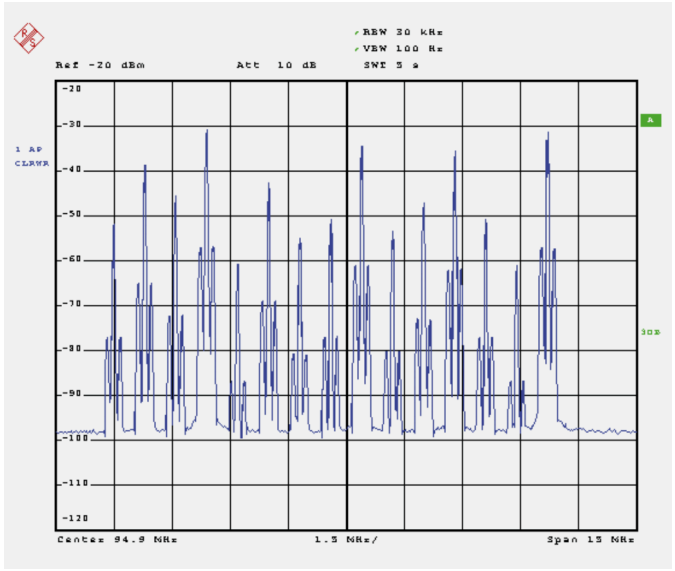

Figure 21: FIFTEEN HD RADIO SIGNALS

DRM

The DRM generator is a real-time software modulator for DRM30 and DRM+. It combines DRM multiplexer and modulator capabilities in a Software Defined Radio (SDR) application. The software is remote controllable and supports the latest xHE-AAC and HE-AAC codecs.

GNSS

GNSS receivers need to be tested during development as not all available GNSS signals (e.g. Galileo) are transmitted in full operational constellation.

The GNSS constellation and signal simulation software (Gipsie) provided by IZT S1000/ IZT S1010 supports the simulation of all available GNSS satellite constellations and their respective civil available signals for an arbitrary number of receivers within a fully controlled environment.

A realistic simulation is achieved by applying error models for orbits, atmospheric conditions, receiver hardware as well as multipath and interference by means of jamming and spoofing. An input trajectory can be used in the NMEA or KML format.

The GNSS constellation software is available in different configurations for the supported satellite standards. The option IZT-S1000-GNSS-HS defines a specially built edition of the GNSS simulation software which supports moving objects in excess of 600m/s. The regular edition is limited to less than 600m/s. With IZT-S1000-GNSS-ECALL-BASE it is possible to test eCall-Systems as specified in the Commission Delegated Regulation (EU) 2017/79.

Sirius XM Satellite Radio

The IZT S1000/ IZT S1010 offers a real-time modulation for all Sirius XM signals including all new overlay waveforms (Figure 22).

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 on the fly. The time consuming process of generating and loading new streams into the generators is eliminated.

Real-time modulation allows many hours of continuous content without signal gaps and makes the IZT S1000/ IZT S1010 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.

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 or filter assembly or RF switch. The adjustable voltage output can supply power to an external amplifier.

The supported SXM waveforms are:

- Sirius Terrestrial and Satellite
- Sirius Overlay
- Sirius Next Generation Overlay NGO
- XM Terrestrial and Satellite
- XM Hierachical / Overlay

Sirius XM Acceptance Test

The IZT S1000/ IZT S1010 is ideally suited for a fully automated type acceptance test of Sirius or XM receivers without any additional test equipment. Even blocking tests can be performed from one piece of equipment. The remote control software configures and executes all measurements.

IZT provides the necessary test scenarios and software setups for an automated XM TA2 test.

The ability to stream content allows it to be used for XM TA1 testing.

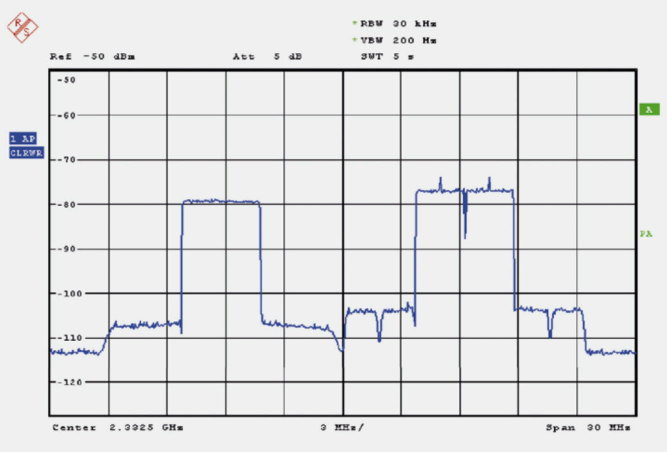

Figure 22: FULL SIRIUS XM RADIO SIGNAL USING EIGHT VIRTUAL SIGNAL GENERATORS

The IZT S1000 can be used to fully stimulate the new X28 receiver modules.

USER FRIENDLY OPERATION

The IZT S1000's/ IZT S1010´s front panel and Graphical User Interface have been specially designed for a rapid and user friendly control of multiple signals. These support a fast and reliable navigation within the signal generator and enable the user to configure complex scenarios in just a few steps.

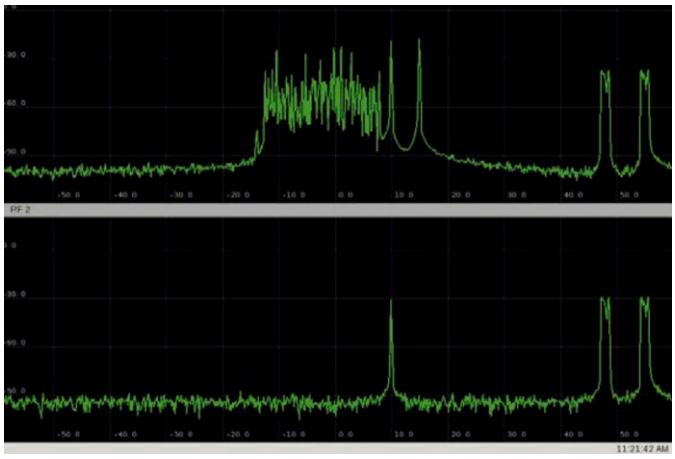

Figure 23: EXAMPLE OF A FULL FM SPECTRUM

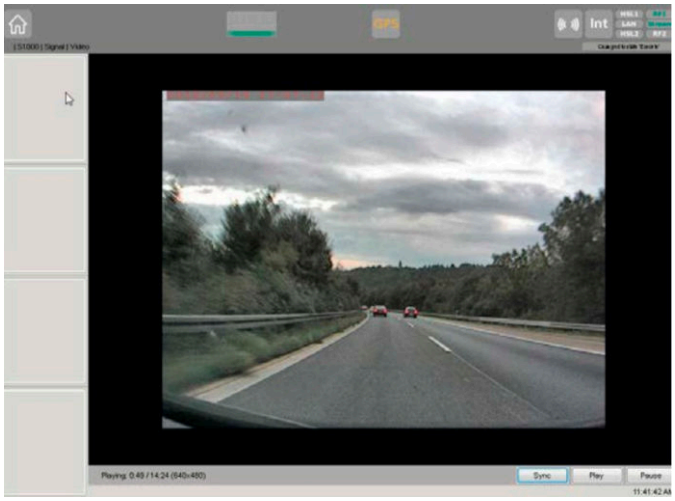

Figure 24: VIDEO REPLAY SYNCHRONIZED TO RF SPECTRUM

Easy Control of Multiple Signals

The parameters of the Virtual Signal Generators are organized in a grid layout with a minimum number of layers (Figure 25). The front panel allows fast 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 optimal support for the user by checking settings for inconsistencies and giving hints about how to resolve them.

Figure 25: SCREENSHOT OF THE GRAPHICAL USER INTERFACE

Comprehensive Spectrum and Video Visualization

The spectrum visualization provides a very quick overview of all generated signals in the 120 MHz bandwidth. As the IZT S1000/ IZT S1010 supports up to 31 signals and has versatile impairment functionality, it helps to verify and check the configuration.

The IZT S1000/ IZT S1010 permits a video visualization of IZT R3000 recordings (Figure 24), which are combined with video content. This helps to acquire additional video information besides the GPS location when replaying recordings. The video is fully synchronous to the start time, duration, length and loop parameters.

Full Remote Control via Ethernet, Serial Port and GPIB

The IZT S1000 is fully remote controlled through SCPI commands received via RS-232, Ethernet 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/ IZT S1010 Signal Generators to replicate setups.

LabVIEW applications and drivers are available for easy integration of the IZT S1000/ IZT S1010 into automated test setups (Figure 26). The Single Command Center can operate the IZT S1000/ IZT S1010 on all interfaces remotely while extracting SCPI command lists. The Multiple Command Center replays the SCPI command lists for automated test routines either in a single loop or continuously in a time controlled way.

Figure 26: LABVIEW FOR AUTOMATED TEST SETUPS

GPS Interface

This option enables the GPS extraction of the NMEA Data from IZT R3000 recordings. The embedded GPS meta data inside the I/Q streams is extracted and sent to map visualization software. IZT provides the QLandkarte GT software and the replayed route is shown on the mapping tool. Additionally it is possible to send the NMEA to a RS232 interface.

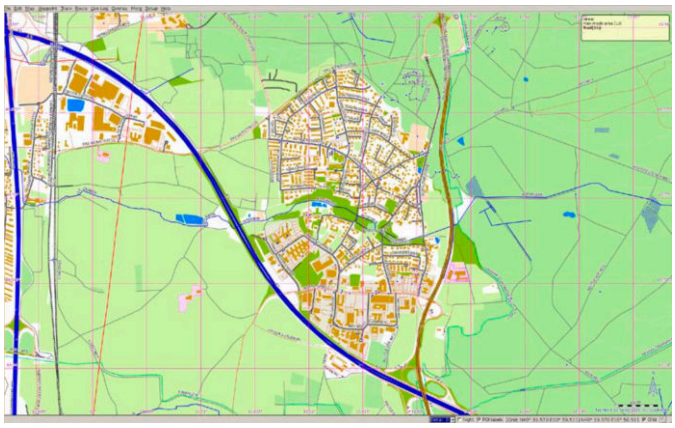

Figure 27: MAP VISUALIZATION SOFTWARE SHOWS A REPLAYED ROUTE.

Applications

CUSTOMER SPECIFIC SOLUTIONS

The IZT S1000/IZT S1010 digital multi-channel signal generator is the perfect source of today's RF waveforms with increasing complexity and bandwidth. They comprise in one unit the simultaneous replaying of 31 RF signal channels and allow to replace extensive setups while reducing time and cost. It enables the user to consolidate multiple conventional RF generators into one compact, cost effective, flexible, and easy-to-use RF test source.

RECEIVER TESTING

The entire supply chain of radio receivers can benefit from testing scenarios. This includes product development, validation and production line testing. Chip set manufacturers, suppliers and car manufacturers need to cover a variety of testing scenarios as automotive radio receivers are becoming more and more complex, and user experience increasingly important.

When testing radio receivers for DAB, it is important to cover the whole range of DAB functionality. On one side, encoding and signaling needs to be tested in compliance with the DAB specification, while on the other hand, reception conditions also need to be considered. Finally, the relation between DAB services and other bearers such as FM needs to be taken into account.

The IZT S1000/ IZT S1010 and IZT ContentServer form a comprehensive test setup covering these requirements.

If you need further information about receiver testing also take a look in our application note[1] and our technical article[2].

TESTING eCall SYSTEMS

The Innovationszentrum für Telekommunikationstechnik GmbH IZT enhanced the signal generator IZT S1000/ IZT S1010 for testing emergency call (eCall) systems. Now it is possible to test eCall systems with the IZT S1000/ IZT S1010 Signal Generator in combination with the GIPSIE® software which was developed in cooperation with OHB Digital Solutions GmbH. The solution offers a compact multi-channel high performance platform for complex and versatile testing in one device. The GNSS options from the GIPSIE® project enable simulations of eCall test scenarios with the IZT S1000/ IZT S1010 for testing eCall systems regarding the requirements of the European Union.

If you need further information about testing eCall systems also take a look in our application note[3].

RECORD AND PLAYBACK

The ability to record RF signals during test drives and to reproduce them in the laboratory can significantly reduce time-to-market and cost when developing radio receivers. The IZT Record and Replay system (IZT RecPlay) is widely used in the car industry and enables manufacturers to test and to verify their implementations in a very reliable and reproducible way. Applications include in-car entertainment systems with analog and digital broadcasting such as DAB, but also GNSS used for navigation and its relation to traffic information received from broadcast signals.

If you need further information about record and playback also take a look in our Brochure about IZT RecPlay[4] and our technical article[5].

[1] https://www.izt-labs.de/izt/media/Testing-DAB-Receivers-with-the-DAB-ContentServer-and-the-S1000-Signal-Generator.pdf
[2] https://www.izt-labs.de/izt/media/Digital-Broadcasting-IZT-Solutions.pdf
[3] https://www.izt-labs.de/izt/media/IZT-S1000-IZT-S1010-testing-eCall-systems.pdf
[4] https://www.izt-labs.de/record-playback-izt-recplay/
[5] https://www.izt-labs.de/izt/media/Technical-Article-Virtual-Field-Tests-IZT-Record-and-Playback-System.pdf

Specifications IZT S1000 / IZT S1010

Technical specifications		
Frequency	Range Resolution	9 kHz – 3 GHz 0.001 Hz
Instantaneous bandwidth	9 kHz – 30 MHz 90 MHz – 2940 MHz	30 MHz 120 MHz
Reference	Accuracy Ageing Temperature stability Warm-up time	OCXO $\pm 5 \times 10^{-8}$ per year $< \pm 1 \times 10^{-8}$ 10 min
Power level	Maximum output power Resolution Uncertainty Range Dynamic range	+20 dBm typical 0.1 dB ±0.5 dB: +10 dBm – -50 dBm; ±1.0 dB: below -50 dBm -134 dBm – +20 dBm (peak) > 75 dB typical
Spectral purity	Harmonics f > 30 MHz Harmonics f < 30 MHz Non harmonics > 30 MHz Non harmonics < 30 MHz	< -30 dBc at +10 dBm < -40 dBc at +10 dBm < -75 dBc typical < -80 dBc typical
Output IP3	< 30 MHz @ 10 dBm dualtone, 2 MHz spacing 100 MHz @ 10 dBm dualtone, 2 MHz spacing 1575 MHz @ 10 dBm dualtone, 2 MHz spacing 2332.5 MHz @ 10 dBm dualtone, 2 MHz spacing	35 dBm typical 40 dBm typical 34 dBm typical 32 dBm typical

DCLK IN	
Connector type	SMA, female, 50 Ω
Coupling	AC; DC max 50 V
Center frequency	160 MHz
Input level	-25 dBm to +12 dBm > +4 dBm result in compression
Input refl ection |s11|	< -15 dB @ 100 MHz – 1000 MHz
Impedance	50 Ω

DCLK OUT	
Connector type	SMA, female, 50 Ω
Coupling	AC, DC max. 50 V
Center frequency	160 MHz
Impedance	50 Ω
Output level	+12 dBm (ON) -24 dBm (OFF)
Waveform	Square, Duty-Cycle = 50% ca. +2.0 Vpp @ 50 Ω
Spurs, non harmonic	< -90 dBc typical
Phasenoise	-90 dBc/Hz typical @ 10 Hz offset -102 dBc/Hz typical @ 100 Hz offset -128 dBc/Hz typical @ 1 kHz offset -146 dBc/Hz typical @ 10 kHz offset -154 dBc/Hz typical @ 100 kHz offset -155 dBc/Hz typical @ 1 MHz offset -155 dBc/Hz typical @ 10 MHz offset -155 dBc/Hz typical @ 30 MHz offset

Technical values S1010-DC	
Voltage	10 – 30 V DC
Current	Max. 40 A
Security	No polarity protection
Cable diameter	Min. 6 mm²
Cable lenght	Max. 4 m @ 6 mm² Max 6.6 m @ 10 mm²
Max resistance of cable	10 mΩ

Reference IN/OUT	
Connector type	BNC, female, 50 Ω
Coupling	AC; DC max 50 V
Center frequency	10 MHz
Tuning range	+/-5 Hz
Input reflection |s11|	< -20 dB @ 10 MHz – 200 MHz
Input level max.	+18 dBm
Input level min.	0 dBm
Input leakage	-70 dBm typical
Output impedance	50 Ω
Output level	+6.5 dBm
Output waveform	Square: -0.6 V to +0.6 V Duty-Cyle: 50 % @ 50 Ω

System specifcation	Memory Extension	Memory Extension+
Operating system	Debian Linux 9 64 Bit	Windows 7 Professional 64 Bit
RAM	16 GB	16 GB
Storage HDD	4 x 3.5” Tray (removable) 2 x 12 TB Raid0 System	8 x 3.5” Tray (removable) 2 x 9 TB Raid5 System (by default) or 2 x 12 TB Raid0 System 4 x 2.5” Tray (removable)
System HDD	1 TB (removable)	500 GB (removable)
CPU	Intel core i7-4770S 4 x 3,1 GHz	Intel core i7-6700 4 x 4 GHz
Ethernet	4 x Gbit high-speed ports	6 x Gbit high-speed Ports
	2 x optical 10 Gbit (optional)	2 x optical 10 Gbit (optional)
Interfaces	2 x USB 2.0 (front) 4 x USB 2.0 (back) 2 x USB 3.0 (back)	2 x USB 2.0 (front) 4 x USB 2.0 (back) 4 x USB 3.0 (back)
	2 x RS232 Serial Ports (back)	1 x RS232 Serial Ports (back)
Display interface	1 x VGA (up to 1920 x 1200) 1 x HDMI (up to 1920 x 1080) 1 x DVI-D (up to 1920 x 1080)	2 x Display Port (up to 4096 x 2304) 1 x DVI-D (up to 2560 x 1600)
Graphic	Intel HD 4000/5000 Graphics	Intel HD Graphics 530
Display	24” TFT	24” TFT
Input	USB keyboard, USB mouse	USB keyboard, USB mouse
MTBF	> 36,500 h (Telcordia SR-332, Issue 3) @ 35°C environmental temperature	> 45,000 h (Telcordia SR-332, Issue 3) @ 35°C environmental temperature
Input voltage range	100 V – 240 V (AC)	100 V – 240 V (AC)
AC supply frequency	50 Hz – 60 Hz	50 Hz – 60 Hz
Max. input current	1.4 A (100 V) – 0.58 A (240 V)	2.0 A (100 V) – 0.83 A (240 V)
Dimensions (W x H x D)	435 mm x 88 mm (2 RU) x 550 mm (+30 mm incl. grips)	426 mm (+52 mm for ears) x 178 mm (4 RU) x 490 mm (+50 mm incl. grips)
Weight	13.5 kg	25.8 kg

Signal Generation		
Integrated hard disk	Size	1 TB
Internal memory	Size	4 GB, 8 GB (optional)
External LAN	Connection	2 x 1000 BaseT UDP / TCP / 10 Gbit optical
Channels	Number	Up to 31
Data representation	Data format Input sample rate	12/16 Bit I/Q Variable up to 40 MS/s

Digital	Standards	
Sirius Satellite Radio	Supported channels Source	Satellite 1, terrestrial, satellite 2 Encrypted TE1 files provided by Sirius; sample file pre-installed
XM Satellite Radio	Supported channels Source	Satellite 1A, 2A, 2B, 1B; terrestrial A & B TDM/TDMH meta files provided by XM; sample file pre-installed
HD Radio	Supported channels Source	Multiple radio stations possible iBiquity test vectors, all pre-installed; updates to test vectors from IZT FTP server
AM	Source	I/Q files generated from audio files with offline tool
FM	Source RDS	I/Q f les generated from audio files with offline tool Included in I/Q files
DAB	Supported channels Source	Up to 31 I/Q files modulated from ETI files or live modulation from ETI files and real-time EDI/ETI; compatible with ETI files obtained from WorldDMB
DAB+	Supported channels Source	Up to 31 I/Q files modulated from ETI files or live modulation from ETI files and real-time EDI/ETI; compatible with ETI files obtained from WorldDMB
DVB-T	Supported channels Source	Up to 16 I/Q files generated by offline tool from TS files
DVB-T2	Supported channels Source	Up to 16 I/Q files generated by offline tool from TS files
ISDB-T	Supported channels Source	Up to 16 I/Q files generated by offline tool from TS files
DRM30/DRM+	Supported channels Source	Up to 31 I/Q files generated by offline tool from audio files

General Data		IZT S1000	IZT S1010
Power supply, nominal values	Input voltage range AC supply frequency Max input current	100 V – 240 V (AC) 50 Hz – 60 Hz 1.4 A (100 V) – 0.6 A (240 V)	100 V – 240 V (AC) 50 Hz – 60 Hz 2 A (100 V) – 0.85 A (240 V)
EMC		Meets EN 55022, classB QP, AV FCC 47 CFR Part 15, Subpart B, Class B	Meets EN 55022, classB QP, AV FCC 47 CFR Part 15, Subpart B, Class B
Environmental conditions	Operating temperature Storage temperature	0 °C – 55 °C -40 °C – +70 °C	0 °C – 50 °C -40 °C – +70 °C
Dimensions (W x H x D)	Without angles With angles	446 mm x 88 mm x 570 mm 482 mm x 88 mm x 595 mm	452 mm x 141 mm x 569 mm 482 mm x 141 mm x 594 mm
Weight		12 kg (including keyboard)	16 kg (including keyboard)

Ordering Guide

Hardware IZT S1000	Description
IZT S1000-CHS	Chassis and all digital hardware
IZT S1000-ESATA	ESATA interface to connect an external HDD to the internal processor
IZT S1000-10G	10 Gbit option
IZT S1000-TCS	Transport case (for packaging)
IZT S1000-RF3	RF output 9 kHz – 3 GHz [6]
IZT S1000-RFS3	RF synthesizer 3 GHz
IZT S1000-RF6	RF output 9 kHz – 6 GHz [7]
IZT S1000-RFS6	RF synthesizer 6 GHz
IZT S1000-8GB	8 GB high-speed memory (increases the internal memory from 4 GB to 8 GB)
IZT S1000-GPIB	GPIB interface (adds the physical interface “GPIB” for remote control)
IZT S1000-FHS	Frequency hopping module
IZT S1000-FHC	Additional frequency hopping channel
IZT S1000-EXT_SYNC	External synchronization interface
IZT S1000-MTX	RF switching matrix (2 RF inputs to 4 RF outputs distribution and switch)
IZT S1000-MTA	Switching matrix accessories kit

Hardware IZT S1010	Description
IZT S1010-CHS	Chassis and all digital hardware
IZT S1010-SDD	Solid state data disk for IZT S1010-CHS3
IZT S1010-RCK-MNT	19” Rack mounting kit with a slide mechanism for IZT S1010-CHS3
IZT S1010-DC	DC supply for IZT S1010-CHS3
IZT S1010-10G	10 Gbit option
IZT S1010-TCS	Transport case (for packaging)
IZT S1000-RF3	RF output 9 kHz – 3 GHz [8]
IZT S1000-RFS3	RF synthesizer 3 GHz
IZT S1000-RF6	RF output 9 kHz – 6 GHz [9]
IZT S1000-RFS6	RF synthesizer 6 GHz
IZT S1000-8GB	8 GB high-speed memory (increases the internal memory from 4 GB to 8 GB)
IZT S1000-GPIB	GPIB interface (adds the physical interface “GPIB” for remote control)
IZT S1000-FHS	Frequency hopping module
IZT S1000-FHC	Additional frequency hopping channel
IZT S1000-EXT_SYNC	External synchronization interface
IZT S1000-MTX	RF switching matrix (2 RF inputs to 4 RF outputs distribution and switch)
IZT S1000-MTA	Switching matrix accessories kit

[6] IZT S1000 can be equipped with one or two RF outputs; requires at least one synthesizer IZT S1000-RFS3 RF
[7] IZT S1000 can be equipped with one or two RF outputs; requires at least one synthesizer IZT S1000-RFS6 RF
[8] IZT S1000 can be equipped with one or two RF outputs; requires at least one synthesizer IZT S1000-RFS3 RF
[9] IZT S1000 can be equipped with one or two RF outputs; requires at least one synthesizer IZT S1000-RFS6 RF

Software	Description
IZT S1000-GUI	Graphical user interface
IZT S1000-LBV	LabVIEW driver
IZT S1000-110	One virtual signal generator VSG [10]
IZT S1000-110a	Bundle 31 VSG channels
IZT S1000-120	Streaming input (high-speed LAN streaming, 2 Gbit ports for streaming data)
IZT S1000-130	PSI mode
IZT S1000-140	Advanced streaming (enables time controlled streaming)
IZT S1000-201	Modulator for “legacy” Sirius Satellite Radio signals [11]
IZT S1000-201a	Modulator for Sirius overlay waveform [12]
IZT S1000-201b	Sirius spectral representation
IZT S1000-201c	Sirius next generation overlay NGO
IZT S1000-202	Modulator for XM Satellite Radio signals [13]
IZT S1000-202a	Modulator for XM overlay waveform [14]
IZT S1000-202b	XM spectral representation
IZT S1000-203	DAB real-time modulator
IZT S1000-203b	Live EDI input for IZT S1000-203
IZT S1000-220	HD Radio™license to play digital HD AM and FM files [15]
IZT S1000-220a	HD Radio™ test vector upgrade [16]
IZT S1000-221	Audio real-time modulator; modulates audio directly from sound card input
IZT S1000-230	Internal HDD streaming
IZT S1000-301	Phase noise simulation
IZT S1000-302	Nonlinearity simulation and TX 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 S1000-310	Impairment bundle (301/302/305)
IZT S1000-402	FM RDS: Generation of AM and FM signals from audio waveform files [17]
IZT S1000-403	DAB modulator
IZT S1000-407	DAB/DAB+/DMB ContentServer Embedded Edition[18]
IZT S1000-407b	DAB/DAB+/DMB ContentServer Embedded Edition upgrade[19]

[10] up to 31 VSGs are possible
[11] Requires 3 IZT S1000-110 VSGs
[12] Requires IZT S1000-201 modulator
[13] Requires 5 IZT S1000-110 VSGs
[14] Requires IZT S1000-202 modulator
[15] Requires at least one IZT S1000-110 VSG
[16] Upgrades S1000 to latest release of iBiquity test vectors
[17] includes RDS encoder
[18] Can be extended by additional options of the IZT DAB ContentServer. Full-featured DAB functionality is available with the IZT DAB ContentServer Developer Edition. For further information, please refer to the IZT DAB ContentServer brochure
[19] Can be extended by additional options of the IZT DAB ContentServer. Full-featured DAB functionality is available with the

Software	Description
IZT S1000-408	DVB-T modulation toolbox
IZT S1000-409	DRM30 modulator
IZT S1000-409a	DRM30 modulator for MDI input
IZT S1000-410	DRM30/DRM+ modulator
IZT S1000-410a	DRM30/DRM+ modulator for MDI input
IZT S1000-410b	DRM30/DRM+ modulator bundle (IZT S1000-410/-410a)
IZT S1000-411	Software modulation generator (SMG)
IZT S1000-412	GPS output
IZT S1000-413	Spectrum display
IZT S1000-414	Video playback
IZT S1000-416	DRM30/DRM+ upgrade xHE-AAC / HE-AAC
IZT S1000-417	DRM30/DRM+ upgrade MDI output streaming
IZT S1000-418	DVB-T modulation toolbox
IZT S1000-419	DVB-T2 modulation toolbox
IZT S1000-420	ISDB-T modulation toolbox
IZT S1000-500	WBS (wideband streaming) GUI [20]
IZT S1000-520	WBS (wideband streaming) from optical 10G LAN
IZT S1000-530	Trigger functionality for starting signals
IZT S1000-531	Marker functionality

Memory Extension	Description
IZT S1000 Memory Extension	Enhances the IZT S1000 streaming capabilities to wideband signals; provides 2 x 12 TB storage capacity
IZT S1000 Memory Extension+	Enhances the IZT S1000 streaming capabilities to wideband signals; provides 2 x 9 TB storage capacity with fault tolerance
IZT S1000 Memory Extension-WBS	Enhances the IZT S1000 streaming capabilities to enable streaming of wideband signals above 60MHz

Service	Description
IZT Software Support Contract	Support for IZT software options
IZT WE2	Warranty extension to 2 years
IZT WE3	Warranty extension to 3 years
IZT S1000-CLC	Factory calibration recommended in a 2-year cycle (IZT certificate included)

IZT DAB ContentServer Developer Edition. For further information, please refer to the IZT DAB ContentServer brochure

[20] different FW and SW variant and Memory Extension-WBS needed

GNSS Options	Features of Satellite Constellation Simulator (Gipsie)
IZT S1000-GNSS-BASE	GPS constellation and IF signal simulator including the following signals: → GPS L1 C/A, GPS L2 C, GPS L5 I/Q Simulation of the following features: - Satellite orbits based on ephemeris or orbit integration - Satellite clock model - Atmospheric delays - Antenna gain pattern - IF signal parameters including RFFE simulation - Statistical multipath model with time-dependant obstruction mask - Realistic and reproducible noise components - User-configurable navigation message contents
IZT S1000-GNSS-HS	GNSS simulation version which supports moving objects in excess of 600m/s
IZT S1000-GNSS-GLONASS	Additional GLONASS signals: → GLONASS G1 C/A, GLONASS G2 C/A
IZT S1000-GNSS-GALILEO	Additional Galileo signals: → Galileo E1 OS, Galileo E5 (E5a + E5b) OS
IZT S1000-GNSS-BEIDOU	Additional Beidou signals: → Beidou B1 D1-Nav, Beidou B2 D1-Nav
IZT S1000-GNSS-NAVIC	Additional NavIC signals: → NavIC L5 SPS, NavIC S SPS
IZT S1000-GNSS-QZSS	Additional QZSS signals: → QZSS L1 C/A, QZSS L2 CM, QZSS L5 I/Q, QZSS L1 SLAS, QZSS E6 CLAS
IZT S1000-GNSS-SBAS	Additional SBAS signals: → SBAS L1 C/A The following SBAS systems are supported: → WAAS, EGNOS, SDCM, GAGAN, MSAS
IZT S1000-GNSS-MULT-RCV	Multiple receivers within one simulation sharing a consistent and realistic simulation of noise and environmental components
IZT S1000-GNSS-ECALL-BASE	Predefined eCall Test scenarios: → Includes IZT S1000-GNSS-BASE, IZT S1000-GNSS-SBAS and IZT S1000-GNSS-GALILEO - GIPSIE scenarios - Precomputed IF signals - Predefined IZTGUI Configurations
IZT S1000-GNSS-ECALL-VAL	eCall Receiver Validation: Validation software for user receiver per eCall requirements based on NMEA receiver logs

ContentServer	Options	Description
IZT DABCS-060	DAB ContentServer Developer Edition [21]	Full-featured development and testing of DAB equipment (includes one DAB+ Encoder license)
IZT DABCS-061	DAB ContentServer Developer Edition upgrade	Full-featured development and testing of DAB equipment (includes one DAB+ Encoder license). Upgrade from IZT S1000-407 (ContentServer Embedded Edition)
IZT DABCS-201	DAB Audio Encoder	Additional MPEG Audio Layer-II audio encoder license
IZT DABCS-202	DAB+ Audio Encoder	Additional MPEG-4 HE-AAC v2 audio encoder license
IZT DABCS-203	DMB Audio Encoder	Additional MPEG-4 HE-AAC v2 audio encoder license
IZT DABCS-302	Live Audio Input upgrade	Adds live audio input to Developer Edition

[21] Can be extended by additional options of the IZT DAB ContentServer. Full-featured DAB functionality is available with the IZT DAB ContentServer Developer Edition. For further information, please refer to the IZT DAB ContentServer brochure

IZT S1000 / IZT S1010
High-Performance Signal Generator

Product Information

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 IZT quality management system is ISO 9001:2015 certified.

All data provided in this document is non-binding.This data serves informational purposes only and is especially not guaranteed in any way. Depending upon the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

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Quality Management ISO 9001 www.dekra-ead.com DEKRA certified

IZT Innovationszentrum Telekommunikationstechnik

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