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IZT
Innovationszentrum
Telekommunikationstechnik

IZT RecPlay

The ultimate Record & Replay System for RF signals

- Excellent RF performance
- Extremely low RF emission
- Many hours of continuous record & replay
- Diversity & multi-frequency setup
- Ideal for MIMO system testing
- Powerful off-line post-processing

IZT RecPlay

The ultimate Record & Replay System for RF signals

IZT RecPlay provides the perfect platform for RF receiver design validation of analog and digital radio, broadcast standards and telecommunication systems. It includes a state-of-the-art wideband recorder with integrated high-performance RF receiver, an external server for data streaming and a revolutionary signal generator, which combines 31 virtual signal generators in one platform.

With a real-time bandwidth of up to 25 MHz or 120 MHz and a frequency range of 9 kHz to 3 GHz, 6 GHz or 18 GHz, the recorder covers the whole FM broadcast band simultaneously. The unmatched bandwidth of 120 MHz allows the replay generator to combine multiple recorded and calculated scenarios.

IZT's innovative high-performance record & replay system for high-quality RF signals offers customers greatly reduced costs for field-testing, repeatable lab tests, fidelity in reproducing real RF environment and shorter time to market.

IZT RecPlay is the ideal platform for RF receiver design validation of analog and digital radio, video and Global Navigation Satellite Systems (GNSS) and development of automotive car infotainment systems and chipsets.

Overview

The RF Recorder is suitable for recording receive scenarios in different countries with excellent signal quality. The recordings can be stored in a library for functional testing of receivers. It is possible to record and replay signals with up to eight antennas.

The recorder covers the frequency range from 9 kHz to 3 GHz (6 GHz and 18 GHz options available) with a real-time bandwidth selectable up to 25 MHz, which is sufficient to cover the whole FM broadcast band simultaneously. The replay generator covers the frequency range from 9 kHz to 3 GHz for a bandwidth of 120 MHz, which allows to combine different recorded and calculated scenarios inside this bandwidth.

The IZT RecPlay System consists of three components: a recording system, a server with software for off-line editing and signal sources to replay the signals. Benefits include greatly reduced costs for field testing, repeatable tests in the lab and fidelity in reproducing real RF environment which allows a shorter time to market.

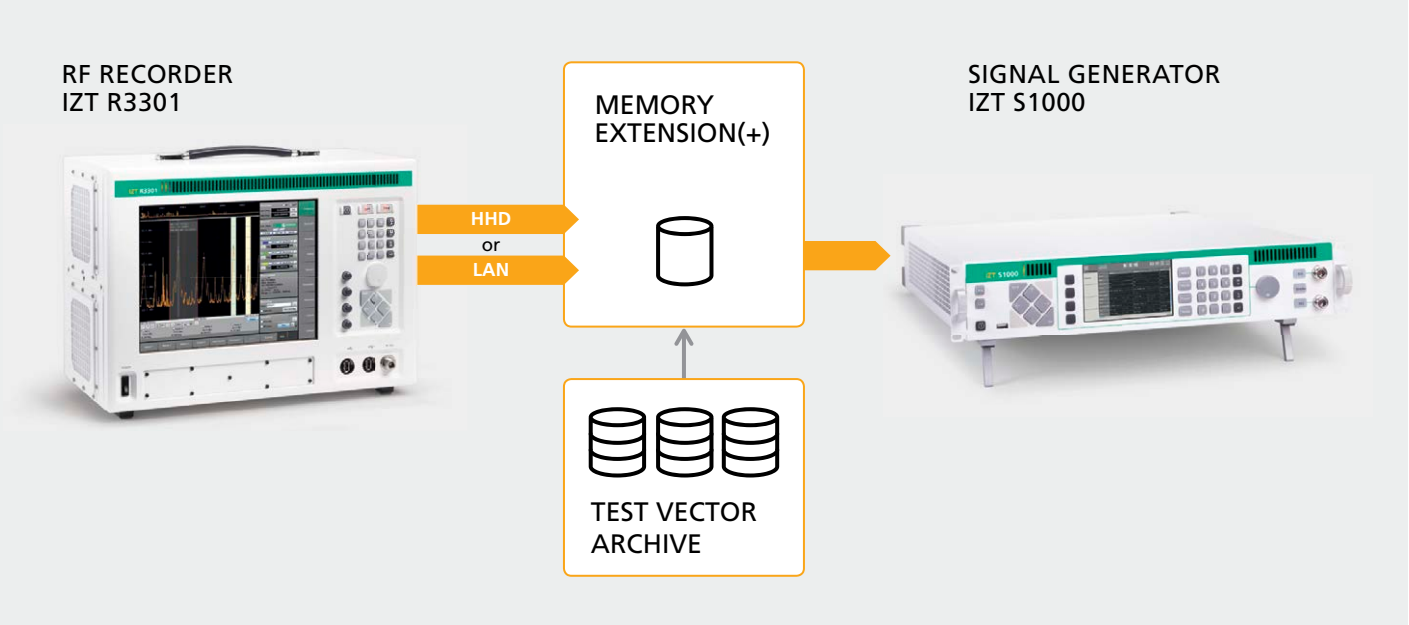


FIGURE 1: EXAMPLE OF A ONE CHANNEL IZT RECPLAY SETUP

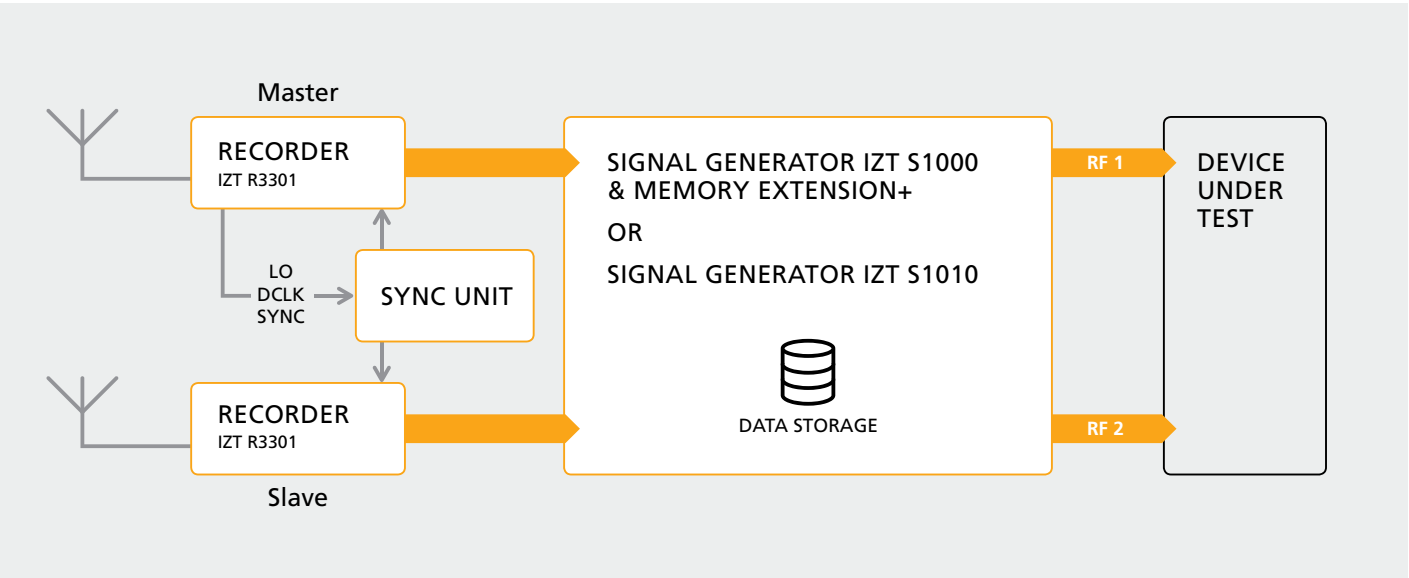


FIGURE 2: IZT RECPLAY TWO-CHANNEL SYSTEM SETUP FOR DIVERSITY AND MULTI-FREQUENCY SCENARIO

RECPLAY SYSTEM

The IZT RecPlay record and replay system consists of at least one IZT R3301 RF Recorder with integrated high-performance RF receiver and built-in Sensor Controller, a memory extension for data streaming and one IZT S1000 Signal Generator for replay of the recorded I/Q data (Figure 1). The IZT S1000 and the external memory extension can also be replaced by the IZT S1010, which includes the memory function for long-term signal streaming.

An IZT RecPlay system for diversity recording consists of one IZT R3301 RF Recorder per antenna and is synchronized by an external clock distribution (Figure 2).

As a common reference clock alone (for example 10 MHz) would not be sufficient to ensure that all receivers operate phase-synchronously, one master IZT R3301 creates all necessary clock and synchronization signals, like system clock and both VHF/UHF local oscillators, and sends them to a central clock distribution that amplifies the signals and passes them on to all receivers. A trigger impulse starts the sample-synchronous recording of the system. Intercommunication between master and slaves of the built-in servers is controlled via optical LAN interface to minimize EMI. The built-in GPS receiver of the master serves as time and location reference.

If necessary, a calibration signal can be coupled into the antenna feeds, which allows to establish zero phase shift between the antenna inputs. The captured data streams of up to approximately 120 MB/sec are sent via internal GB Ethernet to each built-in server and is stored on an integrated RAID system.

Figure 3 shows the block diagram of the recording system configured for two diversity signals. The system is modular and can be expanded up to eight antenna signals.

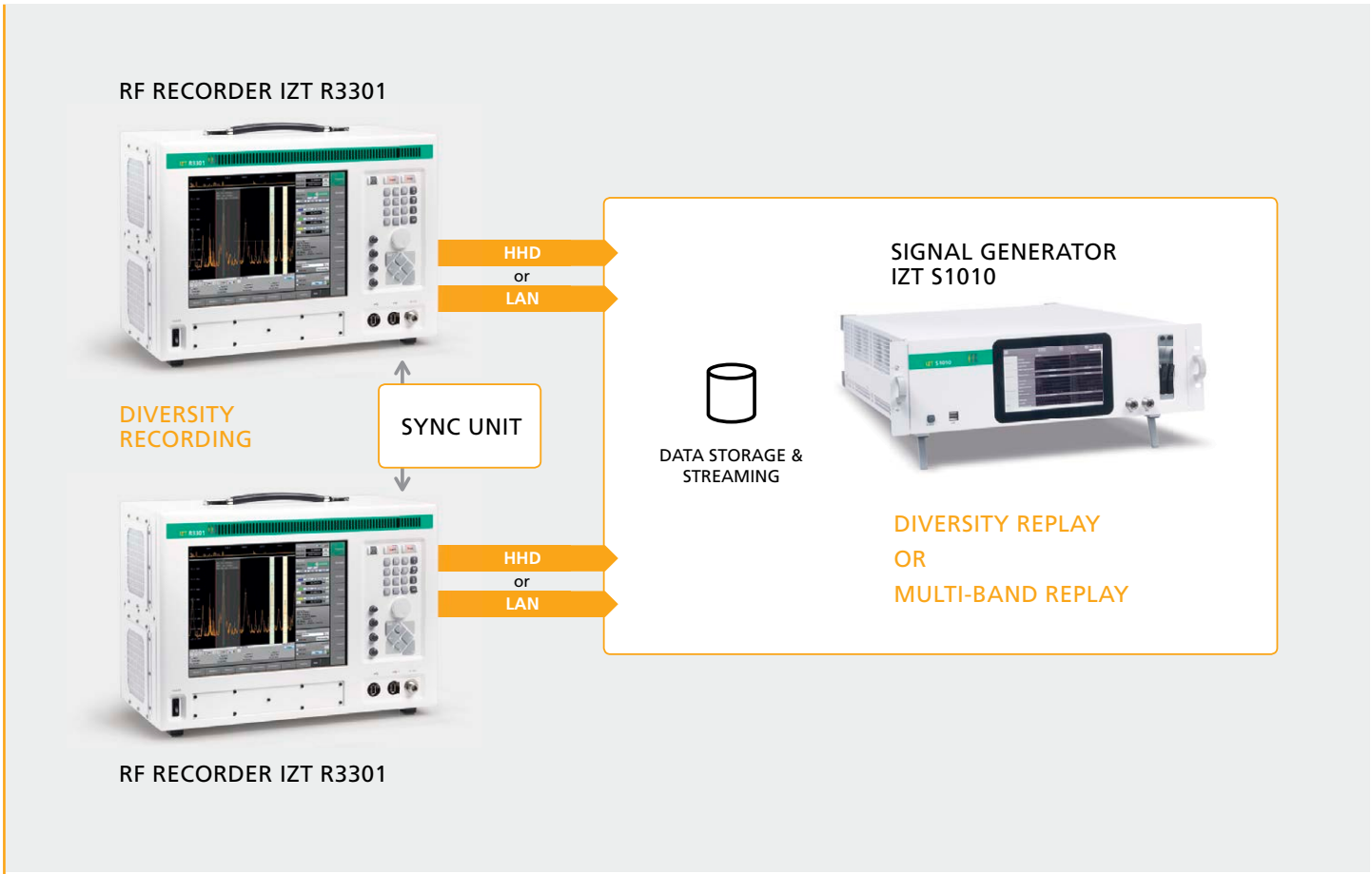


FIGURE 3: IZT RECPLAY DIVERSITY AND MULTI-BAND SETUP WITH STREAMING SERVER FOR DATA POST PROCESSING

Key Features

RECORDING SYSTEM

The IZT R3301 RF Recorder is a portable receiver with built-in server for data recording. It is optimized for recording RF signals in mobile and portable applications.

The outstanding RF performance and signal processing matches the professional IZT R3000 Receiver series. These receivers were developed for applications of regulatory agencies, military and civilian radio surveillance and as lab test equipment.

The system is designed to produce good signal quality under extreme dynamic range and has successfully passed many rigorous technical evaluations with civilian and military customers.

With its very high dynamic range (Figure 4) and excellent phase noise this receiver platform is the ideal solution for the needs of modern digital modulation standards.

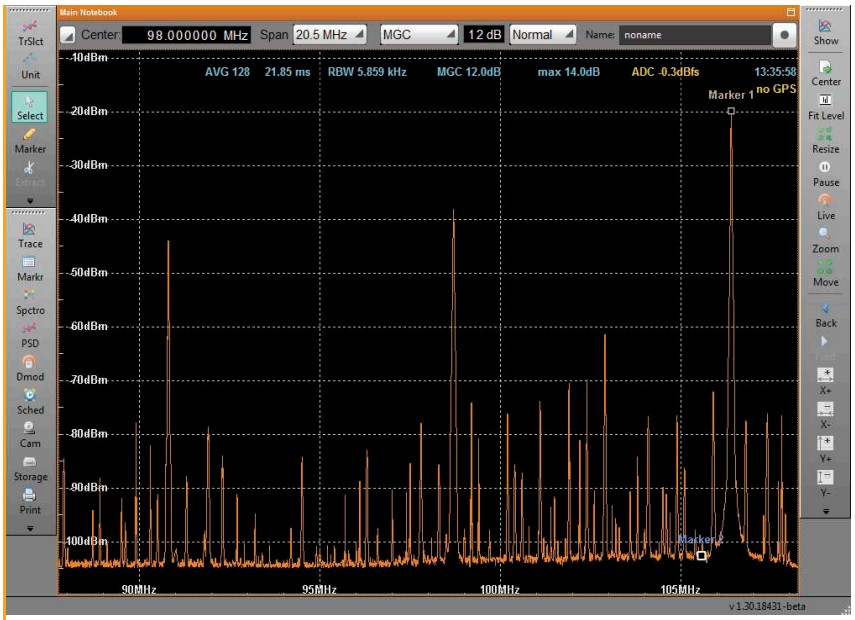


FIGURE 4: FM BROADCAST RECORDING WITH HIGH DYNAMIC RANGE

Thanks to its front panel control, touch screen and integrated processing hardware, the IZT R3301 RF Recorder is the perfect portable RF recording system. While having a compact and rugged design, it also meets CISPR 25 / EN 55025 for extremely low RF emissions. The wide range AC and DC power supply is completed by an uninterrupted power supply (UPS) for surge and sub voltage protection against DC supply fluctuations.

An internal GPS module adds location information to the received signals.

The IZT R3301 is characterized as follows:

- Portable, rugged design
- Continuous I/Q data recording
- Swappable RAID system (Figure 5)
- Built-in GPS for embedded location information
- 10 V DC to 30 V DC power supply
- 100 V AC to 240 V AC supply with built-in UPS
- Control via touch screen
- Synchronization interface (Figure 6)
- Low RF emissions
- Built-in high-end IZT R3000 Receiver technology

The outstanding RF performance of the integrated IZT R3000 Receiver technology is based on a very modern and market proven receive system with excellent reception at very good signal quality. It is highly insensitive to strong adjacent band interference due to sub-octave pre-selector filters and high first intermediate frequency.

The integrated IZT R3000 Receiver is characterized as follows:

- 9 kHz to 3 GHz frequency range
- Frequency range upgradeable up to 18 GHz
- Real-time bandwidth up to 25 MHz
- Very low phase noise
- High linear RF frontend for excellent IP3 performance
- Pre-selector filter bank guaranties best IP2 performance
- Additional digital filtering
- IF Filter bandwidth: 6.25 kHz to 25 MHz
- 1 Hz tuning resolution
- Multichannel recording of up to 4 different sub-bands

An External Synchronization Unit (Figure 7) provides phase coherent clock to multiple IZT R3301 RF Recorders in diversity or multi-frequency setups.

It can be enhanced by a calibrated signal source (connected directly at the junction plane of the antenna connectors) in test scenarios which require phase matching between the antennas.

Remote connection between multiple recorder units is made via optical LAN interface to prevent electromagnetic interference. An optical LAN converter allows for complete remote control of a single IZT R3301 unit over longer distances without EMI problems, for example in a highly sensitive RF measurement setup inside an EMI chamber.

FIGURE 5: EASY RAID STORAGE SWAPPING

FIGURE 6: EXTERNAL INTERFACES FOR POWER SUPPLY, LAN, GPS ANTENNA AND SYNCHRONIZATION

FIGURE 7: SYNCHRONIZATION UNIT IZT R3301-SNC

OTHER IZT RF RECORDER PLATFORMS

IZT R3302

The IZT R3302 is the more ruggedized, display-less variant of the IZT R3301 RF Recorder. Like the IZT R3301 it comes with an built-in Sensor Controller and integrated data storage configuration, a wide-range DC supply with UPS and a built-in GPS module.

IZT R3410 / IZT R3411 + Notebook

Small size mobile single channel RF recording systems can be provided by combining IZT R3410 or IZT R3411 Receivers with external light-weight Sensor Controllers and IZT Signal Suite recorder applications. Mobile sensor controllers based on notebooks are available in different ready-to-use configurations specified by IZT to customer requirements.

The compact variant of the successful R3000 series combines a limited weight of less than 7 kg with a fanless design suited for harsh environments by maintaining the excellent RF performance and a real-time bandwidth of 25 MHz. While the IZT R3410 can provide frequency coverage from 9 kHz up to 18 GHz, the IZT R3411 is further reduced in size and weight below 5 kg covering either HF or VUHF (20 MHz to 3 GHz) frequency ranges.

IZT R3600 + IZT P2500

The IZT R3600 offers up to five channels with 25 MHz instantaneous bandwidth each and covers the frequency range from 9 kHz to 3 GHz or even 6 GHz. The innovative multi-channel receiver system enables users to combine phase-coherent and/or multi-frequency RF recordings by choosing common or individual reference clock per channel. The scalable multi-channel receiver system with integrated frequency and clock conditioning reduces the number of external devices and minimizes overall system costs.

The compact design in one 19-inch, 8 U chassis combined with external powerful 19-inch, 2 U IZT Sensor Controllers facilitates easy transport and set-up.

IZT R4010 / IZT R4000 + IZT P2500

The IZT R4010 features excellent RF performance together with a large real-time bandwidth of 120 MHz. In order to reduce the massive amount of data being collected, it features the unique capability to dynamically extract parts of the full instantaneous bandwidth and record and post process them separately. The IZT R4000 in combination with the P2500 has sufficient processing power for additional software features like modulation recognition, Communication System Monitoring or demodulation for analog and digital standards.

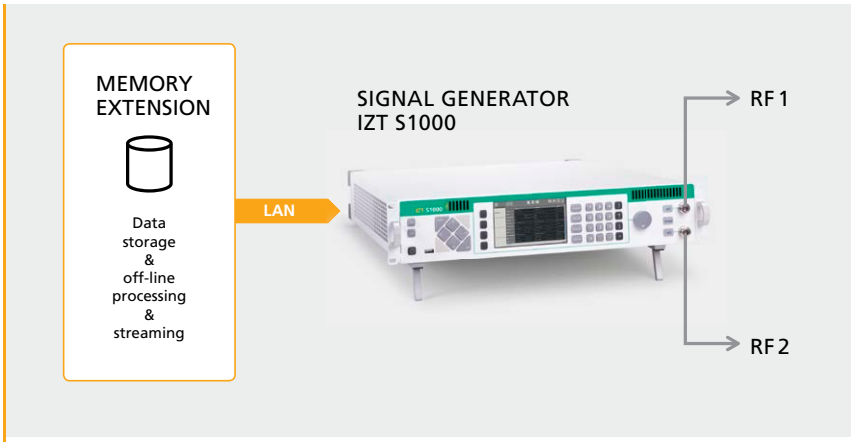


FIGURE 8: PLAYER FOR DIVERSITY SIGNALS, USING A SINGLE IZT S1000 WITH TWO RF OUTPUTS

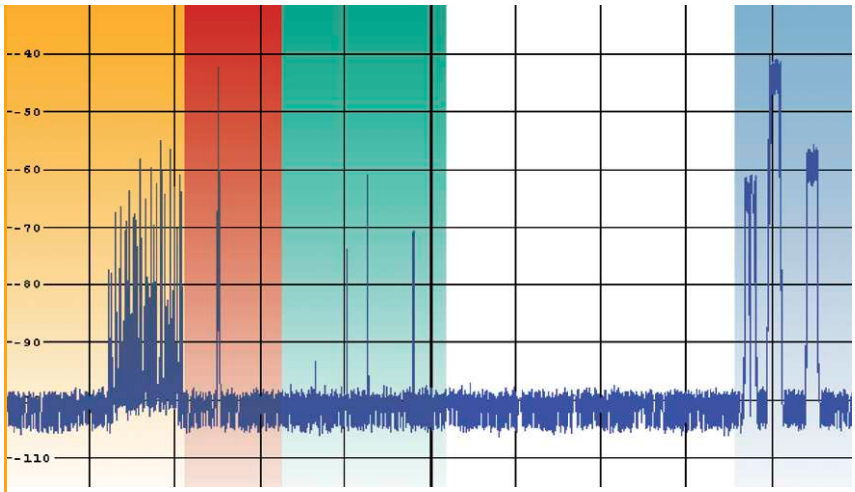


FIGURE 9: SYNTHESIZED 120 MHZ SPECTRUM CONSISTING OF DIFFERENT SIGNAL TYPES

REPLAY SYSTEM

Replay of the RF signals is done with signal generator IZT S1000 / IZT S1010. Contrary to most signal generators available today, the IZT S1000 / IZT S1010 has been specifically designed to replay complex signals comprising a large number of individual carriers.

The IZT S1000 is characterized as follows:

- 9 kHz to 3 GHz frequency range
- 120 MHz bandwidth
- 31 Virtual Signal Generators
- Diversity replay for two antennas
- Phase synchronous replay of diversity signals
- Continuous data streaming of 225 MB/s
- Sharing of the available streaming capacity
- Real-time impairment simulation
- Modulators for DAB, DAB+, DMB, DRM 30, DRM+, XM, Sirius, HD Radio
- Universal ARB function with up to 8 GB RAM
- Easy to use compact setup

Figure 8 shows a setup for playing two diversity signals with a maximum bandwidth of 120 MHz. The IZT S1010 additionally has a built-in memory extension.

The setup can be expanded easily to a system with more diversity channels by combining multiple externally synchronized IZT S1000 / IZT S1010 Signal Generators.

For the most demanding applications, data can be streamed from the external IZT S1000 Memory Extension directly into the FPGA via dual Gbit LAN. The same function is available by the integrated memory extension of the IZT S1010 (Figure 10).

FIGURE 10: IZT S1010 REPLAY SETUP
WITH REAL-TIME GPS MAP VISUALIZATION

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 LAN connections via the dual Gbit LAN 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.

Additional signals can be generated from the internal 4 GB memory while wide-band signals are streamed from the external IZT S1000 Memory Extension or from the internal memory in case of an IZT S1010.

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

	Signal 1		Signal 2		Signal 3	
Format	IZT R3000		IZT R3000		IZT R3000	
Sampling Rate	24000000.00000 Hz		24000000.00000 Hz		24000000.00000 Hz	
	Harddisk		Harddisk		Harddisk	
Filename	Erlangen_CH1_FM-Diversity_20150820.cbb		Erlangen_CH2_FM-Diversity_20150820.cbb		Erlangen_CH3_DAB_20150820.cbb	
Length	21.162 s		21.162 s		21.162 s	
Skip & Duration	0.000 s	-1.000 s	0.000 s	-1.000 s	0.000 s	-1.000 s
Streaming Time	Immediately		Immediately		Immediately	
Streaming Offset	0.000 ns		0.000 ns		0.000 ns	
Loops	0	-1	0	-1	0	-1
Time	0.000 s	21.162 s	0.000 s	21.162 s	0.000 s	21.162 s
Progress						
Source	Harddisk		Harddisk		Harddisk	
Mode	On		On		Off	
Impairments	Off	1	Off	1	Off	1
Output	RF1		RF1		RF1	
	RF 1	RF 2	RF 1	RF 2	RF 1	RF 2
Frequency Name	Select ...	Select ...	Select ...	Select ...	DAB6A	DAB6A
Frequency	97.750000006 MHz	97.750000006 MHz	97.750000006 MHz	97.750000006 MHz	181.936000000 MHz	181.936000000 MHz
Gain Control	Auto		Auto		Auto	
Power	-134.0 dBm	-134.0 dBm	-134.0 dBm	-134.0 dBm	-134.0 dBm	-134.0 dBm
Gain	0.0 dB	0.0 dB	0.0 dB	0.0 dB	0.0 dB	0.0 dB
Eff. Bandwidth	0.00000 Hz		0.00000 Hz		0.00000 Hz	
C/N	-922337203685477632.0	-922337203685477632.0	-922337203685477632.0	-922337203685477632.0	-922337203685477632.0	-922337203685477632.0
C/No	40.0 dBHz	40.0 dBHz	40.0 dBHz	40.0 dBHz	40.0 dBHz	40.0 dBHz

FIGURE 11: IZT S1000 GUI STREAMING MULTIPLE VSG SIGNALS WITH VARIABLE BANDWIDTHS AT INDIVIDUAL CENTER FREQUENCIES AND POWER LEVELS

IZT SIGNAL SUITE – DATA PROCESSOR

The IZT Signal Suite 'Data Processor' is a powerful unique data processing application that allows to review and edit recorded data off-line. Its exceptional feature is extracting individual signals from wideband recordings, which means an easy to use cut-out function in time and frequency domain.

Its basic main features are:

- Signal extraction of individual signals
- Fast interactive display of spectrum and spectrogram
- Meta data display, like receiver settings and location information
- Markers in spectrum and spectrogram, e.g. reference, delta, TOA
- Supports processing diversity and multi-channel recordings

Extraction of signals selected in spectrogram with adjustable time range and individual center frequency and conversion into IZT S1000 / S1010 replay files or other I/Q data formats (Figure 14).

Several plug-in interfaces enable various additional functionality in combination with the Data Processor application:

- I/Q data interface via plug-in 'Signal Import/Export'
- Analog and digital demodulation of recorded signals, e.g. CW, AM, FM, DAB
- Map visualization of embedded NMEA data via plug-in 'GPS Interface'
- Synchronous video replay via plug-in 'Video Camera Interface'
- Viewing and analysis of spectrum/specrogram recordings in scan mode via plug-in 'Panorama Scan'
- Fast zoom and scroll function in spectrum/spectrogram display via plug-in 'Long-term Spectrogram Recording'

FIGURE 12: OFF-LINE VISUALIZATION OF GPS LOCATION INFORMATION

Plug-in 'Signal Import/Export' supports a variety of I/Q data formats, such as 8 bit to 32 bit RAW-IQ, WAV-IQ including RF64 standard and several 3rd party vendor formats, e.g. importing R&S ESMD and Averna (NI) I/Q files. With this plug-in any captured signal can be exported to be shared with other IZT S1000 / S1010 users or for later file based analysis with 3rd party tools.

IZT SIGNAL SUITE – VIEWER

A separate IZT Viewer application allows to view and demodulate recordings or signals which have been extracted before. It provides cost-effective easy to use handling of I/Q data with combinations of marker types in spectrum and spectrogram display – which also supports the analysis of diversity and multi-channel recordings (Figure 27, Page 17). Later on enhancement of IZT Viewer with options for signal extraction and data import/export can upgrade to the full functionality of the IZT Data Processor.

For both off-line I/Q post-processing and signal analysis, IZT provides workstation solutions with specially selected components for efficiently handling the sophisticated algorithms with optimum performance.

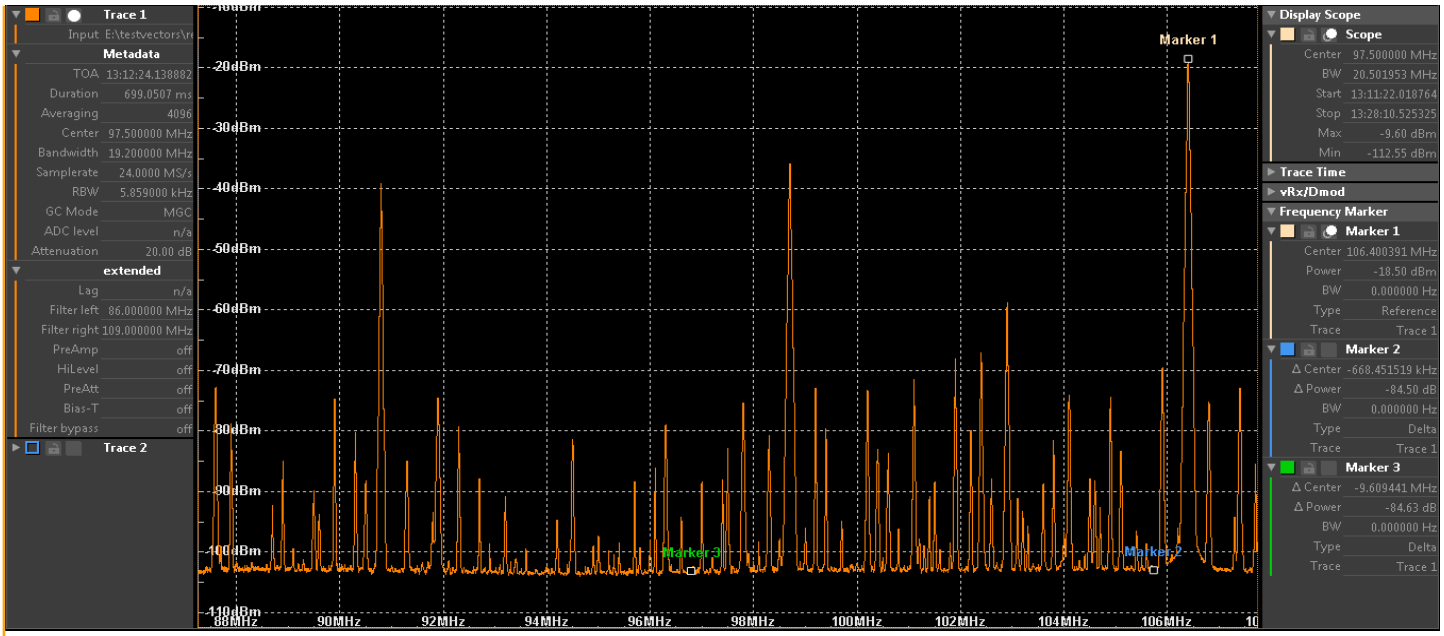
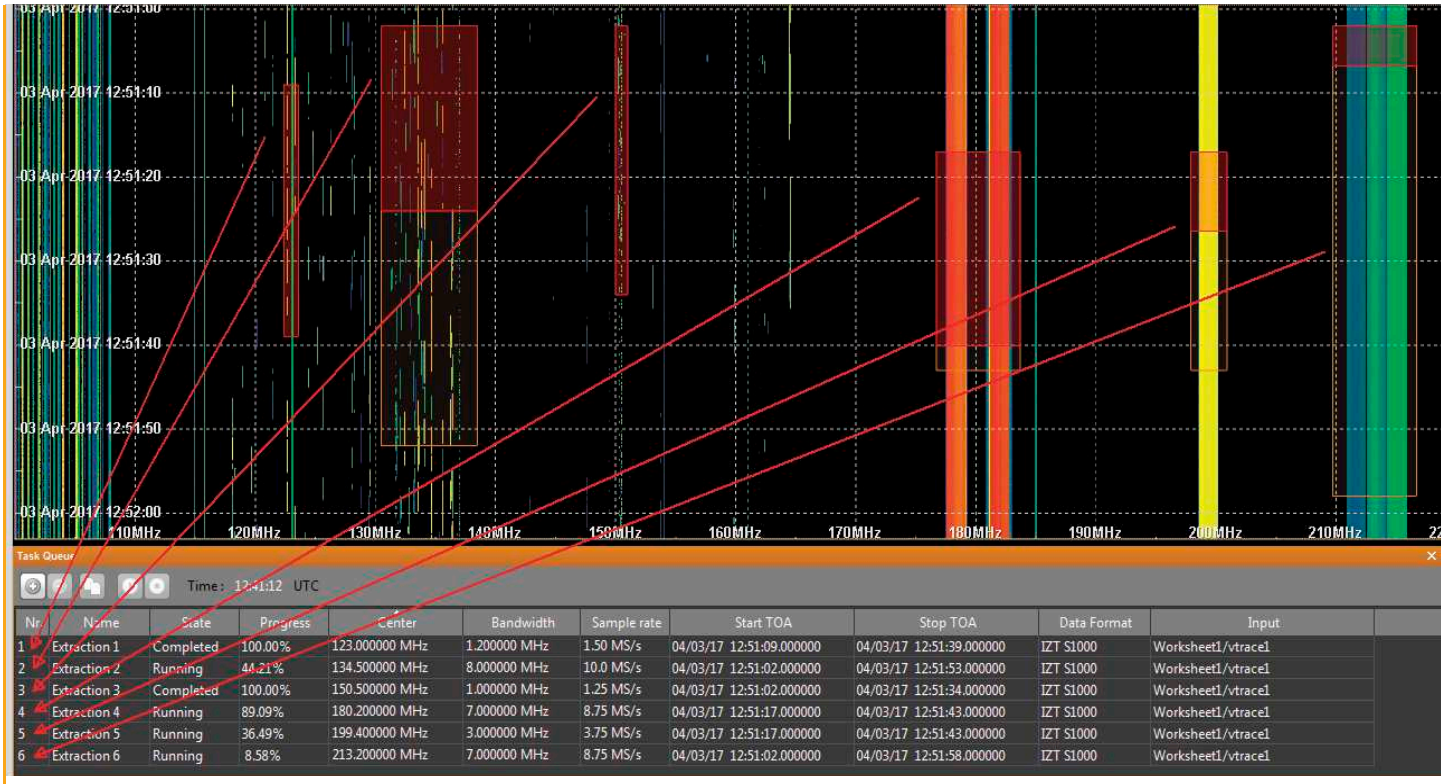


FIGURE 13: SPECTRUM PROCESSED FROM IQ-FILE WITH DYNAMIC METADATA (LEFT) AND FREQUENCY MARKERS (RIGHT) OF WIDEBAND RECORDING



Nr.	Name	State	Progress	Center	Bandwidth	Sample rate	Start TOA	Stop TOA	Data Format	Input
1	Extraction 1	Completed	100.00%	123.000000 MHz	1.200000 MHz	1.50 MS/s	04/03/17 12:51:09.000000	04/03/17 12:51:39.000000	IZT S1000	Worksheet1/vtrace1
2	Extraction 2	Running	44.21%	134.500000 MHz	8.000000 MHz	10.0 MS/s	04/03/17 12:51:02.000000	04/03/17 12:51:53.000000	IZT S1000	Worksheet1/vtrace1
3	Extraction 3	Completed	100.00%	150.500000 MHz	1.000000 MHz	1.25 MS/s	04/03/17 12:51:02.000000	04/03/17 12:51:34.000000	IZT S1000	Worksheet1/vtrace1
4	Extraction 4	Running	89.09%	180.200000 MHz	7.000000 MHz	8.75 MS/s	04/03/17 12:51:17.000000	04/03/17 12:51:43.000000	IZT S1000	Worksheet1/vtrace1
5	Extraction 5	Running	36.49%	199.400000 MHz	3.000000 MHz	3.75 MS/s	04/03/17 12:51:17.000000	04/03/17 12:51:43.000000	IZT S1000	Worksheet1/vtrace1
6	Extraction 6	Running	8.58%	213.200000 MHz	7.000000 MHz	8.75 MS/s	04/03/17 12:51:02.000000	04/03/17 12:51:58.000000	IZT S1000	Worksheet1/vtrace1

FIGURE 14: EXTRACTING MULTIPLE SIGNALS SIMULTANEOUSLY WITH INDIVIDUAL TIMELINE, BANDWIDTHS AND CENTER FREQUENCIES

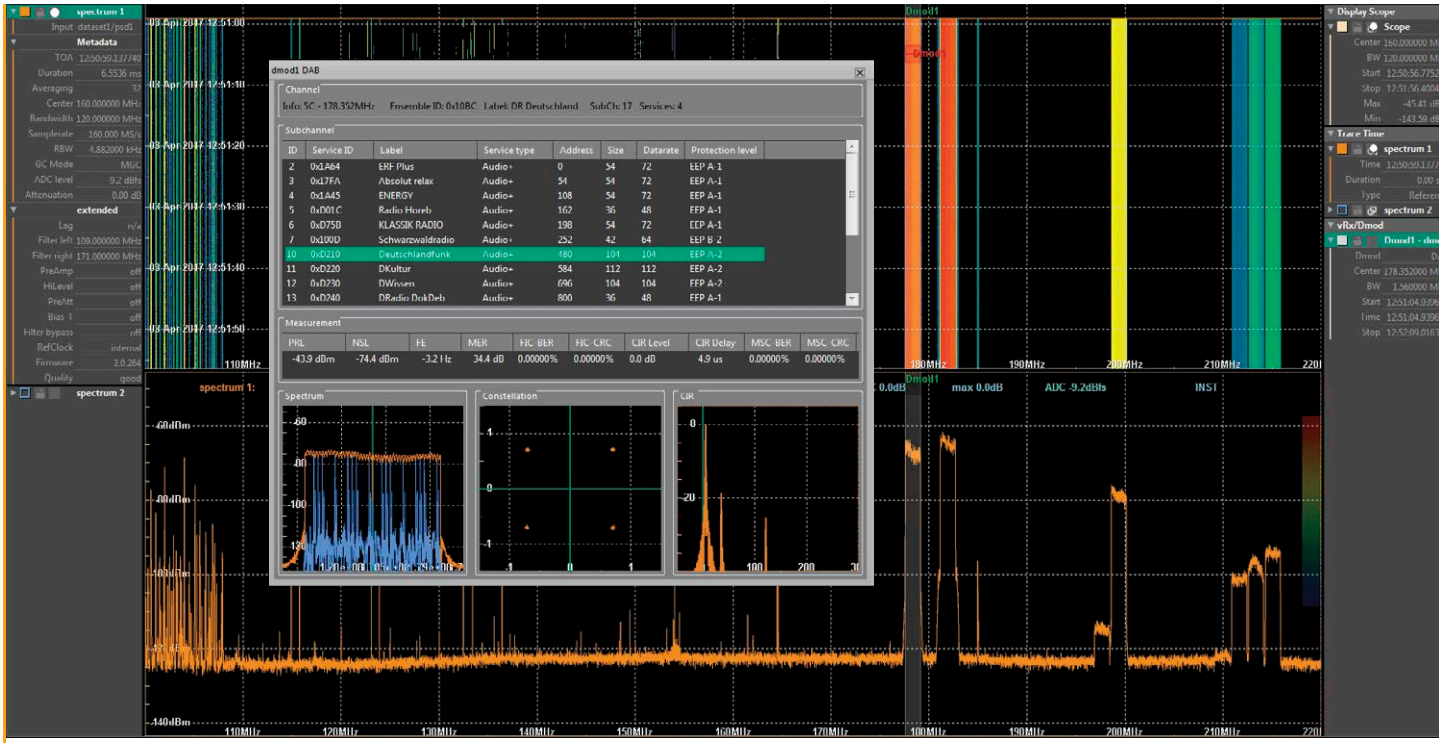


FIGURE 15: DAB SIGNAL DEMODULATION PROCESSED OFF-LINE ON A 120 MHZ WIDEBAND RECORDING MADE WITH IZT R4000 RF RECORDER

IZT SIGNAL SUITE – PLUG-INS

Mask Triggered Recording

Plug-in 'Mask Triggered Recording' allows capturing signals from the receiver or off-line from recordings with adjustable followup time. The trigger event can be defined by power limits exceeding spectrum masks (Figure 16), captured reference traces with adjustable offset, manually by pressing the recording button or by an external trigger pulse.

In combination with plug-in 'Pre-recording' the trigger can record signals with adjustable pre-recording time. This allows to capture RF content even before the trigger event has occured, for example to synchronize GNSS receivers to a replayed GPS signal with IZT S1000 / IZT S1010 Signal Generator by taking into account the lock time of the chip-set.

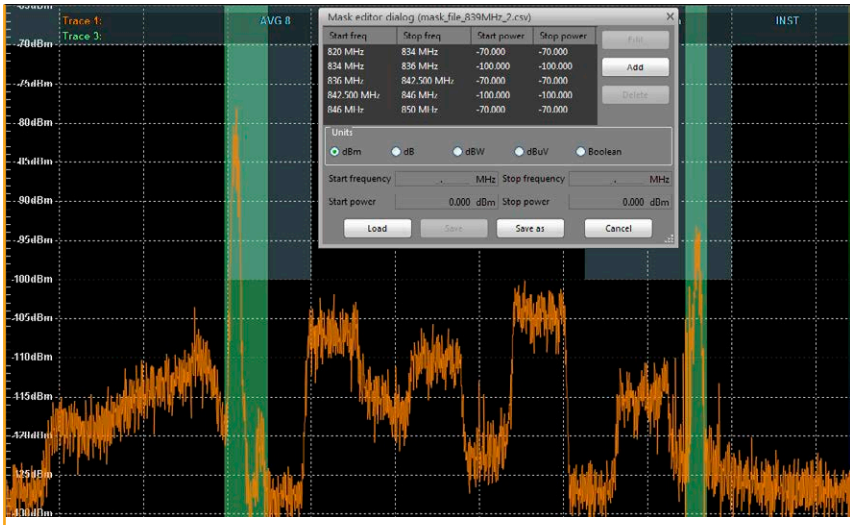


FIGURE 16: MASK TRIGGERED RECORDING

Panorama Scan

In frequency ranges beyond the real-time bandwidth of the recorder a continuous scanning functionality provides panorama spectrum or spectrogram display, including rapid frequency zoom. This 'Panorama Scan' functionality can also be combined with mask trigger and long-term spectrogram recording.

Long-term Spectrogram Recording

The standard spectrogram is fast enough to show several minutes of PSD data, but users working with long recordings may want an overview over hours (Figure 17), days or even weeks of data in one spectrogram.

The plug-in 'Long-term Spectrogram Recording' is able to show even these enormous amounts of data and update the display in seconds. By zooming within the spectrogram a user can drill down from a high level overview, showing one week of data on a single page, to a microsecond display, showing the maximum possible time resolution of the sensor. All this happens seamlessly, within the same display and with update times that are usually less than one or two seconds.

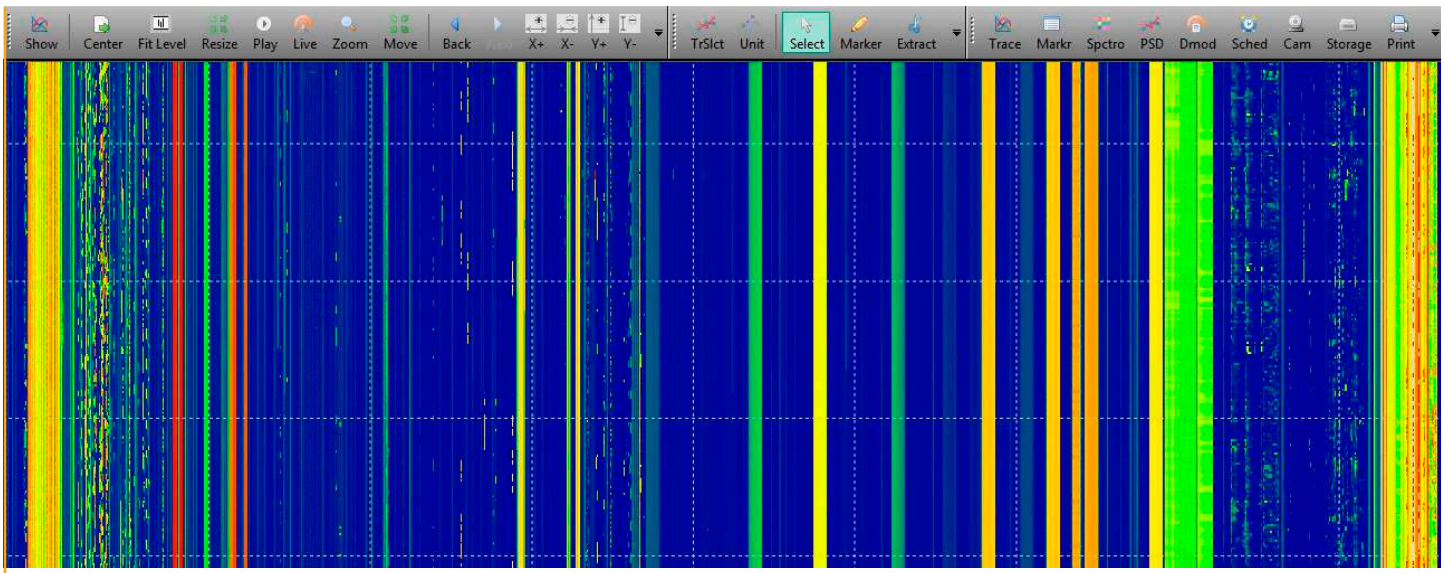


FIGURE 17: LONG-TERM SPECTRUM-BAND RECORDING IN PANORMA SCAN MODE.

Time Scheduled Recording

Plug-in 'Time Scheduled Recording' allows time scheduled planning of recording events (Figure 18).

- Time scheduled receiver configuration and recording
- Planned tasks are automatically stored and resumed
- Setup configuration can be selected easily by recalling stored project files
- Configuration of individual parameters such as centre frequency, real-time bandwidth, gain modes, recording name and recording group supported
- Supports multi-channel recording with several receivers and vRx/Dmod sub-bands
- Manual test run functionality allows schedule configuration checking
- Start/stop time and start/length time programming

Video Camera Interface

Plug-in 'Video Camera Interface' supports synchronous recording and replay of IP based video camera data streams with IZT Signal Suite RecPlay recorder (Figure 19) and off-line post-processing application IZT Signal Suite Data Processor. This allows capturing additional terrain information like traffic situation, building density, and weather conditions in addition to the GPS location information, which is implemented by design inside the IZT I/Q metadata data stream.

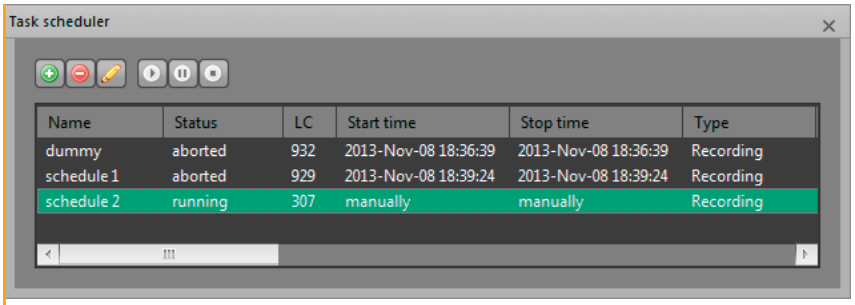


FIGURE 18: TIME TABLE SHOWING PLANNED RECORDING EVENTS INCLUDING STATUS INFORMATION

FIGURE 19: VIDEO CAPTURE WITH RF RECORDER

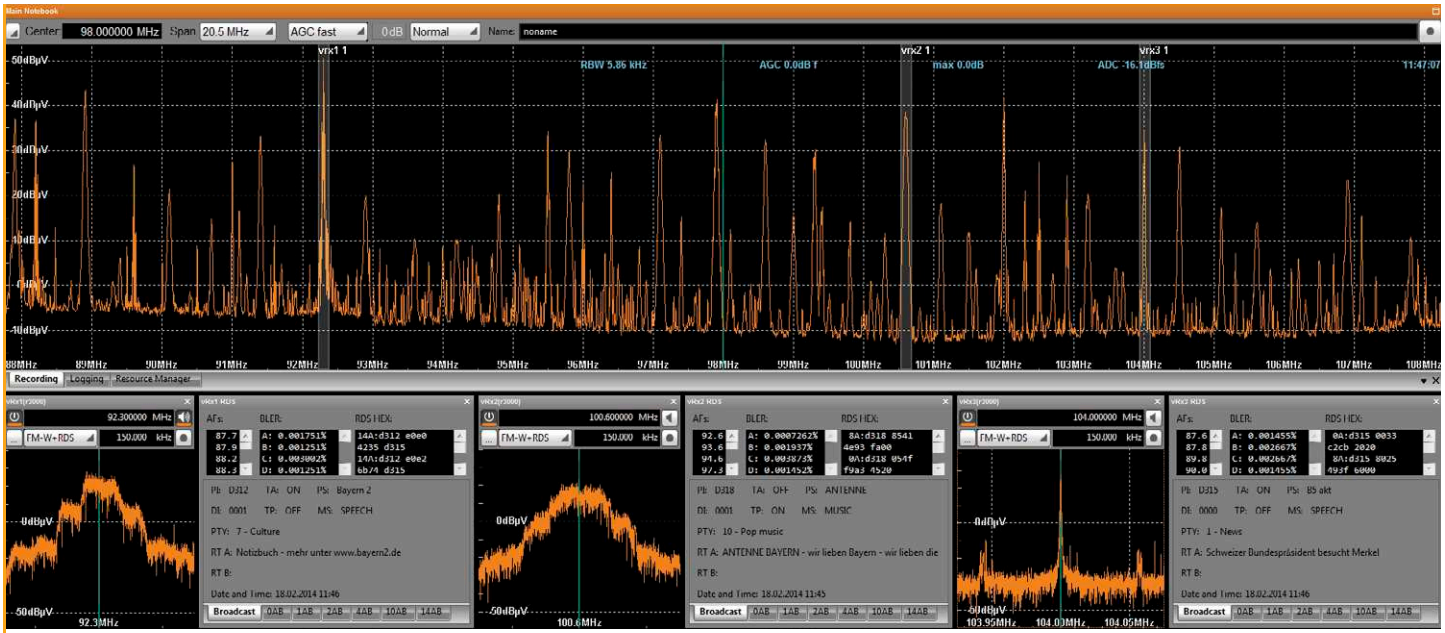


FIGURE 20: SIMULTANEOUS RDS DECODING OF THREE DIFFERENT FM BROADCAST STATIONS

RDS Decoding

Plug-in 'RDS Decoding' allows comfortable RDS decoding of FM broadcast stations with 'live' signals from the receiver (Figure 20) as well as extracting RDS information from file based I/Q data streams with post-processing application IZT Signal Suite Data Processor.

- RDS decoding of FM broadcast stations including enhanced RDS group information for all relevant information
- Decoding live signals with IZT recorder & IZT R4000 GUI
- Simultaneous multi-channel decoding due to IZT vRx/Dmod techniques
- File based I/Q data off-line decoding with IZT Data Processor
- Export of decoded RDS information into CSV table, binary and hex file

DAB/DAB+ Decoding

Plug-in 'DAB/DAB+ Decoding' enables comfortable DAB/DAB+ decoding of DAB broadcast stations with live signals from the receiver (Figure 21).

Using IZT's post-processing application IZT Signal Suite Data Processor, users can extract content and quality information from file-based I/Q data streams

- Spectrum (phase reference- & null symbol)
- Channel Impulse Response (CIR)
- Constellation diagram
- Level (phase reference- & null symbol)
- Frequency error
- Modulation Error Ratio (MER)
- Ensemble configuration
- FIC
- MSC (per sub-channel individually)
- Audio decoding

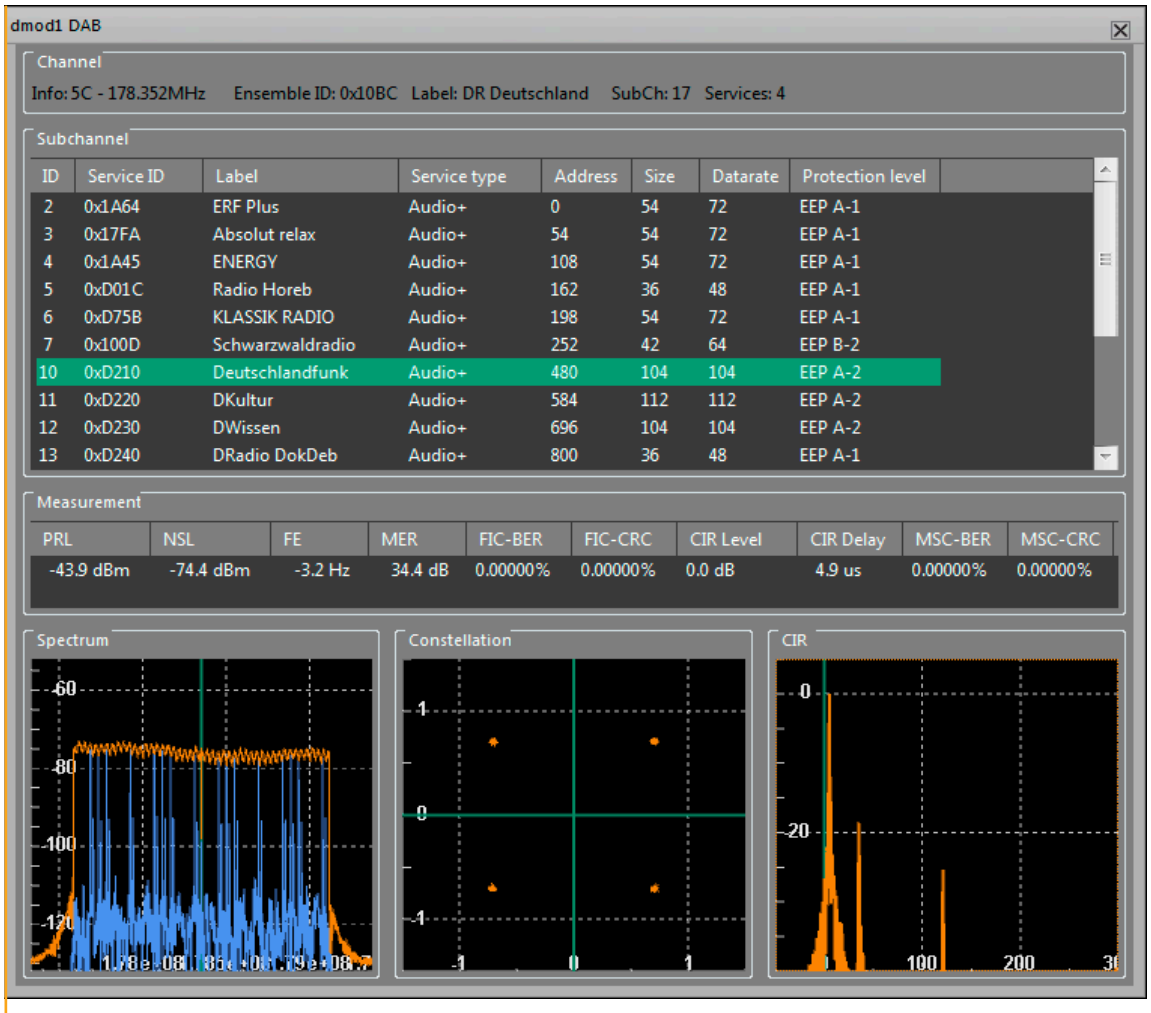


FIGURE 21: DAB/DAB+ ENSEMBLE WITH MEASUREMENT PARAMETERS

Persistence Display

Plug-in 'Persistence Display' is a special spectrum representation method which provides display views of signals varying over time by colorizing its number of occurrences. Parameters like measurement duration and colorization weighting can be adjusted instantaneously by the user. This functionality allows the identification of rarely emitted interferes inside known signal scenarios.

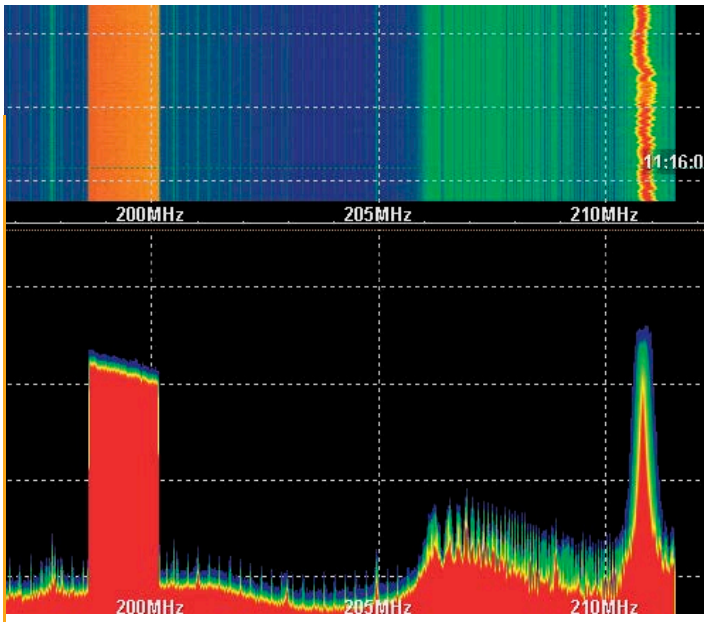


FIGURE 22: PERSISTENCE VIEW INDICATES THE NUMBER OF SIGNAL OCCURRENCES

FIGURE 23: EMBEDDED I/Q METADATA AND TAGGING INFORMATION

TESTVECTOR ARCHIVE

High-Capacity Storage Solution

Over time IZT RecPlay power users are collecting a ma ssive amount of captured signal data - especially when it comes to creating a test-vector archive, like needed for storing data of numerous test drives with different signal content or the high data rates of wide-band multi-channel or sub-band recorder setups. For this purpose IZT offers high-capacity high-performance storage solutions with fast data transfer capabilities via fiber optic 10 Gbit Ethernet. A typical setup starts with a net storage capacity of 54 TB in data protecting RAID-6 configuration. This basic setup can be enhanced easily in 8 steps to a full capacity of up to 486 TB.

If needed the high-capacity storage configuration can also be enhanced by a suitable optical switch to split several testvectors from the archive to multiple memory extensions of IZT S1000 / IZT S1010 replay setups.

Database

With an increasing number of recorded signals the need of finding signals with a certain content and properties out of a huge amount of data files arises. Therefore IZT Signal Suite Database provides easy finding of signal streams on huge storage drives of replay setups and high-capacity data archives by filtering key criteria like file properties, I/Q metadata and tagging information.

In addition to I/Q metadata such as center frequency, bandwidth and other receiver settings the operator can manually add tag information describing the recording setup and his intention about the content, as for example, operator name, location, single channel, diversity or multi-channel setup, signal content and purpose of the recording or test-drive.

Your Benefits

TECHNICAL BENEFITS

Continuous or triggered RF recording, long-term spectrum monitoring and diversity or multi-frequency setups are only some application examples, which combine high-quality RF-performance, state-of-the-art digital processing and flexible interfacing of IZT sensor technology. The modular concept provides different hardware options and software plug-ins to perfectly fulfil your needs.

FASTER TIME-TO-MARKET

Record your required test signals with the IZT R3301 or one of the other IZT recorder platforms, which are perfectly tailored to your application. Replay your individual recorded test signals in your lab and enable faster time-to-market instead of testing your application in open fields. This not only safes time, this also reduce your costs.

EXCELLENT RF PERFORMANCE

The IZT R3000 / IZT R4000 Receiver Family is a versatile high-performance wideband receiver system which combines state-of-the-art high-frequency technologies with the latest developments in digital signal processing thus providing one of the most comprehensive RF sensor platforms available today.

MAXIMUM FLEXIBILITY

Various model variants offer maximum flexibility for every application. The modular design of the IZT R3000 offers the possibility to customer-specific mechanical modifications. This ranges from simple additional antenna inputs over multiple receivers in one housing to complex modifications. Please contact IZT for further information.

COMPACT DESIGN

The portable design of the R3301 (Figure 25) enables a usage in different environments and an easy transportation to your application in open fields. If there are use cases which require even more robustness, the display-less rugged variant IZT R3302 will be the perfect choice.

FIGURE 24: IZT R3410 RF RECORDER SETUPP WITH SENSOR CONTROLLER IZT P1010

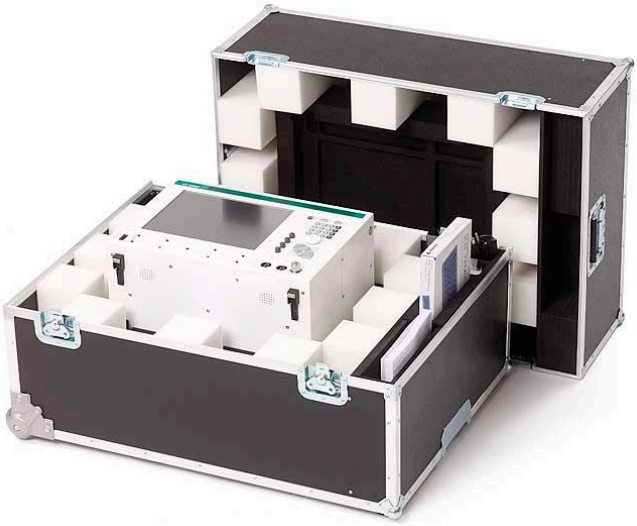


FIGURE 25: TRANSPORT CASE FOR THE IZT R3301

FIGURE 26: EXTERNAL GPS RECEIVER FOR NMEA LOCATION INFORMATION

Applications

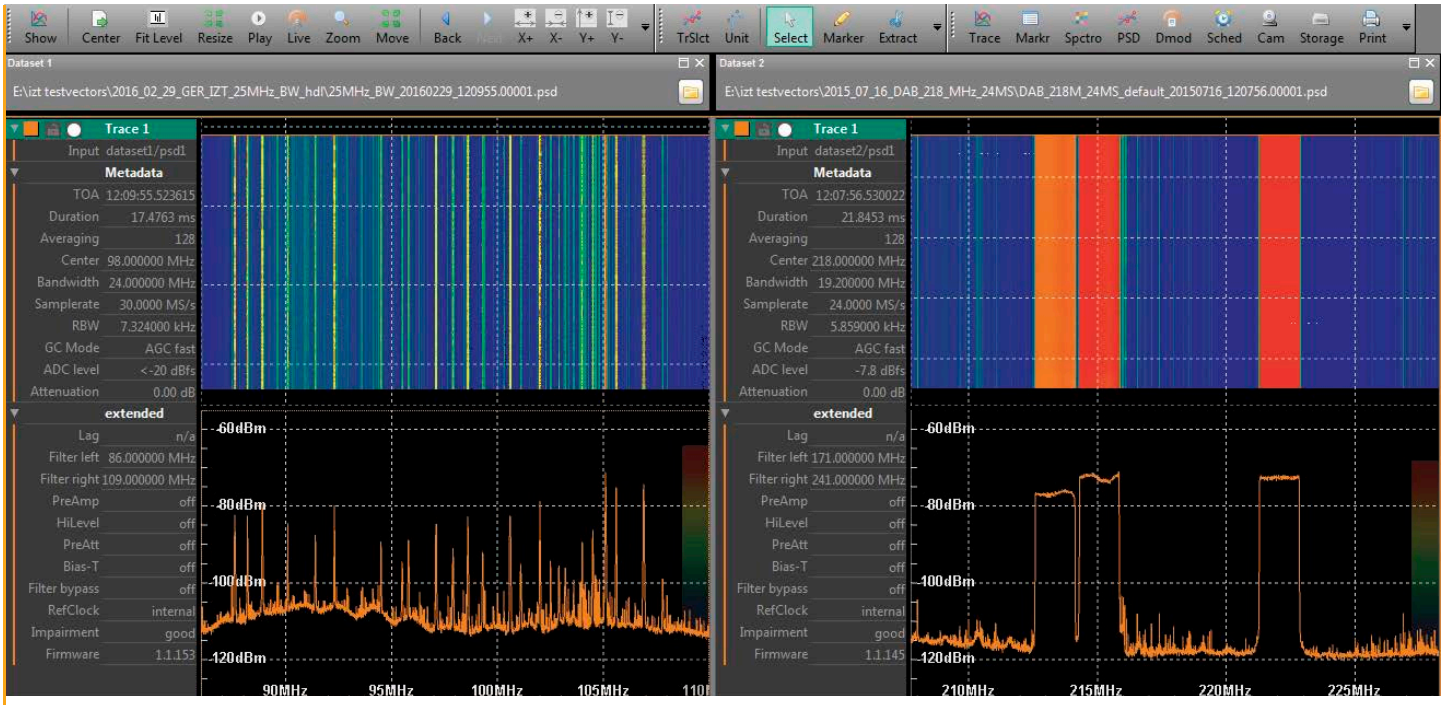


FIGURE 27: FM-DAB MULTI-FREQUENCY SCENARIO VISUALIZES TWO RECORDINGS WITH VIEWER OR DATA PROZESSOR

DIVERSITY SETUP

The system is ideal for handling phase coherent and frame synchronous recordings with multiple antennas at the same center frequency, for example for validation of FM broadcast diversity-tuners.

This challenging use case requires a very high accuracy in signal and data processing of the record and replay system.

MULTI-BAND SETUP

The system also fits perfectly into handling frame synchronous recording with multiple antenna channels at different center frequencies. This is an important use case for automotive customers for testing seamless DAB to FM linking in the field.

The setup allows also to record DAB and DVB or the GNSS satellite signal and any other service at the same time.

The diversity antenna setup and the multi-frequency antenna setup can be combined for covering both a phase coherent FM broadcast diversity and also frame synchronous DAB recording by using a IZT RecPlay setup consisting of three synchronized RF recorders, for example two IZT R3301 for FM broadcast and one IZT R4010 for covering the entire DAB band at once..

MONITORING AND INTERFERER CAPTURE

The system is a perfect platform for long-term spectrum band monitoring and automated selective high dynamic range I/Q data capture: trigger events caused by interferers, which have been defined by spectrum mask criteria are automatically starting the wide-band I/Q recording process of both the interferer itself and the GNSS services.

The recorded signals can be replayed with the IZT S1000 / IZT S1010 Signal Generator and fed to a reference receiver for evaluation. The file-based pre-recording ensures that this receiver will have sufficient time to acquire lock before the interference event. Recorded triggered signal events are automatially sorted in sub-folders together with captured video and GPS NMEA location information.

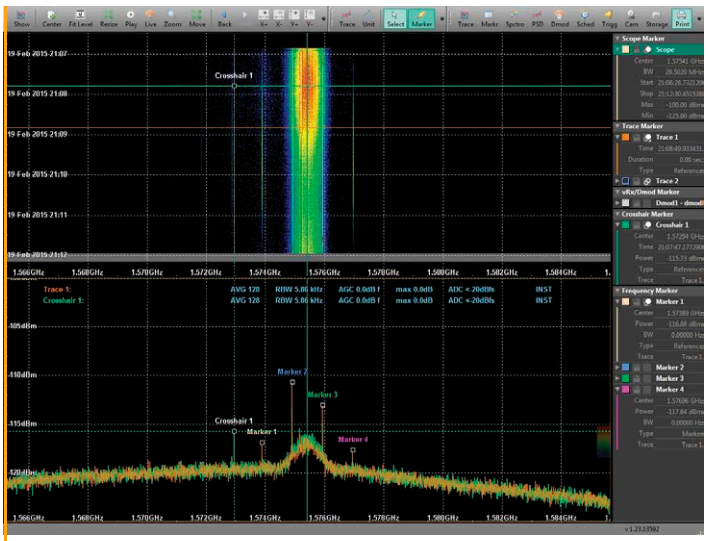


FIGURE 28: GPS MONITORING AND INTERFERER CAPTURE

Specifications IZT R3301 RF Recorder

Technical Specifications		
Frequency range	HF	9 kHz – 30 MHz [1]
	VUHF	20 MHz – 3 GHz [2]
Conversion concept	9 kHz – 30 MHz [1] (HF)	Direct sampling
	20 MHz – 3 GHz [2] (VUHF)	Double superheterodyne conversion
RF input	Impedance	50 Ohm
Maximum input power	HF	+20 dBm, +30 dBm with input attenuator active
	VUHF	+15 dBm
Tuning resolution	HF, VUHF	1Hz
VSWR	HF, VUHF	< 2.1
Tuning accuracy	HF, VUHF	< 0.2 Hz
Reference frequency	HF, VUHF	10 MHz internal/external
Internal reference frequency	HF, VUHF	$< 1 \cdot 10^{-7}$
Input sensitivity	HF: 100 kHz – 30 MHz	-120 dBm @ 3 kHz BW
	@ S/N = 10 dB	-111 dBm @ 25 kHz BW
	VUHF: 20 MHz – 3 GHz	-114 dBm @ 3 kHz BW
	@ S/N = 10 dB	-105 dBm @ 25 kHz BW
		-92 dBm @ 500 kHz BW
Oscillator phase noise	HF	-130 dBc/Hz typical @ 1 kHz offset
		-140 dBc/Hz typical @ 10 kHz offset
	VUHF	-120 dBc/Hz typical @ 10 kHz offset
Sweep time	HF, VUHF	< 3 ms typical
Scanning speed	HF, VUHF	> 4 GHz/s, linear
		> 175 GHz/s, within 25 MHz bandwidth
Input IP3	HF	+40 dBm, typical
	VUHF	+24 dBm, typical (low distortion mode)
		+13 dBm, typical (normal mode)
Noise figure	HF	9 dB typical
	VUHF	10 dB, typical (low noise mode)
		15 dB, typical (normal mode)
IF rejection	HF	not applicable
	VUHF	> 120 dB typical
Image rejection	HF	not applicable
	VUHF	> 110 dB typical
Oscillator reradiation at antenna input	HF	not applicable
	VUHF	< -110 dBm
Preselector	HF	12-band
	VUHF	11-band
IF bandwith	HF, VUHF	6.25 kHz – 24 MHz

[1] DEGRADED PERFORMANCE: 9 KHZ – 500 KHZ
[2] DEGRADED PERFORMANCE: 20 MHZ – 30 MHZ

Signal processing		
Data representation	Data format: 16/32 bit I/Q with embedded IZT CBB metadata information	
Output sample rate	variable up to 30 MS/s	
Data storage	4 x 2.5" SATA HDD or SSD, removable tray; 4 TB RAID system by default	
Recording modes	Stand-alone / diversity and multi-frequency (with second unit and Synchronisation Kit)	
Gain control	AGC fast/slow with adjustable ADC backoff and deadband, MGC	

Interfaces		
Antenna input	HF, VUHF	N, female, 50 Ω
Data storage system	SATA tray	4 x 2.5" HDD or SSD, 9.5 mm height, removable
Ethernet	1 Gbit Ethernet	RJ45, CAT 6
	10 Gbit Ethernet, optical	LC-Duplex , 10 Gbit fiber optical
USB	2 x USB 3.0	
GPS antenna	Input	SMA, female, 50 Ohm
	Active biasing	< 60 mA @ 3 V DC
Synchronization	Input	3 x SMA, female, 50 Ω (DCLK, 2 VUHF LO)
	Output	3 x SMA, female, 50 Ω (DCLK, 2 VUHF LO)
Trigger pulse	Input	SMA, female, CMOS 3.3 V (5 V tolerant input)
	Output	SMA, female, CMOS 3.3 V
Reference input	10 MHz	SMA, female, 50 Ω
Remote control	Proprietary Connector	D-SUB 9, female

General data	
Operating temperature	5°C to +40°C
Storage temperature	-20°C to +60°C
Humidity	Max. 85%, non-condensing
EMI / EMC	CISPR 22 / CISPR 25 (EN 55022 / EN 55025)
MTBF	> 70.000 hrs
Power supply	AC: 100 V – 240 V, 47 Hz – 63 Hz, 240 VA, DC: 10 V – 30 V, approx. 125 W
	UPS: Li-Ion, 99,9 Wh; approx. 20 min. recording, 25 min. measurement
Dimensions (WxHxD)	450 mm x 347 mm x 234 mm
Weight	Approx. 17 kg
Operating system	Windows 10 (64 bit)
Integrated hard disk	System disk SSD 250 GB
Internal memory	8 GB

Frequency Range Extension	IZT R3301-RF6	IZT R3301-RF18
Frequency range	3 GHz – 6 GHz	3 GHz – 18 GHz
RF input	50 Ohm [3)]	50 Ohm
Maximum input power	+15 dBm	+10 dBm
VSWR	< 2.1	< 2.1
Oscillator phase noise	-120 dBc/Hz typical @ 10 kHz offset	-114 dBc/Hz typical @ 10 kHz offset
Sweep time	< 3 ms typical	10 ms
Scanning speed	> 4 GHz/s, linear	> 1.5 GHz/s, linear
	> 175 GHz/s, within 25 MHz bandwidth	> 175 GHz/s, within 25 MHz bandwidth
Input IP3	+18 dBm (normal mode)	+25 dBm (low distortion mode)
	+2 dBm (low noise mode)	+15 dBm typical (low noise mode)
Noise figure	7 dB, typical (low noise mode, LNA on, maximum gain)	15 dB typical (low noise mode)
	17 dB, typical (normal mode, LNA off, maximum gain)	23 dB, typical (normal mode, LNA off, maximum gain)
IF rejection	> 120 dB typical	> 120 dB typical
Image rejection	> 110 dB typical	> 110 dB typical
Oscillator reradiation	< -110 dBm	< -110 dBm
Preselector filter	8-band	Tracking bandpass filter

[3)] THE RECEIVER'S VUHF ANTENNA INPUT IS USED, ELECTRONIC RF INPUT SWITCH. SPECIFICATION SUBJECT TO CHANGE WITHOUT FURTHER NOTICE.

Specifications IZT S1000 / IZT S1010 Signal Generator

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

Signal generation		
Integrated hard disk	Size	500 GB
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	12/16 bit I/Q
	Input sample rate	Variable, up to 40 MS/s

General data		IZT S1000	IZT S1010
Power supply, nominal values	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) – 0.6 A (240 V)	2 A (100 V) – 0.85 A (240 V)
EMC		Meets EN 55022, classB QP, AV	Meets EN 55022, classB QP, AV
		FCC 47 CFR Part 15, Subpart B, Class B	FCC 47 CFR Part 15, Subpart B, Class B
Environmental conditions	Operating temperature	0 °C to +55 °C	0 °C to +50 °C
	Storage temperature	-40 °C to +70 °C	-40 °C to +70 °C
Dimensions (WxHxD)	Without angles	446 mm x 88 mm (2 RU) x 570 mm	452 mm x 141 mm (2 RU) x 569 mm
	With angles	482 mm x 88 mm (2 RU) x 595 mm	482 mm x 141 mm (2 RU) x 594 mm
Weight		12 kg (including keyboard)	16 kg (including keyboard)

Specifications IZT S1000 Memory Extension

System specification	IZT S1000 Memory Extension	IZT S1000 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
LAN	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)	2 x USB 2.0 (front)
	4 x USB 2.0 (back)	4 x USB 2.0 (back)
	2 x USB 3.0 (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)	2 x Display Port (up to 4096 x 2304)
	1 x HDMI (up to 1920 x 1080)	1 x DVI-D (up to 2560 x 1600)
	1 x DVI-D (up to 1920 x 1080)	
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 (WxHxD)	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

Environmental specifications	
Operating temperature	0°C to +50°C
Storage temperature	-40°C to +70°C
Operating humidity	5% – 95% non-condensing
Storage humidity	5% – 99% non-condensing
Maximum operating altitude	2000 m

Ordering Guide

IZT RF Recorder Hardware options		
IZT R3301 / IZT R3302	**IZT R3301-CHS**	Receiver Chassis with built-in Sensor Controller
	IZT R3301-SNC	Synchronization Kit for synchronizing two IZT R3301 recording units
	IZT R3301-TCS	Transport Case for shipping with trolley function
	IZT R3302-CHS	Receiver Chassis IP54 with built-in Sensor Controller
	IZT R3302-TCS	Transport Case for shipping with trolley function
	IZT R3302-ESI	External Synchronization Interfaces including trigger function
	IZT R3302-MDM	Interface for cellular remote access via built-in cellular modem and external antenna connector (IP54)
	IZT R3302-WIM	Interface for WIFI remote access via built-in module and external antenna connector (IP54)
	IZT R3302-WIU	Interface for WIFI remote access via external USB connector
	IZT R3300-SDD	Solid State Data Disk 1 TB SSD, up to 4x for IZT R3301/R3302
	IZT R3300-GSR	GPS Synchronous Reference Clock
	IZT R3000-HF	HF Frontend frequency range 9 kHz – 30 MHz
	IZT R3000-RF3	VUHF Frontend frequency range 20 MHz – 3 GHz
	IZT R3000-RF6	Frequency Range Extension 3 GHz – 6 GHz for VUHF Frontend
	IZT R3000-RF18	Frequency Range Extension 3 GHz – 18 GHz for VUHF Frontend
	IZT R3000-OCX	Oven Stabilized Reference Oscillator
	IZT R3000-BST	Bias-T [1]
	IZT R3000-AAI-RF5	3x3 Antenna Switch (one of up to three RF inputs is switched electronically to one of the built-in RF front-ends by software)
IZT R3410 / IZT R3411	**IZT R3410-CHS**	Ruggedized Receiver Chassis
	IZT R3410-DCW	Wide DC Input (7.5 V – 30 V)
	IZT R3411-CHS	Ruggedized Receiver Chassis [2]
	IZT R3000-HF	HF Frontend frequency range 9 kHz – 30 MHz
	IZT R3000-RF3	VUHF Frontend frequency range 20 MHz – 3 GHz
	IZT R3000-RF6	Frequency Range Extension 3 GHz – 6 GHz for VUHF Frontend
	IZT R3000-RF18	Frequency Range Extension 3 GHz – 18 GHz for VUHF Frontend
	IZT R3000-OCX	Oven Stabilized Reference Oscillator
	IZT R3000-TRIG	Trigger
	IZT R3000-BST	Bias-T [1]
	IZT R3000-AAI-RF5	3x3 Antenna Switch (one of up to three RF inputs is switched electronically to one of the built-in RF front-ends by software)
	IZT P1010	Portable Sensor Controller notebook selected and configured for running IZT Signal Suite for IQ recording of up to 30 MS/s, including 1TB SSD data storage, SD-Card Dongle and 2nd Ethernet interface via USB adapter; Win10 (EN)

[1] CAN NOT BE COMBINED WITH OPTION R3000 AAI-RF5
[2] MODEL IZT R3411 CAN BE EQUIPPED ONLY WITH FRONTEND R3000-HF OR R3000-RF3; OPTION R3000-RF6 AND R3000-RF18 NOT AVAILABLE FOR MODEL IZT R3411

IZT R4000 / IZT R4010	**IZT R4000-CHS**	Wideband Receiver Chassis 120 MHz receiver base configuration (19”/3U) with 32k real-time RMS power calculation and PSD with adjustable averaging, including external high-performance Sensor Controller & data storage configuration IZT P2500 (19”/2U) with 10 Gbit optical Ethernet interface and 5h storage capacity at full 120 MHz recording bandwidth
	IZT R4010-CHS	Wideband Receiver Chassis with built-in Sensor Controller 120 MHz receiver base configuration (19”/3U) with 32k real-time RMS power calculation and PSD with adjustable averaging, including built-in Sensor Controller with touch display and GPS receiver (can be enhanced either with built-in data storage configuration or with external high-performance Sensor controller and data storage solution)
	IZT 4010-TCS	Transport Case for shipping with trolley function
	IZT R4010-SDD	Storage Configuration 4x 2.5” tray, including 4x 1TB SSD
	IZT R4010-10G	Additional 10 Gbit Optical Ethernet Interface for data transfer to external components
	IZT R4010-DCW	Wide-range DC Power Supply (11 V – 30 V) instead of AC supply
	IZT R4000-HVHF	HVHF Frontend frequency range 9 kHz – 140 MHz direct sampling with electronically configurable preselector filters
	IZT R4000-RF3W	VUHF Frontend (120 MHz filter) frequency range 108 MHz – 3 GHz
	IZT R4000-RF6	Frequency Range Extension 3 GHz – 6 GHz for VUHF Frontend
	IZT R4000-RF18	Frequency Range Extension 3 GHz – 18 GHz for VUHF Frontend
	IZT P2500	High-performance Sensor Controller (19”/2 RU) with 10 Gbit Optical Ethernet Interface and 16 TB storage capacity (for 5h storage capacity at full 120MHz recording bandwidth in combination with IZT R4010)
IZT A1000 External accessories	**IZT A1000-CAM**	IP Camera Kit (requires IZT SignalSuite-274)
	IZT A1000-GPS	External GPS Receiver for NMEA location information
	IZT A1000-RTS	External Reference Time Source (19”/1 RU) for 10MHz, 1PPS, NTP and GPS NMEA output

IZT RF Recorder Software options		
Applications	**IZT SignalSuite-800**	GUI Base R3000
	IZT SignalSuite-810	RF Recorder R3000 – 25 MHz
	IZT SignalSuite-812	RF Recorder R4000 – 120 MHz
	IZT SignalSuite-812b	RF Recorder R4000 – 80 MHz
	IZT SignalSuite-812c	RF Recorder R4000 – 60 MHz
	IZT SignalSuite-812d	RF Recorder R4000 – 40 MHz
	IZT SignalSuite-820	Viewer
	IZT SignalSuite-830	Data Processor
Enhanced software options	**IZT SignalSuite-130**	Panorama Scan
	IZT SignalSuite-190	COM-SDK
	IZT SignalSuite-220	Time Scheduled Recording
	IZT SignalSuite-230	Long-term Spectrogram Recording
	IZT SignalSuite-240	Mask Triggered Recording
	IZT SignalSuite-242	Pre-recording
	IZT SignalSuite 250	Persistence Display
	IZT SignalSuite-260	Signal Import/Export
	IZT SignalSuite-262	Signal Extraction
	IZT SignalSuite-270	GPS Interface
	IZT SignalSuite-274	Video Camera Interface
	IZT SignalSuite-300	Automatic Frequency SelectiveRecording [3)]
	IZT SignalSuite-310	Time Shift Signal Access
	IZT SignalSuite-510	Sensor Synchronization
	IZT SignalSuite-520	Communication Interface
Analysis & demodulator plug-ins	**IZT SignalSuite-600**	RDS Demodulator
	IZT SignalSuite-610	DAB/DAB+ Demodulator
	IZT SignalSuite-612	DAB ETI/EDI Interface
	IZT SignalSuite-630	CellularBase Analysis – bundle (GSM/UMTS/LTE)
	IZT SignalSuite-650	Signal Segmentation
	IZT SignalSuite-660	Modulation Analyzer
License Management	**IZT A1000-CMB**	Metal Case USB Dongle for using IZT Signal Suite options on Win7 or Win10 based systems
	IZT A1000-CMC	Compact Robust USB Dongle for using IZT Signal Suite options on Win7 or Win10 based systems
	IZT A1000-CMD	SD Card Dongle for using IZT Signal Suite options on Win7 or Win10 based systems

[3)] CAN ONLY BE COMBINED WITH RF RECORDER R4000

IZT Signal Generator Hardware options*		
IZT S1000	**IZT S1000-CHS**	Chassis and all digital hardware
	IZT S1000 Memory Extension	Streaming Server (monitor and keyboard/mouse included)
	IZT S1000 Memory Extension+	Diversity & Data Processing Server (monitor and keyboard/mouse included)
IZT S1010	**IZT S1010-CHS**	Chassis and all digital hardware
	IZT S1010-SDD	Solid State Data Disk for IZT S1010-CHS3
	IZT S1010-10G	10 Gbit Option
	IZT S1010-TCS	Transport Case for packaging
IZT S1000 / IZT S1010	**IZT S1000-RF3**	RF Output 9 kHz – 3 GHz
	IZT S1000-RFS3	RF Synthesizer 3 GHz
	IZT S1000-RF6	RF Output 9 kHz – 6 GHz
	IZT S1000-RFS6	RF Synthesizer 6 GHz
	IZT S1000-8GB	8 GB High-speed Memory (increases the internal memory from 4 GB – 8 GB)

IZT Signal Generator Software options*		
IZT S1000 / IZT S1010	**IZT S1000-GUI**	Graphical User Interface
	IZT S1000-110	One Virtual Signal Generator VSG (up to 31 VSGs are possible)
	IZT S1000-120	Streaming Input (high-speed LAN streaming, 2 Gbit ports for streaming data)
	IZT S1000-412	GPS Output
	IZT S1000-413	Spectrum Display
	IZT S1000-414	Video Playback
	IZT S1000-500	WBS (wideband streaming) GUI
	IZT S1000-520	WBS (wideband streaming) from optical 10G LAN

IZT Service		
	IZT WE2	Warranty Extension to 2 years
	IZT WE3	Warranty Extension to 3 years
	IZT Software Support Contract	Support for IZT software options
	IZT Training	IZT Training Course
	IZT R3000-CLC	Factory Calibration
	IZT R3000-CAL	Accredited ISO Calibration
	IZT R4000-CLC	Factory Calibration
	IZT R4000-CAL	Accredited ISO Calibration
	IZT S1000-CLC	Factory Calibration
	IZT S1000-CAL	Accredited ISO Calibration

* FOR FURTHER HARDWARE AND SOFTWARE OPTIONS PLEASE CONSIDER THE IZT S1000 BROCHURE WITH ORDERING GUIDE OR CONTACT OUR SALES TEAM

IZT RecPlay

The ultimate Record & Replay System for RF signals

STUMPF.POOL-X.DE REV.5.0 02/2019

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.

INNOVATIONSZENTRUM FÜR TELEKOMMUNIKATIONSTECHNIK GMBH IZT AM WEICHSELGARTEN 5 · 91058 ERLANGEN, GERMANY
GENERAL MANAGER: RAINER PERTHOLD · TEL: +49 (0)9131 9162-0 · FAX: -190 · SALES@IZT-LABS.DE · WWW.IZT-LABS.DE

Innovationszentrum
Telekommunikationstechnik