IZT R4000

The next Generation of digital Wideband Receivers

- Digitizer
- Wideband Receiver and Recorder
- Signal Collection System

Innovationszentrum Telekommunikations-technik GmbH

IZT R4000
Digital Wideband Receiver

The IZT R4000 is a unique and novel concept for a radio frequency receiving system. It is perfectly adapted to the needs of modern COMINT and ELINT systems, wideband satellite surveillance and continuous broadband radio signal recording.
It features an instantaneous real-time bandwidth of 120 MHz and covers the frequency range up to 18 GHz.
Three independent digital processing paths provide PSD and I/Q data. Its architecture is ideal for distributed post-processing of the received signals by multiple workstations.
A smart buffering concept and storage of all received signals makes sure that every bit of information received from the air can be provided for post processing.
The powerful signal processing of the IZT R4000 is combined with adequate RF frontend technology designed to meet customer demands for excellent dynamic range even in high-bandwidth applications.
The IZT R4000 digitizes signals up to 140 MHz directly without additional frequency conversion resulting in an exceptional dynamic range. For higher-frequency applications the input frequency range can be extended to 3 GHz, 6 GHz or 18 GHz, using the VUHF or SHF frontends.
The IZT R4000 includes highly-selective configurable signal pre-selectors to avoid signal overload problems, high-quality RF front-ends, and broadband digitizers. On the backend, the IZT R4000 supports multiple users with signal processing, a storage system, and multiple parallel virtual receiver interfaces.

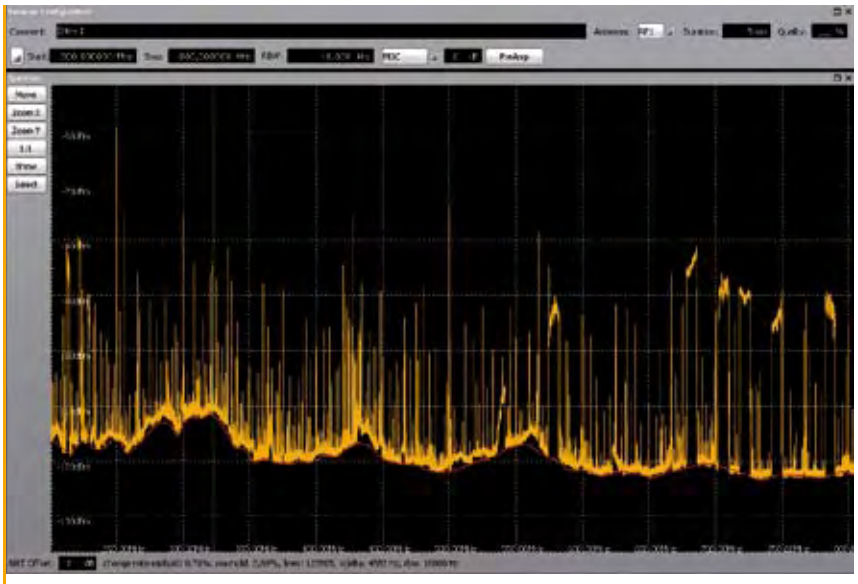

figure 1: 120 MHz input spectrum

Overview

The IZT R4000 is a high performance digital receiver with an instantaneous bandwidth of 120 MHz.

The IZT R4000 is available with different front-ends ranging from 9 kHz up to 3 GHz, 6 GHz or 18 GHz or alternatively with an IF interface only. But the revolution is not the exceptional frontend performance it is the powerful signal processing with unique features.

The patented digital signal processing provides two independent spectra data streams and multichannel I/Q data streams with variable bandwidths in order to allow the use of the IZT R4000 wideband receiver in a multitude of applications:

- Spectrum Monitoring
- Signal Collection System
- Wideband Data Recorder
- Direction Finder
- Waveform Digitizer
- Real Time Signal Analyzer

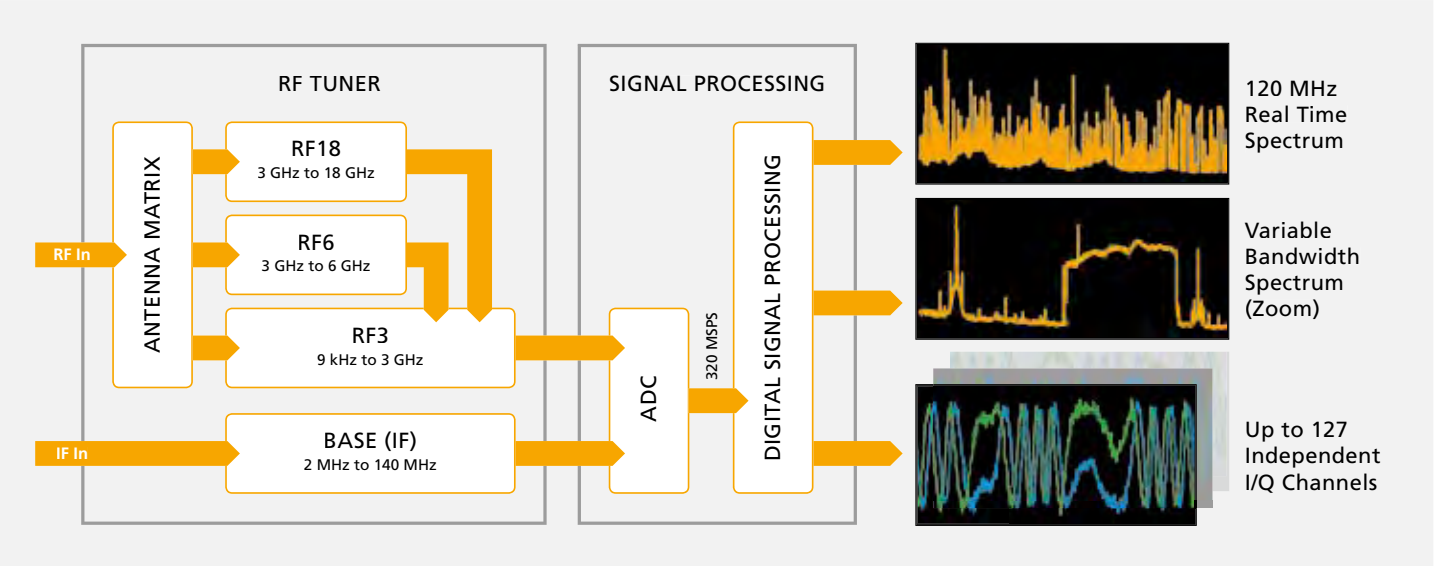

figure 2: System overview

High Performance Spectrum

The IZT R4000 independently calculates two spectra of the input signal.

The broadband spectrum always covers the full receiver bandwidth of 120 MHz continuously.
Using a 4096-point FFT, the time resolution of the spectrum can be as fast as 25.6 us per spectrum. This is orders of magnitude faster than swept analysis techniques and meets the demand for systems being able to capture today's hopping, transient signals.
A number of detectors such as RMS, max and min can simultaneously be used to ensure that short burst signals are identified.
The broadband spectrum is provided to the user and can also be used internally by the system for assessing signal activity in the received frequency band. I/Q data channel extraction can then be automatically triggered on the frequencies of interest.

The IZT R4000 offers a second fast and high resolution spectrum with a configurable window for detailed analysis. Its span, center frequency and resolution bandwidth functions are adjustable. Different detectors and configurable averaging settings are also provided.
By choosing between different window functions the user can trade frequency resolution against amplitude accuracy.

Real Time Bandwidth	Frequency Resolution (approx.)	Time Resolution (approx.)
120 MHz	39 kHz	25.6 µs
60 MHz	19.5 kHz	51.2 µs
30 MHz	9.8 kHz	102 µs
15 MHz	4.9 kHz	205 µs
7.5 MHz	2.4 kHz	410 µs
3.75 MHz	1.2 kHz	820 µs
1.875 MHz	600 Hz	1.6 ms
1 MHz	300 Hz	3.2 ms
500 kHz	150 Hz	6.5 ms
250 kHz	75 Hz	13 ms
125 kHz	38 Hz	26 ms
60 kHz	19 Hz	52 ms
30 kHz	10 Hz	105 ms
15 kHz	5 Hz	210 ms
7.5 kHz	2.5 Hz	420 ms
3.75 kHz	1.2 Hz	840 ms

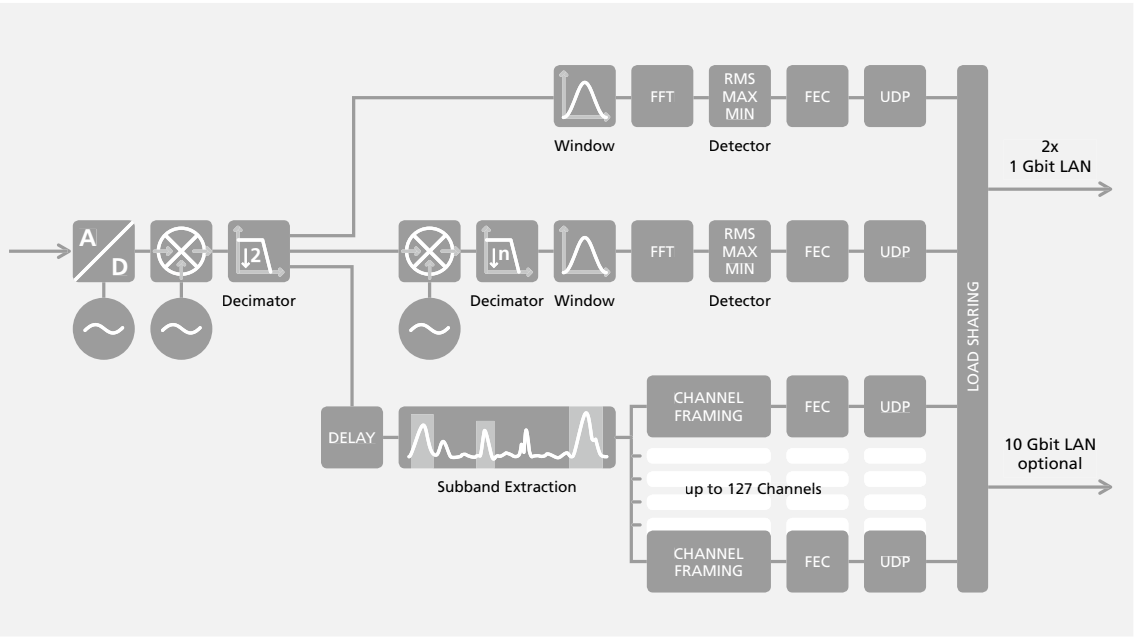

figure 3: Block diagram of R4000 signal processing

Multichannel I/Q

Sub-band Extraction

The IZT R4000 can extract sub-bands containing I/Q data from the receivers input bandwidth of 120 MHz. The IZT R4000 can handle as many as 127 sub-bands, which is more than sufficient for the instantaneous receiver bandwidth. The bandwidth of each sub-band is user-adjustable.
Each of the sub-channels can then be sent via LAN to client PCs for further analysis. It is possible to send all sub-channels to one single client but it is also possible to send every sub-band to individual clients.

An internal data memory within the IZT R4000 allows to buffer of up to four seconds of I/Q data at the receiver's full bandwidth of 120 MHz.
This allows the user to analyze the spectrum data for interesting signals and once detected it is possible to retrieve the respective sub-band from history without missing the beginning of the transmission.

With a timing resolution of less than 20 microseconds the sub-band extraction is fast enough to track fast frequency hopping systems. The bandwidth of the sub-bands ranges from 1 MHz to 120 MHz.

Further bandwidth reduction and the extraction of narrowband signals from sub-bands is performed at the PC client.

Single-band Extraction

The most basic method is to extract only one frequency band at a fixed center frequency. This results in one single broadband I/Q data stream as often used in test and measurement applications as for example wideband recorders.
The maximum bandwidth for one single channel is dependent on the type of LAN interface.

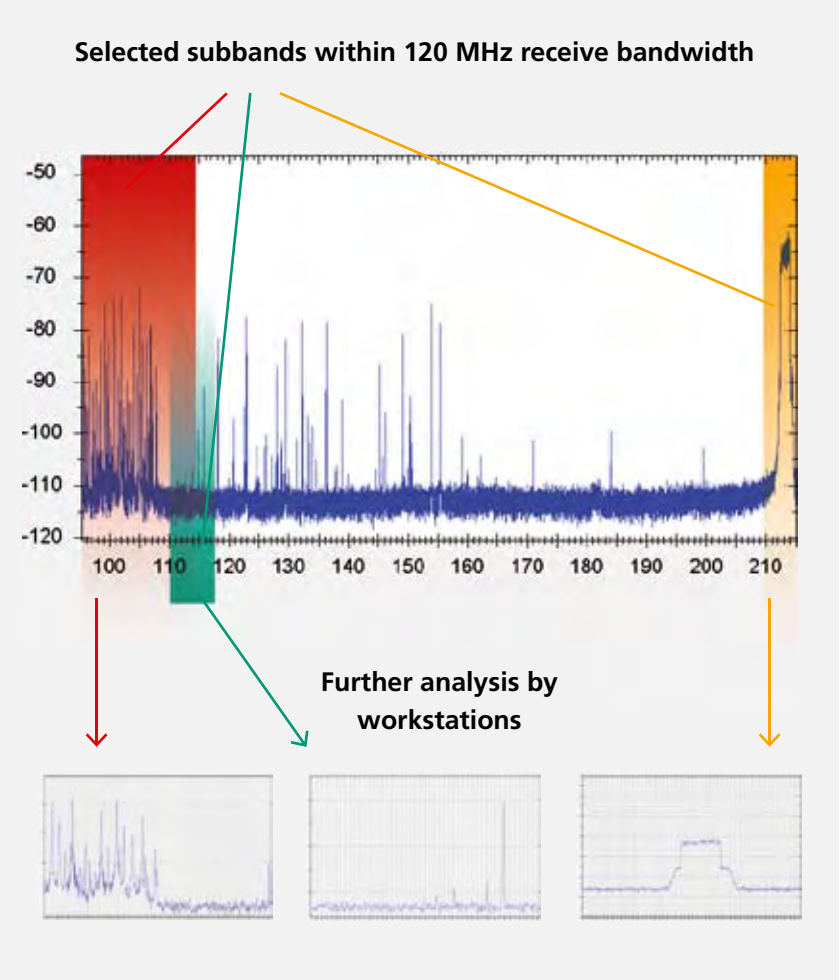

figure 4: Sub-band extraction

Interface Type	I/Q Bandwidth
1 GBit LAN	~ 30 MHz
2x 1 GBit LAN	~ 60 MHz
10 GBit LAN	> 120 MHz

Capture

All signals within the 120 MHz acquisition bandwidth are recorded in the IZT R4000 internal memory. This allows full bandwidth snapshots in environments where only 1GBit LAN is available.

Distributed Clients

One distinctive feature is the concept of using the IZT R4000 in multi client applications.
The IZT R4000 can deal with multiple clients at the same time, which can be the workstations of individual operators or a cluster of computers automatically scanning available signals for useful information. Each of the extracted sub-bands can be sent to individual clients. All clients can also configure their active sub-bands dynamically.

For more information please read the application example in this document.

Synchronization

The IZT R4000 features a high stability internal reference clock. The receiver can also be synchronized to an external 10 MHz reference source.
Signal processing and all RF local oscillators are fully synchronous and can be locked to an external standard (e.g. GPS). A trigger pulse or 1 PPS signal can be used to synchronize multiple receivers with sample accuracy.

For phase coherent synchronization of multiple receivers it is possible to provide common local oscillator and clock signals.

Bandwidth Extension

The system architecture is easily scalable by adding more receivers.
The basic bandwidth extension would only require the supply of a synchronization pulse like a 1PPS signal and a 10 MHz reference to all receivers. The receivers could then provide adjacent spectra each up to 120 MHz wide.
For phase coherence between the receivers it is possible to supply an additional synchronization unit which provides phase locked LO signals for up to seven IZT R4000 units. A patented method allows reconstructing I/Q signals with a realtime bandwidth of up to 700 MHz.

Data and Control Interfaces

All digital signal and control data is transmitted and received via Gigabit Ethernet LAN. This allows fast, simple and cost efficient integration of the IZT R4000 into IT environment.
In standard configuration the data is sent to a PC client via two Gigabit LANs. This interface can be complemented with a 10 GBit LAN.
The data streams are transmitted via UDP to a single or multiple clients.

IF-Interface

The IZT R4000 comes with an IF-Interface enabling customers to use the receiver without integrated frontends at IF frequencies.The frequency range of the IF-interface is 2 MHz to 140 MHz and includes gain stages and necessary anti-aliasing filters.

RF Frontends

The combination of extensive preselection capabilities and exceptional digitization quality makes the IZT R4000 the perfect tool for signal intercept and monitoring.

IZT R4000-RF3

The IZT R4000 digitizes signals up to 140 MHz directly without additional frequency conversion. This results in an exceptional dynamic range. In order to manage the challenging and large VHF band signal environment, the IZT R4000 features a uniquely configurable, highly linear and highly selective preselector. Low- and highpass filters spaced in a ratio of 1:1.26 are available to the user. This allows the user to limit the amount of incoming signal energy and provide very effective protection against unwanted IP2 products. The user can freely cascade one of 16 high- and 16 lowpass filters. Figure 5 shows the filter curves (green: highpass, blue: lowpass) with the red curve indicating a selected filter combination.
The frequency range from 140 MHz to 3000 MHz is covered by a highly linear tuner.

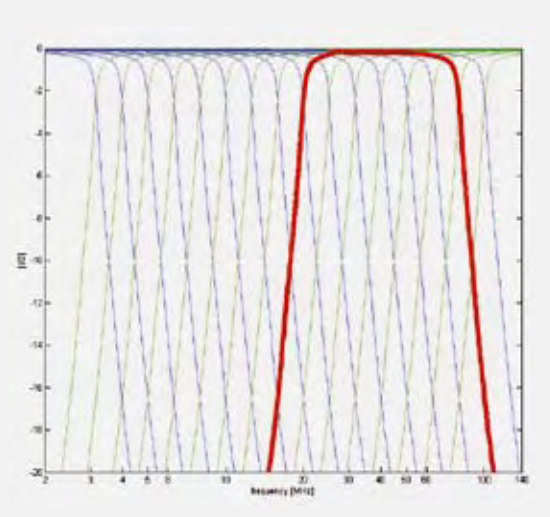

figure 5: Shown in red: selected low- and highpass combination

IZT R4000-RF6

The option R4000-RF6 covers the frequency range from 3 GHz to 6 GHz with high performance preselector filters and an exceptional phase stability, which makes it ideally suited for interferometric direction finding and radio monitoring.

IZT R4000-RF18

The frequency extension R4000-RF18 covers the frequency range from 3 GHz to 18 GHz and is ideally suited for monitoring and recording of microwave or satellite signals. Preselection is performed by means of a highly selective tracking bandpass filter.

Integration into Customer Systems

System integrators and 3rd parties can easily integrate the IZT R4000 into their system software. A R4000 client application provided by IZT will run on the customers PC or server. This application provides a command and control interface as well as the data streams using TCP/IP connections. The interface format is compatible with the IZT R3000 series.
Other methods for receiver communication and data transfer are possible on request.

User Interface / Software

IZT also provides full system solutions. In this case the IZT R4000 is provided in combination with one or multiple servers. Applications include

- Wideband Recorder
- Signal Collection System
- Hopper Detection

IZT also provides customized software and hardware to realize dedicated solutions for individual customer requests.

Application Example: Signal Collection System

With its large instantaneous bandwidth and the feature to extract up to 127 I/Q channels simultaneously, the IZT R4000 is the ideal means for signal collection systems.
Typical radio monitoring applications require a flexible access scheme where all intercepted signals are buffered while in parallel, operators or automatic classification and analysis tools browse through the available content.

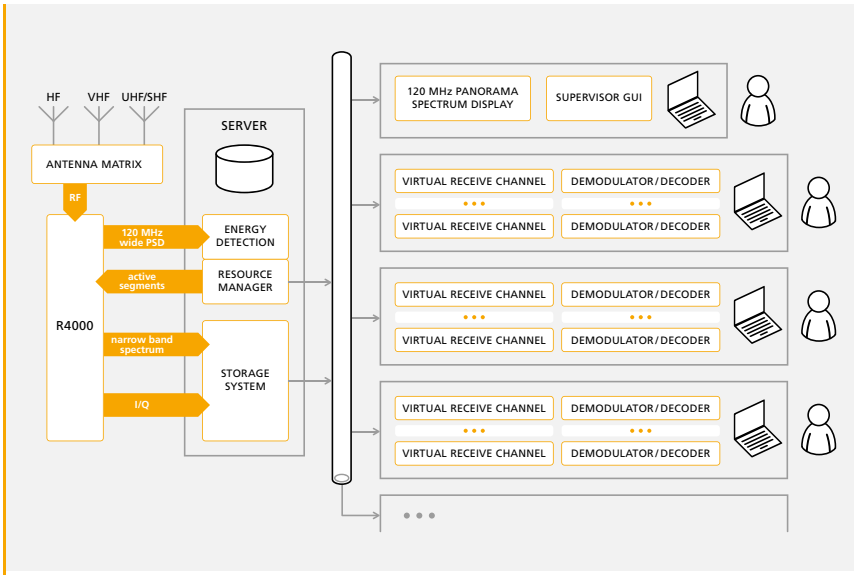

figure 6: Multi operator signal collection system

Energy Detection and Triggering

Based on the broadband spectrum, the control software identifies all occupied portions of the receive spectrum. This information is combined with user input selections regarding:

- Frequency block priorities
- Preselector and IF bandwidth settings
- Frequency block exclusions
- Noise riding or fixed threshold settings

The energy detection then provides an internal list of active sub-channels which are to be extracted.

Multiple Clients and Seamless On-/Offline Operation

The IZT R4000 can deal with multiple clients at the same time, which can be the workstations of individual operators or a cluster of computers automatically scanning available signals for useful information.

A "time/frequency-map" of all intercepted sub-bands is continuously distributed to all clients in real-time together with a spectrum preview. This serves as the directory for the operators or the automated system to identify what signals are generally available.

The storage concept of the IZT R4000 now gives the clients the opportunity to request multiple signals in parallel, each defined by time, span and frequency range, no matter whether they were recorded in the past or are becoming available in real-time.

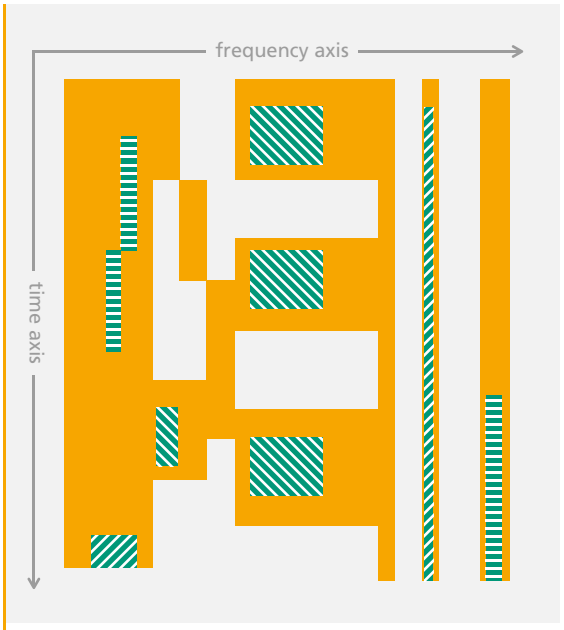

figure 7: Time/frequency-map of intercepted sub-bands

= captured sub-band
= extracted signal client 1
= extracted signal client 2
= extracted signal client N

Technical Specifications

R4000 BASE: Digital Signal Processing		
Analog to digital converter	Sampling rate	320 MSPS
	SFDR, 9 kHz to 140 MHz	90 dB, typical (referenced to full scale of ADC)
	SFDR, 120 MHz to 18 GHz	75 dB, typical (referenced to full scale of ADC)
IF bandwidth		120 MHz
I/Q	Number of channels	up to 127, independent
	Channel bandwidth	100 Hz to 120 MHz
	Data buffering	up to 4 seconds, with respect to spectrum data
Spectrum	Number of channels	two independent spectrum channels
	Bandwidth	120 MHz to 3.6 kHz (120 MHz / 2^n)
	Frequency resolution	39 kHz to 1.2 Hz (160 MHz / 4096 / 2^n)
	FFT width	4096
	FFT window	Hamming, Hanning, Blackman-Harris, Polyphase m=3,
		user-configurable coefficients (up to 3x4096)
	Averaging	1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024
	Detector	Max, Min, RMS
Interfaces	RF input	N, female, 50 Ω (one common RF input or up to 4 individual RF inputs for the frequency range)
	IF input	N, female, 50 Ω
	External reference input	10 MHz, BNC, female, 50 Ω
	Trigger pulse input	SMA, female, CMOS 3.3 Volt (5 Volt tolerant input)
	Trigger pulse output	SMA, female, CMOS 3.3 Volt
	Synchronisation input 1PPS	BNC, female, CMOS 3.3 Volt (5 Volt tolerant input)
	External synchronization	up to 10x SMA, female, 50 Ω
	Service interface	RS232, D-SUB 9, male
	LAN	2x1 Gigabit LAN, approx. 1.8 Gbps throughput
	LAN (Option R4000-10G)	10 Gigabit LAN
	Additional Interfaces	GPIB, USB 2.0, VGA, RS232

General Data	
Operating temperature	0°C ... +50°C
Storage temperature	-40°C ... +70°C
Humidity	max. 85%, non-condensing
EMI / EMC	EN 61010-1:2002, EN 61000-6-2:2002, EN 61000-6-3:2002
Power supply	100 – 240 VAC, 50-60 Hz,
	100 – 200 VA (depending on optional equipment)
Dimensions (WxHxD)	19" x 3 RU x 570 mm
Weight	approximately 15 kg

Specification subject to change without further notice.

Technical Specifications

R4000 BASE: IF Input		
Frequency range	Baseband input	2 MHz to 140 MHz
Maximum input power		+15 dBm
Tuning resolution		1 Hz
Tuning accuracy		< 0.2 Hz
VSWR		< 2.1
Internal reference stability		< 1 x 10^{-7}
Oscillator phase noise		-130 dBc/Hz typical @ 1 kHz offset
		-140 dBc/Hz typical @ 10 kHz offset
Sweep time		< 3 ms
Scanning speed	Frequency scan within 120 MHz bandwidth	> 4000 GHz /sec
3rd-order intercept point		+40 dBm, typical
Noise figure		15 dB

R4000-RF3: Frequency Extension 9 kHz to 3 GHz		
Frequency range		9 kHz to 3 GHz
Conversion concept	9 kHz to 140 MHz	Direct sampling
	140 (20) MHz to 3 GHz	Double conversion superheterodyne
Maximum input power		+15 dBm
Tuning resolution		1 Hz
Tuning accuracy		< 0.2 Hz
VSWR		< 2.1
Internal reference stability		< 1 x 10^{-7}
Oscillator phase noise	9 kHz to 140 MHz	-130 dBc/Hz typical @ 1 kHz offset
		-140 dBc/Hz typical @ 10 kHz offset
	140 MHz to 3 GHz	-120 dBc/Hz typical @ 10 kHz offset
Sweep time		< 3 ms
Scanning speed	Frequency scan, linear	> 40 GHz /sec
	Frequency scan within 120 MHz bandwidth	> 4000 GHz /sec
3rd-order intercept point	9 kHz to 140 MHz (Normal mode)	+40 dBm, typical
	140 MHz to 3 GHz (Low distortion mode)	+24 dBm, typical
	140 MHz to 3 GHz (Normal mode)	+13 dBm, typical
Noise figure	9 kHz to 140 MHz (Normal mode)	10 dB, typical
	140 MHz to 3 GHz (Low noise mode)	10 to 12 dB, typical
	140 MHz to 3 GHz (Normal mode)	14 to 15 dB, typical
IF rejection		> 120 dB, typical
Image rejection		> 110 dB, typical
Oscillator reradiation at antenna output		< -110 dBm, typical
Preselector filter	9 kHz to 140 MHz	More than 100 highpass/lowpass filter combinations
	140 MHz to 3 GHz	11-Band suboctave filter

R4000-RF6: Frequency Extension 3 GHz to 6 GHz		
Frequency range		3 GHz to 6 GHz
Maximum input power		+15 dBm
Tuning resolution		1 Hz
Tuning accuracy		< 0.2 Hz
VSWR		< 2.1
Internal reference stability		< 1 x 10^{-7}
Oscillator phase noise		- 120 dBc/Hz typical @ 10 kHz offset
Sweep time		< 3 ms
Scanning speed	Frequency scan, linear	> 40 GHz /sec
	Frequency scan within 120 MHz bandwidth	> 4000 GHz /sec
3rd-order intercept point	Normal mode	+18 dBm, typical
	Low noise mode	+2 dBm, typical
Noise figure	Low noise mode	6 dB, typical
	Normal mode	16 dB, typical
IF rejection		> 120 dB, typical
Image rejection		> 110 dB, typical
Oscillator reradiation at antenna output		< -100 dBm, typical
Preselector filter		8-Band suboctave filter

R4000-RF18: Frequency Extension 3 GHz to 18 GHz		
Frequency range		3 GHz to 18 GHz
Impedance		50 Ohm
Maximum input power		+10 dBm
Tuning resolution		1 Hz
Tuning accuracy		< 0.2 Hz
VSWR		< 2.1
Internal reference stability		< 1 x 10^{-7}
Oscillator phase noise		-114 dBc/Hz typical @ 10 kHz offset
Sweep time		< 10 ms
Scanning speed	Frequency scan, linear	> 12 GHz /sec
	Frequency scan within 120 MHz bandwidth	> 4000 GHz /sec
3rd-order intercept point	Low distortion mode	+25 dBm, typical
Noise figure	Low noise mode	15 dB, typical
IF rejection		> 120 dB, typical
Image rejection		> 110 dB, typical
Oscillator reradiation at antenna output		< -100 dBm, typical
Preselector Filter		Tracking bandpass filter

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Digital Wideband Receiver

REV.1.2 08/2011 DESIGN@POOL-X.DE

Ordering Guide		
Hardware options	**IZT R4000-BASE**	Wideband Receiver with IF Input, 1 GBit LAN Interface
	IZT R4000-RF3	Frequency range 9 kHz – 3 GHz
	IZT R4000-RF6	Frequency range extension: 3 GHz – 6 GHz (Requires option R4000-RF3)
	IZT R4000-RF18	Frequency range extension: 3 GHz – 18 GHz (Requires option R4000-RF3)
	IZT R4000-10G	10 GBit LAN Interface
	IZT R4000-SVR	Server
Software options	**IZT R4000-100**	IZT Signal Suite – R4000
	IZT R4000-120	IZT Signal Suite – Wideband Recorder
	IZT R4000-200	IZT Signal Suite – Signal Collection System

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About IZT

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

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

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

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