IZT C3040
Satellite Link Emulator

Innovationszentrum Telekommunikations-technik GmbH

- World leading RF quality
- Frequency conversion from input to output
- 100 MHz instantaneous bandwidth
- Simulation of uplink, payload and downlink
- Accurate synchronization of multiple IZT C3040
- Spectrum display with automatic C/N control

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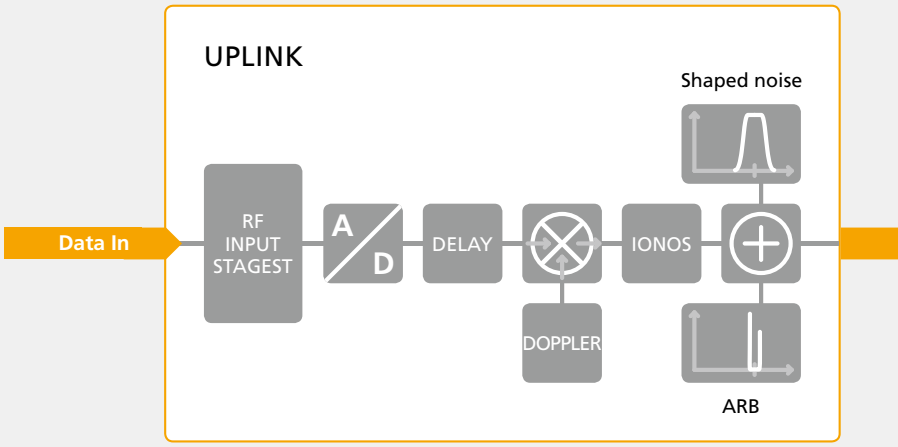
Satellite Link Emulator

The IZT C3040 Satellite Link Emulator provides a cost effective, time-saving total solution with exceptional functionality for satellite and aircraft RF link testing.

Accurate, comprehensive and repeatable simulation of uplink, payload and downlink in the IZT C3040 let system engineers create realistic scenarios for testing their product in a laboratory environment. Key applications include:

- **Satellite (LEO, GEO, MEO)**
- **UAV**
- **Modem, transmitter, and receiver testing**
- **Telemetry tracking system and range verification**
- **Training and education**



- Delay and delay variation over time
- Doppler simulation – frequency dependent
- Effects of the ionosphere – time variant
- Interference caused by other signals

figure 1: IZT C3040 structure

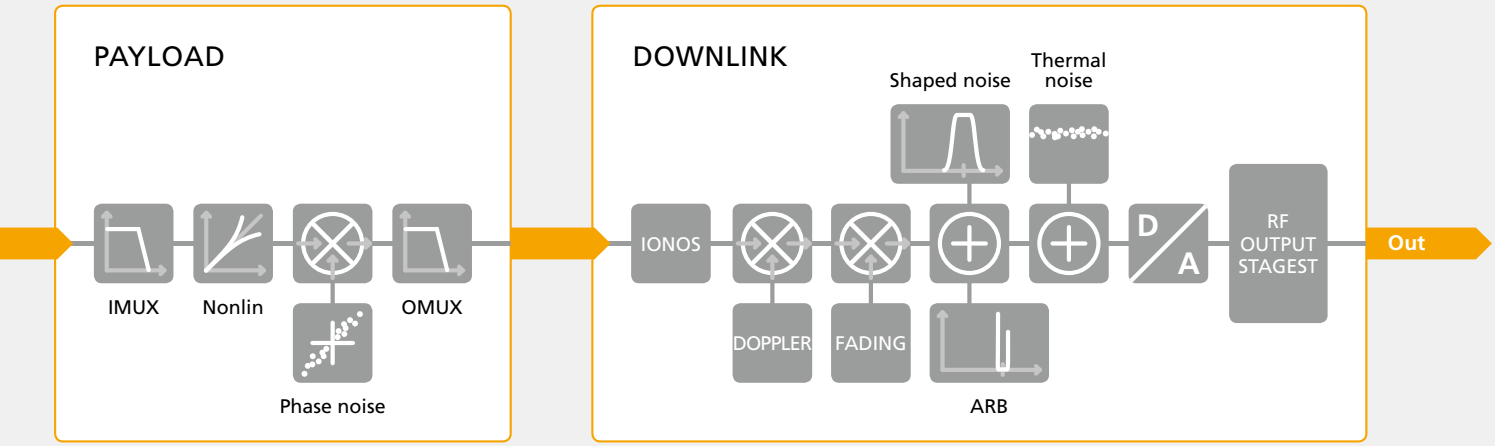
1. Functionality

The IZT C3040 is a wideband digital satellite link emulator supporting a bandwidth of up to 100 MHz which meets the demanding requirements of today's communication systems.

The IZT C3040 uses high quality hardware and highly optimized DSP code to simulate the effects which uplink, payload and downlink have on the signal.

These effects include delay and delay variation over the time, impairments caused by the MUX filters of the satellite and effects of the ionosphere and the propagation through the atmosphere.

Figure 1 provides an overview of the full capabilities of the IZT C3040.



- IMUX filtering
- Nonlinearity (AM/AM and AM/PM) caused by the amplifier
- Phase noise
- OMUX filtering
- Effects of the ionosphere and propagation through the atmosphere
- Large and small scale fading
- Interference by other signals
- Thermal noise

2. Control Software

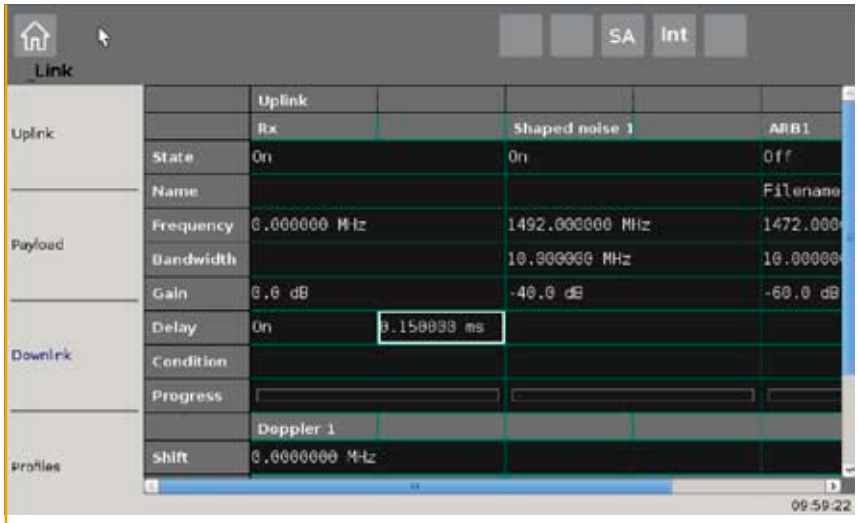


figure 2: Intuitive local user interface

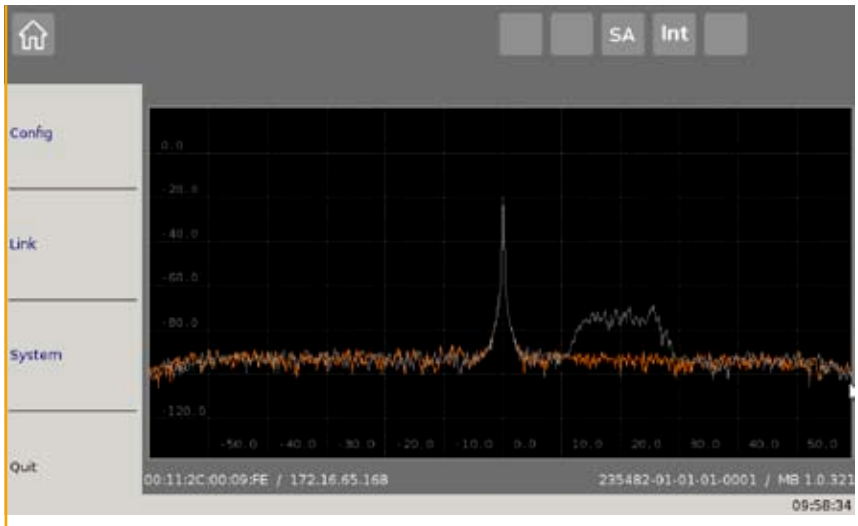


figure 3: Spectrum display

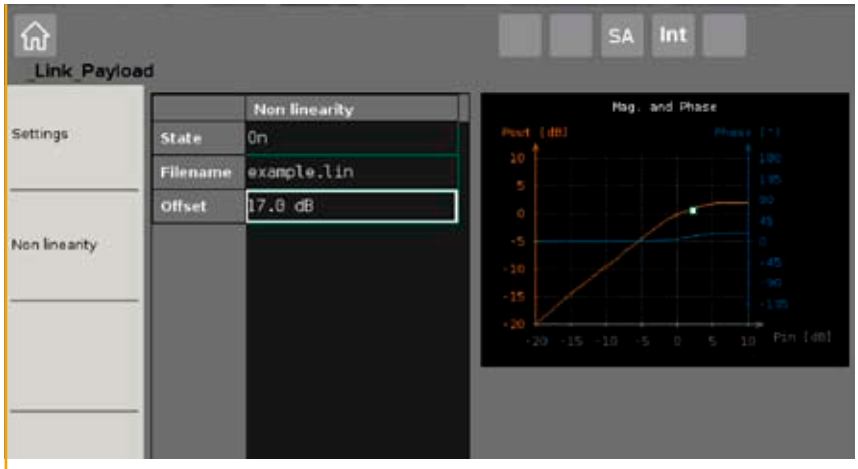


figure 4: Nonlinearity control

Intuitive Local User Interface

IZT C3040's intuitive local graphical user interface allows the user to easily configure all settings and functions of the unit. Soft keys on the front panel assist to navigate through the menu screen, the 640x480 pixel colour display provides immediate feedback on the information of interest.

Spectrum Display

The spectrum display function calculates and plots the signal spectrum at various stages within the IZT C3040. This feature greatly increases the user's awareness and can even replace costly external test equipment.

With the spectrum display option, IZT C3040 also has the capability to measure signal power within a user defined portion of the instantaneous bandwidth, providing automatic or semi-automatic adjustment of the noise density to accurately match a C/N0 value set by the operator.

Nonlinearity Control

The IZT C3040 provides excellent guidance for the operator to configure the nonlinearity.

Amplitude distribution and signal power are continuously measured at the input and output of the nonlinearity simulation. The result is then presented in the selected nonlinearity curve as output power and angle vs. input power.

Comprehensive Remote Control Interface

All functions of the IZT C3040 can be remote controlled via SCPI commands received via LAN, RS232 or optionally GPIB. Users of IZT signal generators or IZT channel simulators can quickly adapt their control software to the IZT C3040.

3. Digital Signal Processing

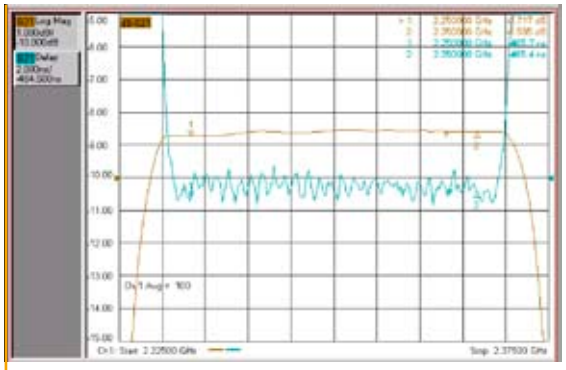


figure 5: IZT C3040 gain and group delay flatness

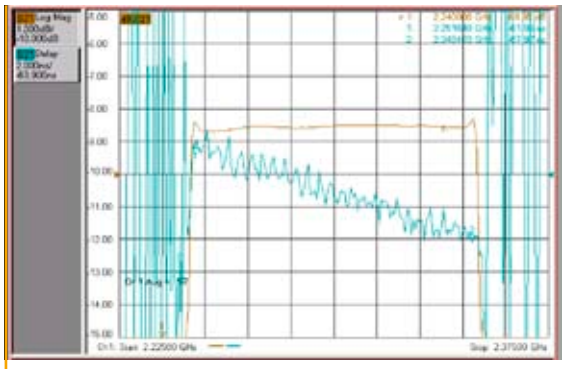


figure 6: Emulation of the ionosphere with IZT C3040

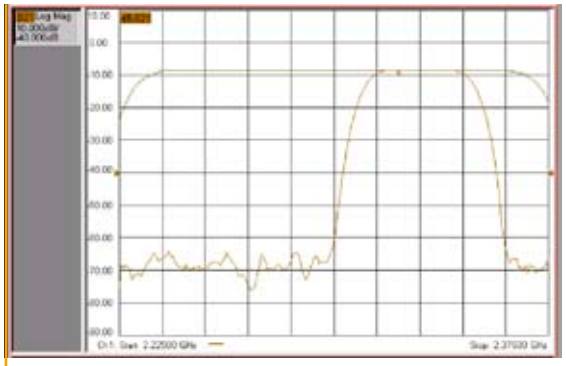


figure 7: IMUX and OMUX filtering

Hardware

The IZT C3040 uses latest FPGA technology to perform the digital signal processing. After digitization with 320 MSamples/sec the signal is converted to complex baseband and subsequent processing is performed at 160 MSamples/sec (complex). To account for spectral re-growth, the nonlinearity simulation is performed to 320 MSamples.

Delay

The IZT C3040 can simulate a continuously variable delay of up to 800 msec. After an initial setting, its variation is tied to the Doppler simulation of the link. It is continuously variable to simulate actual movement of the payload. Variations will resemble a linear increase of distance between transmitter and receiver.

Ionosphere

The IZT C3040 can perform a simulation of the time-dispersive effect of the ionosphere both on uplink and downlink. It is controlled by the user specifying the Total Electron Content (TEC) and the actual frequencies used on uplink and downlink. The conditions of the ionosphere can be altered while the simulation is running.

IMUX and OMUX Filters

The IZT C3040 provides two digital filters on either end of the payload simulation to mimic the satellite IMUX and OMUX filters or model a memory in the amplifier. The user may either specify the filter coefficients directly or provide a complex frequency response, which will be transformed into a FIR filter by the IZT C3040 control software. IMUX and OMUX are independent.

Noise and Interference

Behind the IMUX filter and at the very end of the simulation chain, two independent noise sources and two independent arbitrary waveform generators are available. The power spectral density of the noise source can be controlled by the user as a function of frequency. In order to set a defined C/N, a power detector measures the signal power passing through the IMUX filter and within a user-defined frequency band.

The arbitrary waveform generator holds up to 1 GByte (256 MSamples) of data. Its output power is adjustable. The sample rate is variable up to the full bandwidth of the IZT C3040.

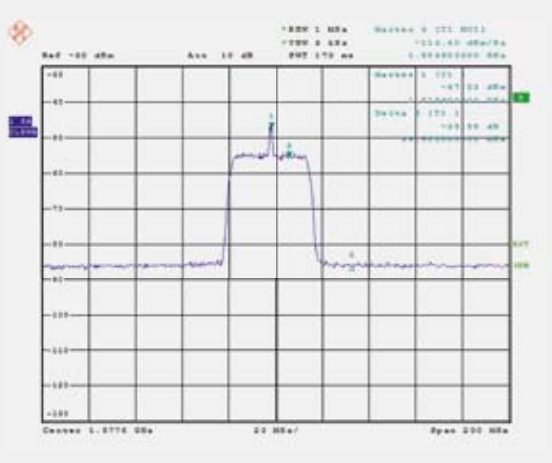


figure 8: Signal with interferer

Phase Noise

The IZT C3040 supports an accurate phase noise simulation with up to 10 MHz bandwidth. The user can specify a desired frequency response or mask which will be the pre-calculated. The IZT C3040 can simulate phase noise introduced by the local oscillators in the simulated link with up to 10 MHz offset from the carrier. The user specifies a "mask" (noise power density versus frequency) and can then adjust the amount of phase perturbation introduced by the simulator. As an example, the phase noise profile for "DVB-S2 typical" is shown in figure 5. The total (RMS) phase modulation is adjustable during the simulation.

Specified phase noise mask:

-25 dBc/Hz@100 Hz
-50 dBc/Hz@1 kHz
-73 dBc/Hz@10 kHz
-93 dBc/Hz@100 kHz
-103 dBc/Hz@1 MHz
-114 dBc/Hz@>10 MHz

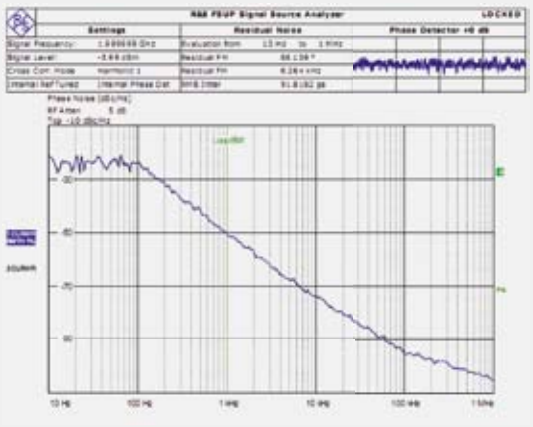


figure 9: Simulated phase noise "DVB-S2 typical"

Nonlinearity

The IZT C3040 can simulate a memoryless distortion (AM/AM and AM/PM) as it would be introduced by the amplifier in the payload. The user specifies the data as complex gain versus input power in tabular format.

The nonlinearity table contains 1024 complex coefficients as a function of amplifier input amplitude. Linear interpolation is used between adjacent table entries. Real-time measurements of the signal amplitude statistics at the input and output of the nonlinearity simulation give the user the necessary feedback about the current operating point of the nonlinearity.

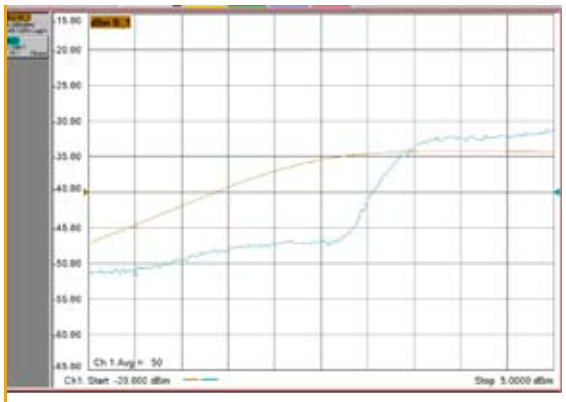


figure 10: Emulation of payload nonlinearity

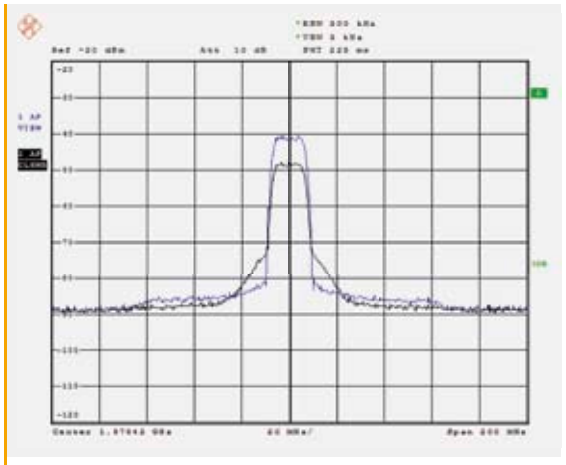


figure 11: Nonlinearity simulation with a QAM signal

Fading

To simulate rain fades or scintillation, the IZT C3040 has the capability to weight the signal with a complex fading coefficient which is continually streamed from RAM or the control software.

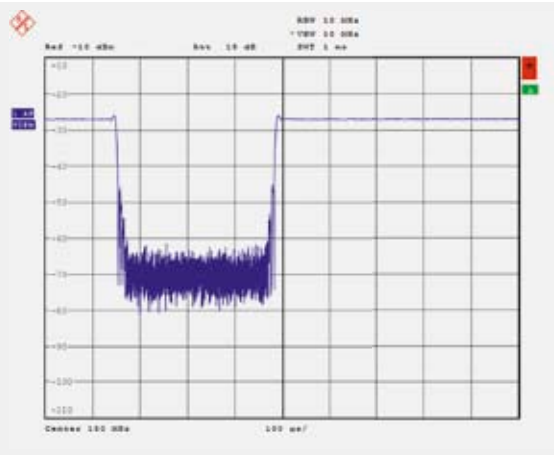


figure 12: Signal drop-out simulated with fast fading option

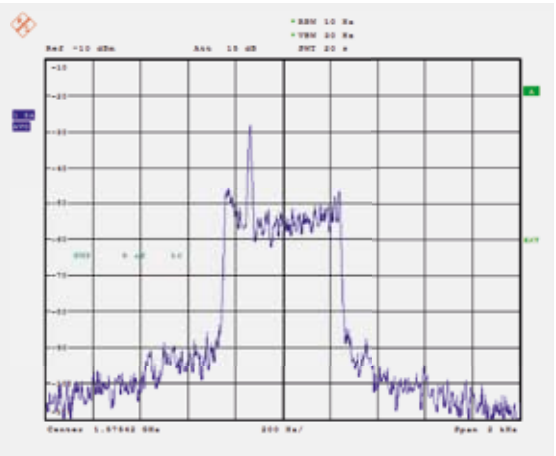


figure 13: Rice fading

Analog Performance

The IZT C3040 uses high-performance broadband RF converters which it shares with IZT's receivers and signal sources. This minimizes uncontrolled and unwanted degradation of signal quality in the system under test.

The IZT C3040 uses sophisticated digital correction of the analogue frequency response which results in a typical amplitude ripple of ±0.2 dB and ±1 nsec group delay ripple over its 100 MHz instantaneous bandwidth.

At the same time, the IZT C3040 has excellent spurious performance, signal-to-noise ratio and linearity as shown in figure 14 and figure 15.

Converters and Synthesizers

The IZT C3040 can be equipped with different analogue modules. Currently available are:

- Input module 40 MHz … 3 GHz
- Input module 3 GHz … 6.6 GHz
- Input module 6 GHz … 18 GHz
- Output module 40 MHz … 3 GHz

The IZT C3040 can be fit with single or dual synthesizers. A single synthesizer means identical center frequencies for the input and the output signal.

When two synthesizers are installed, the IZT C3040 allows completely independent center frequencies for input and output signal.

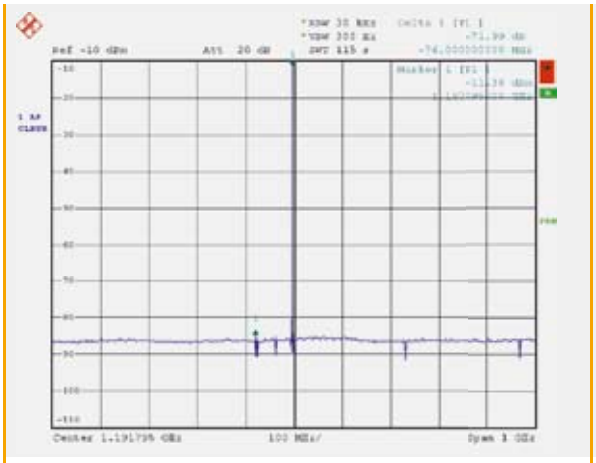


figure 14: Excellent spurious performance and signal-to-noise ratio

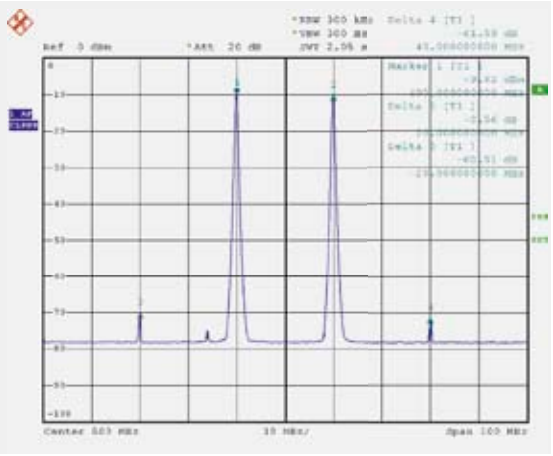


figure 15: IZT C3040 third order intermodulation products

4. Specifications

Specifications IZT C3040			
IF Frequency	240 MHz or direct sampling		
RF Input Frequencies	40 MHz up to 3 GHz (6.6 GHz /18 GHz optional)		
RF Output Frequencies	40 MHz up to 3 GHz		
1dB Instantaneous bandwidth	100 MHz		
3dB Instantaneous bandwidth	108 MHz		
Delay Range	150 µs to 800 ms		
Delay Resolution	1 ns (1 ps possible)		
Delay Rate	31.25 ms/s (continuous phase)		
	discrete reconfiguration of any delay possible		
Delay Accuracy	1 ns		
Signal Doppler shift Range	±50 MHz or greater with two independent synthesizers		
Signal Doppler shift Resolution	1 Hz		
Carrier Doppler shift Range	-1.25 to 1.25 MHz		
Carrier Doppler shift Resolution	0.1 Hz		
Carrier Doppler shift Rate	file : 100 MHz/ms		
	live : 100 MHz/100 ms		
Carrier Doppler shift Accuracy	0.1 Hz		
Fading attenuation Range	70 dB		
Fading attenuation Resolution	0.1 dB		
Fading attenuation Rate	file: 1000.0 dB/ms		
	live: 70.0 dB/100 ms		
Fading attenuation Accuracy	0.01dB (at <40 dB att.), 0.13 dB (at 60 dB att.)		
AWGN Range	-174.0 up to -70 dBm/Hz for 100 MHz BW		
	Note: depends on ref. levels and AWGN bandwidth		
AWGN Resolution	0.1 dB		
AWGN Rate	live: 70.0 dB/100 ms		
AWGN Accuracy	0.1 dB		
Input Noise Figure	20 dB min, typ.		
Internal LO Specifications (includes RF input stage, Signal Processing, and RF output stage)	SSB Phase Noise L(f)	Standard OCXO	Low Phase Noise Opt.
	@ 10 Hz	-70 dBc/Hz	-75 dBc/Hz
	@ 100 Hz	-70 dBc/Hz	-75 dBc/Hz
	@ 1 kHz	-90 dBc/Hz	-95 dBc/Hz
	@ 10 kHz	-115 dBc/Hz	115 dBc/Hz
	@ 100 kHz	-115 dBc/Hz	115 dBc/Hz
	@ 1 MHz	-130 dBc/Hz	-130 dBc/Hz
Internal LO Stability	same as reference		

10 MHz External Reference IN Requirements	SSB Phase Noise L(f) @ 10 Hz < -120 dBc/Hz		
	SSB Phase Noise L(f) @ 100 Hz < -135 dBc/Hz		
	SSB Phase Noise L(f) @ 1 kHz < -150 dBc/Hz		
	SSB Phase Noise L(f) @ 10 kHz < -150 dBc/Hz		
	SSB Phase Noise L(f) @ 100 kHz < -150 dBc/Hz		
	SSB Phase Noise L(f) @ 1 MHz < -150 dBc/Hz		
10 MHz External Reference IN Level	0 to +18 dBm @ 50 Ohm		
10 MHz External Reference IN Stability	same as internal reference or better		
10 MHz External Reference IN Freq Accuracy	< ±5Hz (impact on output frequency)		
10 MHz Reference OUT Specifications	SSB Phase Noise L(f)	Standard OCXO	Low Phase Noise Opt.
	@ 10 Hz	-120 dBc/Hz	-125 dBc/Hz
	@ 100 Hz	-135 dBc/Hz	-145 dBc/Hz
	@ 1 kHz	-150 dBc/Hz	-165 dBc/Hz
	@ 10 kHz	-150 dBc/Hz	-165 dBc/Hz
	@ 100 kHz	-150 dBc/Hz	-165 dBc/Hz
	@ 1 MHz	-150 dBc/Hz	-165 dBc/Hz
10 MHz Reference OUT Level	+6 dBm @ 50 Ohm		
10 MHz Reference OUT Stability	< ±1 x 10-9 at time of calibration		
	Aging < ±5 x 10-10 / day after 30 days operation		
	< ±50 x 10-9 / year		
	Temperature variation < ±2 x 10-10 / °C		
Amplitude Response	±0.5 dB over 100 MHz typ.		
Insertion Loss	0.0 dB (depending on gain setting)		
Max Noise Floor / Output Noise Density	see AWGN		
Min Noise Floor / Output Noise Density	see AWGN		
Max RF Input Power	+20 dBm		
Min RF Input Power	-30 dBm (for full ADC loading)		
Max RF Output Power	+15 dBm pep		
Min RF Output Power	-120 dBm		
Spurious Emissions Suppression	-70 dBc		
Input VSWR	1:1.2 or better		
Output VSWR	1:1.2 or better		
Internal (software) Trigger Feature	stream based dynamic configuration		
External (hardware) Trigger Feature	stream activation on next PPS by external command		
Test Scenario Length (File-based Simulation)	limited only by HDD space		
Dynamic Update Rate (File-based Simulation)	1 kSPS for delay, frequency and gain		
	156.25 kSPS for fast fading		

Test Scenario Length (Real-time Interface-based Simulation)	no limit as received from TCP/IP
Dynamic Update Rate (Real-time Interface-based Simulation)	100 ms or better
IMUX Filter	up to 256 complex FIR coefficients, 160 MSps
OMUX Filter	up to 256 complex FIR coefficients, 160 MSps
Nonlinearity	AM/AM and AM/PM, 1024 coefficients, linear interpolation
Compliance	Meets EN 55022, class B, QP, AV
	FCC 47 part 15 Class A
	European Directive 98/336/EEC Class A (Emissions)
Environmental	Nominal Operating Temperature: +18…25°C
	Maximum Operating Temperature: +5…40°C
	Humidity: 10…90% (non-condensing)
	Altitude: max. 2000 m
Power Supply	100 - 240 V AC,50 Hz to 60 Hz
	200 Watts (typ.)
	Input current: 2 A (100 V) to 0.85 A (240 V)
Display	5 inch TFT Color
	1 x DBHD-15F VGA port
Size	19” 3U
	570 mm deep
Weight	approx. 12 kg, depending on RF module configuration

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Ordering Guide	
IZT C3040 Channel Simulator	Chassis
	RF Output 3 GHz
	RF Input 3 GHz
	RF Synthesizer
IZT C3040-DC6	RF Input 6.6 GHz
IZT C3040-DC18	RF Input 18 GHz
IZT C3040-RFS	RF Synthesizer
IZT C3040-GPIB	GPIB Interface
IZT C3040-TRIG	External trigger input
IZT C3040-LPN	Low phase noise
IZT C3040-101	Delay
IZT C3040-104	IMUX/OMUX Filter
IZT C3040-106	True doppler simulation
IZT C3040-107	Additive white gaussian noise
IZT C3040-108	Shaped noise
IZT C3040-109	Phase noise simulation
IZT C3040-110	Nonlinearity simulation
IZT C3040-111	Fast fading
IZT C3040-112	Arbitrary waveform generator
IZT C3040-113	Ionosphere simulation
IZT C3040-114	Spectrum display
IZT WE2	Warranty extension to 2 years
IZT WE3	Warranty extension to 3 years

Innovationszentrum für Telekommunikationstechnik GmbH IZT

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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.