Satellite Channel Simulator
IZT C5040

Product Information

- Cost-effective and time-saving method for simulating complete bidirectional satellite transmission links
- Comprehensive modelling of the satellite channel
- Complex operating scenarios for testing transceivers, terminals and satellites
- Hand-off simulation for complex satellite constellations
- Frequency range up to 3 GHz with a bandwidth of 250 MHz

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Overview

IZT satellite channel simulators provide a cost-effective and time-saving method of simulating complete bidirectional satellite transmission links without the actual satellites being available.

Complex operating scenarios for testing transceivers, terminals and satellites can be simulated. Effects due to modifications to the transmission method, the satellite or the terminal equipment can be simulated before implementation with the IZT satellite channel simulator.

During the lifetime of the satellites, the satellite channel simulator can be used to simulate and analyze effects and problems. IZT satellite channel simulators provide excellent signal quality and a comprehensive simulation of effects on a satellite channel.

The IZT C5040's optimized and scalable signal processing units offer real-time simulation of influences on the signal at the satellite (non linearity, IMUX / OMUX filter, phase noise, interference, antenna gain, Doppler shift) as well as on the transmission link (interference, rain fading, scintillation, reflections, thermal noise).

With the IZT C5040 satellite based communication systems can be extensively simulated and tested prior to their realization. In addition, complex operational scenarios for equipment (receivers, transmitters, satellite phones) and satellite testing can be set up in a very cost-effective way. The IZT C5040 is a scalable system based on individual hardware units that can be configured from uni-directional links to bi-directional links with hundreds of terminals.

Figure 1: Installation of multiple IZT C5040

Key Features

Channel Effects

Delay The IZT C5040 can simulate a variable link delay of up to 800 ms in each direction. Additionally, the delay variation is tied to the Doppler simulation of the link. The delay is continuously variable to simulate any arbitrary movement of the payload. This dynamic variation can be obtained through orbital information and atmospheric effects or defined by a time indexed profile.

Doppler The IZT C5040 provides the ability to simulate time-variant, phase continuous Doppler frequency profiles. The profiles can either be based on math functions or on time indexed orbit description (ECEF) and ground site descriptions for transmitters and receivers. The Doppler simulation covers up to 24 hours of satellite movement.

Rain Fade To simulate rain fade, the IZT C5040 has the capability to apply time-varying attenuation profiles. Uplink Power Control (UPC) effects can be included in rain fade simulations by defining clear sky EIRP and maximum EIRP. The IZT C5040 provides a profile depth of up to 24 hours at a 1 millisecond time resolution.

Fixed Attenuation Fixed offsets in attenuation representative of static clear sky conditions can be applied.

Interference The C5040 facilitates several instances of interference signal generators to emulate for example in-band adjacent beam co-channel interference.The interference waveform generator supports AWGN, CW, and several types of PSK and QAM modes. Bandwidth and center frequency of the interference are variable and user controllable. The interference signal level is settable relative to the carrier signal level.Every instance of the arbitrary waveform generator holds up to 3.5 GB of data.

Thermal Noise AWGN generators in both uplink and downlink provide the means to emulate channel AWGN to reflect constant noise such as antenna and receiver noise temperature. The AWGN signal level is settable relative to the carrier signal level.

Fading The Multipath Fading Simulator allows for modelling reflections of the signal on terrain, fixed and moving objects. It supports up to eight propagation paths (taps) with a variable delay on top of the set link delay. Each propagation path (tap) can be processed with an individual Doppler spectrum. Various Doppler spectra, specific models like e.g. Rayleigh or Ricean fading, are generated online or can be streamed from HDD to the Fading Simulator block. This concept allows the users to apply their own, specific fading models.

Satellite Payload Effects

Linear Filter Distortion (IMUX / OMUX) The IZT C5040 provides two digital filters on either end of the payload simulation to mimic the satellite's IMUX and OMUX filter amplitude and group delay response. 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 C5040 control software. IMUX and OMUX filters are independent.

Phase Noise The IZT C5040 supports an accurate phase noise simulation with up to 37.5 MHz bandwidth. The user can specify a desired frequency response or mask (noise power density versus frequency).Phase noise can be emulated at various stages of the IZT C5040, representing transmitter, receiver and satellite phase noise performance.
The total (RMS) phase modulation is adjustable during the simulation. The exceptional underlying phase noise performance of the IZT C5040 allows simulating phase noise introduced by typical payload frequency conversion stages.

Automatic Level Control (ALC) The IZT C5040 provides automatic level control (ALC) simulation. This is emulating the effect of additional payload noise due to the ALC loop increasing the forward payload gain to compensate for the de-creased signal strength at the satellite's input for example caused by rain fade.

LTWTA Nonlinearity The IZT C5040 emulates the nonlinear response of the payload LTWTA by providing AM/AM and Phase versus IBO modeling. The user can either use any of the generic models or use his own actual measured AM/AM and Phase versus IBO data to emulate the LTWTA nonlinear response.
Real-time measurements of the signal amplitude statistics at the input and output of the nonlinearity simulation provide the user with valuable feedback about the current operating point of the non-linearity.

Thermal Noise and In-band Noise Two AWGN generators provide the means to emulate thermal noise effects at the input of the payload and in-band noise to represent the LTWTA noise. The AWGN signal level is settable relative to the carrier signal level.

Interference Two independent interference signal generators provide the capability to add interference induced by transponder loading. The interferers can be added both before and after the LTWTA nonlinearity emulation.

Other Effects The IZT C5040 can emulate fixed frequency offsets representative of transponder frequency translation offsets and fixed attenuation offsets representative of static variations in payload gain.

Payload Preset The payload preset dialog allows the user to quickly configure the payload IMUX, OMUX, phase noise and nonlinearity based on the satellite channel in one single step.

Control Software

Spectrum Display The spectrum display function calculates and plots the signal spectrum at various stages within the IZT C5040. This feature greatly increases the user's awareness and can even replace costly external test equipment.

Nonlinearity Display The IZT C5040 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 versus input power.

Remote Control Functionality All functions of the IZT C5040 can be controlled remotely with either SCPI or SNMP via LAN. Users of IZT Signal Generators or IZT Channel Simulators can quickly adapt their control software to the IZT C5040.

Offline Tools The IZT C5040 comes with helpful offline tools intended to support the customer in generating complex simulation scenarios. The interference generator is used by the operator to specify up to four carriers with individually, selectable modulation types (AWGN, CW, QPSK, 8PSK, 16QAM, 16APSK, or 32APSK). Each carrier may have a different modulation type, carrier frequency and C/I ratio. The modulation type determines if the operator sets the bandwidth or symbol rate.
After specifying the interference parameters the waveform is calculated and the interference generator will signal completion of the calculation and plot the spectral waveform.
The spectral waveform plot can be used by the operator to visualize the interference waveform's spectral performance.

Specifications

Parameter	Specification
Input frequency range	100 MHz to 3000 MHz
Output frequency range	100 MHz to 3000 MHz
Channel bandwidth	250 MHz
Input power range	-10 dBm to -50 dBm
Output power range	+10 dBm to -50 dBm
Gain flatness	+/- 0.35 dB
Gain slope stability	0.5 dBpp (over operating temperature range)
Group delay flatness	<1 nspp
Input return loss	<16 dB
Output return loss	<16 dB

Table 1: RF Specification

Parameter	Condition	Specification
Amplitude profile time increments	Minimum	1 ms
	Maximum	1 s
Amplitude profile record length	Maximum	1 hour
Amplitude control range	Maximum	0.0 dB
	Minimum	-50.0 dB
Amplitude increments	Nominal	0.1 dB
Amplitude change rate	Maximum	10 dB/s
Step amplitude change	Maximum	20 dB

Table 2: Amplitude profile

Parameter	Condition	Specification
Delay profile time increments	Minimum	1 ms
	Maximum	1 s
Delay profile record length	Maximum	1 hour
Delay error	Between applied delay and computed delay, maximum	0.4 ns
Delay control range	Minimum	0.1 ms
	Maximum	800 ms
Delay increment	Nominal	0.1 ns
Delay change rate	Maximum	+/-100 us/s
Step delay change	Maximum within 0.1 ms	+/-10 ms
Delay accuracy/drift		<+/-0.25 ns/ms

Table 3: Delay profile

Parameter	Condition	Specification
Frequency offset profile time increments	Minimum	1 ms
	Maximum	1 s
Frequency offset profile record length	Maximum	1 hour
Frequency offset increments	Programmable increments of	1 Hz
Frequency offset change intervals	Computed and applied often enough to have a frequency offset jump less than	10 Hz[1]
Frequency offset error	Between applied frequency offset and computed frequency offset, maximum	1 Hz
Frequency offset control range	Maximum	+/-1 MHz
	Minimum	0 Hz
Frequency offset change rate	Maximum	+/-10 kHz/s
Step frequency offset change	Maximum within 0.1 ms	+/-1 MHz

Table 4: Frequency offset

Parameter	Condition	Specification
AWGN profile time increments	Minimum	1 ms
	Maximum	1 s
AWGN profile record length	Maximum	1 hour
AWGN control range	Relative to the desired signal maximum	10 dB
	Minimum	-30 dB
Signal-to-noise ratio	Relative to the desired signal maximum	30 dB
	Minimum	-10 dB
AWGN increments	Nominal	0.1 dB
AWGN change rate	Maximum	10 dB/s

Table 5: AWGN profile

Parameter	Specification
Linear filter distortion	Up to 1024 complex FIR coeffcients
Linear filter distortion amplitude accuracy	<+/-0.5 dB amplitude ripple error
Linear filter distortion group delay accuracy	<1 ns group delay error

Table 6: IMUX/OMUX filter

[1] frequency changes are phase continuous

Parameter	Specification
Nonlinearity AM/AM distortion versus IBO	<+/- 0.1 dB
Nonlinearity phase distortion versus IBO	<+/- 0.5°
Nonlinearity dynamic range	60 dB

Table 7: Non-Linearity

Parameter	Specification
RF input	SMA female, 50 Ohm
RF output	SMA female, 50 Ohm
10 MHz reference input	BNC female, 50 Ohm, 5 dBm to 15 dBm, 50 Ohm
Trigger / synchronization input	SMA female, 1 PPS, 3.3 V LVTTL
Command and control interface	Gigabit ethernet

Table 8: Interfaces

Parameter	Specification
Voltage	100 VAC – 240 VAC
Temperature range, operating	15°C – 30°C
Temperature range, non-operating	-20°C – 70°C
Humidity, operating	10% – 80% max, non-condensing
Humidity, non-operating	10% – 90% max, non-condensing
Form factor	19"

Table 9: Environmental

Ordering Guide

Hardware Option	Description
IZT C5040-UPL	Uplink Simulation Unit
IZT C5040-PLD	Payload Simulation Unit
IZT C5040-DNL	Downlink Simulation Unit
IZT C5040-CSU	Central Synchronization Unit
IZT C5040-SVR	Command and Control Server, Switch
IZT C5040-DSPL	Keyboard and Display, 19" rackmount

Software Option	Description
IZT WE2	Warranty extension to 2 years
IZT WE3	Warranty extension to 3 years

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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.

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