IZT C3040
Satellite Link Simulator

Product Information

- 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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The IZT C3040 Satellite Link Emulator provides a cost-eff ective, 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 verif cation
- Training and education

Overview

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.

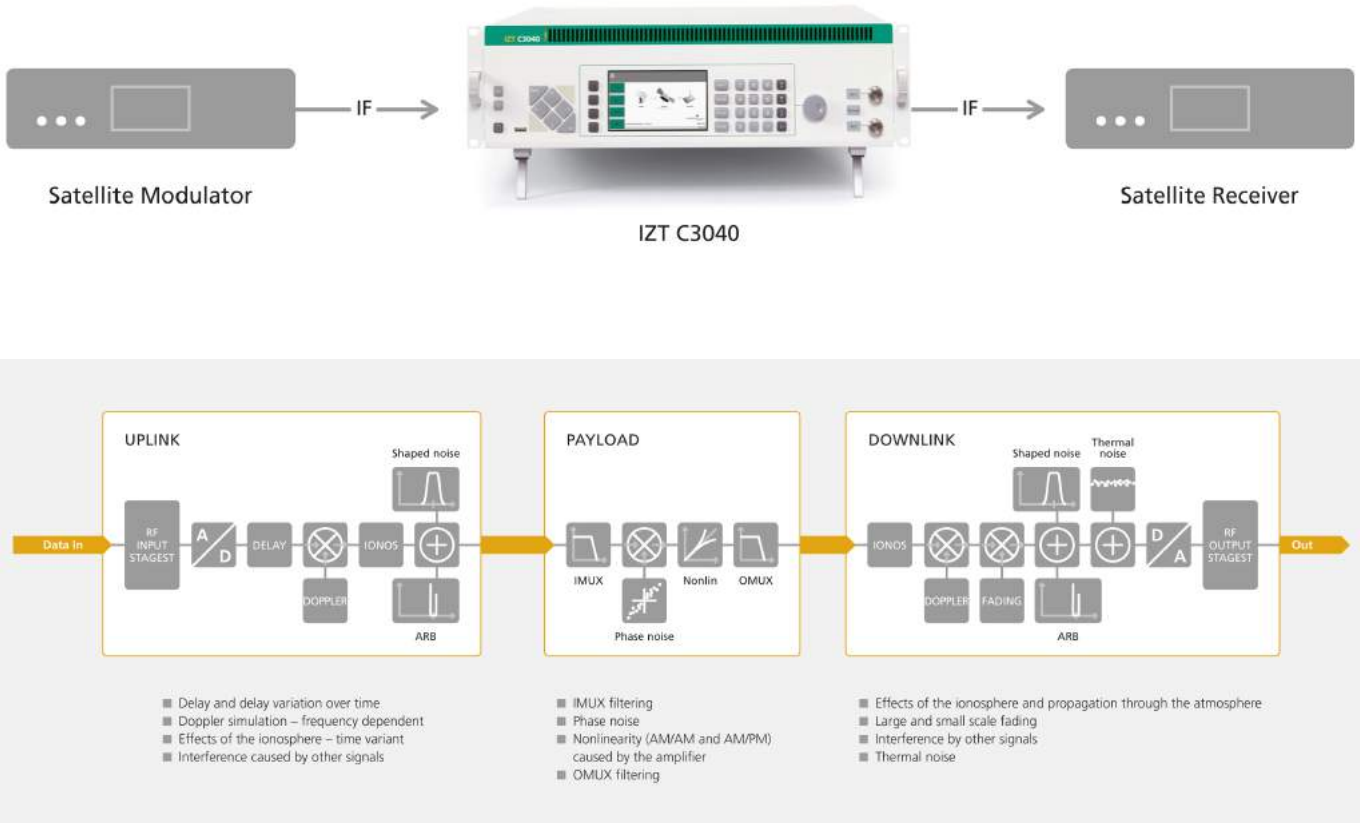

FIGURE 1: IZT C3040 STRUCTURE

Key Features

CONTROL SOFTWARE

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 640 x 480 pixel colour display provides immediate feedback on the information of interest.

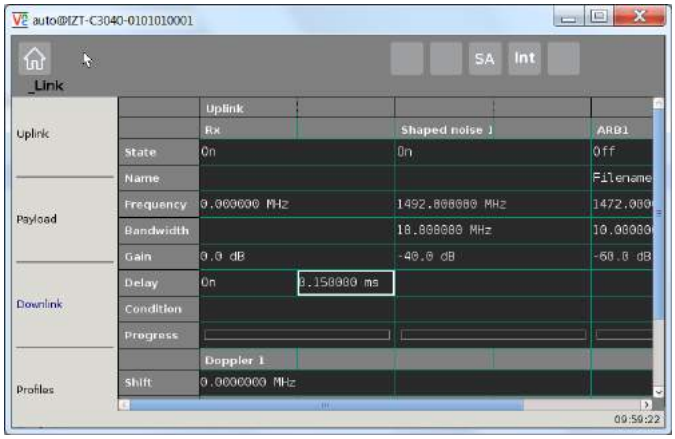

FIGURE 2: INTUITIVE LOCAL USER INTERFACE

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.

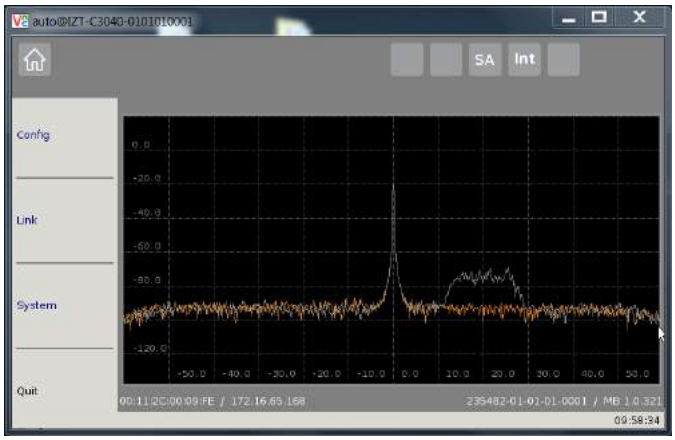

FIGURE 3: SPECTRUM DISPLAY

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 versus input power.

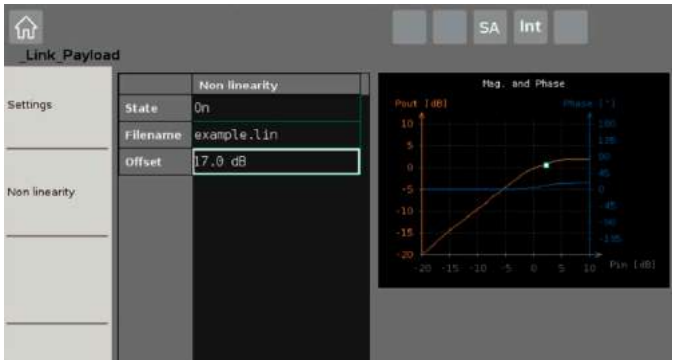

FIGURE 4: NONLINEARITY CONTROL

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.

DIGITAL SIGNAL PROCESSING

Hardware

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

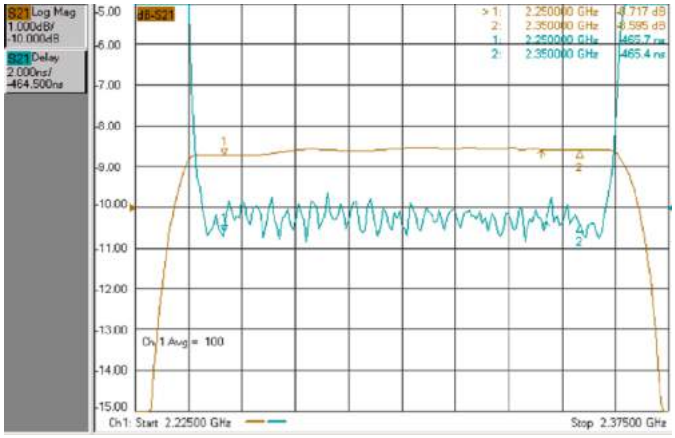

FIGURE 5: IZT C3040 GAIN AND GROUP DELAY FLATNESS

Delay

The IZT C3040 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.

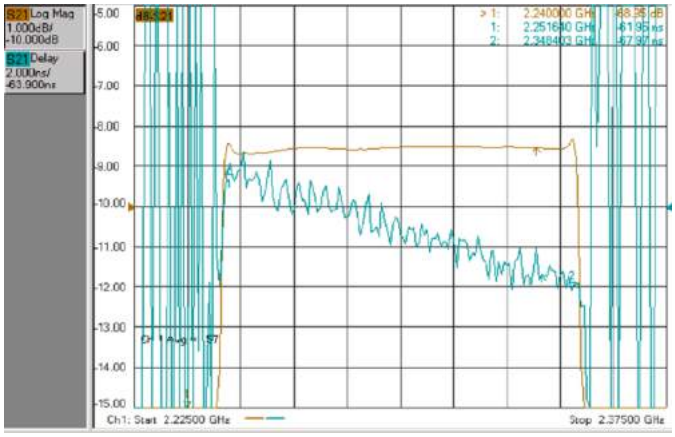

FIGURE 6: EMULATION OF THE IONOSPHERE WITH IZT C3040

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.

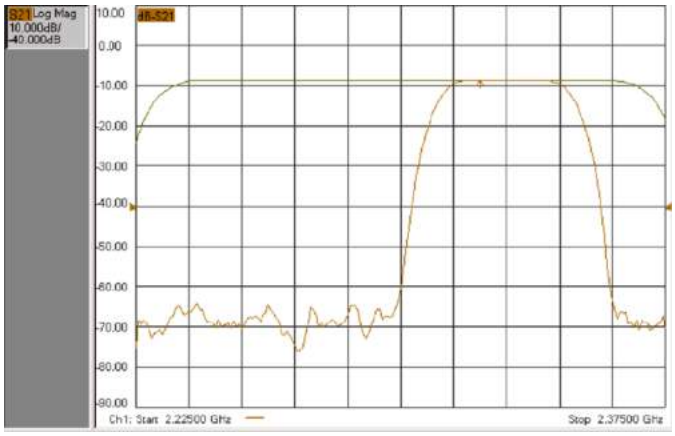

FIGURE 7: IMUX AND OMUX FILTERING

Noise and Interference

At the input of the IMUX filter and at the very end of the simulation chain, two independent noise sources and two independent Arbitrary Waveform Generators (ARB) 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 userdefined frequency band.

The IZT C3040 contains an Arbitrary Waveform Generator for emulating other traffic on the transponder, signals in adjacent bands or interference scenarios. In standard configuration, the ARB has a maximum depth of 512 megasamples (16 bit, complex). An optional memory extension increases the depth to 1536 megasamples.

The ARB can be software-configured to contain multiple banks, which the user can pre-load with different scenarios and switch during the emulation. The maximum sample rate of the ARB is 160 megasamples per second corresponding to a maximum signal bandwidth of 100 MHz. A user configurable vaiable sample rate converter allows to use lower sample rates, if desired. The center frequency and power of the ARB signal can be varied through software while the emulation is running.

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 9. The total (RMS) phase modulation is adjustable during the simulation.

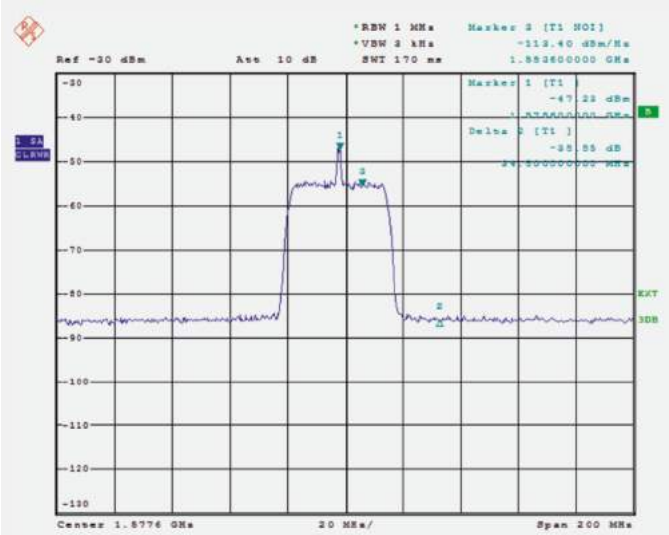

FIGURE 8: SIGNAL WITH INTERFERER

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

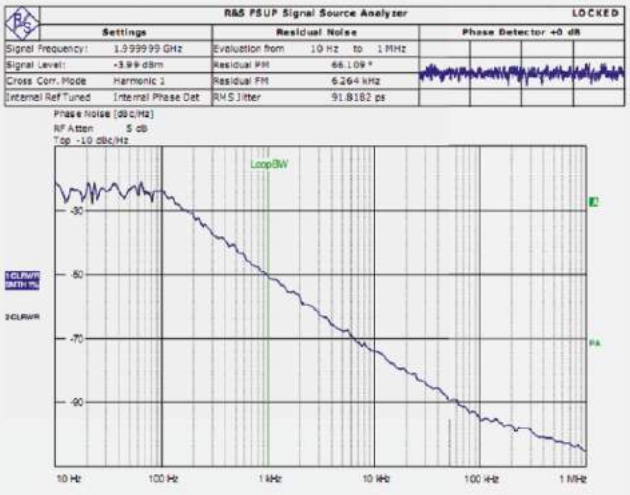

FIGURE 9: SIMULATED PHASE NOISE “DVB-S2 TYPICAL”

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.

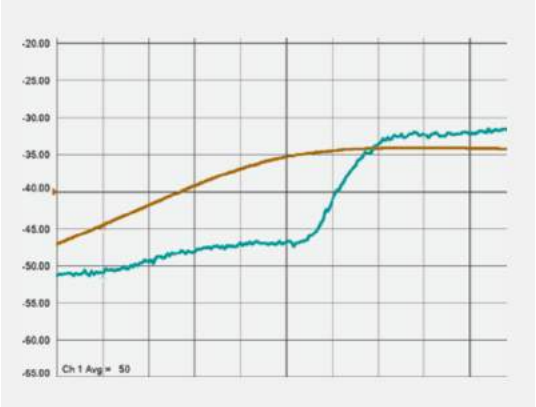

FIGURE 10: EMULATION OF PAYLOAD NONLINEARITY

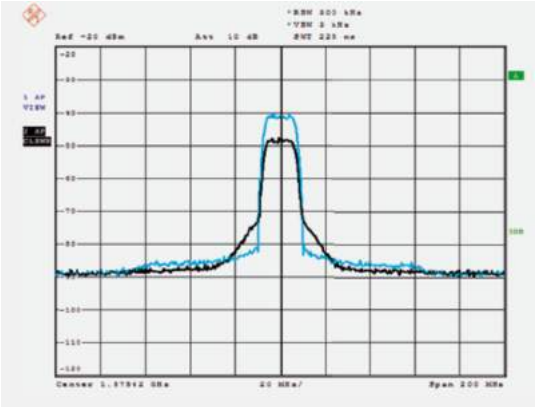

FIGURE 11: NONLINEARITY SIMULATION WITH A QAM SIGNAL

Fading Simulator

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 between 0 µs and 100 µs on top of the set link delay. Each propagation path (tap) can be processed with an individual Doppler spectrum with a maximum Doppler of ±50 kHz. Various Doppler spectra, which model 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.

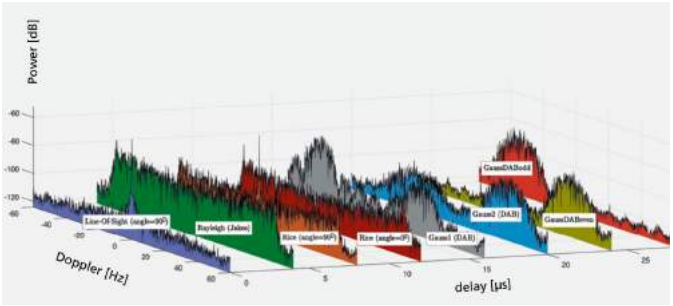

FIGURE 12: DOPPLER DELAY SPECTRUM

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.

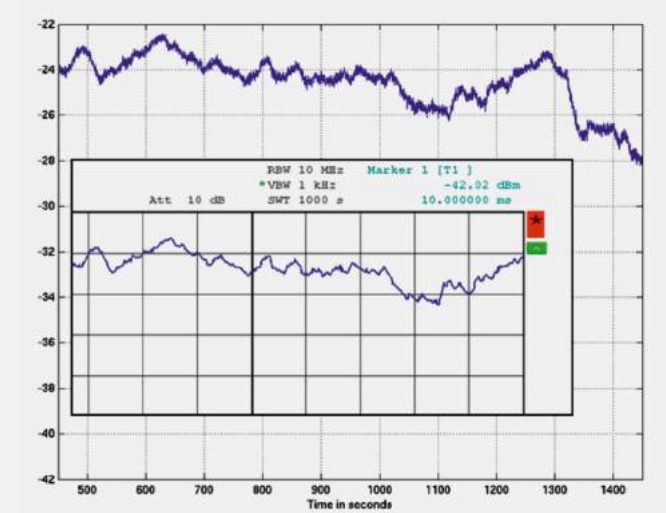

FIGURE 13: EXAMPLE OF A RAIN FADE SIMULATION

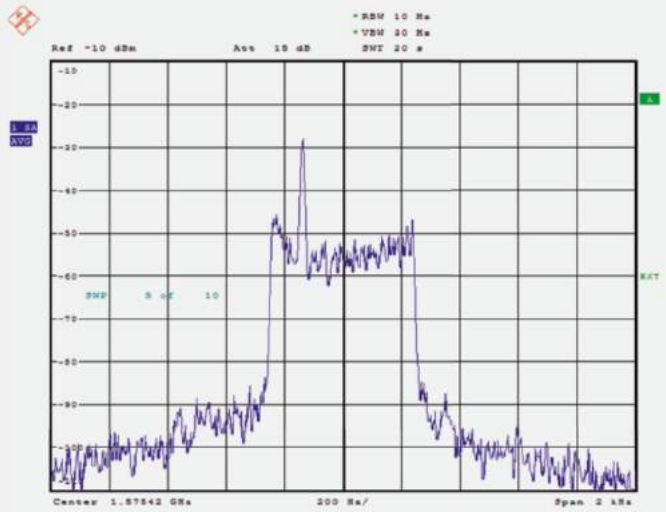

FIGURE 14: RICIAN FADING

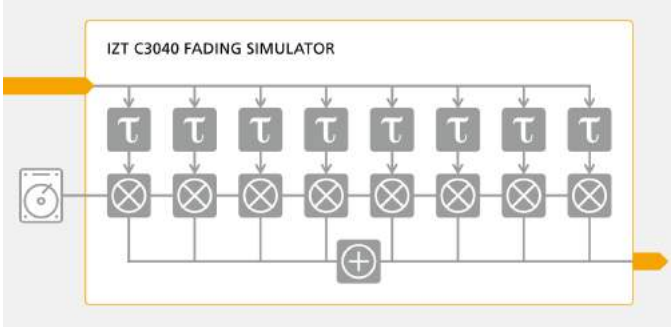

FIGURE 15: BLOCKDIAGRAM OF THE FADING SIMULATOR

Real-Time Interface

The real-time interface allows users to reconfigure one or multiple IZT C3040 precisely every 100 ms. Using a timestamp mechanism the new values for delay, frequency shift and gain are send by the user in advance (at least 250 ms before the time is reached) and will be executed by the FPGA exactly at the specified instance.

Key features of the real-time interface are:

- Reconf guration of delay, frequency shift and gain
- Reconf guration every 100 ms possible (or less if no update needed)
- Windows COM Driver allows use of RTI in C++, C#, MATLAB and others

TM1 Fading Model

This terrestrial fading model implements a two-ray multipath model (Rummler model) with 6.3 ns delay between the main (stronger) and secondary path rays. The main path may either lead (minimum phase) or lag (non minimum phase) the secondary path. Additionally the user can configure the frequency offset and depth of the so created notch. Time variant configuration of the frequency offset and the depth of the notch allow to test realistic scenarios.

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 ±0.5 dB and ±1 ns 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 16 and figure 17.

Converters and Synthesizers

The IZT C3040 can be equipped with different analogue modules.

Currently available are:

- Input module 40 MHz to 3 GHz
- Output module 40 MHz to 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.

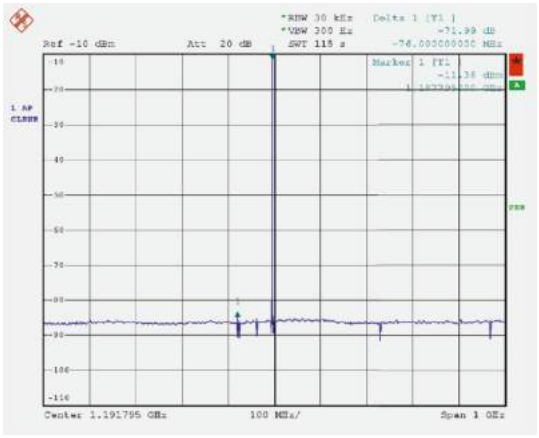

FIGURE 16: EXCELLENT SPURIOUS PERFORMANCE AND SIGNAL-TO-NOISE RATIO

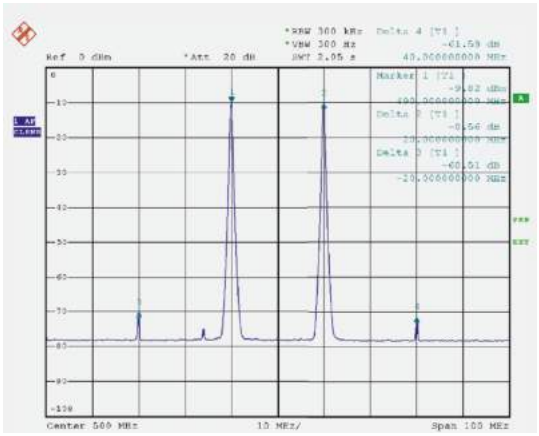

FIGURE 17: IZT C3040 THIRD ORDER INTERMODULATION PRODUCTS

Specifications

Parameter	Specification
IF frequency	240 MHz or direct sampling
RF input frequencies	40 MHz up to 3 GHz
RF output frequencies	40 MHz up to 3 GHz
1 dB instantaneous bandwidth	100 MHz
3 dB 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 – 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 refeference 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[1]	SSB phase noise L(f) Standard OCXO Low phase noise option @ 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

[1] Includes RF input stage, signal processing, and RF output stage

Parameter	Specification
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 Ω
10 MHz external reference IN stability	Same as internal reference or better
10 MHz external reference IN freq accuracy	< ±5 Hz (impact on output frequency)
10 MHz reference OUT specifcations	SSB phase noise L(f) Standard OCXO Low phase noise option @ 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 Ω
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 typical
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 confguration
External (hardware) trigger feature	Stream activation on next PPS by external command
Test scenario length[2]	Limited only by HDD space
Dynamic update rate[3]	1 kSPS for delay, frequency and gain 156.25 kSPS for fast fading
Test scenario length[4]	No limit as received from TCP/IP

[2] File based simulation
[3] File based simulation
[4] Real-time interface based simulation

Parameter	Specification
Dynamic update rate[5]	100 ms or better
IMUX filter	up to 256 complex FIR coefficients, 160 MSps
OMUX filter	up to 256 complex FIR coefficients, 160 MSps
NonInnearity	AM/AM and AM/PM, 1024 coefficients, linear interpolation
Fading Simulator	Up to 8 taps Delay 0 to 100 µs conf gurable in 0.1 ns[6] Fading characteristics from HDD with complex I/Q samples Maximum Doppler Spread ±50 kHz
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 to 25°C Maximum operating temperature: +5 to 40°C Humidity: 10 to 90 % (non-condensing) Altitude: max. 2000 m
Power supply	100 V – 240 V AC,50 Hz – 60 Hz 200 W (typical) Input current: 2 A (100 V) – 0.85 A (240 V)
Display	5 inch TFT color 1 x DBHD-15F VGA port
Dimensions (WxHxD)	19” x 3U x 570 mm
Weight	Approximately 12 kg, depending on RF module configuration

[5] Real-time interface based simulation
[6] Plus latency of all other active processing stages

Ordering Guide

Hardware Option	Description
IZT C3040-CHS	Chassis
IZT C3040-UC3	RF output 3 GHz
IZT C3040-DC3	RF input 3 GHz
IZT C3040-RFS	RF synthesizer
IZT C3040-GPIB	GPIB interface
IZT C3040-TRIG	External trigger
IZT C3040-LPN	Low phase noise
IZT CTV19	Clock distribution unit to synchronize up to six IZT C3040

Software Option	Description
IZT C3040-101	Delay
IZT C3040-104	IMUX / OMUX filter
IZT C3040-106	Profiles
IZT C3040-107	White 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 (ARB)
IZT C3040-113	Ionosphere simulation
IZT C3040-114	Spectrum display
IZT C3040-115	Rain fade
IZT C3040-116	TM1 fading model (Rummler model)
IZT C3040-117	Multipath fading
IZT C3040-118	Real-time interface

Service 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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