Channel Simulator

The Kratos Channel Simulator is a powerful, yet economical communications link simulator that addresses a broad range of IF and RF hardware-in-the-loop test, operational, and training applications.

The Channel Simulator creates RF and/or IF signals that precisely match those that occur when transmitters and receivers are in motion with respect to one another. By accurately duplicating the motion effects and RF channel physics effects on an RF link, the Channel Simulator allows bench testing of what once required actual motion and distance between a transmitter and receiver.

Channel Simulator channel effects include physics-compliant, phase-continuous, real-time carrier and signal Doppler shift, range delay, range attenuation, fading, and noise. In addition, multiple test and/or interference signals can be generated with the optional multi-channel Signal Generator. A comprehensive selection of upconverters and downconverters are also available, allowing signals to be generated or received in a wide range of frequency bands (UHF, L, S, C, X, and Ku).

The Channel Simulator enables comprehensive test and training activities without actual flights of satellites, missiles, UAVs, targets, and aircraft carrying transmitters or receivers under test. Because the Channel Simulator enables real-time, hardware-in-the-loop emulation of propagation effects rather than computer-based, off-line simulation, the Channel Simulator is the cost-effective alternative between computer-based simulation and leasing flight time or satellite bandwidth.

Advantages

The Channel Simulator is a general purpose RF/IF test and measurement instrument for communications system- and component-level testing and verification, both in the laboratory and in the field. Key applications include:

Flight/Ground System Testing

- *Satellite (LEO, GEO, MEO, Micro, Nano Pico)*
- *UAV*
- *Missile and target applications*
- *Modem, transmitter, and receiver testing*
- *Telemetry tracking system and range verification*
- *Reference signal and interference signal generation on-air or in the laboratory*
- *Training and education*

Communication System Testing

- *Compliance*
- *Performance*
- *Loopback*
- *System acceptance*
- *RF channel modes*
- *ATE*
- *Automatic self test*

Highlights

- *Applicable to communication systems based on any signal type, from CW to WLAN, FM to OFDM*
- *Flexibility in channel counts allows for simultaneous testing of one to tens of channels*

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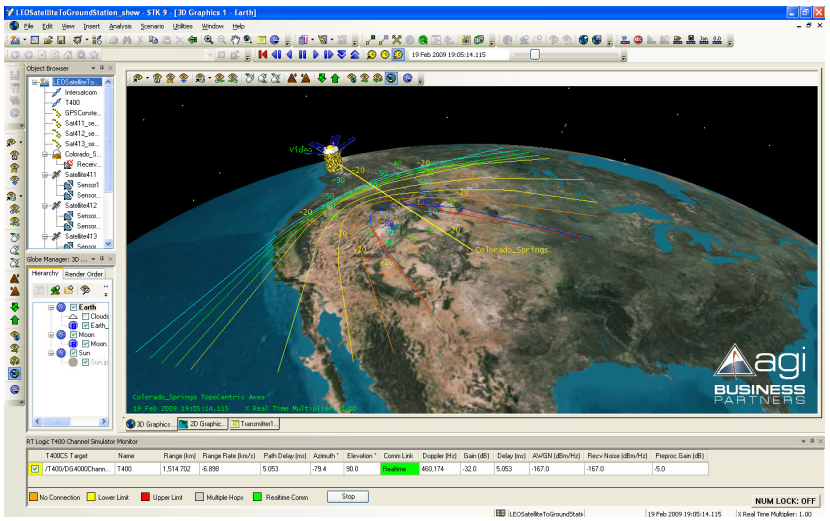
Software Architecture

The Channel Simulator client/server software architecture facilitates a wide range of local and remote control options. Local control is provided by an easy-to-use Graphical User Interface (GUI). Users can also create their own channel simulation profiles, from a comma-separated listing of RF effects values. Programmatic control capabilities include a well-documented control protocol and an optional plugin to Analytical Graphics, Inc.'s Systems Tool Kit® (STK). This provides a seamless real-time connection between the motion effects and RF modeling included in STK and Channel Simulator real-world creation of the physics-compliant channel effects.



Channel Simulator

The Channel Simulator generates physics-compliant, phase-continuous, real-time carrier and signal Doppler shift, range delay, range attenuation, fading, and Additive White Gaussian Noise (AWGN). These effects can be individually applied or in combination. Together, they precisely duplicate propagation effects encountered in LEO, MEO, HEO, and GEO satellite applications, as well as aircraft, UAV, missile, target, and range test scenarios.

When Communication Really Counts

Develop and test realistically, thoroughly, quickly, and easily, under the most punishing RF and complex motion conditions imaginable, without ever leaving the lab.

The Channel Simulator adds dynamic, phase continuous, physics-compliant signal and carrier Doppler shift, delay, path loss, noise, and interference to test signals.

Seamless Integration with AGI's STK simulation software allows the communication link parameters of a scenario to become programming parameters for hardware in-the-loop testing. Key scenario parameters include antenna properties, troposphere effects, refraction, fog, rain, clouds, body shielding, and finite ray multi-path.

The Channel Simulator low-noise, wide-bandwidth, physics-compliant RF signal path allows system testing indistinguishable from actual, ground-to-space, space-to-ground, ground-to-air, air-to-ground, and air-to-air deployment.

The Channel Simulator is a specialized single piece of test equipment that economically and efficiently replaces an assemblage of non-specialized test equipment typically utilized in communication system testing.

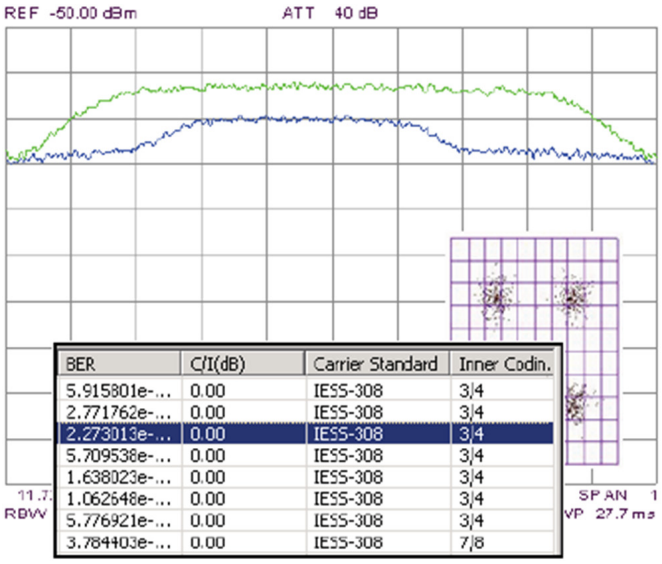
The Channel Simulator is expandable, allowing the system to cover a wide range of channel counts, functions, and frequencies. One Channel Simulator card is typically configured in a system to emulate a single communication path, for example, an uplink or a downlink. A single channel simulator card can also be used to simulate both uplink and downlink through bent-pipe transponders. When emulating a bidirectional or full duplex communication link, the Channel Simulator system is typically configured with two cards. Signal recorders/players, signal generators, and spectrum analyzers can also be included in the Channel Simulator system, further expanding its testing capabilities. The Channel Simulator can be inserted into a system under test in multiple ways, including direct cabling or utilizing amplifiers, signal conditioners, and antennas for over the air operations.

Local control of the Channel Simulator is accomplished through the use of the included GUI or simulation (SIM) files. Static control of the channel simulator can be accomplished through the GUI. SIM files are utilized for real-time recreation of signals between transmitters and receivers in motion. SIM files are created in standard Comma Separated Value (CSV) format, and can be based on range, frequency, and time information, or can be built with time, Doppler, delay, attenuation, and noise values directly. SIM files can also be created from STK reports. SIM files allow developers to build nominal, worst-case, and mission-specific scenarios, providing precise, repeatable, phase-continuous local control of the Channel Simulator.

Programmatic control of the Channel Simulator is facilitated over an Ethernet connection utilizing a control protocol or optional plugin to AGI's STK software. When using STK and the plugin as the Channel Simulator front-end control software, the Channel Simulator produces IF/RF signals with exacting signal behavior for any scenario. Kratos's STK plugin provides real-time, phase-continuous control of the Channel Simulator when playing STK scenarios. STK provides intuitive, quick visual development of communication link scenarios, without requiring user expertise in channel models, propagation effects, link budgets, or orbital/flight science. Users with expertise in these areas can utilize their own simulation software or test executive, programmatically linking with the Channel Simulator through the control protocol.

Signal Generator

The Channel Simulator provides test and/or interference signal generation capability. The Signal Generator cards are capable of producing up to eight (8) signals with independently adjustable frequency offset, modulation type, data rate, PRN code (and trigger delay), amplitude, and filtering. These signals can be used as nominal test signals, or can be configured to represent worst-case signal conditions for comprehensive receiver system testing, diversity combiner testing, jammer rejection tests, etc. These signals can also be configured as interfering signals to test avoidance/mitigation capabilities.



BER	C/I(dB)	Carrier Standard	Inner Codin.
5.915801e-...	0.00	IESS-308	3/4
2.771762e-...	0.00	IESS-308	3/4
2.273013e-...	0.00	IESS-308	3/4
5.709538e-...	0.00	IESS-308	3/4
1.638023e-...	0.00	IESS-308	3/4
1.062648e-...	0.00	IESS-308	3/4
5.776921e-...	0.00	IESS-308	3/4
3.784403e-...	0.00	IESS-308	7/8

Spectrum, Signal, and Interference Analyzer

The Channel Simulator Spectrum, Signal, and Interference Analyzer provides complete signal analysis and automated spectrum monitoring capabilities. Advanced features include display of C/No, Eb/No, BER, and C/I metrics, as well as determination of carrier standard and inner coding schemes.

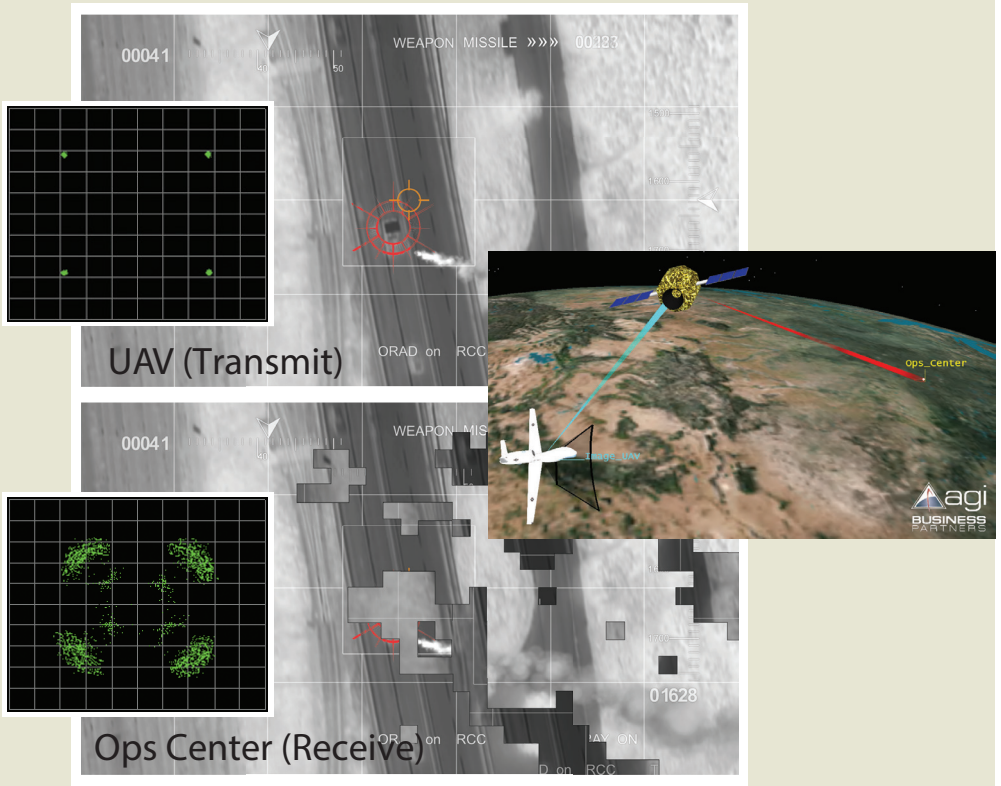
Sophisticated interference analysis processing allows identification and study of jammer, covert or accidental interference sources, and their impacts on signals of interest. Carrier-Under-Carrier analysis supports the identification and study of signals that might intentionally or unintentionally appear beneath the main signal.

Frequency Converters

RF up/downconverters are available for a wide range of input and output frequencies. This allows the Channel Simulator to generate RF signals for realistic receiver testing. Frequency up/downconverters are useful when tests need to be run at RF, and when the IF of the devices to be tested is not accessible or differs from the Channel Simulator IF. Additionally, in-house or third-party up/downcoverters can often be used in conjunction with the Channel Simulator.

Realistically Test

A UAV sensor video being relayed via satellite might be transmitted by the UAV, as shown in the top panel (UAV Transmit). This depicts good video clarity and a QPSK modulation with very low Error Vector Magnitude (EVM). The same signal, after traveling through the atmosphere and space to reach the operations center, is affected by RF channel dynamics. These effects include carrier and signal Doppler shift, delay, AWGN, atmospheric refraction, and fading. Additional perturbations include noise sources on the transponder and receiver, as well as fading components related to body shielding of the antenna and boresight pointing errors. The net impact can be degradation of the signal, as shown in the lower panel (Ops Center Receive). The QPSK modulation now has high EVM and poor video clarity. The Channel Simulator provides a simple, cost-effective means of bench-testing critical communication systems under realistic conditions. When communications really count, rely on the Channel Simulator for rigorous, realistic testing.



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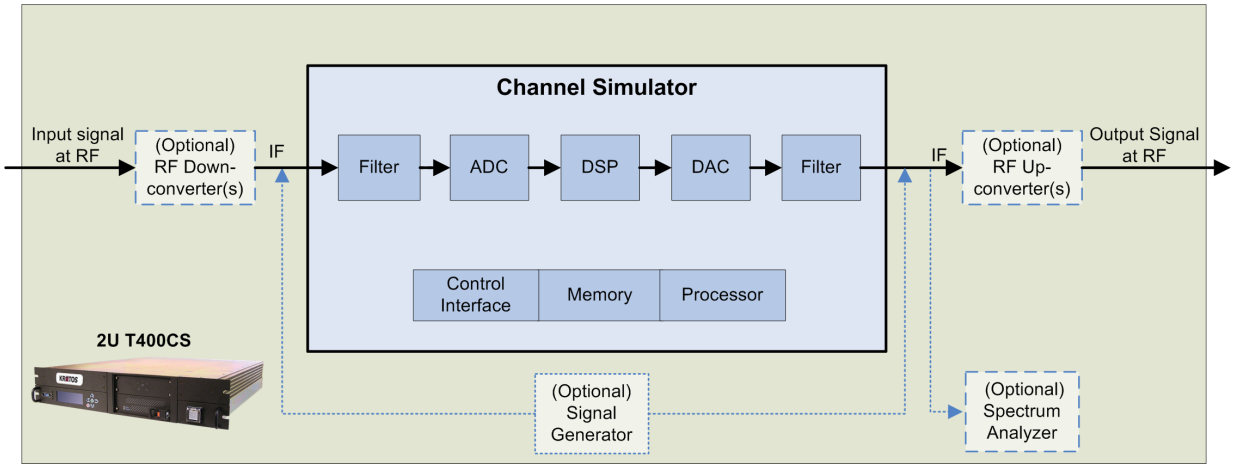
Hardware Architecture

At a high level, the Channel Simulator contains Analog-to-Digital (ADC), Digital Signal Processing (DSP), memory, and Digital-to-Analog (DAC) components, along with a processor and an external control interface. Optionally, the Channel Simulator can include:

- RF up/downconverters: Convert signals between their native frequencies and the IF used within the Channel Simulator.
- Signal Generator: Provides test and/or interference signal generation capability.
- Spectrum Analyzer: Provides signal analysis capabilities in the frequency and/or time domains.

The Channel Simulator hardware is implemented with a series of compact PCI (cPCI) modules controlled by a cPCI CPU running Microsoft® Windows® 7. The flexible architecture of the Channel Simulator allows for multiple channel simulator cards, signal generator cards, spectrum analyzers, frequency converters, etc.



Key Specifications

Channel Simulation

Bandwidth (3 dB)	40 MHz (0.5 dB flatness available)	85 MHz (0.5 dB flatness available)	250 MHz
Intermediate Frequency	70 MHz	160, 266 MHz	1200 MHz
Delay			
Range	3 µs - 1.25 s	3 µs - 1.25 s	3 µs - 2.01 s
Resolution	14 ps	14 ps	38 fs
Velocity	146.4 km/s	146.4 km/s	36.6 km/s
Phase			
Range	0-360 degrees	0-360 degrees	N/A
Carrier Doppler			
Range	+/- 20 MHz	+/- 42.5 MHz	+/- 125 MHz
Resolution	25 mHz (0.8 mHz**)	25 mHz (0.8 mHz**)	93 mHz
Signal Doppler			
Range	+/- 20.5 kHz	+/- 20.5 kHz	+/- 15.2 kHz
Attenuation			
Range	0-60 dB	0-60 dB	0-60 dB
Resolution *	0.001 dB	0.001 dB	0.001 dB
AWGN			
Range	-168 to -102 dBm/Hz	-168 to -102 dBm/Hz	-168 to -102 dBm/Hz
Resolution*	0.5 dB	0.5 dB	0.5 dB
System			
ADC	12 bits	12 bits	10 bits
DAC	16 bits	16 bits	14 bits
Complex Filter (User Programmable)	40 Tap (optional)	40 Tap (optional)	None

* typical
** in geosynchronous mode (with reduced Doppler range)
Intermediate Frequency (IF) performance stated in table. Contact Kratos for RF converter performance.

RF Frequency Coverage

Ranges available using optional Kratos upconverters and downconverters.

RF Band	Input Range	Output Range
UHF-Band	225-400 MHz	225-400 MHz
L/S-Band	900-2,450 MHz	900-2,450 MHz
C-Band	3,400-4,200 MHz	5,850-6,425 MHz
X-Band	7,250-7,750 MHz	7,900-8,400 MHz
Ku-Band	10,700-12,750 MHz	13,750-14,500 MHz

Other ranges available using non-Kratos converters.

Signal Generation

- Channels, 8 per card
- Standard modulation types, BPSK, QPSK, OQPSK, SOQPSK-TG and SOQPSK-MIL, 8PSK, 16APSK, 16QPSK, 32APSK , MSK, FSK, AM, FM, CW, PCM-FM
- Standard filter types, rectangular, raised cosine (cutoff 0.5, rolloff 0.3), root-raised cosine (cutoff 0.5, rolloff 0.3614)
- Standard PRN codes, 127, 511, 2047, 215-1, 220-1, 223-1 , PRN 01 – PRN 16, (user-selectable error injection)
- Data rates, modulation type dependent
- Frequency offset, 0 KHz ±20/42.5 MHz
- Internal and external trigger for PRN start
- Independent trigger delay per channel
- AM and FM depth controls for AM and FM modulation mode