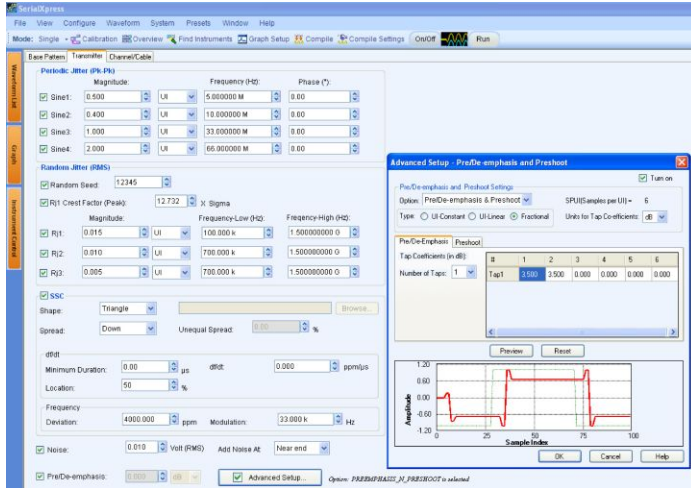# SerialXpress® Advanced Jitter Generation for AWG
SDX100, SDXUP Datasheet

SerialXpress is a powerful easy-to-use software package to synthesize high-speed serial data signals for Arbitrary Waveform Generators (AWG). It runs directly on the AWG5000/7000/70000 Series arbitrary waveform generators or from an external PC.

Key features

- **Flexibility**: Jitter generation has become so flexible that the user now has the freedom to try various permutations and combinations of jitter parameters like Pj, Rj, ISI, Noise, Delay, etc.

- **Replicate scenarios**: The signals are digitally synthesized. All AWG setups can be recalled and the scenarios can be replicated on any other AWG within seconds.

- **Analog nature of digital signals**: In reality all digital signals are analog in nature and hence SerialXpress exploits the capabilities of an AWG to generate real-world signals.

- **Ease of use**: It is easy to integrate a multitude of Sj tones into the waveforms at no additional cost. Band-limited Rj can be injected with ease.

- **Crest Factor Emulation (CFE)**: Users can now apply any amount of peak pseudo-random jitter needed to their bit patterns which can reduce test times. Test cases can be repeated accurately enabling fast receiver debug cycles. SerialXpress can also create worst-case scenarios to stress receivers by accurately controlling the Crest Factor of the random jitter.

- **Programmable pre/de-emphasis and preshoot**: Most of the next-generation standards like PCIe, 10GbE, SAS, or USB 3.0 need more than one tap for pre/de-emphasis signal generation. The SerialXpress Advanced Pre/De-emphasis feature offers the ultimate in flexibility, giving users the ability to program the pre/de-emphasis and preshoot sample by sample.

- **Channel emulation through cascaded S-parameter filter**: Touchstone files can easily be inserted to simulate the exact behavior of cable emulators, which can be again controlled and modified by adding jitter and other parameters. You can also tweak the imported touchstone file data to adjust the ISI and see how the receiver responds to those variations. The effect of the channel can also be de-embedded by selecting the Inverse filtering option. Closed EYE can be opened up by adding the right amount of pre-emphasis or by varying the rise time. You can also cascade up to 6 touchstone files to emulate a cascaded channel that might include connectors, fixtures, and channel models.

- **ISI Direct Dial-in**: ISI can be directly dialed-in at ease. It is no longer necessary to use FR4 traces which are inflexible and need frequent calibration when switching from one to another.

- **Presets**: SerialXpress supports any emerging standard data rate from 500 Kb/s to 8 Gb/s when teamed with the appropriate Tektronix AWG. There are ready-to-use presets that allow you a head-start on your testing.

- **Offline mode**: SerialXpress applications can run on an external PC, thereby reducing the time taken to synthesize large waveforms and leaving the AWG free for continued testing.

Applications

- Design, debug, characterization, and compliance testing of high-speed serial data receivers

- SATA, PCIe, SAS, DisplayPort, Fibre channel, HDMI, USB, MIPI, Receiver testing

Jitter generation made easy

SerialXpress enables creation of exact waveforms required for thorough and repeatable design validation, margin/characterization, and conformance testing of high-speed serial data receivers. It considerably simplifies the signal creation and jitter simulations, thus reducing overall development and test time.

SerialXpress supports generation of jitter (Random, Periodic (Sinusoidal), Inter Symbol Interference (ISI), and Duty Cycle Distortion (DCD)), and also supports Spread Spectrum Clocking (SSC), pre-emphasis, and noise addition. This allows the user to create a combination of various impairments simultaneously to stress the receiver. SerialXpress also allows the waveforms to be captured from Tektronix oscilloscopes and to be replayed using arbitrary waveform generators.

A programmatic interface enables easy integration of SerialXpress into test automation systems.

Scrambling, PWM, 4-PAM, and 8B/10B encoding

The input data pattern can be scrambled by defining a polynomial. The user could enable the 8b/10b encoding option if the input pattern is in 8-bit word format before applying other impairments like jitter, SSC, and ISI. Users can also define the pattern duty cycle using the Pulse Width Modulation (PWM) feature, which allows for alternatively encoding the bit stream to 4-PAM.

Jitter addition

Up to 4 different sinusoidal jitters with different amplitudes, frequencies, and phases can be added to the base pattern. Three independent band-limited random jitters can also be added to the base pattern.

SSC modulation

SSC can be added with precisely controlled profile, spread, deviation, modulation, and df/dt. It supports Triangular, Sinusoidal, and Custom SSC profiles, where the custom SSC profile allows you to import your own user-defined profile by literally allowing any kind of shape to be added as SSC to the base pattern. You can also define the exact location and duration of df/dt on the SSC slope.

Advanced emphasis

Many standards such as PCIe require the output waveform to be pre/de-emphasized. SerialXpress allows easy addition of pre/de-emphasis, including preshoot, with all other jitter parameters. Vertical noise can also be added at both near and far end of the channel.

ISI creation

SerialXpress allows creation of ISI in two ways. First, the ISI value can be directly dialed-in. Second, an S-parameter file generated from a Tektronix sampling oscilloscope or a vector network analyzer can be directly convolved with the base pattern to recreate the channel characteristics. By applying inverse filtering the effects of the channel can be de-embedded from the system. Also, ISI within the S-parameter can be scaled upward or downward, which will change the characteristics of the channel.

Delay

SerialXpress allows users to introduce delay to the waveform, and this feature can also generate skew between channels or patterns.

Base pattern

SerialXpress is bundled with several sample patterns for various standards like SATA, Display Port, SAS, PCIe, HDMI, USB, MIPI, and Fibre Channel. Patterns can also be directly entered in a Binary, Symbol, or Hex editor or loaded as a file.

Idle state

Standards like SATA call for OOB signaling which requires idle state [1] followed by a burst. Now the user can directly create this idle state without the need of using additional power dividers. Noise and offset can also be added to these idle state waveforms. Idle state can also be defined as a part of pattern definition.

Calibration

SerialXpress has a built-in calibration routine which controls a Tektronix oscilloscope and calibrates the output of the AWG for periodic jitter and random jitter, reducing the need for time-consuming manual calibration.

Bandwidth expansion filter

Rise time of the AWG can be expanded further by applying the bandwidth expansion filter. For example, when used with AWG7122C and Option 06, this compensates for the DAC roll-off at higher frequencies and extends the bandwidth up to 9 GHz.

Marker outputs

Marker outputs can be configured to be the same as the input base pattern or to generate clocks at a user-defined frequency including subdata rates.

Batch processing

When more than one pattern needs to be synthesized, you can use batch processing that enables creation of multiple waveforms with a combination of random jitter and sinusoidal jitter with a maximum of 4 different frequencies.

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[1] When idle state (z) is included in the pattern definition, no jitter is applied.

Overview window

All the jitter parameters can be switched ON/OFF from the Overview window.
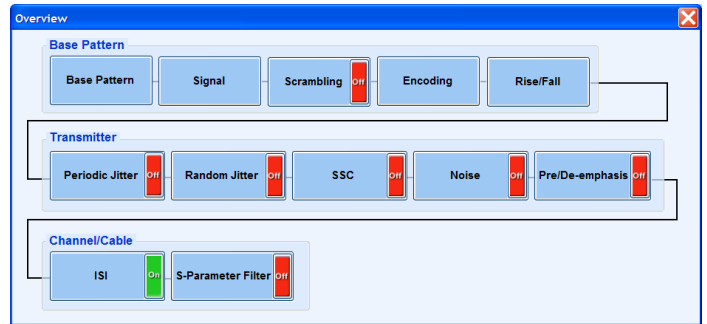
Overview window

Specifications

General

User interface	Can reside and run on Windows 7.
Compatibility for import of waveform/pattern files	Tektronix TDS6000, DSA/DPO70000, MSO70000, and DSA/DPO7000 Series oscilloscopes. Tektronix Data Timing Generators DTG5000 Series.

Instrument control

Tektronix Arbitrary Waveform Generator controls	SerialXpress® runs on an external PC or on AWG5000/7000/70000 Series arbitrary waveform generators; waveform transfer and control of the AWG5000/7000/70000 Series can be performed directly from SerialXpress
Analog	Interleave and zeroing on/off, DAC resolution, sampling frequency, amplitude, offset, run, stop, and channel output on/off
Digital markers	Amplitude high, low, and delay
Tektronix oscilloscope controls	Remote control Tektronix oscilloscope parameters from SerialXpress
General settings	Run, stop, single, and autoset
Vertical settings	Channel, scale
Horizontal settings	Scale, record length, sampling rate

SerialXpress for jitter creation

Mode	Single, sequence
Base data standard patterns	
SATA	Idle state, LFTP, MFTP, HFTP, SFCPAlignR12, SFCPAlignR12-badbit, Gen1R12FCP4A, Gen1R25FCP4A, Gen1R10FCP2AnewLBP, Gen1R10FCP2AnewLBPErr, Gen2R8FCP2AnewLBP, Gen2R8FCP2AnewLBPErr, LTDP RD-, LTDP RD+, HTDP RD-, HTDP RD+, LFSCP RD-, LFSCP RD+, SSOP RD-, SSOP RD+, LBP, COMP RD-, COMP RD+
PCIe	Compliance pattern
SAS	CJTPAT, JTPAT RD+, JTPAT RD-
Display port	PRBS7, D24.3, D10.2, frequency lock, and symbol lock
HDMI	480P Gray RGB, 720P Gray RGB, 1080P 8-bit Gray RGB, 1080P 10-bit Gray RGB, 1080P 12-bit Gray RGB
Fibre channel	JTPAT, CJTPAT, SPAT, CSPAT
USB	minadd1N, minadd1P, TSEQ, CPO, CP1, CP2, CP3, CP4, CP6, CP8, BERC, BRST
MIPI	CJTPAT_FC, Clock
General	Clock, PRBS (7, 9, 15, 16, user defined)
File input	Annotated .txt - Binary (1, 0, z) and Symbol (D, K, z words) [2]
Pattern editor	Binary, hex, symbol
Data rate	500 Kb/s to 8 Gb/s (direct synthesis with ×3 oversampling) and 12 Gb/s (binary data with ×2 oversampling)
Encoding	NRZ, NRZI, 4-PAM [3], 8B/10B with starting disparity RD+, RD-

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[2] "z" represents the idle state in a pattern definition.

[3] 4-PAM and PWM are mutually exclusive.

SerialXpress for jitter creation

Pulse width modulation	On/Off
T_Minor	0 to 0.5 UI
Rise time	10/90, 20/80
	1/sampling rate to 1/data rate
DCD	0 to 1 UI
Periodic jitter	Up to a maximum of 4 sinusoidal jitter
Amplitude	0 to 50 UI
Frequency	10 kHz to data rate/2
Phase	0 to 360 degrees
Random jitter	Up to max of 3 (Rj1, Rj2, and Rj3) with random seed on/off
Amplitude	0 to 0.5 UI
Frequency	1 Hz to data rate/2
Crest factor	1 to 20
Idle state	53 nS to 100 µS
Offset	-0.5 V to +0.5 V
SSC	
Shape	Triangle, sinusoidal, custom
Spread	Up, down, center, unequal (0 to 100%)
df/dt	0 to 5000 ppm/µs

Minimum duration	Location
0 to 5 µs	20% to 80%

Frequency deviation	0 to 200,000 ppm
Frequency modulation	0 to 500 kHz
Noise	0 to 100 ppm
Vertical noise	0 to 0.5 V_{RMS} with far end or near end
Pre/De-emphasis	0 to 20 dB
Advanced pre/de-emphasis	On/Off
Options	Pre/de-emphasis, preshoot, pre/de-emphasis and preshoot
Type	UI-constant, UI-linear, fractional
Units for tap co-efficients	dB, Volts
Delay	0 to 50 ps
ISI direct dial-in	0 to 1 UI
S-parameter	
Mode	Noncascading, cascading (6 max)
Filter bandwidth	None, auto, and custom
Plot frequency response	On/Off
File formats	s1p, s2p, s4p, and s8p (single-ended and differential)

Datasheet

SerialXpress for jitter creation

ISI scaling 0 to 10

Inverse filter (de-embed) On/Off

Aggressor	Signal	Amplitude scale	Data rate	Direction	Swap aggressor and victim
Enabled when s8p touchstone file is selected	Pattern from file, clock, same as victim	0 to 5	500 Kb/s to 12 Gb/s	Same as victim, opposite to victim	On/Off

Presets SATA Gen1, Gen2, Gen3

USB 3.0

Display port HBR, RBR

HDMI 27 MHz, 222 MHz, 74.25 MHz, and 148.5 MHz at 60 Hz

Batch processing

Random jitter 0 to 0.5 UI with 0.01 increments

Sinusoidal jitter 0 to 50 UI with 0.01 increments

Sinusoidal frequency 10 kHz to data rate/2 (max of 4 frequencies)

Bandwidth enhancement filter On/Off

Calibration Periodic jitter, random jitter

Marker setting base pattern

Clock frequency Data rate, data rate/2, data rate/4, data rate/8, user defined (in Hz)

Graphs DPO EYE

Normal EYE

Rise/fall time

Simulated data

Random, periodic, and total jitter

Jitter summary

TIE spectrum

System requirements

The following PC configuration is required to install the offline version:

Note: The hardware requirements detailed here are the minimum required. Additional processing power and memory will increase the performance of the generation software.

PC Genuine Intel Pentium class >1.2 GHz processor recommended

Motherboard chip set Intel or 100% compatible

Operating system Windows 7

RAM 1 Gigabytes (GB)

Hard disk space 2 GB of available space for the applications and documentation

Display XVGA 1024×768 with 120 dpi font size recommended

Media drive CD-ROM or DVD

Accessories Keyboard and Microsoft mouse or compatible pointing device

System requirements

Ordering information

Models

SerialXpress®   Jitter Generation Software Package for Tektronix AWG5000/7000/70000 Series.

                                         Includes: USB dongle

Software packages and options

SDX100   Jitter Generation Software Package for the AWG5000/7000/70000 Series (includes USB dongle)

    Option ISI   Include S-parameter and ISI creation (requires SDX100 as prerequisite)

    Option SSC   Include Spread Spectrum Clock (requires SDX100 as prerequisite)

Upgrade options

SDXUP   Base software upgrade for SDX100

    Option ISI   Upgrade to include S-parameter and ISI creation option for SDX100

    Option SSC   Upgrade to include Spread Spectrum Clock option for SDX100

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tektronix.com.

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