

# LE160 LE320 Linear Equalizer Datasheet

## Tektronix Linear Equalizer



32 Gbps 2 Channel Linear Equalizer (LE320)

### Key performance specifications

- Supports signal equalization on data rates from 8 Gbps to 32 Gbps
- 20 dB automatic or manual gain Control
- Integrated variable gain amplifier with differential 50 mV sensitivity

### Key features

- Clock-less design transfers incident signal impairments to outputs. No clock to data alignment concerns.
- 9 user adjustable fixed width taps spaced 18 ps apart on the LE320 and 24 ps apart on the LE160.
- Fixed tap delay design eliminates external reference clock requirements.
- USB programmable receiver gain and multi UI equalization allows 20 dB of equalization.
- USB programmable channel modeling allows electronic channel emulation.
- USB programmable pre-emphasis and differential outputs amplitude well in excess of 2 V differential.
- USB programmable output duty cycle symmetry control.
- Precision output level controls permit signaling from "0" (Return to Zero) well in excess of 2 V differentially.
- User defined presets and stored configurations tailored for key technologies.

### Applications

- OIF-CEI-28G
- 100G-KR4, -CR4
- InfiniBand QDR, FDR, EDR
- FC16, FC32

### Receiver testing at all signal speeds

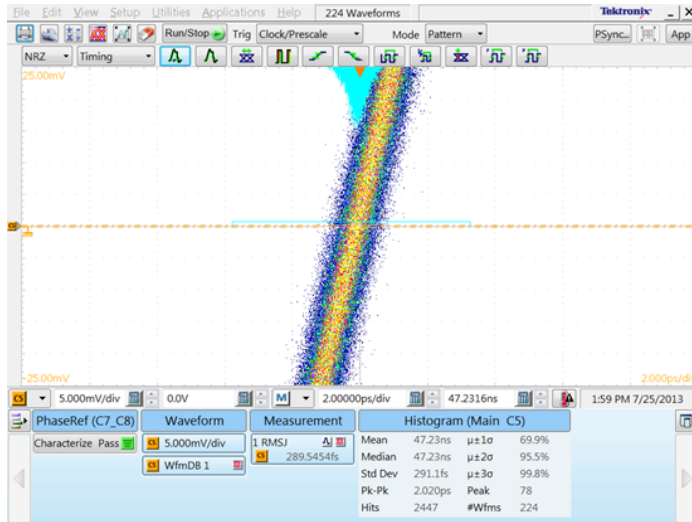
Receiver testing at signaling speeds above 8 Gbps requires precise attention to signal conditioning and equalization. Multi-Tap pre-emphasis is a common requirement where a pre-cursor, main-cursor and post-cursor controls are called out by receiver specifications. The LE320 and LE160 offer flexible controls permitting the user to tune these levels of pre-emphasis as needed for 100 G standards.

Multi-generational speeds require characterizing receivers against a wide array of physical channel loss profiles, which typically involves stocking up an array of backplanes or specialized reference channels. The flexible 9-tap filter configuration of the LE320 and LE160 can be structured to model a full passive frequency dependent loss profile. These profiles (loss or gain) can be stored and recalled electronically to facilitate silicon test under a broad set of conditions without the overhead of having many physical reference channels to test against.

The dynamic range of these linear equalizer output allows a user to apply precision output controls to regulate the amplitude from 2.7 V (differential peak to peak) to 0 V with a special output (Return to zero) mode of operation permitting continuous or burst mode tri-state signaling found in various power and state management applications such as LFPS or OOB measurements. These structured return to zero operations are key to power management state and link state training capabilities.

## Jitter addition

Random jitter addition of the LE320/LE160 is below key limits allowed by various 100G standards. Offering high precision levels of RMS Random jitter ( $<300 \text{ fs}_{\text{RMS}}$ ) permits usage in demanding 100G receiver testing programs.

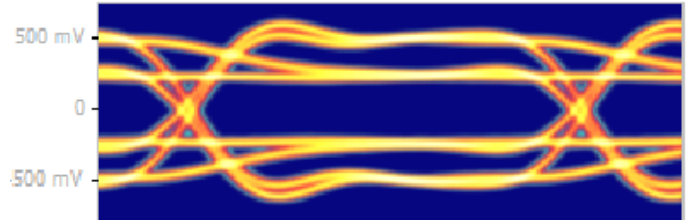


This data set shows that RMS RJ as measured on a PRBS-7 pattern is within typical 100 G operating limits (taken with a Tektronix DSA8300 with 50 GHz 80E09 sampling heads, with a 80A04 60 GHz Phase reference module).

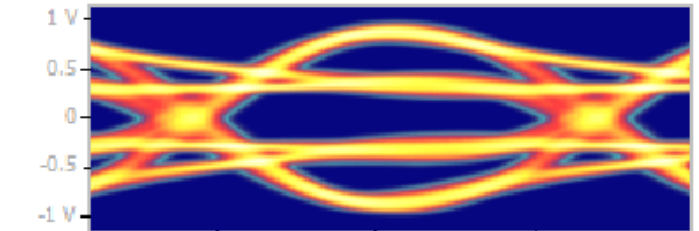
- RJ RMS  $< 300 \text{ fs}$  under optimized conditions<sup>1</sup>
- DDJ ptp  $< 6 \text{ ps}$  under optimized conditions<sup>1</sup>
- Rise/Fall time  $15 \text{ ps}$  (typical)

## Operational examples

The following illustrations show operational examples:



10 Gbps 40G-KR4



25.8 Gbps 100G-KR4

<sup>1</sup> Additive Jitter. The LE320/LE160 can be configured to many conditions resulting in increased Data Dependent Jitter (DDJ) and Random Jitter (Rj), for example in a backplane emulation configuration. The LE320 can be tuned to have  $< 300 \text{ fs}$  RJ RMS and  $< 6 \text{ ps}$  of DDJ.

# Specifications

All specifications apply to all models unless noted otherwise.

## Data input (single-ended)

<b>Number of taps</b>	9 physical taps standard with four time-domain mapped taps depending on the data rate.
<b>Operating data rate range</b>	LE160, 4 Gb/s to 21 Gb/s LE320, 8 Gb/s to 32 Gb/s <sup>2</sup>
<b>Coupling</b>	AC coupled
<b>Maximum data input level</b>	800 mV <sub>p-p</sub> (typical) The maximum input signal level acceptable to the data input for proper operation. Not the input damage level.
<b>Data input sensitivity</b>	40 mV <sub>p-p</sub> (typical) The minimum input signal level acceptable to the data input for proper operation
<b>Data input termination</b>	100 Ω differential 50 Ω single-ended
<b>Connector type</b>	2.92 mm female
<b>Input return loss</b>	(typical)
<b>LE160</b>	10 dB RL 0.2 to 7 GHz 5 dB RL > 7 GHz to 30 GHz
<b>LE320</b>	10 dB RL 0.2 to 7 GHz 5 dB RL > 7 GHz to 30 GHz

## Data output (differential)

<b>Minimum settable amplitude range (DP/DN)</b>	0 mV <sub>p-p</sub> to 2000 mV <sub>p-p</sub> maximum differential Pattern: 1100, taps set for flat loss
<b>Settable amplitude resolution</b>	0.15 dB (typical)
<b>Coupling</b>	AC coupled
<b>Skew between DP and DN</b>	<2 ps (typical), 4 ps (specified), taps set for flat frequency response
<b>Additive random jitter</b>	
<b>LE160</b>	220 fs <sub>RMS</sub> (typical), input pattern 1100 <sup>3</sup>
<b>LE320</b>	300 fs <sub>RMS</sub> (typical), input pattern 1100 <sup>3</sup>
<b>Tap range</b>	-63 to +63 tap settings
<b>Tap resolution</b>	1.6%, any tap

<sup>2</sup> Operation down to 8 Gbps is supported with single tap response.

<sup>3</sup> Additive Jitter. The LE320/LE160 can be configured to many conditions resulting in increased Data Dependent Jitter (DDJ) and Random Jitter (Rj), for example in a backplane emulation configuration. The LE320 can be tuned to have < 300 fs RJ RMS and < 6 ps of DDJ.

# Datasheet

## Data output (differential)

<b>Connector type</b>	2.92 mm, female
<b>Zero output state timing constant</b>	$\pm 600$ mV, single ended signaling level to 0 V $\pm 10$ mV in $\leq 40$ UI = 2.9 ns; idle state (fall time after enable asserted)
<b>Consecutive run length amplitude droop</b>	<10 % maximum droop (typical)

## Physical characteristics

Dimensions are with bumpers attached.

<b>Height</b>	4.01 cm (1.58 in.)
<b>Width</b>	12.62 cm (4.97 in.)
<b>Depth</b>	9.02 cm (3.55 in.)
<b>Weight</b>	0.34 kg (12 oz.)

## Control interface

<b>Computer programmable interface</b>	USB, program all interface settings
--	-------------------------------------

## Ordering information

### Models

LE320	32 Gbs Linear Equalizer
LE160	16 Gbs Linear Equalizer

### Standard accessories

119-7836-xx	AC power adapter
174-6106-xx	USB cable, USB-A to Mini USB-B for PC connection
174-6362-xx	Two (2) 6-in coaxial cables, K male to K male, for LE to DUT connection
174-5969-xx	1 m coaxial cable, phase-matched pair

### Instrument options

#### Instrument options

LE320 Option CDS	Adds channel design software
LE320 Option SPM	Adds S-parameter channel modeler
LE160 Option CDS	Adds channel design software
LE160 Option SPM	Adds S-parameter channel modeler

#### Power plug options

Opt. A0	North America power plug (115 V, 60 Hz)
Opt. A1	Universal Euro power plug (220 V, 50 Hz)
Opt. A2	United Kingdom power plug (240 V, 50 Hz)
Opt. A3	Australia power plug (240 V, 50 Hz)
Opt. A4	North America power plug (240 V, 50 Hz)
Opt. A5	Switzerland power plug (220 V, 50 Hz)
Opt. A6	Japan power plug (100 V, 50/60 Hz)
Opt. A10	China power plug (50 Hz)
Opt. A11	India power plug (50 Hz)

## Service options

<b>Opt. C3</b>	Calibration Service 3 Years
<b>Opt. C5</b>	Calibration Service 5 Years
<b>Opt. D1</b>	Calibration Data Report
<b>Opt. D3</b>	Calibration Data Report 3 Years (with Opt. C3)
<b>Opt. D5</b>	Calibration Data Report 5 Years (with Opt. C5)
<b>Opt. R3</b>	Repair Service 3 Years (including warranty)
<b>Opt. R5</b>	Repair Service 5 Years (including warranty)
<b>Opt. R3DW</b>	Repair Service Coverage 3 Years (includes product warranty period). 3-year period starts at time of instrument purchase
<b>Opt. R5DW</b>	Repair Service Coverage 5 Years (includes product warranty period). 5-year period starts at time of instrument purchase

**ASEAN / Australasia** (65) 6356 3900  
**Belgium** 00800 2255 4835\*  
**Central East Europe and the Baltics** +41 52 675 3777  
**Finland** +41 52 675 3777  
**Hong Kong** 400 820 5835  
**Japan** 81 (3) 6714 3010  
**Middle East, Asia, and North Africa** +41 52 675 3777  
**People's Republic of China** 400 820 5835  
**Republic of Korea** 001 800 8255 2835  
**Spain** 00800 2255 4835\*  
**Taiwan** 886 (2) 2722 9622

**Austria** 00800 2255 4835\*  
**Brazil** +55 (11) 3759 7627  
**Central Europe & Greece** +41 52 675 3777  
**France** 00800 2255 4835\*  
**India** 000 800 650 1835  
**Luxembourg** +41 52 675 3777  
**The Netherlands** 00800 2255 4835\*  
**Poland** +41 52 675 3777  
**Russia & CIS** +7 (495) 6647564  
**Sweden** 00800 2255 4835\*  
**United Kingdom & Ireland** 00800 2255 4835\*

**Balkans, Israel, South Africa and other ISE Countries** +41 52 675 3777  
**Canada** 1 800 833 9200  
**Denmark** +45 80 88 1401  
**Germany** 00800 2255 4835\*  
**Italy** 00800 2255 4835\*  
**Mexico, Central/South America & Caribbean** 52 (55) 56 04 50 90  
**Norway** 800 16098  
**Portugal** 80 08 12370  
**South Africa** +41 52 675 3777  
**Switzerland** 00800 2255 4835\*  
**USA** 1 800 833 9200

\* European toll-free number. If not accessible, call: +41 52 675 3777

Updated 10 April 2013

**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](http://www.tektronix.com).

Copyright © Tektronix, Inc. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specification and price change privileges reserved. TEKTRONIX and TEK are registered trademarks of Tektronix, Inc. All other trade names referenced are the service marks, trademarks, or registered trademarks of their respective companies.



26 Sep 2014

65W-29484-2

[www.tektronix.com](http://www.tektronix.com)

**Tektronix**<sup>®</sup>

