

LMH1219 Low Power 12G UHD Adaptive Cable Equalizer with Integrated Reclocker

1 Features

- Supports ST-2082-1(12G), ST-2081-1(6G), ST-424(3G), ST-292(HD), and ST-259(SD)
- Supports SFF8431 (SFP+) for SMPTE 2022-5/6
- Compatible with DVB-ASI and AES10 (MADI)
- Integrated Reference-Less Reclocker Locks to SMPTE and 10GbE Rate: 11.88 Gbps, 5.94 Gbps, 2.97 Gbps, 1.485 Gbps, or Divide-by-1.001 Sub-Rates, 270 Mbps and 10.3125 Gbps
- Adaptive Cable Equalizer at Input 0 (IN0)
- Cable Reach (Belden 1694A):
 - 75 m at 11.88 Gbps (4Kp60 UHD)
 - 120 m at 5.94 Gbps (UHD)
 - 200 m at 2.97 Gbps (FHD)
 - 280 m at 1.485 Gbps (HD)
 - 600 m at 270 Mbps (SD)
- Adaptive Board Trace Equalizer at Input 1 (IN1)
- Low Power: 250 mW (Typical)
- Power Saving Mode: 16 mW
- Integrated Input Return Loss Network
- 2:1 Input Mux, 1:2 Fanout Output With De-Emphasis
- Supports Signal Splitter Mode (–6 dB Launch Amplitude)
- On-Chip Loop Filter Capacitor and Eye Monitor
- Powers from Single 2.5 V with On-Chip 1.8 V Regulator
- Configurable by Control Pins, SPI, or SMBus Interface
- 4 mm × 4 mm 24-pin QFN Package
- Operating Temperature Range: –40°C to +85°C

2 Applications

- SMPTE Compatible Serial Digital Interface
- UHDTV/4K/8K/HDTV/SDTV Video
- Broadcast Video Routers, Switchers, Distribution Amplifiers, and Monitors
- Digital Video Processing and Editing
- 10 GbE - SDI Media Gateway

3 Description

The LMH1219 is a low-power, dual-input and dual-output, adaptive equalizer with integrated reclocker. It supports SMPTE video rates up to 11.88 Gbps and 10 GbE video over IP, enabling UHD video for 4K/8K applications. An extended reach adaptive cable equalizer at IN0 is designed to equalize data transmitted over 75 Ω coaxial cable and operates over a wide range of data rates from 125 Mbps to 11.88 Gbps. An adaptive board trace equalizer at IN1 is SFF-8431 compatible and supports both SMPTE and 10 GbE data rates.

The integrated reclocker attenuates high frequency jitter and provides the best signal integrity. High input jitter tolerance of the reclocker improves timing margin. The reclocker has a built-in loop filter, and operates without the need of a precision input reference clock. A non-disruptive eye monitor allows real time measurement of the serial data to simplify system debug and accelerate board bring-up.

The integrated 2:1 Mux and 1:2 Fanout provide flexibility for multiple video signals. The output drivers offer programmable de-emphasis to compensate board trace losses at its outputs. The integrated return loss network meets stringent SMPTE specifications across all data rates. The typical power consumption of LMH1219 is 250 mW. In the absence of input signal, power is further reduced to 16 mW.

The LMH1219 is pin compatible to LMH1226 (12G UHD reclocker) and LMH0324 (3G adaptive cable equalizer).

Device Information⁽¹⁾

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|-------------|----------|-------------------|
| LMH1219 | QFN (24) | 4.00 mm × 4.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Block Diagram

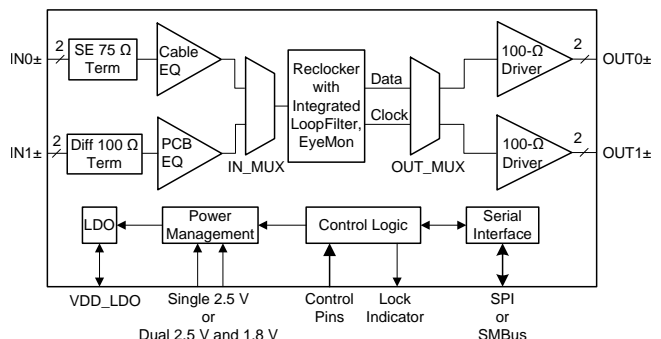


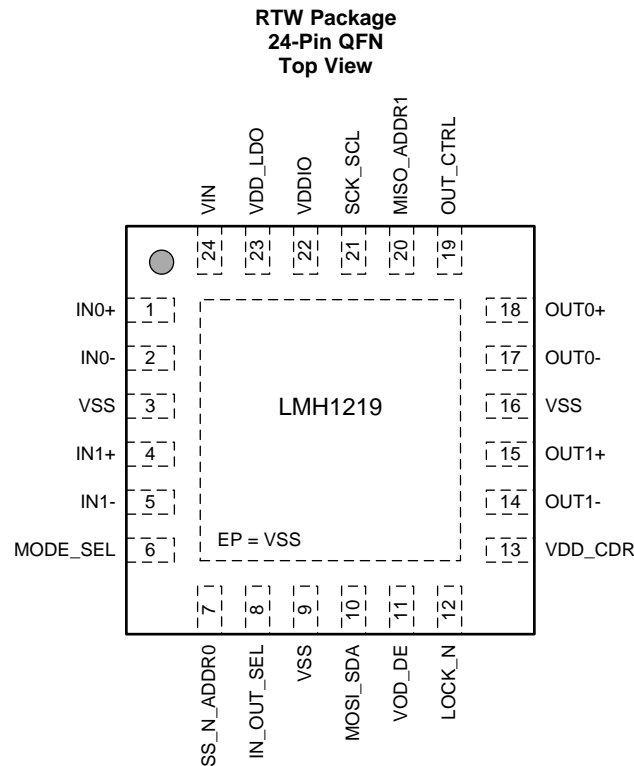
Table of Contents

| | | | |
|--|-----------|--|-----------|
| 1 Features | 1 | 7.3 Feature Description | 17 |
| 2 Applications | 1 | 7.4 Device Functional Modes | 22 |
| 3 Description | 1 | 7.5 LMH1219 Register Map | 27 |
| 4 Revision History | 2 | 8 Application and Implementation | 40 |
| 5 Pin Configuration and Functions | 3 | 8.1 Application Information | 40 |
| 6 Specifications | 5 | 8.2 Typical Application | 40 |
| 6.1 Absolute Maximum Ratings | 5 | 9 Power Supply Recommendations | 47 |
| 6.2 ESD Ratings | 5 | 10 Layout | 47 |
| 6.3 Recommended Operating Conditions | 5 | 10.1 PCB Layout Guidelines | 47 |
| 6.4 Thermal Information | 6 | 10.2 Layout Example | 49 |
| 6.5 Electrical Characteristics | 6 | 11 Device and Documentation Support | 50 |
| 6.6 Recommended SMBus Interface AC Timing Specifications | 12 | 11.1 Receiving Notification of Documentation Updates | 50 |
| 6.7 Serial Parallel Interface (SPI) AC Timing Specifications | 13 | 11.2 Community Resources | 50 |
| 6.8 Typical Characteristics | 14 | 11.3 Trademarks | 50 |
| 7 Detailed Description | 16 | 11.4 Electrostatic Discharge Caution | 50 |
| 7.1 Overview | 16 | 11.5 Glossary | 50 |
| 7.2 Functional Block Diagram | 16 | 12 Mechanical, Packaging, and Orderable Information | 50 |

4 Revision History

| | |
|---|-------------|
| Changes from Revision C (October 2017) to Revision D | Page |
| • First public release of full production data sheet; add top navigator link for TI reference design | 1 |
| • Moved LMH1219 and LMH0324 Compatibility to Application Information | 40 |
| Changes from Revision B (February 2017) to Revision C | Page |
| • add package drawings | 50 |
| Changes from Revision A (May 2016) to Revision B | Page |
| • Changed eq_en_bypass bit description from "Gain Stages 3 and 4" to "Gain Stages 2 and 3" | 29 |
| • Changed bit location of IN1 Carrier Detect Power Down Control from Reg 0x13[5] to Reg 0x15[6] | 29 |
| Changes from Original (April 2016) to Revision A | Page |
| • Deleted min and max VOD_DE amplitude specification when VOD_DE = Level F | 9 |
| • Changed typical VOD_DE amplitude specifications for Levels F, R, and L | 9 |
| • Changed DEM value and DEM register settings in Table 5 to match correct VOD_DE pin logic levels | 20 |
| • Added new row for VOD = 5, DEM = 5 setting in Table 10 | 43 |

5 Pin Configuration and Functions



Pin Functions

| PIN | | I/O ⁽¹⁾ | DESCRIPTION |
|-------------------------------|-----|--------------------|--|
| NAME | NO. | | |
| High Speed Differential I/O'S | | | |
| IN0+ | 1 | I, Analog | Single-ended complementary inputs, 75-Ω internal termination from IN0+ or IN0- to internal common mode voltage and return loss compensation network. Requires external 4.7-μF AC coupling capacitors. IN0+ is the 75-Ω input port for the adaptive cable equalizer in SMPTE video applications. |
| IN0- | 2 | I, Analog | |
| IN1+ | 4 | I, Analog | Differential complementary inputs with internal 100-Ω termination. Requires external 4.7-μF AC coupling capacitors for SMPTE and 10 GbE. |
| IN1- | 5 | I, Analog | |
| OUT0+ | 18 | O, Analog | Differential complementary outputs with 100-Ω internal termination. Requires external 4.7-μF AC coupling capacitors. Output driver OUT0± can be disabled under user control. |
| OUT0- | 17 | O, Analog | |
| OUT1+ | 15 | O, Analog | Differential complementary outputs with 100-Ω internal termination. Requires external 4.7-μF AC coupling capacitors. Output driver OUT1± can be disabled under user control. |
| OUT1- | 14 | O, Analog | |
| Control Pins | | | |
| LOCK_N | 12 | O, LVCMOS, OD | LOCK_N is the reclocker lock indicator for the selected input. LOCK_N is pulled LOW when the reclocker has acquired locking condition. LOCK_N is an open drain output, 3.3 V tolerant, and requires an external 2-kΩ to 5-kΩ pull-up resistor to logic supply. LOCK_N pin can be re-configured to indicate CD_N (Carrier Detect) or INT_N (Interrupt) for IN0 or IN1 through register programming. |
| IN_OUT_SEL | 8 | I, 4-LEVEL | IN_OUT_SEL selects the signal flow at input ports to output ports. See Table 2 for details. This pin setting can be overridden by register control. |
| OUT_CTRL | 19 | I, 4-LEVEL | OUT_CTRL selects the signal flow from the selected IN port to OUT0± and OUT1±. It selects reclocked data, reclocked data and clock, bypassed reclocker data (equalized data to output driver), or bypassed equalizer and reclocker data. See Table 4 for details. This pin setting can be overridden by register control. |

(1) I = Input, O = Output, IO = Input or Output, OD = Open Drain, LVCMOS = 2-State Logic, 4-LEVEL = 4-State Logic

Pin Functions (continued)

| PIN | | I/O ⁽¹⁾ | DESCRIPTION |
|--|----------|--------------------|---|
| NAME | NO. | | |
| VOD_DE | 11 | I, 4-LEVEL | VOD_DE selects the driver output amplitude and de-emphasis level for both OUT0± and OUT1±. See Table 5 for details. This pin setting can be overridden by register control. |
| MODE_SEL | 6 | I, 4-LEVEL | MODE_SEL enables SPI or SMBus serial control interface. See Table 6 for details. |
| Serial Control Interface (SPI Mode), MODE_SEL = F (Float) | | | |
| SS_N | 7 | I, LVCMOS | SS_N is the Slave Select. When SS_N is at logic Low, it enables SPI access to the LMH1219 slave device. SS_N is a LVCMOS input referenced to VDDIO. |
| MISO | 20 | O, LVCMOS | MISO is the SPI control serial data output from the LMH1219 slave device. MISO is a LVCMOS output referenced to VDDIO. |
| MOSI | 10 | I, LVCMOS | MOSI is used as the SPI control serial data input to the LMH1219 slave device. MOSI is LVCMOS input referenced to VDDIO. |
| SCK | 21 | I, LVCMOS | SCK is the SPI serial input clock to the LMH1219 slave device. SCK is LVCMOS referenced to VDDIO. |
| Serial Control Interface (SMBus MODE), MODE_SEL = L (1 kΩ to VSS) | | | |
| ADDR0 | 7 | Strap, 4-LEVEL | ADDR[1:0] are SMBus address straps to select one of the 16 supported SMBus addresses. ADDR[1:0] are 4-level straps and are read into the device at power up. |
| ADDR1 | 20 | Strap, 4-LEVEL | |
| SDA | 10 | IO, LVCMOS, OD | SDA is the SMBus bi-directional open drain SDA data line to or from the LMH1219 slave device. SDA is an open drain IO and tolerant to 3.3 V. SDA requires an external 2-kΩ to 5-kΩ pull-up resistor to the SMBus termination voltage. |
| SCL | 21 | I, LVCMOS, OD | SCL is the SMBus input clock to the LMH1219 slave device. It is driven by a LVCMOS open drain driver from the SMBus master. SCL is tolerant to 3.3 V and requires an external 2-kΩ to 5-kΩ pull up resistor to the SMBus termination voltage. |
| Power | | | |
| VSS | 3, 9, 16 | I, Ground | Ground reference. |
| VIN | 24 | I, Power | VIN is connected to an external power supply. It accepts either 2.5 V ± 5% or 1.8 V ± 5%. When VIN is powered from 2.5 V, VDD_LDO is the output of an on-chip LDO regulator. For lower power operation, both VIN and VDD_LDO should be connected to a 1.8 V supply. |
| VDDIO | 22 | I, Power | VDDIO powers the LVCMOS IO and 4-level input logic and connects to 2.5 V ± 5%. |
| VDD_LDO | 23 | IO, Power | VDD_LDO is the output of the internal 1.8 V LDO regulator when VIN is connected to a 2.5 V supply. VDD_LDO output requires external 1-μF and 0.1-μF bypass capacitors to VSS. The internal LDO is designed to power internal circuitry only. VDD_LDO is an input when VIN is powered from 1.8 V for lower power operation. When VIN is connected to a 1.8 V supply, both VIN and VDD_LDO should be connected to a 1.8 V supply. |
| VDD_CDR | 13 | I, Power | VDD_CDR powers the reclocker circuitry and connects to 2.5 V ± 5% supply. |
| EP | | I, Ground | EP is the exposed pad at the bottom of the QFN package. The exposed pad must be connected to the ground plane through a via array. See Figure 41 for details. |

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) ⁽¹⁾⁽²⁾

| | MIN | MAX | UNIT |
|---|------|------|------|
| Supply Voltage for 2.5 V Mode (VDD_CDR, VIN, VDDIO) | –0.5 | 2.75 | V |
| Supply Voltage for 1.8 V Mode (VIN, VDD_LDO) | –0.5 | 2.0 | V |
| 4-Level Input/Output Voltage (IN_OUT_SEL, OUT_CTRL, VOD_DE, MODE_SEL, ADDR0, ADDR1) | –0.5 | 2.75 | V |
| SMBus Input/Output Voltage (SDA, SCL) | –0.5 | 4.0 | V |
| SPI Input/Output Voltage (SS_N, MISO, MOSI, and SCK) | –0.5 | 2.75 | V |
| Input Voltage (IN0±, IN1±) | –0.5 | 2.75 | V |
| Input Current (IN0±, IN1±) | –30 | 30 | mA |
| Junction Temperature | | 125 | °C |
| Storage temperature | –65 | 150 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) For soldering specifications, see application note [SNOA549](#).

6.2 ESD Ratings

| | | VALUE | UNIT |
|--|--|-------|------|
| V _(ESD) Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±4500 | V |
| | Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±1500 | |

- (1) JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 500 V HBM is possible with the necessary precautions. Pins listed as ±4500 V may actually have higher performance.
- (2) JEDEC document JEP157 states that 250 V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250 V CDM is possible with the necessary precautions. Pins listed as ±1500 V may actually have higher performance.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| | | | MIN | NOM | MAX | UNIT |
|---|--|------------------------------|-------|-----|-------|-------------------|
| Single Supply Mode ⁽¹⁾ | VIN, VDDIO, VDD_CDR to VSS | | 2.375 | 2.5 | 2.625 | V |
| Dual Supply Mode ⁽²⁾⁽³⁾ | VIN, VDD_LDO to VSS | | 1.71 | 1.8 | 1.89 | V |
| | VDD_CDR, VDDIO to VSS | | 2.375 | 2.5 | 2.625 | |
| VDD _{SMBUS} | SMBus: SDA, SCL Open Drain Termination Voltage | | 2.375 | | 3.6 | V |
| V _{IN0_LAUNCH} | Source Launch Amplitude before coaxial cable | Normal mode | 0.72 | 0.8 | 0.88 | V _{p-p} |
| | | Splitter mode | 0.36 | 0.4 | 0.44 | |
| V _{IN1_LAUNCH} | Source Differential Launch Amplitude | before 5-inch board trace | 300 | | 850 | mV _{p-p} |
| | | before 20-inch board trace | 650 | | 1000 | |
| T _{JUNCTION} | Operating Junction Temperature | | | | 100 | °C |
| T _{AMBIENT} | Ambient Temperature | | –40 | 25 | 85 | °C |
| NT _{ps_{max}} ⁽⁴⁾ | Maximum Supply Noise Tolerance | 50 Hz to 1 MHz, sinusoidal | | <20 | | mV _{p-p} |
| | | 1.1 MHz to 6 GHz, sinusoidal | | <10 | | |

- (1) In Single Supply Mode, the VIN, VDDIO and VDD_CDR supplies are 2.5 V. The VDD_LDO is the 1.8 V LDO output of an internal LDO regulator, the VDD_LDO pin should not be connected to any external supply voltage.
- (2) In Dual Supply Mode, the VIN and VDD_LDO are connected to a 1.8 V supply, while the VDD_CDR and VDDIO supplies are 2.5 V.
- (3) In Dual Supply Mode, the VDDIO and VDD_CDR supply should be powered before or at the same time as VIN and VDD_LDO = 1.8 V.
- (4) The sum of the DC supply voltage and AC supply noise should not exceed the recommended supply voltage range.

6.4 Thermal Information

| THERMAL METRIC ⁽¹⁾⁽²⁾ | | LMH1219 | UNIT |
|----------------------------------|--|-----------|------|
| | | RTW (QFN) | |
| | | 24 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 33.2 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 28.8 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 11.2 | °C/W |
| ψ_{JT} | Junction-to-top characterization parameter | 0.3 | °C/W |
| ψ_{JB} | Junction-to-board characterization parameter | 11.3 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | 2.2 | °C/W |

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report ([SPRA953](#)).
- (2) No heat sink is assumed for these estimations. Depending on the application, a heat sink, faster air flow, and/or reduced ambient temperature (< 85°C) may be required to maintain the maximum junction temperature specified in [Electrical Characteristics](#).

6.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------|---|---|------|-----|------|------|
| POWER | | | | | | |
| PD_{DUAL} | Power Dissipation, Dual Supply Mode | Measured with PRBS-10, Locked to 11.88 Gbps at IN0+, VOD = default, only OUT0 enabled | | 250 | | mW |
| PD_{Z_DUAL} | Power Dissipation, Dual Supply Mode | Power Save Mode, no input signal | | 16 | | mW |
| PD_{SINGLE} | Power Dissipation, Single Supply Mode | Measured with PRBS-10, Locked to 11.88 Gbps at IN0+, VOD = default, only OUT0 enabled | | 290 | | mW |
| PD_{Z_SINGLE} | Power Dissipation, Single Supply Mode | Power Save Mode, no input signal | | 27 | | mW |
| IDD_{DUAL} | Current Consumption, Dual Supply Mode | Measured at 2.5 V supply with PRBS-10, Locked to 11.88 Gbps at IN0+, VOD = Default, only OUT0 enabled | | 64 | 70 | mA |
| | | Measured at 1.8 V supply with PRBS-10, Locked to 11.88 Gbps at IN0+, VOD = Default, only OUT0 enabled | | 50 | 62 | |
| IDD_{Z_DUAL} | Current Consumption, Dual Supply Mode | Forced Power Save Mode, MODE_SEL = LEVEL-H, Measured at 2.5 V supply | | 4 | 5 | mA |
| | | Forced Power Save Mode, MODE_SEL = LEVEL-H, Measured at 1.8 V supply | | 3 | 9 | |
| IDD_{TRANS_DUAL} | Current Consumption, Dual Supply Mode Acquiring Lock, HEO/VEO Lock Monitor Disabled | Measured at 2.5 V supply with PRBS-10, IN1±, Acquiring Lock VOD = Default, OUT0 and OUT1 enabled | | 90 | 101 | mA |
| | | Measured at 1.8 V supply with PRBS-10, IN1±, Acquiring Lock VOD = Default, OUT0 and OUT1 enabled | | 30 | 37 | |
| VDD_{LDO} | LDO 1.8 V Output Voltage | VIN = 2.5 V, Single Supply Mode | 1.71 | 1.8 | 1.89 | V |

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|--|---|-------------|-------------|-------------|------|
| LVCMOS DC SPECIFICATIONS | | | | | | |
| V _{IH} | High Level Input Voltage | 2-Level Input (SS_N, SCK, MOSI), VDDIO = 2.5 V | 0.7 × VDDIO | | VDDIO + 0.3 | V |
| | | 2-Level Input (SCL, SDA), VDDIO = 2.5 V | 0.7 × VDDIO | | 3.6 | |
| V _{IL} | Low Level Input Voltage | 2-Level Input (SS_N, SCK, MOSI), VDDIO = 2.5 V | -0.3 | | 0.3 × VDDIO | V |
| | | 2-Level Input (SCL, SDA), VDDIO = 2.5 V | 0 | | 0.3 × VDDIO | |
| V _{OH} | High Level Output Voltage | I _{OH} = −2 mA, (MISO), VDDIO = 2.5 V | 0.8 × VDDIO | | VDDIO | V |
| V _{OL} | Low Level Output Voltage | I _{OL} = 2 mA, (MISO), VDDIO = 2.5 V | 0 | | 0.2 × VDDIO | V |
| | | I _{OL} = 3 mA, (LOCK_N, SCL, SDA), VDDIO = 2.5 V | | | 0.4 | |
| I _{IH} | Input High Leakage Current | SPI Mode: LVCMOS (SS_N, SCK, MOSI), Vinput = VDDIO | | | 15 | μA |
| | | SMBus Mode: LVCMOS (LOCK_N, SCL, SDA), Vinput = VDDIO | | | 10 | |
| I _{IL} | Input Low Leakage Current | SPI Mode: LVCMOS (SS_N), Vinput = VSS | -40 | | | μA |
| | | SPI Mode: LVCMOS (SCK, MOSI), Vinput = VSS | -15 | | | |
| | | SMBus Mode: LVCMOS (LOCK_N, SCL, SDA), Vinput = VSS | -10 | | | |
| 4-LEVEL LOGIC DC SPECIFICATIONS (REFERENCE TO VDDIO, APPLY TO ALL 4-LEVEL INPUT CONTROL PINS) | | | | | | |
| V _{4_LVL_H} | LEVEL-H Input Voltage | Pull-up 1 kΩ to VDDIO | | VDDIO | | V |
| V _{4_LVL_F} | LEVEL-F Default Voltage | Float, VDDIO = 2.5 V | | 2/3 × VDDIO | | V |
| V _{4_LVL_R} | LEVEL-R Input Voltage | External Pull-down 20 kΩ to VSS, VDDIO = 2.5 V | | 1/3 × VDDIO | | V |
| V _{4_LVL_L} | LEVEL-L Input Voltage | External Pull-down 1 kΩ to VSS | | 0 | | V |
| I _{4_LVL_IH} | Input High Leakage Current | 4-Levels (IN_OUT_SEL, OUT_CTRL, VOD_DE, MODE_SEL), Vinput = VDDIO | 20 | 45 | 80 | μA |
| | | SMBus Mode: 4-Levels (ADDR0, ADDR1), Vinput = VDDIO | 20 | 45 | 80 | |
| I _{4_LVL_IL} | Input Low Leakage Current | 4-Levels (IN_OUT_SEL, OUT_CTRL, VOD_DE, MODE_SEL), Vinput = VSS | -160 | -93 | -40 | μA |
| | | SMBus Mode: 4-Levels (ADDR0, ADDR1), Vinput = VSS | -160 | -93 | -40 | |
| RECEIVER SPECIFICATIONS (IN0+) | | | | | | |
| R _{IN0_TERM} | DC Input Termination | IN0+ and IN0- to VSS | 63 | 75 | 87 | Ω |
| R _{LIN0_S11} | Input Return Loss Reference to 75 Ω ⁽¹⁾ | S11, 5 MHz to 1.485 GHz | | −20 | | dB |
| | | S11, 1.485 GHz to 3 GHz | | −18 | | |
| | | S11, 3 GHz to 6 GHz | | −13 | | |
| | | S11, 6 GHz to 12 GHz | | −6.5 | | |
| V _{IN0_CM} | IN0 DC Common Mode Voltage | Input common mode voltage at IN0+ or IN0- to VSS | | 1.4 | | V |

(1) This parameter was measured with an LMH1219EVM.

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | MIN | TYP | MAX | UNIT |
|--------------------------------|--|--|-----|------|-----|----------|
| V _{WANDER} | Input DC Wander | SD, signal at IN0+, Input launch amplitude = 0.8 Vp-p | | 100 | | mVp-p |
| | | HD, 3G, 6G, 12G, signal at IN0+, Input launch amplitude = 0.8 Vp-p | | 50 | | |
| RECEIVER SPECIFICATIONS (IN1±) | | | | | | |
| R _{IN1_TERM} | DC Input Differential Termination | Measured across IN1+ to IN1- | 80 | 100 | 120 | Ω |
| R _{LIN1_SDD11} | Input Differential Return Loss ⁽¹⁾ | SDD11, 10 MHz - 2.8 GHz | | −21 | | dB |
| | | SDD11, 2.8 GHz - 6 GHz | | −17 | | |
| | | SDD11, 6 GHz - 11.1 GHz | | −8 | | |
| R _{LIN1_SCD11} | Differential to Common Mode Conversion ⁽¹⁾ | SCD11, 10 MHz to 11.1 GHz | | −23 | | dB |
| V _{IN1_CM_TOL} | Input AC Common Mode Voltage Tolerance | | | 15 | | mV (rms) |
| V _{IN1_CM} | IN1 DC Common Mode Voltage | Input common mode voltage at IN1+ or IN1- to VSS | | 2.06 | | V |
| C _{DON_IN1} | CD_N = LOW, Carrier Detect (Default) Assert ON Threshold Level for input voltage | 10.3125 Gbps, 1010 Clock Pattern | | 39 | | mVp-p |
| | | 10.3125 Gbps, PRBS-31 Pattern | | 25 | | |
| | | 11.88 Gbps, EQ and PLL Pathological Pattern | | 20 | | |
| C _{DOFF_IN1} | CD_N = HIGH, Carrier Detect (Default) De-Assert OFF Threshold Level | 10.3125 Gbps, 1010 Clock Pattern | | 15 | | mVp-p |
| | | 10.3125 Gbps, PRBS-31 Pattern | | 15 | | |
| | | 11.88 Gbps, EQ and PLL Pathological Pattern | | 18 | | |

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|--|--|-----|-----|-----|----------|
| TRANSMITTER OUTPUT (OUT0± AND OUT1±) | | | | | | |
| VOD | Output Differential Voltage ⁽²⁾ | 8T pattern, VOD_DE = LEVEL-H, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | | 410 | | mVp-p |
| | | 8T pattern, VOD_DE = LEVEL-F, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | 485 | 560 | 620 | |
| | | 8T pattern, VOD_DE = LEVEL-R, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | | 635 | | |
| | | 8T pattern, VOD_DE = LEVEL-L, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | | 810 | | |
| VOD _{DE} | De-emphasized Output Differential Voltage ⁽²⁾ | 8T pattern, VOD_DE = LEVEL-H, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | | 410 | | mVp-p |
| | | 8T pattern, VOD_DE = LEVEL-F, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | | 500 | | |
| | | 8T pattern, VOD_DE = LEVEL-R, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | | 480 | | |
| | | 8T pattern, VOD_DE = LEVEL-L, see Figure 13 SD, HD, 3G, 6G, 12G, and 10 GbE | | 480 | | |
| R _{OUT_TERM} | DC Output Differential Termination | Measured across OUTn+ and OUTn- | 80 | 100 | 120 | Ω |
| t _R /t _F | Output Rise/Fall Time ⁽³⁾ | 20% - 80% using 8T Pattern SD, HD, 3G, 6G, 12G and 10 GbE, measured after 1 inch trace | | 45 | | ps |
| RL _{TX-SDD22} | Output Differential Return Loss Measured with the Device Powered Up and Outputs a 10-MHz Clock Signal ⁽³⁾ | SDD22, 10 MHz - 2.8 GHz | | -17 | | dB |
| | | SDD22, 2.8 GHz - 6 GHz | | -15 | | |
| | | SDD22, 6 GHz - 11.1 GHz | | -15 | | |
| RL _{TX-SCC22} | Output Common Mode Return Loss Measured with the Device Powered Up and Outputs a 10-MHz Clock Signal ⁽³⁾ | SCC22, 10 MHz - 4.75 GHz | | -12 | | dB |
| | | SCC22, 4.75 GHz - 11.1 GHz | | -12 | | |
| V _{TX_CM} | AC Common Mode Voltage ⁽³⁾ | Default Setting, PRBS-31, 10.3125 Gbps | | 5 | | mV (rms) |

(2) ATE production tested with DC method.

(3) This parameter was measured with an LMH1219EVM.

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------------|---|--|-----|-------|------|-----------|
| OUTPUT JITTER | | | | | | |
| T_J | Total Jitter ($BER \leq 1e-12$), Reclocked Output ⁽⁴⁾ | 11.88 Gbps, PRBS-10, TX launch amplitude = 720 mV, 75 m Belden 1694A at IN0+ | | 0.11 | 0.15 | UI |
| | | 5.94 Gbps, PRBS-10, TX launch amplitude = 720 mV, 120 m Belden 1694A at IN0+ | | 0.106 | | UI |
| | | 2.97 Gbps, PRBS-10, TX launch amplitude = 720 mV, 200 m Belden 1694A at IN0+ | | 0.075 | | UI |
| | | 1.485 Gbps, PRBS-10, TX launch amplitude = 720 mV, 300 m Belden 1694A at IN0+ | | 0.07 | | UI |
| | | 270 Mbps, PRBS-10, TX launch amplitude = 720 mV, 600 m Belden 1694A at IN0+ | | 0.07 | | UI |
| | | 10.3125 Gbps, PRBS-10, 500 mVp-p and 1000 mVp-p launch amplitude, 20 inch FR4 board trace at IN1± | | 0.09 | 0.15 | UI |
| R_J | Random Jitter, Reclocked Output | 11.88 Gbps, PRBS-10, TX launch amplitude = 720 mV, 75 m Belden 1694A at IN0+ | | 5.7 | | mUI (rms) |
| | | 10.3125 Gbps, PRBS-10, 500 mVp-p and 1000 mVp-p launch amplitude, 20 inch FR4 board trace at IN1± | | 4.1 | | mUI (rms) |
| D_J | Deterministic Jitter, Reclocked Output | 11.88 Gbps, PRBS-10, TX launch amplitude = 720 mV, 75 m Belden 1694A at IN0+ | | 40 | | mUI |
| | | 10.3125 Gbps, PRBS-10, 500 mVp-p and 1000 mVp-p launch amplitude, 20 inch FR4 board trace at IN1± | | 34 | | mUI |
| T_{JRAW} | Total Jitter ($BER \leq 1e-12$), RAW (Reclocker Bypassed) | 125 Mbps, PRBS-10, TX launch amplitude = 800 mV, 600 m Belden 1694A at IN0+ | | 0.17 | | UI |
| | | 1.25 Gbps, PRBS-10, 500 mVp-p and 1000 mVp-p launch amplitude, 20 inch FR4 board trace at IN1± | | 0.17 | | |

(4) These limits are ensured by bench characterization and are not production tested.

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | CONDITIONS | MIN | TYP | MAX | UNIT |
|--------------------------------|---|---|-----|--------------|-----|------|
| CLOCK AND DATA RECOVERY | | | | | | |
| LOCK _{RATE} | IN0+ Reclocker Lock Data Rates ⁽⁵⁾ | SMPTE 12G, /1 | | 11.88 | | Gbps |
| | | SMPTE 12G, /1.001 | | 11.868 | | Gbps |
| | | SMPTE 6G, /1 | | 5.94 | | Gbps |
| | | SMPTE 6G, /1.001 | | 5.934 | | Gbps |
| | | SMPTE 3G, /1 | | 2.97 | | Gbps |
| | | SMPTE 3G, /1.001 | | 2.967 | | Gbps |
| | | SMPTE HD, /1 | | 1.485 | | Gbps |
| | | SMPTE HD, /1.001 | | 1.4835 | | Gbps |
| | | SMPTE SD, /1 | | 270 | | Mbps |
| | IN1± Reclocker Lock Data Rate | 10 GbE | | 10.3125 | | Gbps |
| BYPASS _{RATE} | IN0+ Bypass Reclocker Data Rate | MADI | | 125 | | Mbps |
| | IN1± Bypass Reclocker Data Rate | 1 GbE | | 1.25 | | Gbps |
| BW _{PLL} | PLL Bandwidth | Measured with 0.2 UI SJ at –3 dB, 10.3125 Gbps | | 8 | | MHz |
| | | Measured with 0.2 UI SJ at –3 dB, 11.88 Gbps | | 13 | | |
| | | Measured with 0.2 UI SJ at –3 dB, 5.94 Gbps | | 7 | | |
| | | Measured with 0.2 UI SJ at –3 dB, 2.97 Gbps | | 5 | | |
| | | Measured with 0.2 UI SJ at –3 dB, 1.485 Gbps | | 3 | | |
| | | Measured with 0.2 UI SJ at –3 dB, 270 Mbps | | 1 | | |
| J _{PEAKING} | PLL Jitter Peaking | SD, HD, 3G, 6G, 12G (IN0+), and 10 GbE (IN1±) | | 0.3 | | dB |
| J _{TOL_IN1} | IN1 Input Jitter Tolerance per SFF-8431 Appendix D.11 | Total jitter tolerance combination of Dj, Pj, and Rj at 10 GbE, with RX stress eye mask Y1, Y2 limits | | >0.7 | | UI |
| J _{TOL_IN0} | IN0 Input Jitter Tolerance with SJ | IN0+ EQ bypassed, Sinusoidal jitter, tested at 3G, 6G and 12G; SJ amplitude low to high sweep, tested at BER ≤ 1e-12 | | 0.65 | | UI |
| T _{LOCK} | Reclocker Lock Time | All supported data rates, disable HEO/VEO monitor, IN0 EQ bypassed | | 5 | | ms |
| T _{ADAPT} | EQ Adapt Time | Adaptation Time for EQ at IN0 | | 5 | | ms |
| TEMP _{LOCK} | VCO Lock with Temp Ramp | Lock Temperature Range (5°C per min, ramp up and down), –40°C to 85°C operating range, at 10.3125 Gbps and 11.88 Gbps | | 125 | | °C |
| T _{LATENCY} | Reclocker Latency ⁽⁶⁾ | Adapt mode 0, All supported data rates, disable HEO/VEO monitor, IN0 EQ bypassed | | 1.5 UI + 220 | | ps |
| | | Adapt mode 0, All supported data rates, disable HEO/VEO monitor, IN1± EQ = default | | 1.5 UI + 190 | | |

(5) IN1± can also be configured to lock to SMPTE data rates via register override control. For more information, refer to the LMH1219 Programming Guide.

(6) This parameter is data rate dependent. For example, at 11.88 Gbps, 1.5 UI = 1.5 x 84.17 ps = 126.25 ps. Therefore, T_{Latency} = (126.25 + 220) ps = 346.25 ps.

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--|-----|-------|-----|------|
| T_{PD-RAW} Propagation Delay, RAW (reclocker bypassed) | All supported data rates, IN0 EQ bypassed | | 300 | | ps |
| | Raw Data (reclocker bypassed), IN1± EQ = default | | 250 | | |
| F_{CLKOUT} Output Clock Frequency OUT1 Programmed to Output Recovered Clock | Operating at 11.88 Gbps | | 297 | | MHz |
| | Operating at 5.94 Gbps | | 297 | | MHz |
| | Operating at 2.97 Gbps | | 2.97 | | GHz |
| | Operating at 1.485 Gbps | | 1.485 | | GHz |
| | Operating at 270 Mbps | | 270 | | MHz |

6.6 Recommended SMBus Interface AC Timing Specifications

over recommended operating supply and temperature ranges (unless otherwise specified)⁽¹⁾⁽²⁾⁽³⁾

| PARAMETER | TEST CONDITIONS | MIN | NOM | MAX | UNIT |
|---|-----------------|-----|-----|-----|------|
| F_{SCL} SMBus SCL Frequency | | 10 | | 400 | kHz |
| T_{BUF} Bus Free Time Between Stop and Start Condition | | 1.3 | | | μs |
| $T_{HD:STA}$ Hold time after (Repeated) Start Condition. After this period, the first clock is generated. | | 0.6 | | | μs |
| $T_{SU:STA}$ Repeated Start Condition Setup Time | | 0.6 | | | μs |
| $T_{SU:STO}$ Stop Condition Setup Time | | 0.6 | | | μs |
| $T_{HD:DAT}$ Data Hold Time | | 0 | | | ns |
| $T_{SU:DAT}$ Data Setup Time | | 100 | | | ns |
| T_{LOW} Clock Low Period | | 1.3 | | | μs |
| T_{HIGH} Clock High Period | | 0.6 | | | μs |
| T_R Clock/Data Rise Time | | | | 300 | ns |
| T_F Clock/Data Fall Time | | | | 300 | ns |

(1) These parameters support SMBus 2.0 specifications.

(2) These parameters are not production tested.

(3) See [Figure 1](#) for timing diagrams.

6.7 Serial Parallel Interface (SPI) AC Timing Specifications

over recommended operating supply and temperature ranges (unless otherwise specified) ⁽¹⁾

| PARAMETER | TEST CONDITIONS | MIN | NOM | MAX | UNIT |
|-------------------|------------------------------|-----|-------------------------|-----|------|
| F _{SCK} | SPI SCK Frequency | | 10 | 20 | MHz |
| T _{SCK} | SCK Period | | 50 | | ns |
| T _{PH} | SCK Pulse Width High | | 0.40 x T _{SCK} | | ns |
| T _{PL} | SCK Pulse Width Low | | 0.40 x T _{SCK} | | ns |
| T _{SU} | MOSI Setup Time | | 4 | | ns |
| T _H | MOSI Hold Time | | 4 | | ns |
| T _{SSSU} | SS_N Setup Time | | 14 | | ns |
| T _{SSH} | SS_N Hold Time | | 4 | | ns |
| T _{SSOF} | SS_N Off Time | | 1 | | μs |
| T _{ODZ} | MISO Driven-to-Tristate Time | | 20 | | ns |
| T _{OZD} | MISO Tristate-to-Driven Time | | 10 | | ns |
| T _{OD} | MISO Output Delay Time | | 15 | | ns |

(1) See Figure 2 for timing diagrams.

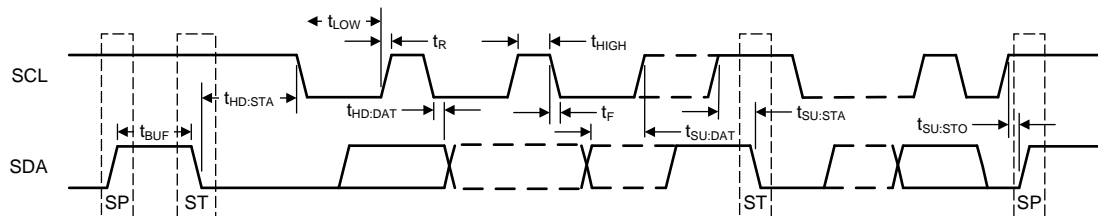


Figure 1. SMBus Timing Parameters

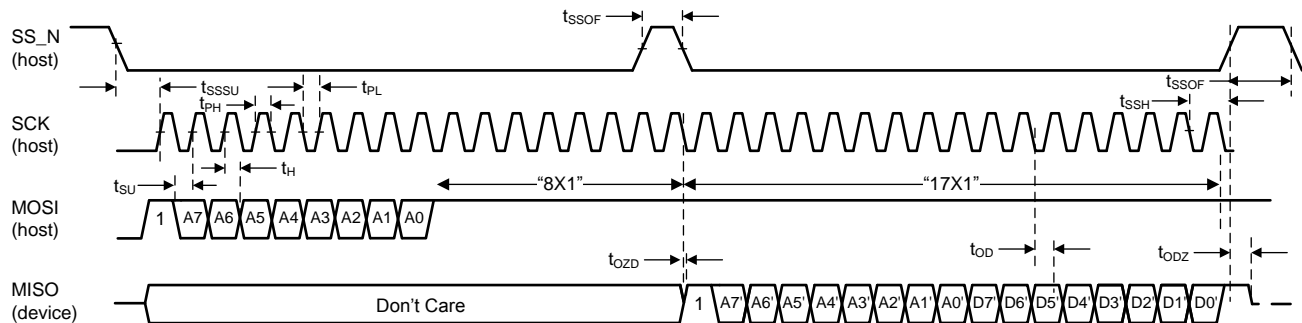


Figure 2. SPI Timing Parameters

6.8 Typical Characteristics

$T_A = 25^\circ\text{C}$ and $V_{IN} = V_{DDIO} = V_{DD_CDR} = 2.5\text{ V}$ (unless otherwise noted)

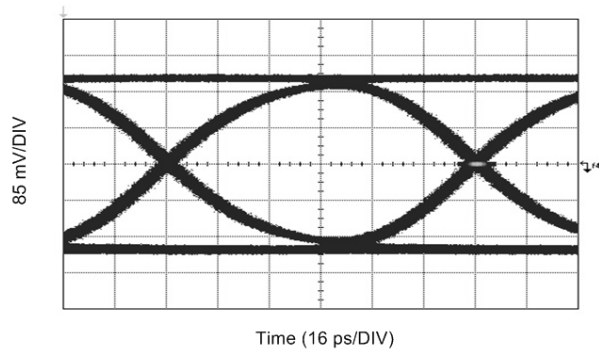


Figure 3. 10.3125 Gbps, IN1: 20 in. FR4 Trace

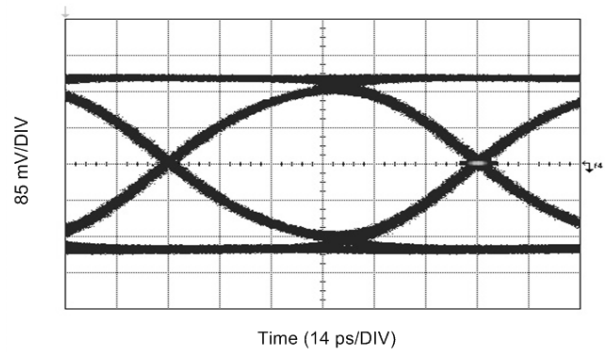


Figure 4. 11.88 Gbps, IN0: 75 m Belden 1694A

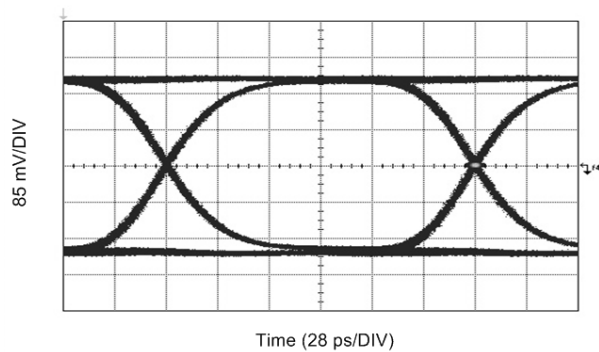


Figure 5. 5.94 Gbps, IN0: 120 m Belden 1694A

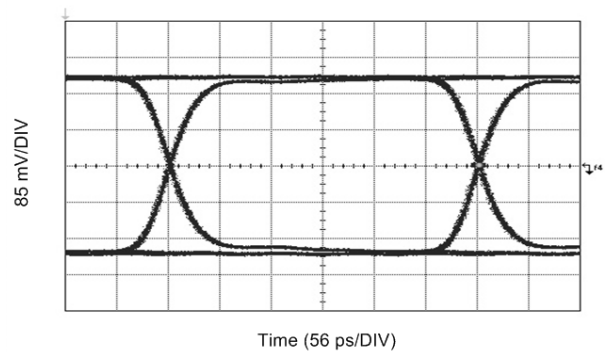


Figure 6. 2.97 Gbps, IN0: 200 m Belden 1694A

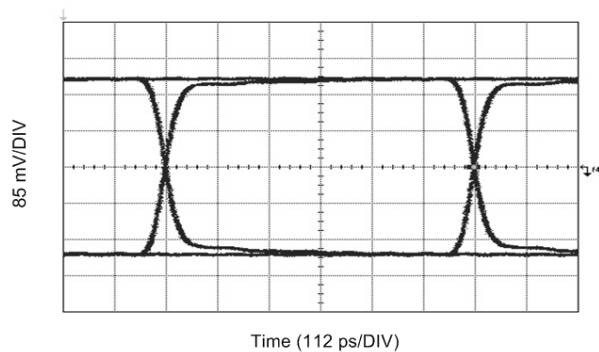


Figure 7. 1.485 Gbps, IN0: 280 m Belden 1694A

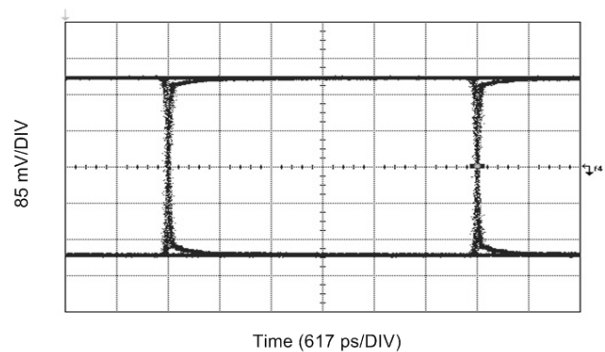
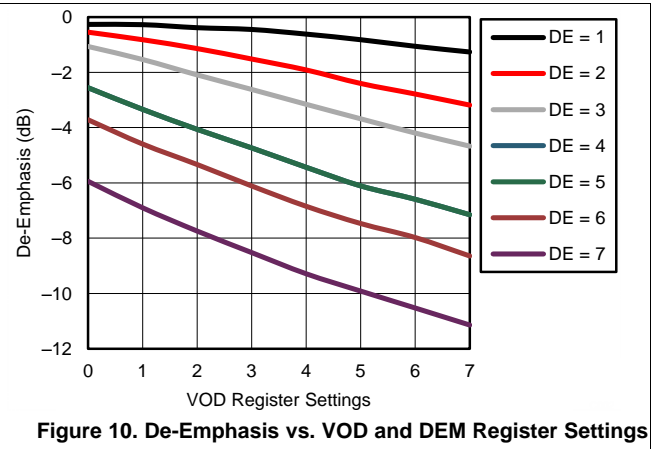
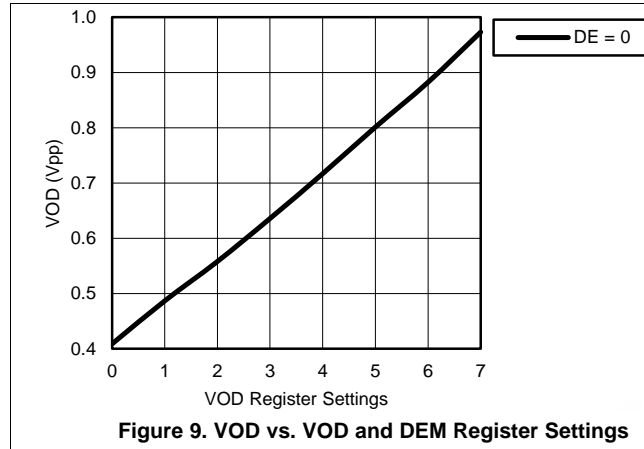


Figure 8. 270 Mbps, IN0: 600 m Belden 1694A

Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$ and $V_{IN} = V_{DDIO} = V_{DD_CDR} = 2.5\text{ V}$ (unless otherwise noted)



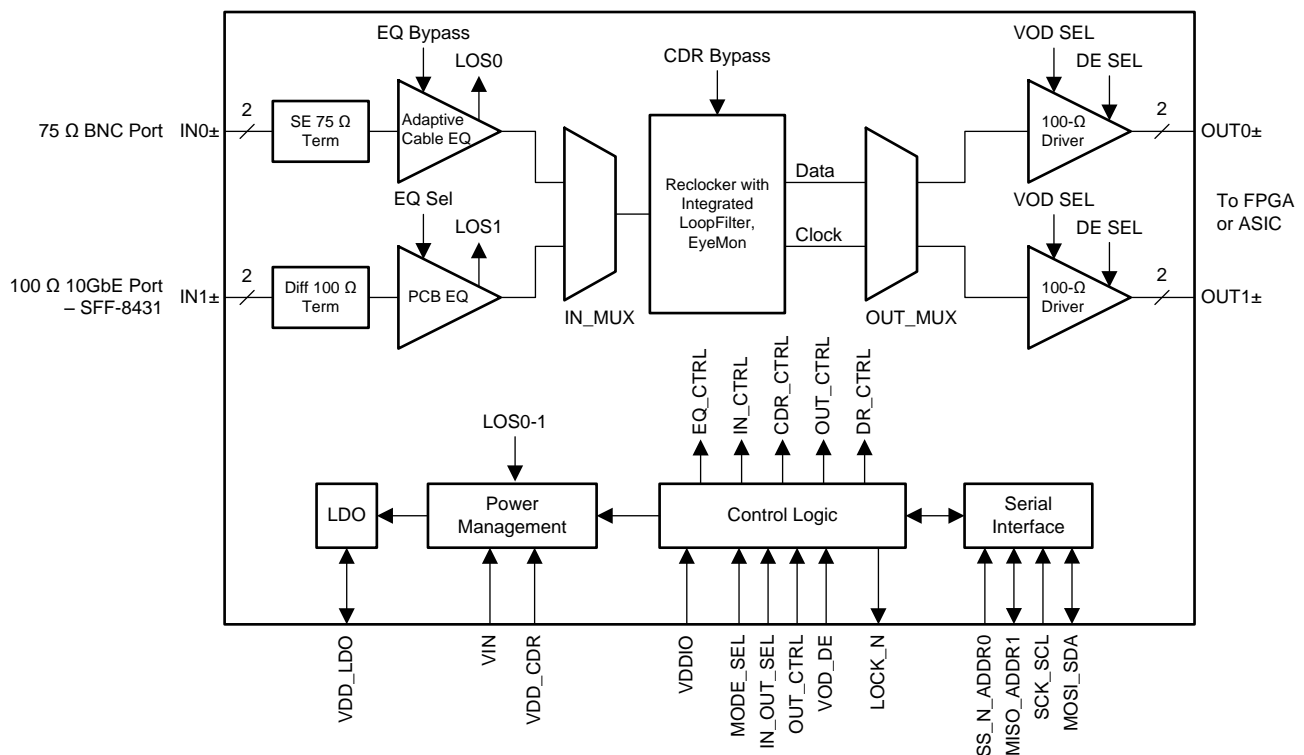
7 Detailed Description

7.1 Overview

The LMH1219 is a SMPTE compatible, low-power UHD adaptive cable equalizer with integrated reclocker. The LMH1219 has two inputs: a 75-Ω cable equalizer and a 100-Ω PCB (printed circuit board) equalizer. The 75-Ω cable equalizer input features an internal 75-Ω termination and compensation network for meeting stringent SMPTE return loss requirements. The 100-Ω PCB equalizer input supports high speed signals across differential PCB traces that connect to an external SFF-8431 optical module or on-board FPGA. An internal 2:1 input mux allows users to select between the 75-Ω cable equalizer and the 100-Ω PCB equalizer. The selected input then passes through a multi-rate reclocker with a built-in loop-filter. The multi-rate reclocker is compatible with SMPTE data rates (11.88, 5.94, 2.97, 1.485 Gbps, 270 Mbps) and their divide-by-1.001 sub-rates. It is also compatible with the 10 GbE data rate (10.3125 Gbps). After the reclocker, an internal 1:2 fan-out mux allows users to select the data or clock content for each output. At both outputs, the LMH1219 has 100-Ω drivers with de-emphasis. The de-emphasis feature of the drivers is designed to compensate for insertion loss caused by output PCB traces.

The operating mode of the LMH1219 can be set by 4-level control pins, SPI, or SMBus serial control interface. The LMH1219 can be powered from a single 2.5 V supply or dual 2.5 V/1.8 V supplies for lower power consumption. The LMH1219 is offered in a small 4 mm x 4 mm 24-lead QFN package.

7.2 Functional Block Diagram



7.3 Feature Description

The LMH1219 consists of several key blocks:

- [4-Level Input Configuration Pins](#)
- [Input Carrier Detect](#)
- [-6 dB Splitter Mode Launch Amplitude for IN0](#)
- [Continuous Time Linear Equalizer \(CTLE\)](#)
- [Input-Output Mux Selection](#)
- [Clock and Data Recovery \(CDR\) Reclocker](#)
- [Internal Eye Opening Monitor \(EOM\)](#)
- [Output Function Control](#)
- [Output Driver Amplitude and De-Emphasis Control](#)
- [Status Indicators and Interrupts](#)

7.3.1 4-Level Input Configuration Pins

The 4-level input configuration pins use a resistor divider to provide four logic states for each control pin. There is an internal 30-k Ω pull-up and a 60-k Ω pull-down connected to the control pin that sets the default voltage at $2/3 \times VDDIO$. These resistors, together with the external resistor, combine to achieve the desired voltage level. By using the 1-k Ω pull-down, 20-k Ω pull-down, no connect, and 1-k Ω pull-up, the optimal voltage levels for each of the four input states are achieved as shown in [Table 1](#).

Table 1. 4-Level Control Pin Settings

| LEVEL | SETTING | RESULTING PIN VOLTAGE |
|-------|---------------------------|-----------------------|
| H | Tie 1 k Ω to VDDIO | VDDIO |
| F | Float (leave pin open) | $2/3 \times VDDIO$ |
| R | Tie 20 k Ω to VSS | $1/3 \times VDDIO$ |
| L | Tie 1 k Ω to VSS | 0 |

Typical 4-Level Input Thresholds:

- Internal Threshold between L and R = $0.2 \times VDDIO$
- Internal Threshold between R and F = $0.5 \times VDDIO$
- Internal Threshold between F and H = $0.8 \times VDDIO$

7.3.2 Input Carrier Detect

Both inputs of the LMH1219 have a Carrier Detect circuit to monitor the presence or absence of the input signal. When the input signal amplitude for the selected input (determined by IN_OUT_SEL pin) surpasses the Carrier Detect assert threshold, the LMH1219 operates in normal mode.

In the absence of an input signal, the LMH1219 automatically goes into Power Save Mode to conserve power consumption. When a valid signal is detected, the LMH1219 automatically exits Power Save Mode and returns to the normal operating mode.

7.3.3 -6 dB Splitter Mode Launch Amplitude for IN0

The LMH1219 is designed to equalize data transmitted through a coaxial cable driven by a SMPTE compatible cable driver with launch amplitude of 800 mVp-p $\pm 10\%$. In applications where a 1:2 passive splitter is used, the signal amplitude is reduced by half due to the 6 dB insertion loss of the splitter. The LMH1219 is designed to support -6 dB splitter mode for IN0, enabled by SPI or SMBus serial interface. For more information, refer to the LMH1219 Register Map and the Programming Guide.

7.3.4 Continuous Time Linear Equalizer (CTLE)

The LMH1219 has two Continuous Time Linear Equalizer (CTLE) blocks, one for each input. The CTLE compensates for frequency-dependent loss due to the transmission media prior to the device input. The CTLE accomplishes this by applying variable gain to the input signal, thereby boosting higher frequencies more than lower frequencies.

Only one CTLE is enabled at a time, in accordance with the input channel selected by the input mux. If IN0 is selected, the IN0 cable CTLE is powered on and the IN1 PCB CTLE is powered off. Alternatively, the two CTLEs can be bypassed either by using the OUT_CTRL pin or via register control.

7.3.4.1 Adaptive Cable Equalizer (IN0+)

If IN0 is selected, adaptive cable equalization is enabled by default. IN0 has an on-chip 75-Ω termination to the input common mode voltage and includes a series return loss compensation network for meeting stringent SMPTE return loss requirements. It is designed for AC coupling, requiring a 4.7-μF AC coupling capacitor for minimizing base-line wander due to the rare-occurring pathological bit pattern. The cable equalizer is designed with high gain and low noise circuitry to compensate for the insertion loss of a coaxial cable, such as Belden 1694A, which is widely used in broadcast video infrastructures.

Internal control loops are used to monitor the input signal quality and automatically select the optimum equalization boost and DC offset compensation. The LMH1219 is designed to handle the stringent pathological pattern defined in the SMPTE RP 198 and SMPTE RP 178 standards.

7.3.4.2 Adaptive PCB Trace Equalizer (IN1±)

The IN1 PCB equalizer has an on-chip 100-Ω termination and is designed for AC coupling, requiring a 4.7-μF AC coupling capacitor for minimizing base-line wander due to the rare-occurring pathological bit pattern. The PCB equalizer can compensate up to 20 inches of board trace at data rates up to 11.88 Gbps. There are two adapt modes for IN1: AM0 manual mode and AM1 adaptive mode. In AM0 manual mode, fixed EQ boost settings are applied through user-programmable register control, whereas in AM1 adaptive mode, state machines automatically find the optimal equalization setting from a set of 16 pre-determined settings defined in Registers 0x40-0x4F.

If IN1 is selected, AM1 adaptive mode is enabled at the 10 GbE data rate by default. The PCB equalizer is able to adapt at 10.3125 Gbps (10 GbE) and 2.97 Gbps, 5.94 Gbps, and 11.88 Gbps (SMPTE) data rates. At 1.485 Gbps and 270 Mbps data rates, the equalization is fixed at 0x00 (minimum EQ boost). This fixed EQ value can be changed via register control. For more details, refer to the LMH1219 Register Map and Programming Guide.

7.3.5 Input-Output Mux Selection

By default, the LMH1219 input-to-output signal flow and data rate selection are configured by the IN_OUT_SEL pin logic settings shown in Table 2. These settings can be overridden via register control by applying the appropriate override bit values. For more information, refer to the LMH1219 Register Map and Programming Guide.

Table 2. IN_OUT_SEL Pin Settings

| LEVEL | DEFINITION |
|-------|---|
| H | SMPTE Data Rates: IN0 to OUT0 and OUT1 |
| F | SMPTE Data Rates: IN0 to OUT0 (OUT1 disabled) |
| R | 10 GbE Data Rate: IN1 to OUT1 (OUT0 disabled) |
| L | 10 GbE Data Rate: IN1 to OUT0 and OUT1 |

7.3.6 Clock and Data Recovery (CDR) Reclocker

After the input signal passes through the CTLE, the equalized data is fed into the clock and data recovery (CDR) block. Using an internal PLL, the CDR locks to the incoming equalized data and recovers a clean internal clock to re-sample the equalized data. The LMH1219 CDR is able to tolerate high input jitter, tracking low frequency input jitter below the PLL bandwidth while reducing high frequency input jitter above the PLL bandwidth.

The supported data rates are listed in Table 3. By default, IN0 locks to SMPTE data rates and IN1 locks to the 10 GbE data rate, according to the IN_OUT_SEL pin logic shown previously in Table 2. IN1 can be programmed to lock to SMPTE data rates via register control by applying the appropriate override bit values. For more information, refer to the LMH1219 Register Map and Programming Guide.

Table 3. Supported Data Rates

| INPUT | DATA RATE | RECLOCKER MODE |
|-------|---|-----------------------------------|
| IN0+ | 11.88 Gbps, 5.94 Gbps, 2.97 Gbps, 1.485 Gbps, 270 Mbps ⁽¹⁾ | Reclocker Enabled |
| | 125 Mbps | Reclocker Disabled (CDR Bypassed) |
| IN1± | 10.3125 Gbps | Reclocker Enabled |
| | 1.25 Gbps | Reclocker Disabled (CDR Bypassed) |

(1) Divide-by-1.001 lock rates available only for 11.88 Gbps, 5.94 Gbps, 2.97 Gbps, and 1.485 Gbps.

NOTE

If the selected data rate (SMPTE or 10 GbE) is changed while the device is operating with active data, a CDR reset and release is required for the CDR to re-acquire lock. If the input data signal is toggled off and on after the selected data rate is changed, the Carrier Detect circuit will reset the CDR. In this case, no register write is needed for the CDR to re-acquire lock.

7.3.7 Internal Eye Opening Monitor (EOM)

The LMH1219 has an on-chip eye opening monitor (EOM) that can be used to analyze, monitor, and diagnose the post-equalized waveform, just prior to the CDR reclocker. The EOM is operational for 2.97 Gbps and higher data rates.

The EOM monitors the post-equalized waveform in a time window that spans one unit interval and a configurable voltage range that spans up to ± 400 mV differential. The time window and voltage range are divided into 64 steps, so the result of the eye capture is a 64×64 matrix of *hits*, where each point represents a specific voltage and phase offset relative to the main data sampler. The number of *hits* registered at each point needs to be taken in context with the total number of bits observed at that voltage and phase offset in order to determine the corresponding probability for that point. The number of bits observed at each point is configurable.

The resulting 64×64 matrix produced by the EOM can be processed by software and visualized in a number of ways. Two common ways to visualize this data are shown in [Figure 11](#) and [Figure 12](#). These diagrams depict examples of eye monitor plots implemented by software. The first plot is an example using the EOM data to plot a basic eye using ASCII characters, which can be useful for simple diagnostic software. The second plot shows the first derivative of the EOM data, revealing the density of hits and the actual waveforms and crossings that comprise the eye.

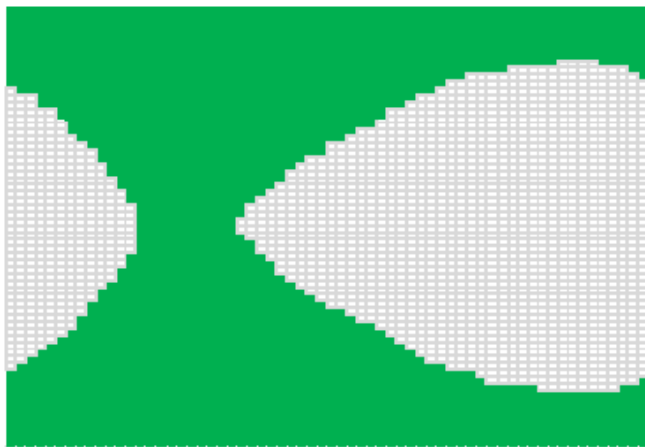


Figure 11. Internal Input Eye Monitor Plot

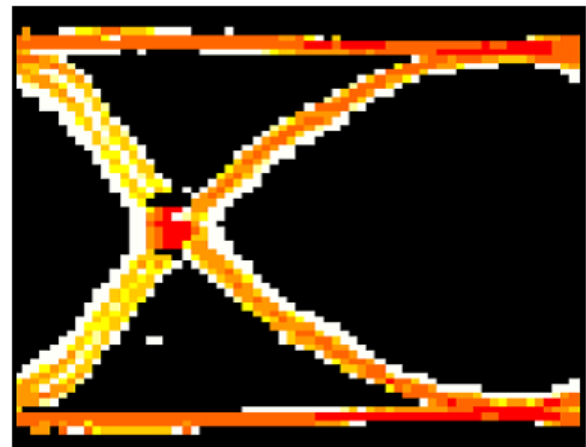


Figure 12. Internal Eye Monitor Hit Density Plot

A common measurement performed by the EOM is the horizontal and vertical eye opening. The horizontal eye opening (HEO) represents the width of the post-equalized eye at 0-V differential amplitude, measured in unit intervals or picoseconds (ps). The vertical eye opening (VEO) represents the height of the post-equalized eye, measured midway between the mean zero crossing of the eye. This position in time approximates the CDR sampling phase.

7.3.8 Output Function Control

By default, the LMH1219 output function control for OUT0 and OUT1 is configured by the OUT_CTRL pin logic settings shown in Table 4. These settings can be overridden via register control by applying the appropriate override bit values. For more information, refer to the LMH1219 Register Map and Programming Guide.

Table 4. OUT_CTRL Pin Settings

| LEVEL | DEFINITION |
|-------|---|
| H | OUT0 and OUT1: Raw Data, Both EQ and Reclocker Bypassed |
| F | OUT0 and OUT1: Recovered Data, Both EQ and Reclocker Enabled |
| R | OUT0: Recovered Data, EQ and Reclocker Enabled OUT1: Full-Rate Recovered Clock if Data Rate ≤ 3 Gbps. 297 MHz Recovered Clock if Data Rate > 3 Gbps ⁽¹⁾ |
| L | OUT0 and OUT1: Equalized Data, EQ Enabled, Reclocker Bypassed |

(1) This setting is only valid for SMPTE data rates. It is not supported for the 10 GbE data rate.

7.3.9 Output Driver Amplitude and De-Emphasis Control

The VOD_DE control pin selects the output amplitude and de-emphasis settings for both OUT0 and OUT1. It offers users the capability to select higher output amplitude and de-emphasis levels for longer board trace that connects the drivers to their downstream receivers. Driver de-emphasis provides transmitter equalization to reduce the ISI caused by the board trace.

By default, the output driver VOD and de-emphasis settings are configured by the VOD_DE pin logic settings shown in Table 5. These settings can be overridden via register control by applying the appropriate override bit values. When these parameters are controlled by registers, the VOD and de-emphasis levels for each channel can be programmed independently. For more information, refer to the LMH1219 Register Map and the Programming Guide.

Table 5. Recommended VOD_DE Pin and Register Settings for Different FR4 Trace Lengths⁽¹⁾

| VOD_DE LEVEL | VOD REG SETTING OUT0±: 0x30[5]=1, 0x30[2:0] OUT1±: 0x32[5]=1, 0x32[2:0] | DEM REG SETTING OUT0±: 0x31[6]=1, 0x31[2:0] OUT1±: 0x33[6]=1, 0x33[2:0] | VOD (mVpp) ⁽²⁾ | VOD _{DE} (mVpp) ⁽²⁾ | DEM (dB) | FR4 TRACE LENGTH (inches) |
|--------------|---|---|---------------------------|---|----------|---------------------------|
| H | 0 | 0 | 410 | 410 | 0 | 0 – 1 |
| F | 2 | 2 | 560 | 500 | -0.9 | 2 – 4 |
| R | 3 | 3 | 635 | 480 | -2.4 | 5 – 6 |
| L | 5 | 5 | 810 | 480 | -6.1 | 7 – 8 |

(1) The output drivers are capable of providing higher VOD and DEM levels (max settings are 7). For more VOD and de-emphasis levels, refer to Table 10.

(2) See Figure 13.

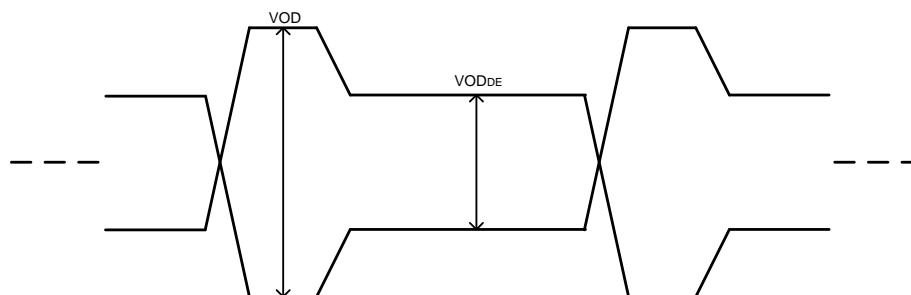


Figure 13. VOD and VOD_{DE} Levels

7.3.10 Status Indicators and Interrupts

7.3.10.1 LOCK_N (Lock Indicator)

The LOCK_N pin is a 3.3 V tolerant, active-low open drain output. An external resistor to the logic supply is required. By default, LOCK_N is the reclocker lock indicator, and this pin asserts low when the LMH1219 achieves lock to a valid SMPTE or 10 GbE data rate. The LOCK_N pin functionality can also be configured via register control to indicate CD_N (Carrier Detect) or INT_N (Interrupt) events. For more information about how to reconfigure the LOCK_N pin functionality, refer to the LMH1219 Register Map and the Programming Guide.

7.3.10.2 CD_N (Carrier Detect)

The LOCK_N pin can be reconfigured via register control to indicate a CD_N (Carrier Detect) event. When configured as a CD_N output, the pin asserts low at the end of adaptation after a valid signal is detected by the Carrier Detect circuit of the selected input. Under register control, this pin can be reconfigured to indicate CD_N for IN0 or IN1. For more information about how to configure the LOCK_N pin for CD_N functionality, refer to the LMH1219 Register Map and the Programming Guide.

7.3.10.3 INT_N (Interrupt)

The LOCK_N pin can be configured to indicate an INT_N (Interrupt) event. When configured as an INT_N output, the pin asserts low when an interrupt occurs, according to the programmed interrupt masks. Seven separate masks can be programmed via register control as interrupt sources:

- If there is a Loss of Signal (LOS) event on IN0, irrespective of the input channel selected (2 separate masks).
- If there is a Loss of Signal (LOS) event on IN1, irrespective of the input channel selected (2 separate masks).
- If HEO or VEO falls below a certain threshold after CDR is locked (1 mask).
- If a CDR Lock event has occurred (2 separate masks).

INT_N is a sticky bit, meaning that it will flag after an interrupt occurs and will not clear until read back. Once the Interrupt Status Register is read, the INT_N pin will assert high again. For more information about how to configure the LOCK_N pin for INT_N functionality, refer to the LMH1219 Register Map and the Programming Guide.

7.3.11 Additional Programmability

The LMH1219 supports extended programmability through the use of an SPI or SMBus serial control interface. Such added programmability includes:

- Cable Length Indicator (CLI)
- Digital MUTE_{REF}

7.3.11.1 Cable Length Indicator (CLI)

The Cable Length Indicator (CLI) indicates the length of the coax cable attached to IN0+. CLI is accessible through CableEQ/Driver Page Reg 0x25[5:0]. The 6-bit setting ranges in decimal value from 0 to 55 (000000'b to 110111'b in binary), corresponding to approximately 0 to 600 m of Belden 1694A cable.

7.3.11.2 Digital MUTE_{REF}

Digital MUTE_{REF} CableEQ/Driver Page Reg 0x03[5:0] sets the threshold for the maximum cable length at IN0+ to be equalized before muting the outputs. The MUTE_{REF} register value is directly proportional to the cable length being equalized. MUTE_{REF} is data rate dependent. Follow the steps below to set the MUTE_{REF} register setting for any desired SDI rate:

1. Connect the desired input cable length at which the driver output needs to be muted.
2. Send video patterns to IN0+ at the SD rate (270 Mbps). At SD, the Cable Length Indicator (CLI) has the largest dynamic range.
3. Read back Cable EQ/Driver Page Reg 0x25[5:0] to record the CLI value.
4. Copy the CLI value, and write this value to Digital MUTE_{REF} Cable EQ/Driver Page Reg 0x03[5:0].

7.4 Device Functional Modes

The LMH1219 operates in one of two modes: System Management Bus (SMBus) or Serial Peripheral Interface (SPI) mode. In order to determine the mode of operation, the proper setting must be applied to the MODE_SEL pin at power-up, as detailed in [Table 6](#).

Table 6. MODE_SEL Pin Settings

| LEVEL | DEFINITION |
|-------|--|
| H | Forced Power Save Mode, only SPI is enabled (all other circuitry powered down) |
| F | Select SPI Interface for register access |
| R | Reserved for factory testing – do not use |
| L | Select SMBus Interface for register access |

NOTE

Changing logic states between LEVEL-L and LEVEL-H after power up is not allowed.

7.4.1 System Management Bus (SMBus) Mode

If MODE_SEL = L, the LMH1219 is in SMBus mode. In SMBus mode, Pins 10 and 21 are configured as SDA and SCL. Pins 7 and 20 act as 4-level address straps for ADDR0 and ADDR1 at power up to determine the 7-bit slave address of the LMH1219, as shown in [Table 7](#).

Table 7. SMBus Device Slave Addresses⁽¹⁾

| ADDR0 (LEVEL) | ADDR1 (LEVEL) | 7-BIT SLAVE ADDRESS [HEX] | 8-BIT WRITE COMMAND [HEX] |
|---------------|---------------|---------------------------|---------------------------|
| L | L | 1D | 3A |
| L | R | 1E | 3C |
| L | F | 1F | 3E |
| L | H | 20 | 40 |
| R | L | 21 | 42 |
| R | R | 22 | 44 |
| R | F | 23 | 46 |
| R | H | 24 | 48 |
| F | L | 25 | 4A |
| F | R | 26 | 4C |
| F | F | 27 | 4E |
| F | H | 28 | 50 |
| H | L | 29 | 52 |
| H | R | 2A | 54 |
| H | F | 2B | 56 |
| H | H | 2C | 58 |

- (1) The 8-bit write command consists of the 7-bit slave address (Bits 7:1) with 0 appended to the LSB to indicate an SMBus write. For example, if the 7-bit slave address is 0x1D (001 1101'b), the 8-bit write command is 0x3A (0011 1010'b).

7.4.1.1 SMBus Read and Write Transactions

SMBus is a two-wire serial interface through which various system component chips can communicate with the master. Slave devices are identified by having a unique device address. The two-wire serial interface consists of SCL and SDA signals. SCL is a clock output from the master to all of the slave devices on the bus. SDA is a bidirectional data signal between the master and slave devices. The LMH1219 SMBus SCL and SDA signals are open drain and require external pull-up resistors.

Start and Stop:

The master generates start and stop patterns at the beginning and end of each transaction.

- Start: High to low transition (falling edge) of SDA while SCL is high.
- Stop: Low to high transition (rising edge) of SDA while SCL is high.

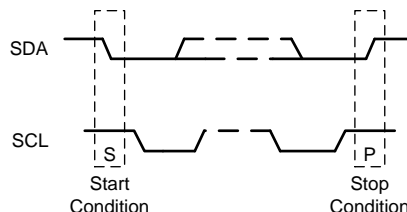


Figure 14. Start and Stop Conditions

The master generates nine clock pulses for each byte transfer. The 9th clock pulse constitutes the ACK cycle. The transmitter releases SDA to allow the receiver to send the ACK signal. An ACK is recorded when the device pulls SDA low, while a NACK is recorded if the line remains high.

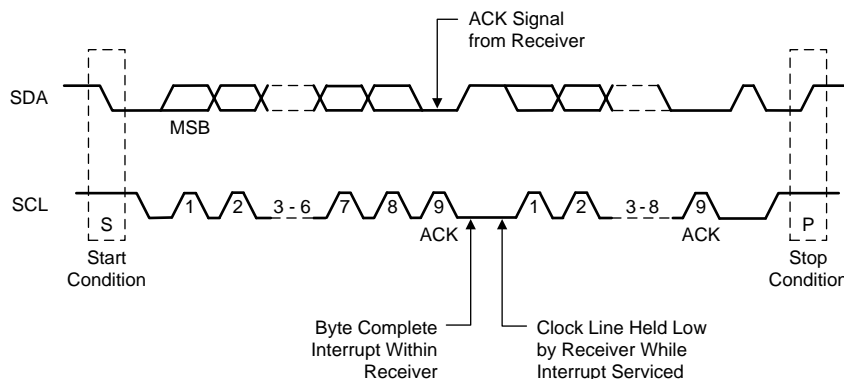


Figure 15. Acknowledge (ACK)

7.4.1.1.1 SMBus Write Operation Format

Writing data to a slave device consists of three parts, as illustrated in Figure 16:

1. The master begins with a start condition, followed by the slave device address with the $\overline{R/\overline{W}}$ bit set to 0'b.
2. After an ACK from the slave device, the 8-bit register word address is written.
3. After an ACK from the slave device, the 8-bit data is written, followed by a stop condition.

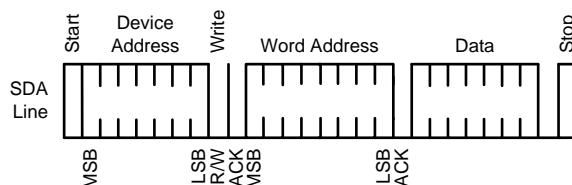


Figure 16. SMBus Write Operation

7.4.1.1.2 SMBus Read Operation Format

Reading data from a slave device consists of four parts, as illustrated in Figure 17:

1. The master begins with a start condition, followed by the slave device address with the R/W bit set to 0'b.
2. After an ACK from the slave device, the 8-bit register word address is written.
3. After an ACK from the slave device, the master initiates a re-start condition, followed by the slave address with the R/W bit set to 1'b.
4. After an ACK from the slave device, the 8-bit data is read back. The last ACK is high if there are no more bytes to read, and the last read is followed by a stop condition.

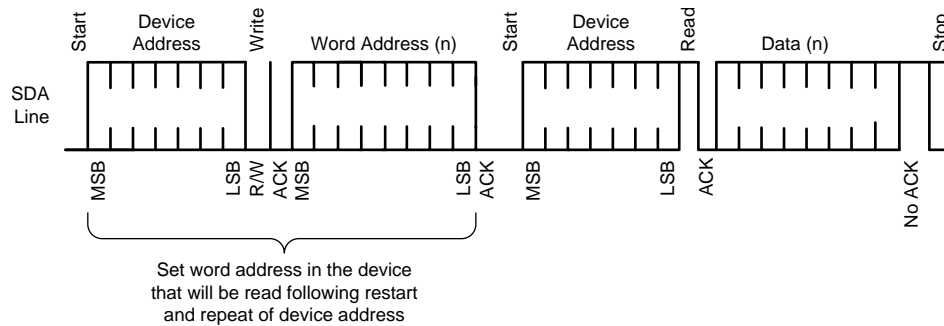


Figure 17. SMBus Read Operation

7.4.2 Serial Peripheral Interface (SPI) Mode

If MODE_SEL = F or H, the LMH1219 is in SPI mode. In SPI mode, the following pins are used for SPI bus communication:

- MOSI (pin 10): Master Output Slave Input
- MISO (pin 20): Master Input Slave Output
- SS_N (pin 7): Slave Select (active low)
- SCK (pin 21): Serial clock (input to the LMH1219 slave device)

7.4.2.1 SPI Read and Write Transactions

Each SPI transaction to a single device is 17 bits long and is framed by SS_N when asserted low. The MOSI input is ignored, and the MISO output is floated whenever SS_N is de-asserted (high).

The bits are shifted in left-to-right. The first bit is R/W, which is 1'b for "read" and 0'b for "write." Bits A7-A0 are the 8-bit register address, and bits D7-D0 are the 8-bit read or write data. The previous SPI command, address, and data are shifted out on MISO as the current command, address, and data are shifted in on MOSI. In all SPI transactions, the MISO output signal is enabled asynchronously when SS_N asserts low. The contents of a single MOSI or MISO transaction frame are shown in Table 8.

Table 8. 17-Bit Single SPI Transaction Frame

| R/W | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

7.4.2.1.1 SPI Write Transaction Format

For SPI writes, the R/W bit is 0'b. SPI write transactions are 17 bits per device, and the command is executed on the rising edge of SS_N. The SPI transaction always starts on the rising edge of the clock.

The signal timing for a SPI Write transaction is shown in Figure 18. The "prime" values on MISO (for example, A7') reflect the contents of the shift register from the previous SPI transaction and are *don't-care* for the current transaction.

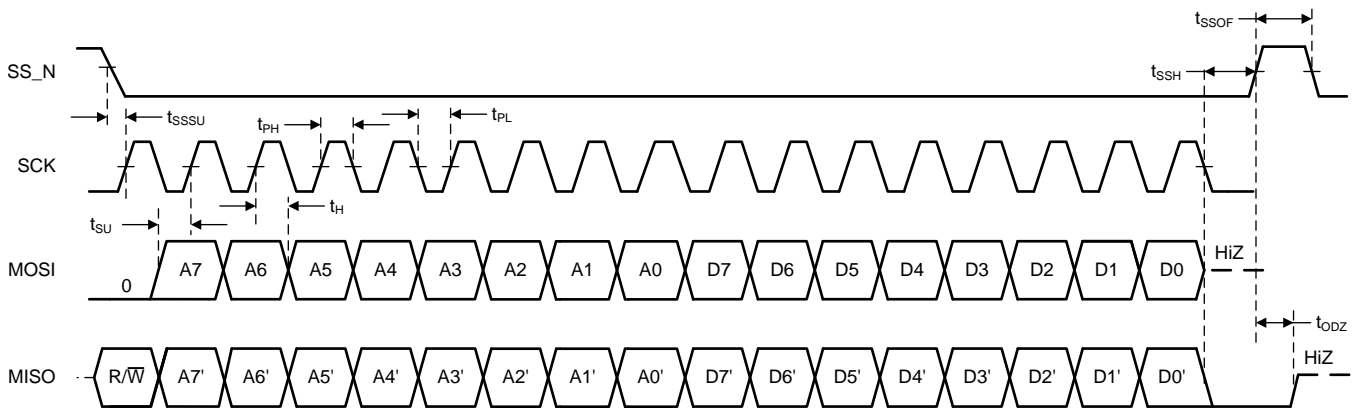


Figure 18. Signal Timing for a SPI Write Transaction

7.4.2.1.2 SPI Read Transaction Format

A SPI read transaction is 34 bits per device and consists of two 17-bit frames. The first 17-bit read transaction frame shifts in the address to be read, followed by a dummy transaction second frame to shift out 17-bit read data. The $\overline{R/\overline{W}}$ bit is 1'b for the read transaction, as shown in [Figure 19](#).

The first 17 bits from the read transaction specifies 1-bit of $\overline{R/\overline{W}}$ and 8-bits of address A7-A0 in the first 8 bits. The eight 1's following the address are ignored. The second dummy transaction acts like a read operation on address 0xFF and needs to be ignored. However, the transaction is necessary in order to shift out the read data D7-D0 in the last 8 bits of the MISO output. As with the SPI Write, the “prime” values on MISO during the first 16 clocks are *don't-care* for this portion of the transaction. The values shifted out on MISO during the last 17 clocks reflect the read address and 8-bit read data for the current transaction.

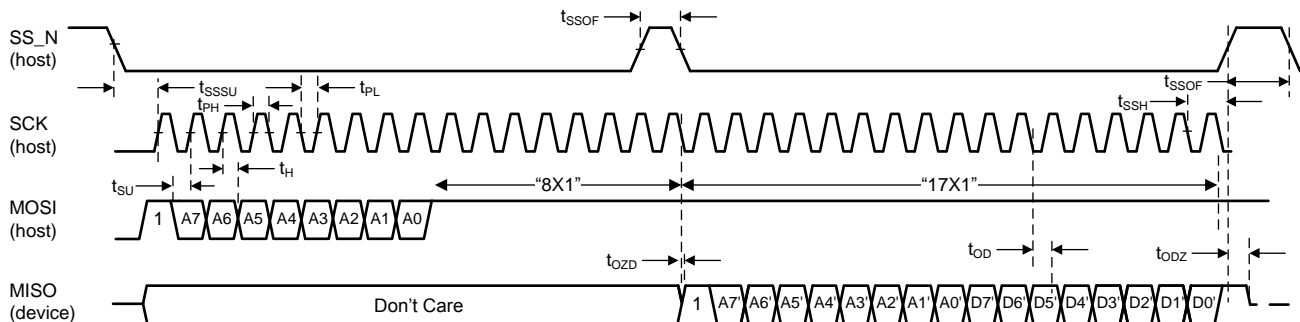


Figure 19. Signal Timing for a SPI Read Transaction

7.4.2.2 SPI Daisy Chain

The LMH1219 supports SPI daisy-chaining among multiple devices, as shown in [Figure 20](#).

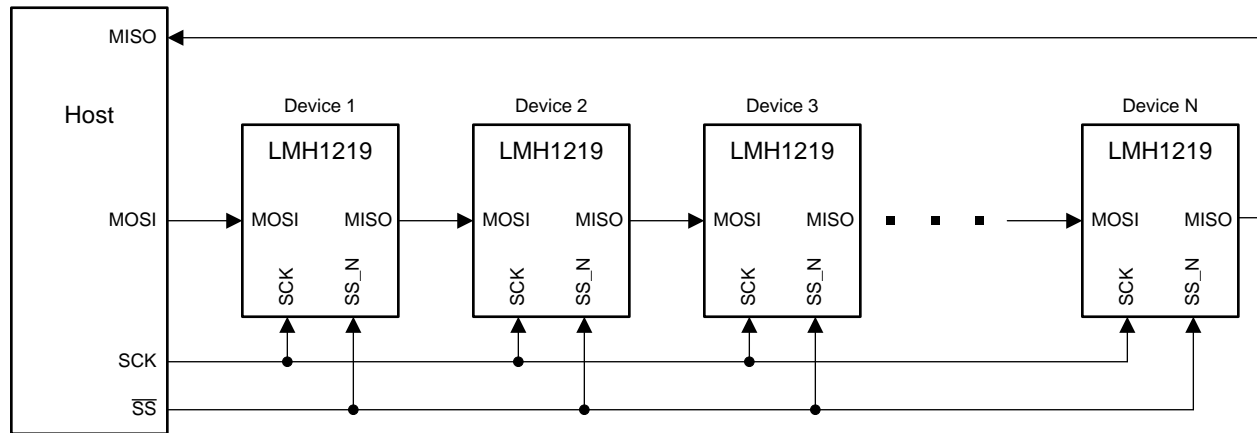


Figure 20. Daisy-Chain Configuration

Each LMH1219 device is directly connected to the SCK and SS_N pins of the host. The first LMH1219 device in the chain is connected to the host's MOSI pin, and the last device in the chain is connected to the host's MISO pin. The MOSI pin of each intermediate LMH1219 device in the chain is connected to the MISO pin of the previous LMH1219 device, thereby creating a serial shift register. In a daisy-chain configuration of N x LMH1219 devices, the host conceptually sees a shift register of length 17 x N for a basic SPI transaction, during which SS_N is asserted low for 17 x N clock cycles.

7.5 LMH1219 Register Map

The LMH1219 register map is divided into three register pages. These register pages are used to control different aspects of the LMH1219 functionality. A brief summary of the pages is shown below:

1. **Share Register Page:** This page corresponds to global parameters, such as LMH1219 device ID and LOCK_N status configuration. This is the default page at start-up.
2. **CTLE/CDR Register Page:** This page corresponds to IN1 PCB CTLE, input and output mux settings, CDR settings, and output interrupt overrides. Access this page by setting Reg 0xFF[2:0] = 100'b.
3. **CableEQ/Drivers Register Page:** This page corresponds to IN0 Cable EQ and both OUT0 and OUT1 driver output settings. Access this page by setting Reg 0xFF[2:0] = 101'b.

For typical device configurations and proper register reset sequencing, reference the appropriate sections of the LMH1219 Programming Guide.

Please note the following about the LMH1219 default register values in the register map:

- Default register values were read after power-up with no active inputs applied to IN0 or IN1.
- Default register values for Reserved "Read-Only" bits may vary dynamically from part to part.

7.5.1 Share Register Page

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|--------------------------------|-----|------------|---------|------|--|
| 0x00 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x01 | Reserved | 7:0 | Reserved | 0x40 | R | Reserved |
| 0x02 | Reserved | 7:0 | Reserved | 0x02 | RW | Reserved |
| 0x03 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x04 | Reserved | 7:0 | Reserved | 0x01 | RW | Reserved |
| 0x05 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x06 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x07 | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0x08 | Reserved | 7:0 | Reserved | 0x11 | RW | Reserved |
| 0x09 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0xE2 | Reset Share/Channel Regs | 7:5 | Reserved | 0x10 | R | Reserved |
| | | 4 | reset_done | | R | 0 = Internal state machine register initialization not done. 1 = Internal state machine register initialization done. |
| | | 3:1 | Reserved | | RW | Reserved |
| | | 0 | reset_init | | RW | 1 = Initialize internal state machine register settings. Refer to the LMH1219 Programming Guide for details. |
| 0xF0 | Device Revision | 7:0 | Version | 0x02 | R | Device Revision |
| 0xF1 | Device ID | 7:0 | Device_ID | 0x80 | R | For LMH1219, Device ID = 0x80 |

LMH1219

SNLS530D – APRIL 2016 – REVISED JUNE 2018

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| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|--------------------------------|-----|--------------------|---------|------|--|
| 0xFF | Register Communication Control | 7:6 | lock_output_ctrl | 0x00 | RW | Controls the output on LOCK pin if Reg 0xFF[5:4] = 01'b 00 = Lock status from Reclocker 01 = CableEQ/Driver Reg 0x00[7] status output 10 = Logical OR of LOCK status from Reclocker and CableEQ/Driver Reg 0x00[7] status 11 = Logical AND of LOCK status from Reclocker and CableEQ/Driver Reg 0x00[7] status |
| | | 5:4 | los_int_bus_sel | | RW | Controls the output on LOCK_N pin 00 = Default behavior (LOCK_N outputs lock status from reclocker) 01 = LOCK_N pin output status determined by Reg 0xFF[7:6] 10 = LOS of selected input (IN0 or IN1) 11 = Interrupts are output on LOCK_N pin, as determined by CTLE/CDR Page Reg 0x56[6:0] |
| | | 3 | Reserved | | RW | Reserved |
| | | 2 | page_select_enable | | RW | 0 = The shared registers are enabled. 1 = Enables communication access to the Register Page specified in Reg 0xFF[1:0]. |
| | | 1:0 | page_select | | RW | Enable communication access to a specific Register Page 00 = CTLE/CDR Register Page 01 = CableEQ/Drivers Register Page Other values are invalid. |

7.5.2 CTLE/CDR Register Page

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|-----------------------------|-----|--------------------|---------|------|---|
| 0x00 | Reset CTLE/CDR Registers | 7:3 | Reserved | 0x00 | RW | Reserved |
| | | 2 | rst_CTLE/CDR_regs | | RW | Reset registers (self-clearing) 0 = Normal Operation 1 = Reset CTLE/CDR Registers. Register re-initialization procedure required after resetting the CTLE/CDR Registers. |
| | | 1:0 | Reserved | | RW | Reserved |
| 0x01 | LOS Status | 7:2 | Reserved | 0x03 | RW | Reserved |
| | | 1 | LOS1 | | R | 0 = Signal Present on IN1 1 = Loss of Signal on IN1 |
| | | 0 | Reserved | | R | Reserved |
| 0x02 | CDR_Status | 7:0 | CDR_Status | 0x41 | R | CDR status indicator. See "Lock Data Rate Indication" subsection in the LMH1219 Programming Guide for more information. |
| 0x03 | IN1 Manual EQ Boost | 7:6 | eq_BST0 | 0x80 | RW | Used for setting manual EQ value for IN1 when Reg 0x2D[3] = 1. EQ boost value can be read back on CTLE/CDR Page Reg 0x52. [7:6]: 2-bit control for Stage 0 of the CTLE. [5:4]: 2-bit control for Stage 1 of the CTLE. [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| | | 5:4 | eq_BST1 | | RW | |
| | | 3:2 | eq_BST2 | | RW | |
| | | 1:0 | eq_BST3 | | RW | |
| 0x04 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x05 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x06 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x07 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x08 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x09 | Output Mux Override Control | 7:6 | Reserved | 0x00 | RW | Reserved |
| | | 5 | reg_out_control_ov | | RW | Output Mux Override Control 0 = Reg 0x1C[3:2] determines the output selection for both OUT0 and OUT1 1 = Enable individual output mux control based on values from Reg 0x1C[7:5] and Reg 0x1E[7:5] |
| | | 4:3 | Reserved | | RW | Reserved |
| | | 2:0 | Reserved | | RW | Reserved |

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|--|-----|-----------------------|---------|------|---|
| 0x0A | CDR Reset Control | 7:4 | Reserved | 0x50 | RW | Reserved |
| | | 3 | reg_cdr_reset_ov | | RW | 0 = Disables CDR Reset (Normal Operating Mode) 1 = Enables Reg 0x0A[2] to control CDR Reset |
| | | 2 | reg_cdr_reset | | RW | 0 = No CDR Reset if Reg 0x0A[3] = 1 1 = CDR Reset if Reg 0x0A[3] = 1 |
| | | 1:0 | Reserved | | RW | Reserved |
| 0x0B | Reserved | 7:0 | Reserved | 0x1F | RW | Reserved |
| 0x0C | CDR Output Status Control | 7:4 | reg_sh_status_control | 0x08 | RW | Value determines what CDR status outputs are displayed in CTLE/CDR Page Reg 0x02. See "Lock Data Rate Indication" subsection in the LMH1219 Programming Guide for more information. |
| | | 3:0 | Reserved | | RW | Reserved |
| 0x0D | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x0E | Reserved | 7:0 | Reserved | 0x93 | RW | Reserved |
| 0x0F | Reserved | 7:0 | Reserved | 0x69 | RW | Reserved |
| 0x10 | Reserved | 7:0 | Reserved | 0x27 | RW | Reserved |
| 0x11 | EOM Voltage Range Control | 7:6 | eom_sel_vrange | 0xE0 | RW | Sets the expected incoming eye diagram vertical eye opening interval if Reg 0x2C[6] = 0 00 = 3.125 mV (3.125 mV x 64 = 200 mV; ±100 mV range) 01 = 6.25 mV (6.25 mV x 64 = 400 mV; ±200 mV range) 10 = 9.375 mV (9.375 mV x 64 = 600 mV; ±300 mV range) 11 = 12.5 mV (12.5 mV x 64 = 800 mV; ±400 mV range) |
| | | 5 | eom_PD | | RW | 0 = EOM is always powered up 1 = Power down EOM when not in use |
| | | 4:0 | Reserved | | RW | Reserved |
| 0x12 | Reserved | 7:0 | Reserved | 0xA0 | RW | Reserved |
| 0x13 | IN1 CTLE Control | 7:4 | Reserved | 0x90 | RW | Reserved |
| | | 3 | eq_PD_EQ | | RW | IN1 CTLE Power-Down Control 0 = Powers up EQ of IN1 1 = Powers down EQ of IN1 Note: The un-selected channel is always powered-down. |
| | | 2 | Reserved | | RW | Reserved |
| | | 1 | eq_en_bypass | | RW | 0 = Enable Gain Stages 2 and 3 of IN1 CTLE 1 = Bypass Gain Stages 2 and 3 of IN1 CTLE |
| | | 0 | Reserved | | RW | Reserved |
| 0x14 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x15 | IN1 Carrier Detect Control and Threshold Setting | 7 | Reserved | 0x00 | RW | Reserved |
| | | 6 | cd_1_PD | | RW | IN1 Carrier Detect Power Down Control 0 = Power Up IN1 Carrier Detect 1 = Power Down IN1 Carrier Detect |
| | | 5:4 | cd_1_refa_sel | | RW | Controls IN1 Carrier Detect Assert and De-Assert Thresholds 0000 = Default levels (nominal) 0101 = Nominal - 2 mV 1010 = Nominal + 5 mV 1111 = Nominal + 3 mV |
| | | 3:2 | cd_1_refd_sel | | RW | |
| | | 1:0 | Reserved | | RW | Reserved |
| 0x16 | Reserved | 7:0 | Reserved | 0x25 | RW | Reserved |
| 0x17 | Reserved | 7:0 | Reserved | 0x25 | RW | Reserved |
| 0x18 | Reserved | 7:0 | Reserved | 0x40 | RW | Reserved |
| 0x19 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x1A | Reserved | 7:0 | Reserved | 0xA0 | RW | Reserved |
| 0x1B | Reserved | 7:0 | Reserved | 0x03 | RW | Reserved |

LMH1219

SNLS530D – APRIL 2016 – REVISED JUNE 2018

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| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|------------------|-----|------------------------------|---------|------|---|
| 0x1C | OUT Mux Select_0 | 7:5 | out_sel0_data_mux | 0x58 | RW | In normal operating mode, Reg 0x1C[7:5] returns the mux select value applied at OUT0. When Reg 0x09[5] = 1, OUT0 mux selection is controlled by Reg 0x1C[7:5] as follows: 000 = Mute 001 = 10 MHz Clock 010 = Raw Data (EQ Only) 100 = Retimed Data Other Settings are invalid. |
| | | 4 | VCO_Div40 | | RW | When Reg 0x09[5] = 1 and Reg 0x1E[7:5] = 101'b, OUT1 clock selection can be controlled by Reg 0x1C[4] as follows: 0 = OUT1 outputs 10 MHz clock 1 = OUT1 outputs VCO divide-by-40 |
| | | 3:2 | drv_out_ctrl | | RW | Controls output mux selection for both OUT0 and OUT1 if Reg 0x3F[3] = 1 to override the OUT_CTRL pin 00 = Mute both OUT0 and OUT1 01 = When CDR is locked, output reclocked data on OUT0 and output clock on OUT1. If locked data rate is ≤ 3G, OUT1 = VCO. If locked data rate is > 3G, OUT1 = VCO/40. When unlocked, output raw data on OUT0 and mute OUT1. 10 = When locked, output retimed data on both OUT0 and OUT1. When unlocked, output raw data on both OUT0 and OUT1. This is the default setting. 11 = Output raw data on both OUT0 and OUT1. |
| | | 1:0 | Reserved | | RW | Reserved |
| 0x1D | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x1E | OUT Mux Select_1 | 7:5 | out_sel1_data_mux | 0x09 | RW | In normal operating mode, Reg 0x1E[7:5] returns the mux select value applied at OUT1. When Reg 0x09[5] = 1, OUT1 mux selection is controlled by Reg 0x1E[7:5] as follows: 000 = Raw Data (EQ Only) 001 = Retimed Data 010 = Full Rate VCO clock 101 = 10 MHz Clock if Reg 0x1C[4] = 0 and VCO/40 clock if Reg 0x1C[4] = 1 111 = Mute Other Settings are invalid |
| | | 4:0 | Reserved | | RW | Reserved |
| 0x1F | OUT1 Polarity | 7 | sel_inv_out1 | 0x10 | RW | 0 = OUT1 normal polarity 1 = Inverts OUT1 driver polarity Note: No polarity inversion for OUT0 |
| | | 6:0 | Reserved | | RW | Reserved |
| 0x20 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x21 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x22 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x23 | HEO_VEO_OV | 7 | eom_get_heo_veo_ov | 0x40 | RW | 0 = Disable HEO/VEO Acquisition override. 1 = Enable HEO/VEO Acquisition override. Value determined by Reg 0x24[1]. |
| | | 6:0 | Reserved | | | Reserved |
| 0x24 | EOM Control | 7 | fast_eom | 0x40 | RW | 0 = Disable Fast EOM mode 1 = Enable Fast EOM mode |
| | | 6 | Reserved | | R | Reserved |
| | | 5 | get_heo_veo_error_no_hits | | R | Zero Crossing Error Detector Status 0 = Zero crossing errors in the eye diagram observed 1 = No zero crossing errors in the eye diagram observed |
| | | 4 | get_heo_veo_error_no_opening | | R | Vertical Eye Closure Detector Status 0 = Open eye diagram detected 1 = Eye diagram completely closed |
| | | 3:2 | Reserved | | R | Reserved |
| | | 1 | eom_get_heo_veo | | RW | 1 = Acquire HEO and VEO (self-clearing) if Reg 0x23[7] = 1 |
| | | 0 | eom_start | | RW | 1 = Start EOM counter (self-clearing) |

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|--|-----|--------------------|---------|------|--|
| 0x25 | EOM_MSB | 7:0 | eom_count_msb | 0x00 | R | MSBs of EOM counter |
| 0x26 | EOM_LSB | 7:0 | eom_count_lsb | 0x00 | R | LSBs of EOM counter |
| 0x27 | HEO | 7:0 | heo | 0x00 | R | HEO value. This is measured in 0-63 phase settings. To get HEO in UI, read HEO, convert hex to dec, then divide by 64. |
| 0x28 | VEO | 7:0 | veo | 0x00 | R | VEO value. This is measured in 0-63 vertical steps. To get VEO in mV, convert hex to dec, then multiply by the EOM Voltage Range defined in Reg 0x29[6:5]. |
| 0x29 | Auto EOM Voltage Range | 7 | Reserved | 0x00 | RW | Reserved |
| | | 6:5 | eom_vrange_setting | | R | Readback of automatic EOM Voltage Range granularity. 00 = 3.125 mV 01 = 6.25 mV 10 = 9.375 mV 11 = 12.5 mV |
| | | 4:0 | Reserved | | RW | Reserved |
| 0x2A | EOM_timer_thr | 7:0 | eom_timer_thr | 0x30 | RW | EOM timer for how long to check each phase/voltage setting. |
| 0x2B | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x2C | VEO Scale | 7 | Reserved | 0x72 | RW | Reserved |
| | | 6 | veo_scale | | RW | 0 = VEO scaling based on manual Voltage Range settings (see Reg 0x11[7:6]) 1 = Enable Auto VEO scaling |
| | | 5:0 | Reserved | | RW | Reserved |
| 0x2D | CTLE Boost Override | 7:4 | Reserved | 0x00 | RW | Reserved |
| | | 3 | reg_eq_bst_ov | | RW | IN1 EQ Boost Override Control 0 = Disable IN1 EQ boost override 1 = Override the internal IN1 EQ boost settings with values in Reg 0x03[7:0] |
| | | 2:0 | Reserved | | RW | Reserved |
| 0x2E | Reserved | 7:0 | Reserved | 0x24 | RW | Reserved |
| 0x2F | Rate Overrides | 7:6 | refn_rate | 0x06 | RW | Reference Rate Selection for CDR Lock if Reg 0x3F[2] = 1 00 = Select SMPTE rates 01 = Select 10G Ethernet rate Other settings are Invalid |
| | | 5:0 | Reserved | | R | Reserved |
| 0x30 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x31 | IN1 Adaptation Mode and Input Mux Select | 7 | Reserved | 0x00 | RW | Reserved |
| | | 6:5 | adapt_mode | | RW | Adapt Mode Override Value if Reg 0x3F[5] = 1 00 = Manual CTLE for IN1. Set CTLE/CDR Page Reg 0x2D[3] = 1 to enable IN1 EQ boost settings with values in Reg 0x03[7:0]. 01 = Automatic CTLE Adaptation for IN1. |
| | | 4:2 | Reserved | | RW | Reserved |
| | | 1:0 | input_mux_ch_sel | | RW | Input Mux Selection if Reg 0x3F[4] = 1 to override IN_OUT_SEL pin 00 = IN0 to OUT0 and OUT1 01 = IN0 to OUT0 only 10 = IN1 to OUT1 only 11 = IN1 to OUT0 and OUT1 |
| 0x32 | HEO/VEO Interrupt Threshold | 7:4 | heo_int_thresh | 0x11 | RW | Compares HEO value, Reg 0x27[7:0] vs. threshold from Reg 0x32[7:4] x 4. |
| | | 3:0 | veo_int_thresh | | RW | Compares VEO value. Reg 0x28[7:0] vs. threshold from Reg 0x32[3:0] x 4. |
| 0x33 | Reserved | 7:0 | Reserved | 0x88 | RW | Reserved |
| 0x34 | Reserved | 7:0 | Reserved | 0x3F | RW | Reserved |
| 0x35 | Reserved | 7:0 | Reserved | 0x1F | RW | Reserved |
| 0x36 | Reserved | 7:0 | Reserved | 0x11 | RW | Reserved |
| 0x37 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x38 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |

LMH1219

SNLS530D – APRIL 2016 – REVISED JUNE 2018

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| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|--|-----|--------------------|---------|------|--|
| 0x39 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x3A | Low Data Rate IN1 EQ Boost | 7:6 | fixed_eq_BST0 | 0x00 | RW | Fixed IN1 CTLE setting for 270M and 1.5G SMPTE rates. If Reg 0x3F[0] = 0, Reg 0x3A fixed IN1 CTLE setting is also used for 3G rate. [7:6]: 2-bit control for Stage 0 of the CTLE [5:4]: 2-bit control for Stage 1 of the CTLE. [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| | | 5:4 | fixed_eq_BST1 | | RW | |
| | | 3:2 | fixed_eq_BST2 | | RW | |
| | | 1:0 | fixed_eq_BST3 | | RW | |
| 0x3B | Reserved | 7:0 | Reserved | 0x96 | R | Reserved |
| 0x3C | Reserved | 7:0 | Reserved | 0x90 | R | Reserved |
| 0x3D | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x3E | HEO_VEO Lock Monitor Enable | 7 | heo_veo_lockmon_en | 0x80 | RW | Enable HEO/VEO lock monitoring. Once the lock and adaptation processes are complete, HEO/VEO monitoring is performed once per the interval determined by Reg 0x69[3:0]. |
| | | 6:0 | Reserved | | RW | |
| 0x3F | Pin Override Register Control | 7:6 | Reserved | 0x01 | RW | Reserved |
| | | 5 | mr_adapt_mode_ov | | RW | 0 = Normal Behavior (Automatic Adaptation when IN1 is selected) 1 = Override Automatic Adaptation for IN1. Adaptation behavior is controlled by Reg 0x31[6:5]. |
| | | 4 | mr_in_out_sel_ov | | RW | 0 = Input channel selection determined by IN_OUT_SEL pin 1 = Override input channel selection pin settings. Input selection is controlled by Reg 0x31[1:0]. |
| | | 3 | mr_out_ctrl_ov | | RW | 0 = Output mux settings determined by OUT_CTRL pin 1 = Override output mux pin settings. Output mux is controlled by Reg 0x1C[3:2]. |
| | | 2 | mr_refn_rate_ov | | RW | 0 = SMPTE or 10 GbE reference rates determined by IN_OUT_SEL pin 1 = Override reference rate pin settings. Reference rates for CDR lock are controlled by Reg 0x2F[7:6]. |
| | | 1 | mr_eqbst_pin_ov | | RW | 0 = IN1 EQ boost Bypass is controlled by OUT_CTRL pin behavior 1 = Override IN1 EQ boost pin control. IN1 EQ boost bypass characteristics are controlled by settings in Reg 0x2D[3] and Reg 0x03[7:0]. |
| | | 0 | mr_en_3G_divsel_eq | | RW | 0 = Disables IN1 EQ Adaptation for 3G data rate 1 = Enables IN1 EQ Adaptation for 3G data rate |
| 0x40 | IN1 Index 0 Boost for Adaptation | 7:6 | EQ_index_0_BST0 | 0x00 | RW | Index 0 Boost [7:6]: 2-bit control for Stage 0 of the CTLE [5:4]: 2-bit control for Stage 1 of the CTLE. [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| | | 5:4 | EQ_index_0_BST1 | | RW | |
| | | 3:2 | EQ_index_0_BST2 | | RW | |
| | | 1:0 | EQ_index_0_BST3 | | RW | |
| 0x41 | IN1 Index 1 Boost for Adaptation | 7:6 | EQ_index_1_BST0 | 0x40 | RW | Index 1 Boost [7:6]: 2-bit control for Stage 0 of the CTLE [5:4]: 2-bit control for Stage 1 of the CTLE. [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| | | 5:4 | EQ_index_1_BST1 | | RW | |
| | | 3:2 | EQ_index_1_BST2 | | RW | |
| | | 1:0 | EQ_index_1_BST3 | | RW | |
| 0x42 | IN1 Index 2 Boost for Adaptation | 7:6 | EQ_index_2_BST0 | 0x80 | RW | Index 2 Boost [7:6]: 2-bit control for Stage 0 of the CTLE [5:4]: 2-bit control for Stage 1 of the CTLE. [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| | | 5:4 | EQ_index_2_BST1 | | RW | |
| | | 3:2 | EQ_index_2_BST2 | | RW | |
| | | 1:0 | EQ_index_2_BST3 | | RW | |
| 0x43 | IN1 Index 3 Boost for Adaptation | 7:6 | EQ_index_3_BST0 | 0x50 | RW | Index 3 Boost [7:6]: 2-bit control for Stage 0 of the CTLE [5:4]: 2-bit control for Stage 1 of the CTLE. [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| | | 5:4 | EQ_index_3_BST1 | | RW | |
| | | 3:2 | EQ_index_3_BST2 | | RW | |
| | | 1:0 | EQ_index_3_BST3 | | RW | |

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|-----------------------------------|-----|------------------|---------|------|--|
| 0x44 | IN1 Index 4 Boost for Adaptation | 7:6 | EQ_index_4_BST0 | 0xC0 | RW | Index 4 Boost |
| | | 5:4 | EQ_index_4_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_4_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_4_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x45 | IN1 Index 5 Boost for Adaptation | 7:6 | EQ_index_5_BST0 | 0x90 | RW | Index 5 Boost |
| | | 5:4 | EQ_index_5_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_5_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_5_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x46 | IN1 Index 6 Boost for Adaptation | 7:6 | EQ_index_6_BST0 | 0x54 | RW | Index 6 Boost |
| | | 5:4 | EQ_index_6_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_6_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_6_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x47 | IN1 Index 7 Boost for Adaptation | 7:6 | EQ_index_7_BST0 | 0xA0 | RW | Index 7 Boost |
| | | 5:4 | EQ_index_7_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_7_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_7_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x48 | IN1 Index 8 Boost for Adaptation | 7:6 | EQ_index_8_BST0 | 0xB0 | RW | Index 8 Boost |
| | | 5:4 | EQ_index_8_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_8_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_8_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x49 | IN1 Index 9 Boost for Adaptation | 7:6 | EQ_index_9_BST0 | 0x95 | RW | Index 9 Boost |
| | | 5:4 | EQ_index_9_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_9_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_9_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x4A | IN1 Index 10 Boost for Adaptation | 7:6 | EQ_index_10_BST0 | 0x69 | RW | Index 10 Boost |
| | | 5:4 | EQ_index_10_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_10_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_10_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x4B | IN1 Index 11 Boost for Adaptation | 7:6 | EQ_index_11_BST0 | 0xD5 | RW | Index 11 Boost |
| | | 5:4 | EQ_index_11_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_11_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_11_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x4C | IN1 Index 12 Boost for Adaptation | 7:6 | EQ_index_12_BST0 | 0x99 | RW | Index 12 Boost |
| | | 5:4 | EQ_index_12_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_12_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_12_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x4D | IN1 Index 13 Boost for Adaptation | 7:6 | EQ_index_13_BST0 | 0xA5 | RW | Index 13 Boost |
| | | 5:4 | EQ_index_13_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_13_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_13_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x4E | IN1 Index 14 Boost for Adaptation | 7:6 | EQ_index_14_BST0 | 0xE6 | RW | Index 14 Boost |
| | | 5:4 | EQ_index_14_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_14_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_14_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x4F | IN1 Index 15 Boost for Adaptation | 7:6 | EQ_index_15_BST0 | 0xF9 | RW | Index 15 Boost |
| | | 5:4 | EQ_index_15_BST1 | | RW | [7:6]: 2-bit control for Stage 0 of the CTLE |
| | | 3:2 | EQ_index_15_BST2 | | RW | [5:4]: 2-bit control for Stage 1 of the CTLE. |
| | | 1:0 | EQ_index_15_BST3 | | RW | [3:2]: 2-bit control for Stage 2 of the CTLE. [1:0]: 2-bit control for Stage 3 of the CTLE. |
| 0x50 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |

LMH1219

SNLS530D – APRIL 2016 – REVISED JUNE 2018

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| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|----------------------------|-----|--------------------------|---------|------|---|
| 0x51 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x52 | IN1 Active EQ Readback | 7:0 | eq_bst_to_ana | 0x00 | R | IN1 CTLE boost setting readback from Active CTLE Adaptation. |
| 0x53 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x54 | Interrupt Status Register | 7 | cardet | 0x00 | R | 0 = Carrier Detect from the selected input de-asserted 1 = Carrier Detect from the selected input asserted Note: Clears when Reg 0x54 is read-back. |
| | | 6 | cdr_lock_int | | R | 0 = No interrupt from CDR Lock 1 = CDR Lock Interrupt Note: Clears when Reg 0x54 is read-back. |
| | | 5 | carrier_det1_int | | R | 0 = No interrupt from IN1 Carrier Detect 1 = IN1 Carrier Detect Interrupt Note: Clears when Reg 0x54 is read-back. |
| | | 4 | carrier_det0_int | | R | 0 = No interrupt from IN0 Carrier Detect 1 = IN0 Carrier Detect Interrupt Note: Clears when Reg 0x54 is read-back. |
| | | 3 | heo_veo_int | | R | 0 = No interrupt from HEO/VEO 1 = HEO/VEO Threshold Reached Interrupt Note: Clears when Reg 0x54 is read-back. |
| | | 2 | cdr_lock_loss_int | | R | 0 = No interrupt from CDR Lock 1 = CDR Loss of Lock Interrupt Note: Clears when Reg 0x54 is read-back. |
| | | 1 | carrier_det1_loss_int | | R | 0 = No interrupt from IN1 Carrier Detect 1 = IN1 Carrier Detect Loss Interrupt Note: Clears when Reg 0x54 is read-back. |
| | | 0 | carrier_det0_loss_int | | R | 0 = No interrupt from IN0 Carrier Detect 1 = IN0 Carrier Detect Loss Interrupt Note: Clears when Reg 0x54 is read-back. |
| 0x55 | Reserved | 7:0 | Reserved | 0x02 | R | Reserved |
| 0x56 | Interrupt Control Register | 7 | Reserved | 0x00 | RW | Reserved |
| | | 6 | cdr_lock_int_en | | RW | 0 = Disable interrupt if CDR lock is achieved 1 = Enable interrupt if CDR lock is achieved |
| | | 5 | carrier_det1_int_en | | RW | 0 = Disable interrupt if IN1 Carrier Detect is asserted 1 = Enable interrupt if IN1 Carrier Detect is asserted |
| | | 4 | carrier_det0_int_en | | RW | 0 = Disable interrupt if IN0 Carrier Detect is asserted 1 = Enable interrupt if IN0 Carrier Detect is asserted |
| | | 3 | heo_veo_int_en | | RW | 0 = Disable interrupt if HEO/VEO threshold is reached 1 = Enable interrupt if HEO/VEO threshold is reached |
| | | 2 | cdr_lock_loss_int_en | | RW | 0 = Disable interrupt if CDR loses lock 1 = Enable interrupt if CDR loses lock |
| | | 1 | carrier_det1_loss_int_en | | RW | 0 = Disable interrupt if there is loss of signal (LOS) on IN1 1 = Enable interrupt if there is loss of signal (LOS) on IN1 |
| | | 0 | carrier_det0_loss_int_en | | RW | 0 = Disable interrupt if there is loss of signal (LOS) on IN0 1 = Enable interrupt if there is loss of signal (LOS) on IN0 |
| 0x60 | Reserved | 7:0 | Reserved | 0x26 | RW | Reserved |
| 0x61 | Reserved | 7:0 | Reserved | 0x31 | RW | Reserved |
| 0x62 | Reserved | 7:0 | Reserved | 0x70 | RW | Reserved |
| 0x63 | Reserved | 7:0 | Reserved | 0x3D | RW | Reserved |
| 0x64 | Reserved | 7:0 | Reserved | 0xFF | RW | Reserved |
| 0x65 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x66 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x67 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x68 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|----------------------------|-----|------------------|---------|------|--|
| 0x69 | HEO_VEO Lock Monitor | 7:4 | Reserved | 0x0A | RW | Reserved |
| | | 3:0 | hv_lckmon_cnt_ms | | RW | While monitoring lock, these bits set the amount of interval times to monitor HEO or VEO lock. Each interval is 6.5 ms. Therefore, by default, Reg 0x69[3:0] = 1010'b causes HEO_VEO lock monitor to occur once every 65 ms. |
| 0x6A | HEO and VEO Lock Threshold | 7:4 | veo_lck_thrsh | 0x44 | RW | HEO/VEO lock thresholds. Lock will not be declared until $HEO \geq (heo_lck_thrsh \times 4)$ and $VEO \geq (veo_lck_thrsh \times 4)$. |
| | | 3:0 | heo_lck_thrsh | | RW | |
| 0x6B | Reserved | 7:0 | Reserved | 0x40 | RW | Reserved |
| 0x6C | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x6D | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x6E | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x6F | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x70 | Reserved | 7:0 | Reserved | 0x03 | RW | Reserved |
| 0x71 | Reserved | 7:0 | Reserved | 0x20 | R | Reserved |
| 0x72 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x73 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x74 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x75 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x77 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x80 | Reserved | 7:0 | Reserved | 0x50 | RW | Reserved |
| 0x81 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x82 | Reserved | 7:0 | Reserved | 0x80 | RW | Reserved |
| 0x83 | Reserved | 7:0 | Reserved | 0x70 | RW | Reserved |
| 0x84 | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0x85 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x87 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x90 | Reserved | 7:0 | Reserved | 0xA5 | RW | Reserved |
| 0x91 | Reserved | 7:0 | Reserved | 0x23 | RW | Reserved |
| 0x92 | Reserved | 7:0 | Reserved | 0x2C | RW | Reserved |
| 0x93 | Reserved | 7:0 | Reserved | 0x32 | RW | Reserved |
| 0x94 | Reserved | 7:0 | Reserved | 0x37 | RW | Reserved |
| 0x95 | Reserved | 7:0 | Reserved | 0x3E | RW | Reserved |
| 0x98 | Reserved | 7:0 | Reserved | 0x3F | RW | Reserved |
| 0x99 | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0x9A | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0x9B | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0x9C | Reserved | 7:0 | Reserved | 0x06 | RW | Reserved |
| 0x9D | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0x9E | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0xA0 | SMPT Data Rate Lock Enable | 7:5 | Reserved | 0x1F | RW | Reserved |
| | | 4 | dvb_enable | | RW | 0 = Disable CDR Lock to 270 Mbps 1 = Enable CDR Lock to 270 Mbps |
| | | 3 | hd_enable | | RW | 0 = Disable CDR Lock to 1.485/1.4835 Gbps 1 = Enable CDR Lock to 1.485/1.4835 Gbps |
| | | 2 | 3G_enable | | RW | 0 = Disable CDR Lock to 2.97/2.967 Gbps 1 = Enable CDR Lock to 2.97/2.967 Gbps |
| | | 1 | 6G_enable | | RW | 0 = Disable CDR Lock to 5.94/5.934 Gbps 1 = Enable CDR Lock to 5.94/5.934 Gbps |
| | | 0 | 12G_enable | | RW | 0 = Disable CDR Lock to 11.88/11.868 Gbps 1 = Enable CDR Lock to 11.88/11.868 Gbps |

7.5.3 CableEQ/Drivers Register Page

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|------------------------------------|-----|--------------------------|---------|------|---|
| 0x00 | Reset CableEQ/Drivers Registers | 7 | adapt_cd | 0x08 | RW | LOCK_N pin status 0 = LOCK_N indicates when Coarse Adaptation for IN0 is done 1 = LOCK_N indicates carrier detect (CD_N) for IN0 |
| | | 6 | Reserved | | RW | Reserved |
| | | 5 | reg_power_save_ov | | RW | IN0 Power Save Override Control for Cable EQ 0 = Disable Power Save Mode override. Automatic Power Save when no input signal detected. 1 = Enable Power Save Mode override. Power Save mode control set by value in Reg 0x00[4:3]. Note: Unused input is always powered down automatically. |
| | | 4:3 | reg_power_save | | RW | IN0 Auto Power Save Mode control for Cable EQ if Reg 0x00[5] = 1 00 = Enable Power Save Mode when no input signal is detected 01 = Disable auto Power Save Mode (disable power down) 10 = Reserved 11 = Force Power Save Mode Note: Unused input is always powered down automatically. |
| | | 2 | rst_cableEQ/Drivers_regs | | RW | Reset registers (self-clearing) 0 = Normal operation 1 = Reset CableEQ/Drivers Registers. Register re-initialization procedure required after resetting the CableEQ/Drivers Registers. Refer to the LMH1219 Programming Guide for details. |
| | | 1:0 | Reserved | | RW | Reserved |
| 0x01 | EQ Observation Status | 7:1 | Reserved | 0x80 | R | Reserved |
| | | 0 | adaptation_status | | R | 0 = Adaptation not completed 1 = Adaptation completed |
| 0x02 | Rate and Driver Observation Status | 7 | Reserved | 0x07 | R | Reserved |
| | | 6 | IN0 Carrier Detect | | R | Carrier Detect Status of IN0 0 = No signal present at IN0 1 = Signal present at IN0 |
| | | 5:3 | freq_rate_det | | R | Readback of rate detected 001 = 125M-270M 010 = 1.5G-3G 100 = 6G-12G |
| | | 2 | power_save_status | | R | Observation Bit 0 = Power Save Mode is Inactive 1 = Power Save Mode is Active |
| | | 1 | mute_tx1 | | R | Observation Bit 0 = OUT1 Driver is Active 1 = OUT1 Driver is in Mute Note: When muted, driver output remains at common mode voltage. |
| | | 0 | mute_tx0 | | R | Observation Bit 0 = OUT0 Driver is Active 1 = OUT0 Driver is in Mute Note: When muted, driver output remains at common mode voltage. |
| 0x03 | MUTERef Control | 7:6 | Reserved | 0x3F | RW | Reserved |
| | | 5:0 | MUTERef | | RW | Digital MUTERef sets the threshold at which the output will be muted. See the "Digital MUTE _{REF} " subsection of the LMH1219 datasheet for more information. |
| 0x04 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x05 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x06 | Reserved | 7:0 | Reserved | 0xA0 | RW | Reserved |
| 0x07 | Reserved | 7:0 | Reserved | 0x24 | RW | Reserved |
| 0x08 | Reserved | 7:0 | Reserved | 0x27 | RW | Reserved |

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|------------------------|-----|---------------|---------|------|---|
| 0x09 | Reserved | 7:0 | Reserved | 0x01 | RW | Reserved |
| 0x0A | Reserved | 7:0 | Reserved | 0x05 | RW | Reserved |
| 0x0B | Reserved | 7:0 | Reserved | 0x37 | RW | Reserved |
| 0x0C | Reserved | 7:0 | Reserved | 0x01 | RW | Reserved |
| 0x0D | Reserved | 7:0 | Reserved | 0x25 | RW | Reserved |
| 0x0E | Reserved | 7:0 | Reserved | 0x37 | RW | Reserved |
| 0x0F | Reserved | 7:0 | Reserved | 0x02 | RW | Reserved |
| 0x10 | Reserved | 7:0 | Reserved | 0x0A | RW | Reserved |
| 0x11 | Reserved | 7:0 | Reserved | 0x02 | RW | Reserved |
| 0x12 | Reserved | 7:0 | Reserved | 0x08 | RW | Reserved |
| 0x13 | Reserved | 7:0 | Reserved | 0x04 | RW | Reserved |
| 0x14 | Reserved | 7:0 | Reserved | 0x3C | RW | Reserved |
| 0x15 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x16 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x17 | Reserved | 7:0 | Reserved | 0x08 | RW | Reserved |
| 0x18 | Reserved | 7:0 | Reserved | 0x01 | RW | Reserved |
| 0x19 | Reserved | 7:0 | Reserved | 0x08 | RW | Reserved |
| 0x1A | Reserved | 7:0 | Reserved | 0x01 | RW | Reserved |
| 0x1B | Reserved | 7:0 | Reserved | 0xA7 | RW | Reserved |
| 0x1C | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x1D | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x1E | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x1F | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x20 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x21 | Reserved | 7:0 | Reserved | 0xC0 | RW | Reserved |
| 0x22 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x23 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x24 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x25 | Cable Length Indicator | 7:6 | Reserved | 0x00 | R | Reserved |
| | | 5:0 | CLI | | R | Readback of Cable Length Indicator (CLI) after adaptation. See the "Cable Length Indicator (CLI)" subsection of the LMH1219 datasheet for more information. |
| 0x26 | Reserved | 7:0 | Reserved | 0x05 | R | Reserved |
| 0x27 | EQ Bypass Override | 7:4 | Reserved | 0x00 | RW | Reserved |
| | | 3 | eq_bypass_ov | | RW | Override eq_bypass value to analog core 0 = Disable EQ Bypass override 1 = Enable EQ Bypass override. Value of EQ Bypass Control determined by Reg 0x27[2]. |
| | | 2 | eq_bypass_val | | RW | Override value of eq_bypass 0 = Do not Bypass Cable EQ. Use Adaptive EQ 1 = Bypass Cable EQ |
| | | 1:0 | Reserved | | RW | Reserved |
| 0x28 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x29 | Reserved | 7:0 | Reserved | 0x20 | R | Reserved |
| 0x2A | Reserved | 7:0 | Reserved | 0x40 | RW | Reserved |
| 0x2B | Reserved | 7:0 | Reserved | 0x89 | RW | Reserved |
| 0x2C | Reserved | 7:0 | Reserved | 0x0B | RW | Reserved |
| 0x2D | Reserved | 7:0 | Reserved | 0x20 | RW | Reserved |
| 0x2E | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x2F | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |

LMH1219

SNLS530D – APRIL 2016 – REVISED JUNE 2018

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| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|--------------------------|-----|--------------|---------|------|--|
| 0x30 | OUT0 Output Control | 7 | tx0_mute_ov | 0x0A | RW | OUT0 Mute Override Control 0 = Disable OUT0 Mute Override Control 1 = Enable OUT0 Mute Override Control by value in Reg 0x30[6]. |
| | | 6 | tx0_mute_val | | RW | 0 = Normal Operation 1 = Mute OUT0 if Reg 0x30[7] = 1 |
| | | 5 | tx0_vod_ov | | RW | OUT0 VOD Override Control 0 = VOD settings for OUT0 determined by VOD_DE pin 1 = Override VOD pin settings for OUT0. VOD settings for OUT0 are controlled by Reg 0x30[2:0] |
| | | 4:3 | Reserved | | RW | Reserved |
| | | 2:0 | tx0_vod | | RW | VOD settings for OUT0 if Reg 0x30[5] = 1. See the "Output Amplitude vs. VOD Register Settings" graph in the Typical Characteristics subsection of the LMH1219 datasheet for more information. |
| 0x31 | OUT0 De-Emphasis Control | 7 | Reserved | 0x01 | RW | Reserved |
| | | 6 | tx0_dem_ov | | RW | OUT0 De-Emphasis Override Control 0 = De-emphasis for OUT0 determined by VOD_DE pin 1 = Override De-emphasis settings for OUT0. De-emphasis settings for OUT0 are controlled by Reg 0x31[2:0] |
| | | 5 | tx0_PD_ov | | RW | OUT0 Power Down Override Control 0 = Disable OUT0 Power Down Override Control 1 = Enable OUT0 Power Down Override Control by value in Reg 0x31[4] |
| | | 4 | tx0_PD | | RW | 0 = Normal Operation 1 = Power Down OUT0 if Reg 0x31[5] = 1 |
| | | 3 | Reserved | | RW | Reserved |
| | | 2:0 | tx0_dem | | RW | De-emphasis settings for OUT0 if Reg 0x31[6] = 1. See the "Output De-emphasis vs. VOD Register Settings" graph in the Typical Characteristics subsection of the LMH1219 datasheet for more information. |
| 0x32 | OUT1 Output Control | 7 | tx1_mute_ov | 0x0A | RW | OUT1 Mute Override Control 0 = Disable OUT1 Mute Override Control 1 = Enable OUT1 Mute Override Control by value in Reg 0x32[6]. |
| | | 6 | tx1_mute_val | | RW | 0 = Normal Operation 1 = Mute OUT1 if Reg 0x32[7] = 1 |
| | | 5 | tx1_vod_ov | | RW | OUT1 VOD Override Control 0 = VOD settings for OUT1 determined by VOD_DE pin 1 = Override VOD pin settings for OUT1. VOD settings for OUT1 are controlled by Reg 0x32[2:0] |
| | | 4:3 | Reserved | | RW | Reserved |
| | | 2:0 | tx1_vod | | RW | VOD settings for OUT0 if Reg 0x32[5] = 1. See the "Output Amplitude vs. VOD Register Settings" graph in the Typical Characteristics subsection of the LMH1219 datasheet for more information. |

| Address | Register Name | Bit | Field | Default | Type | Description |
|---------|--------------------------------|-----|--------------|---------|------|--|
| 0x33 | OUT1 De-Emphasis Control | 7 | Reserved | 0x11 | RW | Reserved |
| | | 6 | tx1_dem_ov | | RW | OUT1 De-Emphasis Override Control 0 = De-emphasis for OUT1 determined by VOD_DE pin 1 = Override De-emphasis settings for OUT1. De-emphasis settings for OUT1 are controlled by Reg 0x33[2:0] |
| | | 5 | tx1_PD_ov | | RW | OUT1 Power Down Override Control 0 = Disable OUT1 Power Down Override Control 1 = Enable OUT1 Power Down Override Control by value in Reg 0x33[4]. |
| | | 4 | tx1_PD | | RW | 0 = Normal Operation 1 = Power Down OUT1 if Reg 0x33[5] = 1 |
| | | 3 | Reserved | | RW | Reserved |
| | | 2:0 | tx1_dem | | RW | De-emphasis settings for OUT1 if Reg 0x33[6] = 1. See the "Output De-emphasis vs. VOD Register Settings" graph in the Typical Characteristics subsection of the LMH1219 datasheet for more information. |
| 0x34 | Splitter_Reg | 7 | hi_gain_mode | 0x17 | RW | -6 dB Launch Amplitude Adaptation Mode 0 = Enable EQ adaptation with nominal 800 mV launch amplitude 1 = Enable EQ adaptation with 400 mV launch amplitude |
| | | 6:0 | Reserved | | | Reserved |
| 0x35 | Reserved | 7:0 | Reserved | 0x61 | RW | Reserved |
| 0x36 | Reserved | 7:0 | Reserved | 0x02 | RW | Reserved |
| 0x37 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x38 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x39 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x3A | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x3B | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x3C | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x3D | Reserved | 7:0 | Reserved | 0x7F | RW | Reserved |
| 0x3E | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x3F | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x40 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x41 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x42 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x43 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x44 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x45 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x46 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x47 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x48 | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x49 | Reserved | 7:0 | Reserved | 0x01 | R | Reserved |
| 0x4A | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x4B | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x4C | Reserved | 7:0 | Reserved | 0x00 | R | Reserved |
| 0x4D | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x4E | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x4F | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x50 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x51 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x52 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x53 | Reserved | 7:0 | Reserved | 0x00 | RW | Reserved |
| 0x54 | Reserved | 7:0 | Reserved | 0x0F | R | Reserved |

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

8.1.1 General Guidance for SMPTE and 10 GbE Applications

SMPTE specifies the requirements for the Serial Digital Interface to transport digital video over coaxial cables. One of the requirements is meeting return loss, which specifies how closely the port resembles 75-Ω impedance across a specified frequency band. The SMPTE specifications also defines the use of AC coupling capacitors for transporting uncompressed serial data streams with heavy low frequency content. The use of 4.7-μF AC coupling capacitors is recommended to avoid low frequency DC wander. SFF-8431 (SFP+) requires the 100-Ω transmit signal to meet the electrical, return loss, jitter, and eye mask specifications. TI recommends placing the LMH1219 as close as possible to the 75-Ω BNC and 100-Ω SFP+ optical module in order to meet the specifications for SMPTE and SFF-8431. Refer to [Table 9](#) for design guidelines.

8.1.2 Optimizing Time to Adapt and Lock

When carrier detect is asserted the LMH1219 continuously adapts the cable equalizer to the optimal gain and bandwidth. The time required to adapt the equalizer and achieve lock to the incoming signal can be optimized by manually programming the highest data rate expected in the application. Refer to LMH1219 programming guide for more details.

8.1.3 LMH1219 and LMH0324 Compatibility

The LMH1219 is pin compatible with the LMH0324 (3 Gbps adaptive cable equalizer) when the LMH0324 RSV_L pin is tied to 2.5 V. This pin compatibility allows users to upgrade easily from a 3 Gbps equalizer to a 12 Gbps UHD equalizer with integrated reclocker. See [Figure 21](#) for details.

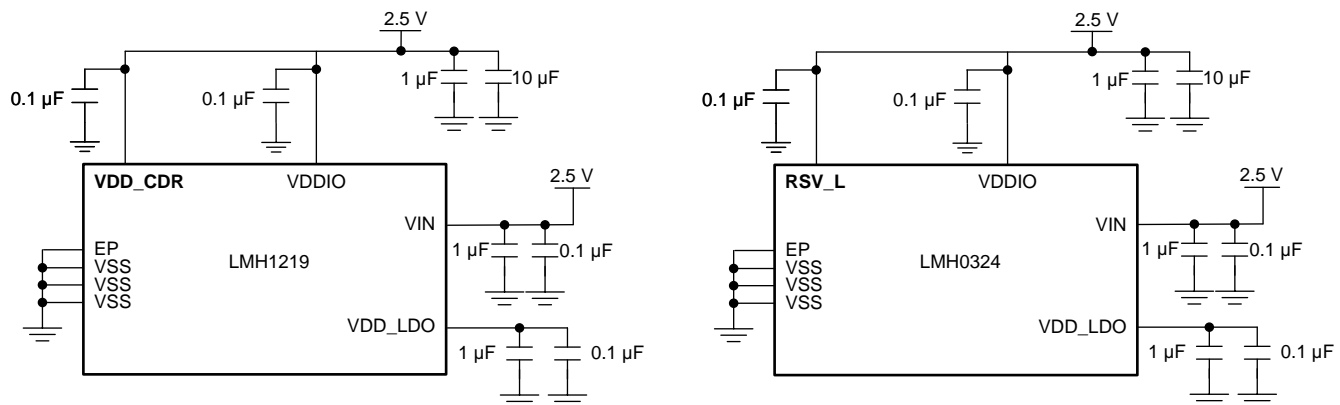


Figure 21. Pin Connections for LMH1219 and LMH0324 Compatibility

8.2 Typical Application

The LMH1219 is a low-power cable equalizer with integrated reclocker that supports SDI data rates up to 11.88 Gbps and 10 GbE. [Figure 22](#) shows a typical implementation of the LMH1219 as a SDI adaptive cable equalizer at IN0+. Signal attenuated by a long coax cable is applied to the LMH1219 at the BNC port. Signal from a 10 GbE optical module is connected to the input port at IN1±. Equalized and reclocked data is output at OUT0± and OUT1± to a downstream video processor.

Typical Application (continued)

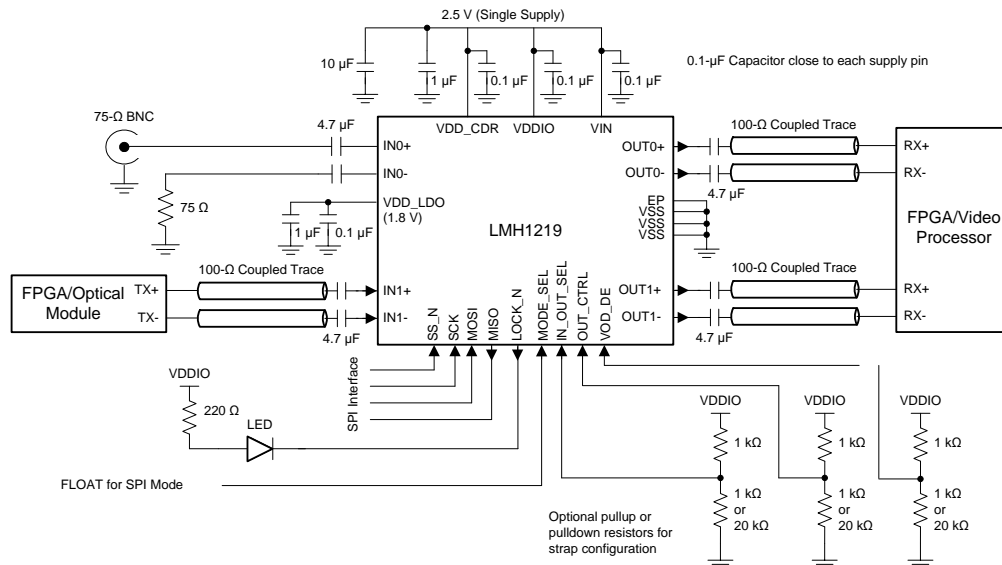


Figure 22. LMH1219 SPI Mode Connection Diagram

8.2.1 Design Requirements

Table 9. LMH1219 Design Requirements

| DESIGN PARAMETER | REQUIREMENTS |
|--|--|
| IN0+ Input AC coupling capacitor | AC Coupling capacitor at IN0+ should be a 4.7-µF capacitor. Choose a small 0402 surface mount ceramic capacitor. IN0- should be AC terminated with 4.7 µF and 75 Ω to VSS. |
| IN1± Input AC coupling capacitors | AC Coupling capacitors at IN1± should be 4.7-µF capacitors. Choose small 0402 surface mount ceramic capacitors. This allows both SMPTE and 10 GbE data traffic. |
| Output AC coupling capacitors | Both OUT0± and OUT1± require AC coupling capacitors. Choose small 0402 surface mount ceramic capacitors. 4.7-µF AC coupling capacitors are recommended. |
| DC power supply decoupling capacitors | Decoupling capacitors are required to minimize power supply noise. Place 10-µF and 1-µF bulk capacitors close to each device. Place a 0.1-µF capacitor close to each supply pin. |
| VDD_LDO decoupling capacitors | Place 1-µF and 0.1-µF surface mount ceramic capacitors as close as possible to the device VDD_LDO pin. |
| High speed board trace for IN0 | IN0+ and IN0- should be routed with uncoupled board traces with 75-Ω characteristic impedance. |
| High Speed IN1, OUT0, and OUT1 trace impedance | IN1±, OUT0± and OUT1± should be routed with coupled board traces with 100-Ω differential impedance. |
| SMPTE return loss | Place BNC within 1 inch of the LMH1219 and consult BNC vendor for recommended BNC landing pattern to meet SMPTE requirements. |
| IN0+ and IN1± cross talk | When a long length coax cable is connected to IN0+, the signal amplitude at IN0+ can be just a few mVp-p. Layout precautions must be taken to minimize crosstalk from adjacent devices or from adjacent input port IN1±. To reduce cross coupling effects, keep IN1± traces as far from IN0± as possible. When IN1± is not used, it is recommended to turn off the signal source to IN1± for best results. |
| Use of SPI or SMBus interface | Set MODE_SEL to Level-F (pin unconnected) for SPI. Set MODE_SEL to Level-L (connect 1 kΩ to VSS) for SMBus. SMBus is 3.3 V tolerant. |

8.2.2 Detail Design Procedure

The following general design procedure is recommended:

1. Select a suitable power supply voltage for the LMH1219. See [Power Supply Recommendations](#) for details.
2. Check that the power supply meets the DC and AC requirements in [Recommended Operating Conditions](#).
3. Select the proper pull-high or pull-low resistors for IN_OUT_SEL and OUT_CTRL for setting the signal path.

4. If -6 dB launch amplitude or other expanded programmable features are needed, select the use of SPI or SMBus by setting Level-F or Level-L for MODE_SEL, respectively.
5. Choose a high quality 75-Ω BNC that is capable of supporting 11.88 Gbps applications. Consult a BNC supplier regarding insertion loss, impedance specifications, and recommended footprint for meeting SMPTE return loss.
6. Depending on the length and insertion loss of the output traces for OUT0± and OUT1±, select the proper pull-high or pull-low resistors for VOD_DE to set the output amplitude and de-emphasis settings. Refer to [Table 5](#) for details.
7. Follow all design requirements detailed in [Table 9](#) to optimize LMH1219 performance.
8. For additional layout recommendations, refer to [PCB Layout Guidelines](#).

8.2.3 Recommended VOD and DEM Register Settings

[Table 10](#) shows recommended output amplitude and de-emphasis register settings for most applications.

Table 10. VOD and DEM Register Settings

| VOD REG SETTING OUT0±: 0x30[5]=1, 0x30[2:0] OUT1±: 0x32[5]=1, 0x32[2:0] | DEM REG SETTING OUT0±: 0x31[6]=1, 0x31[2:0] OUT1±: 0x33[6]=1, 0x33[2:0] | VOD (mVpp) | DEM (dB) |
|---|---|------------|----------|
| 0 | 0 | 410 | 0 |
| 1 | 1 | 486 | -0.1 |
| 2 | 1 | 560 | -0.1 |
| 2 | 2 | 560 | -0.9 |
| 3 | 1 | 635 | -0.3 |
| 3 | 2 | 635 | -1.3 |
| 3 | 3 | 635 | -2.4 |
| 4 | 1 | 716 | -0.5 |
| 4 | 2 | 716 | -1.8 |
| 4 | 3 | 716 | -3.0 |
| 4 | 4 | 716 | -4.0 |
| 5 | 1 | 810 | -0.8 |
| 5 | 2 | 810 | -2.4 |
| 5 | 3 | 810 | -3.6 |
| 5 | 4 | 810 | -4.6 |
| 5 | 5 | 810 | -6.1 |
| 6 | 1 | 880 | -1.0 |
| 6 | 2 | 880 | -2.7 |
| 6 | 3 | 880 | -4.0 |
| 6 | 4 | 880 | -5.0 |
| 6 | 5 | 880 | -6.5 |
| 7 | 1 | 973 | -1.2 |
| 7 | 2 | 973 | -3.1 |
| 7 | 3 | 973 | -4.6 |
| 7 | 4 | 973 | -5.7 |
| 7 | 5 | 973 | -7.1 |

8.2.4 Application Performance Plots

Depending on the selected input, the LMH1219 performance was measured with the test setups shown in Figure 23 and Figure 24.

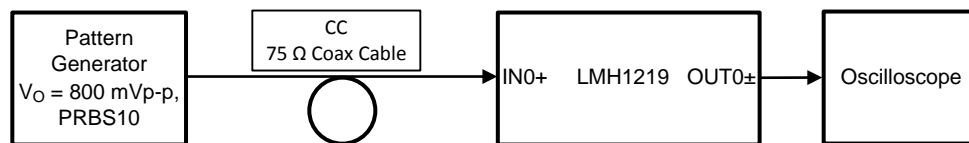


Figure 23. Test Setup for LMH1219 Cable Equalizer (IN0+)

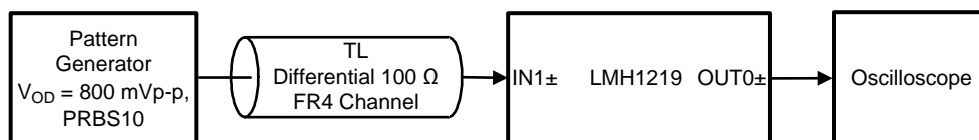
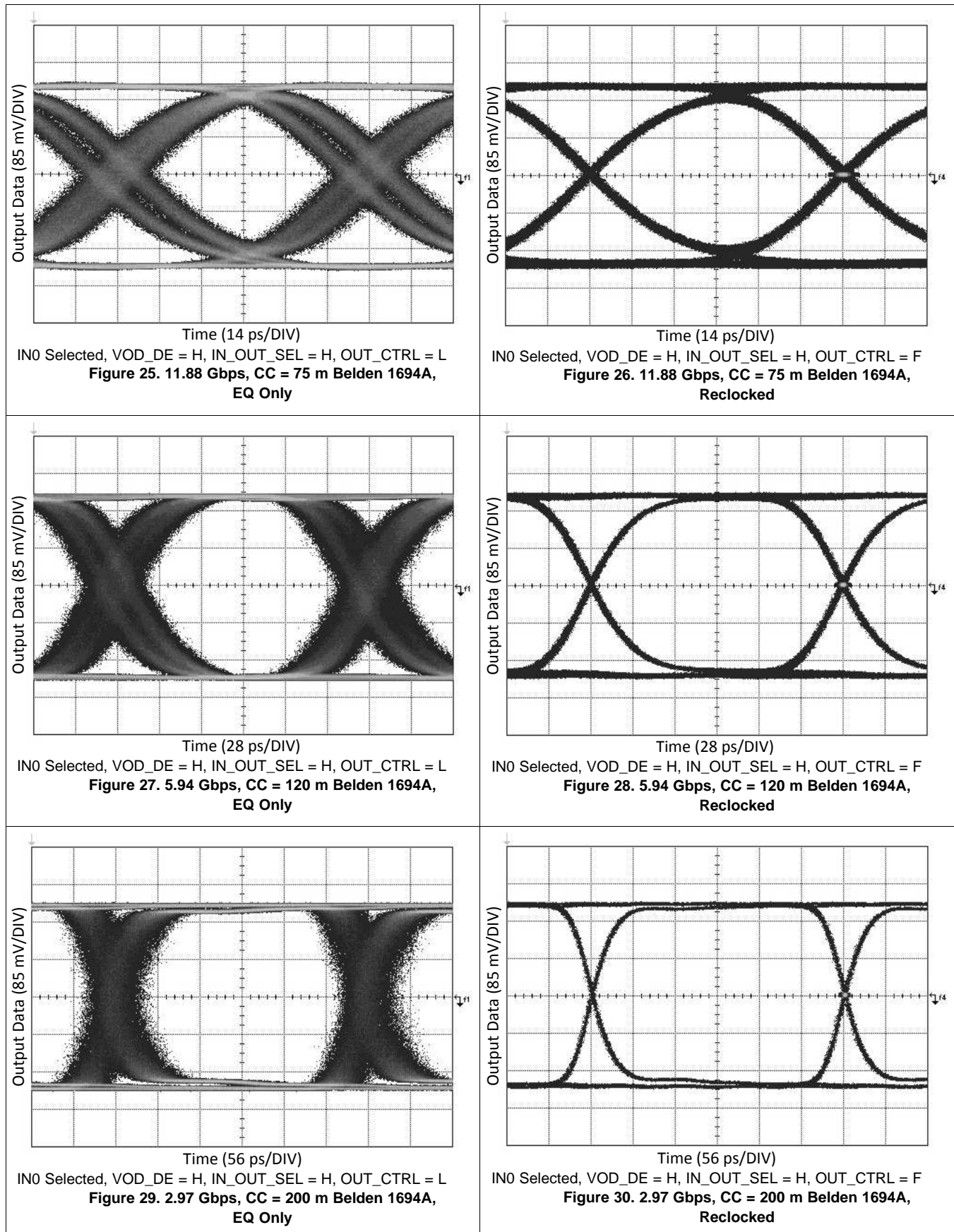
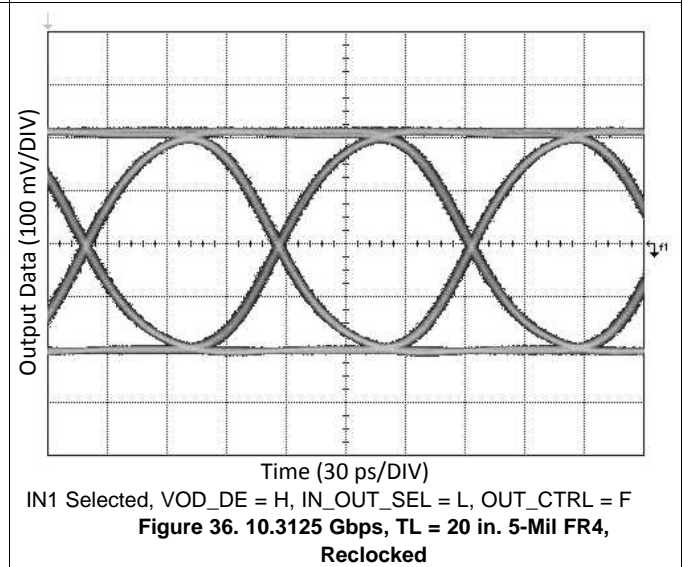
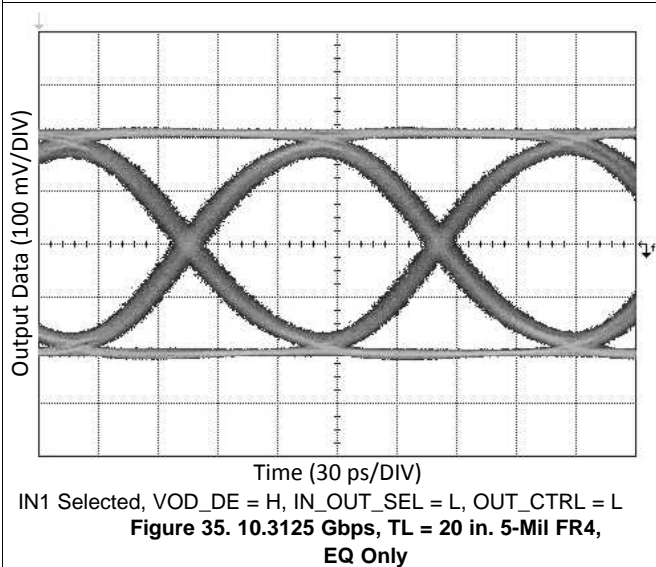
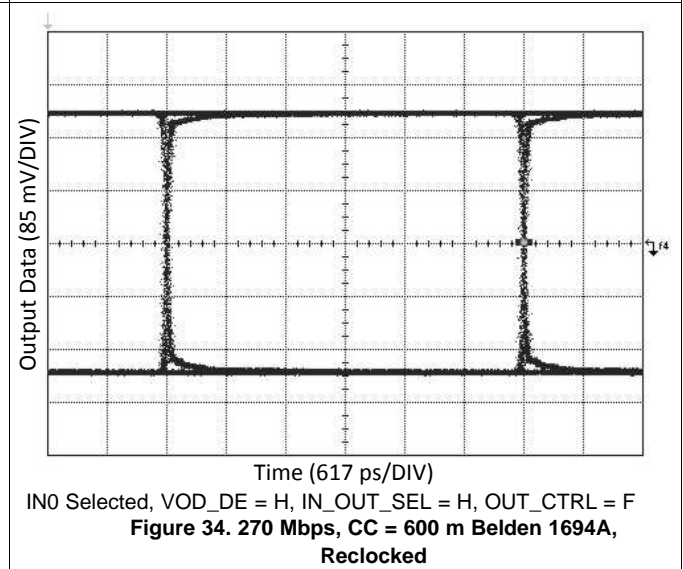
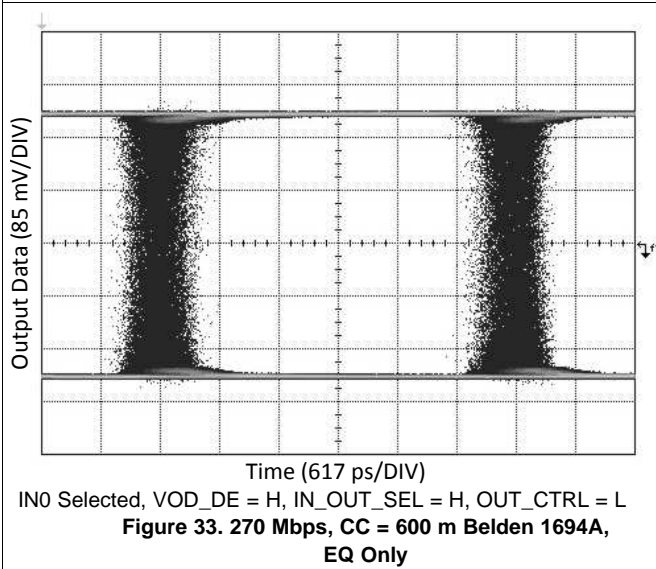
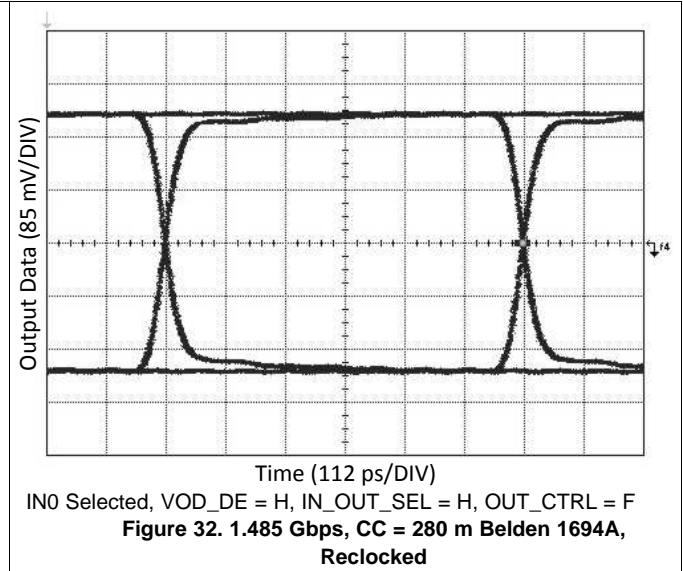
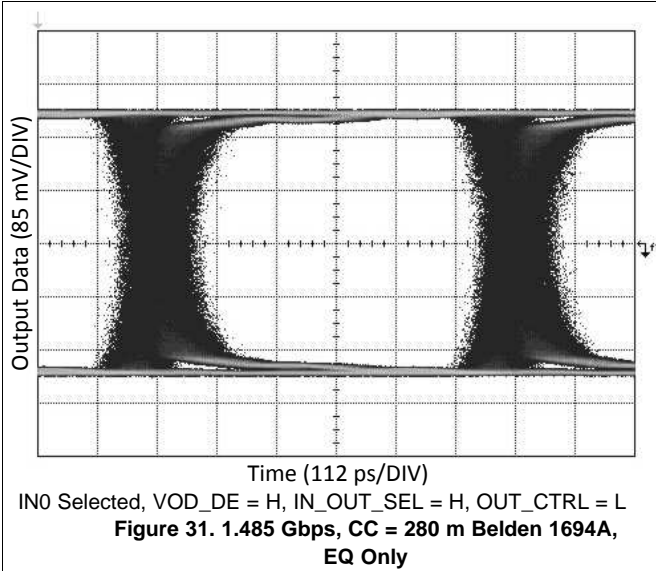


Figure 24. Test Setup for LMH1219 PCB Equalizer (IN1±)

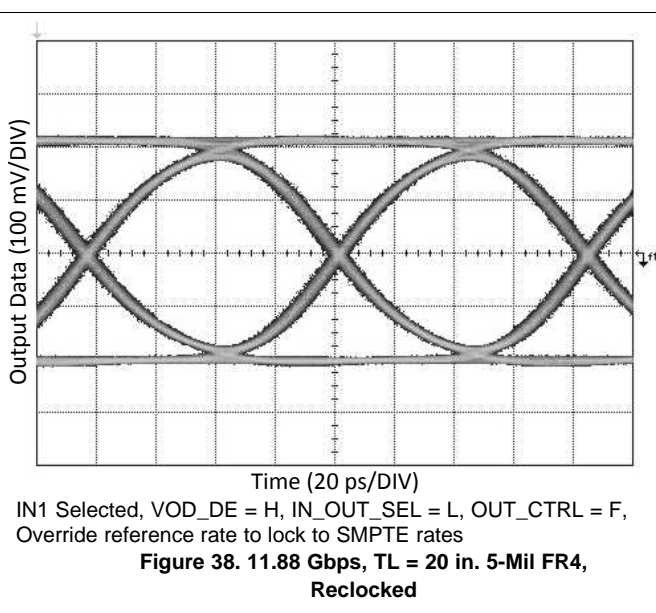
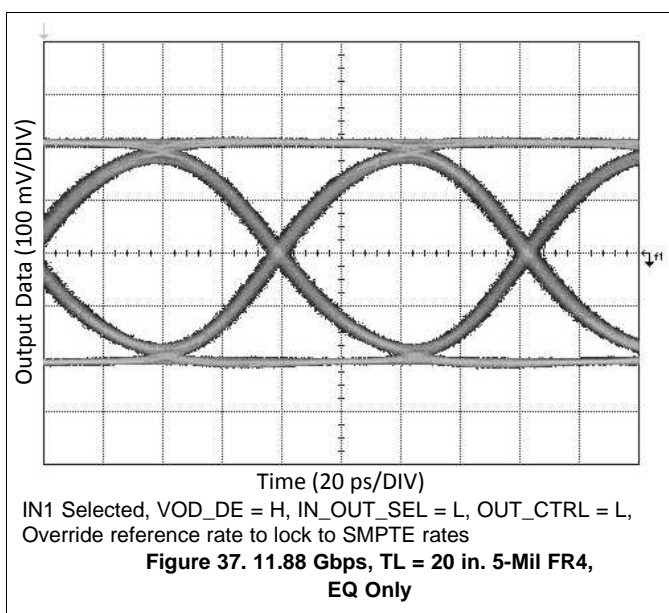
The eye diagrams in this subsection show how the LMH1219 improves overall signal integrity in the data path for 75-Ω coax cable input length (CC) when IN0 is selected and 100-Ω differential FR4 PCB trace when IN1 is selected.





LMH1219

SNLS530D – APRIL 2016 – REVISED JUNE 2018

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9 Power Supply Recommendations

The LMH1219 is designed to provide flexibility in supply rails. There are two ways to power the LMH1219:

- **Single Supply Mode (2.5 V):** This mode offers ease of use, with the internal circuitry receiving power from the on-chip 1.8 V regulator. In this mode, 2.5 V is applied to VDD_CDR, VIN, and VDDIO. See [Figure 39](#) for more details.
- **Dual Supply Mode (2.5 V and 1.8 V):** This mode provides lower power consumption. In this mode, 1.8 V is connected to both VIN and VDD_LDO. VDD_CDR, and VDDIO are powered from a 2.5 V supply. See [Figure 40](#) for more details.
- When Dual Supply Mode is used, the 2.5 V supply for VDD_CDR and VDDIO should be powered *before or at the same time* as the 1.8 V supply that powers VIN and VDD_LDO.

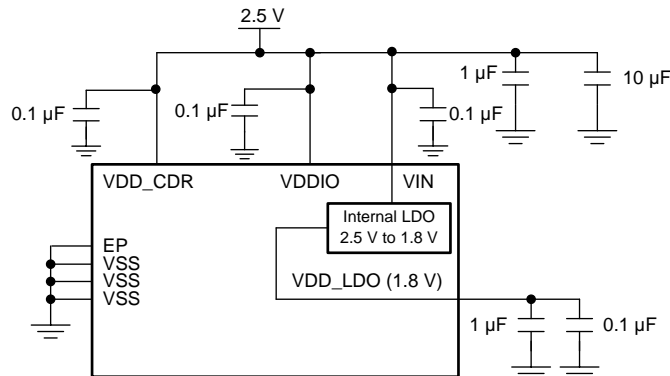


Figure 39. Typical Connection for Single 2.5 V Supply

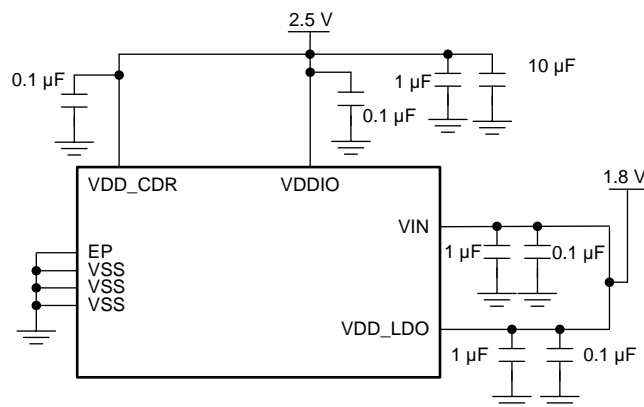


Figure 40. Typical Connection for Dual 2.5 V and 1.8 V Supply

For power supply de-coupling, 0.1-µF surface-mount ceramic capacitors are recommended to be placed close to each VDD_CDR, VIN, VDD_LDO, and VDDIO supply pin to VSS. Larger bulk capacitors (for example, 10 µF and 1 µF) are recommended for VDD_CDR and VIN. Good supply bypassing requires low inductance capacitors. This can be achieved through an array of multiple small body size surface-mount bypass capacitors in order to keep low supply impedance. Better results can be achieved through the use of a buried capacitor formed by a VDD and VSS plane separated by 2-4 mil dielectric in a printed circuit board.

10 Layout

10.1 PCB Layout Guidelines

The following guidelines are recommended for designing the board layout for the LMH1219:

1. Choose a suitable board stack-up that supports 75-Ω single-ended trace and 100-Ω differential trace routing on the board's top layer. This is typically done with a Layer 2 ground plane reference for the 100-Ω

PCB Layout Guidelines (continued)

differential traces and a second ground plane at Layer 3 reference for the 75- Ω single end traces.

2. Use single-ended uncoupled trace designed with 75- Ω impedance for signal routing to IN0+ and IN0-. The trace width is typically 8-10 mil reference to a ground plane at Layer 3.
3. Place anti-pad (ground relief) on the power and ground planes directly under the 4.7- μ F AC coupling capacitor and IC landing pads to minimize parasitic capacitance. The size of the anti-pad depends on the board stack-up and can be determined by a 3-dimension electromagnetic simulation tool.
4. Use a well-designed BNC footprint to ensure the BNC's signal landing pad achieves 75- Ω characteristic impedance. BNC suppliers usually provide recommendations on BNC footprint for best results.
5. Keep trace length short between the BNC and IN0+. The trace routing for IN0+ and IN0- should be symmetrical, approximately equal lengths and equal loading.
6. Use coupled differential traces with 100- Ω impedance for signal routing to IN1 \pm , OUT0 \pm and OUT1 \pm . They are usually 5-8 mil trace width reference to a ground plane at Layer 2.
7. The exposed pad EP of the package should be connected to the ground plane through an array of vias. These vias are solder-masked to avoid solder flowing into the plated-through holes during the board manufacturing process.
8. Connect each supply pin (VDD_CDR, VIN, VDDIO, VDD_LDO) to the power or ground planes with a short via. The via is usually placed tangent to the supply pins' landing pads with the shortest trace possible.
9. Power supply bypass capacitors should be placed close to the supply pins. They are commonly placed at the bottom layer and share the ground of the EP.

10.2 Layout Example

The following example demonstrates the high speed signal trace routing to the LMH1219.

1. BNC footprint and anti-pad: Consult BNC manufacturer for proper size.
2. Anti-pad under passive components.
3. 75- Ω single ended trace. Trace width should be similar to that of the IC landing pad (10 mil).
4. 100- Ω coupled trace.
5. Vias with solder mask.

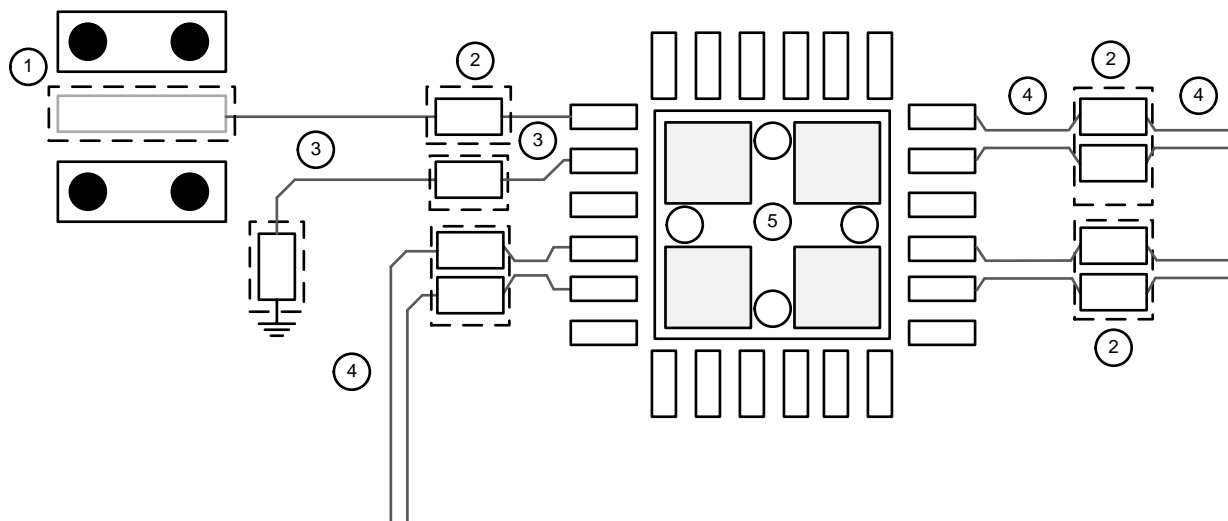


Figure 41. LMH1219 PCB Layout Example

11 Device and Documentation Support

11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.2 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.3 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

11.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LMH1219RTWR | ACTIVE | WQFN | RTW | 24 | 3000 | RoHS & Green | SN | Level-3-260C-168 HR | -40 to 85 | L1219A2 | Samples |
| LMH1219RTWT | ACTIVE | WQFN | RTW | 24 | 250 | RoHS & Green | SN | Level-3-260C-168 HR | -40 to 85 | L1219A2 | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LMH1219RTWR | WQFN | RTW | 24 | 3000 | 330.0 | 12.4 | 4.3 | 4.3 | 1.3 | 8.0 | 12.0 | Q1 |
| LMH1219RTWT | WQFN | RTW | 24 | 250 | 178.0 | 12.4 | 4.3 | 4.3 | 1.3 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LMH1219RTWR | WQFN | RTW | 24 | 3000 | 356.0 | 356.0 | 36.0 |
| LMH1219RTWT | WQFN | RTW | 24 | 250 | 208.0 | 191.0 | 35.0 |

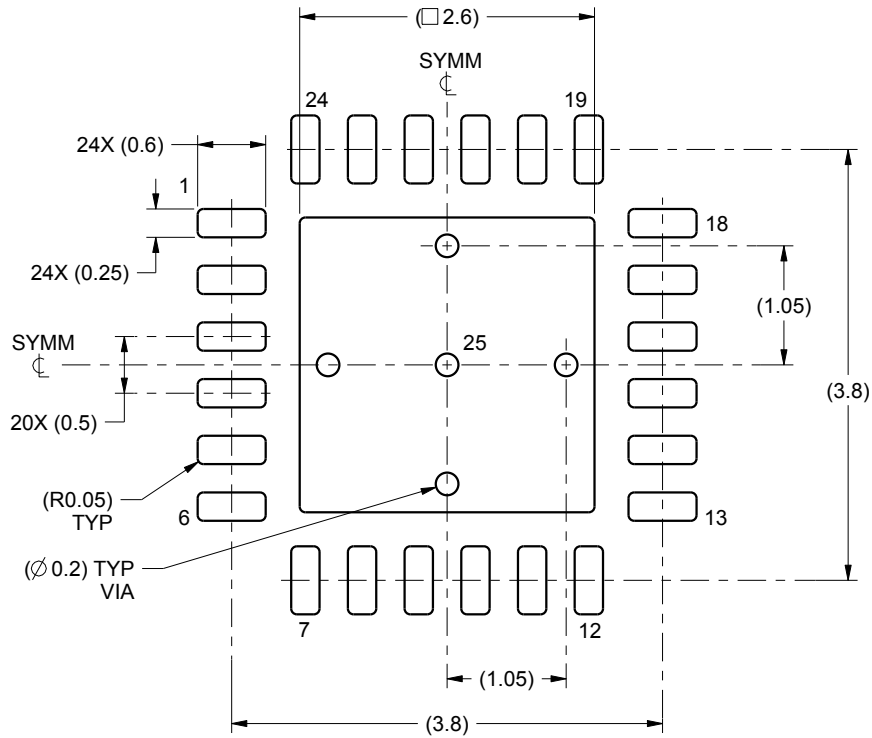
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

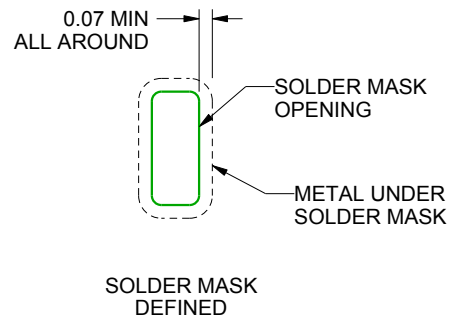
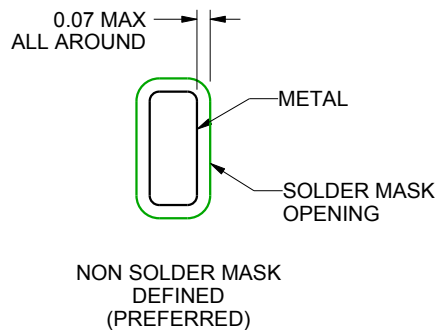
RTW0024A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

4222815/A 03/2016

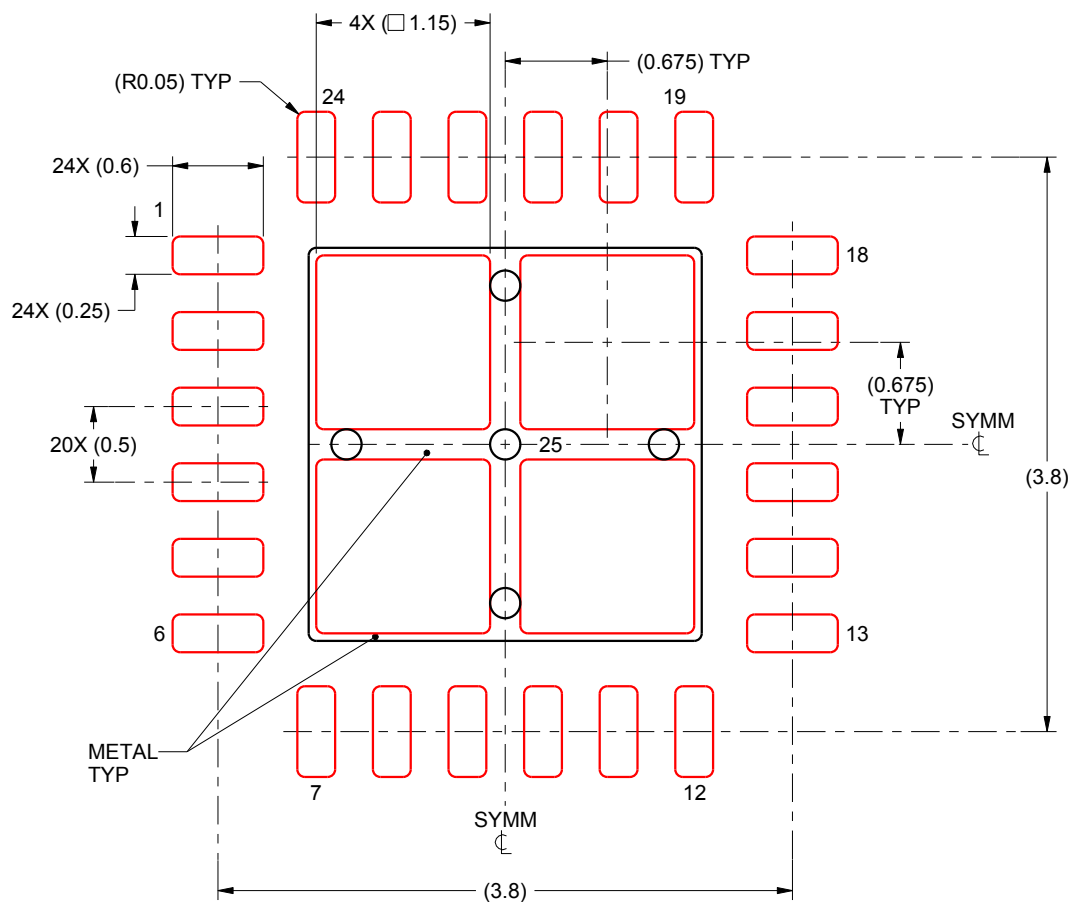
NOTES: (continued)

- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).

RTW0024A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 25:
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4222815/A 03/2016

NOTES: (continued)

5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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