

# DS64BR401

*DS64BR401 Quad Bi-Directional Repeater with Equalization and De-Emphasis*

# Datasheet.Support



Literature Number: SNLS304F

## DS64BR401

# Quad Bi-Directional Repeater with Equalization and De-Emphasis

## General Description

The DS64BR401 is a quad lane bi-directional signal conditioning repeater for 6.0/3.0/1.5 Gbps SATA/SAS and other high-speed bus applications with data rates up to 6.4 Gbps. The device performs both receive equalization and transmit de-emphasis on each of its 8 channels to compensate for channel loss, allowing maximum flexibility of physical placement within a system. The receiver's continuous time linear equalizer (CTLE) provides a boost of up to +33 dB at 3 GHz and is capable of opening an input eye that is completely closed due to inter-symbol interference (ISI) induced by the interconnect medium. The transmitter features a programmable output de-emphasis driver and allows amplitude voltage levels to be selected from 600 mVp-p to 1200 mVp-p to suit multiple application scenarios. This Low Power Differential Signaling (LPDS) output driver is a power efficient implementation that maintains compatibility with AC coupled CML receiver. The programmable settings can be applied via pin settings or SMBus interface.

To enable seamless upgrade from SAS/SATA 3.0 Gbps to 6.0 Gbps data rates without compromising physical reach, DS64BR401 automatically detects the incoming data rate and selects the optimal de-emphasis pulse width. The device detects the out-of-band (OOB) idle and active signals of the SAS/SATA specification and passes through with minimum signal distortion.

With a typical power consumption of 200 mW/lane (100 mW/channel) at 6.4 Gbps, and control to turn-off unused channels, the DS64BR401 is part of National's PowerWise family of energy efficient devices.

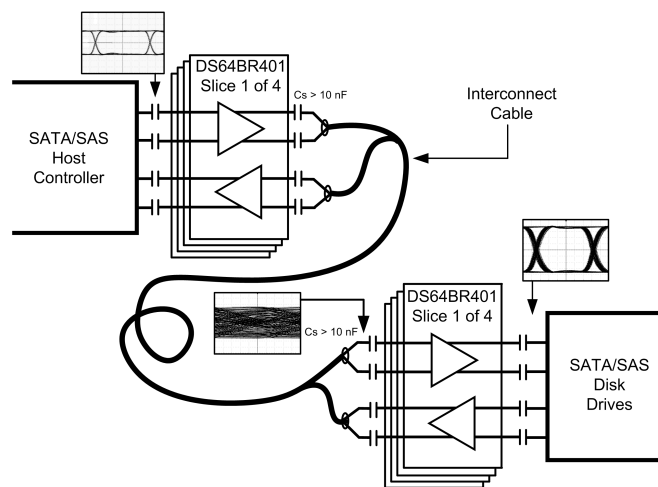
## Features

- Quad lane bi-directional repeater up to 6.4 Gbps rate
- Signal conditioning on input and output for extended reach
- Adjustable receive equalization up to +33 dB gain
- Adjustable transmit de-emphasis up to -12 dB
- Adjustable transmit VOD (600 mVp-p to 1200 mVp-p)
- <0.25 UI of residual DJ at 6.4 Gbps with 40" FR4 trace
- Automatic de-emphasis scaling based on rate detect
- SATA/SAS: OOB signal pass-through, <3 ns (typ) envelope distortion
- Adjustable electrical IDLE detect threshold
- Low power (100 mW/channel), per-channel power down
- Programmable via pin selection or SMBus interface
- Single supply operation at 2.5V  $\pm$ 5%
- >6 kV HBM ESD Rating
- 3.3V LVCMOS input tolerant for SMBus interface
- High speed signal flow-thru pinout package: 54-pin LLP (10 mm x 5.5 mm)

## Applications

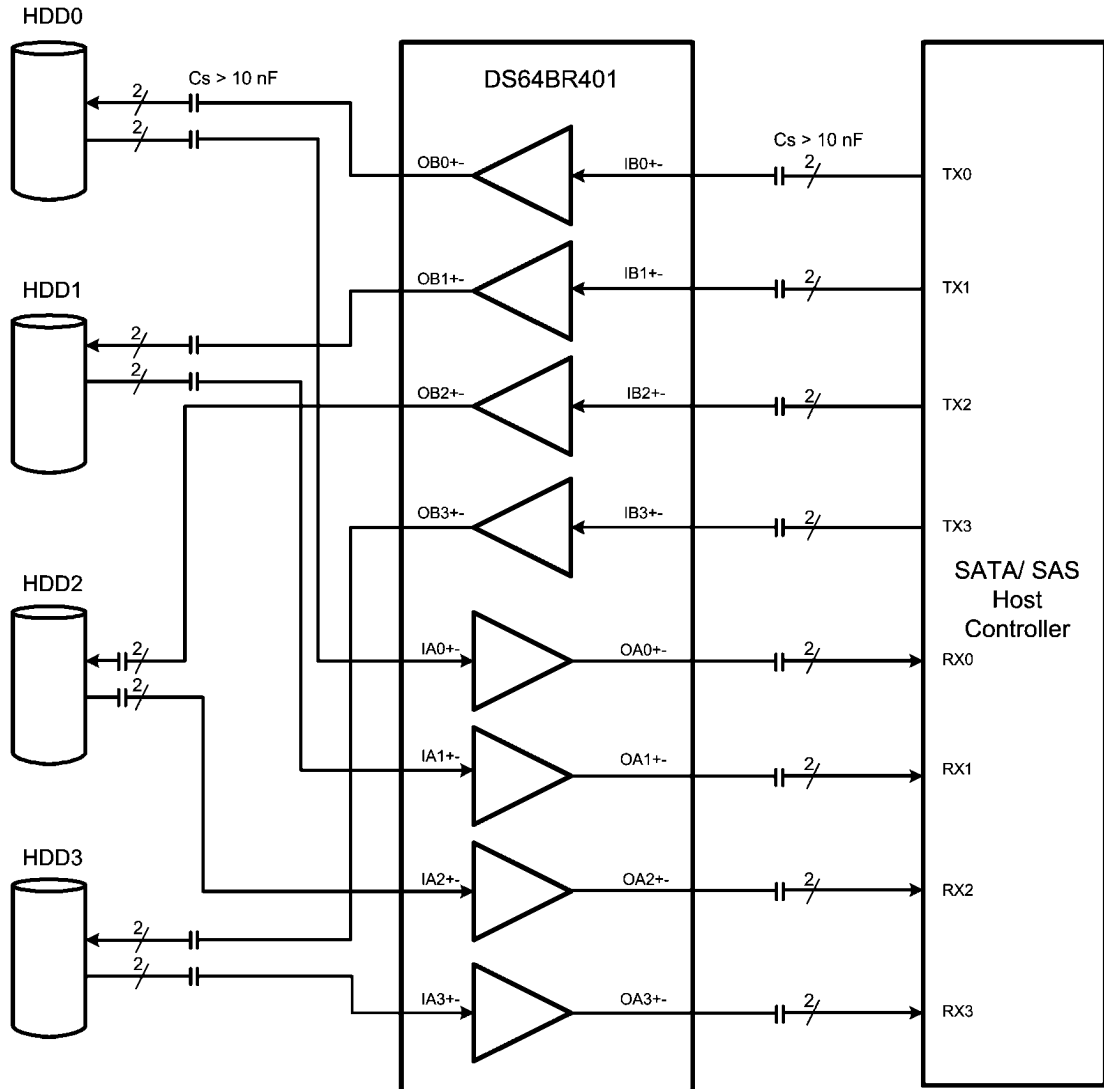
- SATA (1.5, 3.0 and 6 Gbps)
- SAS (1.5, 3.0 and 6 Gbps)
- XAUI (3.125 Gbps), RXAUI (6.25 Gbps)
- sRIO – Serial Rapid I/O
- Fibre Channel (4.25 Gbps)
- 10GBase-CX4, InfiniBand 4x (SDR & DDR)
- QSFP active copper cable modules
- High-speed active cable and FR-4 backplane traces

## Typical Cable Application



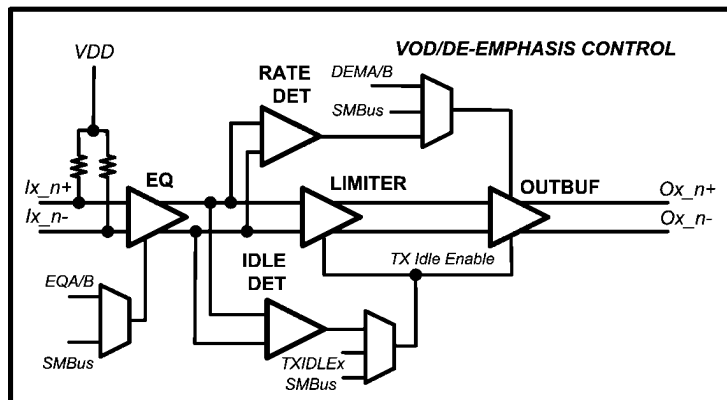
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## Typical Application Connection Diagram



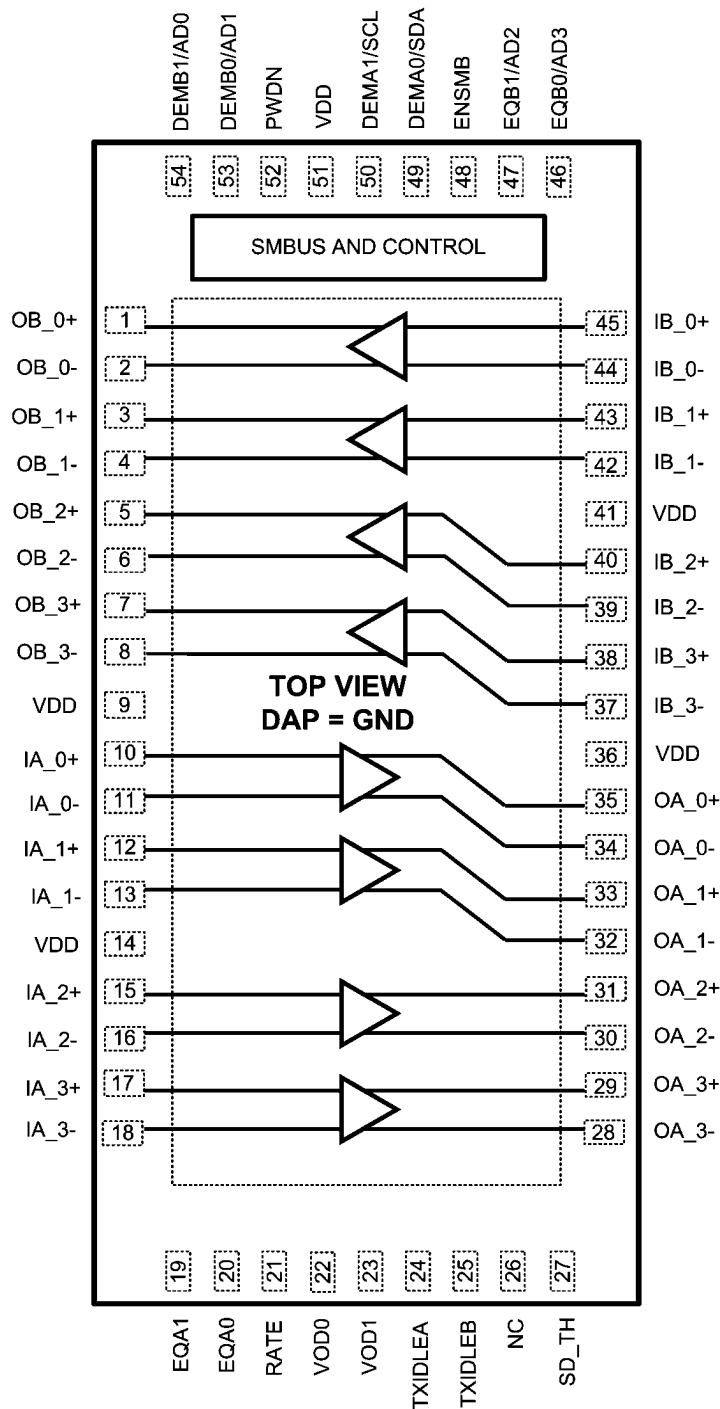
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## Block Diagram - Detail View of the Each Channel (1 of 8)



30073086

# Pin Diagram



DS64BR401 Pin Diagram 54L LLP

30073092

## Ordering Information

| NSID         | Qty                                 | Spec | Package |
|--------------|-------------------------------------|------|---------|
| DS64BR401SQ  | Tape & Reel Supplied As 2,000 Units | NOPB | SQA54A  |
| DS64BR401SQE | Tape & Reel Supplied As 250 Units   | NOPB | SQA54A  |

## Pin Descriptions

| Pin Name  | Pin Number                           | I/O, Type                              | Pin Descriptions  |
|---|--------------------------------------|--|---|
| <b>Differential High Speed I/O's</b>                            |                                      |  |   |
| IA_0+, IA_0-,<br>IA_1+, IA_1-,<br>IA_2+, IA_2-,<br>IA_3+, IA_3- | 10, 11<br>12, 13<br>15, 16<br>17, 18 | I, CML                                 | Inverting and non-inverting CML differential inputs to the equalizer. A gated on-chip 50Ω termination resistor connects INA_n+ to VDD and INA_n- to VDD when enabled.   |
| OA_0+, OA_0-,<br>OA_1+, OA_1-,<br>OA_2+, OA_2-,<br>OA_3+, OA_3- | 35, 34<br>33, 32<br>31, 30<br>29, 28 | O, LPDS                                | Inverting and non-inverting low power differential signaling (LPDS) 50Ω outputs with de-emphasis. Compatible with AC coupled CML inputs.  |
| IB_0+, IB_0-,<br>IB_1+, IB_1-,<br>IB_2+, IB_2-,<br>IB_3+, IB_3- | 45, 44<br>43, 42<br>40, 39<br>38, 37 | I, CML                                 | Inverting and non-inverting CML differential inputs to the equalizer. A gated on-chip 50Ω termination resistor connects INB_n+ to VDD and INB_n- to VDD when enabled.   |
| OB_0+, OB_0-,<br>OB_1+, OB_1-,<br>OB_2+, OB_2-,<br>OB_3+, OB_3- | 1, 2<br>3, 4<br>5, 6<br>7, 8         | O, LPDS                                | Inverting and non-inverting low power differential signaling (LPDS) 50Ω outputs with de-emphasis. Compatible with AC coupled CML inputs.  |
| <b>Control Pins — Shared (LVCMOS)</b>                           |                                      |  |   |
| ENSMB   | 48                                   | I, LVCMOS w/<br>internal pull-<br>down | System Management Bus (SMBus) enable pin.<br>When pulled high provide access internal digital registers that are a means of auxiliary control for such functions as equalization, de-emphasis, VOD, rate, and idle detection threshold.<br>When pulled low, access to the SMBus registers are disabled and SMBus function pins are used to control the Equalizer and De-Emphasis.<br>Please refer to “SMBus configuration Registers” section and Electrical Characteristics - Serial Management Bus Interface for detail information. |
| <b>ENSMB = 1 (SMBUS MODE)</b>                                   |                                      |  |   |
| SCL   | 50                                   | I, LVCMOS                              | ENSMB = 1<br>SMBUS clock input pin is enabled. External pull-up resistor maybe needed. Refer to R <sub>TERM</sub> in the SMBus specification.   |
| SDA   | 49                                   | I, LVCMOS<br>O, Open<br>Drain          | ENSMB = 1<br>The SMBus bi-directional SDA pin is enabled. Data input or open drain output. External pull-up resistor is required. Refer to R <sub>TERM</sub> in the SMBus specification.  |
| AD0–AD3   | 54, 53, 47, 46                       | I, LVCMOS w/<br>internal pull-<br>down | ENSMB = 1<br>SMBus Slave Address Inputs. In SMBus mode, these pins are the user set SMBus slave address inputs. See section — System Management Bus (SMBus) and Configuration Registers for additional information.   |
| <b>ENSMB = 0 (NORMAL PIN MODE)</b>                              |                                      |  |   |
| EQA0, EQA1<br>EQB0, EQB1  | 20, 19<br>46, 47                     | I, Float,<br>LVCMOS                    | EQA/B, 3–level controls the level of equalization of the A/B sides. The EQA/B pins are active only when ENSMB is de-asserted (Low). Each of the 4 A/B channels have the same level unless controlled by the SMBus control registers. When ENSMB goes high the SMBus registers provide independent control of each lane. See <a href="#">Table 1</a> , <a href="#">Table 2</a> , <a href="#">Table 3</a>   |

| Pin Name                                  | Pin Number           | I/O, Type                          | Pin Descriptions  |
|---|----------------------|------------------------------------|---|
| DEMA0, DEMA1<br>DEMB0, DEMB1              | 49, 50<br>53, 54     | I, Float,<br>LVCMOS                | DEMA/B, 3-level controls the level of de-emphasis of the A/B sides. The DEMA/B pins are only active when ENSMB is de-asserted (Low). Each of the 4 A/B channels have the same level unless controlled by the SMBus control registers. When ENSMB goes High the SMBus registers provide independent control of each lane. See <a href="#">Table 4</a>                                    |
| <b>Control Pins — Both Modes (LVCMOS)</b> |                      |                                    |   |
| RATE                                      | 21                   | I, Float,<br>LVCMOS                | RATE, 3-level controls the pulse width of de-emphasis of the output.<br>RATE = 0 forces 3 Gbps,<br>RATE = 1 forces 6 Gbps,<br>RATE = Float enables auto rate detection and the pulse width (pull-back) is set appropriately after each exit from IDLE. This requires the transition from IDLE to ACTIVE state — OOB signal. See <a href="#">Table 4</a>                                 |
| TXIDLEA, TXIDLEB                          | 24, 25               | I, Float,<br>LVCMOS                | TXIDLEA/B, 3-level controls the driver output.<br>TXIDLEA/B = 0 disables the signal detect/squelch function for all A/B outputs.<br>TXIDLEA/B = 1 forces the outputs to be muted (electrical idle).<br>TXIDLEA/B = Float enables the signal auto detect/squelch function and the signal detect voltage threshold level can be adjusted using the SD_TH pin. See <a href="#">Table 5</a> |
| VOD0, VOD1                                | 22, 23               | I, LVCMOS w/<br>internal pull-down | VOD[1:0] adjusts the output differential amplitude voltage level.<br>VOD[1:0] = 00 sets output VOD = 600 mV (Default)<br>VOD[1:0] = 01 sets output VOD = 800 mV<br>VOD[1:0] = 10 sets output VOD = 1000 mV<br>VOD[1:0] = 11 sets output VOD = 1200 mV   |
| PWDN                                      | 52                   | I, LVCMOS                          | PWDN = 0 enables the device (normal operation).<br>PWDN = 1 disables the device (low power mode).<br>Pin must be driven to a logic low at all times for normal operation  |
| <b>Analog</b>                             |                      |                                    |   |
| SD_TH                                     | 27                   | I, ANALOG                          | Threshold select pin for electrical idle detect threshold. Float pin for typical default 130 mVp-p (differential), otherwise connect resistor from SD_TH to GND to set threshold voltage. See <a href="#">Table 6</a> , <a href="#">Figure 5</a>  |
| <b>Power</b>                              |                      |                                    |   |
| VDD                                       | 9, 14, 36, 41,<br>51 | Power                              | Power supply pins. 2.5 V +/-5%  |
| GND                                       | DAP                  | Power                              | DAP is the large metal contact at the bottom side, located at the center of the 54 pin LLP package. It should be connected to the GND plane with at least 4 via to lower the ground impedance and improve the thermal performance of the package.   |
| NC  | 26                   |                                    | No Connect — Leave pin open   |

1 = HIGH, 0 = LOW, FLOAT = 3rd input state.

Don't drive FLOAT pin; pin is internally biased to mid level with 50 kΩ pull-up/pull-down.

Internal pulled-down = Internal 30 kΩ pull-down resistor to GND is present on the input.

Input edge rate for LVCMOS/FLOAT inputs must be faster than 50 ns from 10–90%.

## Absolute Maximum Ratings *(Note 1)*

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

|                              |                     |
|------------------------------|---------------------|
| Supply Voltage (VDD)         | -0.5V to +3.0V      |
| LVC MOS Input/Output Voltage | -0.5V to +4.0V      |
| CML Input Voltage            | -0.5V to (VDD+0.5V) |
| LPDS Output Voltage          | -0.5V to (VDD+0.5V) |
| Analog (SD_TH)               | -0.5V to (VDD+0.5V) |
| Junction Temperature         | +125°C              |
| Storage Temperature          | -40°C to +125°C     |

|   |                       |
|---|-----------------------|
| Maximum Package Power Dissipation at 25°C |                       |
| SQA54A Package                            | 4.21 W                |
| Derate SQA54A Package                     | 52.6mW/°C above +25°C |

|                         |        |
|-------------------------|--------|
| ESD Rating              |        |
| HBM, STD - JESD22-A114C | ≥6 kV  |
| MM, STD - JESD22-A115-A | ≥250 V |

|  |          |
|--|----------|
| CDM, STD - JESD22-C101-C   | ≥1250 V  |
| Thermal Resistance   |          |
| $\theta_{JC}$  | 11.5°C/W |
| $\theta_{JA}$ , No Airflow, 4 layer JEDEC  | 19.1°C/W |
| For soldering specifications: see product folder at <a href="http://www.national.com">www.national.com</a> |          |
| <a href="http://www.national.com/ms/MS/MS-SOLDERING.pdf">www.national.com/ms/MS/MS-SOLDERING.pdf</a>       |          |

## Recommended Operating Conditions

|  | Min   | Typ | Max   | Units |
|--|-------|-----|-------|-------|
| Supply Voltage                                       |       |     |       |       |
| VDD to GND   | 2.375 | 2.5 | 2.625 | V     |
| Ambient Temperature                                  | -10   | 25  | +85   | °C    |
| SMBus (SDA, SCL)                                     | 0     |     | 3.6   | V     |
| CML Differential Input Voltage                       | 0     |     | 2.0   | Vp-p  |
| Supply Noise Tolerance up to 50 MHz, <i>(Note 4)</i> |       | 100 |       | mVp-p |

## Electrical Characteristics

Over recommended operating supply and temperature ranges with default register settings unless other specified. *(Note 3)*

| Symbol  | Parameter  | Conditions   | Min | Typ   | Max   | Units |
|---|--|--|-----|-------|-------|-------|
| <b>POWER</b>  |  |  |     |       |       |       |
| PD  | Power Dissipation                                    | PWDN = 0,<br>EQx = 0, DEMx = 0 dB,<br>K28.5 pattern<br>VOD = 1.0 Vp-p      |     | 758   | 950   | mW    |
|   |  | PWDN = 1, ENSMB = 0  |     | 0.92  | 1.125 | mW    |
| <b>LVC MOS / LVTTL DC SPECIFICATIONS</b>                      |  |  |     |       |       |       |
| V <sub>IH</sub>   | High Level Input Voltage                             |  | 2.0 |       | 3.6   | V     |
| V <sub>IL</sub>   | Low Level Input Voltage                              |  | 0   |       | 0.8   | V     |
| I <sub>IH</sub>   | Input High Current                                   | V <sub>IN</sub> = 3.3V,<br>Inputs OPEN: SDA, SCL, PWDN                     | -15 |       | +15   | μA    |
|   |  | V <sub>IN</sub> = 3.3V,<br>Inputs with PULL-DOWN<br>and FLOAT — mid level  | -15 |       | +120  | uA    |
| I <sub>IL</sub>   | Input Low Current                                    | V <sub>IN</sub> = 0V,<br>Inputs OPEN: SDA, SCL, PWDN and with<br>PULL-DOWN | -15 |       | +15   | μA    |
|   |  | V <sub>IN</sub> = 0V,<br>Inputs with FLOAT — mid level                     | -80 |       | +15   | uA    |
| <b>CML RECEIVER INPUTS (IN<sub>n+</sub>, IN<sub>n-</sub>)</b> |  |  |     |       |       |       |
| RL <sub>RX-DIFF</sub>   | Rx Differential Return Loss (SDD11), <i>(Note 2)</i> | 150 MHz – 1.5 GHz  |     | -20   |       | dB    |
|   |  | 150 MHz – 3.0 GHz  |     | -13.5 |       |       |
|   |  | 150 MHz – 6.0 GHz  |     | -8    |       |       |
| RL <sub>RX-CM</sub>   | Rx Common Mode Input Return Loss (SCC11)             | 150 MHz – 3.0 GHz, <i>(Note 2)</i>   |     | -10   |       | dB    |
| R <sub>RX-IB</sub>  | Rx Impedance Balance (SDC11)                         | 150 MHz – 3.0 GHz, <i>(Note 2)</i>   |     | -27   |       | dB    |
| I <sub>IN</sub>   | Maximum current allowed at IN+ or IN- input pin.     |  | -30 |       | +30   | mA    |

| Symbol                               | Parameter   | Conditions  | Min  | Typ                   | Max  | Units             |
|--------------------------------------|---|---|------|-----------------------|------|-------------------|
| R <sub>IN</sub>                      | Input Resistance  | Single ended to V <sub>DD</sub> , (Note 2)  |      | 50                    |      | Ω                 |
| R <sub>ITD</sub>                     | Input Differential Impedance between IN+ and IN-  | DC tested, (Note 2)   | 85   | 100                   | 115  | Ω                 |
| R <sub>ITIB</sub>                    | Input Differential Impedance Imbalance  | DC tested, (Note 2)   |      |                       | 5    | Ω                 |
| R <sub>ICM</sub>                     | Input Common Mode Impedance   | DC tested, (Note 2)   | 20   | 25                    | 35   | Ω                 |
| V <sub>RX-DIFF</sub>                 | Differential Rx peak to peak voltage  | DC voltage, SD_TH = 20 kΩ to GND  | 0.1  |                       | 1.2  | V                 |
| V <sub>RX-SD_TH</sub>                | Electrical Idle detect threshold (differential)   | SD_TH = Float, (Note 6), Figure 5   | 40   |                       | 175  | mVp-p             |
| <b>LPDS OUTPUTS (OUT_n+, OUT_n-)</b> |   |   |      |                       |      |                   |
| V <sub>OD</sub>                      | Output Voltage Swing  | R <sub>L</sub> = 50 Ω ±1% to GND (AC coupled with 10 nF), 6.4 Gbps, (Note 5)<br>DEMx = 0 dB,<br>VOD[1:0] = 00 | 500  | 600                   | 700  | mV <sub>P-P</sub> |
|                                      |   | VOD[1:0] = 11   | 1100 | 1265                  | 1450 | mV <sub>P-P</sub> |
| V <sub>OCM</sub>                     | Output Common-Mode Voltage  | Single-ended measurement DC-Coupled with 50Ω termination, (Note 2)  |      | V <sub>DD</sub> - 1.4 |      | V                 |
| T <sub>TX-RF</sub>                   | Transmitter Rise/ Fall Time   | 20% to 80% of differential output voltage, measured within 1" from output pins, (Note 2, Note 5), Figure 1    |      | 67                    | 85   | ps                |
| T <sub>RF-DELTA</sub>                | Tx rise/fall mismatch   | 20% to 80% of differential output voltage, (Note 2, Note 5)   |      |                       | 0.1  | UI                |
| RL <sub>TX-DIFF</sub>                | Tx Differential Return Loss (SDD22), (Note 2)   | Repeating 1100b (D24.3) pattern, VOD = 1.0 Vp-p, 150 MHz – 1.5 GHz  |      | -11                   |      | dB                |
|                                      |   | 150 MHz – 3.0 GHz   |      | -10                   |      |                   |
|                                      |   | 150 MHz – 6.0 GHz   |      | -5                    |      |                   |
| RL <sub>TX-CM</sub>                  | Tx Common Mode Return Loss (SCC22)  | Repeating 1100b (D24.3) pattern, VOD = 1.0 Vp-p, (Note 2)<br>50 MHz – 3.0 GHz                                 |      | -10                   |      | dB                |
| R <sub>TX-IB</sub>                   | Tx Impedance Balance (SDC22)  | Repeating 1100b (D24.3) pattern, VOD = 1.0 Vp-p, (Note 2)<br>50 MHz – 3.0 GHz                                 |      | -30                   |      | dB                |
| I <sub>TX-SHORT</sub>                | Tx Output Short Circuit Current Limit   | OA/B_n = GND  |      |                       | 90   | mA                |
| R <sub>OTD</sub>                     | Output Differential Impedance between OUT+ and OUT-   | DC tested, (Note 2)   | 85   | 100                   | 125  | Ω                 |
| R <sub>OTIB</sub>                    | Output Differential Impedance Imbalance   | DC tested, (Note 2)   |      |                       | 5    | Ω                 |
| R <sub>OCM</sub>                     | Output Common Mode Impedance  | DC tested, (Note 2)   | 20   | 25                    | 35   | Ω                 |
| V <sub>TX-CM-DELTA</sub>             | Common Mode Voltage Delta between active burst and electrical Idle of an OOB signal         | (Note 7)  |      |                       | ±40  | mV                |
| T <sub>DI</sub>                      | Max time to transition to valid electrical idle after leaving active burst in OOB signaling | VIN = 800 mVp-p, repeating 1100b (D24.3) pattern at 3 Gbps, SD_TH = Float, Figure 3                           |      | 6.5                   | 9.5  | ns                |



| Symbol              | Parameter  | Conditions  | Min | Typ  | Max  | Units              |
|---------------------|--|---|-----|------|------|--------------------|
| T <sub>ID</sub>     | Max time to transition to valid active burst after leaving idle in OOB signaling | V <sub>IN</sub> = 800 mVp-p, repeating 1100b (D24.3) pattern at 3 Gbps, SD_TH = Float, <a href="#">Figure 3</a>   |     | 5.5  | 8    | ns                 |
| T <sub>PD</sub>     | Differential Propagation Delay (Low to High and High to Low Edge)                | Propagation delay measured at midpoint crossing between input to output, <a href="#">Figure 2</a> , EQx[1:0] = 11, DEMx[1:0] = -6 dB                          | 150 | 200  | 250  | ps                 |
|                     |  | EQx[1:0] = OFF, DEMx[1:0] = 0 dB  | 120 | 170  | 220  | ps                 |
| T <sub>LSK</sub>    | Lane to Lane Skew in a Single Part   | V <sub>DD</sub> = 2.5 V, T <sub>A</sub> = 25°C  |     |      | 27   | ps                 |
| T <sub>PPSK</sub>   | Part to Part Propagation Delay Skew  | V <sub>DD</sub> = 2.5 V, T <sub>A</sub> = 25°C  |     |      | 35   | ps                 |
| <b>EQUALIZATION</b> |  |   |     |      |      |                    |
| DJ1                 | Residual Deterministic Jitter at 6.4 Gbps  | Tx Launch Amplitude = 0.8 to 1.2 Vp-p, 40" 4-mil FR4 trace, EQx[1:0] = 0F, DEMx[1:0] = 0 dB, VOD = 1.0 Vp-p, K28.5, SD_TH = float, ( <a href="#">Note 2</a> ) |     | 0.12 | 0.25 | U <sub>I,P-P</sub> |
| DJ2                 | Residual Deterministic Jitter at 6.4 Gbps  | Tx Launch Amplitude = 0.8 to 1.2 Vp-p, 12 meters (30 AWG), EQx[1:0] = 1F, DEMx[1:0] = 0 dB, VOD = 1.0 Vp-p, K28.5, SD_TH = float, ( <a href="#">Note 2</a> )  |     | 0.05 | 0.15 | U <sub>I,P-P</sub> |
| DJ3                 | Residual Deterministic Jitter at 3.2 Gbps  | Tx Launch Amplitude = 0.8 to 1.2 Vp-p, 40" 4-mil FR4 trace, EQx[1:0] = 0F, DEMx[1:0] = 0 dB, VOD = 1.0 Vp-p, K28.5, SD_TH = float, ( <a href="#">Note 2</a> ) |     | 0.05 | 0.12 | U <sub>I,P-P</sub> |
| DJ4                 | Residual Deterministic Jitter at 3.2 Gbps  | Tx Launch Amplitude = 0.8 to 1.2 Vp-p, 12 meters (30 AWG), EQx[1:0] = 1F, DEMx[1:0] = 0 dB, VOD = 1.0 Vp-p, K28.5, SD_TH = float, ( <a href="#">Note 2</a> )  |     | 0.06 | 0.16 | U <sub>I,P-P</sub> |
| RJ                  | Random Jitter  | Tx Launch Amplitude = 0.8 to 1.2 Vp-p, Repeating 1100b (D24.3) pattern  |     | 0.5  |      | psrms              |

| Symbol             | Parameter                                 | Conditions  | Min | Typ  | Max  | Units             |
|--------------------|---|---|-----|------|------|-------------------|
| <b>DE-EMPHASIS</b> |   |   |     |      |      |                   |
| DJ5                | Residual Deterministic Jitter at 6.4 Gbps | Tx Launch amplitude = 0.8 to 1.2 V <sub>p-p</sub> , 10" 4-mil FR4 trace, EQx[1:0] = OFF, DEMx[1:0] = -6 dB, VOD = 1.0 V <sub>p-p</sub> , K28.5, RATE = 1 (Note 2) |     | 0.09 | 0.20 | UI <sub>p-p</sub> |
| DJ6                | Residual Deterministic Jitter at 3.2 Gbps | Tx Launch amplitude = 0.8 to 1.2 V <sub>p-p</sub> , 20" 4-mil FR4 trace, EQx[1:0] = OFF, DEMx[1:0] = -6 dB, VOD = 1.0 V <sub>p-p</sub> , K28.5, RATE = 0 (Note 2) |     | 0.07 | 0.18 | UI <sub>p-p</sub> |

**Note 1:** "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Recommended Operating Conditions is not implied. The Recommended Operating Conditions indicate conditions at which the device is functional and the device should not be operated beyond such conditions. Absolute Maximum Numbers are guaranteed for a junction temperature range of -40°C to +125°C. Models are validated to Maximum Operating Voltages only.

**Note 2:** Typical values represent most likely parametric norms at V<sub>DD</sub> = 2.5V, T<sub>A</sub> = 25°C., and at the Recommended Operation Conditions at the time of product characterization and are not guaranteed.

**Note 3:** The Electrical Characteristics tables list guaranteed specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not guaranteed.

**Note 4:** Allowed supply noise (mV<sub>p-p</sub> sine wave) under typical conditions.

**Note 5:** Measured with clock-like {11111 00000} pattern.

**Note 6:** Measured at package pins of receiver. The 130 mV<sub>p-p</sub> is a typical threshold level and does not include hysteresis, thus less than 40 mV<sub>p-p</sub> is IDLE, greater than 175 mV<sub>p-p</sub> is ACTIVE. SD\_TH pin connected with resistor to GND overrides this default setting.

**Note 7:** Common-mode voltage (VCM) is expressed mathematically as the average of the two signal voltages with respect to local ground.

$VCM = (A + B) / 2$ , A = OUT+, B = OUT-.

## Electrical Characteristics — Serial Management Bus Interface

Over recommended operating supply and temperature ranges unless other specified.

| Symbol  | Parameter  | Conditions                               | Min   | Typ  | Max  | Units         |
|---|--|--|-------|------|------|---------------|
| <b>SERIAL BUS INTERFACE DC SPECIFICATIONS</b>                   |  |  |       |      |      |               |
| $V_{OL}$  | Data (SDA) Low Level Output Voltage  | $I_{OL} = 3\text{mA}$                    |       |      | 0.4  | V             |
| $V_{IL}$  | Data (SDA), Clock (SCL) Input Low Voltage  |  |       |      | 0.8  | V             |
| $V_{IH}$  | Data (SDA), Clock (SCL) Input High Voltage   |  | 2.1   |      | 3.6  | V             |
| $I_{PULLUP}$  | Current Through Pull-Up Resistor or Current Source   | High Power Specification                 | 4     |      |      | mA            |
| $V_{DD}$  | Nominal Bus Voltage  |  | 2.375 |      | 3.6  | V             |
| $I_{LEAK-Bus}$  | Input Leakage Per Bus Segment  | (Note 8)                                 | -200  |      | +200 | $\mu\text{A}$ |
| $I_{LEAK-Pin}$  | Input Leakage Per Device Pin   |  |       | -15  |      | $\mu\text{A}$ |
| $C_I$   | Capacitance for SDA and SCL  | (Note 8, Note 9)                         |       |      | 10   | pF            |
| $R_{TERM}$  | External Termination Resistance pull to $V_{DD} = 2.5\text{V} \pm 5\%$ OR $3.3\text{V} \pm 10\%$ | $V_{DD3.3}$<br>(Note 8, Note 9, Note 10) |       | 2000 |      | $\Omega$      |
|   |  | $V_{DD2.5}$<br>(Note 8, Note 9, Note 10) |       | 1000 |      | $\Omega$      |
| <b>SERIAL BUS INTERFACE TIMING SPECIFICATIONS. See Figure 4</b> |  |  |       |      |      |               |
| FSMB  | Bus Operating Frequency  | (Note 11)                                | 10    |      | 100  | kHz           |
| TBUF  | Bus Free Time Between Stop and Start Condition   |  | 4.7   |      |      | $\mu\text{s}$ |
| THD:STA   | Hold time after (Repeated) Start Condition. After this period, the first clock is generated.     | At $I_{PULLUP}$ , Max                    | 4.0   |      |      | $\mu\text{s}$ |
| TSU:STA   | Repeated Start Condition Setup Time  |  | 4.7   |      |      | $\mu\text{s}$ |
| TSU:STO   | Stop Condition Setup Time  |  | 4.0   |      |      | $\mu\text{s}$ |
| THD:DAT   | Data Hold Time   |  | 300   |      |      | ns            |
| TSU:DAT   | Data Setup Time  |  | 250   |      |      | ns            |
| $T_{TIMEOUT}$   | Detect Clock Low Timeout   | (Note 11)                                | 25    |      | 35   | ms            |
| $T_{LOW}$   | Clock Low Period   |  | 4.7   |      |      | $\mu\text{s}$ |
| $T_{HIGH}$  | Clock High Period  | (Note 11)                                | 4.0   |      | 50   | $\mu\text{s}$ |
| $T_{LOW}:SEXT$  | Cumulative Clock Low Extend Time (Slave Device)  | (Note 11)                                |       |      | 2    | ms            |
| $t_F$   | Clock/Data Fall Time   | (Note 11)                                |       |      | 300  | ns            |
| $t_R$   | Clock/Data Rise Time   | (Note 11)                                |       |      | 1000 | ns            |
| $t_{POR}$   | Time in which a device must be operational after power-on reset                                  | (Note 11)                                |       |      | 500  | ms            |

**Note 8:** Recommended value. Parameter not tested in production.

**Note 9:** Recommended maximum capacitance load per bus segment is 400pF.

**Note 10:** Maximum termination voltage should be identical to the device supply voltage.

**Note 11:** Compliant to SMBus 2.0 physical layer specification. See System Management Bus (SMBus) Specification Version 2.0, section 3.1.1 SMBus common AC specifications for details.

# Timing Diagrams

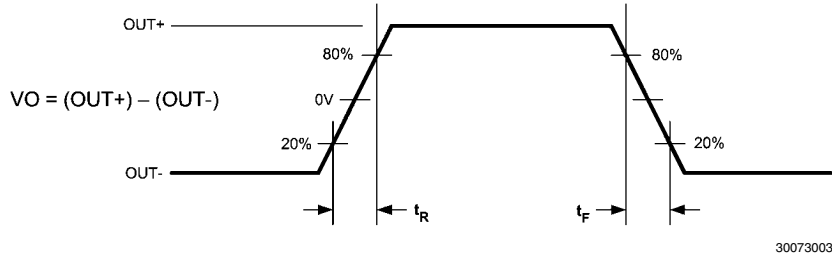


FIGURE 1. LPDS Output Transition Times

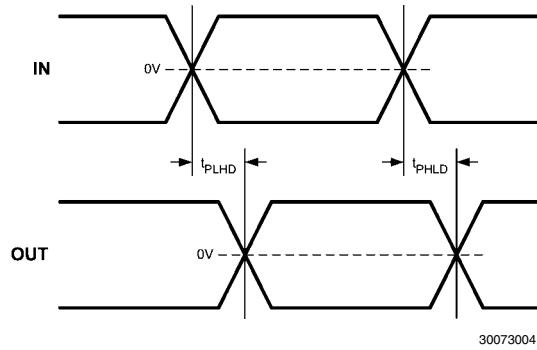


FIGURE 2. Propagation Delay Timing Diagram

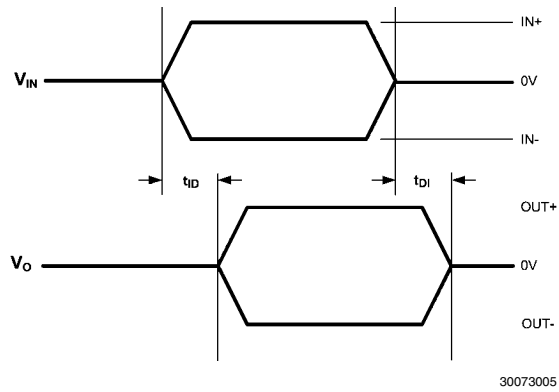


FIGURE 3. Idle Timing Diagram

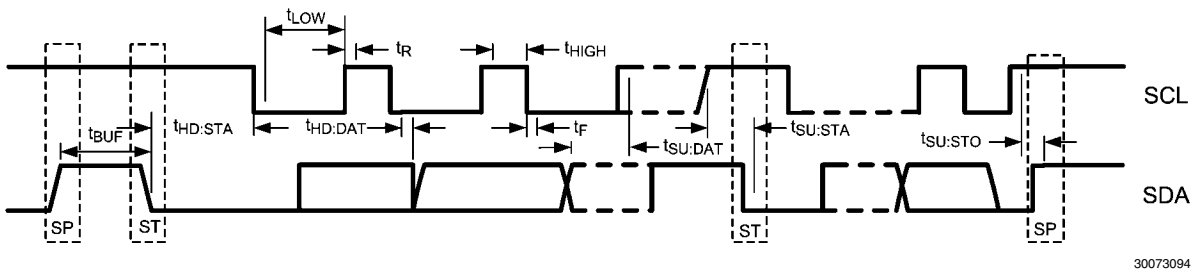


FIGURE 4. SMBus Timing Parameters

## Functional Description

The DS64BR401 is a quad repeater optimized for backplane trace or cable interconnect up to 6.4 Gbps. The DS64BR401 operates in two modes: Pin Control Mode (ENSMB = 0) and SMBus Mode (ENSMB = 1).

### Pin Control Mode:

When in pin mode (ENSMB = 0), the repeater is configurable with external pins. Equalization and de-emphasis can be selected via pin for each side independently. When de-emphasis is asserted VOD is automatically increased per the De-Emphasis table below for improved performance over lossy media. Rate optimization is also pin controllable, with pin selections for 3 Gbps, 6 Gbps, and auto detect. The receiver electrical idle detect threshold is also programmable via an optional external resistor on the SD\_TH pin.

### SMBUS Mode

When in SMBus mode the equalization, de-emphasis are all programmable on a individual lane basis, instead of grouped

by sides as in the pin mode case. Upon assertion of ENSMB the RATE, EQx and DEMx functions revert to register control immediately. The EQx and DEMx pins are converted to AD0-AD3 SMBus address inputs. The other external control pins remain active unless their respective registers are written to and the appropriate override bit is set, in which case they are ignored until ENSMB is driven low. On powerup and when ENSMB is driven low all registers are reset to their default state. If PWDN = 1 is asserted while ENSMB = 1, the registers retain their current state.

Equalization settings accessible via the pin controls were chosen to meet the needs of most applications. If additional fine tuning or adjustment is needed, additional equalization settings can be accessed via the SMBus registers. Each input has a total of 24 possible equalization settings. The tables show a typical gain for each gain stage (GST[4:3]) and boost level (BST[2:0]) combination. When using SMBus mode, the Equalization and De-Emphasis levels are set using registers. See [Table 8](#) (register map) for more information.

**TABLE 1. Equalization Settings with GST=1 for Pins or SMBus Registers**

| EQ1 | EQ0 | EQ Setting |           | EQ Gain (dB) |         | Suggested Use                               |
|-----|-----|------------|-----------|--------------|---------|---|
|     |     | GST [4:3]  | BST [2:0] | 1.5 GHz      | 3.0 GHz |   |
| F   | F   | 00         | 000       | 0            | 0       | Bypass - Default Setting                    |
|     |     | 01         | 000       | 2.0          | 3.8     |   |
|     |     | 01         | 001       | 2.6          | 4.9     |   |
| 1   | 1   | 01         | 010       | 3.3          | 5.8     | 8 inch FR4 (4-mil trace) or < 0.7m (30 AWG) |
|     |     | 01         | 011       | 3.9          | 6.8     |   |
|     |     | 01         | 100       | 4.9          | 8.2     |   |
|     |     | 01         | 101       | 5.5          | 8.9     |   |
|     |     | 01         | 110       | 6.0          | 9.4     |   |
|     |     | 01         | 111       | 6.5          | 10.0    |   |

F=Float (don't drive pin, each float pin has an internal 50K Ohm resistor to VDD and GND), 1=High, 0=Low

**TABLE 2. Equalization Settings with GST=2 for Pins or SMBus Registers**

| EQ1 | EQ0 | EQ Setting |           | EQ Gain (dB) |         | Suggested Use                         |
|-----|-----|------------|-----------|--------------|---------|---------------------------------------|
|     |     | GST [4:3]  | BST [2:0] | 1.5 GHz      | 3.0 GHz |                                       |
| 0   | 0   | 10         | 000       | 4.8          | 9.2     | 12" FR4 (4-mil trace) or 1m (30 AWG)  |
| F   | 0   | 10         | 001       | 6.3          | 11.7    | 20" FR4 (4-mil trace) or 5m (30 AWG)  |
|     |     | 10         | 010       | 7.6          | 13.6    |                                       |
|     |     | 10         | 011       | 9.1          | 15.6    |                                       |
| F   | 1   | 10         | 100       | 11.1         | 18.4    | 35" FR4 (4-mil trace) or 9m (30 AWG)  |
| 0   | 1   | 10         | 101       | 12.4         | 20.0    | 40" FR4 (4-mil trace) or 10m (30 AWG) |
|     |     | 10         | 110       | 13.4         | 20.9    |                                       |
|     |     | 10         | 111       | 14.5         | 22.0    |                                       |

F=Float (don't drive pin, each float pin has an internal 50K Ohm resistor to VDD and GND), 1=High, 0=Low

TABLE 3. Equalization Settings with GST=3 for Pins or SMBus Registers

| EQ1 | EQ0 | EQ Setting |           | EQ Gain (dB) |         | Suggested Use                        |
|-----|-----|------------|-----------|--------------|---------|--------------------------------------|
|     |     | GST [4:3]  | BST [2:0] | 1.5 GHz      | 3.0 GHz |                                      |
| 1   | 0   | 11         | 000       | 7.7          | 14.6    | 25" FR4 (4-mil trace) or 6m (30 AWG) |
|     |     | 11         | 001       | 10.1         | 18.4    |                                      |
| 0   | F   | 11         | 010       | 12.2         | 21.2    | 10m (30 AWG)                         |
|     |     | 11         | 011       | 14.4         | 24.4    |                                      |
| 1   | F   | 11         | 100       | 17.5         | 28.4    | 12m (30 AWG)                         |
|     |     | 11         | 101       | 19.4         | 30.6    |                                      |
|     |     | 11         | 110       | 20.9         | 32.1    |                                      |
|     |     | 11         | 111       | 22.6         | 33.8    |                                      |

F=Float (don't drive pin, each float pin has an internal 50K Ohm resistor to VDD and GND), 1=High, 0=Low

TABLE 4. De-Emphasis Input Select Pins for A and B ports (3-Level Input)

| RATE | DEM1 | DEM0 | De-Emphasis Level (typ) | DE Pulse Width (typ) | VOD (typical)                   | Suggested Use                          |
|------|------|------|-------------------------|----------------------|---------------------------------|--|
| 0/F  | 0    | 0    | 0 dB                    | 0 ps                 | VOD: 600 to 1200 mVp-p          | 10 inch FR4 trace or 1 meter (28 AWG)  |
| 0/F  | 0    | 1    | -3.5 dB                 | 330 ps               | VOD = 1000 mVp-p                | 20 inch FR4 trace or 2 meters (28 AWG) |
|      |      |      | -2 dB                   | 330 ps               | VOD = 1200 mVp-p                | 15 inch FR4 trace or 2 meters (28 AWG) |
| 0/F  | 1    | 0    | -6 dB                   | 330 ps               | VOD = 1000 mVp-p                | 25 inch FR4 trace or 3 meters (28 AWG) |
|      |      |      | -3 dB                   | 330 ps               | VOD = 1200 mVp-p                | 20 inch FR4 trace or 2 meters (28 AWG) |
| 0/F  | 1    | 1    | -9 dB                   | 300 ps enhanced      | VOD = 1000 mVp-p                | 5 meters (28 AWG)                      |
|      |      |      | -11 dB                  | 300 ps enhanced      | VOD = 1200 mVp-p                | 7 meters (28 AWG)                      |
| 0/F  | 0    | F    | -6 dB                   | 300 ps enhanced      | VOD = 1000 mVp-p                | 5 meters (26 AWG)                      |
|      |      |      | -8 dB                   | 300 ps enhanced      | VOD = 1200 mVp-p                | 7 meters (26 AWG)                      |
| 0/F  | 1    | F    | -12 dB                  | 300 ps enhanced      | VOD = 1000 mVp-p                | 8 meters (24 AWG)                      |
|      |      |      | -13 dB                  | 300 ps enhanced      | VOD = 1200 mVp-p                | 9 meters (24 AWG)                      |
| 0/F  | F    | 0    | -9 dB                   | 250 ps enhanced      | VOD = 1000 + 200 mVp-p          | 8 meters (26 AWG)                      |
|      |      |      | -10 dB                  | 250 ps enhanced      | VOD = 1200 + 200 mVp-p          | 9 meters (26 AWG)                      |
| 0/F  | F    | 1    | -12 dB                  | 250 ps enhanced      | VOD: (1000 to 1200) + 200 mVp-p | 10 meters (24 AWG)                     |
| 0/F  | F    | F    | Reserved, don't use     |                      |                                 |  |
| 1/F  | 0    | 0    | 0 dB                    | 0 ps                 | VOD: 600 to 1200 mVp-p          | 5 inch FR4 trace or 0.5 meter (28 AWG) |
| 1/F  | 0    | 1    | -3.5 dB                 | 200 ps               | VOD = 1000 mVp-p                | 10 inch FR4 trace or 1 meter (28 AWG)  |
|      |      |      | -2 dB                   | 200 ps               | VOD = 1200 mVp-p                | 10 inch FR4 trace or 1 meters (28 AWG) |
| 1/F  | 1    | 0    | -6 dB                   | 200 ps               | VOD = 1000 mVp-p                | 20 inch FR4 trace or 2 meters (28 AWG) |
|      |      |      | -3 dB                   | 200 ps               | VOD = 1200 mVp-p                | 15 inch FR4 trace or 1 meters (28 AWG) |
| 1/F  | 1    | 1    | -9 dB                   | 180 ps enhanced      | VOD = 1000 mVp-p                | 3 meters (28 AWG)                      |
|      |      |      | -11 dB                  | 180 ps enhanced      | VOD = 1200 mVp-p                | 4 meters (28 AWG)                      |

| RATE | DEM1 | DEM0 | De-Emphasis Level (typ) | DE Pulse Width (typ) | VOD (typical)                   | Suggested Use     |  |
|------|------|------|-------------------------|----------------------|---------------------------------|-------------------|--|
| 1/F  | 0    | F    | -6 dB                   | 180 ps enhanced      | VOD = 1000 mVp-p                | 3 meters (26 AWG) |  |
|      |      |      | -8 dB                   | 180 ps enhanced      | VOD = 1200 mVp-p                | 4 meters (26 AWG) |  |
| 1/F  | 1    | F    | -12 dB                  | 180 ps enhanced      | VOD = 1000 mVp-p                | 5 meters (24 AWG) |  |
|      |      |      | -13 dB                  | 180 ps enhanced      | VOD = 1200 mVp-p                | 6 meters (24 AWG) |  |
| 1/F  | F    | 0    | -9 dB                   | 160 ps enhanced      | VOD = 1000 + 200 mVp-p          | 5 meters (26 AWG) |  |
|      |      |      | -10 dB                  | 160 ps enhanced      | VOD = 1200 + 200 mVp-p          | 6 meters (26 AWG) |  |
| 1/F  | F    | 1    | -12 dB                  | 160 ps enhanced      | VOD: (1000 to 1200) + 200 mVp-p | 7 meters (24 AWG) |  |
| 1/F  | F    | F    | Reserved, don't use     |                      |                                 |                   |  |

Note: F = Float (don't drive pin), 1 = High and 0 = Low. Enhanced DE pulse width provides de-emphasis on second bit. When RATE = F (auto rate detection active), the DE level and pulse width settings follow detected rate after exiting IDLE. RATE = 0 is 3 Gbps and RATE = 1 is 6 Gbps. De-emphasis should only be used with VOD = 1000 mVp-p or 1200 mVp-p. VOD less than 1000 mVp-p is not recommended with de-emphasis. Please refer to VOD1 and VOD0 pin description to set the output differential voltage level.

TABLE 5. Idle Control (3-Level Input)

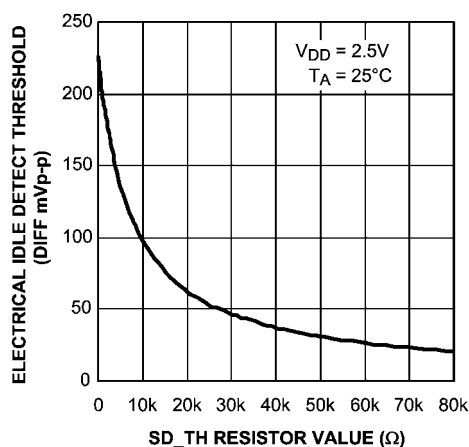
| TXIDLEA/B | Function   |
|-----------|--|
| 0         | This state is for lossy media, dedicated Idle threshold detect circuit disabled, output follows input based on EQ settings. Idle state not guaranteed.   |
| Float     | Float enables automatic idle detection. Idle on the input is passed to the output. Internal 50K $\Omega$ resistors hold TXIDLEA/B pin at a mid level - don't connect this pin if the automatic idle detect function is desired. This is the default state. Output in Idle if differential input signal less than value set by SD_TH pin. |
| 1         | Manual override, output in electrical Idle. Differential inputs are ignored.   |

TABLE 6. Receiver Electrical Idle Detect Threshold Adjust

| SD_TH resistor value ( $\Omega$ ) | Receiver Electrical Idle Detect Threshold (DIFF p-p) |
|-----------------------------------|--|
| Float (no resistor required)      | 130 mV (default condition)                           |
| 0                                 | 225 mV   |
| 80k                               | 20 mV  |

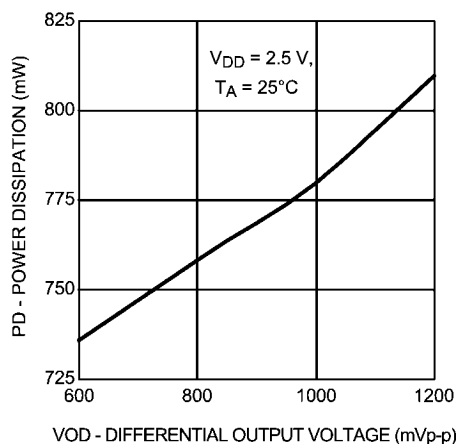
SD\_TH resistor value can be set from 0 through 80k ohms to achieve desired idle detect threshold, see [Figure 5](#)

## Typical Performance Curves



30073093

FIGURE 5. Typical Idle Threshold vs. SD\_TH resistor value



30073095

FIGURE 6. Typical Power Dissipation (PD) vs. Output Differential Voltage (VOD)



## System Management Bus (SMBus) and Configuration Registers

The System Management Bus interface is compatible to SMBus 2.0 physical layer specification. ENSMB must be pulled high to enable SMBus mode and allow access to the configuration registers.

The DS64BR401 has the AD[3:0] inputs in SMBus mode. These pins set the SMBus slave address inputs. The AD[3:0] pins have internal pull-down. When left floating or pulled low the AD[3:0] = 0000'b, the device default address byte is A0'h. Based on the SMBus 2.0 specification, the DS64BR401 has a 7-bit slave address of 1010000'b. The LSB is set to 0'b (for a WRITE), thus the 8-bit value is 1010 0000'b or A0'h. The bold bits indicate the AD[3:0] pin map to the slave address bits [4:1]. The device address byte can be set with the use of the AD[3:0] inputs. Below are some examples.

AD[3:0] = 0001'b, the device address byte is A2'h

AD[3:0] = 0010'b, the device address byte is A4'h

AD[3:0] = 0100'b, the device address byte is A8'h

AD[3:0] = 1000'b, the device address byte is B0'h

The SDA, SCL pins are 3.3V tolerant, but are not 5V tolerant. External pull-up resistor is required on the SDA. The resistor value can be from 1 k $\Omega$  to 5 k $\Omega$  depending on the voltage, loading and speed. The SCL may also require an external pull-up resistor and it depends on the Host that drives the bus.

### TRANSFER OF DATA VIA THE SMBUS

During normal operation the data on SDA must be stable during the time when SCL is High.

There are three unique states for the SMBus:

**START:** A High-to-Low transition on SDA while SCL is High indicates a message START condition.

**STOP:** A Low-to-High transition on SDA while SCL is High indicates a message STOP condition.

**IDLE:** If SCL and SDA are both High for a time exceeding  $t_{BUF}$  from the last detected STOP condition or if they are High for a total exceeding the maximum specification for  $t_{HIGH}$  then the bus will transfer to the IDLE state.

### SMBUS TRANSACTIONS

The device supports WRITE and READ transactions. See Register Description table for register address, type (Read/Write, Read Only), default value and function information.

When SMBus is enabled, the DS64BR401 **must use one of the following De-emphasis settings** (Table 7). The driver de-emphasis value is set on a per channel basis using 8 different registers. Each register (0x11, 0x18, 0x1F, 0x26, 0x2E, 0x35, 0x3C, 0x43) requires one of the following De-emphasis settings when in SMBus mode.

**TABLE 7. De-Emphasis Register Settings (must write one of the following when in SMBus mode)**

| De-Emphasis Value | Register Setting | 3 Gbps Operation                   | 6 Gbps Operation                   |
|-------------------|------------------|------------------------------------|------------------------------------|
| 0.0 dB            | 0x01             | 10" trace or 1 meter 28 awg cable  | 5" trace or 0.5 meter 28 awg cable |
| -3.5 dB           | 0x38             | 20" trace or 2 meters 28 awg cable | 10" trace or 1 meters 28 awg cable |
| -6 dB             | 0x88             | 25" trace or 3 meters cable        | 20" trace or 2 meters cable        |
| -9 dB             | 0x90             | 5 meters 28 awg cable              | 3 meters 28 awg cable              |
| -12 dB            | 0xA0             | 8 meters 28 awg cable              | 5 meters 28 awg cable              |

### WRITING A REGISTER

To write a register, the following protocol is used (see SMBus 2.0 specification).

1. The Host drives a START condition, the 7-bit SMBus address, and a "0" indicating a WRITE.
2. The Device (Slave) drives the ACK bit ("0").
3. The Host drives the 8-bit Register Address.
4. The Device drives an ACK bit ("0").
5. The Host drive the 8-bit data byte.
6. The Device drives an ACK bit ("0").
7. The Host drives a STOP condition.

The WRITE transaction is completed, the bus goes IDLE and communication with other SMBus devices may now occur.

### READING A REGISTER

To read a register, the following protocol is used (see SMBus 2.0 specification).

1. The Host drives a START condition, the 7-bit SMBus address, and a "0" indicating a WRITE.
2. The Device (Slave) drives the ACK bit ("0").
3. The Host drives the 8-bit Register Address.
4. The Device drives an ACK bit ("0").
5. The Host drives a START condition.
6. The Host drives the 7-bit SMBus Address, and a "1" indicating a READ.
7. The Device drives an ACK bit "0".

8. The Device drives the 8-bit data value (register contents).
9. The Host drives a NACK bit "1" indicating end of the READ transfer.
10. The Host drives a STOP condition.

The READ transaction is completed, the bus goes IDLE and communication with other SMBus devices may now occur.

### RECOMMENDED SMBUS REGISTER SETTINGS

When SMBus mode is enabled (ENSMB = 1), the default register are not configured to an appropriate settings. Below is the recommended settings to configure the EQ, VOD and DE to a medium level that supports interconnect length of 20 inches FR4 trace or 3 to 5 meters of cable length. Please refer to , Table 1, Table 2, Table 3, Table 4, Table 7, Table 8 for additional information and recommended settings.

1. Reset the SMBus registers to default values:  
**Write 01'h to address 0x00.**
2. Set de-emphasis to -6 dB enhance for all channels (CH0-CH7):  
**Write 88'h to address 0x11, 0x18, 0x1F, 0x26, 0x2E, 0x35, 0x3C, 0x43.**
3. Set equalization to external pin level EQ[1:0] = 00 (~9 dB at 3 GHz) for all channels (CH0-CH7):  
**Write 30'h to address 0x0F, 0x16, 0x1D, 0x24, 0x2C, 0x33, 0x3A, 0x41.**
4. Set VOD = 1.0V for all channels (CH0-CH7):

Write 0F'h to address 0x10, 0x17, 0x1E, 0x25, 0x2D, 0x34, 0x3B, 0x42.

## Idle and Rate Detection to External Pins

The functions of IDLE and RATE detection to external pins for monitoring can be supported in SMBus mode. The external GPIO pins of 19, 20, 46 and 47 will be changed and they will serve as outputs for IDLE and RATE detect signals.

The following external pins should be set to auto detection:

RATE = F (FLOAT) – auto RATE detect enabled

TXIDLEA/B = F (FLOAT) – auto IDLE detect enabled

There are 4 GPIO pins that can be configured as outputs with reg\_4E[0].

To disable the external SMBus address pins, so pin 46 and 47 can be used as outputs:

### Write 01'h to address 0x4E.

Care must be taken to ensure that only the desired status block is enabled and attached to the external pin as the status blocks can be OR'ed together internally. Register bits reg\_47 [5:4] and bits reg\_4C[7:6] are used to enable each of the status block outputs to the external pins. The channel status blocks can be internally OR'ed together to monitor more than one channel at a time. This allows more information to be presented on the status outputs and later if desired, a diagnosis of the channel identity can be made with additional SMBus writes to register bits reg\_47[5:4] and bits reg\_4C [7:6].

Below are examples to configure the device and bring the internal IDLE and RATE status to pins 19, 20, 46, 47.

To monitor the IDLE detect with two channels ORed (CH0 with CH2, CH1 with CH3, CH4 with CH6, CH5 with CH7):

### Write 32'h to address 0x47.

The following IDLE status should be observable on the external pins:

pin 19 – CH0 with CH2,

pin 20 – CH1 with CH3,

pin 46 – CH4 with CH6,

pin 47 – CH5 with CH7.

Pin = HIGH (VDD) means IDLE is detected (no signal present).

Pin = LOW (GND) means ACTIVE (data signal present).

To monitor the RATE detect with two channels ORed (CH0 with CH2, CH1 with CH3, CH4 with CH6, CH5 with CH7):

### Write C0'h to address 0x4C.

The following RATE status should be observable on the external pins:

pin 19 – CH0 with CH2,

pin 20 – CH1 with CH3,

pin 46 – CH4 with CH6,

pin 47 – CH5 with CH7.

Pin = HIGH (VDD) means high data rate is detected (6 Gbps).

Pin = LOW (GND) means low rate is detected (3 Gbps).

TABLE 8. SMBus Register Map

| Address | Register Name        | Bit (s) | Field         | Type | Default | Description   |
|---------|----------------------|---------|---------------|------|---------|---|
| 0x00    | Reset                | 7:1     | Reserved      | R/W  | 0x00    | Set bits to 0.  |
|         |                      | 0       | Reset         |      |         | SMBus Reset<br>1: Reset registers to default value  |
| 0x01    | PWDN Channels        | 7:0     | PWDN CHx      | R/W  | 0x00    | Power Down per Channel<br>[7]: CHA_3<br>[6]: CHA_2<br>[5]: CHA_1<br>[4]: CHA_0<br>[3]: CHB_3<br>[2]: CHB_2<br>[1]: CHB_1<br>[0]: CHB_0<br>00'h = all channels enabled<br>FF'h = all channels disabled |
| 0x02    | PWDN Control         | 7:1     | Reserved      | R/W  | 0x00    | Set bits to 0.  |
|         |                      | 0       | Override PWDN |      |         | 0: Allow PWDN pin control<br>1: Block PWDN pin control  |
| 0x08    | Pin Control Override | 7:5     | Reserved      | R/W  | 0x00    | Set bits to 0.  |
|         |                      | 4       | Override IDLE |      |         | 0: Allow IDLE pin control<br>1: Block IDLE pin control  |
|         |                      | 3       | Reserved      |      |         | Set bit to 0.   |
|         |                      | 2       | Override RATE |      |         | 0: Allow RATE pin control<br>1: Block RATE pin control  |
|         |                      | 1:0     | Reserved      |      |         | Set bits to 0.  |

| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x0E    | CH0 - CHB0<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x0F    | CH0 - CHB0<br>EQ Control       | 7:6     | Reserved       | R    | 0x0     | Set bits to 0.   |
|         |                                | 5:0     | CH0 IB0 EQ     | R/W  | 0x20    | IB0 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x10    | CH0 - CHB0<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH0 OB0 VOD    | R/W  | 0x03    | OB0 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x11    | CH0 - CHB0<br>DE Control       | 7:0     | CH0 OB0 DEM    | R/W  | 0x03    | OB0 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x12    | CH0 - CHB0<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |

| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x15    | CH1 - CHB1<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x16    | CH1 - CHB1<br>EQ Control       | 7:6     | Reserved       | R/W  | 0x20    | Set bits to 0.   |
|         |                                | 5:0     | CH1 IB1 EQ     |      |         | IB1 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x17    | CH1 - CHB1<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH1 OB1 VOD    | R/W  | 0x03    | OB1 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x18    | CH1 - CHB1<br>DE Control       | 7:0     | CH1 OB1 DEM    | R/W  | 0x03    | OB1 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x19    | CH1 - CHB1<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |

| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x1C    | CH2 - CHB2<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x1D    | CH2 - CHB2<br>EQ Control       | 7:6     | Reserved       | R/W  | 0x20    | Set bits to 0.   |
|         |                                | 5:0     | CH2 IB2 EQ     |      |         | IB2 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x1E    | CH2 - CHB2<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH2 OB2 VOD    | R/W  | 0x03    | OB2 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x1F    | CH2 - CHB2<br>DE Control       | 7:0     | CH2 OB2 DEM    | R/W  | 0x03    | OB2 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x20    | CH2 - CHB2<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |

| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x23    | CH3 - CHB3<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x24    | CH3 - CHB3<br>EQ Control       | 7:6     | Reserved       | R/W  | 0x20    | Set bits to 0.   |
|         |                                | 5:0     | CH3 IB3 EQ     |      |         | IB3 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x25    | CH3 - CHB3<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH3 OB3 VOD    | R/W  | 0x03    | OB3 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x26    | CH3 - CHB3<br>DE Control       | 7:0     | CH3 OB3 DEM    | R/W  | 0x03    | OB3 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x27    | CH3 - CHB3<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |

| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x2B    | CH4 - CHA0<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x2C    | CH4 - CHA0<br>EQ Control       | 7:6     | Reserved       | R/W  | 0x20    | Set bits to 0.   |
|         |                                | 5:0     | CH4 IA0 EQ     |      |         | IA0 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x2D    | CH4 - CHA0<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH4 OA0 VOD    | R/W  | 0x03    | OA0 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x2E    | CH4 - CHA0<br>DE Control       | 7:0     | CH4 OA0 DEM    | R/W  | 0x03    | OA0 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x2F    | CH4 - CHA0<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |



| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x32    | CH5 - CHA1<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x33    | CH5 - CHA1<br>EQ Control       | 7:6     | Reserved       | R/W  | 0x20    | Set bits to 0.   |
|         |                                | 5:0     | CH5 IA1 EQ     |      |         | IA1 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x34    | CH5 - CHA1<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH5 OA1 VOD    | R/W  | 0x03    | OA1 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x35    | CH5 - CHA1<br>DE Control       | 7:0     | CH5 OA1 DEM    | R/W  | 0x03    | OA1 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x36    | CH5 - CHA1<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |

| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x39    | CH6 - CHA2<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x3A    | CH6 - CHA2<br>EQ Control       | 7:6     | Reserved       | R/W  | 0x20    | Set bits to 0.   |
|         |                                | 5:0     | CH6 IA2 EQ     |      |         | IA2 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x3B    | CH6 - CHA2<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH6 OA2 VOD    | R/W  | 0x03    | OA2 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x3C    | CH6 - CHA2<br>DE Control       | 7:0     | CH6 OA2 DEM    | R/W  | 0x03    | OA2 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x3D    | CH6 - CHA2<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |

| Address | Register Name                  | Bit (s) | Field          | Type | Default | Description  |
|---------|--------------------------------|---------|----------------|------|---------|--|
| 0x40    | CH7 - CHA3<br>IDLE RATE Select | 7:6     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 5       | IDLE auto      |      |         | 0: Allow IDLE_sel control in Bit 4<br>1: Automatic IDLE detect   |
|         |                                | 4       | IDLE select    |      |         | 0: Output is ON (SD is disabled)<br>1: Output is muted (electrical idle)   |
|         |                                | 3:2     | Reserved       |      |         | Set bits to 0.   |
|         |                                | 1       | RATE auto      |      |         | 0: Allow RATE_sel control in Bit 0<br>1: Automatic RATE detect   |
|         |                                | 0       | RATE select    |      |         | 0: 2.5 to 3.2 Gbps<br>1: 5.0 to 6.4 Gbps   |
| 0x41    | CH7 - CHA3<br>EQ Control       | 7:6     | Reserved       | R/W  | 0x20    | Set bits to 0.   |
|         |                                | 5:0     | CH7 IA3 EQ     |      |         | IA3 EQ Control - total of 24 levels<br>(3 gain stages with 8 settings)<br>[5]: Enable EQ<br>[4:3]: Gain Stage Control<br>[2:0]: Boost Level Control<br>Pin [EQ0 EQ1] = Register [EN] [GST] [BST] =<br>Hex Value<br>FF = 100000 = 20'h = Bypass (Default)<br>11 = 101010 = 2A'h<br>00 = 110000 = 30'h<br>0F = 110001 = 31'h<br>01 = 111000 = 38'h<br>1F = 110100 = 34'h<br>10 = 110101 = 35'h<br>F0 = 111010 = 3A'h<br>F1 = 111100 = 3C'h                 |
| 0x42    | CH7 - CHA3<br>VOD Control      | 7:6     | Reserved       | R    | 0x00    | Set bit to 0.  |
|         |                                | 5:0     | CH7 OA3 VOD    | R/W  | 0x03    | OA3 VOD Control<br>03'h = 600 mV (Default)<br>07'h = 800 mV<br>0F'h = 1000 mV<br>1F'h = 1200 mV<br>3F'h = 1400 mV  |
| 0x43    | CH7 - CHA3<br>DE Control       | 7:0     | CH7 OA3 DEM    | R/W  | 0x03    | OA3 DEM Control<br>[7]: DEM TYPE (Compatibility = 0 / Enhanced<br>= 1)<br>[6:0]: DEM Level Control<br>Pin [DEM1 DEM0] = Register [TYPE] [Level<br>Control] = Hex Value<br>00 = 00000001 = 01'h = 0.0 dB<br>01 = 00111000 = 38'h = -3.5 dB<br>0F = 10001000 = 88'h = -6.0 dB<br>01 = 10010000 = 90'h = -9.0 dB<br>1F = 10100000 = A0'h = -12.0 dB<br>F0 = 10010000 = 90'h = -9.0 dB<br>F1 = 10100000 = A0'h = -12.0 dB<br>FF = 11000000 = C0'h = Reserved |
| 0x44    | CH7 - CHA3<br>IDLE Threshold   | 7:4     | Reserved       | R/W  | 0x00    | Set bits to 0.   |
|         |                                | 3:0     | IDLE threshold |      |         | De-assert = [3:2], assert = [1:0]<br>00 = 110 mV, 70 mV (Default)<br>01 = 150 mV, 110 mV<br>10 = 170 mV, 130 mV<br>11 = 190 mV, 150 mV   |

| Address | Register Name                           | Bit (s)  | Field              | Type | Default | Description  |
|---------|---|----------|--------------------|------|---------|--|
| 0x47    | EN<br>Digital Test Point<br>IDLE Detect | 7:6      | Reserved           | R/W  | 0x02    | Set bits to 0.   |
|         |   | 5        | CH2, CH3 CH6, CH7  |      |         | 0: Disabled IDLE Test Point for CH2, 3, 6, 7.<br>1: Enable IDLE Test Point for CH2, 3, 6, 7. |
|         |   | 4        | CH0, CH1 CH4, CH5  |      |         | 0: Disabled IDLE Test Point for CH0, 1, 4, 5.<br>1: Enable IDLE Test Point for CH0, 1, 4, 5. |
|         | 3:2                                     | Reserved | Set bits to 0.     |      |         |  |
|         | Global VOD Adjust                       | 1:0      | VOD Adjust         |      |         | 00 = -25%<br>01 = -12.5%<br>10 = 0% (Default)<br>11 = +12.5%                                 |
| 0x4C    | EN<br>Digital Test Point<br>RATE Detect | 7        | CH2, CH3 CH6, CH7  | R/W  | 0x00    | 0: Disabled RATE Test Point for CH2, 3, 6, 7.<br>1: Enable RATE Test Point for CH2, 3, 6, 7. |
|         |   | 6        | CH0, CH1 CH4, CH5  |      |         | 0: Disabled RATE Test Point for CH0, 1, 4, 5.<br>1: Enable RATE Test Point for CH0, 1, 4, 5. |
|         |   | 5:0      | Reserved           |      |         | Set bits to 0.   |
| 0x4E    | Digital Test                            | 7:1      | Reserved           | R/W  | 0x00    | Set bits to 0.   |
|         |   | 0        | Block AD[3:0] pins |      |         | 1: Configure GPIO pin 46, 47, 53, 54 to be outputs.  |

## Applications Information

### GENERAL RECOMMENDATIONS

The DS64BR401 is a high performance circuit capable of delivering excellent performance. Careful attention must be paid to the details associated with high-speed design as well as providing a clean power supply. Refer to the LVDS Owner's Manual for more detailed information on high speed design tips to address signal integrity design issues.

### PCB LAYOUT CONSIDERATIONS FOR DIFFERENTIAL PAIRS

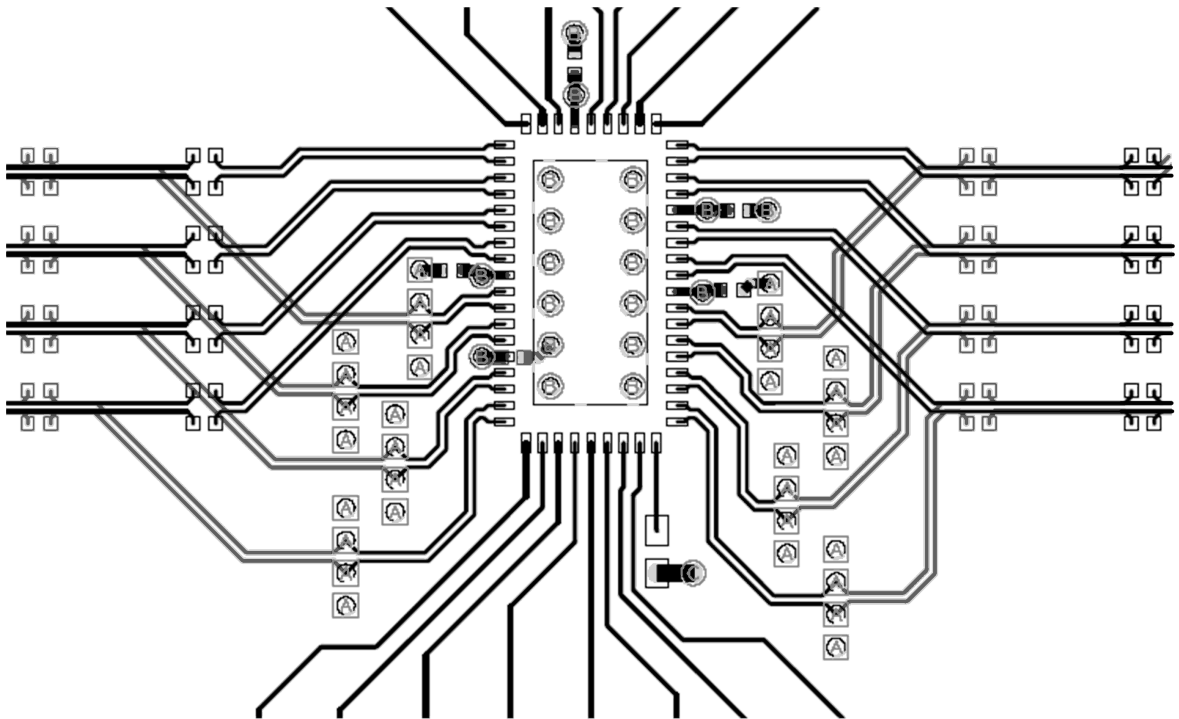
The CML inputs and LPDS outputs must have a controlled differential impedance of  $100\Omega$ . It is preferable to route differential lines exclusively on one layer of the board, particularly for the input traces. The use of vias should be avoided if possible. If vias must be used, they should be used sparingly and must be placed symmetrically for each side of a given differential pair. Route the differential signals away from other signals and noise sources on the printed circuit board. See AN-1187 for additional information on LLP packages.

The graphic shown below depicts a typical microstrip trace routing design of the top and bottom layers. This should be used as a reference to achieve the optimal system performance. Impedance discontinuities at the differential via can be minimized or eliminated by increasing the swell around each via hole. To further improve the signal quality, a ground

via placed close to the signal via for a low inductance return current path is recommended. When the via structure is associated with stripline trace and a thick board, further optimization such as back drilling is often used to reduce the high frequency effects of via stubs on the signal path. To minimize cross-talk coupling, it is recommended to have  $>3X$  gap spacing between the differential pairs. For example, if the trace width is 5 mils with 5 mils spacing –  $100\Omega$  differential impedance (closely coupled). The gap spacing between the differential pairs should be  $>15$  mils.

### POWER SUPPLY BYPASSING

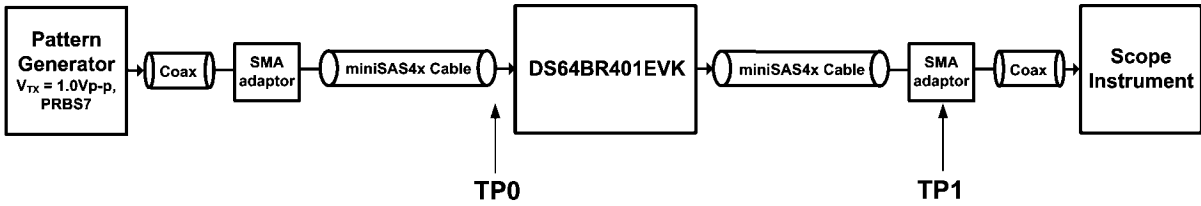
Two approaches are recommended to ensure that the DS64BR401 is provided with an adequate power supply. First, the supply (VDD) and ground (GND) pins should be connected to power planes routed on adjacent layers of the printed circuit board. The layer thickness of the dielectric should be minimized so that the  $V_{DD}$  and GND planes create a low inductance supply with distributed capacitance. Second, careful attention to supply bypassing through the proper use of bypass capacitors is required. A  $0.01\ \mu\text{F}$  bypass capacitor should be connected to each  $V_{DD}$  pin such that the capacitor is placed as close as possible to the DS64BR401. Smaller body size capacitors can help facilitate proper component placement. Additionally, three capacitors with capacitance in the range of  $2.2\ \mu\text{F}$  to  $10\ \mu\text{F}$  should be incorporated in the power supply bypassing design as well. These capacitors can be either tantalum or an ultra-low ESR ceramic.



30073002

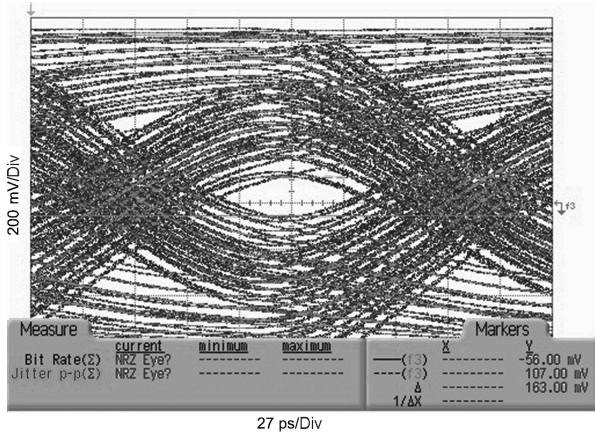
FIGURE 7. Typical PCB Trace Routing

# Typical Performance Eye-Diagram Characteristics



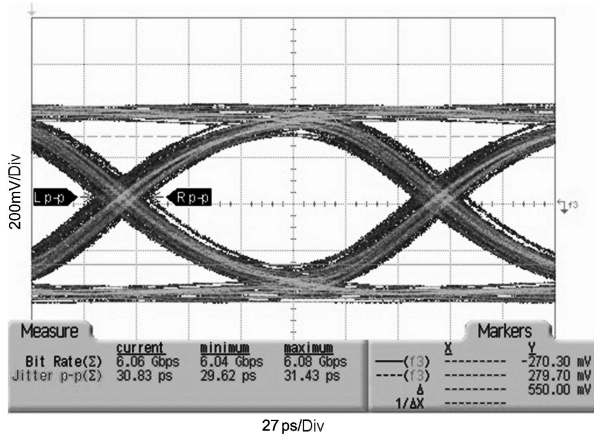
30073096

FIGURE 8. Test Setup Connection Diagram



30073097

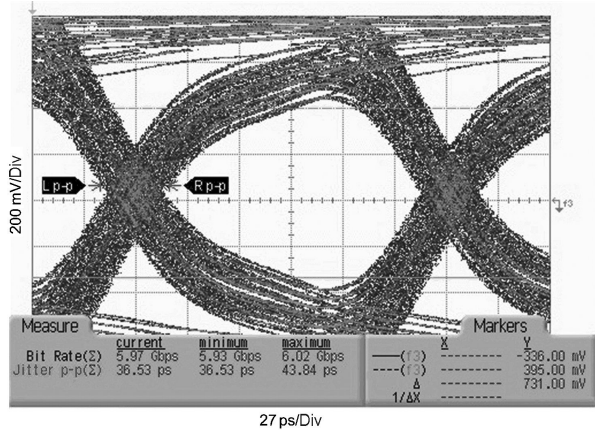
TP0: Input — After 5m 26-AWG Cable at 6 Gbps



30073098

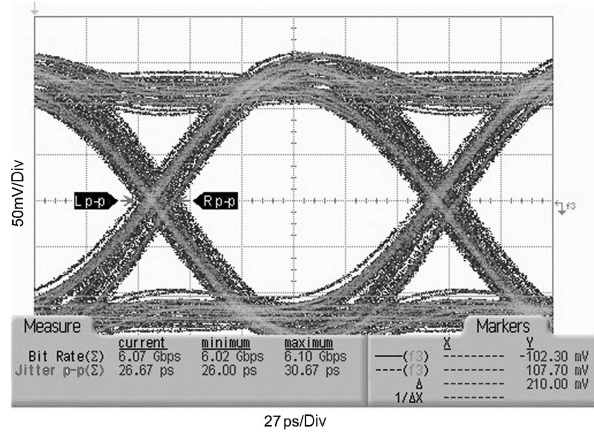
TP1: Output — After 1m 28-AWG Cable at 6 Gbps (EQ[1:0] = F0, DEM[1:0] = 01)

FIGURE 9.



30073099

TP0: Input — After 1m 28-AWG cable at 6 Gbps

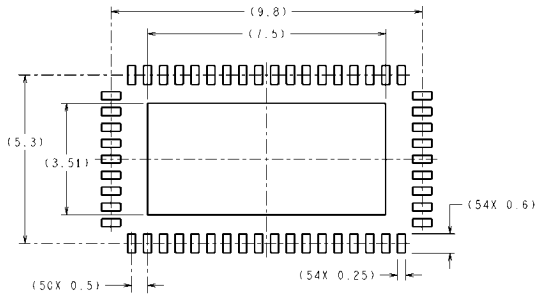


30073001

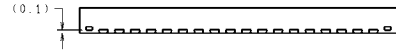
TP1: Output — After 5m 26-AWG Cable at 6 Gbps (EQ[1:0] = 11, DEM[1:0] = F0)

FIGURE 10.

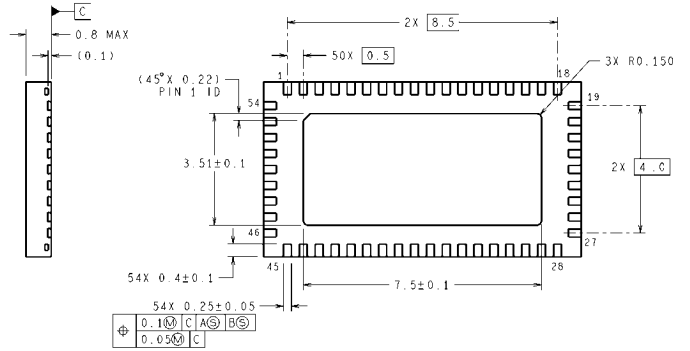
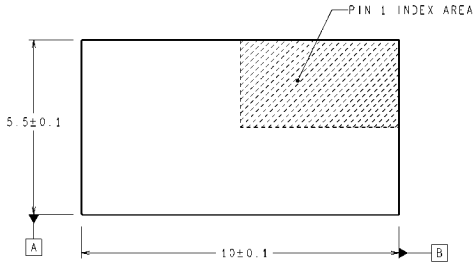
**Physical Dimensions** inches (millimeters) unless otherwise noted



DIMENSIONS ARE IN MILLIMETERS  
DIMENSIONS IN ( ) FOR REFERENCE ONLY



RECOMMENDED LAND PATTERN



SQA54A (Rev B)

**54-pin LLP Package (5.5 mm x 10 mm x 0.8 mm, 0.5 mm pitch)**  
**Order Number: DS64BR401SQ — Tape & Reel Supplied As 2,000 Units,**  
**DS64BR401SQE — Tape & Reel Supplied As 250 Units**  
**Package Number: SQA54A**

# Notes



## Notes

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| LDOs                           | <a href="http://www.national.com/ldo">www.national.com/ldo</a>               | Quality and Reliability      | <a href="http://www.national.com/quality">www.national.com/quality</a>             |
| LED Lighting                   | <a href="http://www.national.com/led">www.national.com/led</a>               | Feedback/Support             | <a href="http://www.national.com/feedback">www.national.com/feedback</a>           |
| Voltage References             | <a href="http://www.national.com/vref">www.national.com/vref</a>             | Design Made Easy             | <a href="http://www.national.com/easy">www.national.com/easy</a>                   |
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| Serial Digital Interface (SDI) | <a href="http://www.national.com/sdi">www.national.com/sdi</a>               | Mil/Aero                     | <a href="http://www.national.com/milaero">www.national.com/milaero</a>             |
| Temperature Sensors            | <a href="http://www.national.com/tempensors">www.national.com/tempensors</a> | SolarMagic™                  | <a href="http://www.national.com/solarmagic">www.national.com/solarmagic</a>       |
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