



LXT304A

Low-Power T1/E1 Short-Haul Transceiver with Receive JA

Datasheet

The LXT304A is a fully integrated low-power transceiver for both North American 1.544 Mbps (T1), and International 2.048 Mbps (E1) applications. It features a constant low output impedance transmitter allowing for high transmitter return loss in T1/E1 applications. Transmit pulse shapes (DSX-1 or E1) are selectable for various line lengths and cable types. The LXT304A is microprocessor controllable through a serial interface. The device provides receive jitter attenuation starting at 3 Hz.

The LXT304A offers a variety of diagnostic features including transmit and receive monitoring. The device incorporates an on-chip crystal oscillator, and also accepts digital inputs. It uses an advanced double-poly, double-metal CMOS process and requires only a single +5 V power supply.

Applications

- PCM/Voice Channel Banks
- Data Channel Bank/Concentrator
- T1/E1 multiplexer
- Digital Access and Cross-connect Systems (DACS)
- Computer to PBX interface (CPI & DMI)
- High-speed data transmission lines
- Interfacing Customer Premises Equipment to a CSU
- Digital Loop Carrier (DLC) terminals

Product Features

- Low power consumption (400 mW maximum)
40% less than the LXT300
- Constant low output impedance transmitter regardless of data pattern (3 Ω typical)
- High transmit and receive return loss exceeds ETSI ETS 300166 and G.703 recommendations
- Meets or exceeds all industry specifications including ITU G.703, ANSI T1.403 and AT&T Pub 62411
- Compatible with most popular PCM framers
- Line driver, data recovery and clock recovery functions
- Minimum receive signal of 500 mV
- Selectable slicer levels (E1/DSX-1) improve SNR
- Programmable transmit equalizer shapes pulses to meet DSX-1 pulse template from 0 to 655 ft.
- Local and remote loopback functions
- Transmit/Receive performance monitors with DPM and LOS outputs
- Receiver jitter tolerance 0.4 UI from 40 kHz to 100 kHz
- Receive jitter attenuation starting at 3 Hz meets TBR12/13 specification
- Serial control interface
- Analog/digital LOS monitor per G.775
- Available in 28-pin DIP or PLCC



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Contents

| | | |
|------------|--|-----------|
| 1.0 | Pin Assignments and Signal Descriptions | 6 |
| 2.0 | Functional Description | 9 |
| 2.1 | Power Requirements..... | 9 |
| 2.2 | Reset Operation | 9 |
| 2.3 | Receiver | 9 |
| 2.3.1 | Jitter Attenuation | 10 |
| 2.4 | Transmitter | 10 |
| 2.4.1 | Driver Performance Monitor | 11 |
| 2.4.2 | Line Code | 11 |
| 2.5 | Operating Modes..... | 12 |
| 2.5.1 | Host Mode Operation | 12 |
| 2.5.2 | Hardware Mode Operation | 14 |
| 2.5.3 | Diagnostic Mode Operation..... | 14 |
| 2.5.3.1 | Transmit All Ones..... | 14 |
| 2.5.3.2 | Local Loopback | 15 |
| 2.5.3.3 | Remote Loopback | 15 |
| 3.0 | Application Information | 17 |
| 3.1 | 1.544 Mbps T1 Interface Application..... | 17 |
| 3.1.1 | 2.048 Mbps E1 Interface Applications..... | 18 |
| 3.1.2 | Line Protection | 18 |
| 3.1.3 | D4 Channel Bank Applications..... | 19 |
| 4.0 | Test Specifications | 21 |
| 5.0 | Mechanical Specifications | 28 |

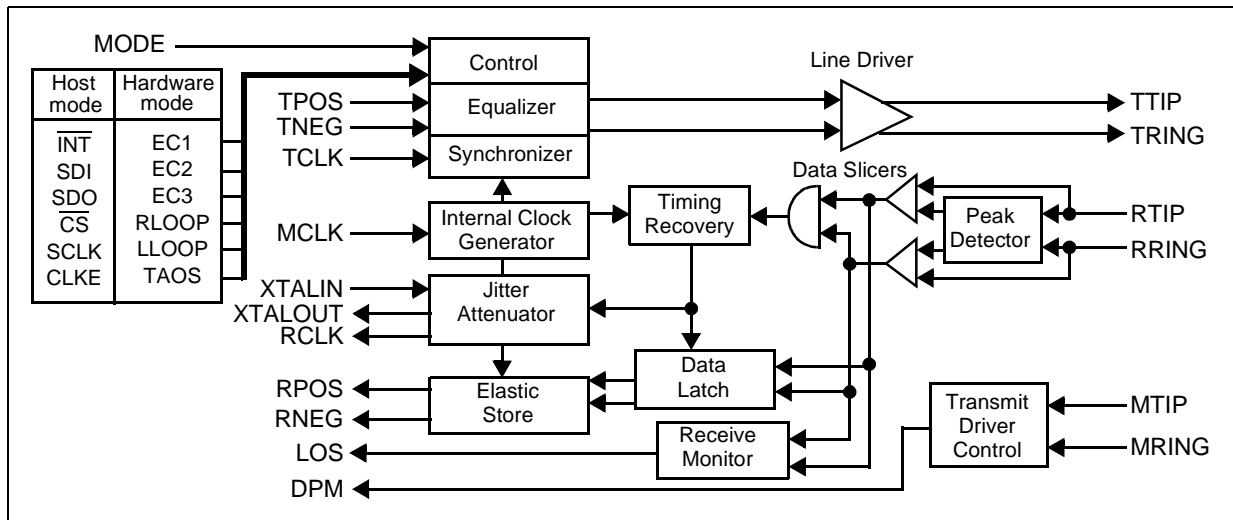
Figures

| | | |
|----|---|----|
| 1 | LXT304A Block Diagram | 5 |
| 2 | LXT384 Pin Assignments and Package Markings | 6 |
| 3 | 50% AMI Coding | 12 |
| 4 | LXT304A Serial Interface Data Structure | 13 |
| 5 | Transmit All Ones | 14 |
| 6 | Local Loopback with TAOS | 14 |
| 7 | Local Loopback | 15 |
| 8 | Remote Loopback | 15 |
| 9 | Typical LXT304A 1.544 Mbps T1 Application (Host Mode) | 17 |
| 10 | Typical LXT304A E1 2.048 Mbps 120 W Application (Hardware Mode) | 19 |
| 11 | Typical Receive Input Jitter Tolerance (Loop Mode) | 23 |
| 12 | LXT304A Receive Jitter Transfer Performance (Typical) | 24 |
| 13 | LXT304A Receive Clock Timing Diagram | 25 |
| 14 | LXT304A Transmit Clock Timing Diagram | 25 |
| 15 | LXT304A Serial Data Input Timing Diagram | 26 |
| 16 | LXT304A Serial Data Output Timing Diagram | 27 |
| 17 | Package Specifications | 28 |

Tables

| | | |
|----|--|----|
| 1 | Pin Descriptions | 6 |
| 2 | Equalizer Control Inputs | 11 |
| 3 | Host Mode CLKE Settings | 12 |
| 4 | LXT304A Serial Data Output Bits (See Figure 4) | 13 |
| 5 | LXT304A External Crystal Specifications | 16 |
| 6 | T1/E1 Input/Output Configurations | 20 |
| 7 | Absolute Maximum Ratings | 21 |
| 8 | Recommended Operating Conditions and Characteristics | 21 |
| 9 | Electrical Characteristics (Over Recommended Operating Conditions) | 21 |
| 10 | Analog Characteristics (Over Recommended Operating Conditions) | 22 |
| 11 | LXT304A Receive Timing Characteristics (See Figure 13) | 24 |
| 12 | LXT304A Master Clock and Transmit Timing Characteristics (See Figure 14) | 25 |
| 13 | LXT304A Serial I/O Timing Characteristics (See Figure 15 and Figure 16) | 26 |

Figure 1. LXT304A Block Diagram



1.0 Pin Assignments and Signal Descriptions

Figure 2. LXT384 Pin Assignments and Package Markings

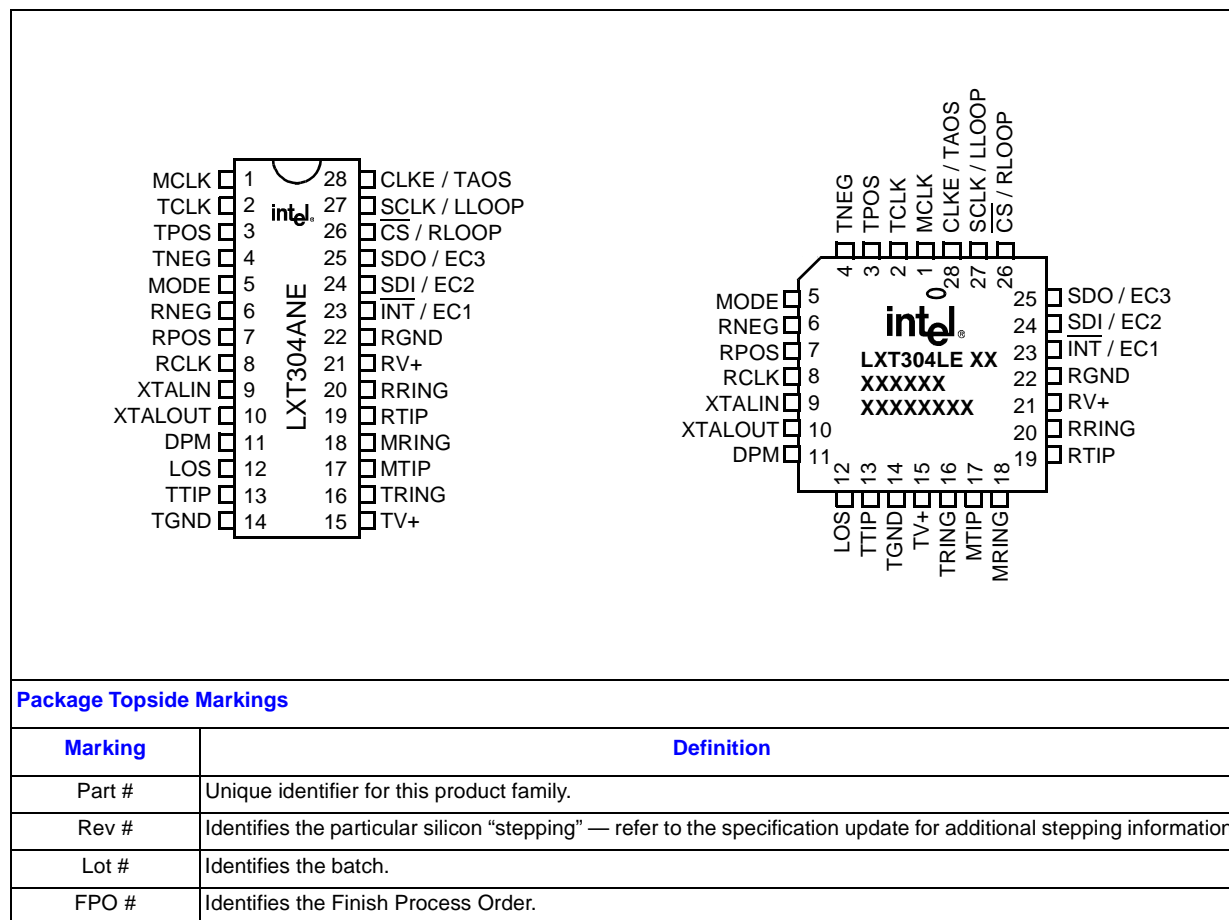


Table 1. Pin Descriptions

| Pin # | Sym | I/O ¹ | Description |
|---|------|------------------|---|
| 1 | MCLK | DI | Master Clock. A 1.544 or 2.048 MHz clock input used to generate internal clocks. Upon Loss of Signal (LOS), RCLK is derived from MCLK. If MCLK is not supplied, this pin should be grounded. |
| 2 | TCLK | DI | Transmit Clock. Transmit clock input. TPOS and TNEG are sampled on the falling edge of TCLK. If TCLK is not supplied, the transmitter remains powered down. |
| 3 | TPOS | DI | Transmit Positive Data. Input for positive pulse to be transmitted on the twisted-pair cable. |
| 4 | TNEG | DI | Transmit Negative Data. Input for negative pulse to be transmitted on the twisted-pair cable. |
| 1. Entries in I/O column are: DI = Digital Input; DO = Digital Output; AI = Analog Input; AO = Analog Output; S = Supply. | | | |

Table 1. Pin Descriptions (Continued)

| Pin # | Sym | I/O ¹ | Description |
|-------|-------------------------|------------------|---|
| 5 | MODE | DI | Mode Select. Setting MODE to High puts the LXT304A in the Host Mode. In the Host Mode, the serial interface is used to control the LXT304A and determine its status. Setting MODE to Low puts the LXT304A in the Hardware mode. In the Hardware mode, the serial interface is disabled and hard-wired pins are used to control configuration and report status. |
| 6 | RNEG | DO | Receive Negative Data; Receive Positive Data. Received digital outputs. A signal on RNEG corresponds to detection of a negative pulse on RTIP and RRING. A signal on RPOS corresponds to detection of a positive pulse on RTIP and RRING. RNEG and RPOS outputs are Non-Return-to-Zero (NRZ). Both outputs are stable and valid on the rising edge of RCLK. In the Host mode, CLKE determines the clock edge at which these outputs are stable and valid. In the Hardware mode both outputs are stable and valid on the rising edge of RCLK. |
| 7 | RPOS | DO | |
| 8 | RCLK | DO | Recovered Clock. This is the clock recovered from the signal received at RTIP and RRING. |
| 9 | XTALIN | AI | Crystal Input; Crystal Output. An external crystal operating at four times the bit rate (6.176 MHz for DSX-1, 8.192 MHz for E1 applications with an 18.7 pF load) is required to enable the jitter attenuation function of the LXT304A. These pins may also be used to disable the jitter attenuator by connecting the XTALIN pin to the positive supply through a resistor, and tying the XTALOUT pin to ground. |
| 10 | XTALOUT | AO | |
| 11 | DPM | DO | Driver Performance Monitor. DPM goes High when the transmit monitor loop (MTIP and MRING) does not detect a signal for 63 \pm 2 clock periods. DPM remains Low until a signal is detected. |
| 12 | LOS | DO | Loss of Signal. LOS goes High when 175 consecutive spaces have been detected at RTIP and RRING. LOS returns Low when the received signal reaches 12.5% ones density, based on 4 ones in any 32-bit period with no more than 15 consecutive zeros. |
| 13 | TTIP | AO | Transmit Tip; Transmit Ring. Differential Driver Outputs. These low impedance outputs achieve maximum power savings through a 1:1.15 transformer (T1), or a 1:1 (75 Ω) or 1:1.26 (120 Ω) transformer (E1) without additional components. To provide higher return loss, resistors may be used in series with a transformer as specified in "Application Information" on page 17. |
| 16 | TRING | AO | |
| 14 | TGND | S | Transmit Ground. Ground return for the transmit drivers power supply TV+. |
| 15 | TV+ | S | Transmit Power Supply. +5 VDC power supply input for the transmit drivers. TV+ must not vary from RV+ by more than \pm 0.3 V. |
| 17 | MTIP | AI | Monitor Tip; Monitor Ring. These pins are used to monitor the tip and ring transmit outputs. The transceiver can be connected to monitor its own output, or to the output of another LXT304A on the board. To prevent false interrupts in the Host mode, if the monitor is not used, apply a clock signal to one of the monitor pins and tie the other monitor pin to the clock's approximate mid-level voltage. The monitor clock can range from 100 kHz to the TCLK frequency. |
| 18 | MRING | AI | |
| 19 | RTIP | AI | Receive Tip; Receive Ring. The AML signal received from the line is applied at these pins. A center-tapped, center-grounded, 2:1 step-up transformer is required on these pins. Data and clock from the signal applied at these pins are recovered and output on the RPOS, RNEG and RCLK pins. |
| 20 | RRING | AI | |
| 21 | RV+ | S | Receive Power Supply. +5 VDC power supply for all circuits except the transmit drivers. (Transmit drivers are supplied by TV+.) |
| 22 | RGND | S | Receive Ground. Ground return for power supply RV+. |
| 23 | $\overline{\text{INT}}$ | DO | Interrupt (Host mode). This LXT304A Host mode output goes Low to flag the host processor when LOS or DPM go active. $\overline{\text{INT}}$ is an open-drain output and should be tied to power supply RV+ through a resistor. $\overline{\text{INT}}$ is reset by clearing the respective register bit (LOS and/or DPM.) |
| | EC1 | DI | Equalizer Control 1 (Hardware mode). The signal applied at this pin (in LXT304A Hardware mode) is used in conjunction with EC2 and EC3 inputs to determine shape and amplitude for AML transmit pulses. |

1. Entries in I/O column are: DI = Digital Input; DO = Digital Output; AI = Analog Input; AO = Analog Output; S = Supply.

Table 1. Pin Descriptions (Continued)

| Pin # | Sym | I/O ¹ | Description |
|---|-----------------|------------------|--|
| 24 | SDI | DI | Serial Data In (Host mode). The serial data input stream is applied to this pin when the LXT304A operates in the Host mode. SDI is sampled on the rising edge of SCLK. |
| | EC2 | DI | Equalizer Control 2 (Hardware mode). The signal applied at this pin (in LXT304A Hardware mode) is used in conjunction with EC1 and EC3 inputs to determine shape and amplitude for AMI transmit pulses. |
| 25 | SDO | DO | Serial Data Out (Host mode). The serial data from the on-chip register is output on this pin in LXT304A Host mode. If CLKE is High, SDO is valid on the rising edge of SCLK. If CLKE is Low, SDO is valid on the falling edge of SCLK. This pin goes to a high-impedance state when the serial port is being written to and when \overline{CS} is High. |
| | EC3 | DI | Equalizer Control 3 (Hardware mode). The signal applied at this pin (in LXT304A Hardware mode) is used in conjunction with EC1 and EC2 inputs to determine shape and amplitude for AMI transmit pulses. |
| 26 | \overline{CS} | DI | Chip Select (Host mode). This input is used to access the serial interface in the LXT304A Host mode. For each read or write operation, \overline{CS} must transition from High to Low, and remain Low. |
| | RLOOP | DI | Remote Loopback (Hardware mode). This input controls loopback functions in the LXT304A Hardware mode. Setting RLOOP High enables the Remote Loopback mode. Setting both RLOOP and LLOOP High causes a Reset. |
| 27 | SCLK | DI | Serial Clock (Host mode). This clock is used in the LXT304A Host mode to write data to or read data from the serial interface registers. |
| | LLOOP | DI | Local Loopback (Hardware mode). This input controls loopback functions in the LXT304A Hardware mode. Setting LLOOP High enables the Local Loopback mode. Setting both LLOOP and RLOOP High causes a Reset. |
| 28 | CLKE | DI | Clock Edge (Host mode). In Host mode, setting CLKE High causes RPOS and RNEG to be valid on the falling edge of RCLK, and SDO to be valid on the rising edge of SCLK. When CLKE is Low, RPOS and RNEG are valid on the rising edge of RCLK, and SDO is valid on the falling edge of SCLK. |
| | TAOS | DI | Transmit All Ones (Hardware mode). When set High, TAOS causes the LXT304A (in Hardware mode) to transmit a continuous stream of marks at the TCLK frequency. Activating TAOS causes TPOS and TNEG inputs to be ignored. TAOS is inhibited during Remote Loopback. |
| 1. Entries in I/O column are: DI = Digital Input; DO = Digital Output; AI = Analog Input; AO = Analog Output; S = Supply. | | | |

2.0 Functional Description

The LXT304A is a fully integrated PCM transceiver for both 1.544 Mbps (DSX-1) and 2.048 Mbps (E1) applications. It allows full-duplex transmission of digital data over existing cable-pair installations. The LXT304A transceiver interfaces with two cable-pairs; one for transmit and one for receive.

2.1 Power Requirements

The LXT304A is a low-power CMOS device. Separate power pins (RV+ and TV+) are provided for the receiver and transmitter circuits. The LXT304A typically operates from a single +5 V power supply that is connected externally to the RV+ and TV+ pins and decoupled to the respective ground pins (RGND and TGND). Refer to “[Application Information](#)” on [page 17](#) for typical decoupling circuitry. Note that when separate power supplies are used, RV+ and TV+ must be within ± 0.3 V of each other. Isolation between the transmit and receive circuits is provided internally.

In normal, local loopback (LLOOP), and transmit all ones (TAOS) operating modes, the transmitter will automatically power down when TCLK is not provided.

2.2 Reset Operation

Upon power up, the transceiver is held static until the power supply reaches approximately 3 V. Upon crossing this threshold, the device begins a 32 ms reset cycle to calibrate the transmit and receive delay lines and lock the Phase Lock Loop to the receive line. A reference clock is required to calibrate the delay lines. The transmitter reference is provided by TCLK. MCLK provides the receiver reference. If the crystal oscillator is grounded, MCLK is used as the receiver reference clock.

In Host mode, reset is commanded by simultaneously writing RLOOP and LLOOP to the register. The reset is initiated on the trailing edge of the reset request.

In Hardware mode, reset is initiated by holding the RLOOP and LLOOP pins High simultaneously for a minimum of 200 ns. In either mode, reset clears all registers to 0 and then the calibration process begins.

2.3 Receiver

The LXT304A receives the signal input from one cable-pair line tied to each side of a center-grounded transformer. 50% Alternate Mark Inversion (AMI) code is received at RTIP and RRING. Recovered data is output at RPOS and RNEG. The recovered clock is output at RCLK. Refer to Test Specifications for LXT304A receiver timing.

The signal received at RTIP and RRING is processed by the peak detector and data slicers. The peak detector samples the inputs and determines the maximum value of the received signal. A percentage of the peak value is provided to the data slicers as a threshold level to ensure optimum signal-to-noise ratio. For DSX-1 applications (set by Equalizer Control inputs EC3 - EC1 \neq 00x),

the threshold is set to 70% of the peak value. This threshold is maintained above 65% for up to 15 successive zeros over the range of specified operating conditions. For E1 applications (EC inputs = 000 or 001) the threshold is 50% of the peak value.

The receiver is capable of accurately recovering signals with up to -13.6 dB of attenuation (from 2.4 V), corresponding to a received signal level of approximately 500 mV. Maximum line length is 1500 feet of ABAM cable (approximately 6 dB of attenuation). Regardless of received signal level, the peak detectors are held above a minimum level of 0.3 V to provide immunity from impulse noise.

After processing through the data slicers, the received signal is routed to the data and clock recovery sections, and to the receive monitor. The data and clock recovery circuits are highly tolerant with an input jitter tolerance significantly better than required by Pub 62411 and TBR12/13. Refer to Test Specifications for additional information.

The receiver monitor loads a digital counter at the RCLK frequency. The counter is incremented each time a zero is received, and reset to zero each time a one (mark) is received. Upon receipt of 175 consecutive zeros, the LOS pin goes high, and a smooth transition replaces the RCLK output with the MCLK. Note that if MCLK is not supplied, the RCLK output will be replaced with the centered crystal clock. The LOS pin is reset when the received signal reaches 12.5% ones density (4 marks in 32 bits) with no more than 15 consecutive zeros.

Recovered clock signals are supplied to the Jitter Attenuator and the data latch. The recovered data is passed to the Elastic Store where it is buffered and synchronized with the dejittered recovered clock (RCLK).

2.3.1 Jitter Attenuation

Jitter attenuation of the LXT304A clock and data outputs is provided by a Jitter Attenuation Loop (JAL) and an Elastic Store (ES). An external crystal oscillating at 4 times the bit rate provides clock stabilization. Refer to [Table 5](#) for crystal specifications. See the [Short Haul FAQ](#) document (on our web site) to find crystals that achieve CTR12/13 compliance.

The ES is a 32 x 2-bit register. Recovered data is clocked into the ES using the recovered clock signal, and clocked out of the ES by the dejittered clock from the JAL. When the bit count in the ES is within two bits of overflowing or underflowing, the ES adjusts the output clock by 1/8 of a bit period. The ES produces an average delay of 16 bits in the receive path.

2.4 Transmitter

Data received for transmission onto the line is clocked serially into the device at TPOS and TNEG. Input synchronization is supplied by the transmit clock (TCLK). If TCLK is not supplied, the transmitter remains powered down, except during remote loopback mode. Refer to Test Specifications for master clock and transmit clock timing characteristics.

The transmitted pulse shape is determined by Equalizer Control signals EC1 through EC3 as shown in [Table 2](#). Equalizer Control signals may be hardwired, in the Hardware mode, or input as part of the serial data stream (SDI) in the Host mode. Shaped pulses are applied to the AMI line driver for transmission onto the cable-pair at TTIP and TRING. The line driver provides a constant low output impedance of 3 Ω (typical). This well controlled output impedance provides excellent

return loss (> 18 dB) when used with external $9.1\ \Omega$ precision resistors ($\pm 1\%$) in series with a transmit transformer (see [Table 6](#) for transformer specifications). The series resistors also provide increased surge protection and reduce short circuit current flow.

Pulses can be shaped for either 1.544 or 2.048 Mbps applications. 1.544 Mbps pulses (for DSX-1 applications) can be programmed to match line lengths from 0 to 655 feet of ABAM cable. The LXT304A also matches FCC and ECSA specifications for CSU applications. A 1:1.15 transmit transformer is used for 1.544 Mbps systems. For higher return loss in DSX-1 applications, use $9.1\ \Omega$ resistors in series with a 1:2.3 transmit transformer.

2.048 Mbps pulses can drive coaxial or shielded twisted-pair lines. For E1 systems, a 1:2 transmit transformer and series resistors are recommended. This design meets or exceeds all ITU and ETSI specifications for transmit and receive return loss. A 1:1 or 1:1.26 transformer may be used (without the series resistors) with reduced return loss.

2.4.1 Driver Performance Monitor

The transceiver incorporates a Driver Performance Monitor (DPM). MTIP and MRING are the DPM inputs and are connected in parallel with TTIP and TRING at the output transformer. The DPM output goes High upon detection of 63 consecutive zeros at MTIP and MRING. DPM is reset when a one is detected on the transmit line, or when a reset command is received.

2.4.2 Line Code

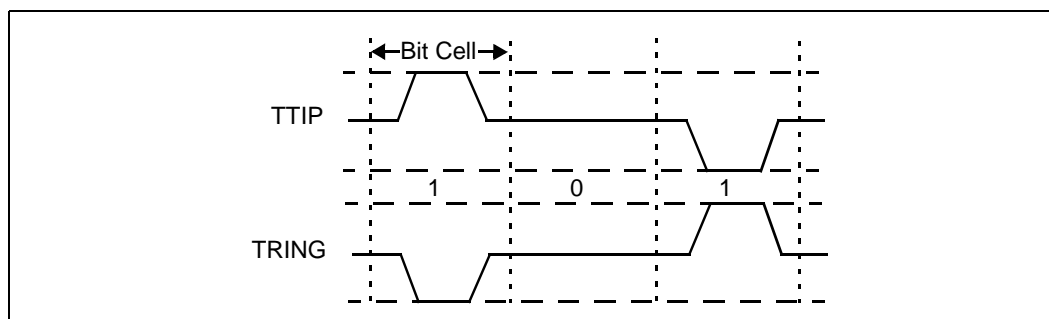
The LXT304A transmits data as a 50% AMI line code as shown in [Figure 3](#). The output driver maintains a constant low output impedance regardless of whether it is driving marks or spaces.

Table 2. Equalizer Control Inputs

| EC3 | EC2 | EC1 | Line Length ¹ | Cable Loss ² | Application | Bit Rate |
|-----|-----|-----|--------------------------|-------------------------|-------------------------------------|------------|
| 0 | 1 | 1 | 0 ~ 133 ft. ABAM | 0.6 dB | DSX-1 | 1.544 Mbps |
| 1 | 0 | 0 | 133 ~ 266 ft. ABAM | 1.2 dB | | |
| 1 | 0 | 1 | 266 ~ 399 ft. ABAM | 1.8 dB | | |
| 1 | 1 | 0 | 399 ~ 533 ft. ABAM | 2.4 dB | | |
| 1 | 1 | 1 | 533 ~ 655 ft. ABAM | 3.0 dB | | |
| 0 | 0 | 0 | ITU Recommendation G.703 | | E1 - Coax ($75\ \Omega$) | 2.048 Mbps |
| 0 | 0 | 1 | | | E1 - Twisted-pair ($120\ \Omega$) | |
| 0 | 1 | 0 | FCC Part 68, Option A | | CSU (DS-1) | 1.544 Mbps |

1. Line length from transceiver to DSX-1 cross-connect point.
2. Maximum cable loss at 772 kHz.

Figure 3. 50% AMI Coding



2.5 Operating Modes

The LXT304A can be controlled through hard-wired pins (Hardware mode) or by a microprocessor through a serial interface (Host mode). The mode of operation is set by the MODE pin. The LXT304A can also be commanded to operate in one of several diagnostic modes.

2.5.1 Host Mode Operation

Setting the MODE pin High allows a host microprocessor to access and control the LXT304A through the serial interface. The serial interface uses a 16-bit word consisting of an 8-bit Command/Address byte and an 8-bit Data byte. Figure 4 shows the serial interface data structure and relative timing.

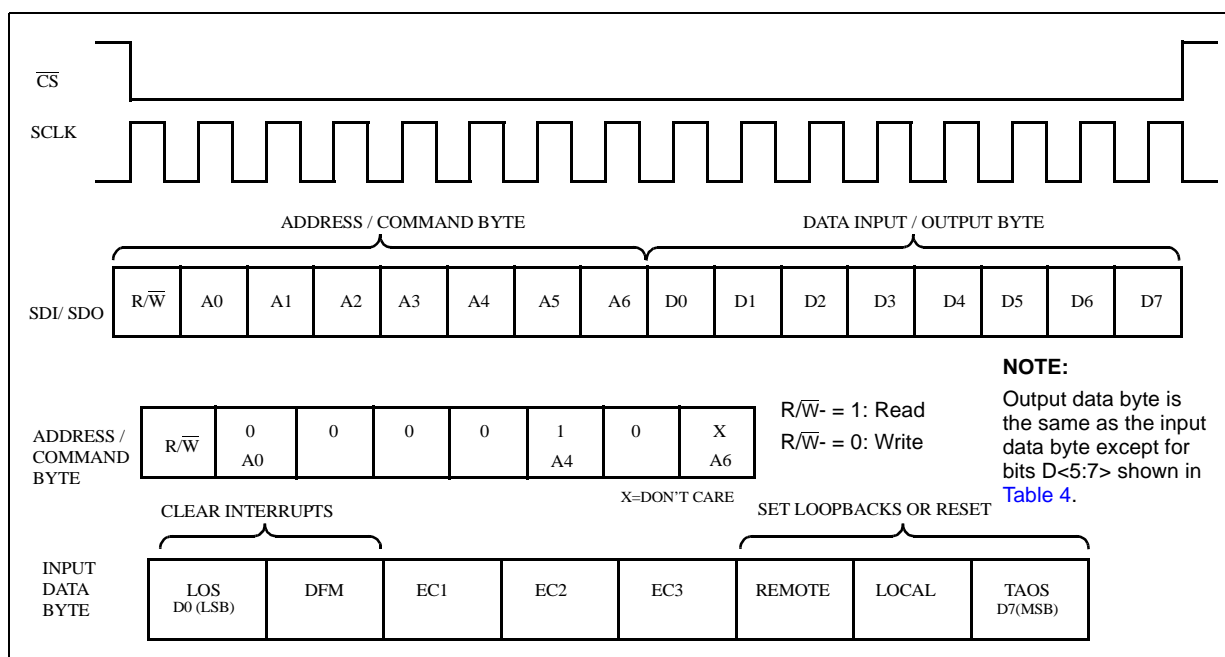
The Host mode provides a latched Interrupt output ($\overline{\text{INT}}$) which is triggered by a change in the Loss of Signal (LOS) and/or the Driver Performance Monitor (DPM) bits. The Interrupt is cleared when the interrupt condition no longer exists, and the host processor enables the respective bit in the serial input data byte.

Host mode also allows control of the serial data and receive data output timing. The Clock Edge (CLKE) signal determines when the RPOS, RNEG, SDO and SDI outputs are valid, relative to the Serial Clock (SCLK) or RCLK edge (see Table 3).

Table 3. Host Mode CLKE Settings

| CLKE Pin | Output | Valid |
|----------|--------|-------------------|
| Low | RPOS | Rising edge RCLK |
| | RNEG | Rising edge RCLK |
| | SDO | Falling edge SCLK |
| High | RPOS | Falling edge RCLK |
| | RNEG | Falling edge RCLK |
| | SDO | Rising edge SCLK |

Figure 4. LXT304A Serial Interface Data Structure



The LXT304A serial port is addressed by setting bit A4 in the Address/Command byte, corresponding to address 16. The LXT304A contains a single output data register so no complex chip addressing scheme is required. The register is accessed by causing the Chip Select (\overline{CS}) input to transition from High to Low. Bit 1 of the Serial Address/Command byte provides read/write control when the chip is accessed. A logic 1 indicates a read operation, and a logic 0 indicates a write operation. Table 4 lists serial data output bit combinations for each status. Serial data I/O timing characteristics are shown in the Test Specifications section.

Table 4. LXT304A Serial Data Output Bits (See Figure 4)

| Bit D5 | Bit D6 | Bit D7 | Status |
|--------|--------|--------|--|
| 0 | 0 | 0 | Reset has occurred, or no program input. |
| 0 | 0 | 1 | TAOS is active. |
| 0 | 1 | 0 | Local Loopback is active. |
| 0 | 1 | 1 | TAOS and Local Loopback are active. |
| 1 | 0 | 0 | Remote Loopback is active. |
| 1 | 0 | 1 | DPM has changed state since last Clear DPM occurred. |
| 1 | 1 | 0 | LOS has changed state since last Clear LOS occurred. |
| 1 | 1 | 1 | LOS and DPM have both changed state since last Clear DPM and Clear LOS occurred. |

2.5.2 Hardware Mode Operation

In Hardware mode, the transceiver is accessed and controlled via the LXT304A pins. With the exception of the Interrupt and CLKE functions, Hardware mode provides all the functions provided in the Host mode. In the Hardware mode RPOS and RNEG outputs are valid on the rising edge of RCLK. To operate in Hardware mode, the MODE pin is set Low. Equalizer Control signals (EC1 through EC3) are input on the INT, SDI and SDO pins respectively. Diagnostic control for Remote Loopback (RLOOP), Local Loopback (LLOOP), and Transmit All Ones (TAOS) modes is provided through the individual pins used to control serial interface timing in the Host mode.

2.5.3 Diagnostic Mode Operation

2.5.3.1 Transmit All Ones

In Transmit All Ones (TAOS) mode, the TPOS and TNEG inputs to the transceiver are ignored. As shown in Figure 5, the transceiver sends a continuous stream of ones when the TAOS mode is activated. As shown in Figure 6, TAOS can be commanded simultaneously with Local Loopback. However, TAOS is inhibited during Remote Loopback.

Figure 5. Transmit All Ones

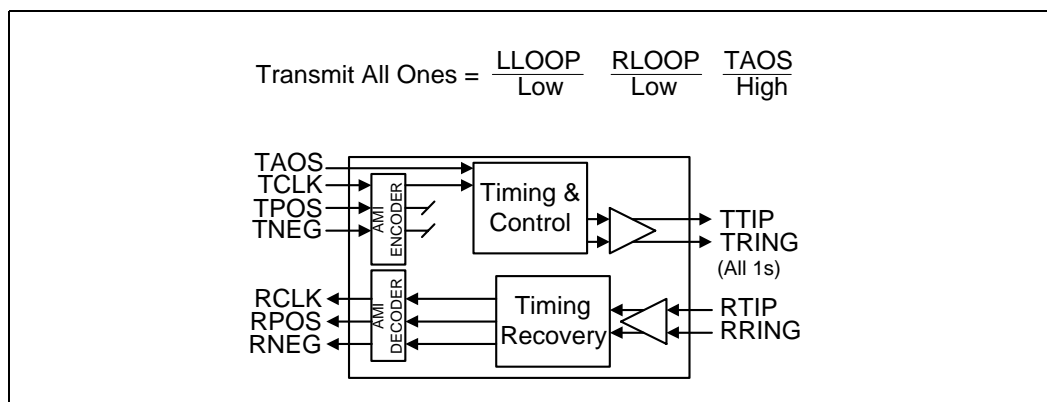
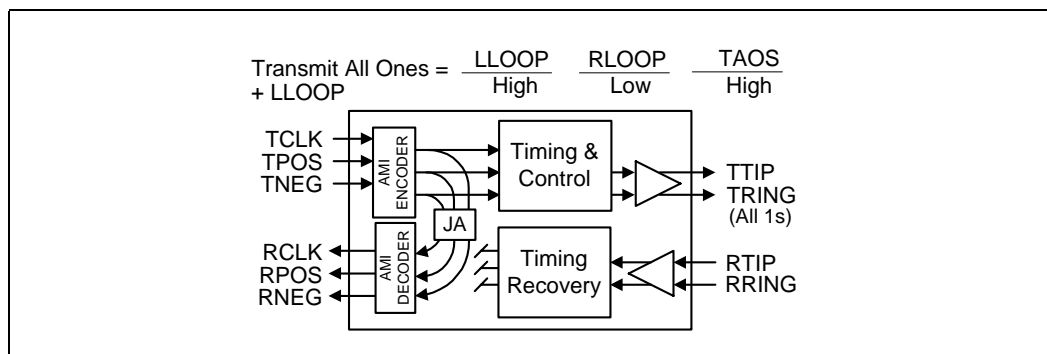


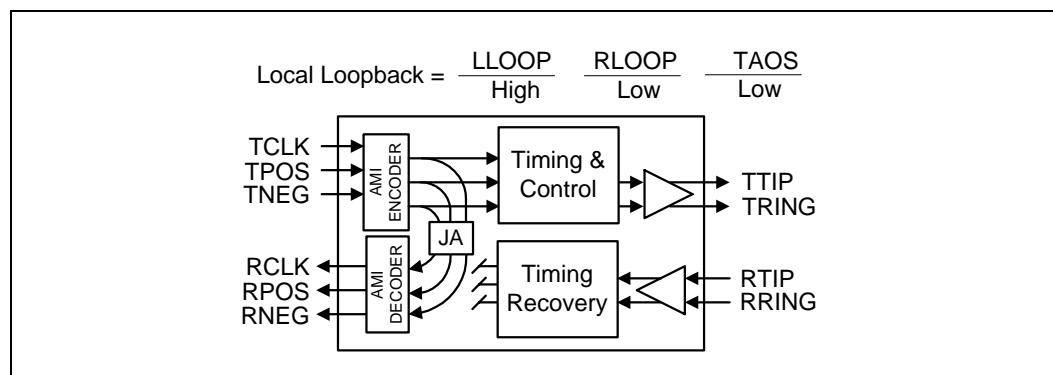
Figure 6. Local Loopback with TAOS



2.5.3.2 Local Loopback

In Local Loopback (LLOOP) mode, the receiver circuits are inhibited. As shown in Figure 7, the transmit data and clock inputs (TPOS, TNEG and TCLK) are looped back to the receive data and clock outputs (RPOS, RNEG and RCLK) through the Rx jitter attenuator. The transmitter circuits are unaffected by the LLOOP command. The TPOS and TNEG inputs will be transmitted normally.

Figure 7. Local Loopback



2.5.3.3 Remote Loopback

In Remote Loopback (RLOOP) mode, the transmit data and clock inputs (TPOS, TNEG and TCLK) are ignored. As shown in Figure 8, the RPOS and RNEG outputs are looped back to the transmit circuits and output on TTIP and TRING at the RCLK frequency. Receiver circuits are unaffected by the RLOOP command and continue to output the RPOS, RNEG and RCLK signals received from the cable-pair.

Figure 8. Remote Loopback

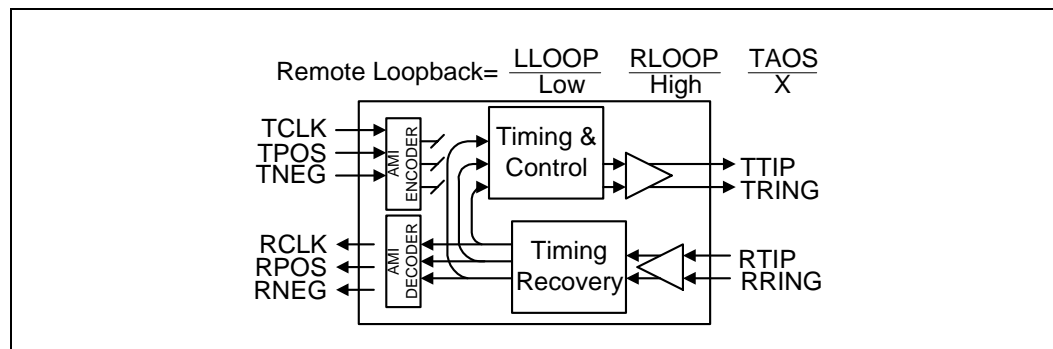


Table 5. LXT304A External Crystal Specifications

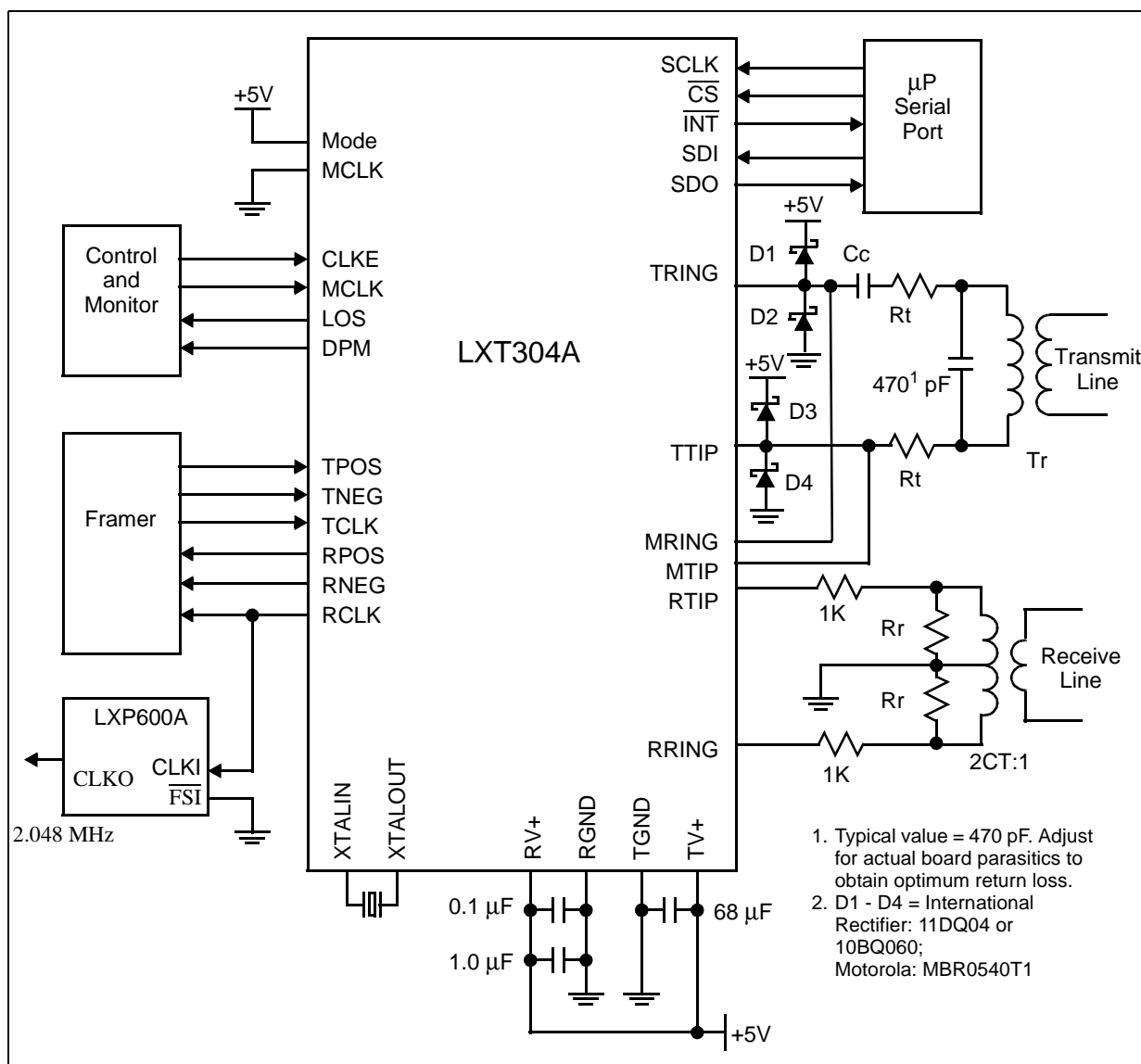
| Parameter | T1 | E1 |
|-----------------------------|--|--|
| Frequency | 6.176 MHz | 8.192 MHz |
| Frequency stability | ± 20 ppm @ 25 °C ± 25 ppm from -40 °C to 85 °C (Ref 25 °C reading) | ± 20 ppm @ 25 °C ± 25 ppm from -40 °C to +85 °C (Ref 25 °C reading) |
| Pullability | CL = 11 pF to 18.7 pF, +ΔF = 175 to 195 ppm CL = 18.7 pF to 34 pF, -ΔF = 175 to 195 ppm | CL = 11 pF to 18.7 pF, +ΔF = 95 to 115 ppm CL = 18.7 pF to 34 pF, -ΔF = 95 to 115 ppm See the Short Haul FAQ document (on our web site) to find crystals that achieve CTR12/13 compliance. |
| Effective series resistance | 40 Ω Maximum | 30 Ω Maximum |
| Crystal cut | AT | AT |
| Resonance | Parallel | Parallel |
| Maximum drive level | 2.0 mW | 2.0 mW |
| Mode of operation | Fundamental | Fundamental |
| Crystal holder | HC49 (R3W), Co = 7 pF maximum CM = 17 fF typical | HC49 (R3W), Co = 7 pF maximum CM = 17 fF typical |

3.0 Application Information

3.1 1.544 Mbps T1 Interface Application

Figure 9 is a typical 1.544 Mbps T1 application. The LXT304A is shown in the Host mode. A T1/ESF framer supplies the digital interface to the LXT304A in Host mode. Both devices are controlled through the serial interface. An LXP600A Clock Adapter (CLAD) provides the 2.048 MHz system backplane clock, locked to the recovered 1.544 MHz clock signal. The power supply inputs are tied to a common bus with appropriate decoupling capacitors installed (68 μ F on the transmit side, 1.0 μ F and 0.1 μ F on the receive side).

Figure 9. Typical LXT304A 1.544 Mbps T1 Application (Host Mode)



3.1.1 2.048 Mbps E1 Interface Applications

Figure 10 is a 2.048 Mbps, E1, twisted-pair application using $15\ \Omega$ Rt resistors in line with the transmit transformer to provide high return loss and surge protection. When high return loss is not a critical factor, a 1:1 or 1:1.26 transformer without in-line resistors provides maximum power savings. The LXT304A is shown in Hardware mode with a typical E1/CRC4 Framer. The hard-wired control lines for TAOS, LLOOP and RLOOP are individually controllable, and the LLOOP and RLOOP lines are also tied to a single control for the Reset function. This configuration is illustrated with a crystal in place to enable the LXT304A Jitter Attenuation Loop, and a single power supply bus.

3.1.2 Line Protection

On the receive side, the $1\ \text{k}\Omega$ series resistors protect the receiver against current surges coupled into the device. Due to the high receiver input impedance (typically $40\ \text{k}\Omega$), the resistors do not affect the receiver sensitivity. On the transmit side, the Schottky diodes (D1-D4) protect the output driver. While not mandatory for normal operation, these protection elements are strongly recommended to improve the design's robustness.

Table 6. T1/E1 Input/Output Configurations

| Bit Rate (Mbps) | Crystal XTAL | Cable (Ω) | Rr ² (Ω) | EC3/2/1 | Transmit Transformer ¹ (Tr) | Rt ² (Ω) | Typical TX Return Loss ³ (dB) | Cc (μF) |
|---|-----------------|--------------|------------------------|--------------------|--|------------------------|---|------------|
| 1.544 (T1) | LXC6176 | 100 | 200 | 0/1/1 - 1/1/1 | 1:1.15 | 0 | 0.5 | 0.47 |
| | | | | | 1:2 | 9.1 | 18 | 0 |
| | | | | | 1:2.3 | 9.1 | 18 | 0 |
| | | | | 0/1/0 ⁴ | 1:2.3 | 0 | 0 ⁴ | 0.47 |
| 2.048 (E1) | LXC8192 | 120 | 240 | 0/0/0 | 1:1.26 | 0 | 0.5 | 0.47 |
| | | | | 0/0/0 | 1:2 | 9.1 | 12 | 0 |
| | | | | 0/0/1 | 1:1 | 0 | 0.5 | 0.47 |
| | | | | 0/0/1 | 1:2 | 1.5 | 18 | 0 |
| | | 75 | 150 | 0/0/0 | 1:1 | 0 | 0.5 | 0.47 |
| | | | | 0/0/0 | 1:2 | 9.1 | 18 | 0 |
| | | | | 0/0/1 | 1:1 | 10 | 5 | 0 |
| | | | | 0/0/1 | 1:2 | 14.3 | 10 | 0 |
| 1. Transformer turns ratio accuracy is ±2%. 2. Rr and Rt values are ±1%. 3. Typical return loss, 51 kHz to 3.072 MHz band. 4. D4 Channel Bank application. | | | | | | | | |

4.0 Test Specifications

Note: The minimum and maximum values in Table 7 through Table 13 and Figure 11 through Figure 16 represent the performance specifications of the LXT304A and are guaranteed by test, except where noted by design.

Table 7. Absolute Maximum Ratings

| Parameter | Sym | Min | Max | Unit |
|--|------------------|------------|-------------|------|
| DC supply (referenced to GND) | RV+, TV+ | -0.3 | 6.0 | V |
| Input voltage, any pin ¹ | V _{IN} | RGND - 0.3 | (RV+) + 0.3 | V |
| Input current, any pin ² | I _{in} | -10 | 10 | mA |
| Storage temperature | T _{STG} | -65 | 150 | °C |
| Caution: Operations at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes. 1. Excluding RTIP and RRING which must stay between -6V and (RV+) + 0.3) V. 2. Transient currents of up to 100 mA will not cause SCR latch up. TTIP, TRING, TV+ and TGND can withstand a continuous current of 100 mA. | | | | |

Table 8. Recommended Operating Conditions and Characteristics

| Parameter | Sym | Min | Typ | Max | Unit |
|--|----------------|------|-----|------|------|
| DC supply ¹ | RV+, TV+ | 4.75 | 5.0 | 5.25 | V |
| Ambient operating temperature | T _A | -40 | 25 | 85 | °C |
| 1. TV+ must not exceed RV+ by more than 0.3 V. | | | | | |

Table 9. Electrical Characteristics (Over Recommended Operating Conditions)

| Parameter | Sym | Min | Max | Unit | Test Conditions |
|--|-----------------|-----|-----|------|--|
| Total power dissipation ^{1,3} | P _D | – | 400 | mW | 100% ones density & maximum line length @ 5.25 V |
| High level input voltage ^{2,3} (pins 1-5, 10, 23-28) | V _{IH} | 2.0 | – | V | |
| Low level input voltage ^{2,3} (pins 1-5, 10, 23-28) | V _{IL} | – | 0.8 | V | |
| High level output voltage ^{2,3} (pins 6-8, 11, 12, 23, 25) | V _{OH} | 2.4 | – | V | I _{OUT} = -400 μA |
| Low level output voltage ^{2,3} (pins 6-8, 11, 12, 23, 25) | V _{OL} | – | 0.4 | V | I _{OUT} = 1.6 mA |
| Input leakage current ⁴ | I _{LL} | -10 | +10 | μA | |
| Three-state leakage current ² (pin 25) | I _{3L} | -10 | +10 | μA | |
| 1. Power dissipation while driving line load over operating temperature range. Includes device and load. Digital input levels are within 10% of the supply rails and digital outputs are driving a 50 pF capacitive load. 2. Functionality of pins 23 and 25 depends on mode. See Host/Hardware mode descriptions. 3. Output drivers will output CMOS logic levels into CMOS loads. 4. Except MTIP and MRING: I _{LL} = ±50 μA. | | | | | |

Table 10. Analog Characteristics (Over Recommended Operating Conditions)

| Parameter | | Min | Typ ¹ | Max | Unit | Test Conditions |
|--|-----------------------|---------------------|------------------|--------------------|--------|-----------------------|
| AMI output pulse amplitudes | DSX-1 | 2.4 | 3.0 | 3.6 | V | measured at the DSX |
| | E1 | 2.7 | 3.0 | 3.3 | V | measured at line side |
| Recommended output load at TTIP and TRING | | — | 75 | — | Ω | |
| Jitter added by the transmitter ² | 10 Hz - 8 kHz | — | — | 0.02 | UI | |
| | 8 kHz - 40 kHz | — | — | 0.025 | UI | |
| | 10 Hz - 40 kHz | — | — | 0.025 | UI | |
| | Broad Band | — | — | 0.05 | UI | |
| Sensitivity below DSX (0 dB = 2.4 V) | | 13.6 | — | — | dB | |
| | | 500 | — | — | mV | |
| Loss of signal threshold | | — | 0.3 | — | V | |
| Data decision threshold | DSX-1 | 63 | 70 | 77 | % peak | |
| | E1 | 43 | 50 | 57 | % peak | |
| Allowable consecutive zeros before LOS | | 160 | 175 | 190 | — | |
| Input jitter tolerance 10 kHz - 100 kHz | | 0.4 | — | — | UI | |
| Jitter attenuation curve corner frequency ³ | | — | 3 | — | Hz | |
| Minimum return loss ^{4,5} | | Transmit Min Typ | | Receive Min Typ | | dB |
| | 51 kHz - 102 kHz | 18 | — | 20 | — | dB |
| | 102 kHz - 2.048 kHz | 18 | — | 20 | — | dB |
| | 2.048 kHz - 3.072 kHz | 18 | — | 20 | — | dB |

1. Typical values are measured at 25 °C and are for design aid only; not guaranteed and not subject to production testing.

2. Input signal to TCLK is jitter-free.

3. Circuit attenuates jitter at 20 dB/decade above the corner frequency.

4. In accordance with ITU G.703/ETS 300166 return loss specifications when wired per [Figure 10](#) (E1).

5. Guaranteed by design.

Figure 11. Typical Receive Input Jitter Tolerance (Loop Mode)

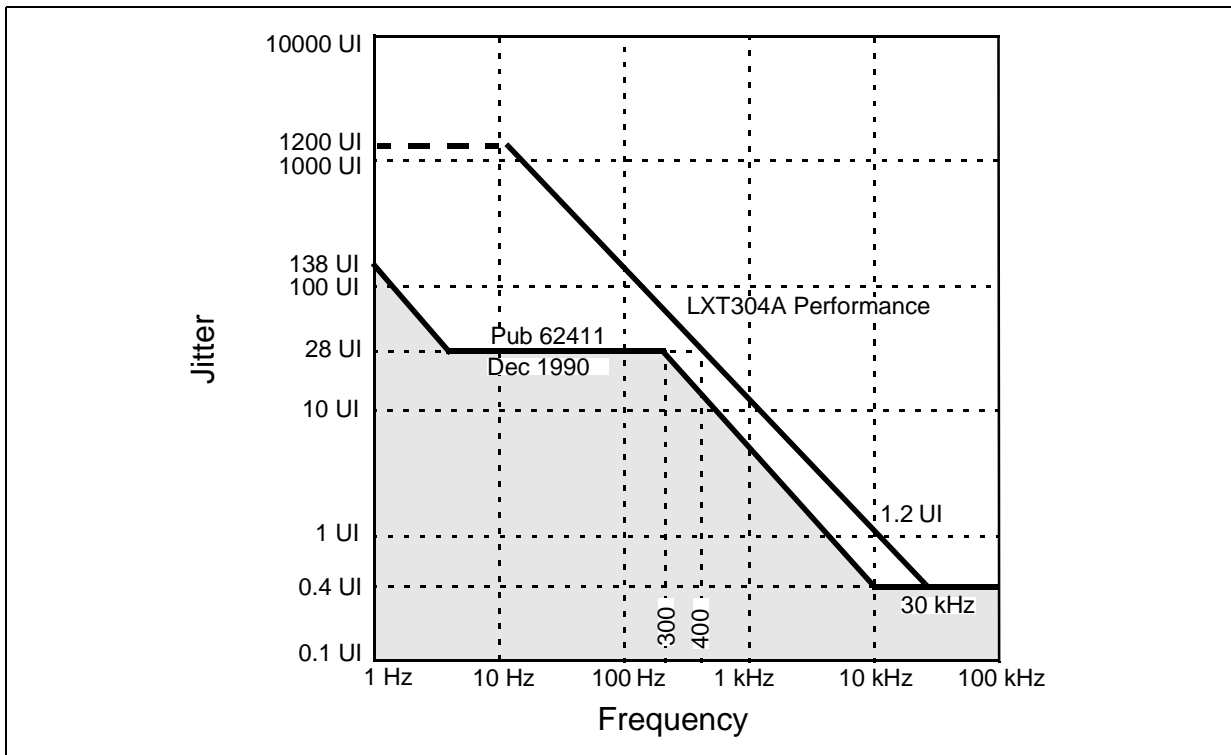


Figure 12. LXT304A Receive Jitter Transfer Performance (Typical)

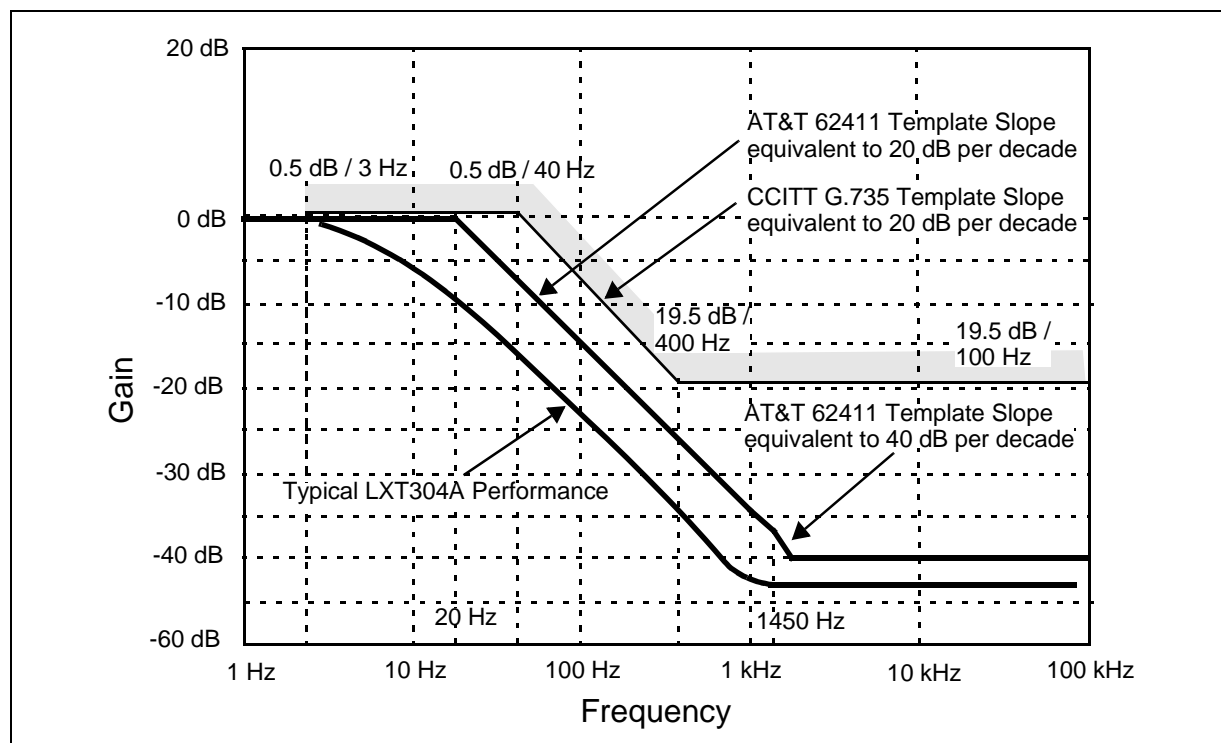


Table 11. LXT304A Receive Timing Characteristics (See Figure 13)

| Parameter | | Sym | Min | Typ ¹ | Max | Unit | Test Conditions |
|-------------------------------------|----|-------|-----|------------------|-----|------|-----------------|
| Receive clock duty cycle | T1 | RCLKd | 40 | 50 | 60 | % | |
| | E1 | RCLKd | 40 | 50 | 60 | % | |
| Receive clock period | T1 | tPW | 594 | 648 | 702 | ns | |
| | E1 | tPW | 447 | 488 | 529 | ns | |
| Receive clock pulse width high | T1 | tPWH | — | 324 | — | ns | |
| | E1 | tPWH | — | 244 | — | ns | |
| Receive clock pulse width low | T1 | tPWL | — | 324 | — | ns | |
| | E1 | tPWL | — | 244 | — | ns | |
| RPOS/RNEG to RCLK rising setup time | T1 | tSUR | — | 274 | — | ns | |
| | E1 | tSUR | — | 194 | — | ns | |
| RCLK rising to RPOS/RNEG hold time | T1 | tHR | — | 274 | — | ns | |
| | E1 | tHR | — | 194 | — | ns | |

1. Typical values are at 25 °C and are for design aid only; they are not guaranteed and not subject to production testing.

Figure 13. LXT304A Receive Clock Timing Diagram

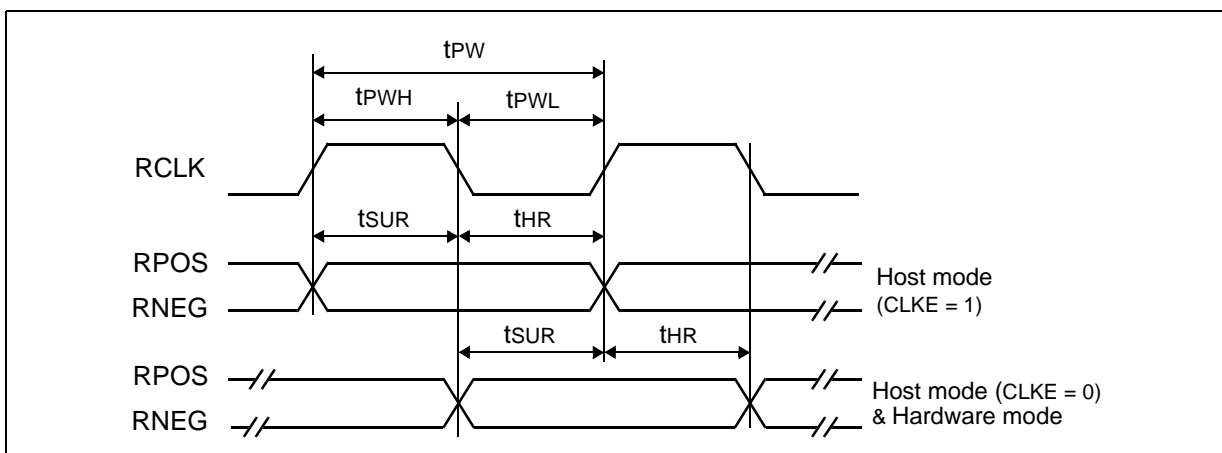


Table 12. LXT304A Master Clock and Transmit Timing Characteristics (See Figure 14)

| Parameter | | Sym | Min | Typ ¹ | Max | Unit |
|------------------------------|-------|-------|-----|------------------|-----|------|
| Master clock frequency | DSX-1 | MCLK | – | 1.544 | – | MHz |
| | E1 | MCLK | – | 2.048 | – | MHz |
| Master clock tolerance | | MCLKt | – | ±100 | – | ppm |
| Master clock duty cycle | | MCLKd | 40 | – | 60 | % |
| Crystal frequency | DSX-1 | fc | – | 6.176 | – | MHz |
| | E1 | fc | – | 8.192 | – | MHz |
| Transmit clock frequency | DSX-1 | TCLK | – | 1.544 | – | MHz |
| | E1 | TCLK | – | 2.048 | – | MHz |
| Transmit clock tolerance | | TCLKt | – | ±50 | – | ppm |
| Transmit clock duty cycle | | TCLKd | 10 | – | 90 | % |
| TPOS/TNEG to TCLK setup time | | tsUT | 25 | – | – | ns |
| TCLK to TPOS/TNEG hold time | | tHT | 25 | – | – | ns |

1. Typical values are at 25 °C and are for design aid only; they are not guaranteed and not subject to production testing.

Figure 14. LXT304A Transmit Clock Timing Diagram

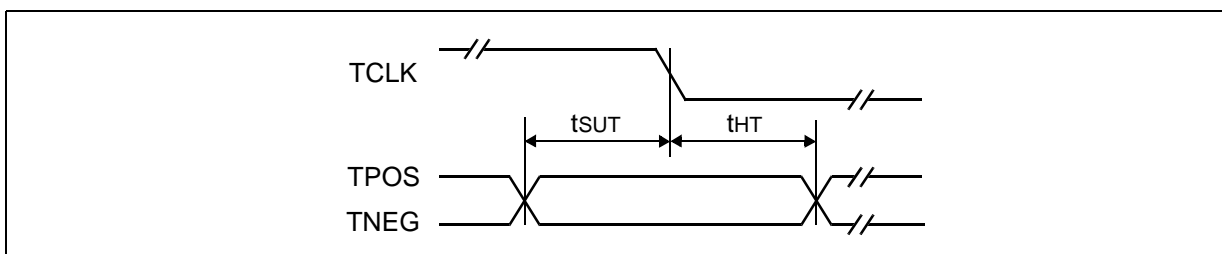


Table 13. LXT304A Serial I/O Timing Characteristics (See Figure 15 and Figure 16)

| Parameter | Sym | Min | Typ ¹ | Max | Unit | Test Conditions |
|--|---------------------------------|-----|------------------|-----|------|--------------------|
| Rise/fall time - any digital output | t _{RF} | — | — | 100 | ns | Load 1.6 mA, 50 pF |
| SDI to SCLK setup time | t _{DC} | 50 | — | — | ns | |
| SCLK to SDI hold time | t _{CDH} | 50 | — | — | ns | |
| SCLK low time | t _{CL} | 240 | — | — | ns | |
| SCLK high time | t _{CH} | 240 | — | — | ns | |
| SCLK rise and fall time | t _R , t _F | — | — | 50 | ns | |
| $\overline{\text{CS}}$ to SCLK setup time | t _{CC} | 50 | — | — | ns | |
| SCLK to $\overline{\text{CS}}$ hold time | t _{CCH} | 50 | — | — | ns | |
| $\overline{\text{CS}}$ inactive time | t _{CWH} | 250 | — | — | ns | |
| SCLK to SDO valid | t _{CDV} | — | — | 200 | ns | |
| SCLK trailing edge or $\overline{\text{CS}}$ rising edge to SDO high Z | t _{CDZ} | — | 100 | — | ns | |

1. Typical values are at 25° C and are for design aid only; they are not guaranteed and not subject to production testing.

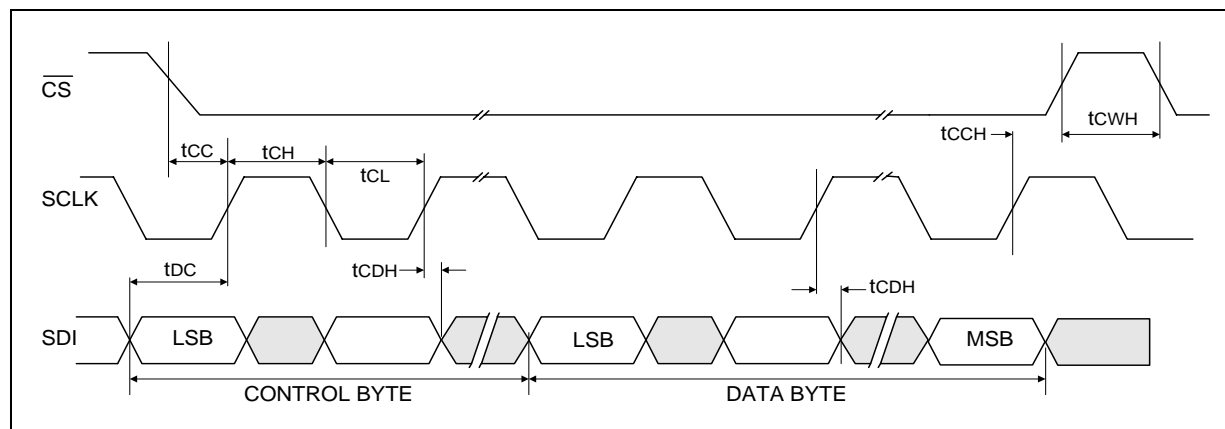
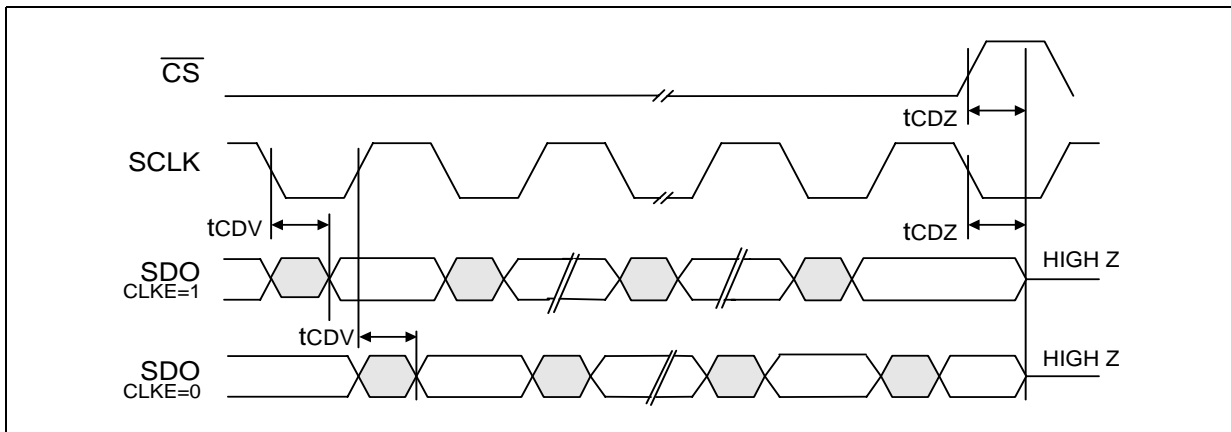
Figure 15. LXT304A Serial Data Input Timing Diagram

Figure 16. LXT304A Serial Data Output Timing Diagram

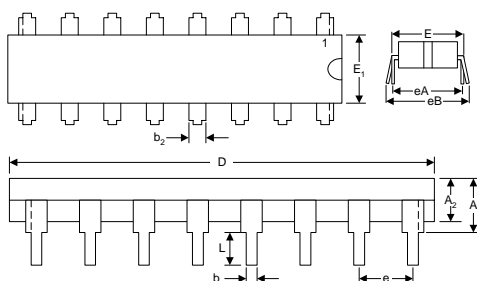


5.0 Mechanical Specifications

Figure 17. Package Specifications

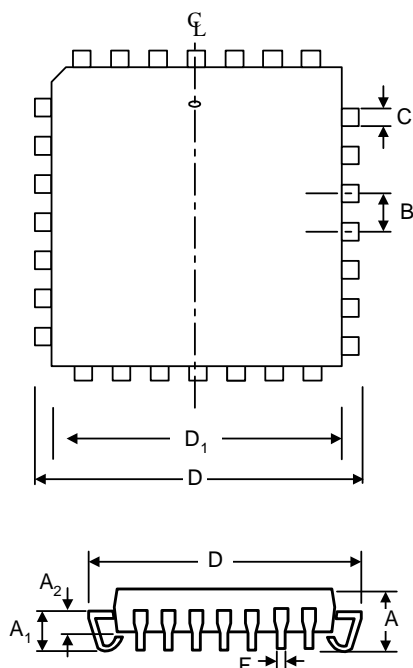
28-pin Plastic Dual In-Line Package

- P/N LXT304ANE
- Extended Temperature Range
(-40°C to 85°C)



28-pin Plastic Leaded Chip Carrier

- P/N LXT304APE
- Extended Temperature Range
(-40°C to 85°C)



| Dim | Inches | | Millimeters | |
|-----|----------------------------------|-------|-----------------------------------|--------|
| | Min | Max | Min | Max |
| A | — | 0.250 | — | 6.350 |
| A2 | 0.125 | 0.195 | 3.175 | 4.953 |
| b | 0.014 | 0.022 | 0.356 | 0.559 |
| b2 | 0.030 | 0.070 | 0.762 | 1.778 |
| D | 1.380 | 1.565 | 35.052 | 39.751 |
| E | 0.600 | 0.625 | 15.240 | 15.875 |
| E1 | 0.485 | 0.580 | 12.319 | 14.732 |
| e | 0.100 BSC ¹ (nominal) | | 2.540 BSC ¹ (nominal) | |
| eA | 0.600 BSC ¹ (nominal) | | 15.240 BSC ¹ (nominal) | |
| eB | — | 0.700 | — | 17.780 |
| L | 0.115 | 0.200 | 2.921 | 5.080 |

1. BSC—Basic Spacing between Centers

| Dim | Inches | | Millimeters | |
|-----|---------------------------------|-------|---------------------------------|--------|
| | Min | Max | Min | Max |
| A | 0.165 | 0.180 | 4.191 | 4.572 |
| A1 | 0.090 | 0.120 | 2.286 | 3.048 |
| A2 | 0.062 | 0.083 | 1.575 | 2.108 |
| B | .050 BSC ¹ (nominal) | | 1.27 BSC ¹ (nominal) | |
| C | 0.026 | 0.032 | 0.660 | 0.813 |
| D | 0.485 | 0.495 | 12.319 | 12.573 |
| D1 | 0.450 | 0.456 | 11.430 | 11.582 |
| F | 0.013 | 0.021 | 0.330 | 0.533 |

1. BSC—Basic Spacing between Centers