19-3354; Rev 1; 12/04

SFP Copper-Cable Preemphasis Driver

General Description

The MAX3982 is a single-channel, copper-cable preemphasis driver that operates from 1Gbps to 4.25Gbps. It provides compensation for copper links, such as 4.25Gbps Fibre Channel, allowing spans of up to 15m with 24AWG. The cable driver provides four selectable preemphasis levels. The input compensates for up to 10in of FR4 circuit board material at 4.25Gbps.

The MAX3982 also features SFP-compliant loss-of-signal detection with selectable sensitivity and TX_DISABLE. Selectable output swing reduces EMI and power consumption. It is packaged in a 3mm x 3mm, 16-pin thin QFN and operates from 0°C to +85°C temperature range.

Applications

SFP Active Copper-Cable Assemblies

Backplanes

1.0625Gbps, 2.125Gbps, and 4.25Gbps Fibre Channel

1.25Gbps Ethernet

2.488Gbps STM16

InfiniBand

PCI Express

Features

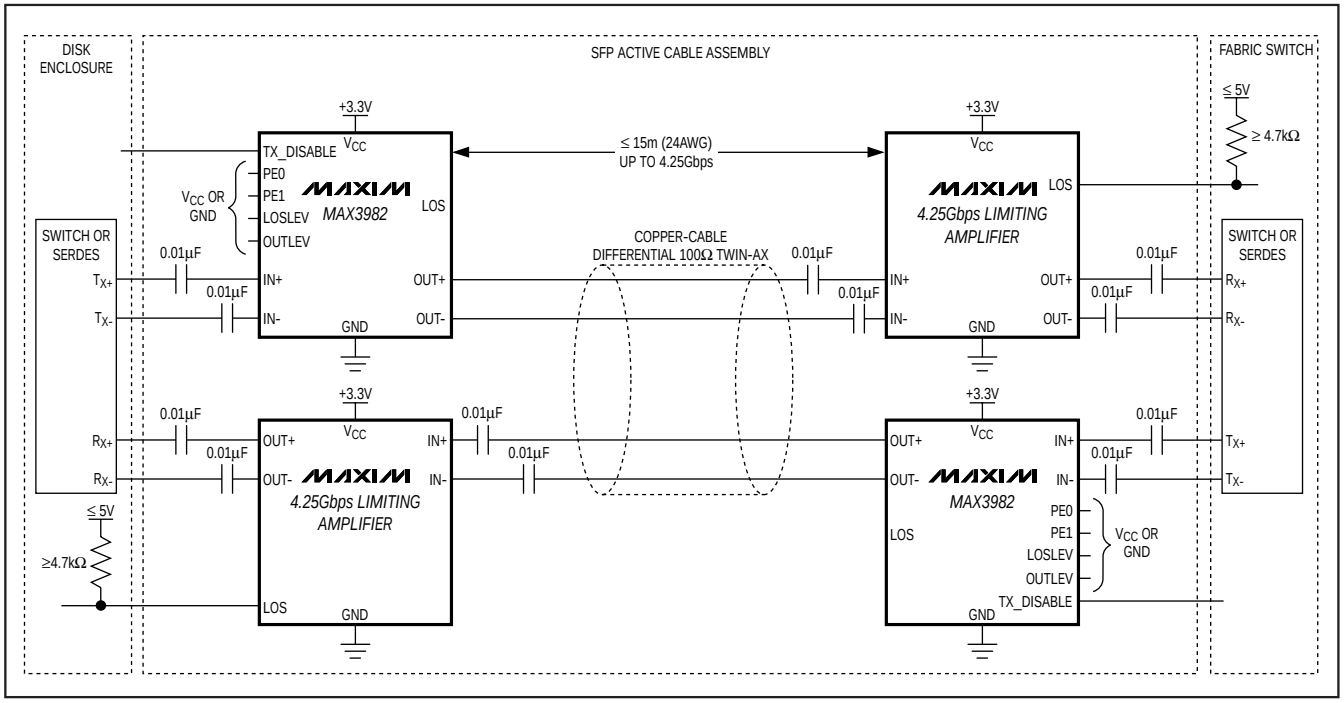
- **Drives Up to 15m with 24AWG Cable**
- **Drives Up to 30in of FR4**
- **0.25W Total Power with +3.3V Supply**
- **Selectable 1600mVP-P or 1200mVP-P Differential Output Swing**
- **Selectable Output Preemphasis**
- **Fixed Input Equalization**
- **Loss-of-Signal Detection with Selectable Sensitivity**
- **Transmit Disable**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	PKG CODE
MAX3982UTE	0°C to +85°C	16 Thin QFN	T1633-4

Pin Configuration appears at end of data sheet.

Typical Application Circuit



ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC}.....-0.5V to +6.0V
Continuous CML Output Current
at OUT+, OUT-.....-25mA to +25mA
Voltage at IN+, IN-, LOSLEV, LOS,
TX_DISABLE, PE0, PE1, OUTLEV .....-0.5V to (V_{CC} + 0.5V)
LOS Open Collector Supply Voltage
with ≥ 4.7kΩ Pullup Resistor.....-0.5V to +5.5V
Continuous Power Dissipation at +85°C
(derate 20.8mW/°C above +85°C).....1.35W
Operating Junction Temperature Range (T_J).....-55C° to +150°C
Storage Ambient Temperature Range (T_S) .....-55C° to +150°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{CC} = +3.0V to +3.6V, T_A = 0°C to +85°C. Typical values are at T_A = +25°C and V_{CC} = +3.3V, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current		TX_DISABLE=low		75	97	mA
Inrush Current		Current beyond steady-state current			10	mA
Power-On-Reset Delay	t_{POR}		1		40	ms
OPERATING CONDITIONS						
Supply Voltage	V_{CC}		3.0	3.3	3.6	V
Supply-Noise Tolerance		1MHz ≤ f < 2GHz		40		mV_{P-P}
Operating Ambient Temperature	T_A		0	25	85	°C
Bit Rate		NRZ data (Note 1)	1.0		4.25	Gbps
CID		Consecutive identical digits (bits) (Note 1)			10	Bits
CONTROL INPUTS: TX_DISABLE, PE0, PE1, OUTLEV, LOSLEV						
Voltage, Logic High	V_{IH}		2.0			V
Voltage, Logic Low	V_{IL}				0.8	V
Current, Logic High	I_{IH}	$V_{IH} = V_{CC}$ + 0.5V			-150	µA
Current, Logic Low	I_{IL}	V_{IL} = 0.8V			350	µA
STATUS OUTPUT: LOS						
LOS Open Collector Current Sink		LOS asserted	0		25	µA
		LOS unasserted, V_{OL} ≤ 0.4V with 4.7kΩ pullup resistor, pullup supply = 5.5V	1.0			mA
		V_{CC} = 0V, pullup supply = 5.5V, external pullup resistor ≥ 4.7kΩ	0		25	µA
LOS Assert Level		LOSLEV = high (Note 1)	100			mV_{P-P}
		LOSLEV = low (Note 1)	50			mV_{P-P}
LOS Deassert Level		LOSLEV = high (Note 1)			300	mV_{P-P}
		LOSLEV = low (Note 1)			120	mV_{P-P}
LOS Hysteresis		LOSLEV = high (Note 1)	20			mV_{P-P}
		LOSLEV = low (Note 1)		4		mV_{P-P}
LOS Response Time		Time from IN dropping below assert level, or rising above deassert level to 50% point of LOS			10	µs
LOS Transition Time		Rise-time or fall-time (10% to 90%), external pullup resistor = 4.7kΩ		250		ns

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +3.0V to +3.6V, T_A = 0°C to +85°C. Typical values are at T_A = +25°C and V_{CC} = +3.3V, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS				MIN	TYP	MAX	UNITS
EQUALIZER AND CABLE DRIVER SPECIFICATIONS									
Input Swing		Measured differentially at point A of Figure 2 (Note 1)				600		2000	mV_{P-P}
Input Resistance		Measured differentially				85	100	115	Ω
Input Return Loss		100MHz to 2GHz (Note 1)				10			dB
Differential Output Swing		Measured differentially at point B of Figure 2 (Notes 1, 2)	TX_DISABLE = low, OUTLEV = high			1450		1800	mV_{P-P}
			TX_DISABLE = low, OUTLEV = low			1000		1350	
			TX_DISABLE = high				40		
Common-Mode Output		(OUT+) + (OUT-), measured at point B of Figure 2; TX_DISABLE = low, OUTLEV = high (Notes 1, 2)						60	mV_{P-P}
Output Resistance		OUT+ or OUT- to V_{CC}, single ended				42	50	58	Ω
Output Return Loss		100MHz to 2GHz (Note 1)				10			dB
Output Transition Time	t_r, t_f	20% to 80% (Notes 1, 3)					50	80	ps
Random Jitter		(Notes 1, 3)						1.6	ps_{RMS}
Output Preemphasis		See Figure 1		PE1	PE0				dB
				0	0		2		
				0	1		4		
				1	0		8		
				1	1		14		
Residual Output Deterministic Jitter at 1.0625Gbps to 2.125Gbps (Notes 1, 4, 5)		Source to IN	OUT to Load	PE1	PE0				UI_{P-P}
		6 mil FR4 ≤ 10in	1m, 24AWG	0	0		0.10	0.15	
			5m, 24AWG	0	1				
			10m, 24AWG	1	0				
			15m, 24AWG	1	1				
Residual Output Deterministic Jitter at 4.25Gbps (Notes 1, 4, 5)		Source to IN	OUT to Load	PE1	PE0				UI_{P-P}
		6 mil FR4 ≤ 10in	1m, 24AWG	0	0		0.15	0.20	
			5m, 24AWG	0	1				
			10m, 24AWG	1	0				
			15m, 24AWG	1	1				

Note 1: Guaranteed by design and characterization.

Note 2: PE1 = PE0 = 1 for maximum preemphasis, load is 50Ω ±1% at each side, and the pattern is 0000011111 at 1Gbps.

Note 3: Measured at point B in Figure 2 using 0000011111 at 1Gbps. PE1 = PE0 = 0 for minimum preemphasis. For transition time, the 0% reference level is the steady-state level after four zeros, just before the transition. The 100% reference level is the maximum voltage of the transition.

Note 4: Tested with CJTPAT, as well as this pattern: 19 zeros, 1, 10 zeros, 1010101010 (D21.5 character), 1100000101 (K28.5+ character), 19 ones, 0, 10 ones, 0101010101 (D10.2 character), 0011111010 (K28.5 character).

Note 5: Cables are unequalized, Amphenol Spectra-Strip 24AWG. Residual deterministic jitter is the difference between the source jitter at point A, and load jitter at point D in Figure 2. The deterministic jitter at the output of the transmission line must be from media-induced loss and not from clock-source modulation.

SFP Copper-Cable Preemphasis Driver

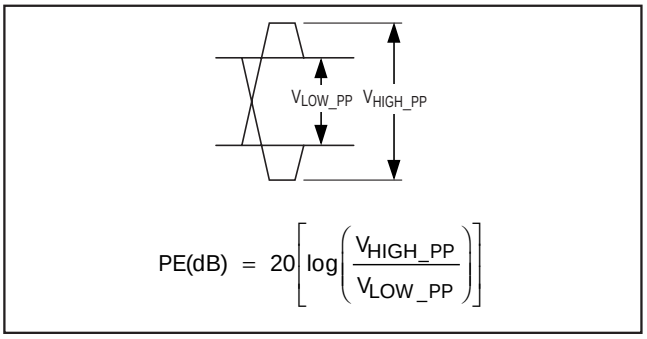


Figure 1. Illustration of Tx Preemphasis in dB

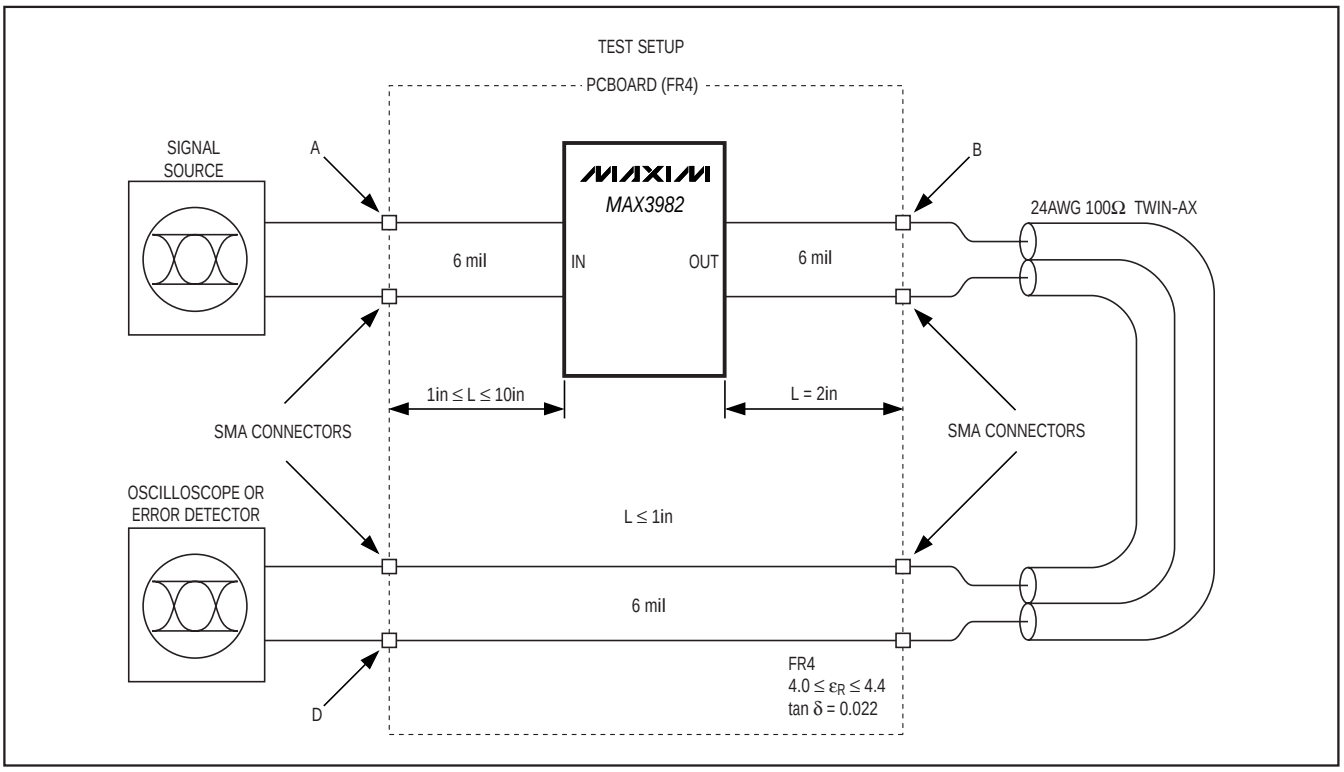


Figure 2. Test Setup. The points labeled A, B, and D are referenced for AC parameter test conditions. Deterministic jitter and eye diagrams measured at point D.

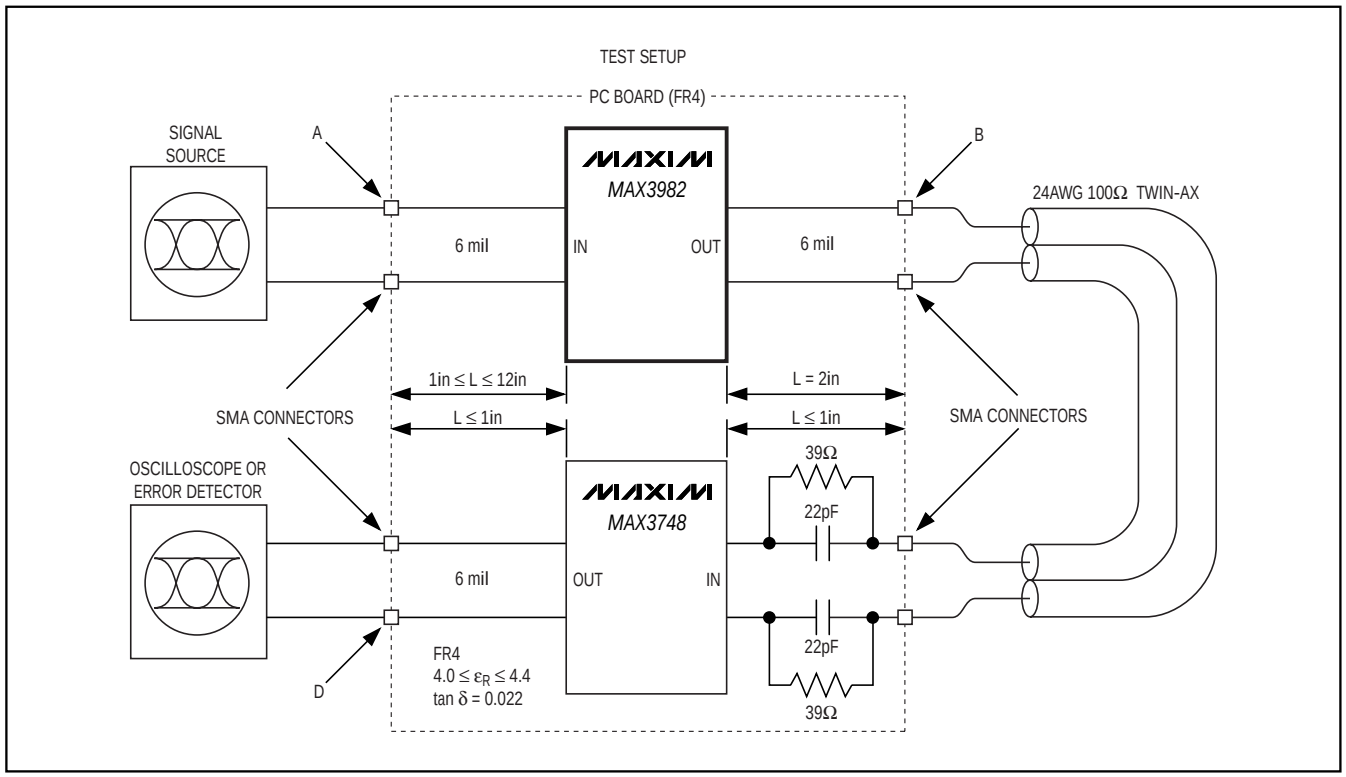
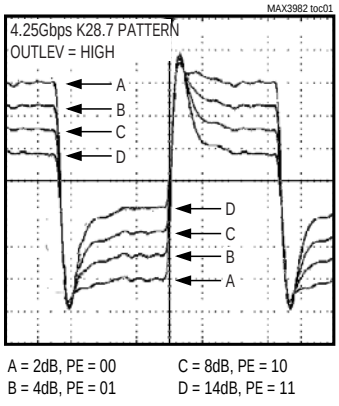


Figure 3. End-to-End Test Setup Using the MAX3748 as a Receiver. Deterministic jitter and eye diagrams measured at point D.

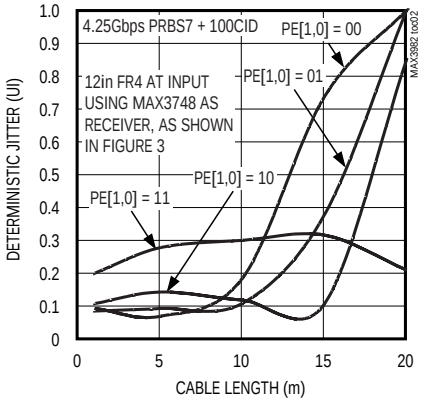
Typical Operating Characteristics

(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted. PRBS7 + 100CID pattern is PRBS 2^7, 100 zeros, 1010, PRBS 2^7, 100 ones, 0101.)

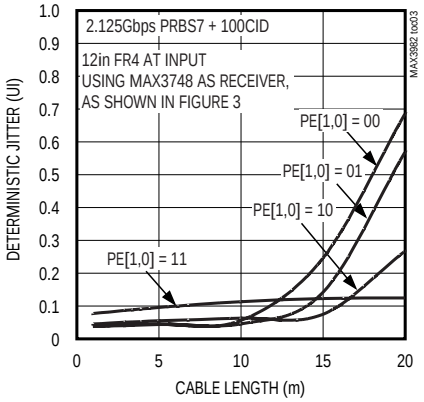
TRANSIENT RESPONSE



END-TO-END DETERMINISTIC JITTER vs. CABLE LENGTH AT 4.25Gbps



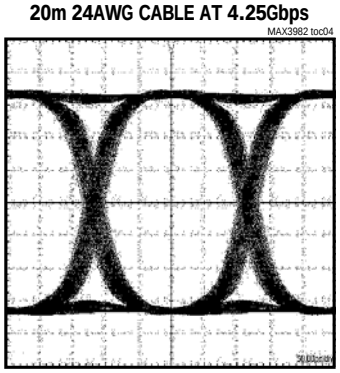
END-TO-END DETERMINISTIC JITTER vs. CABLE LENGTH AT 2.125Gbps



Typical Operating Characteristics (continued)

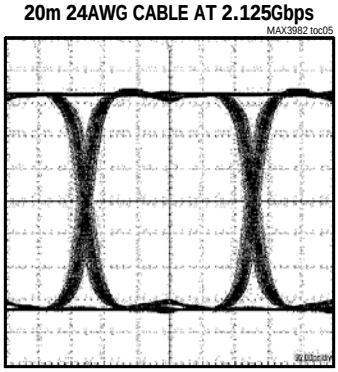
(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted. PRBS7 + 100CID pattern is PRBS 2^7, 100 zeros, 1010, PRBS 2^7, 100 ones, 0101.)

END-TO-END EYE DIAGRAM, 20m 24AWG CABLE AT 4.25Gbps



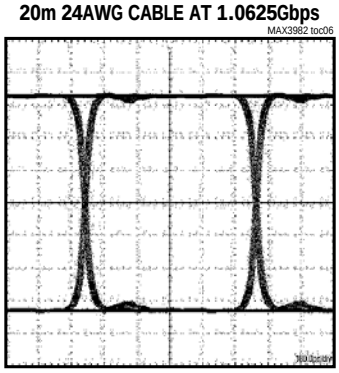
4.25Gbps PRBS7 + 100CID PATTERN, 0in FR4 AT INPUT, USING MAX3748 AS RECEIVER, AS SHOWN IN FIGURE 3

END-TO-END EYE DIAGRAM, 20m 24AWG CABLE AT 2.125Gbps



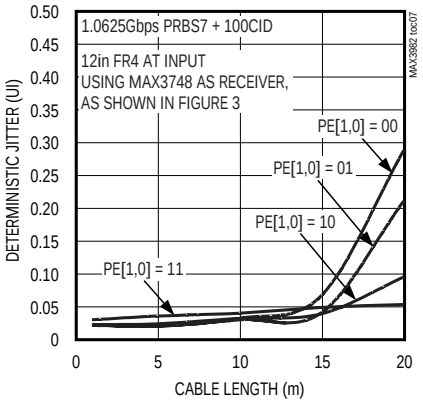
2.125Gbps PRBS7 + 100CID PATTERN, 0in FR4 AT INPUT, USING MAX3748 AS RECEIVER, AS SHOWN IN FIGURE 3

END-TO-END EYE DIAGRAM, 20m 24AWG CABLE AT 1.0625Gbps

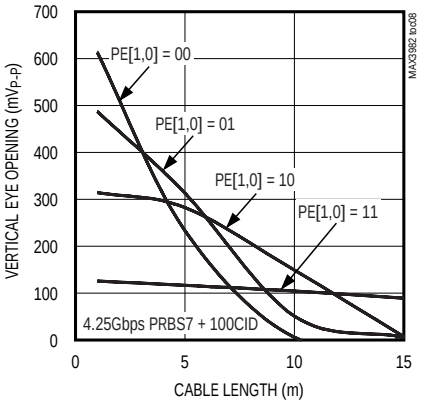


1.0625Gbps PRBS7 + 100CID PATTERN, 0in FR4 AT INPUT, USING MAX3748 AS RECEIVER, AS SHOWN IN FIGURE 3

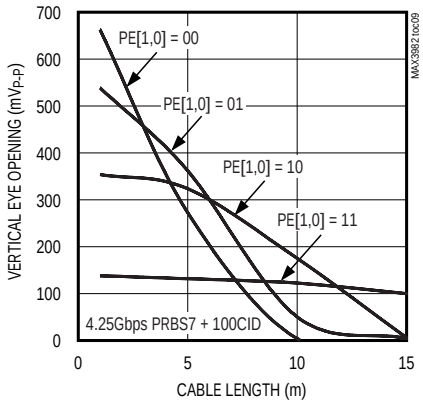
END-TO-END DETERMINISTIC JITTER vs. CABLE LENGTH AT 1.0625Gbps



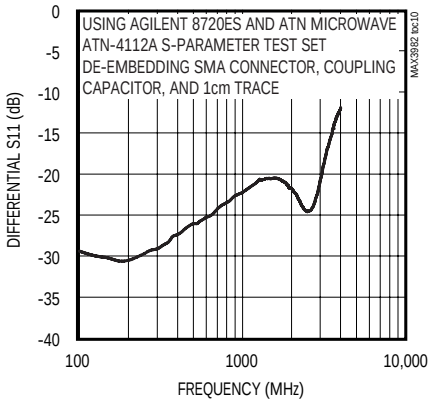
VERTICAL EYE OPENING vs. CABLE LENGTH WITH OUTLEV = LOW



VERTICAL EYE OPENING vs. CABLE LENGTH WITH OUTLEV = LOW



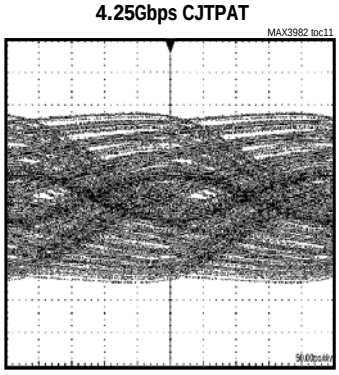
INPUT RETURN LOSS vs. FREQUENCY



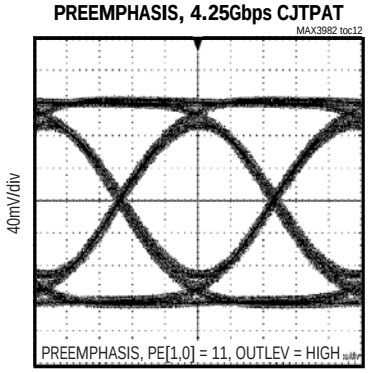
Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted. PRBS7 + 100CID pattern is PRBS 2^7, 100 zeros, 1010, PRBS 2^7, 100 ones, 0101.)

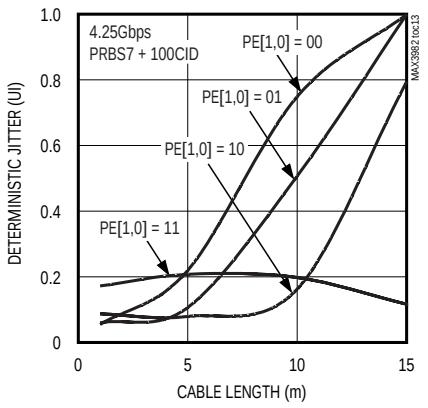
15m 24AWG CABLE ASSEMBLY OUTPUT WITHOUT MAX3982, 4.25Gbps CJTPAT



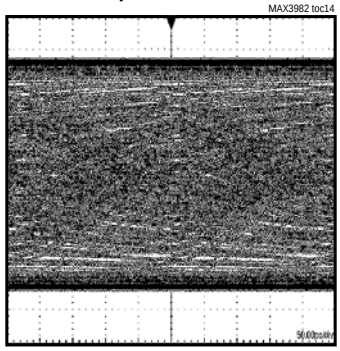
15m 24AWG CABLE ASSEMBLY OUTPUT WITH MAX3982 PREEMPHASIS, 4.25Gbps CJTPAT



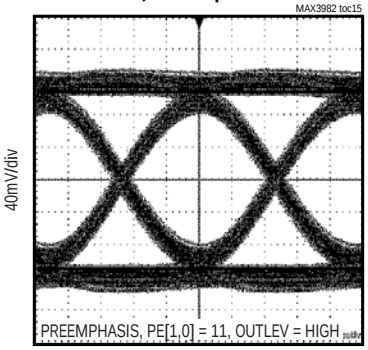
DETERMINISTIC JITTER vs. CABLE LENGTH



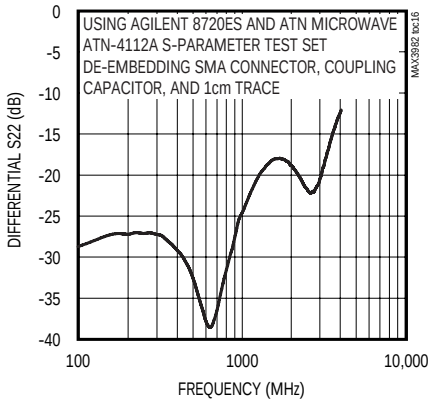
15m 24AWG CABLE ASSEMBLY OUTPUT WITHOUT MAX3982, 4.25Gbps PRBS7 + 100CID



15m 24AWG CABLE ASSEMBLY OUTPUT WITH MAX3982 PREEMPHASIS, 4.25Gbps PRBS7 + 100CID



OUTPUT RETURN LOSS vs. FREQUENCY

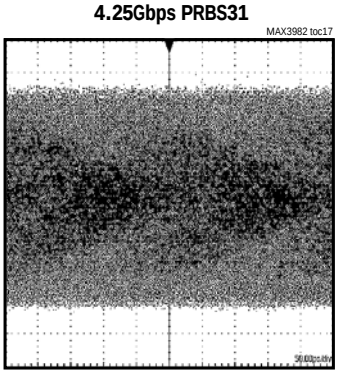


SFP Copper-Cable Preemphasis Driver

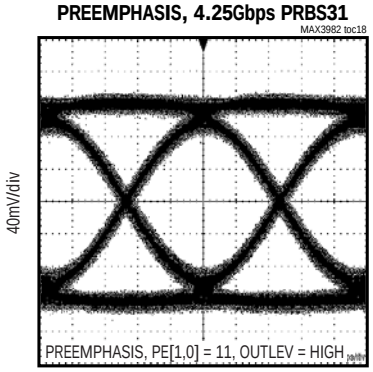
Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted. PRBS7 + 100CID pattern is PRBS 2^7, 100 zeros, 1010, PRBS 2^7, 100 ones, 0101.)

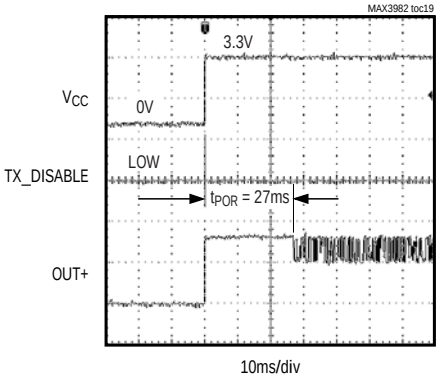
15m 24AWG CABLE ASSEMBLY OUTPUT WITHOUT MAX3982, 4.25Gbps PRBS31



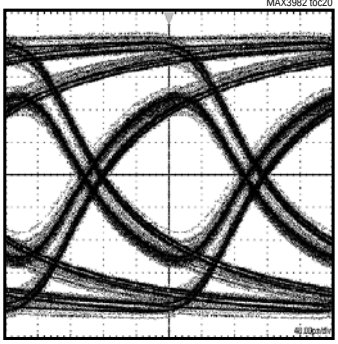
15m 24AWG CABLE ASSEMBLY OUTPUT WITH MAX3982 PREEMPHASIS, 4.25Gbps PRBS31



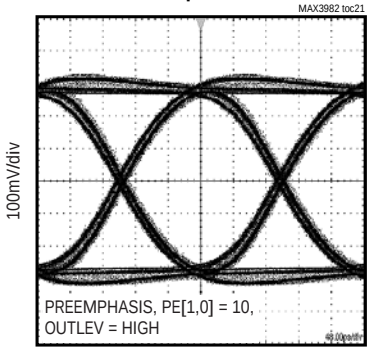
HOT-PLUG WITH TX_DISABLE LOW



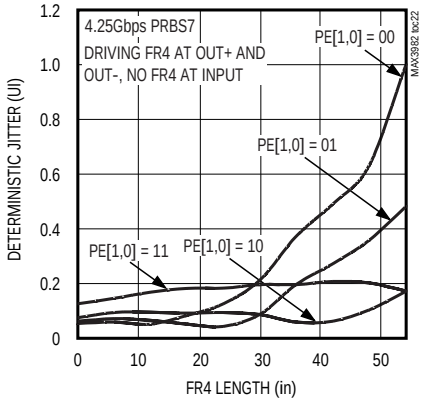
30in FR4 OUTPUT WITHOUT MAX3982, 4.25Gbps CJTPAT



30in FR4 OUTPUT WITH MAX3982 PREEMPHASIS, 4.25Gbps CJTPAT



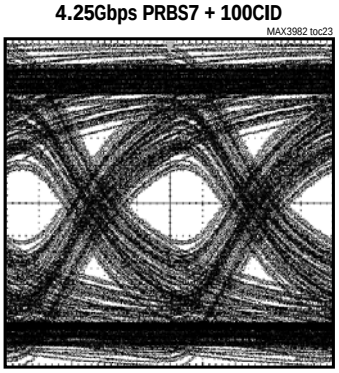
DETERMINISTIC JITTER vs. FR4 LENGTH



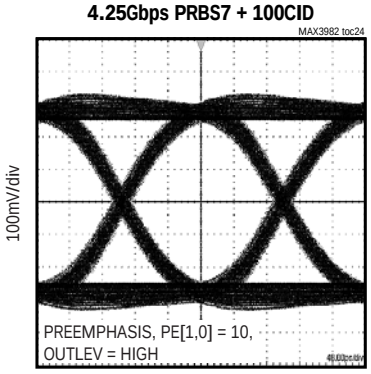
Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted. PRBS7 + 100CID pattern is PRBS 2^7, 100 zeros, 1010, PRBS 2^7, 100 ones, 0101.)

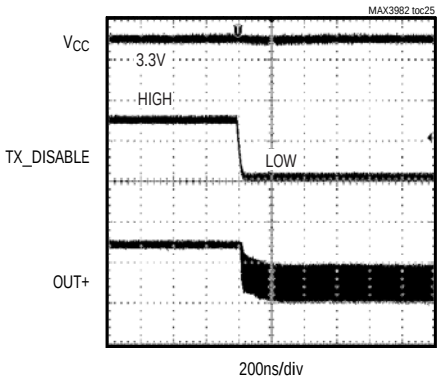
30in FR4 OUTPUT WITHOUT MAX3982 4.25Gbps PRBS7 + 100CID



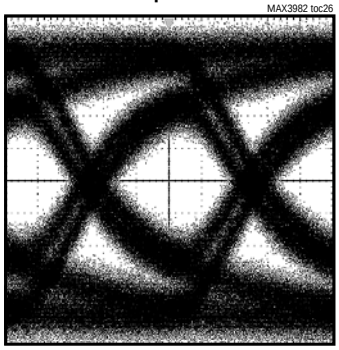
30in FR4 OUTPUT WITH MAX3982 PREEMPHASIS, 4.25Gbps PRBS7 + 100CID



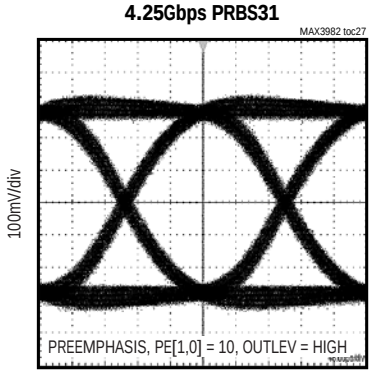
TRANSMITTER ENABLE



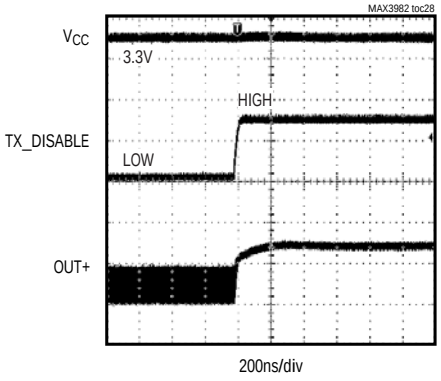
30in FR4 OUTPUT WITHOUT MAX3982, 4.25Gbps PRBS31



30in FR4 OUTPUT WITH MAX3982 PREEMPHASIS, 4.25Gbps PRBS31



TRANSMITTER DISABLE

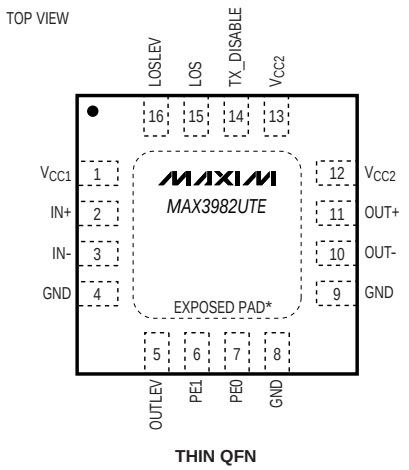


SFP Copper-Cable Preemphasis Driver

Pin Description

PIN	NAME	FUNCTION
1	V_{CC1}	Power-Supply Connection for Input. Connect to +3.3V.
2	IN+	Positive Data Input, CML. This input is internally terminated with 50Ω to V_{CC1}.
3	IN-	Negative Data Input, CML. This input is internally terminated with 50Ω to V_{CC1}.
4, 8, 9	GND	Circuit Ground
5	OUTLEV	Output-Swing Control Input, LVTTL with 40kΩ Internal Pullup. Set to TTL high or open for maximum output swing, or set to TTL low for reduced swing.
6	PE1	Output Preemphasis Control Input, LVTTL with 10kΩ Internal Pullup. This pin is the most significant bit of the 2-bit preemphasis control. Set high or open to assert this bit.
7	PE0	Output Preemphasis Control Input, LVTTL with 10kΩ Internal Pullup. This pin is the least significant bit of the 2-bit preemphasis control. Set high or open to assert this bit.
10	OUT-	Negative Data Output, CML. This output is terminated with 50Ω to V_{CC2}.
11	OUT+	Positive Data Output, CML. This output is terminated with 50Ω to V_{CC2}.
12, 13	V_{CC2}	Power-Supply Connection for Output. Connect to +3.3V.
14	TX_DISABLE	Transmitter Disable Input, LVTTL with 10kΩ Internal Pullup. When high or open, differential output is 40mV_{P-P}. Set low for normal operation.
15	LOS	Loss-of-Signal Detect, TTL Output. This output is open-collector TTL, and therefore requires an external 4.7kΩ to 10kΩ pullup resistor (5.5V maximum). This output sinks current when the input signal level is valid.
16	LOSLEV	LOS Sensitivity Control Input, LVTTL with 40kΩ Internal Pullup. Set to TTL high or open for less sensitivity (higher assert threshold). Set to TTL low for more sensitivity (lower assert threshold).
EP	EXPOSED PAD	Exposed Pad. For optimal thermal conductivity, this pad must be soldered to the circuit board ground.

Pin Configuration



THIN QFN

*THE EXPOSED PAD OF THE QFN PACKAGE MUST BE SOLDERED TO GROUND FOR PROPER THERMAL OPERATION OF THE MAX3982.

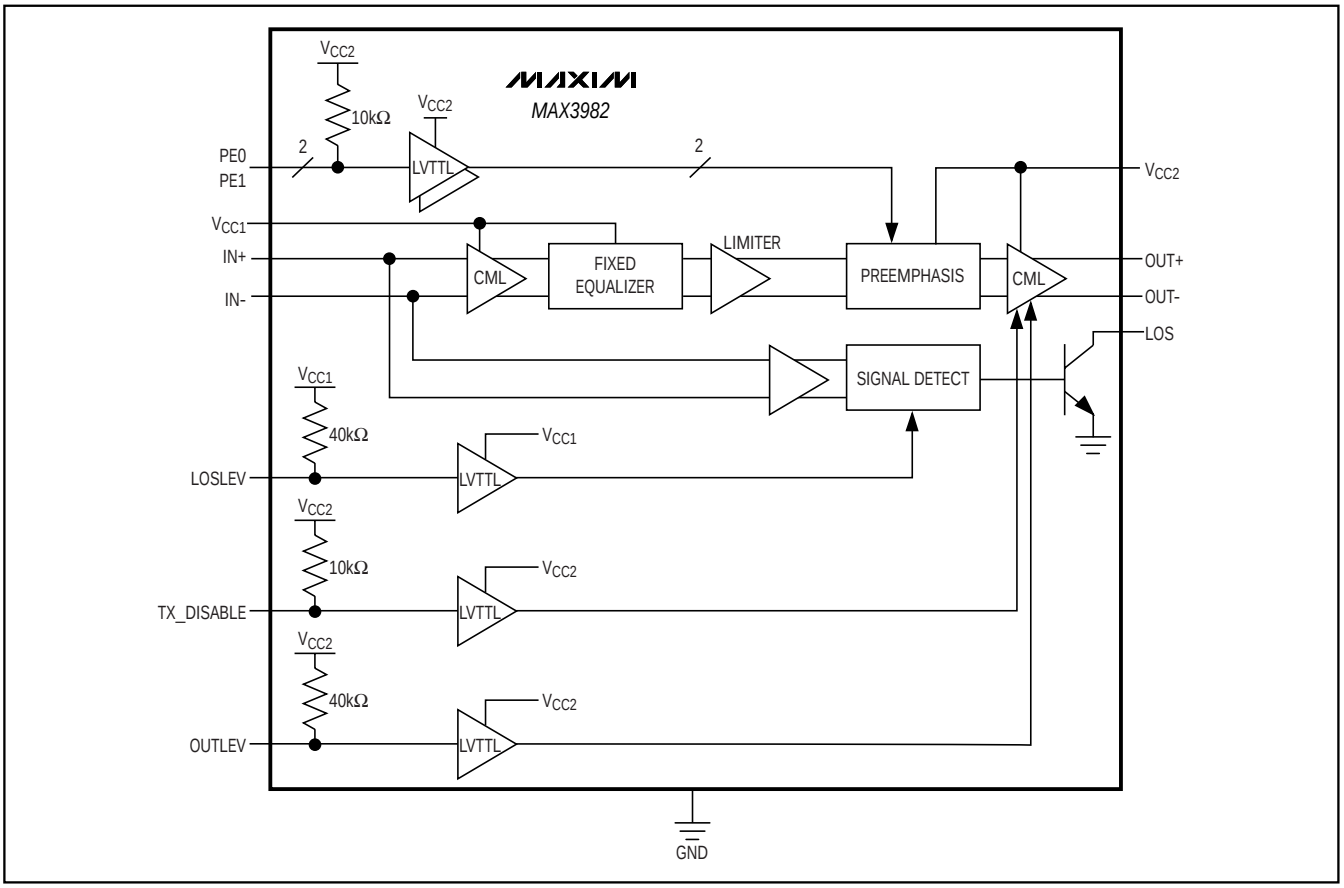


Figure 4. Functional Diagram

Detailed Description

The MAX3982 comprises a PC board receiver, a cable driver, and a loss-of-signal detector with adjustable threshold (Figure 4). Equalization is provided in the receiver. Selectable preemphasis and selectable output amplitude are included in the transmitter. The MAX3982 also includes transmit disable control for the output.

PC Board Receiver and Cable Driver

Data is fed into the MAX3982 through a CML input stage and fixed equalization stage. The fixed equalizer in the receiver corrects for up to 10in of PC board loss on FR4 material at 4.25Gbps.

The cable driver includes four-state preemphasis to compensate for up to 15m of 24AWG, 100Ω balanced cable. Table 1 is provided for easy translation between preemphasis expressions. The OUTLEV pin selects the output amplitude. When OUTLEV is low, the amplitude is 1200mV$_{P-P}$. When OUTLEV is high, the amplitude is 1600mV$_{P-P}$. Residual jitter of the MAX3982 is independent of up to 0.20UI$_{P-P}$ source jitter.

Loss-of-Signal (LOS) Output

Loss-of-signal detection is provided on the data input. Pullup resistors should be connected from LOS to a supply in the range of +3.0V to +5.5V. The LOS output is not valid until power-up is complete. Typical LOS response time is 100ns.

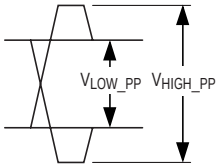
The LOS assert and deassert levels are set by the LOSLEV pin. When LOSLEV is LVTTL high or open, the LOS assert threshold is 180mV$_{P-P}$. When LOSLEV is LVTTL low, the LOS assert threshold is 85mV$_{P-P}$.

TX Disable

Transmit disable is provided to turn off the output when desired. The TX_DISABLE pin can be connected to LOS to automatically squelch the output when the incoming signal is below the threshold set by LOSLEV (see the *Autodetect* section).

Table 1. Preemphasis Translation

Ratio	α	10Gbase–CX4	IN dB	
$\frac{V_{HIGH\_PP}}{V_{LOW\_PP}}$	$\frac{V_{HIGH\_PP} - V_{LOW\_PP}}{V_{HIGH\_PP} + V_{LOW\_PP}}$	$1 - \frac{V_{LOW\_PP}}{V_{HIGH\_PP}}$	$20\left[\log\left(\frac{V_{HIGH\_PP}}{V_{LOW\_PP}}\right)\right]$	
1.26	0.11	0.21	2	
1.58	0.23	0.37	4	
2.51	0.43	0.6	8	
5.01	0.67	0.8	14	



Applications Information

Autodetect

The MAX3982 can automatically detect an incoming signal and enable the data outputs. Autodetect can be accomplished by connecting the LOS pin to TX_DISABLE. TX_DISABLE has a 10kΩ internal pullup resistor. If a loss-of-signal is detected, the TX_DISABLE pin is forced high and disables the outputs. Leaving the inputs to the MAX3982 open (i.e., floating) is not recommended as noise amplification may occur and create undesirable output signals. Autodetect is recommended to eliminate noise amplification or possible oscillation. For periods much greater than 100ns without data transitions, autodetect disables the output.

Layout Considerations

Circuit board layout and design can significantly affect the performance of the MAX3982. Use good high-frequency design techniques, including minimizing ground inductance and using controlled-impedance transmission lines on the data signals. Power-supply decoupling should also be placed as close to the V_{CC} pins as possible. This should be sufficient supply filtering. Always connect all V_{CC} pins to a power plane. Take care to isolate the input from the output signals to reduce feedthrough.

Exposed Pad Package

The exposed-pad, 16-pin QFN package incorporates features that provide a very low thermal resistance path for heat removal from the IC. The exposed pad on the MAX3982 must be soldered to the circuit board for proper thermal performance. For more information on exposed-pad packages, refer to Maxim Application Note HFAN-08.1: *Thermal Considerations of QFN and Other Exposed-Paddle Packages*.

Interface Schematics

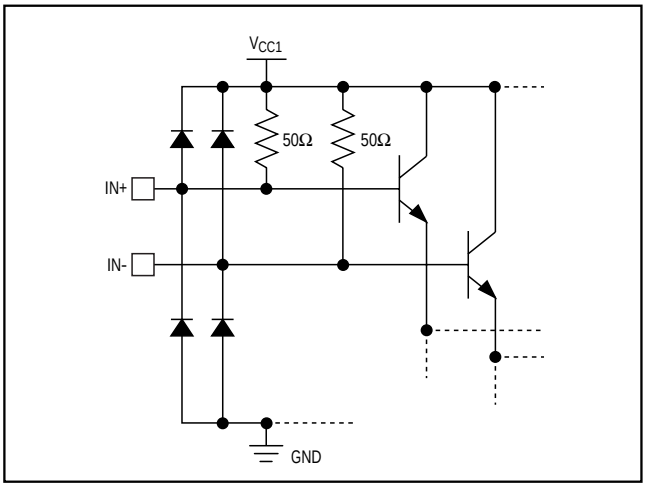


Figure 5. IN+/IN- Equivalent Input Structure

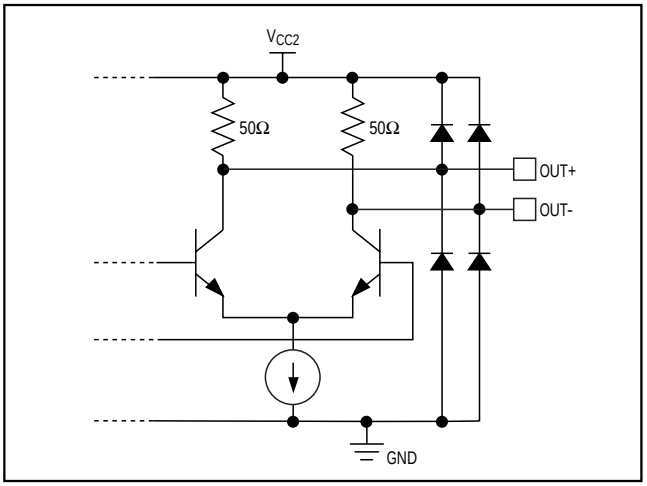
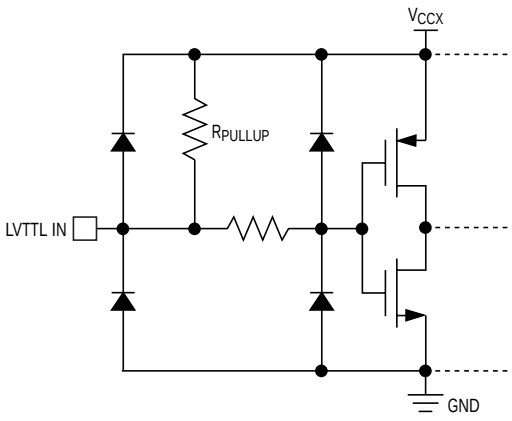


Figure 6. OUT+/OUT- Equivalent Output Structure



PIN NAME	V_{CCX}	R_{PULLUP} (kΩ)
LOSLEV	V_{CC1}	40
OUTLEV	V_{CC2}	40
TX_DISABLE, PE0, PE1	V_{CC2}	10

Figure 7. LVTTL Equivalent Input Structure

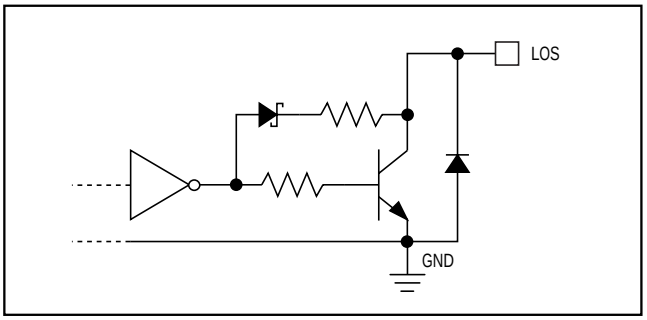


Figure 8. Loss-of-Signal Equivalent Output Structure

Chip Information

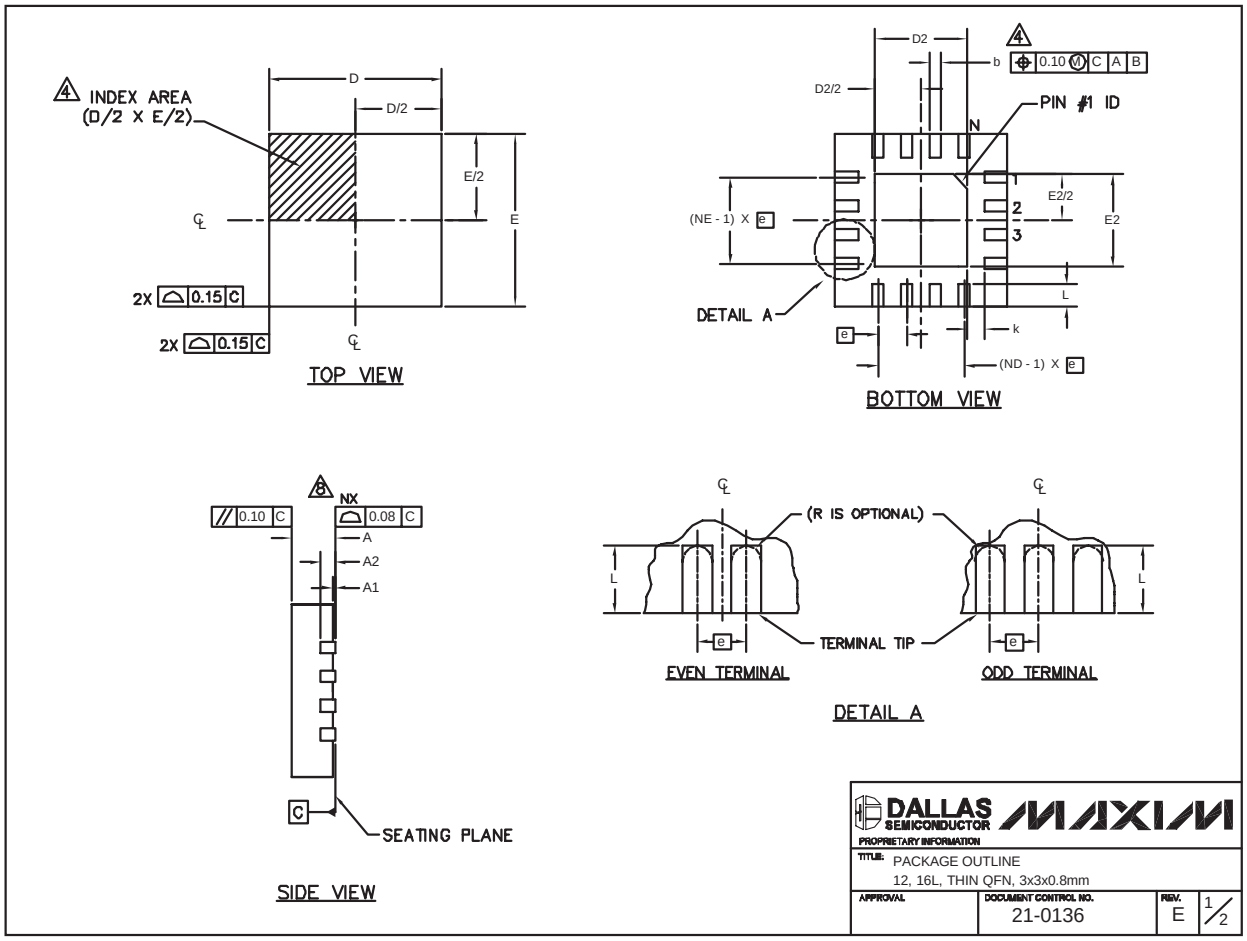
TRANSISTOR COUNT: 2957

PROCESS: SiGe Bipolar

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

12x16L QFN THIN.EPS



Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

PKG	12L 3x3			16L 3x3		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80
b	0.20	0.25	0.30	0.20	0.25	0.30
D	2.90	3.00	3.10	2.90	3.00	3.10
E	2.90	3.00	3.10	2.90	3.00	3.10
e	0.50 BSC.			0.50 BSC.		
L	0.45	0.55	0.65	0.30	0.40	0.50
N	12			16		
ND	3			4		
NE	3			4		
A1	0	0.02	0.05	0	0.02	0.05
A2	0.20 REF			0.20 REF		
k	0.25	-	-	0.25	-	-

EXPOSED PAD VARIATIONS

PKG. CODES	D2			E2			PIN ID	JEDEC	DOWN BONDS ALLOWED
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.			
T1233-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	NO
T1233-3	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	YES
T1633-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO
T1633-2	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	YES
T1633F-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2	N/A
T1633-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.20 mm AND 0.25 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220 REVISION C.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE
12, 16L, THIN QFN, 3x3x0.8mm

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0136	E	2/2