



+2.97V to +5.5V, 125Mbps to 200Mbps Limiting Amplifier with Loss-of-Signal Detector

MAX3645

General Description

The MAX3645 limiting amplifier functions as a data quantizer and is pin compatible with the Mindspeed MC2045-2 and MC2045-2Y postamplifiers. The amplifier accepts a wide range of input voltages and provides constant-level positive emitter-coupled logic (PECL) output voltages with controlled edge speeds.

The MAX3645 features an integrated power detector with complementary PECL loss-of-signal (LOS) outputs that indicate when the input power level drops below a programmable threshold. An optional squelch function holds the data outputs at static levels during a LOS condition.

The MAX3645 operates from a single +3.3V or +5.0V power supply over a -40°C to +85°C temperature range. It is available in 16-pin SO and 16-pin QSOP packages.

Applications

- SONET 155Mbps Transceivers
- Fast Ethernet Receivers
- FDDI 125Mbps Receivers
- FTTx Receivers
- ESCON Receivers

Features

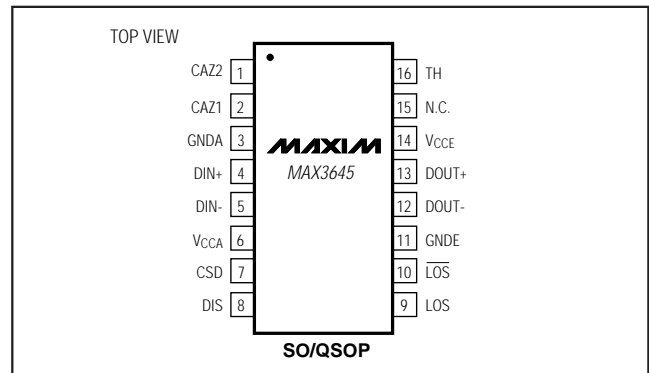
- ◆ Pin Compatible with the Mindspeed MC2045-2/MC2045-2Y
- ◆ 500µV Input Sensitivity (BER = 10⁻¹²)
- ◆ Compatible with 4B/5B Data Coding
- ◆ Programmable LOS Threshold
- ◆ Stable LOS Threshold Over Supply Range
- ◆ Output Disable Function and Automatic Squelch
- ◆ Single +3.3V or +5.0V Power Supply
- ◆ 18mA Supply Current

Ordering Information

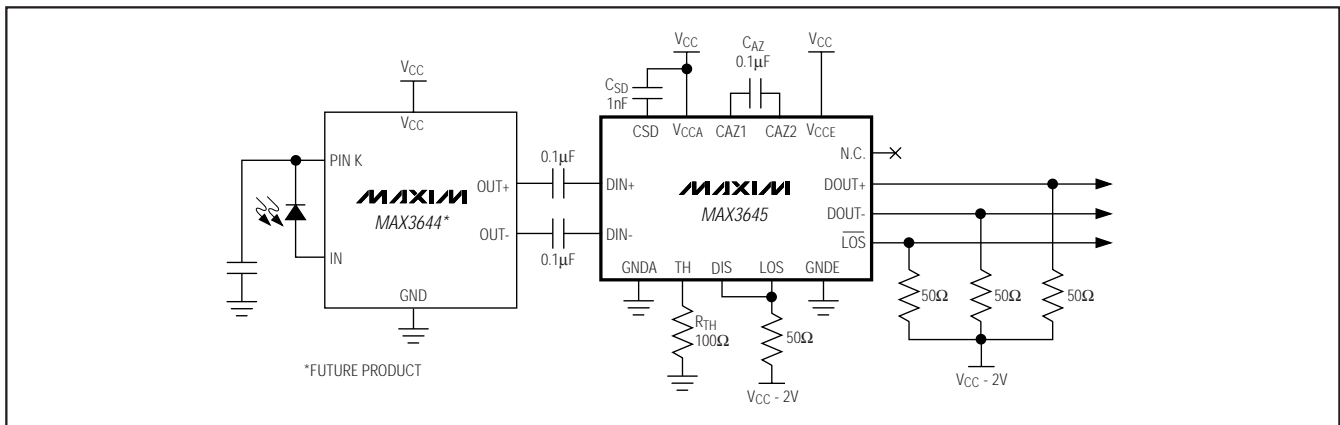
PART	TEMP RANGE	PIN-PACKAGE
MAX3645ESE	-40°C to +85°C	16 SO
MAX3645EEE	-40°C to +85°C	16 QSOP
MAX3645EEE+	-40°C to +85°C	16 QSOP

+ Denotes lead-free package.

Pin Configuration



Typical Application Circuit



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ABSOLUTE MAXIMUM RATINGS

Power-Supply Voltage (V_{CCA} , V_{CCE})-0.5V to +7.0V
 Voltage at CAZ1, CAZ2, DIN+,
 DIN-, CSD, DIS, TH-0.5V to (V_{CC} + 0.5V)
 PECL Output Current (DOUT+, DOUT-, LOS, LOS)50mA
 Differential Voltage between CAZ1 and CAZ2-1.5V to +1.5V
 Differential Voltage between DIN+ and DIN--1.5V to +1.5V

Continuous Power Dissipation ($T_A = +85^\circ\text{C}$)
 16-Pin SO (derate 8.7mW/ $^\circ\text{C}$ above $+85^\circ\text{C}$)565mW
 16-Pin QSOP (derate 8.3mW/ $^\circ\text{C}$ above $+85^\circ\text{C}$)540mW
 Storage Ambient Temperature Range (T_S)-65 $^\circ\text{C}$ to +160 $^\circ\text{C}$
 Lead Temperature (soldering, 10s)+300 $^\circ\text{C}$

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

($V_{CC} = +2.97\text{V}$ to $+5.5\text{V}$, PECL outputs are terminated with 50Ω to $V_{CC} - 2\text{V}$, $R_{TH} = 100\Omega$, $C_{AZ} = 0.1\mu\text{F}$, $C_{SD} = 1\text{nF}$, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$. Typical values are at $V_{CC} = +3.3\text{V}$, $T_A = +25^\circ\text{C}$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Supply Current	I_{CC}	Excludes PECL termination currents		18	27	mA
INPUT SPECIFICATIONS						
Input Resistance	R_{IN}	Single ended; $V_{IN} = \pm 200\text{mV}$	3.3	4.8	6.4	k Ω
Input Sensitivity (Note 1)	V_{IN-MIN}	Single ended			0.5	mV _{P-P}
		Differential			1.0	
Input Overload (Note 1)	V_{IN-MAX}	Single ended	750			mV _{P-P}
		Differential	1500			
Input-Referred Offset Voltage		Unterminated input, output offset divided by DC gain (Note 2)		2	40	μV
Input Common-Mode Voltage	V_{CMM}			$V_{CC} - 0.87$		V
Input-Referred RMS Noise	$V_{IN-NOISE}$	(Notes 2, 3)		36	50	μV_{RMS}
DIS Input High	V_{IH}	PECL or CMOS logic	$V_{CC} - 1160$		V_{CC}	mV
DIS Input Low	V_{IL}	PECL or CMOS logic	0		$V_{CC} - 1480$	mV
DIS Input Current	I_{IL} , I_{IH}	$0\text{V} \leq V_{DIS} \leq V_{CC}$	-10		+10	μA
OUTPUT SPECIFICATIONS						
PECL Output-Voltage High		(Notes 1, 2)	$V_{CC} - 1085$		$V_{CC} - 880$	mV
PECL Output-Voltage Low		(Notes 1, 2)	$V_{CC} - 1830$		$V_{CC} - 1555$	mV
Data Output Transition Time	t_R , t_F	20% to 80% (Notes 1, 2, 4)		0.7	1.4	ns
Pulse-Width Distortion	PWD	(Notes 1, 2, 4, 5)		30	200	ps

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = +2.97V$ to $+5.5V$, PECL outputs are terminated with 50Ω to $V_{CC} - 2V$, $R_{TH} = 100\Omega$, $C_{AZ} = 0.1\mu F$, $C_{SD} = 1nF$, $T_A = -40^\circ C$ to $+85^\circ C$. Typical values are at $V_{CC} = +3.3V$, $T_A = +25^\circ C$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
TRANSFER CHARACTERISTICS						
Bandwidth		Gain = 60dB	150	250		MHz
Low-Frequency Cutoff		$C_{AZ} = \text{open}$		500		kHz
		$C_{AZ} = 0.1\mu F$		0.5		
LOSS-OF-SIGNAL SPECIFICATIONS (Notes 2, 4, 6)						
LOS Sensitivity Range		$0\Omega \leq R_{TH} \leq 2k\Omega$	2		20	mV _{p,p}
LOS Hysteresis		$10\log(V_{DEASSERT}/V_{ASSERT})$	1.4	2		dB
LOS Assert/Deassert Time		(Note 7)	2.3		80.0	μs
LOS Assert Level		$R_{TH} = 0\Omega$, low setting	0.5	0.9	1.3	mV _{p,p}
		$R_{TH} = 1k\Omega$, medium setting	4.8	6.6	8.3	
		$R_{TH} = 2k\Omega$, high setting	12	17	22	
LOS Deassert Level		$R_{TH} = 0\Omega$, low setting	1.1	1.5	1.9	mV _{p,p}
		$R_{TH} = 1k\Omega$, medium setting	8.0	10.8	13.5	
		$R_{TH} = 2k\Omega$, high setting	20	28	36	
Signal-Detect Filter Resistance	R_{SD}	Pin 7	14	20	26	k Ω

Note 1: Between sensitivity and overload, the output amplitude is >95% of the fully limited amplitude and all AC specifications are met.

Note 2: Guaranteed by design and characterization.

Note 3: Noise is derived from BER measurement.

Note 4: The data input transition time is controlled by a 4th-order Bessel filter with $f_{-3dB} = 0.75 \times$ data rate.

Note 5: $PWD = [(width\ of\ wider\ pulse) - (width\ of\ narrower\ pulse)] / 2$, measured with 155Mbps 0011 pattern.

Note 6: All LOS specifications are measured using a 155Mbps $2^{23} - 1$ PRBS pattern.

Note 7: The signal at the input is switched between two amplitudes, SIGNAL_ON and SIGNAL_OFF, as shown in Figure 1.

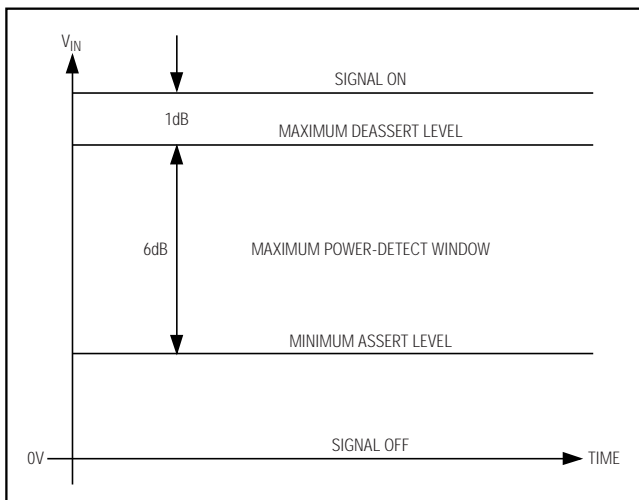


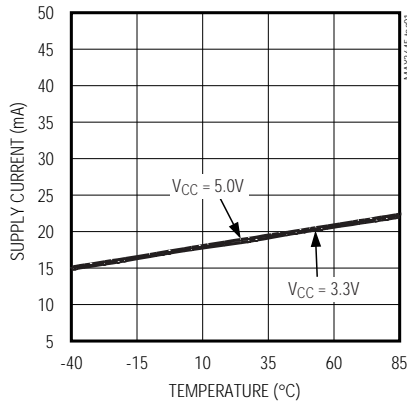
Figure 1. Signal Levels for LOS Assert/Deassert Time Measurement

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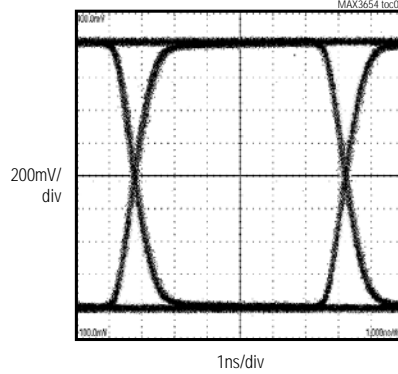
Typical Operating Characteristics

($V_{CC} = 3.3V$, PECL outputs terminated with 50Ω to $V_{CC} - 2V$, $R_{TH} = 100\Omega$, $C_{AZ} = 0.1\mu F$, $C_{SD} = 1nF$, $T_A = +25^\circ C$, unless otherwise noted.)

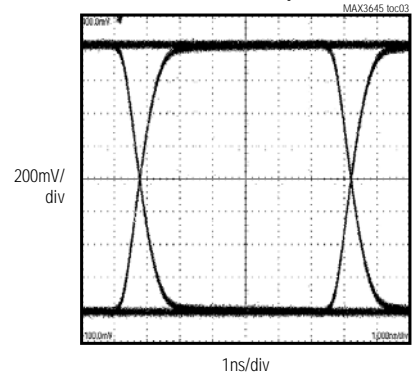
**SUPPLY CURRENT vs. TEMPERATURE
(EXCLUDES PECL OUTPUT CURRENTS)**



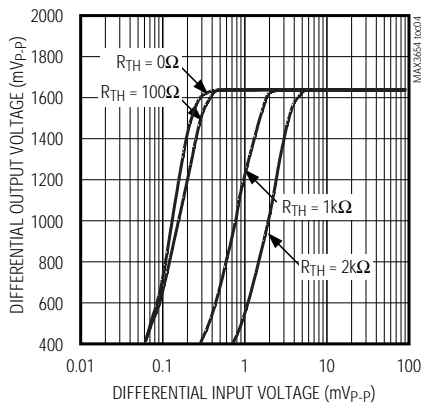
**OUTPUT EYE DIAGRAM
($V_{IN} = 1mV_{p-p}$, 155Mbps, $2^{23} - 1PRBS$)**



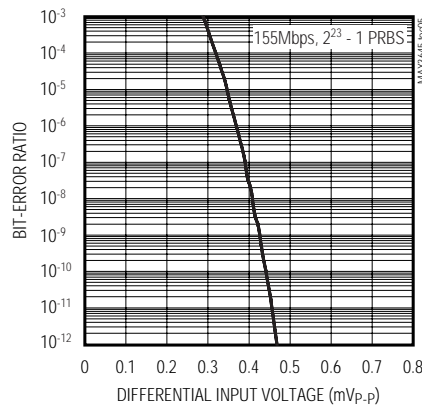
**OUTPUT EYE DIAGRAM
($V_{IN} = 1500mV_{p-p}$, 155Mbps, $2^{23} - 1PRBS$)**



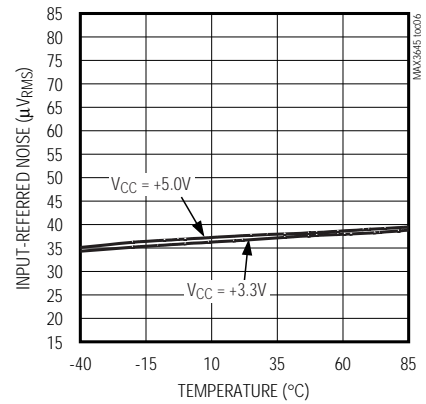
TRANSFER FUNCTION



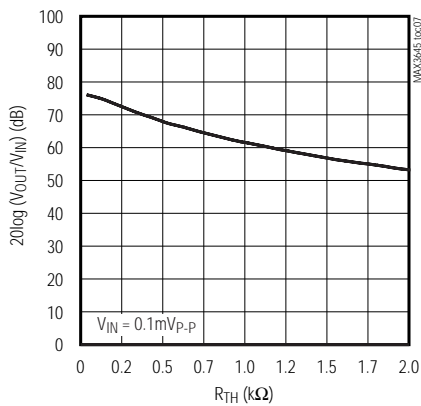
**BIT-ERROR RATIO vs.
DIFFERENTIAL INPUT VOLTAGE**



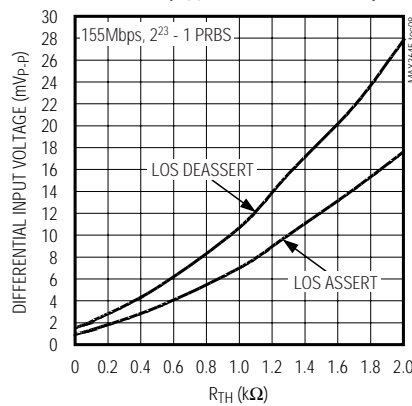
**INPUT-REFERRED RMS NOISE
vs. TEMPERATURE**



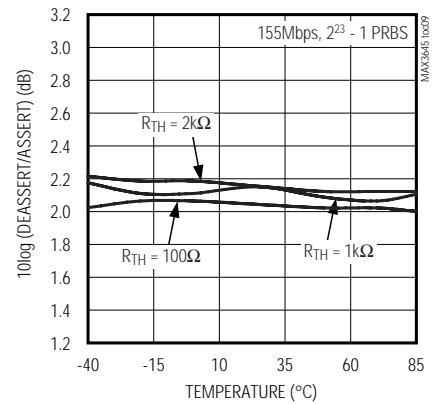
SMALL-SIGNAL GAIN vs. R_{TH}



**LOSS-OF-SIGNAL THRESHOLD
vs. R_{TH} ($V_{CC} = +3.3V$ AND $+5.0V$)**



**LOSS-OF-SIGNAL HYSTERESIS
vs. TEMPERATURE**

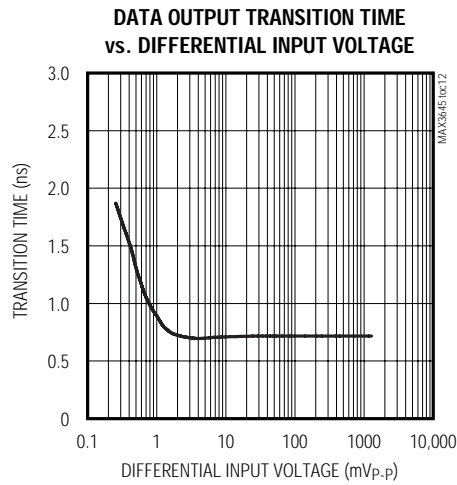
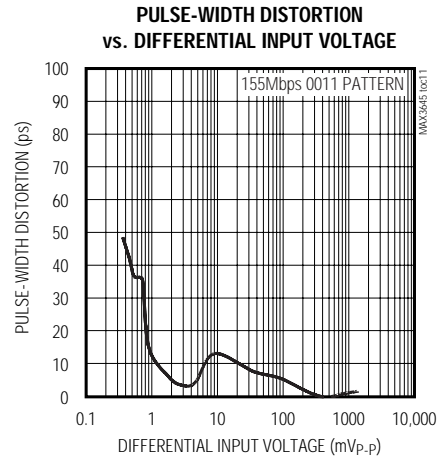
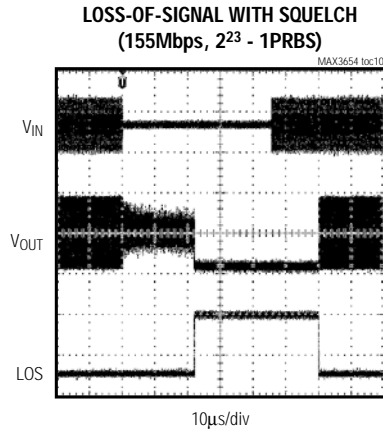


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Typical Operating Characteristics (continued)

($V_{CC} = 3.3V$, PECL outputs terminated with 50Ω to $V_{CC} - 2V$, $R_{TH} = 100\Omega$, $C_{AZ} = 0.1\mu F$, $C_{SD} = 1nF$, $T_A = +25^\circ C$, unless otherwise noted.)



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Pin Description

PIN	MINDSPEED MC2045-2 MC2045-2Y PIN NAME	MAXIM MAX3645 PIN NAME	FUNCTION
1	CAZ-	CAZ2	Offset-Correction-Loop Capacitor Connection. A capacitor connected between this pin and CAZ1 sets the time constant of the offset correction loop. The offset correction is disabled when the CAZ1 and CAZ2 pins are shorted together.
2	CAZ+	CAZ1	Offset-Correction-Loop Capacitor Connection. A capacitor connected between this pin and CAZ2 sets the time constant of the offset correction loop. The offset correction is disabled when the CAZ2 and CAZ1 pins are shorted together.
3	GNDA	GNDA	Analog Supply Ground. Must be at the same potential as the GNDE pin.
4	D _{IN}	DIN+	Positive Data Input
5	\overline{D}_{IN}	DIN-	Negative Data Input
6	V _{CCA}	V _{CCA}	+2.97V to +5.5V Analog Supply Voltage. Must be at same potential as the V _{CCE} pin.
7	C _F	CSD	Signal-Detect-Filter Capacitor Connection. Connect the C _{SD} capacitor between CSD and V _{CCA} .
8	JAM	DIS	Disable Input, PECL or CMOS Compatible. Data outputs are held to a static logic 0 when DIS is asserted high. The LOS function remains active when the outputs are disabled. When connected to the LOS pin, an automatic squelch function is enabled.
9	\overline{ST}	LOS	Positive Loss-of-Signal Output, PECL. LOS is high when the level of the input signal drops below the threshold set by the TH input. LOS is low when the signal level is above the threshold. LOS can be connected directly to DIS for automatic squelch.
10	ST	\overline{LOS}	Negative Loss-of-Signal Output, PECL. \overline{LOS} is low when the level of the input signal drops below the threshold set by the TH input. \overline{LOS} is high when the signal level is above the threshold.
11	GNDE	GNDE	Digital Supply Ground. Must be at the same potential as the GNDA pin.
12	\overline{D}_{OUT}	DOUT-	Negative Data Output, PECL. A high at DIS forces DOUT- high.
13	DOUT	DOUT+	Positive Data Output, PECL. A high at DIS forces DOUT+ low.
14	V _{CCE}	V _{CCE}	+2.97V to +5.5V Digital Supply Voltage. Must be at the same potential as the V _{CCA} pin.
15	NC	N.C.	No Connection
16	V _{SET}	TH	Loss-of-Signal Threshold Pin. Resistor (R _{TH}) to ground sets the LOS threshold. This pin cannot be left open.

Detailed Description

The MAX3645 consists of gain stages, offset correction, power detector, LOS indicators, and PECL output buffers. See Figure 2 for the functional diagram.

Data Input

The data inputs have a single-ended input resistance of 4.8k Ω and are internally DC-biased to V_{CC} - 0.87V (see Figure 3). External capacitors are required to AC-couple the data signals. Pattern-dependent jitter is minimized by using coupling capacitor values large enough to pass the lowest frequencies of interest (consecutive ones and zeros) with the given input resistance.

Typically, 0.1 μ F coupling capacitors yield a -3dB frequency of 354Hz. Capacitor tolerance and input resis-

tance variation (3.3k Ω to 6.4k Ω) must be considered to accurately calculate the -3dB frequency. Capacitor values should be chosen that set the -3dB frequency at least a factor of 10 below the lowest frequency of interest. A capacitor value of 0.1 μ F is recommended.

Gain Stage and Offset Correction

The limiting amplifier provides approximately 74dB (R_{TH} = 100 Ω) of gain. This large gain makes the amplifier susceptible to small DC offsets in the signal path. To correct DC offsets, the amplifier has an internal feedback loop that acts as a DC autozero circuit. By correcting the DC offsets, the limiting amplifier improves receiver sensitivity and power-detector accuracy.

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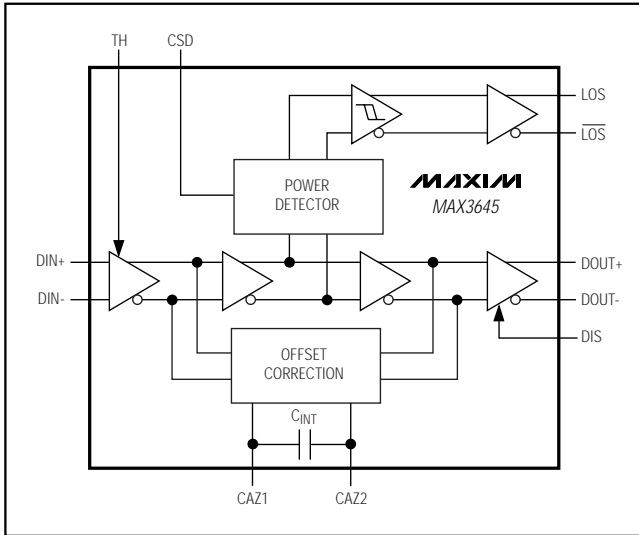


Figure 2. Functional Diagram

The external autozero capacitor (C_{AZ}), in parallel with internal capacitance (C_{INT}), determines the time constant of the DC offset correction loop. With $C_{AZ} = 0.1\mu\text{F}$ (recommended), the -3dB frequency cutoff of the signal path is typically 0.5kHz.

Power Detector and LOS Indicators

The external resistor R_{TH} sets the gain of the first limiting stage. This gain setting controls the threshold at which the power detector indicates an LOS condition. Power detection is accomplished by rectifying and low-pass filtering the data signal, then comparing it to the programmed threshold voltage. A hysteresis of 2dB prevents the LOS output from chattering when the input signal is near the threshold.

PECL Output Buffer

The data outputs (DOUT+, DOUT-) and the loss-of-signal outputs (LOS+, LOS-) are PECL outputs. The equivalent PECL output circuit is shown in Figure 4.

Applications Information

Programming LOS Assert/Deassert Levels

The appropriate value of R_{TH} is determined by using the Loss-Of-Signal Threshold vs. R_{TH} graph in the *Typical Operating Characteristics*.

LOS Time Constant

The lowpass filter of the power detector comprises a $20\text{k}\Omega$ on-chip resistor (R_{SD}) and an external capacitor (C_{SD}). The C_{SD} capacitor value determines the power-

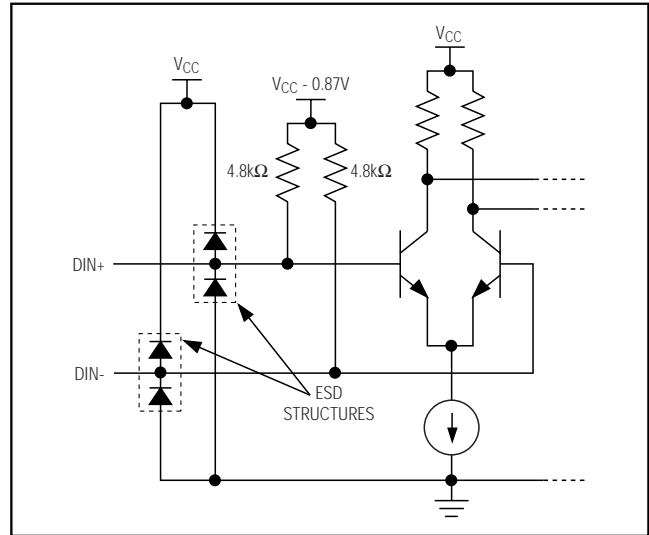


Figure 3. Equivalent Data Input Circuit

detector time constant, which determines the LOS assert/deassert time. With $C_{SD} = 1\text{nF}$ the assert/deassert time is in the range of $2.3\mu\text{s}$ to $80\mu\text{s}$. This provides a long enough time constant to avoid false triggering due to variations in mark density.

Disable Function

When the DIS input is forced high, the disable function is enabled, which holds DOUT+ low and DOUT- high. The disable function is used to prevent the data outputs from toggling due to noise when no signal is present. The LOS output can be connected to the DIS input for automatic squelch.

PECL Output Terminations

The proper termination for a PECL output is 50Ω to $(V_{CC} - 2\text{V})$, but other standard termination techniques can be used. For more information on PECL terminations and how to interface with other logic families, refer to Maxim Application Note *HFAN-01.0: Introduction to LVDS, PECL, and CML*.

Layout Considerations

For best performance, use good high-frequency layout techniques. Filter power supplies, keep ground connections short, and use multiple vias where possible. Power-supply decoupling should be placed close to the VCC pins. Minimize the distance from the preamplifier and use controlled-impedance transmission lines to interface with the outputs when possible.

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Chip Information

TRANSISTOR COUNT: 1026

PROCESS: Silicon bipolar

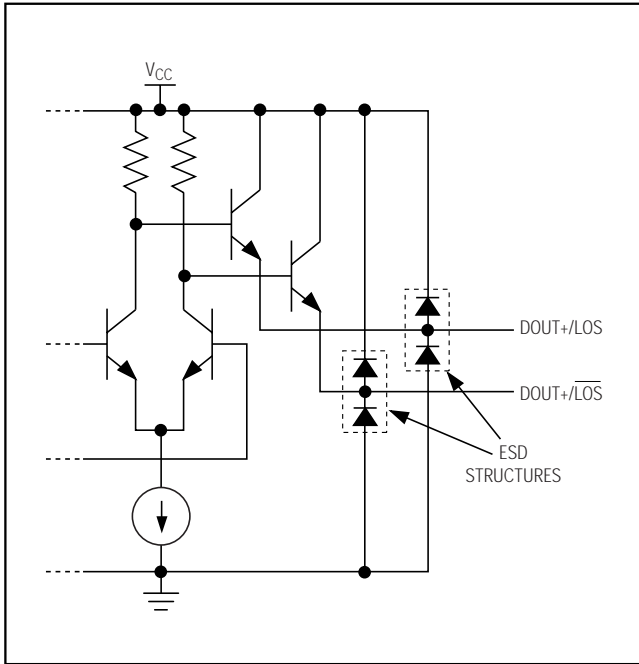


Figure 4. Equivalent PECL Output Circuit

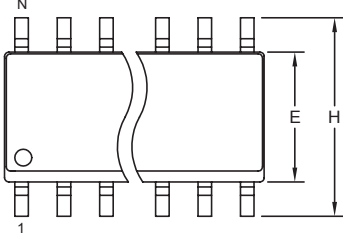
+2.97V to +5.5V, 125Mbps to 200Mbps Limiting Amplifier with Loss-of-Signal Detector

Package Information

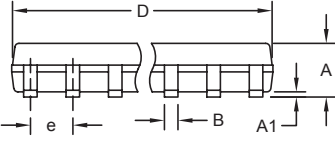
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)

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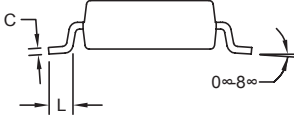
SOICN EPS



TOP VIEW



FRONT VIEW



SIDE VIEW



NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

VARIATIONS:

DIM	INCHES		MILLIMETERS		N	MS012
	MIN	MAX	MIN	MAX		
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, .150" SOIC

APPROVAL	DOCUMENT CONTROL NO. 21-0041	REV. B	1/1
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