

### **General Description**

The MAX9377/MAX9378 are fully differential, highspeed, low-jitter anything-to-LVPECL and anything-to-LVDS translators, respectively, with a selectable divide-by-four function. Low propagation delay and high speed make them ideal for various high-speed network routing and backplane applications at speeds up to 2GHz in nondivide mode.

The MAX9377/MAX9378 accept any differential input signal within the supply rails and with minimum amplitude of 100mV. Inputs are fully compatible with the LVDS, LVPECL, HSTL, and CML differential signaling standards. The MAX9377 outputs are LVPECL and have sufficient current to drive  $50\Omega$  transmission lines. The MAX9378 outputs are LVDS and conform to the ANSI EIA/TIA-644 LVDS standard.

The MAX9377/MAX9378 are available in 8-pin µMAX packages and operate from a single +3.3V supply over the -40°C to +85°C temperature range.

### **Applications**

Backplane Logic Standard Translation

LAN

WAN

**DSLAM** 

DLC

#### **Features**

- ♦ Guaranteed 2GHz Switching Frequency
- ♦ Accept LVDS/LVPECL/Anything Inputs
- ♦ Pin-Selectable Divide-by-Four Function
- ♦ 421ps (typ) Propagation Delays (MAX9377)
- ♦ 30ps (max) Pulse Skew
- ♦ 2ps<sub>RMS</sub> (max) Random Jitter
- ♦ Minimum 100mV Differential Input to Guarantee **AC Specifications**
- **♦ Temperature-Compensated LVPECL Output**
- ♦ +3.0V to +3.6V Power-Supply Operating Range
- ♦ ESD Protection: >2kV Human Body Model (HBM)

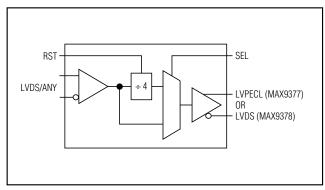
### **Ordering Information**

PART	TEMP RANGE	PIN-PACKAGE
MAX9377EUA	-40°C to +85°C	8 µMAX
MAX9378EUA	-40°C to +85°C	8 µMAX

## **Pin Configuration**

### TOP VIFW 8 V<sub>CC</sub> SEL OUT IN 2 OUT 5 RST GND 4 MAX9377 MAX9378

## **Functional Diagram**



#### **ABSOLUTE MAXIMUM RATINGS**

V <sub>CC</sub> to GND0.3V to +4.1V
Inputs (IN, ĪN, RST, SEL)0.3V to (V <sub>CC</sub> + 0.3V)
IN to IN±3.0V
Short-Circuit Duration (MAX9378 OUT, OUT)Continuous
Continuous Output Current50mA
Surge Output Current100mA
Continuous Power Dissipation ( $T_A = +70^{\circ}C$ )
8-µMAX (derate 5.9mW/°C above +70°C)470.6mW
θ, JA in Still Air+170°C/W

Junction Temperature	+150°C
Storage Temperature Range	65°C to +150°C
ESD Protection	
Human Body Model (IN, IN, OUT, OUT)	≥2kV
Soldering Temperature (10s)	+300°C
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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.

#### DC ELECTRICAL CHARACTERISTICS

 $(V_{CC}=+3.0V\ to\ +3.6V,\ differential\ input\ voltage\ |V_{ID}|=0.1V\ to\ 3.0V,\ input\ voltage\ (V_{IN},\ V_{\overline{IN}})=0\ to\ V_{CC},\ input\ common-mode\ voltage\ V_{CM}=0.05V\ to\ (V_{CC}-0.05V),\ LVPECL\ outputs\ terminated\ with\ 50\Omega\ \pm1\%\ to\ (V_{CC}-2.0V),\ LVDS\ outputs\ terminated\ with\ 100\Omega\ \pm1\%,\ T_A=-40^{\circ}C\ to\ +85^{\circ}C.$  Typical values are at  $V_{CC}=+3.3V,\ |V_{ID}|=0.2V,\ input\ common-mode\ voltage\ V_{CM}=1.2V,\ T_A=+25^{\circ}C,\ unless\ otherwise\ noted.)$  (Notes 1, 2, 3)

PARAMETER	SYMBOL	CONDITIONS		-40°C		+25°C			+85°C			UNITS
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
LVCMOS/LVTTL IN	PUTS (RS	T, SEL)										
Input High Voltage	VIH		2.0		Vcc	2.0		Vcc	2.0		V <sub>C</sub> C	٧
Input Low Voltage	VIL		GND		0.8	GND		0.8	GND		0.8	V
Input High Current	liH	V <sub>IN</sub> = V <sub>CC</sub> or 2V	0		150	0		150	0		150	μΑ
Input Low Current	IլL	V <sub>IL</sub> = 0 or 0.8V	-20		+20	-20		+20	-20		+20	μΑ
DIFFERENTIAL IN	PUTS (IN, Ī	N)										
Differential Input Threshold	V <sub>THD</sub>		-100	±6	+100	-100	±6	+100	-100	±6	+100	mV
Input Current	I <sub>IN</sub> , I <sub>IN</sub>	$V_{IN}$ , $V_{\overline{IN}} = V_{CC}$ or $0V$	-20		+20	-20		+20	-20		+20	μΑ
Input Common- Mode Voltage	V <sub>CM</sub>	Figure 1	0.05		V <sub>CC</sub> - 0.05	0.05		V <sub>CC</sub> - 0.05	0.05		V <sub>CC</sub> - 0.05	V
LVPECL OUTPUTS	OUT, OU	T) (MAX9377)										
Single-Ended Output High Voltage	Vон	Figure 3	V <sub>CC</sub> - 1.085	V <sub>CC</sub> - 1.033	V <sub>CC</sub> - 0.880		V <sub>CC</sub> - 0.992	V <sub>CC</sub> - 0.880	V <sub>CC</sub> - 1.025	V <sub>CC</sub> - 0.978	V <sub>C</sub> C - 0.880	V
Single-Ended Output Low Voltage	V <sub>OL</sub>	Figure 3	V <sub>CC</sub> - 1.830	V <sub>CC</sub> - 1.755	V <sub>CC</sub> - 1.620	V <sub>CC</sub> - 1.810	V <sub>CC</sub> - 1.717	V <sub>CC</sub> - 1.620	V <sub>CC</sub> - 1.810	V <sub>CC</sub> - 1.699	V <sub>CC</sub> - 1.620	V
Differential Output Voltage	V <sub>OH</sub> - V <sub>OL</sub>	Figure 3	595	725		595	725		595	725		mV
LVDS OUTPUTS (	$OUT, \overline{OUT}$	(MAX9378)										
Differential Output Voltage	V <sub>OD</sub>	Figure 2	250	370	450	250	363	450	250	348	450	mV

## **DC ELECTRICAL CHARACTERISTICS (continued)**

 $(V_{CC}=+3.0V\ to\ +3.6V,\ differential\ input\ voltage\ |V_{ID}|=0.1V\ to\ 3.0V,\ input\ voltage\ (V_{IN},\ V_{\overline{IN}})=0\ to\ V_{CC},\ input\ common-mode\ voltage\ V_{CM}=0.05V\ to\ (V_{CC}-0.05V),\ LVPECL\ outputs\ terminated\ with\ 50\Omega\ \pm1\%\ to\ (V_{CC}-2.0V),\ LVDS\ outputs\ terminated\ with\ 100\Omega\ \pm1\%,\ T_A=-40^{\circ}C\ to\ +85^{\circ}C.$  Typical values are at  $V_{CC}=+3.3V,\ |V_{ID}|=0.2V,\ input\ common-mode\ voltage\ V_{CM}=1.2V,\ T_A=+25^{\circ}C,\ unless\ otherwise\ noted.)$  (Notes 1, 2, 3)

PARAMETER SYMBO		CONDITIONS	-40°C			+25°C			+85°C			UNITS
PARAMETER	SYMBOL	CONDITIONS MIN TYP MAX		MIN TYP MAX			MIN	MIN TYP MAX		UNITS		
Change in Magnitude of V <sub>OD</sub> Between Complementary Output States	\Delta VOD	Figure 2		1.0	20		1.0	20		1.0	20	mV
Offset Common- Mode Voltage	vos	Figure 2	1.125		1.375	1.125	1.250	1.375	1.125		1.375	V
Change in Magnitude of VOS Between Complementary Output States	<sub>\Delta VOS</sub>	Figure 2		0.1	20		0.1	20		0.1	20	mV
Output Short- Circuit Current, Either Output Shorted to GND	Ios	V <sub>ID</sub> = ±100mV, one output GND, other output open or shorted to GND		19.0	24		19.0	24		19.0	24	mA
Output Short- Circuit Current, Outputs Shorted Together	I <sub>OSAB</sub>	V <sub>ID</sub> = ±100mV, V <sub>OUT</sub> = V <sub>OUT</sub>		4.0	12		4.0	12		4.0	12	mA
POWER SUPPLY												
	las	MAX9377, all pins open except V <sub>CC</sub> , GND		13	22		15	22		17	22	m A
Supply Current	Icc	MAX9378, R <sub>L</sub> = 100, quiescent, inputs are open		18.0	30		20	30		22	30	mA

#### **AC ELECTRICAL CHARACTERISTICS**

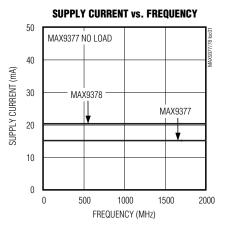
 $(V_{CC}=+3.0V\text{ to }+3.6V,\text{ differential input voltage }|V_{ID}|=0.1V\text{ to }1.2V,\text{ input frequency} \leq 1.34\text{GHz},\text{ differential input transition time}=125ps (20% to 80%), input voltage <math>(V_{IN},V_{\overline{IN}})=0$  to  $V_{CC}$ , input common-mode voltage  $V_{CM}=0.05V$  to  $(V_{CC}-0.05V)$ , LVPECL outputs terminated with  $50\Omega$  ±1% to  $(V_{CC}-2.0V)$  MAX9377, LVDS outputs terminated with  $R_L=100\Omega$  ±1% (MAX9378),  $V_{A}=-40$ °C to  $V_{A}=-40$ °C. Typical values are at  $V_{CC}=+3.3V$ ,  $V_{A}=-40$ °C, input common-mode voltage  $V_{CM}=1.2V$ ,  $V_{A}=+25$ °C, unless otherwise noted.) (Note 4)

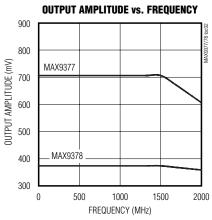
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Reset-to-Differential Output Low Delay	tDR	Figure 4		0.8	1.0	ns
Reset-to-Input Clock Setup Time	tset	Figure 4	0.5			ns
Clock-to-Divider Output Propagation Delay	tPCO	Figure 4 (Note 5)		0.6	1.0	ns
SEL to Switched Output Delay	tsel	Figure 5		0.3	0.6	ns
MAX9377						-
Switching Frequency	f <sub>MAX</sub>	V <sub>OH</sub> - V <sub>OL</sub> ≥ 250mV	2.0	2.5		GHz
Propagation Delay Low to High	tpLH	Figure 3, SEL = 0	250	421	600	ps
Propagation Delay High to Low	tphL	Figure 3, SEL = 0	250	421	600	ps
Pulse Skew ItpLH -tpHLI	tskew	(Note 6)		6	30	ps
Output Low-to-High Transition Time (20% to 80%)	t <sub>R</sub>	Figure 3		116	220	ps
Output High-to-Low Transition Time (20% to 80%)	tF	Figure 3		116	220	ps
Added Random Jitter	t <sub>RJ</sub>	f <sub>IN</sub> = 1.34GHz (Note 7), SEL = 0		0.7	2	ps <sub>(RMS)</sub>
MAX9378			•			
Switching Frequency	f <sub>MAX</sub>	V <sub>OD</sub> ≥ 250mV	2.0	2.5		GHz
Propagation Delay Low to High	tplH	Figure 3, SEL = 0	250	363	600	ps
Propagation Delay High to Low	tphL	Figure 3, SEL = 0	250	367	600	ps
Pulse Skew ItpLH - tpHLI	tskew	Figure 3 (Note 6)		3	30	ps
Output Low-to-High Transition Time (20% to 80%)	t <sub>R</sub>	Figure 2		93	220	ps
Output High-to-Low Transition Time (20% to 80%)	tF	Figure 2		93	220	ps
Added Random Jitter	t <sub>RJ</sub>	f <sub>IN</sub> = 1.34GHz (Note 7), SEL = 0		0.8	2	ps(RMS)

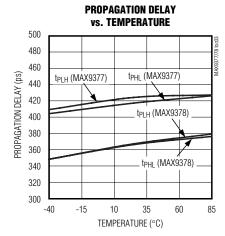
- Note 1: Measurements are made with the device in thermal equilibrium. All voltages are referenced to ground except V<sub>THD</sub>, V<sub>ID</sub>, V<sub>OD</sub>, and ΔV<sub>OD</sub>.
- Note 2: Current into a pin is defined as positive. Current out of a pin is defined as negative.
- Note 3: DC parameters production tested at T<sub>A</sub> = +25°C and guaranteed by design and characterization over the full operating temperature range.
- Note 4: Guaranteed by design and characterization, not production tested. Limits are set at ±6 sigma.
- Note 5: tpco is the delay associated with the frequency-divider function. The total delay when divide-by-four is selected is tpco + tpi H.
- Note 6: tskew is the magnitude difference of differential propagation delays for the same output under same conditions; tskew = ltpHL tpLHl.
- Note 7: Device jitter added to the input signal.

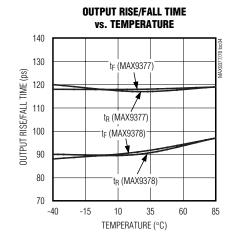
## Typical Operating Characteristics

 $(V_{CC} = +3.3V, \text{ differential input voltage } |V_{ID}| = 0.2V, V_{CM} = 1.2V, \text{ input frequency} = 500MHz, outputs terminated with 50$\Omega$ ±1% to V_{CC} - 2.0V (MAX9377), outputs terminated with 100$\Omega$ ±1% (MAX9378), T_A = +25°C, unless otherwise noted.)$ 









### **Pin Description**

PIN	NAME		FUNCTION						
1	SEL	Frequency Divi GND.	Frequency Divider Select Input. High = divide by four, low = no division. Internal 75k $\Omega$ pulldown to GND.						
2	IN	Differential LVE	DS/Any Noninverting Input						
3	ĪN	Differential LVE	OS/Any Inverting Input						
4	GND	Ground	Ground						
5	RST	Frequency Div	Frequency Divider Reset Input. Active high, asynchronous, reset. Internal 75kΩ pulldown to GND.						
6	OUT	MAX9377	Differential LVPECL Inverting Output. Terminate with 50 $\Omega$ ±1% to V <sub>CC</sub> - 2V.						
0	001	MAX9378	Inverting LVDS Output. Terminate to OUT with $100\Omega \pm 1\%$ .						
7	OUT	MAX9377	Differential LVPECL Noninverting Output. Terminate with 50 $\Omega$ ±1% to V <sub>CC</sub> - 2V.						
/	001	MAX9378	Noninverting LVDS Output. Terminate to $\overline{\text{OUT}}$ with $100\Omega \pm 1\%$ .						
8	Vcc	' ' '	Positive Supply. Bypass from V <sub>CC</sub> to GND with 0.1µF and 0.01µF ceramic capacitors. Place the capacitors as close to the device as possible with the smaller value capacitor closest to the device						

### **Detailed Description**

The MAX9377/MAX9378 are fully differential, high-speed, low-jitter anything-to-LVPECL and anything-to-LVDS translators, respectively, with a selectable divide-by-four function. Low propagation delay and high speed make them ideal for various high-speed network routing and backplane applications at speeds up to 2GHz in nondivide mode.

The MAX9377/MAX9378 accept any differential input signals within the supply rails and with a minimum amplitude of 100mV. Inputs are fully compatible with the LVDS, LVPECL, HSTL, and CML differential signaling standards. The MAX9377 outputs are LVPECL and have sufficient current to drive  $50\Omega$  transmission lines. The MAX9378 outputs are LVDS and conform to the ANSI EIA/TIA-644 LVDS standard.

#### Inputs

Inputs have a wide common-mode range of 0.05V to (VCC - 0.05V), which accommodates any differential signals within the supply rails, and requires a minimum of 100mV to switch the outputs. This allows the MAX9377/MAX9378 inputs to support virtually any differential signaling standard.

#### **RST and SEL Inputs**

The frequency-divide functions are controlled by two LVCMOS/LVTTL inputs, RST and SEL. SEL selects either the divide-by-four function or a no-division function as shown in Table 1. RST, an asynchronous active-high input, resets the divide-by-four within the device and places the circuits into a known state. Setting RST

#### **Table 1. SEL AND RST Truth Table**

RST	SEL	ОИТРИТ
Х	L or open	No frequency division.
Н	Н	Outputs are placed in differential low.
L	Н	Divide-by-four function.

high when powering up the device with SEL high prevents the unknown states with the divider from being propagated to the outputs. If the device is powered up with SEL high but without asserting RST, the outputs are only guaranteed to be 1/4th the input frequency after 2.5 cycles have been applied to the input.

#### **LVPECL Outputs (MAX9377)**

The MAX9377 LVPECL outputs are emitter followers that require external resistive paths to a voltage source ( $V_T = V_{CC} - 2.0V$  typ) more negative than worst-case  $V_{OL}$  for proper static and dynamic operation. When properly terminated, the outputs generate steady-state voltage levels,  $V_{OL}$  or  $V_{OH}$  with fast transition edges between state levels. Output current always flows into the termination during proper operation.

#### **LVDS Outputs (MAX9378)**

The MAX9378 LVDS outputs require a resistive load to terminate the signal and complete the transmission loop. Because the device switches current and not voltage, the actual output voltage swing is determined by the value of the termination resistor. With a 3.5mA typical output current, the MAX9378 produces an output voltage of 350mV when driving a  $100\Omega$  load.

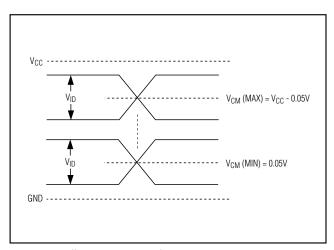


Figure 1. Differential Input Definition

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Figure 2. LVDS Output Load and Transition Times

### **Applications Information**

#### LVPECL Output Termination (MAX9377)

Terminate the MAX9377 LVPECL outputs with  $50\Omega$  to (V<sub>CC</sub> - 2V) or use equivalent Thevenin terminations. Terminate OUT and  $\overline{\text{OUT}}$  with identical termination on each for low output distortion. When a single-ended signal is taken from the differential output, terminate both OUT and  $\overline{\text{OUT}}$ . Ensure that output currents do not exceed the current limits as specified in the *Absolute Maximum Ratings*. Under all operating conditions, the device's total thermal limits should be observed.

#### LVDS Output Termination (MAX9378)

The MAX9378 LVDS outputs are current-steering devices; no output voltage is generated without a termination resistor. The termination resistors should match the differential impedance of the transmission line. Output voltage levels are dependent upon the value of the termination resistor. The MAX9378 is optimized for point-to-point communication with the  $100\Omega$  termination resistor at the receiver inputs. Termination resistance values may range between  $90\Omega$  and  $132\Omega$ , depending on the characteristic impedance of the transmission medium.

#### Supply Bypassing

Bypass V<sub>CC</sub> to ground with high-frequency surface-mount ceramic  $0.1\mu\text{F}$  and  $0.01\mu\text{F}$  capacitors. Place the capacitors as close to the device as possible with the  $0.01\mu\text{F}$  capacitor closest to the device pins.

#### Traces

Circuit board trace layout is very important to maintain the signal integrity of high-speed differential signals.

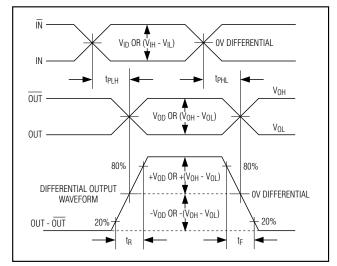


Figure 3. Differential Input-to-Output Propagation Delay Timing Diagram

Maintaining integrity is accomplished in part by reducing signal reflections and skew, and increasing common-mode noise immunity.

Signal reflections are caused by discontinuities in the  $50\Omega$  characteristic impedance of the traces. Avoid discontinuities by maintaining the distance between differential traces, not using sharp corners or using vias. Maintaining distance between the traces also increases common-mode noise immunity. Reducing signal skew is accomplished by matching the electrical length of the differential traces.

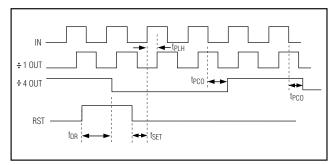


Figure 4. Frequency Divider and Reset Timing Diagram

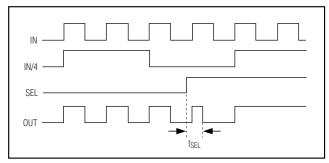


Figure 5. Frequency Select Delay Timing Diagram

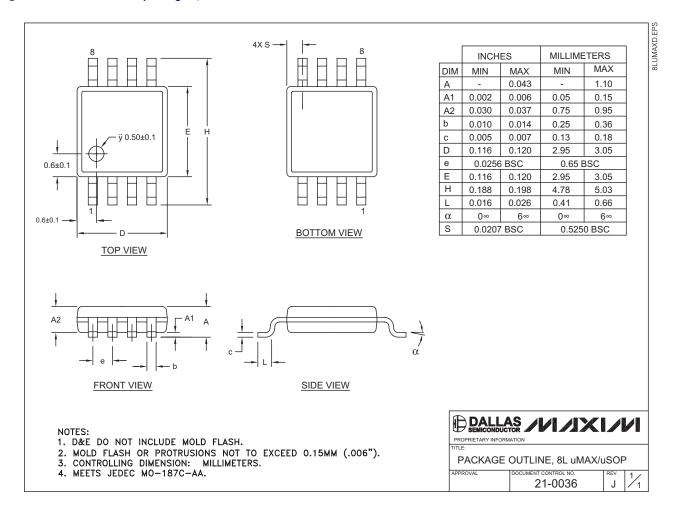
## **Chip Information**

MAX9377 TRANSISTOR COUNT: 614 MAX9378 TRANSISTOR COUNT: 614

PROCESS: 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 <a href="https://www.maxim-ic.com/packages">www.maxim-ic.com/packages</a>.)



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