



+1.2V to +3.6V, 0.1µA, 100Mbps, 8-Channel Level Translators

MAX3013

General Description

The MAX3013 8-channel level translator provides the level shifting necessary to allow 100Mbps data transfer in a multivoltage system. Externally applied voltages, V_{CC} and V_L , set the logic levels on either side of the device. Logic signals present on the V_L side of the device appear as a higher voltage logic signal on the V_{CC} side of the device, and vice-versa.

The MAX3013 features an EN input that, when at logic low, places all inputs/outputs on both sides in tristate and reduces the V_{CC} and V_L supply currents to 0.1µA. This device operates at a guaranteed data rate of 100Mbps for $V_L > 1.8V$.

The MAX3013 accepts a V_{CC} voltage from +1.65V to +3.6V and a V_L voltage from +1.2V to ($V_{CC} - 0.4V$), making it ideal for data transfer between low-voltage ASICs/PLDs and higher voltage systems. The MAX3013 is available in 5 x 4 UCSP™, 20-pin 5mm x 5mm QFN, and 20-pin TSSOP packages.

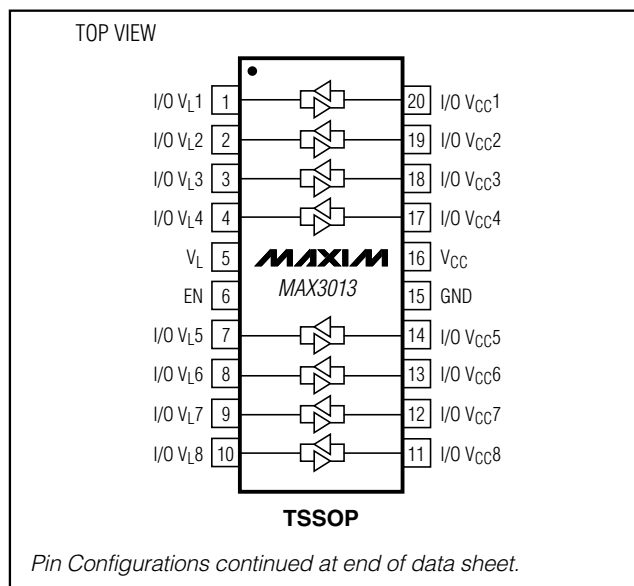
Applications

- Low-Voltage ASIC Level Translation
- Cell Phones
- SPI™, MICROWIRE™ Level Translation
- Portable POS Systems
- Portable Communication Devices
- GPS
- Telecommunications Equipment

Features

- ◆ 100Mbps Guaranteed Data Rate
- ◆ Bidirectional Level Translation
- ◆ V_L Operation Down to +1.2V
- ◆ Ultra-Low 0.1µA Supply Current in Shutdown
- ◆ Low-Quiescent Current (0.1µA)
- ◆ UCSP, QFN, and TSSOP Packages

Pin Configurations



UCSP is a trademark of Maxim Integrated Products, Inc.
SPI is a trademark of Motorola, Inc.
MICROWIRE is a trademark of National Semiconductor Corp.

Typical Operating Circuit appears at end of data sheet.

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	NUMBER OF $V_L \rightarrow V_{CC}$ TRANSLATORS	NUMBER OF $V_L \leftarrow V_{CC}$ TRANSLATORS	DATA RATE (Mbps)
MAX3013EUP	-40°C to +85°C	20 TSSOP	8	8	100
MAX3013EBP-T	-40°C to +85°C	5 x 4 UCSP	8	8	100
MAX3013EGP	-40°C to +85°C	20 QFN-EP*	8	8	100

*EP = Exposed paddle.



+1.2V to +3.6V, 0.1µA, 100Mbps, 8-Channel Level Translators

ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND.)

V _{CC}	-0.3V to +4V
V _L	-0.3V to +4V
I/O V _{CC}	-0.3V to (V _{CC} + 0.3V)
I/O V _L	-0.3V to (V _L + 0.3V)
EN.....	-0.3V to (V _L + 0.3V)
Short-Circuit Duration I/O V _L , I/O V _{CC} to GND.....	Continuous

Continuous Power Dissipation (T_A = +70°C)

20-Pin TSSOP (derate 11mW/°C above +70°C)	879mW
5 x 4 UCSP (derate 10mW/°C above +70°C)	800mW
20-Pin QFN (derate 20.0mW/°C above +70°C)	1.60W
Operating Temperature Range	-40°C to +85°C
Junction Temperature.....	+150°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10s).....	+300°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} = +1.65V to +3.6V, V_L = +1.2V to (V_{CC} - 0.4V) (Note 1), EN = V_L, C_{IOV_L} ≤ 15pF, C_{IOV_{CC}} ≤ 40pF, T_A = T_{MIN} to T_{MAX}. Typical values are at V_{CC} = +3.3V, V_L = +1.8V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLIES						
V _L Supply Range	V _L		1.2		V _{CC} - 0.4	V
V _{CC} Supply Range	V _{CC}		1.65		3.6	V
Supply Current from V _{CC}	I _{QVCC}	I/O V _{CC} ₋ = 0, I/O V _L ₋ = 0 or I/O V _{CC} ₋ = V _{CC} , I/O V _L ₋ = V _L		0.1	1	µA
Supply Current from V _L	I _{QVL}	I/O V _{CC} ₋ = 0, I/O V _L ₋ = 0 or I/O V _{CC} ₋ = V _{CC} , I/O V _L ₋ = V _L		0.1	4	µA
		I/O V _{CC} ₋ = 0, I/O V _L ₋ = 0 or I/O V _{CC} ₋ = V _{CC} , I/O V _L ₋ = V _L , V _L < V _{CC} - 0.2V		0.1	100	
V _{CC} Tristate Output Mode Supply Current	I _{TS-VCC}	T _A = +25°C, EN = 0		0.03	1	µA
V _L Tristate Output Mode Supply Current	I _{TS-VL}	T _A = +25°C, EN = 0		0.1	0.2	µA
		T _A = +25°C, EN = 0, V _L = V _{CC} - 0.2V		1	2	
I/O Tristate Output Mode Leakage Current		T _A = +25°C, EN = 0,			0.15	µA
		T _A = +25°C, EN = 0, V _L = V _{CC} - 0.2V			30	
LOGIC-LEVEL THRESHOLDS						
I/O V _L ₋ Input-Voltage High	V _{IHL}		2/3 x V _L			V
I/O V _L ₋ Input-Voltage Low	V _{ILL}				1/3 x V _L	V
I/O V _{CC} ₋ Input-Voltage High	V _{IHC}		2/3 x V _{CC}			V
I/O V _{CC} ₋ Input-Voltage Low	V _{ILC}				1/3 x V _{CC}	V
EN Input-Voltage High	V _{IH}	T _A = +25°C	2/3 x V _L			V

+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

MAX3013

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +1.65V to +3.6V, V_L = +1.2V to (V_{CC} - 0.4V) (Note 1), EN = V_L, C_{IOVL} ≤ 15pF, C_{IOVCC} ≤ 40pF, T_A = T_{MIN} to T_{MAX}. Typical values are at V_{CC} = +3.3V, V_L = +1.8V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
EN Input-Voltage Low	V _{IL}	T _A = +25°C			1/3 x V _L	V
EN Input Current		T _A = +25°C			±5	μA
I/O V _L _ Output-Voltage High	V _{OHL}	I/O V _L _ source current = 20μA	2/3 x V _L			V
I/O V _L _ Output-Voltage Low	V _{OLL}	I/O V _L _ sink current = 20μA			1/3 x V _L	V
I/O V _{CC} _ Output-Voltage High	V _{OHC}	I/O V _{CC} _ source current = 20μA	2/3 x V _{CC}			V
I/O V _{CC} _ Output-Voltage Low	V _{OLC}	I/O V _{CC} _ sink current = 20μA			1/3 x V _{CC}	V

TIMING CHARACTERISTICS

(V_{CC} = +1.65V to +3.6V, V_L = +1.2V to (V_{CC} - 0.4V) (Note 1), EN = V_L, C_{IOVL} ≤ 15pF, C_{IOVCC} ≤ 40pF, T_A = T_{MIN} to T_{MAX}. Typical values are at V_{CC} = +3.3V, V_L = +1.8V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
I/O V _{CC} _ Rise Time	t _{RVCC}	C _{IOVCC} = 15pF, Figure 1			2.5	ns
		C _{IOVCC} = 20pF, Figure 1			3	
		C _{IOVCC} = 40pF, Figure 1			4	
I/O V _{CC} _ Fall Time	t _{FVCC}	C _{IOVCC} = 15pF, Figure 1			2.5	ns
		C _{IOVCC} = 20pF, Figure 1			3	
		C _{IOVCC} = 40pF, Figure 1			4	
I/O V _{CC} _ One-Shot Output					18.5	Ω
I/O V _L _ Rise Time	t _{RVL}	C _{IOVL} = 15pF, Figure 2			2.5	ns
I/O V _L _ Fall Time	t _{FVL}	C _{IOVL} = 15pF, Figure 2			2.5	ns
I/O V _L _ One-Shot Output Impedance					12.5	Ω
Propagation Delay (Driving I/O V _L)	I/O _{VL-VCC}	C _{IOVCC} = 15pF, Figure 1			6.5	ns

+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

TIMING CHARACTERISTICS (continued)

($V_{CC} = +1.65V$ to $+3.6V$, $V_L = +1.2V$ to $(V_{CC} - 0.4V)$ (Note 1), $EN = V_L$, $C_{IOVL} \leq 15pF$, $C_{IOVCC} \leq 40pF$, $T_A = T_{MIN}$ to T_{MAX} . Typical values are at $V_{CC} = +3.3V$, $V_L = +1.8V$, $T_A = +25^\circ C$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay (Driving I/O $V_{CC_}$)	I/O V_{CC-VL}	$C_{IOVL} = 15pF$, Figure 2			6	ns
Part-to-Part Skew	t $_{PPSKEW}$	$C_{IOVCC} = 15pF$, $C_{IOVL} = 15pF$, $V_{CC} = 2.5V$, $V_L = 1.8V$ (Note 3)			4	ns
Propagation Delay from I/O V_L to I/O $V_{CC_}$ after EN	t $_{EN-VCC}$	$C_{IOVCC} = 15pF$, Figure 3			1000	ns
Propagation Delay from I/O $V_{CC_}$ to I/O V_L after EN	t $_{EN-VL}$	$C_{IOVL} = 15pF$, Figure 4			1000	ns
Maximum Data Rate		$C_{IOVCC} = 15pF$, $C_{IOVL} = 15pF$, $V_L > 1.8V$	100			Mbps
		$C_{IOVCC} = 15pF$, $C_{IOVL} = 15pF$, $V_L > 1.2V$	80			

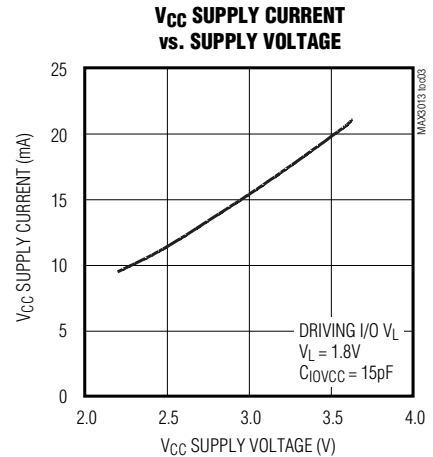
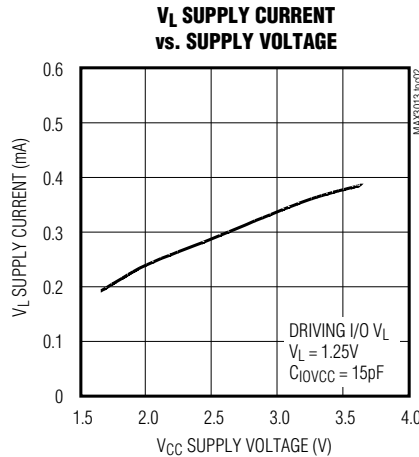
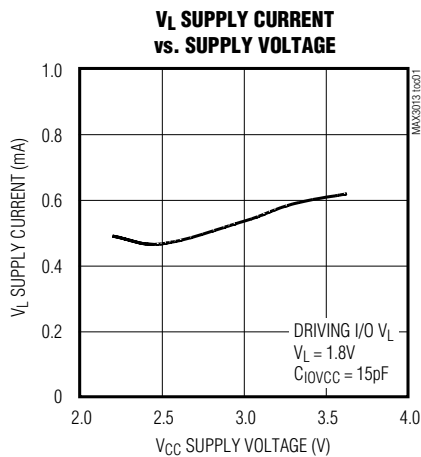
Note 1: V_L must be less than or equal to $V_{CC} - 0.4V$ during normal operation. However, V_L can be greater than $V_{CC} - 0.4V$ during starting up and shutting down conditions.

Note 2: All units are 100% production tested at $T_A = +25^\circ C$. Limits over the operating temperature range are guaranteed by design and not production tested.

Note 3: Not production tested. Guaranteed by design.

Typical Operating Characteristics

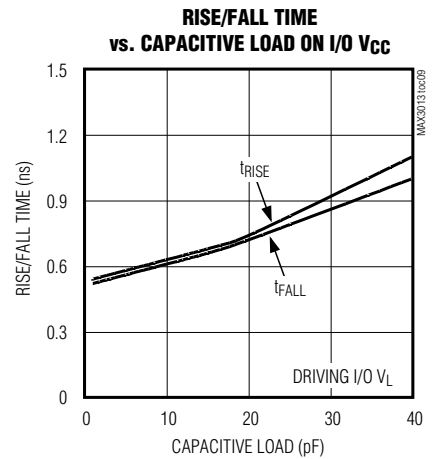
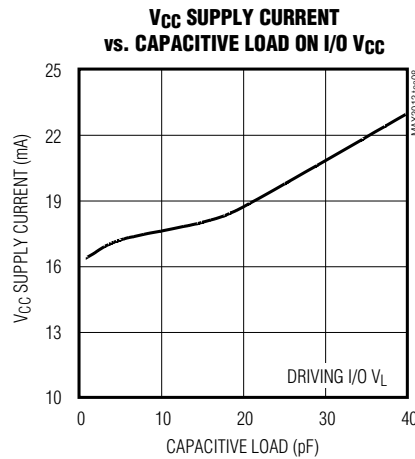
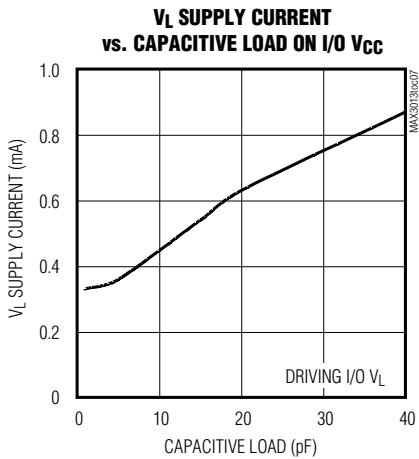
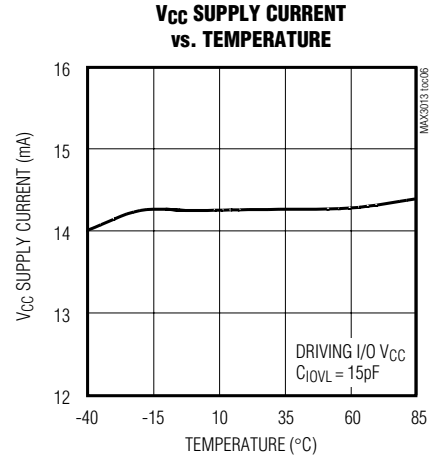
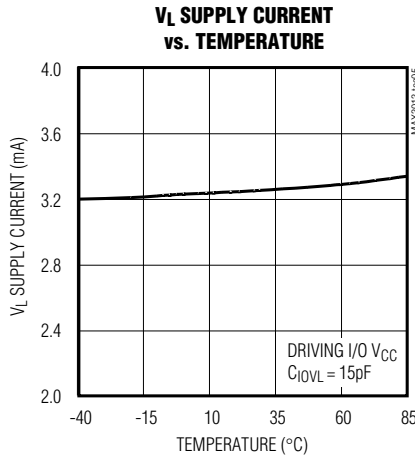
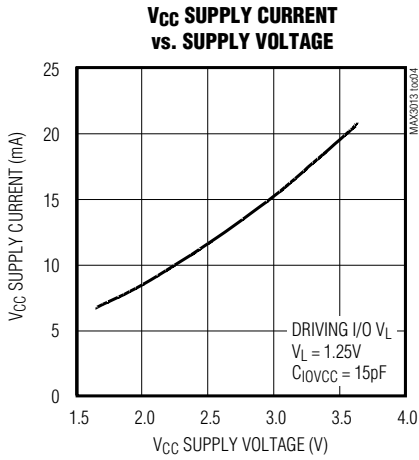
(Data rate = 100Mbps, $V_{CC} = 3.3V$, $V_L = 1.8V$, $T_A = +25^\circ C$, unless otherwise noted.)



+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

Typical Operating Characteristics (continued)

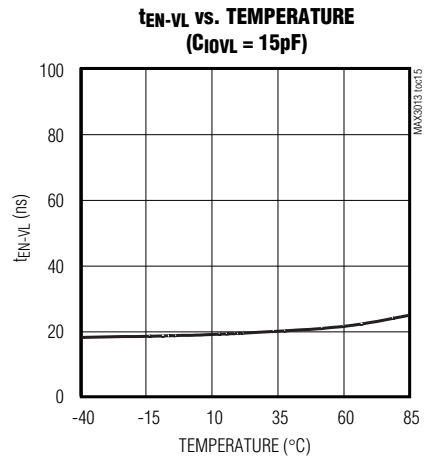
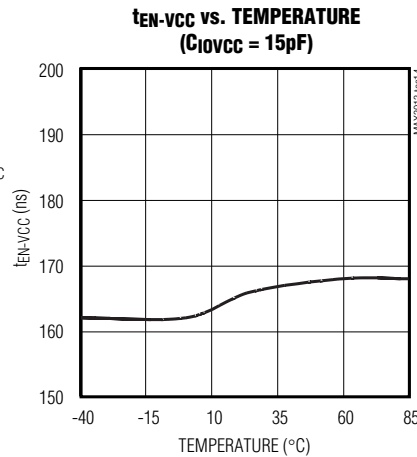
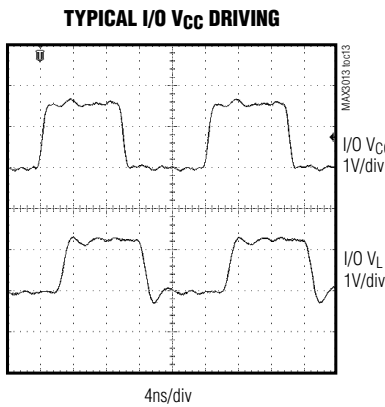
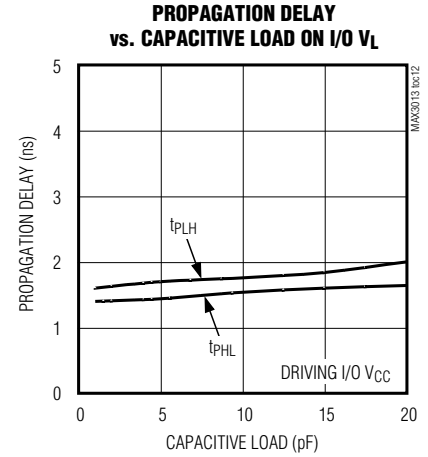
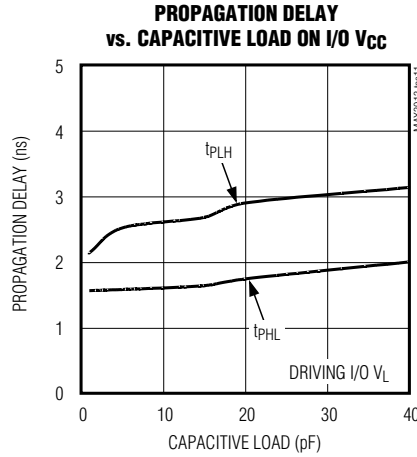
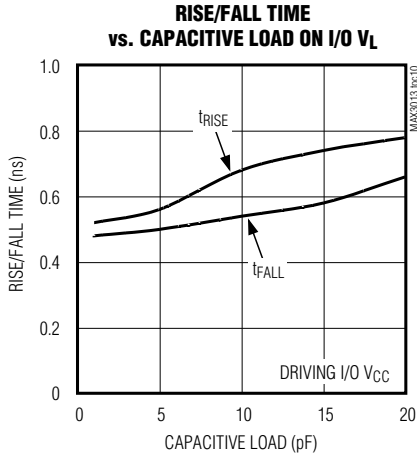
(Data rate = 100Mbps, $V_{CC} = 3.3V$, $V_L = 1.8V$, $T_A = +25^\circ C$, unless otherwise noted.)



+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

Typical Operating Characteristics (continued)

(Data rate = 100Mbps, $V_{CC} = 3.3V$, $V_L = 1.8V$, $T_A = +25^\circ C$, unless otherwise noted.)



+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

Pin Description

MAX3013

PIN		BUMP	NAME	FUNCTION
TSSOP	QFN	UCSP		
1	18	B1	I/O V _L 1	Input/Output 1, Referenced to V _L
2	19	A1	I/O V _L 2	Input/Output 2, Referenced to V _L
3	20	B2	I/O V _L 3	Input/Output 3, Referenced to V _L
4	1	A2	I/O V _L 4	Input/Output 4, Referenced to V _L
5	2	A3	V _L	V _L Input Voltage, +1.2V ≤ V _L ≤ (V _{CC} - 0.4V). Bypass V _L to GND with a 0.1μF capacitor.
6	3	A4	EN	Enable Input. If EN is pulled low, all inputs/outputs are in tristate. Drive EN high (V _L) for normal operation.
7	4	B3	I/O V _L 5	Input/Output 5, Referenced to V _L
8	5	A5	I/O V _L 6	Input/Output 6, Referenced to V _L
9	6	B4	I/O V _L 7	Input/Output 7, Referenced to V _L
10	7	B5	I/O V _L 8	Input/Output 7, Referenced to V _L
11	8	C5	I/O V _{CC} 8	Input/Output 8, Referenced to V _{CC}
12	9	C4	I/O V _{CC} 7	Input/Output 7, Referenced to V _{CC}
13	10	D5	I/O V _{CC} 6	Input/Output 6, Referenced to V _{CC}
14	11	C3	I/O V _{CC} 5	Input/Output 5, Referenced to V _{CC}
15	12	D4	GND	Ground
16	13	D3	V _{CC}	V _{CC} Input Voltage, +1.65V ≤ V _{CC} ≤ +3.6V. Bypass V _{CC} to GND with a 0.1μF capacitor.
17	14	D2	I/O V _{CC} 4	Input/Output 4, Referenced to V _{CC}
18	15	C2	I/O V _{CC} 3	Input/Output 3, Referenced to V _{CC}
19	16	D1	I/O V _{CC} 2	Input/Output 2, Referenced to V _{CC}
20	17	C1	I/O V _{CC} 1	Input/Output 1, Referenced to V _{CC}

**+1.2V to +3.6V, 0.1μA, 100Mbps,
8-Channel Level Translators**

Test Circuits/Timing Diagrams

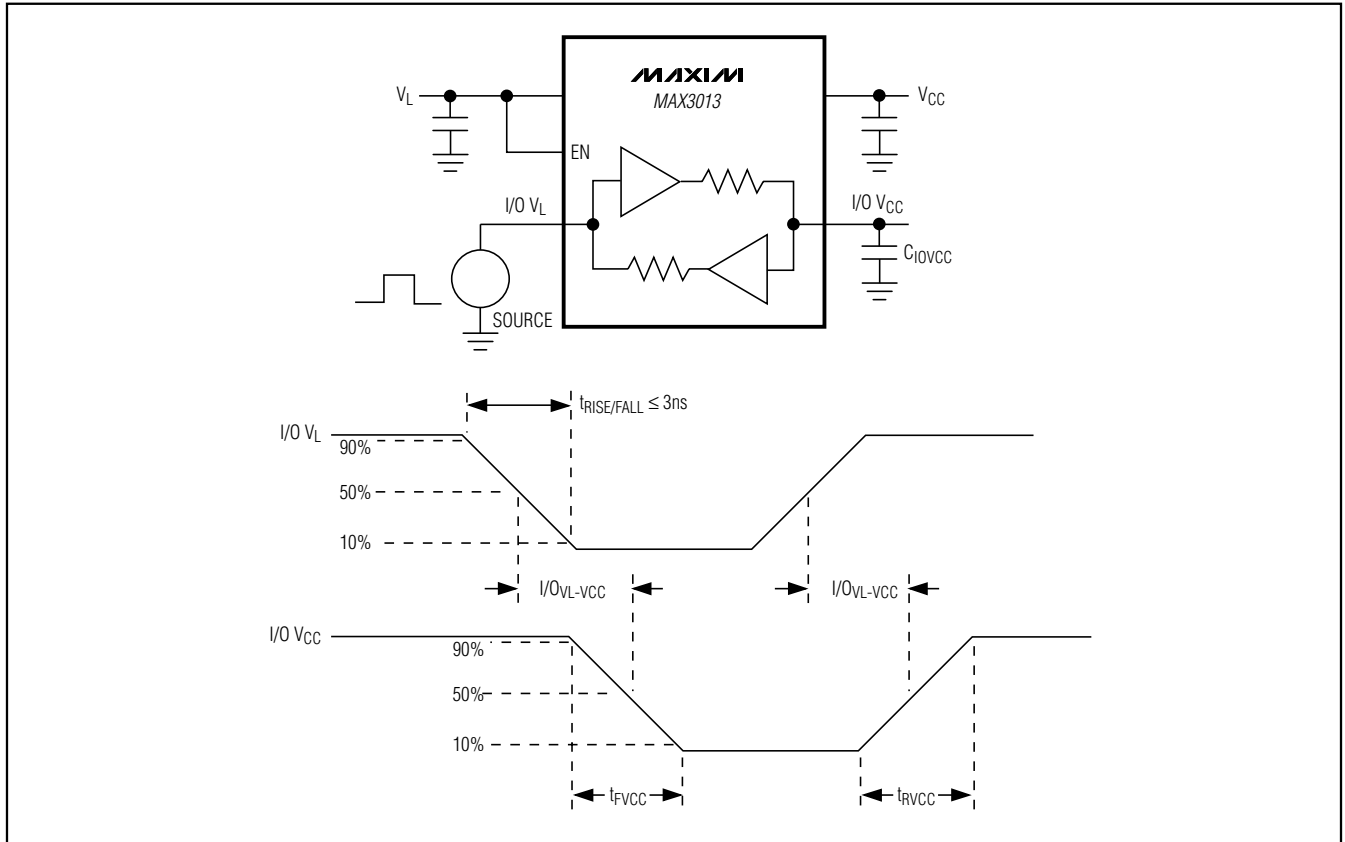


Figure 1. Driving I/O VL Test Circuit and Timing

+1.2V to +3.6V, 0.1 μ A, 100Mbps, 8-Channel Level Translators

Test Circuits/Timing Diagrams (continued)

MAX3013

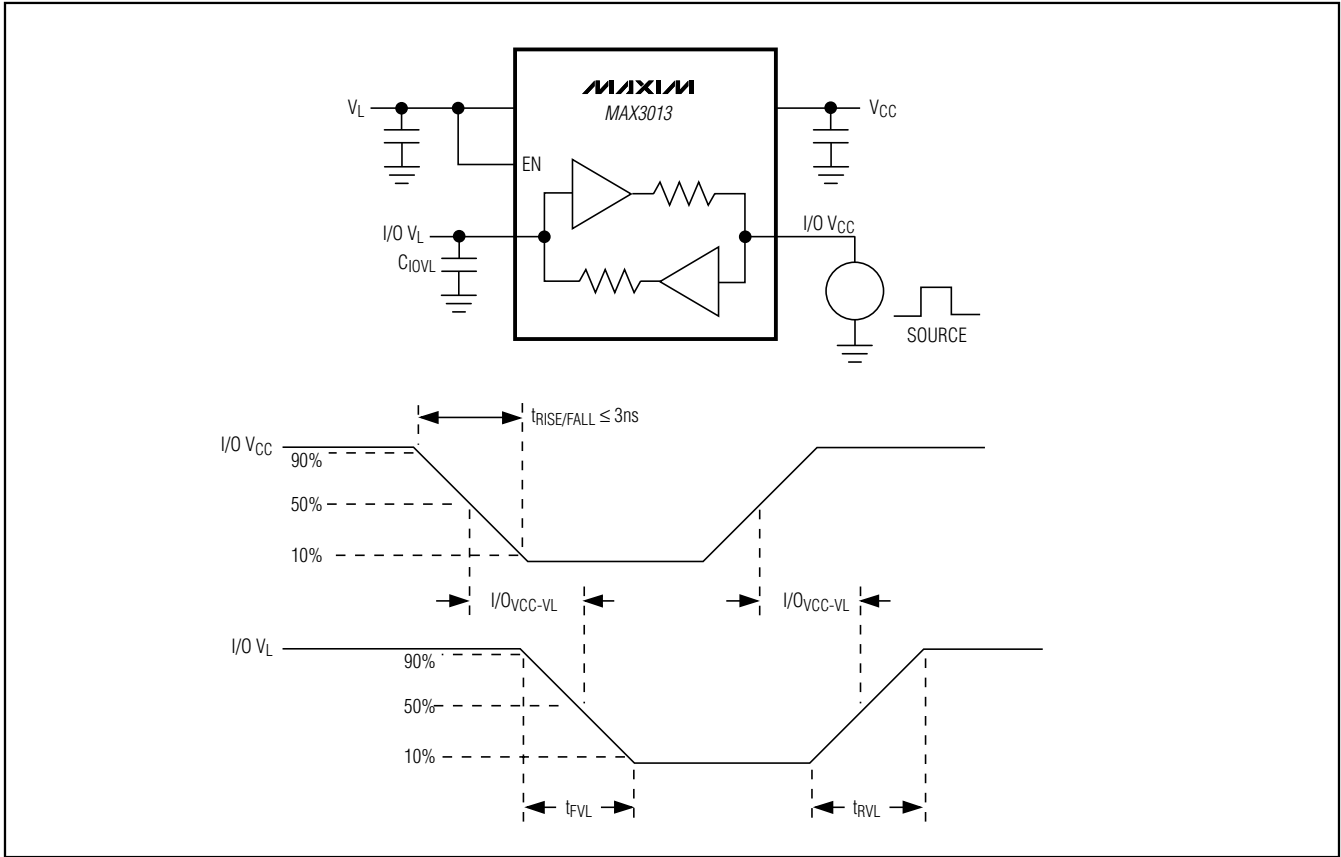


Figure 2. Driving I/O VCC Test Circuit and Timing

+1.2V to +3.6V, 0.1µA, 100Mbps, 8-Channel Level Translators

Test Circuits/Timing Diagrams (continued)

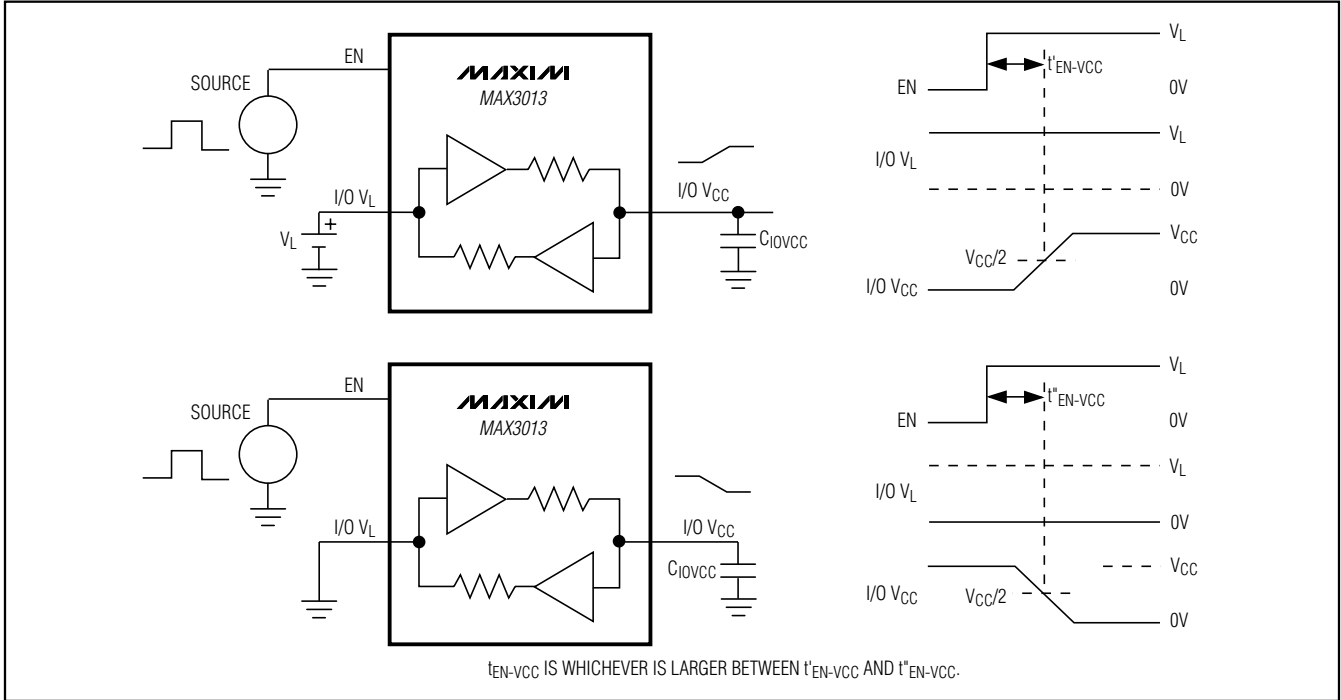


Figure 3. Propagation Delay from I/O V_L to I/O V_{CC} after EN

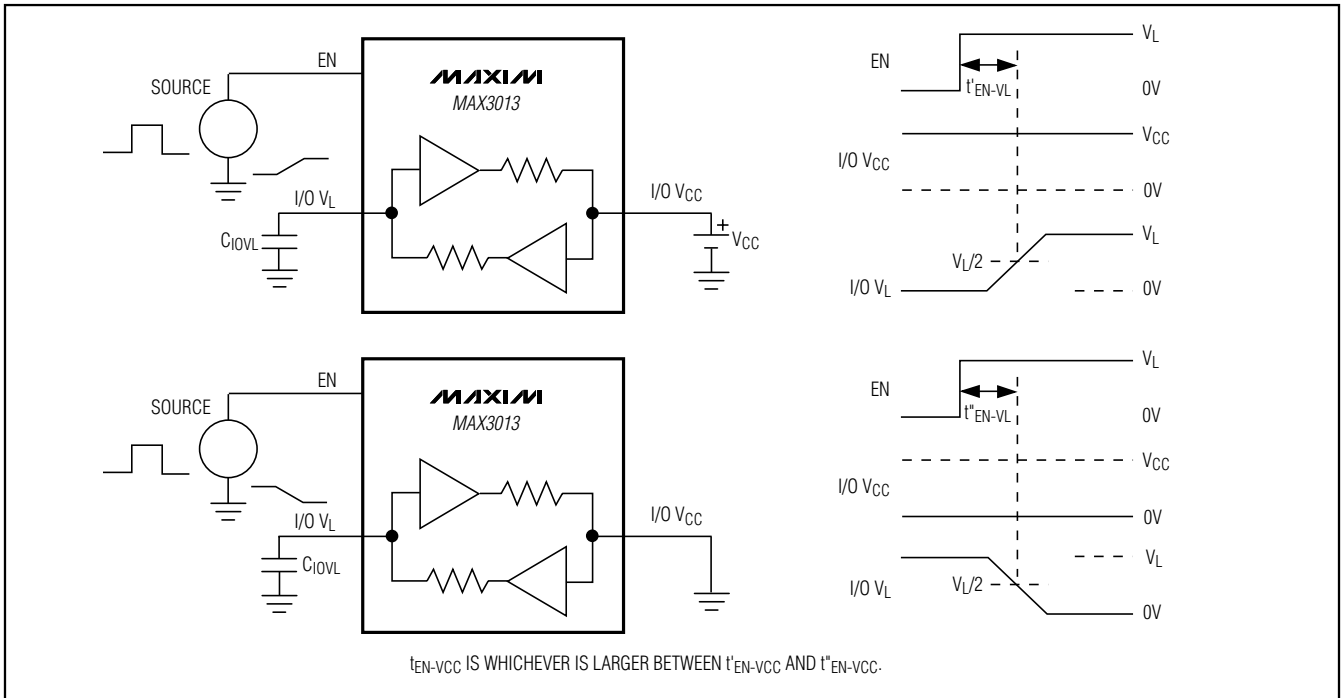


Figure 4. Propagation Delay from I/O V_{CC} to I/O V_L after EN

+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

MAX3013

Detailed Description

The MAX3013 logic-level translator provides the level shifting necessary to allow 100Mbps data transfer in a multivoltage system. Externally applied voltages, V_{CC} and V_L , set the logic levels on either side of the device. Logic signals present on the V_L side of the device appear as a higher voltage logic signal on the V_{CC} side of the device, and vice-versa. The MAX3013 bidirectional level translator allows data translation in either direction ($V_L \leftrightarrow V_{CC}$) on any single data line. The MAX3013 accepts V_L from +1.2V to ($V_{CC} - 0.4V$) and operate with V_{CC} from +1.65V to +3.6V, making it ideal for data transfer between low-voltage ASICs/PLDs and higher voltage systems.

The MAX3013 features an input enable mode (EN) that reduces V_{CC} and V_L supply currents to 0.1μA, when in tristate mode. This device operates at a guaranteed data rate of 100Mbps for $V_L > +1.8V$.

Level Translation

For proper operation, ensure that $+1.65V \leq V_{CC} \leq +3.6V$, $+1.2V \leq V_L \leq (V_{CC} - 0.4V)$. During power-up sequencing, $V_L \geq V_{CC}$ does not damage the device. During power-supply sequencing, when V_{CC} is floating and V_L is powering up, up to 40mA current can be sourced to each load on the V_L side, yet the device does not latch up. The maximum data rate depends heavily on the load capacitance (see the *Typical Operating Characteristics*, Rise/Fall Times), output impedance of the driver, and the operating voltage range (see the *Timing Characteristics*).

Input Driver Requirements

The MAX3013 architecture is based on a one-shot accelerator output stage (see Figure 5). Accelerator output stages are always in tristate mode except when there is a transition on any of the translators on the input side, either I/O V_L or I/O V_{CC} . Then, a short pulse is generated during which the accelerator output stages become active and charge/discharge the capacitances at the I/Os. Due to its bidirectional nature, both input stages become active during the one-shot pulse. This can lead to some current feeding into the external source that is driving the translator. However, this behavior helps to speed up the transition on the driven side.

For proper operation, the external driver must meet the following conditions: $<25\Omega$ output impedance and $>20mA$ output current. Figure 6 shows a graph of Typical Input Current vs. Input Voltage.

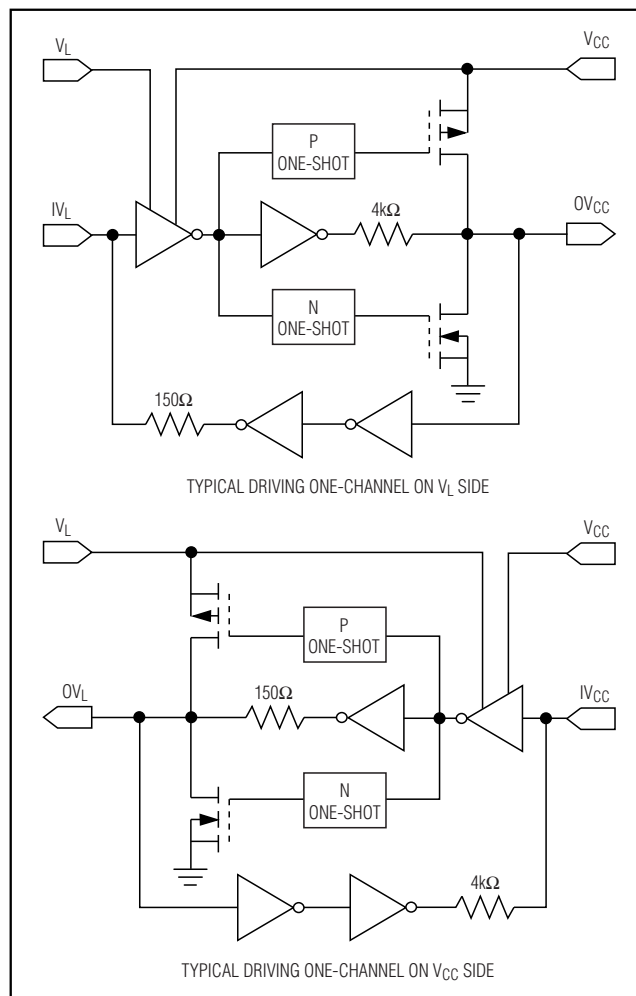


Figure 5. MAX3013 Simplified Diagram (1 I/O line)

Output Load Requirements

The MAX3013 I/O was designed to drive CMOS inputs. Do not load the I/O lines with a resistive load less than 25kΩ. Also, do not place an RC circuit at the input of the MAX3013 to slow down the edges. If a slower data rate is required, please see the MAX3000E/MAX3001E logic-level translator.

For I²C level translation, please refer to the MAX3372E–MAX3379E/MAX3390E–MAX3393E data sheet.

+1.2V to +3.6V, 0.1µA, 100Mbps, 8-Channel Level Translators

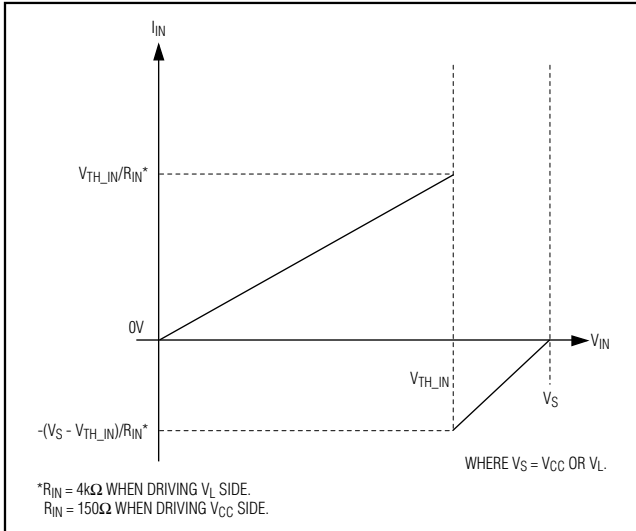


Figure 6. Typical I_{IN} vs. V_{IN}

Enable Input (EN)

The MAX3013 features an EN input. Pull EN low to set the MAX3013 I/O on both sides in tristate output mode. Drive EN to logic high (V_L) for normal operation.

Applications Information

Power-Supply Decoupling

To reduce ripple and the chance of introducing data errors, bypass V_L and V_{CC} to ground with a 0.1µF ceramic capacitor. Place the bypass capacitors as close to the power-supply input pins as possible.

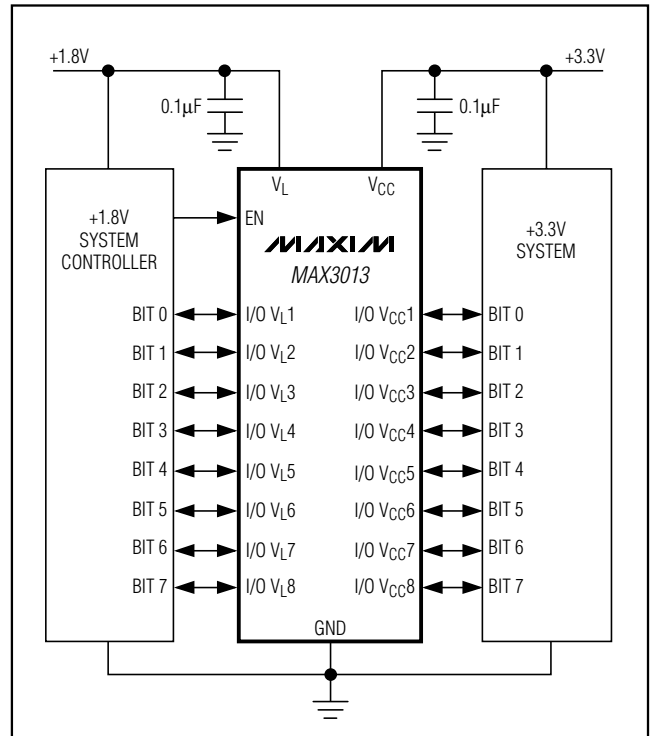
8-Bit Bus Translation

The MAX3013 level-shifts the data present on the I/O line between +1.2V to +3.6V, making it ideal for level translation between a low-voltage ASIC and a higher voltage system. The *Typical Operating Circuit* shows the MAX3013 bidirectional translator in an 8-bit bus level translation from a 1.8V system to a 3.3V system and vice versa.

Unidirectional vs. Bidirectional Level Translator

The MAX3013 bidirectional translator can operate as a unidirectional device to translate signals without inversion. This device provides the smallest solution (UCSP package) for unidirectional level translation without inversion.

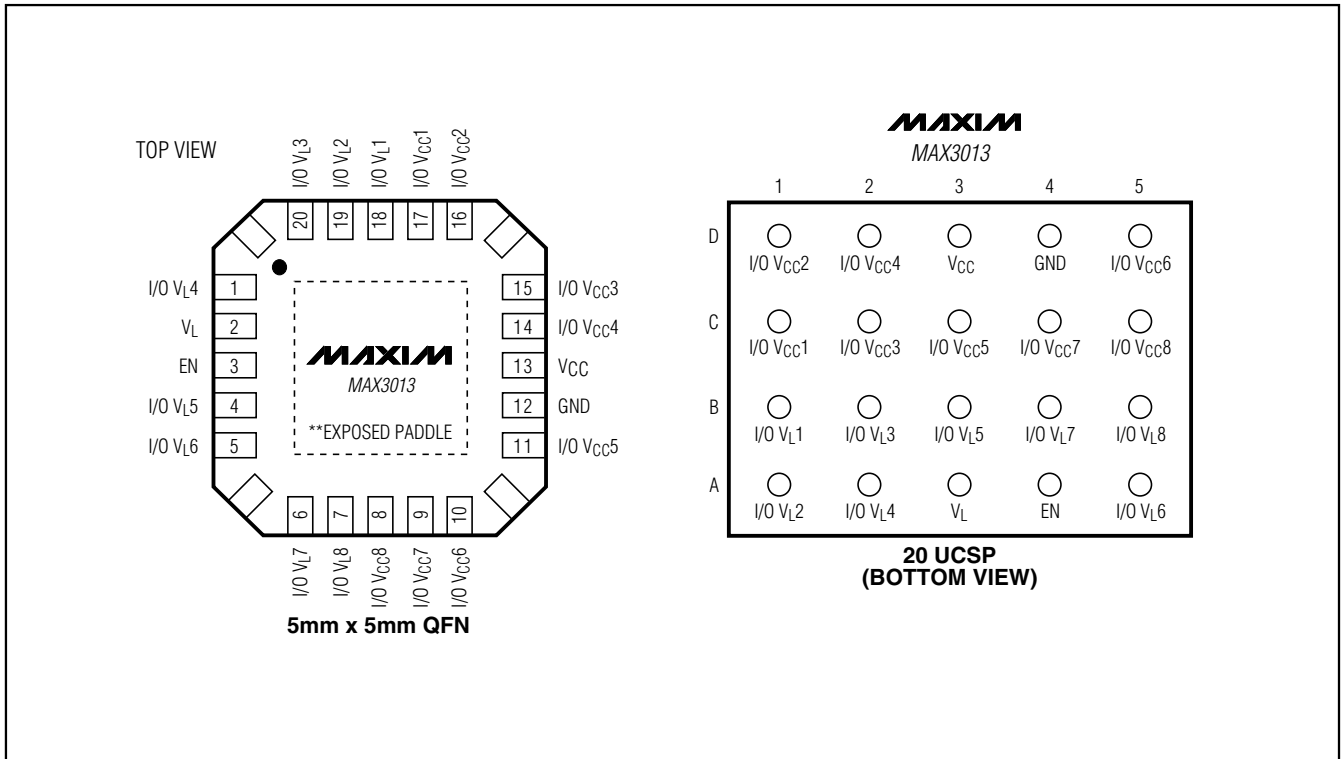
Typical Operating Circuit



+1.2V to +3.6V, 0.1µA, 100Mbps, 8-Channel Level Translators

Pin Configurations (continued)

MAX3013



Chip Information

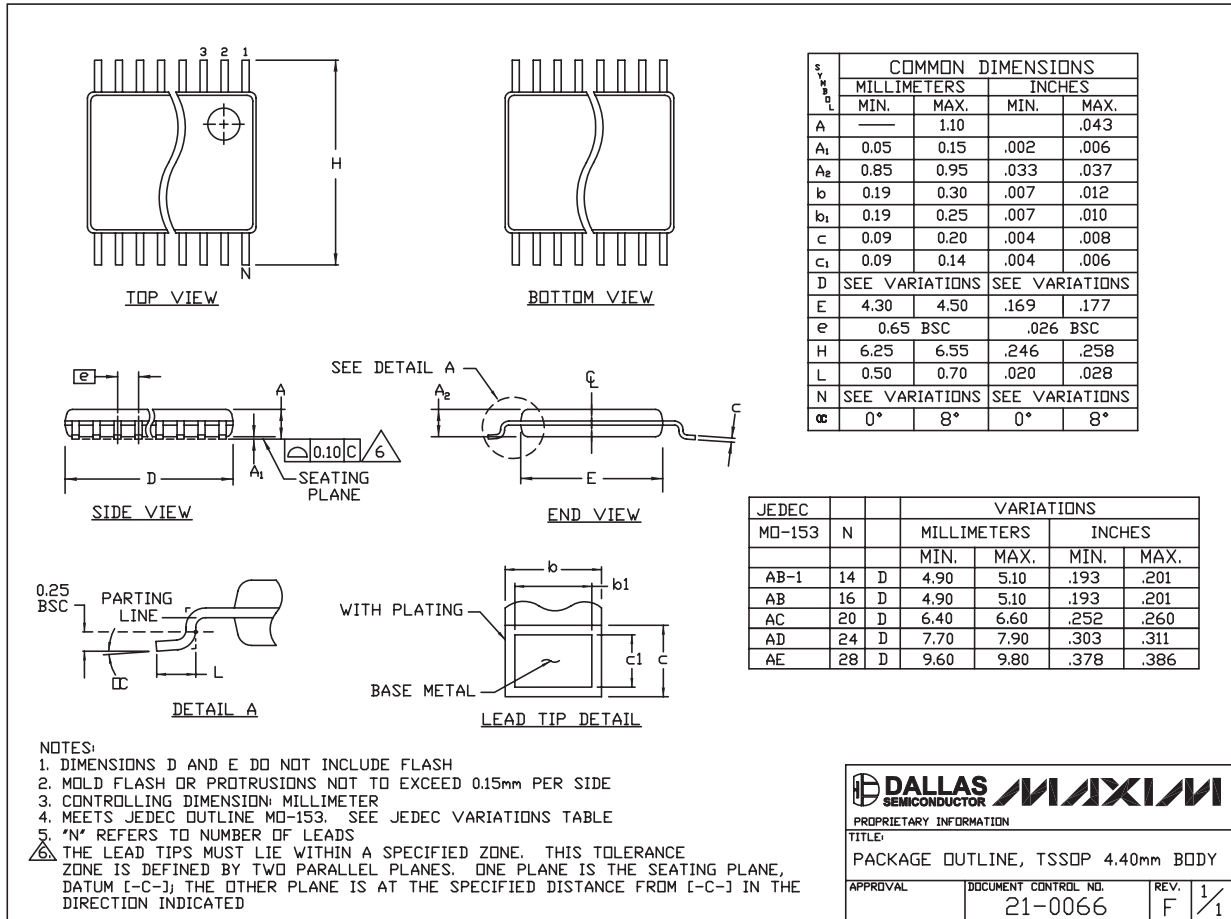
TRANSISTOR COUNT: 1447

PROCESS: BiCMOS

+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

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.)



TSSOP4-40mm, EPS

DALLAS SEMICONDUCTOR **MAXIM**

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, TSSOP 4.40mm BODY

APPROVAL	DOCUMENT CONTROL NO. 21-0066	REV. F	1/1
----------	---------------------------------	-----------	-----

+1.2V to +3.6V, 0.1µA, 100Mbps, 8-Channel Level Translators

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.)

MAX3013

TOP VIEW

COMMON DIMENSIONS	
A	0.62±0.05-0.08
A1	0.29±0.02
A2	0.33 REF.
b	∅0.35±0.03
D1	1.50 BASIC
E1	2.00 BASIC
e	0.50 BASIC
SD	0.25 BASIC
SE	0.00 BASIC

PKG. CODE	VARIABLE DIMENSIONS		DEPOPULATED SOLDER BALLS
	D	E	
B20-1	2.03±0.08	2.54±0.08	NONE
B20-2	2.03±0.08	2.54±0.08	B2, B3, B4
B20-4	2.03±0.08	2.54±0.08	B2, B3, B4, C2, C4
B20-5	2.03±0.08	2.54±0.08	B2, B3, B4, C2, C3, C4
B20-6	2.16±0.08	2.54±0.08	B2, B3, B4

NOTES:
 1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. PRODUCT MARKING: NUMBER OF CHARACTERS AND LINES VARY PER PRODUCT.

BOTTOM VIEW

SIDE VIEW

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, 5x4 UCSP

APPROVAL	DOCUMENT CONTROL NO. 21-0095	REV. I 1/1
----------	---------------------------------	------------

5x4 UCSP.EPS

+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

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.)

