ABSOLUTE MAXIMUM RATINGS

Voltages Referenced to GND
V+ .....-0.3V to +13V
IN+, IN- .....-0.3V to +14V
N_OUT, P_OUT .....-0.3V to (V+ + 0.3V)
N_OUT Continuous Output Current (Note 1) 390mA
P_OUT Continuous Output Current (Note 1).....100mA
Continuous Power Dissipation* (T_A = +70°C)
6-Pin SOT23 (derate 9.1mW/°C above +70°C).....727mW
6-Pin TDFN (derate 18.2mW/°C above +70°C) 1454mW
Operating Temperature Range .....-40°C to +125°C
Storage Temperature Range .....-65°C to +150°C
Junction Temperature.....+150°C
Lead Temperature (soldering, 10s) .....+300°C
Soldering Temperature (reflow) .....+260°C

Note 1: Continuous output current is limited by the power dissipation of the package.
*As per JEDEC51 standard.

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.

PACKAGE THERMAL CHARACTERISTICS (Note 2)

SOT23
Junction-to-Case Thermal Resistance (θ_{JC}).....75°C/W
TDFN
Junction-to-Case Thermal Resistance (θ_{JC}).....8.5°C/W

Note 2: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

ELECTRICAL CHARACTERISTICS

(V+ = +12V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY							
V+ Operating Range	V+			4.0		12.6	V
V+ Undervoltage Lockout	UVLO	V+ rising		3.25	3.6	4.00	V
V+ Undervoltage Lockout Hysteresis					400		mV
V+ Undervoltage Lockout to Output Delay Time		V+ rising			300		ns
V+ Supply Current	I+	IN+ = IN- = V+			0.95	1.5	mA
n-CHANNEL OUTPUT							
Driver Output Resistance—Pulling Down (MAX5048AAUT/MAX5048BAUT)	R_{ON-N}	V_{V+} = +10V, I_{N-OUT} = -100mA	T_A = +25°C		0.23	0.32	Ω
			T_A = +125°C		0.38	0.43	
		V_{V+} = +4.5V, I_{N-OUT} = -100mA	T_A = +25°C		0.24	0.34	
			T_A = +125°C		0.40	0.47	
Driver Output Resistance—Pulling Down (MAX5048AATT/MAX5048BATT)	R_{ON-N}	V_{V+} = +10V, I_{N-OUT} = -100mA	T_A = +25°C		0.31	0.34	Ω
			T_A = +125°C		0.46	0.51	
		V_{V+} = +4.5V, I_{N-OUT} = -100mA	T_A = +25°C		0.32	0.36	
			T_A = +125°C		0.48	0.55	

ELECTRICAL CHARACTERISTICS (continued)

(V+ = +12V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Power-Off Pulldown Resistance		V+ = 0 or unconnected, I_{N-OUT} = -10mA, T_A = +25°C			3.3	10	Ω
Power-Off Pulldown Clamp Voltage		V+ = 0 or unconnected, I_{N-OUT} = -10mA, T_A = +25°C			0.85	1.0	V
Output Leakage Current	I_{LK-N}	N_OUT = V+			6.85	20	µA
Peak Output Current (Sinking)	I_{PK-N}	C_L = 10,000pF			7.6		A
p-CHANNEL OUTPUT							
Driver Output Resistance—Pulling Up (MAX5048AAUT/MAX5048BAUT)	R_{ON-P}	V_{V+} = +10V, I_{P-OUT} = 50mA	T_A = +25°C		2.00	3.00	Ω
			T_A = +125°C		2.85	4.30	
		V_{V+} = +4.5V, I_{P-OUT} = 50mA	T_A = +25°C		2.20	3.30	
			T_A = +125°C		3.10	4.70	
Driver Output Resistance—Pulling Up (MAX5048AATT/MAX5048BATT)	R_{ON-P}	V_{V+} = +10V, I_{P-OUT} = 50mA	T_A = +25°C		2.08	3.08	Ω
			T_A = +125°C		2.93	4.38	
		V_{V+} = +4.5V, I_{P-OUT} = 50mA	T_A = +25°C		2.28	3.38	
			T_A = +125°C		3.18	4.78	
Output Leakage Current	I_{LK-P}	P_OUT = 0			0.001	10	µA
Peak Output Current (Sourcing)	I_{PK-P}	C_L = 10,000pF			1.3		A
LOGIC INPUT							
Logic 1 Input Voltage	V_{IH}	MAX5048A		0.67 x V+			V
		MAX5048B		2.4			
Logic 0 Input Voltage	V_{IL}	MAX5048A				0.33 x V+	V
		MAX5048B				0.8	
Logic-Input Hysteresis	V_{HYS}	MAX5048A			1.6		V
		MAX5048B			0.68		
Logic-Input Current		$V_{IN\_}$ = V+ or 0			0.001	10	µA
Input Capacitance	C_{IN}				2.5		pF
SWITCHING CHARACTERISTICS FOR V+ = +10V							
Rise Time	t_R	C_L = 1000pF			8		ns
		C_L = 5000pF			45		
		C_L = 10,000pF			82		
Fall Time	t_F	C_L = 1000pF			3.2		ns
		C_L = 5000pF			7.5		
		C_L = 10,000pF			12.5		
Turn-On Propagation Delay Time	t_{D-ON}	Figure 1, C_L = 1000pF (Note 4)		7	12	25	ns
Turn-Off Propagation Delay Time	t_{D-OFF}	Figure 1, C_L = 1000pF (Note 4)		7	12	25	ns
Break-Before-Make Time					2.5		ns

ELECTRICAL CHARACTERISTICS (continued)

(V+ = +12V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

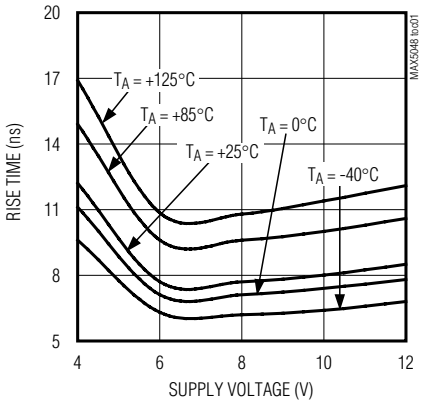
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SWITCHING CHARACTERISTICS FOR V+ = +4.5V						
Rise Time	t_R	C_L = 1000pF		12		ns
		C_L = 5000pF		41		
		C_L = 10,000pF		74		
Fall Time	t_F	C_L = 1000pF		3.0		ns
		C_L = 5000pF		7.0		
		C_L = 10,000pF		11.3		
Turn-On Propagation Delay Time	t_{D-ON}	Figure 1, C_L = 1000pF (Note 4)	8	14	27	ns
Turn-Off Propagation Delay Time	t_{D-OFF}	Figure 1, C_L = 1000pF (Note 4)	8	14	27	ns
Break-Before-Make Time				4.2		ns

Note 3: All DC specifications are 100% tested at T_A = +25°C. Specifications over -40°C to +125°C are guaranteed by design.
Note 4: Guaranteed by design, not production tested.

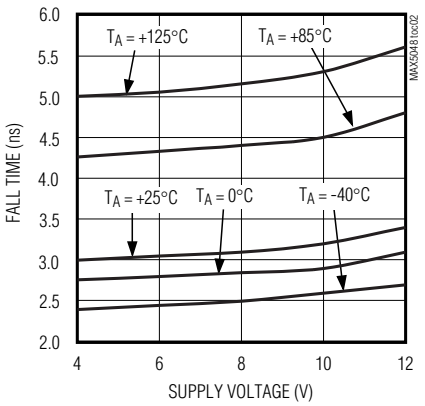
Typical Operating Characteristics

(C_L = 1000pF, T_A = +25°C, unless otherwise noted.)

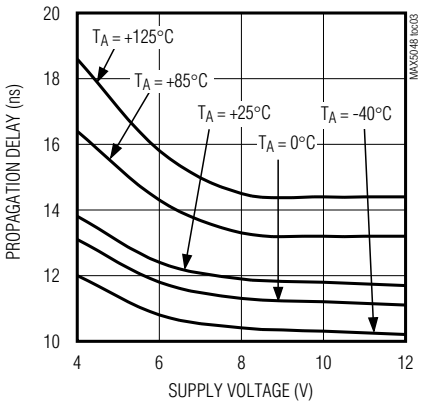
RISE TIME vs. SUPPLY VOLTAGE



FALL TIME vs. SUPPLY VOLTAGE



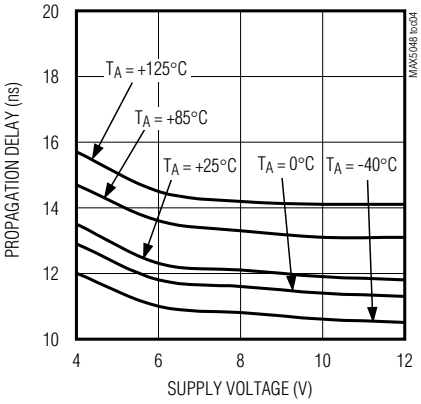
PROPAGATION DELAY TIME, LOW-TO-HIGH vs. SUPPLY VOLTAGE



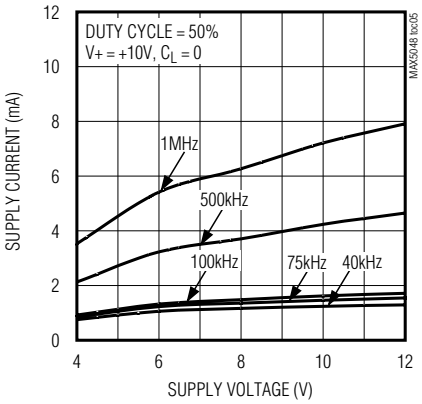
Typical Operating Characteristics (continued)

(C_L = 1000pF, T_A = +25°C, unless otherwise noted.)

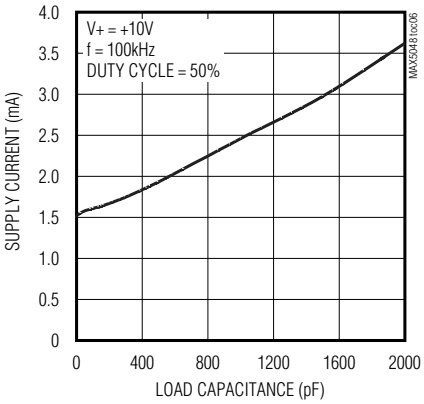
PROPAGATION DELAY TIME, HIGH-TO-LOW vs. SUPPLY VOLTAGE



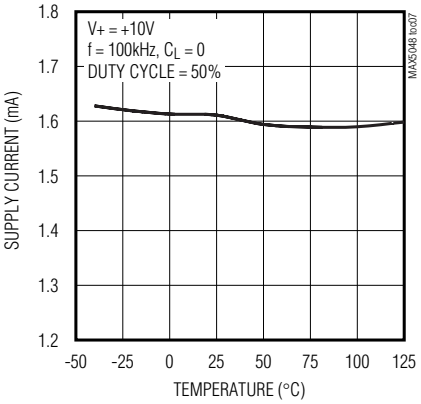
SUPPLY CURRENT vs. SUPPLY VOLTAGE



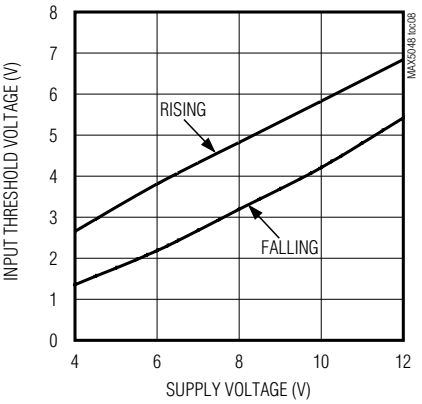
SUPPLY CURRENT vs. LOAD CAPACITANCE



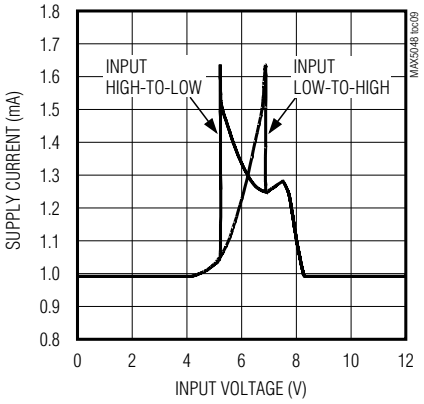
SUPPLY CURRENT vs. TEMPERATURE



MAX5048A INPUT THRESHOLD VOLTAGE vs. SUPPLY VOLTAGE



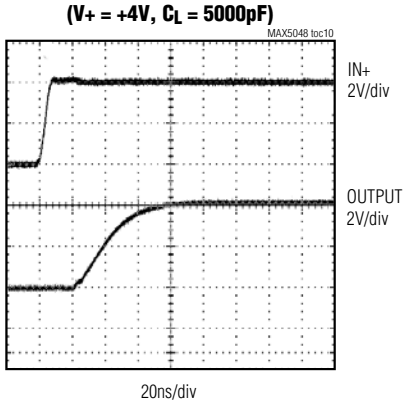
MAX5048A SUPPLY CURRENT vs. INPUT VOLTAGE



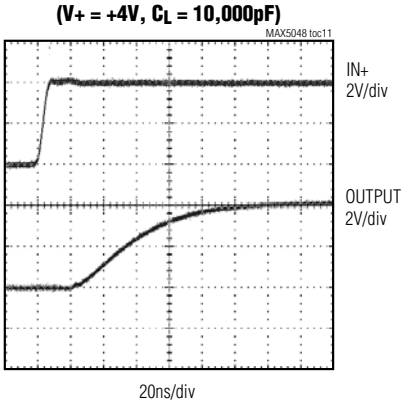
Typical Operating Characteristics (continued)

(C_L = 1000pF, T_A = +25°C, unless otherwise noted.)

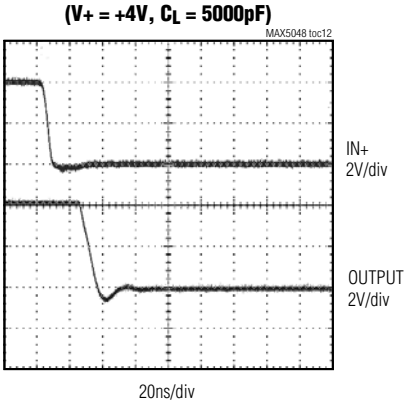
INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +4V, C_L = 5000pF)



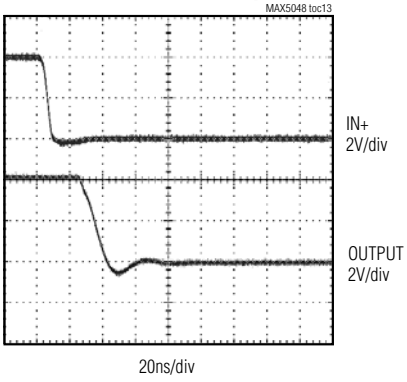
INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +4V, C_L = 10,000pF)



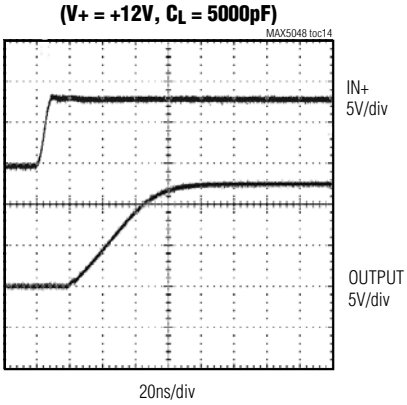
INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +4V, C_L = 5000pF)



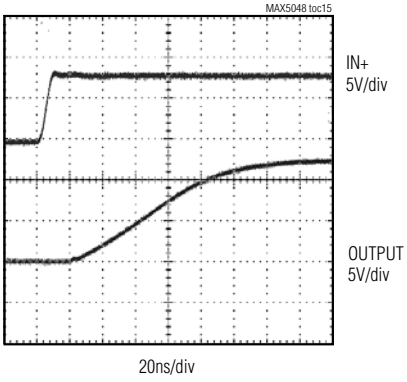
INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +4V, C_L = 10,000pF)



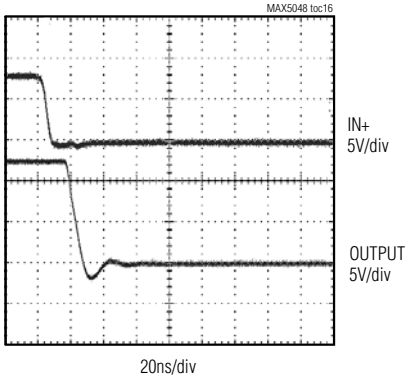
INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +12V, C_L = 5000pF)



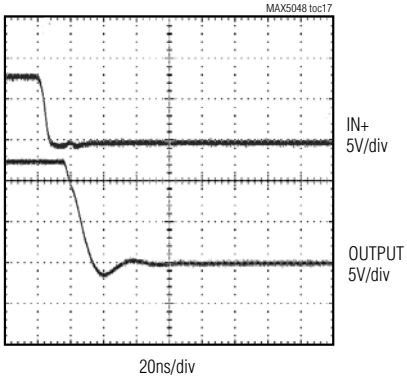
INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +12V, C_L = 10,000pF)



INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +12V, C_L = 5000pF)



INPUT VOLTAGE vs. OUTPUT VOLTAGE (V_+ = +12V, C_L = 10,000pF)



Pin Description

PIN	NAME	FUNCTION
1	V+	Power Supply. Bypass to GND with a 0.1µF ceramic capacitor.
2	P_OUT	p-Channel Open-Drain Output. Sources current for MOSFET turn-on.
3	N_OUT	n-Channel Open-Drain Output. Sinks current for MOSFET turn-off.
4	GND	Ground
5	IN-	Inverting Logic Input Terminal. Connect to GND when not used.
6	IN+	Noninverting Logic Input Terminal. Connect to V+ when not used.
—	EP	Exposed paddle. Connect to GND. Solder EP to the GND plane for improved thermal performance.

Detailed Description

Logic Inputs

The MAX5048A/MAX5048Bs' logic inputs are protected against voltage spikes up to +14V, regardless of the V+ voltage. The low 2.5pF input capacitance of the inputs reduces loading and increases switching speed. These devices have two inputs that give the user greater flexibility in controlling the MOSFET. Table 1 shows all possible input combinations.

The difference between the MAX5048A and the MAX5048B is the input threshold voltage. The MAX5048A has $V_{CC}/2$ CMOS logic-level thresholds, while the MAX5048B has TTL logic-level thresholds (see the *Electrical Characteristics*). For V+ above 5.5V, V_{IH} (typ) = 0.5x(V+) + 0.8V and V_{IL} (typ) = 0.5x(V+) - 0.8V. As V+ is reduced from 5.5V to 4V, V_{IH} and V_{IL} gradually approach V_{IH} (typ) = 0.5x(V+) + 0.65V and V_{IL} (typ) = 0.5x(V+) - 0.65V. Connect IN+ to V+ or IN- to GND when not used. Alternatively, the unused input can be used as an ON/OFF pin (see Table 1).

Table 1. Truth Table

IN+	IN-	p-CHANNEL	n-CHANNEL
L	L	OFF	ON
L	H	OFF	ON
H	L	ON	OFF
H	H	OFF	ON

L = Logic low

H = Logic high

Undervoltage Lockout (UVLO)

When V+ is below the UVLO threshold, the N-channel is ON and the P-channel is OFF, independent of the state of the inputs. The UVLO is typically 3.6V with 400mV typical hysteresis to avoid chattering.

Driver Outputs

The MAX5048A/MAX5048B provide two separate outputs. One is an open-drain P-channel, the other an open-drain N-channel. They have distinct current sourcing/sinking capabilities to independently control the rise and fall times of the MOSFET gate. Add a resistor in series with P_OUT/N_OUT to slow the corresponding rise/fall time of the MOSFET gate.

Applications Information

Supply Bypassing, Device Grounding, and Placement

Ample supply bypassing and device grounding are extremely important because when large external capacitive loads are driven, the peak current at the V+ pin can approach 1.3A, while at the GND pin the peak current can approach 7.6A. V_{CC} drops and ground shifts are forms of negative feedback for inverters and, if excessive, can cause multiple switching when the IN- input is used and the input slew rate is low. The device driving the input should be referenced to the MAX5048A/MAX5048B GND pin especially when the IN- input is used. Ground shifts due to insufficient device grounding may disturb other circuits sharing the same AC ground return path. Any series inductance in the V+, P_OUT, N_OUT and/or GND paths can cause oscillations due to the very high di/dt that results when the MAX5048A/MAX5048B are switched with any capacitive load. A 0.1µF or larger value ceramic capacitor is recommended bypassing V+ to GND and placed as close to the pins as possible. When driving very large loads (e.g., 10nF) at minimum rise time, 10µF or more of parallel storage capacitance is recommended. A ground plane is highly recommended to minimize ground return resistance and series inductance. Care should be taken to place the MAX5048A/MAX5048B as close as possible to the external MOSFET being driven to further minimize board inductance and AC path resistance.

Power Dissipation

Power dissipation of the MAX5048A/MAX5048B consists of three components, caused by the quiescent current, capacitive charge and discharge of internal nodes, and the output current (either capacitive or resistive load). The sum of these components must be kept below the maximum power-dissipation limit.

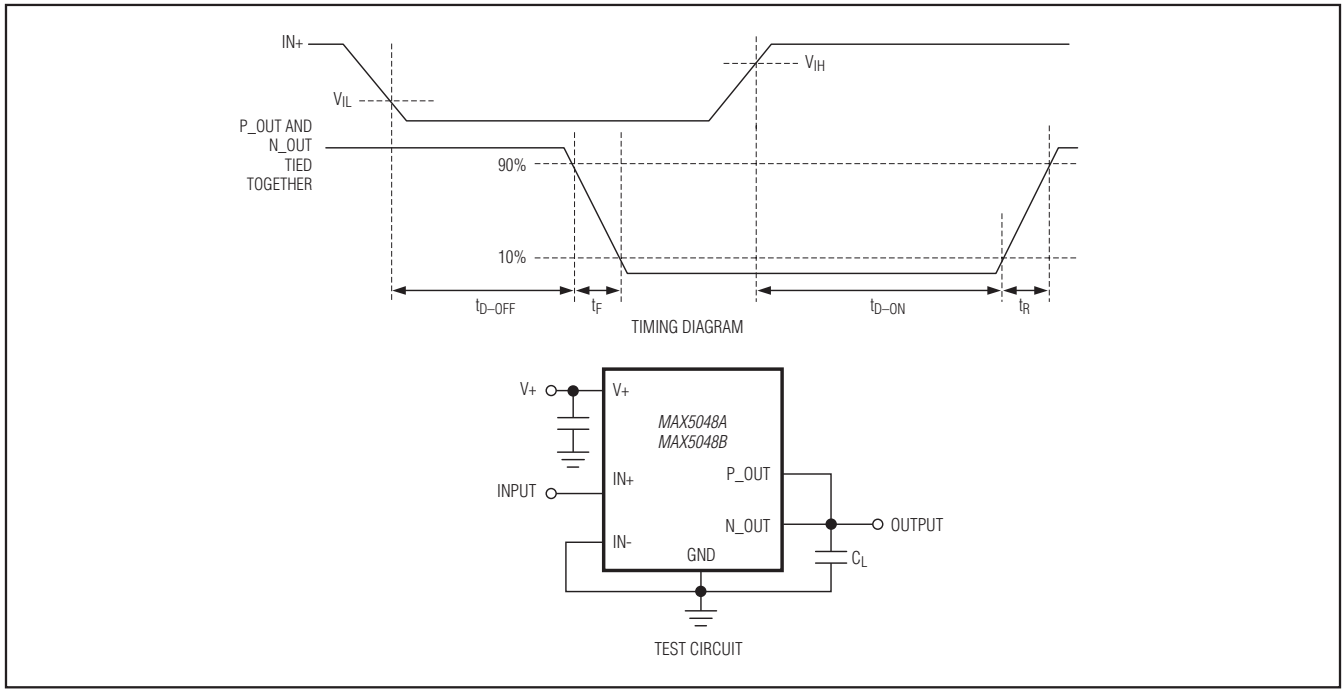


Figure 1. Timing Diagram and Test Circuit

The quiescent current is 0.95mA typical. The current required to charge and discharge the internal nodes is frequency dependent (see the *Typical Operating Characteristics*). The MAX5048A/MAX5048B power dissipation when driving a ground referenced resistive load is:

$$P = D \times R_{ON(MAX)} \times I_{LOAD}^2$$

where D is the fraction of the period the MAX5048A/MAX5048Bs' output pulls high, $R_{ON\ (MAX)}$ is the maximum on-resistance of the device with the output high (P-channel), and I_{LOAD} is the output load current of the MAX5048A/MAX5048B.

For capacitive loads, the power dissipation is:

$$P = C_{LOAD} \times (V+)^2 \times FREQ$$

where C_{LOAD} is the capacitive load, V+ is the supply voltage, and FREQ is the switching frequency.

Layout Information

The MOSFET drivers MAX5048A/MAX5048B source-and-sink large currents to create very fast rise and fall edges at the gate of the switching MOSFET. The high di/dt can cause unacceptable ringing if the trace lengths and impedances are not well controlled. The following PCB layout guidelines are recommended when designing with the MAX5048A/MAX5048B:

- Place one or more 0.1µF decoupling ceramic capacitor(s) from V+ to GND as close to the device as possible. At least one storage capacitor of 10µF (min) should be located on the PC board with a low resistance path to the V+ pin of the MAX5048A/MAX5048B.
- There are two AC current loops formed between the device and the gate of the MOSFET being driven. The MOSFET looks like a large capacitance from gate to source when the gate is being pulled low. The active current loop is from N_OUT of the MAX5048A/MAX5048B to the MOSFET gate to the MOSFET source and to GND of the MAX5048A/MAX5048B. When the gate of the MOSFET is being pulled high, the active current loop is from P_OUT of the MAX5048A/MAX5048B to the MOSFET gate to the MOSFET source to the GND terminal of the decoupling capacitor to the V+ terminal of the decoupling capacitor and to the V+ terminal of the MAX5048A/MAX5048B. While the charging current loop is important, the discharging current loop is critical. It is important to minimize the physical distance and the impedance in these AC current paths.
- In a multilayer PCB, the component surface layer surrounding the MAX5048A/MAX5048B should consist of a GND plane containing the discharging and charging current loops.

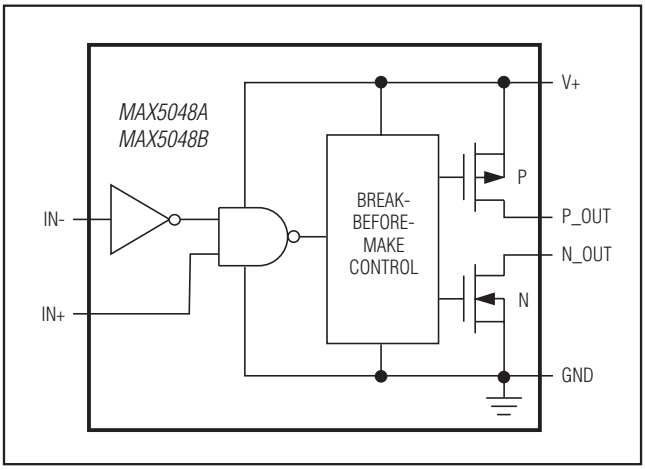


Figure 2. MAX5048A/MAX5048B Functional Diagram

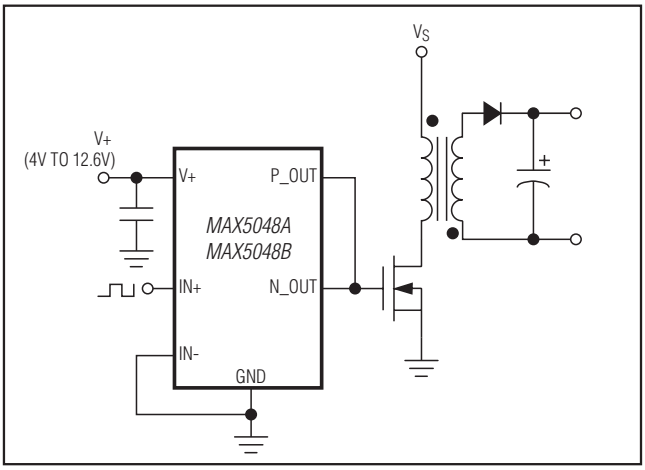


Figure 3. Noninverting Application

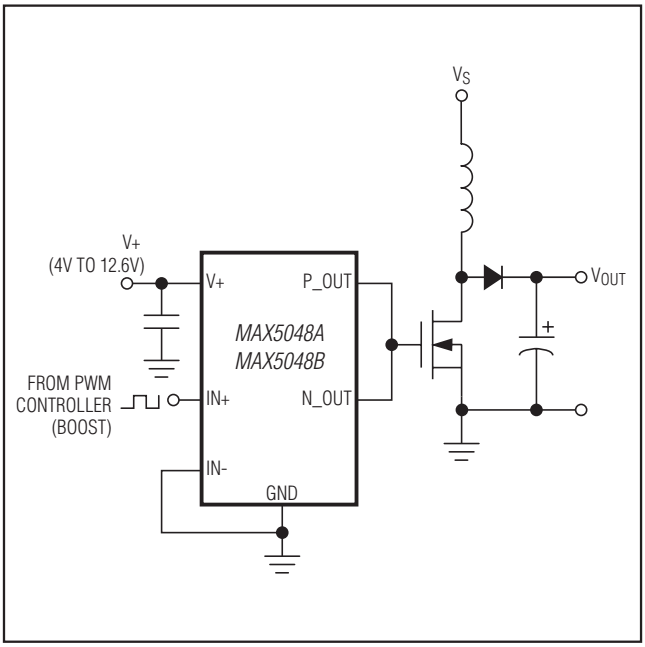


Figure 4. Boost Converter

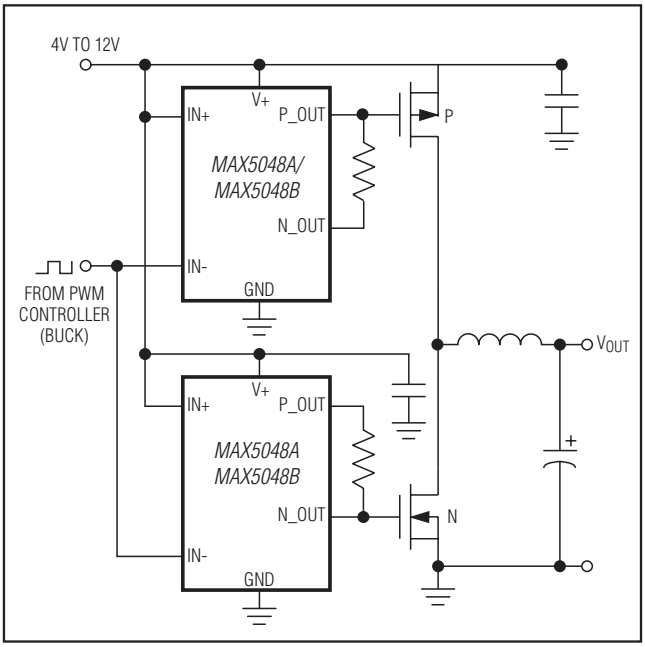
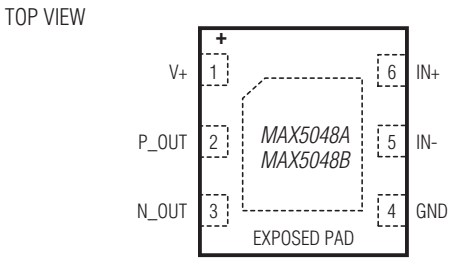


Figure 5. MAX5048A/MAX5048B in High-Power Synchronous Buck Converter

Pin Configurations (continued)



TDFN-EP
(3mm x 3mm)

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
6 SOT23	U6F+6	21-0058	90-0175
6 TDFN	—	21-0137	90-0058

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
5	11/12	Added "+" lead(Pb)-free/RoHS-compliant designations to *Ordering Information*	1, 9
6	10/14	Updated Driver Output Resistance—Pulling Down specifications	2