19-2590; Rev 1; 11/03

EVALUATION KIT AVAILABLE

MAXIM

Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

General Description

The MAX5052/MAX5053 current-mode PWM controllers contain all the control circuitry required for the design of wide-input-voltage isolated and nonisolated power supplies. The MAX5052 is well suited for universal input (rectified 85VAC to 265VAC) or telecom (-36VDC to -72VDC) power supplies. The MAX5053 is well suited for low-input-voltage (10.8VDC to 24VDC) power supplies.

The MAX5052/MAX5053 contain an internal error amplifier that regulates the tertiary winding output voltage. This implements a primary-side regulated, isolated power supply, eliminating the need for an optocoupler. An input undervoltage lockout (UVLO) is provided for programming the input-supply start voltage and to ensure proper operation during brownout conditions. The input-supply start voltage is externally programmable with a voltage-divider. To shutdown the device, the UVLO pin is pulled low. Internal digital soft-start reduces output voltage overshoot. The internal thermal shutdown circuit protects the device in the event the junction temperature exceeds +130°C.

The MAX5052 has an internal bootstrap UVLO with large hysteresis that requires a minimum voltage of 23.6V for startup. The MAX5053 does not have the internal bootstrap UVLO and can be biased directly from a minimum voltage of 10.8V.

The 262kHz switching frequency is internally trimmed to ±12% accuracy; this allows the optimization of the magnetic and filter components resulting in compact, cost-effective power supplies. The MAX5052A/MAX5053A are offered with a 50% maximum duty-cycle limit. The MAX5052B/MAX5053B are offered with a 75% maximum duty-cycle limit. These devices are available in 8-pin µMAX packages and operate over the -40°C to +85°C temperature range.

Applications

- Universal Input AC Power Supplies
- Industrial Power Conversion
- Isolated Telecom Power Supplies
- Isolated Keep-Alive Circuits
- Networking Systems
- 12V Boost Regulators
- Computer Systems/ Servers
- 12V SEPIC Regulators

Functional Diagram/Typical Operating Circuit/Selector Guide appear at end of data sheet.

Features

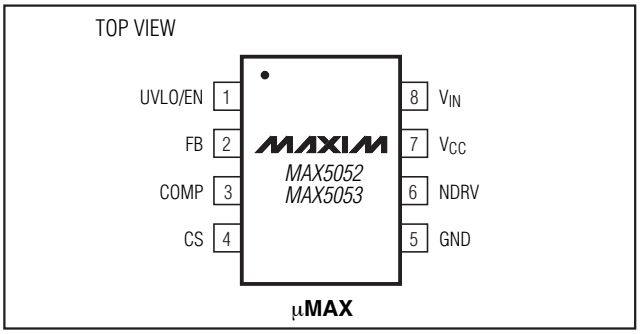
- ♦ **Available in a Tiny 8-Pin µMAX Package**
- ♦ **Current-Mode Control**
- ♦ **50W Output Power**
- ♦ **Universal Offline Input Voltage Range Rectified 85VAC to 265VAC (MAX5052)**
- ♦ **V_{IN} Directly Driven from 10.8V to 24V Input (MAX5053)**
- ♦ **Digital Soft-Start**
- ♦ **Programmable Input Startup Voltage**
- ♦ **Internal Bootstrap UVLO with Large Hysteresis (MAX5052)**
- ♦ **Internal Error Amplifier with 1% Accurate Reference**
- ♦ **Thermal Shutdown**
- ♦ **45µA (typ) Startup Supply Current**
- ♦ **1.4mA (typ) Operating Supply Current**
- ♦ **Fixed Switching Frequency of 262kHz ±12%**
- ♦ **50% Maximum Duty-Cycle Limit (MAX5052A/MAX5053A)**
- ♦ **75% Maximum Duty-Cycle Limit (MAX5052B/MAX5053B)**
- ♦ **60ns Cycle-by-Cycle Current-Limit Response Time**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX5052AEUA	-40°C to +85°C	8 µMAX
MAX5052BEUA	-40°C to +85°C	8 µMAX
MAX5053AEUA	-40°C to +85°C	8 µMAX
MAX5053BEUA	-40°C to +85°C	8 µMAX

Warning: *The MAX5052/MAX5053 are designed to work with high voltages. Exercise caution.*

Pin Configuration



For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

ABSOLUTE MAXIMUM RATINGS

V_{IN} to GND .....-0.3V to +30V
V_{CC} to GND .....-0.3V to +13V
FB, COMP, UVLO, CS to GND .....-0.3V to +6V
NDRV to GND.....-0.3V to (V_{CC} + 0.3V)
Continuous Power Dissipation (T_A = +70°C)
8-Pin µMAX (derate 4.5mW/°C above +70°C) 362mW

Operating Temperature Range .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Junction Temperature.....+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_{IN} = +12V (for MAX5052, V_{IN} must first be brought up to 23.6V for startup), 10nF bypass capacitors at V_{IN} and V_{CC}, C_{NDRV} = 0, V_{UVLO} = +1.4V, V_{FB} = +1.0V, V_{COMP} = floating, V_{CS} = 0V, typical values are measured at T_A = +25°C, T_A = -40°C to + 85°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
UNDERVOLTAGE LOCKOUT/STARTUP						
Bootstrap UVLO Wake-Up Level	V_{SUVR}	V_{IN} rising (MAX5052 only)	19.68	21.6	23.60	V
Bootstrap UVLO Shutdown Level	V_{SUVF}	V_{IN} falling (MAX5052 only)	9.05	9.74	10.43	V
UVLO/EN Wake-Up Threshold	V_{ULR2}	UVLO/EN rising	1.188	1.28	1.371	V
UVLO/EN Shutdown Threshold	V_{ULF2}	UVLO/EN falling	1.168	1.23	1.291	V
UVLO/EN Input Current	I_{UVLO}	T_J = +125°C		25		nA
UVLO/EN Hysteresis				50		mV
V_{IN} Supply Current In Undervoltage Lockout	I_{START}	V_{IN} = +19V, for MAX5052 only when in bootstrap UVLO		45	90	µA
V_{IN} Range	V_{IN}		10.8		24	V
UVLO/EN Propagation Delay	t_{EXTR}	UVLO/EN steps up from +1.1V to +1.4V		12		µs
	t_{EXTF}	UVLO/EN steps down from +1.4V to +1.1V		1.8		
Bootstrap UVLO Propagation Delay	t_{BUVR}	V_{IN} steps up from +9V to +24V		5		µs
	t_{BUVF}	V_{IN} steps down from +24V to +9V		1		
INTERNAL SUPPLY						
V_{CC} Regulator Set Point	V_{CCSP}	V_{IN} = +10.8V to +24V, sinking 1µA to 20mA from V_{CC}	7		10.5	V
V_{IN} Supply Current After Startup	I_{IN}	V_{IN} = +24V		1.4	2.5	mA
Shutdown Supply Current		UVLO/EN = low			90	µA
GATE DRIVER						
Driver Output Impedance	$R_{ON(LOW)}$	Measured at NDRV sinking, 100mA		2	4	Ω
	$R_{ON(HIGH)}$	Measured at NDRV sourcing, 20mA		4	12	
Driver Peak Sink Current				1		A
Driver Peak Source Current				0.65		A
PWM COMPARATOR						
Comparator Offset Voltage	VO_{PWM}	V_{COMP} - V_{CS}	1.15	1.38	1.70	V
CS Input Bias Current	I_{CS}	V_{CS} = 0V	-2		+2	µA
Comparator Propagation Delay	t_{PWM}	V_{CS} = +0.1V		60		ns
Minimum On-Time	$t_{ON(MIN)}$			150		ns

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = +12V (for MAX5052, V_{IN} must first be brought up to 23.6V for startup), 10nF bypass capacitors at V_{IN} and V_{CC}, C_{NDRV} = 0, V_{UVLO} = +1.4V, V_{FB} = +1.0V, V_{COMP} = floating, V_{CS} = 0V, typical values are measured at T_A = +25°C, T_A = -40°C to + 85°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CURRENT-LIMIT COMPARATOR						
Current-Limit Trip Threshold	V_{CS}		262	291	320	mV
CS Input Bias Current	I_{CS}	V_{CS} = 0V	-2		+2	µA
Propagation Delay From Comparator Input to NDRV	t_{PWM}	50mV overdrive		60		ns
Switching Frequency	f_{SW}		230	262	290	kHz
Maximum Duty Cycle	D_{MAX}	MAX505_A		50	50.5	%
		MAX505_B		75	76	
V_{IN} CLAMP VOLTAGE						
V_{IN} Clamp Voltage	V_{INC}	2mA sink current, MAX5052 only (Note 3)	24.1	26.1	29.0	V
ERROR AMPLIFIER						
Voltage Gain		R_{LOAD} = 100kΩ		80		dB
Unity-Gain Bandwidth		R_{LOAD} = 100kΩ, C_{LOAD} = 200pF		2		MHz
Phase Margin		R_{LOAD} = 100kΩ, C_{LOAD} = 200pF		65		degrees
FB Input Offset Voltage					3	mV
COMP Pin Clamp Voltage		High	2.2		3.5	V
		Low	0.4		1.1	
Source Current			0.5			mA
Sink Current			0.5			mA
Reference Voltage	V_{REF}	(Note 2)	1.218	1.230	1.242	V
Input Bias Current					50	nA
COMP Short-Circuit Current				8		mA
THERMAL SHUTDOWN						
Thermal-Shutdown Temperature				130		°C
Thermal Hysteresis				25		°C
DIGITAL SOFT-START						
Soft-Start Duration				15,872		clock cycles
Reference Voltage Steps During Soft-Start				31		steps
Reference Voltage Step				40		mV

Note 1: All devices are 100% tested at T_A = +85°C. All limits over temperature are guaranteed by characterization.

Note 2: V_{REF} is measured with FB connected to the COMP pin (see *Functional Diagram*).

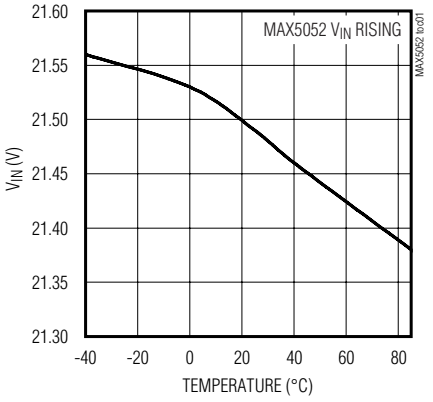
Note 3: The MAX5052 is intended for use in universal input power supplies. The internal clamp circuit is used to prevent the bootstrap capacitor (C1 in Figure 1) from charging to a voltage beyond the absolute maximum rating of the device when EN/UVLO is low. The maximum current to V_{IN} (hence to clamp) when UVLO is low (device in shutdown) must be externally limited to 2mA, max. Clamp currents higher than 2mA may result in clamp voltage higher than 30V, thus exceeding the absolute maximum rating for V_{IN}. For the MAX5053, do not exceed the 24V maximum operating voltage of the device.

Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

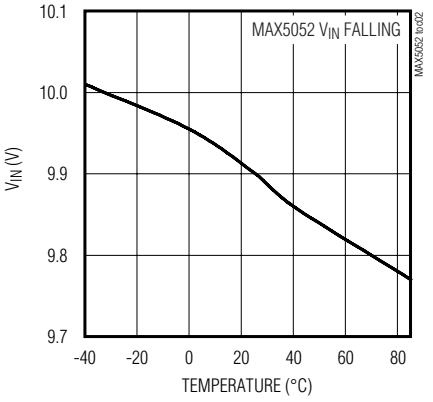
Typical Operating Characteristics

(UVLO = +1.4V, V_{FB} = +1V, V_{COMP} = floating, V_{CS} = 0V, T_A = +25°C, unless otherwise noted.)

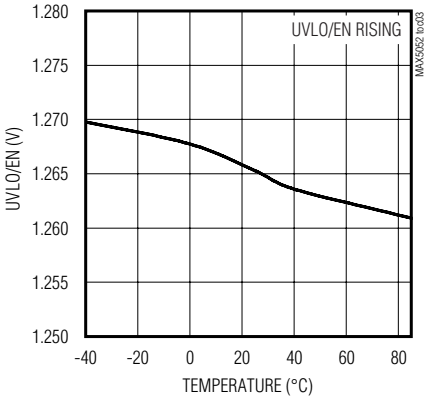
BOOTSTRAP UVLO WAKE-UP LEVEL vs. TEMPERATURE



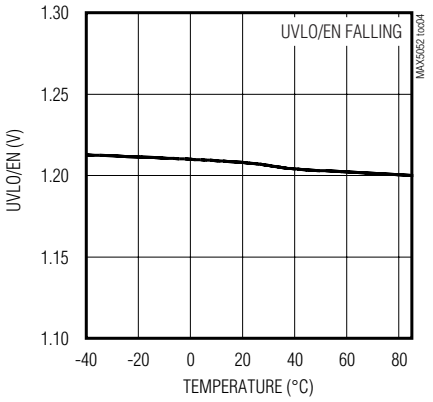
BOOTSTRAP UVLO SHUTDOWN LEVEL vs. TEMPERATURE



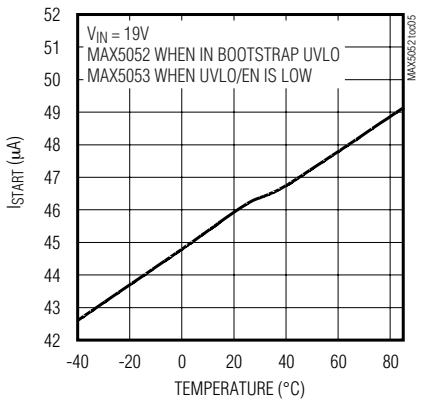
UVLO/EN WAKE-UP THRESHOLD vs. TEMPERATURE



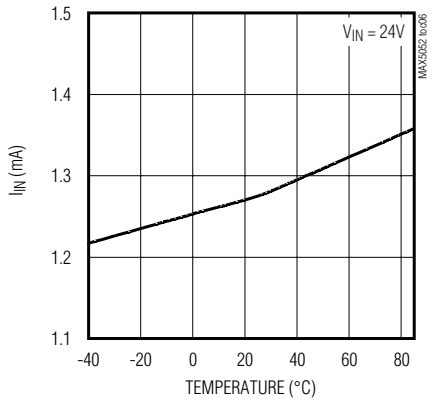
UVLO/EN SHUTDOWN THRESHOLD vs. TEMPERATURE



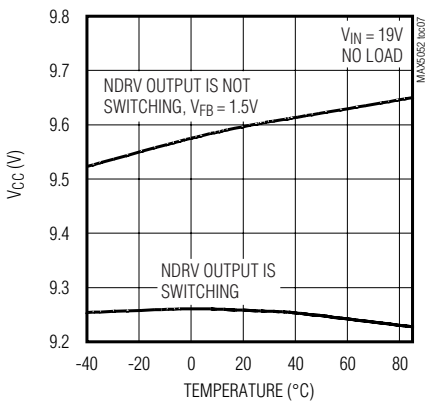
V_{IN} SUPPLY CURRENT IN UNDERVOLTAGE LOCKOUT vs. TEMPERATURE



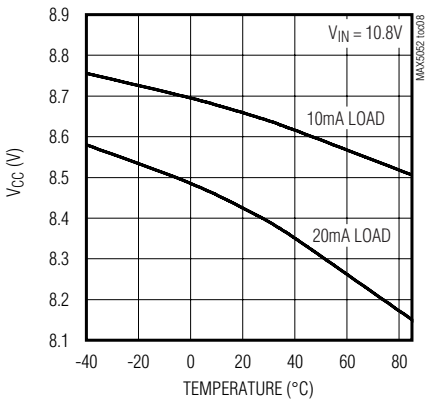
V_{IN} SUPPLY CURRENT AFTER STARTUP vs. TEMPERATURE



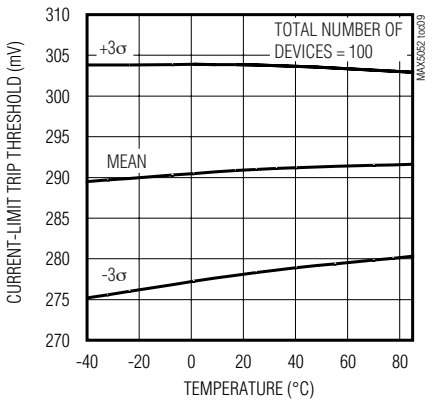
V_{CC} REGULATOR SET POINT vs. TEMPERATURE



V_{CC} REGULATOR SET POINT vs. TEMPERATURE



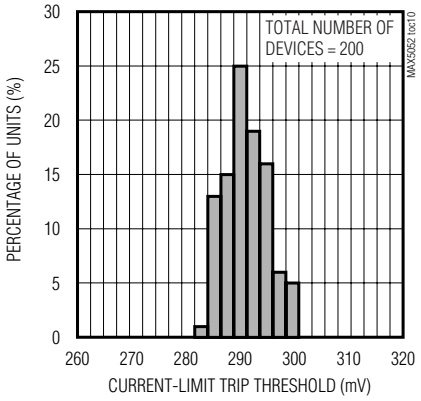
CURRENT-LIMIT TRIP THRESHOLD vs. TEMPERATURE



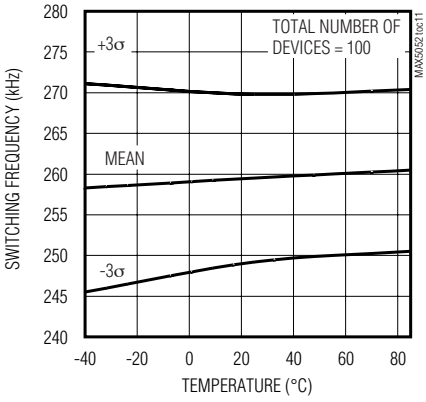
Typical Operating Characteristics (continued)

(UVLO = +1.4V, V_{FB} = +1V, V_{COMP} = floating, V_{CS} = 0V, T_A = +25°C, unless otherwise noted.)

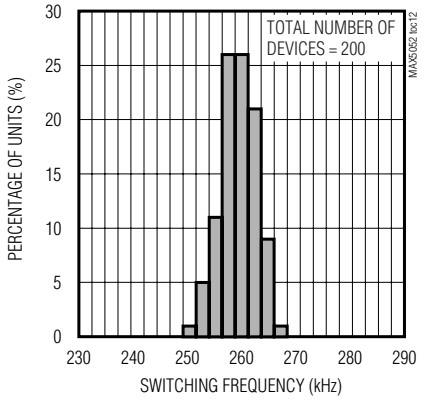
CURRENT-LIMIT TRIP THRESHOLD



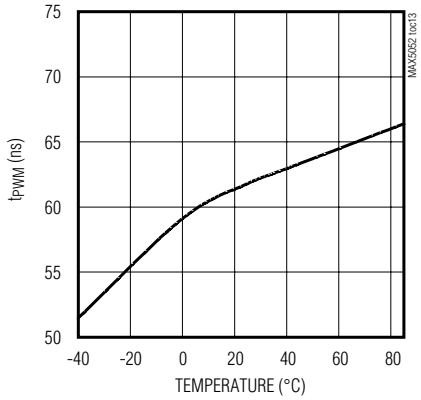
SWITCHING FREQUENCY vs. TEMPERATURE



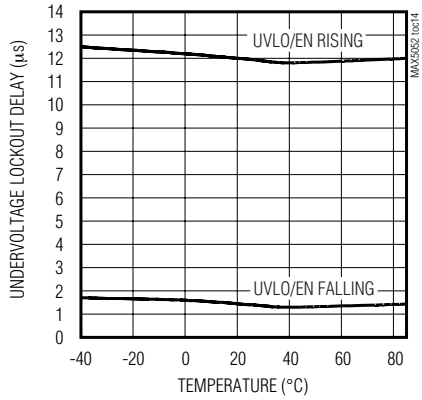
SWITCHING FREQUENCY



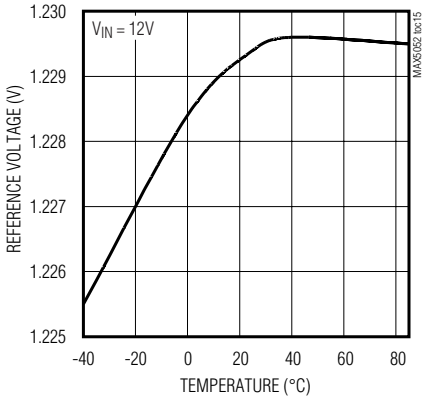
PROPAGATION DELAY FROM CURRENT-LIMIT COMPARATOR INPUT TO NDRV vs. TEMPERATURE



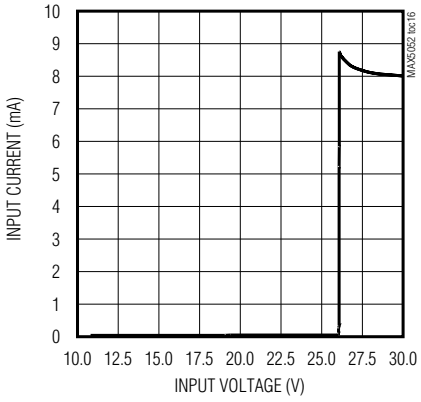
UVLO/EN PROPAGATION DELAY vs. TEMPERATURE



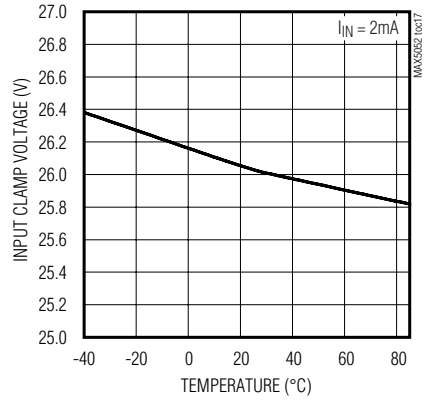
REFERENCE VOLTAGE vs. TEMPERATURE



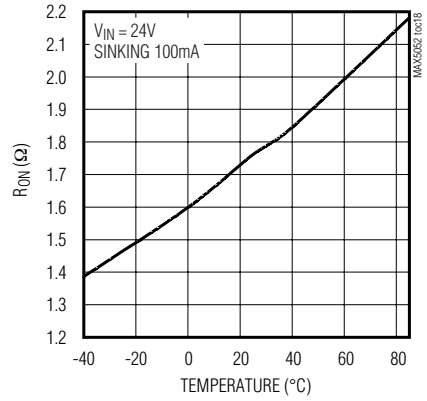
INPUT CURRENT vs. INPUT CLAMP VOLTAGE



INPUT CLAMP VOLTAGE vs. TEMPERATURE



NDRV OUTPUT IMPEDANCE vs. TEMPERATURE

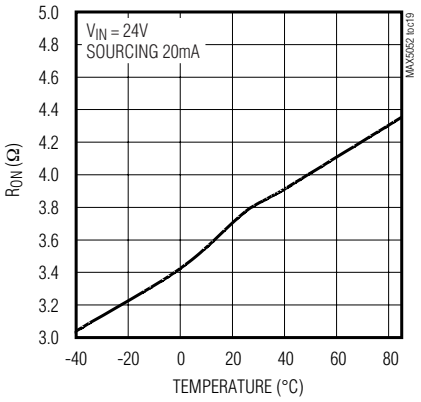


Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

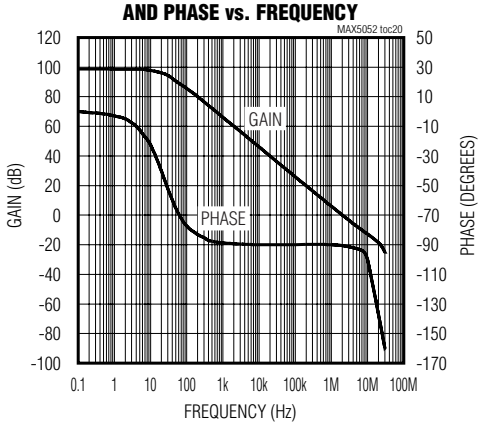
Typical Operating Characteristics (continued)

(UVLO = +1.4V, V_{FB} = +1V, V_{COMP} = floating, V_{CS} = 0V, T_A = +25°C, unless otherwise noted.)

NDRV OUTPUT IMPEDANCE vs. TEMPERATURE



ERROR AMP OPEN-LOOP GAIN AND PHASE vs. FREQUENCY



Pin Description

PIN	NAME	FUNCTION
1	UVLO/EN	Externally Programmable Undervoltage Lockout. UVLO programs the input start voltage. Connect UVLO to GND to disable the device.
2	FB	Error-Amplifier Inverting Input
3	COMP	Error-Amplifier Output
4	CS	Current-Sense Connection for PWM Regulation and Overcurrent Protection. Connect to high side of sense resistor. An RC filter may be necessary to eliminate leading-edge spikes.
5	GND	Power-Supply Ground
6	NDRV	External N-Channel MOSFET Gate Connection
7	V_{CC}	Gate-Drive Supply. Internally regulated down from V_{IN}. Decouple with a 10nF or larger capacitor to GND.
8	V_{IN}	IC Supply. Decouple with a 10nF or larger capacitor to GND. For bootstrapped operation (MAX5052) connect a startup resistor from the input supply line to V_{IN}. Connect the bias winding supply to this point as well (see the *Typical Operating Circuit*). For the MAX5053, connect V_{IN} directly to 10.8V to 24V supply.

Detailed Description

The MAX5052/MAX5053 are current-mode PWM controllers that have been specifically designed for use in isolated and nonisolated power-supply applications. A bootstrap UVLO with a large hysteresis (11.9V), very low startup current, and low operating current result in efficient universal-input power supplies. In addition to the internal bootstrap UVLO, these devices also offer programmable input startup voltage programmed through the UVLO/EN pin. This feature is useful in preventing the power supply from entering a brownout condition, in case the input voltage drops below its minimum value. This is important since switching power supplies increases their input supply current as the input voltage drops in order to keep the output power constant. The MAX5052 is well suited for universal input (rectified 85VAC to 265VAC) or telecom (-36VDC to -72VDC) power supplies. The MAX5053 is well suited for low-input-voltage (10.8VDC to 24VDC) power supplies.

Power supplies designed with the MAX5052 use a high-value startup resistor, R1, that charges a reservoir capacitor, C1 (see Figure 1). During this initial period, while the voltage is less than the internal bootstrap UVLO threshold, the device typically consumes only 45µA of quiescent current. This low startup current and the large bootstrap UVLO hysteresis helps to minimize

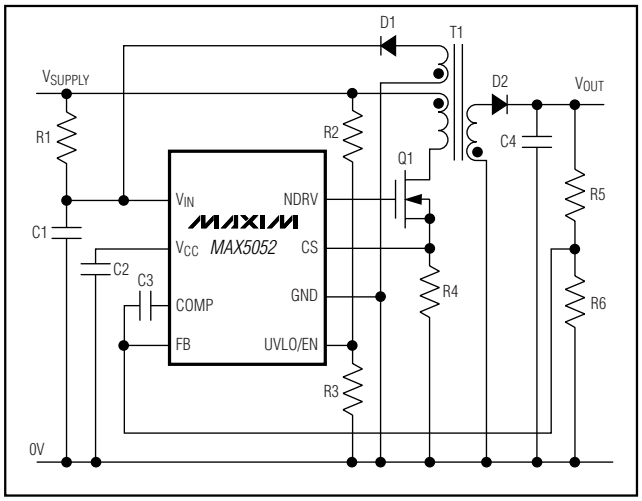


Figure 1. Nonisolated Power Supply with Programmable Input-Supply Start Voltage

the power dissipation across R1 even at the high end of the universal AC input voltage (265VAC).

The MAX5052/MAX5053 include a cycle-by-cycle current limit that turns off the gate drive to the external MOSFET during an overcurrent condition. When using the MAX5052 in the bootstrapped mode (if the power-supply output is shorted), the tertiary winding voltage drops below the 10V threshold causing the UVLO to turn off the gate drive to the external power MOSFET. This reinitiates a startup sequence with soft-start.

MAX5052/MAX5053 Undervoltage Lockout

The MAX5052/MAX5053 have an input voltage UVLO/EN pin. The threshold for this UVLO is 1.28V. Before any operation can commence, the voltage on this pin has to exceed 1.28V. The UVLO circuit keeps the CPWM comparator, ILIM comparator, oscillator, and output driver shut down to reduce current consumption (see the *Functional Diagram*).

Use this UVLO function to program the input-supply start voltage. For example, a reasonable start voltage for a 36V to 72V telecom range might be set at 34V. Calculate the divider resistor values, R2 and R3 (see Figure 1) by using the following formulas:

$$R3 \cong \frac{V_{ULR2} \times V_{IN}}{500 \times I_{UVLO}\left(V_{IN} - V_{ULR2}\right)}$$

The value of R3 is calculated to minimize the voltage-drop error across R2 as a result of the input bias current of the UVLO/EN pin. V_{ULR2} = 1.28V, I_{UVLO} = 50nA (max). V_{IN} is the value of the input-supply voltage where the power supply must start.

$$R2 = \frac{V_{IN} - V_{ULR2}}{V_{ULR2}} \times R3$$

where I_{UVLO} is the UVLO/EN pin input current (50nA), and V_{ULR2} is the UVLO/EN wake-up threshold.

MAX5052 Bootstrap Undervoltage Lockout

In addition to the externally programmable UVLO function offered in both the MAX5052 and MAX5053, the MAX5052 has an additional internal bootstrap UVLO that is very useful when designing high-voltage power supplies (see the *Functional Diagram*). This allows the device to bootstrap itself during initial power-up. The MAX5052 attempts to start when V_{IN} exceeds the bootstrap UVLO threshold of 21.6V.

During startup, the UVLO circuit keeps the CPWM comparator, ILIM comparator, oscillator, and output driver shut down to reduce current consumption. Once V_{IN} reaches 21.6V, the UVLO circuit turns on both the CPWM and ILIM comparators, as well as the oscillator, and allows the output driver to switch. If V_{IN} drops below 9.7V, the UVLO circuit will shut down the CPWM comparator, ILIM comparator, oscillator, and output driver returning the MAX5052/MAX5053 to the startup mode.

MAX5052 Startup Operation

Normally V_{IN} is derived from a tertiary winding of the transformer. However, at startup there is no energy delivered through the transformer, hence, a special bootstrap sequence is required. Figure 2 shows the voltages on V_{IN} and V_{CC} during startup. Initially, both V_{IN} and V_{CC} are 0V. After the line voltage is applied, C1 charges through the startup resistor, R1, to an intermediate voltage. At this point, the internal regulator begins charging C2 (see Figure 1). The MAX5052 uses only 45µA of the current supplied by R1, and the remaining input current charges C1 and C2. The charging of C2 stops when the V_{CC} voltage reaches approximately 9.5V, while the voltage across C1 continues rising until it reaches the wake-up level of 21.6V. Once V_{IN} exceeds the bootstrap UVLO threshold, NDRV begins switching the MOSFET and transfers energy to the secondary and tertiary outputs. If the voltage on the tertiary output builds to higher than 9.9V (the bootstrap UVLO lower threshold), then startup has been accomplished and sustained operation commences.

Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

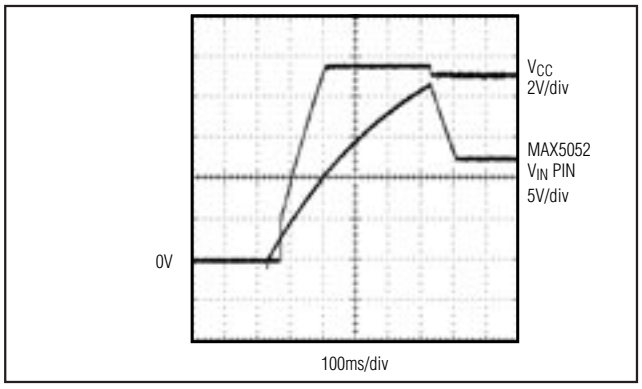


Figure 2. V_{IN} and V_{CC} During Startup when Using the MAX5052 in Bootstrapped Mode (Figure 1)

If V_{IN} drops below 9.9V before startup is complete, the device goes back to low-current UVLO. In this case, increase the value of C1 in order to store enough energy to allow for the voltage at tertiary winding to build up.

Startup Time Considerations For Power Supplies Using the MAX5052

The V_{IN} bypass capacitor, C1, supplies current immediately after wake up (see Figure 1). The size of C1 and the connection configuration of the tertiary winding determine the number of cycles available for startup. Large values of C1 increase the startup time but also supply gate charge for more cycles during initial startup. If the value of C1 is too small, V_{IN} drops below 9.9V because NDRV does not have enough time to switch and build up sufficient voltage across the tertiary output which powers the device. The device goes back into UVLO and does not start. Use a low-leakage capacitor for C1 and C2.

As a rule of thumb, offline power supplies keep typical startup times to less than 500ms even in low-line conditions (85VAC input for universal offline or 36VDC for telecom applications). Size the startup resistor, R1, to supply both the maximum startup bias of the device (90µA) and the charging current for C1 and C2. The bypass capacitor, C2, must charge to 9.5V and C1 to 24V, all within the desired time period of 500ms. Because of the internal 60ms soft-start time of the MAX5052, C1 must store enough charge to deliver current to the device for at least this much time. To calculate the approximate amount of capacitance required, use the following formula:

$$I_g = Q_{gtot} \times f_{SW}$$

$$C1 = \frac{(I_{IN} + I_g)(t_{SS})}{V_{hyst}}$$

where I_{IN} is the MAX5052's internal supply current after startup (1.4mA), Q_{gtot} is the total gate charge for Q1, f_{SW} is the MAX5052's switching frequency (262kHz), V_{hyst} is the bootstrap UVLO hysteresis (12V) and t_{ss} is the internal soft-start time (60ms).

For example:

$$I_g = (8nC)(262kHz) \cong 2.1mA$$

$$C1 = \frac{(1.4mA + 2.1mA)(60ms)}{(12V)} = 17.5\mu F$$

choose 15µF standard value.

Assuming C1 > C2, calculate the value of R1 as follows:

$$I_{C1} = \frac{V_{SUVR} \times C1}{(500ms)}$$

$$R1 = \frac{V_{IN(MIN)} - V_{SUVR}}{I_{C1} + I_{START}}$$

where $V_{IN(MIN)}$ is the minimum input supply voltage for the application (36V for telecom), V_{SUVR} is the bootstrap UVLO wake-up level (23.6V max.), I_{START} is the V_{IN} supply current at startup (90µA, max).

For example:

$$I_{C1} = \frac{(24V)(15\mu F)}{(500ms)} = 0.72mA$$

$$R1 = \frac{(36V) - (12V)}{(0.72mA) + (90\mu A)} = 29.6k\Omega$$

choose 32kΩ standard value.

Choose a higher value for R1 than the one calculated above if longer startup time can be tolerated in order to minimize power loss on this resistor.

The above startup method is applicable to a circuit similar to the one shown in Figure 1. In this circuit, the tertiary winding has the same phase as the output windings. Thus, the voltage on the tertiary winding at any given time is proportional to the output voltage and goes through the same soft-start period as the output voltage. The minimum discharge voltage of C1 from 22V to 10V must be greater than the soft-start time of 60ms.

Another method for bootstrapping the power supply is to have a separate bias winding than the one used for regulating the output voltage and to connect the bias winding so that it is in phase with the MOSFET ON time (see Figure 3). The amount of capacitance required is much

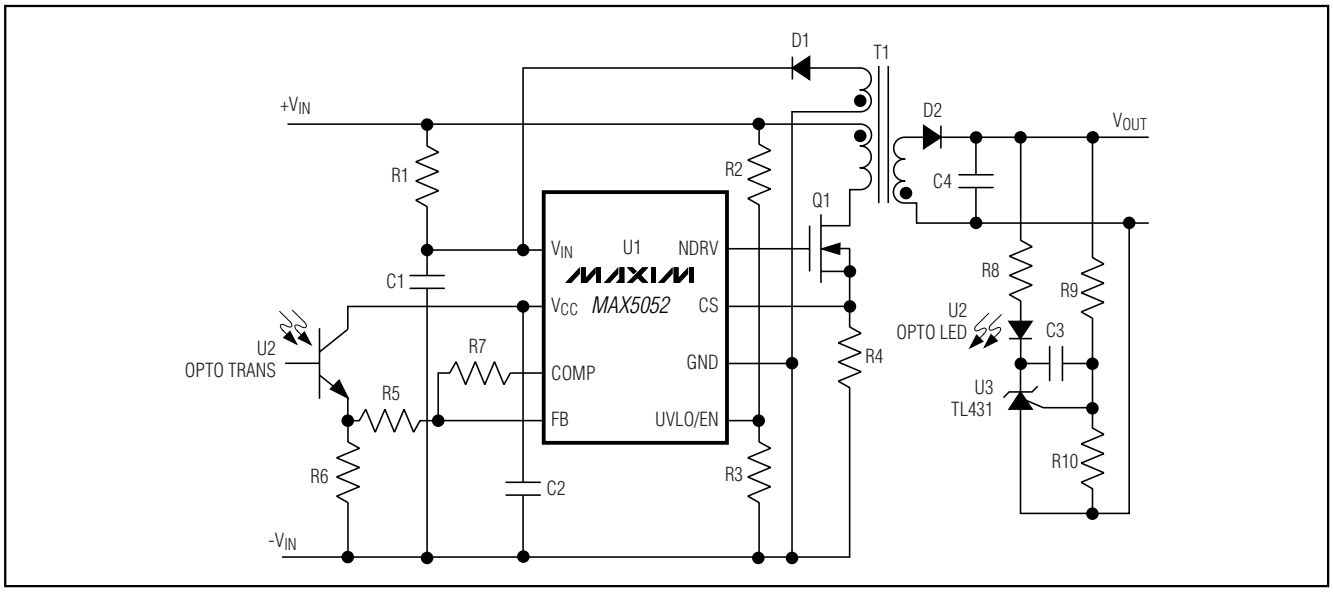


Figure 3. Secondary-Side Regulated, Isolated Power Supply

smaller. However, in this mode, the input voltage range has to be roughly 2:1. Another consideration is if the bias winding is in phase with the output, then the power supply hiccups and soft-start under output short-circuit conditions. Whereas, this property is lost if the bias winding is in phase with the MOSFET ON time.

Soft-Start

The MAX5052/MAX5053 soft-start feature allows the load voltage to ramp up in a controlled manner, eliminating output voltage overshoot. Soft-start begins after UVLO is deasserted. The voltage applied to the noninverting node of the amplifier ramps from 0 to 1.23V in over a 60ms soft-start timeout period. Figure 4 shows the 5V output of the power-supply circuit in Figure 5 during startup. Note the staircase increase of the output voltage. This is a result of the digital soft-starting technique used. Unlike other devices, the MAX5052/MAX5053 reference voltage to the internal amplifier is soft-started; this method results in superior control of the output voltage under heavy- and light-load conditions.

N-Channel MOSFET Switch Driver

The NDRV pin drives an external N-channel MOSFET. The NDRV output is supplied by the internal regulator (V_{CC}), which is internally set to approximately 9.5V. For the universal input voltage range, the MOSFET used must be able to withstand the DC level of the high-line input voltage plus the reflected voltage at the primary of the transformer. For most offline applications that use the discontinuous flyback topology, this requires a MOSFET rated at 600V. NDRV can source/sink in excess of the 650mA/1000mA peak current, so select a MOSFET that yields acceptable conduction and switching losses.

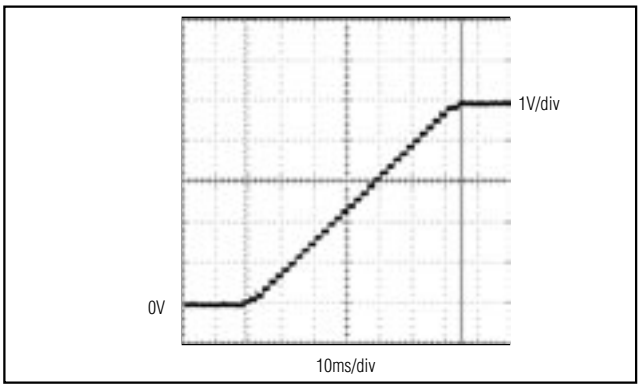


Figure 4. Output Voltage Soft-Start During Initial Startup for the Circuit of Figure 5

Internal Oscillator

The internal oscillator switches at 1.048MHz and is divided down to 262kHz by two D flip-flops. The MAX5052A/MAX5053A invert the Q output of the last D flip-flop to provide a duty cycle of 50% (Figure 6). The MAX5052B/MAX5053B perform a logic NAND operation on the Q outputs of both D flip-flops to provide a duty cycle of 75%.

Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

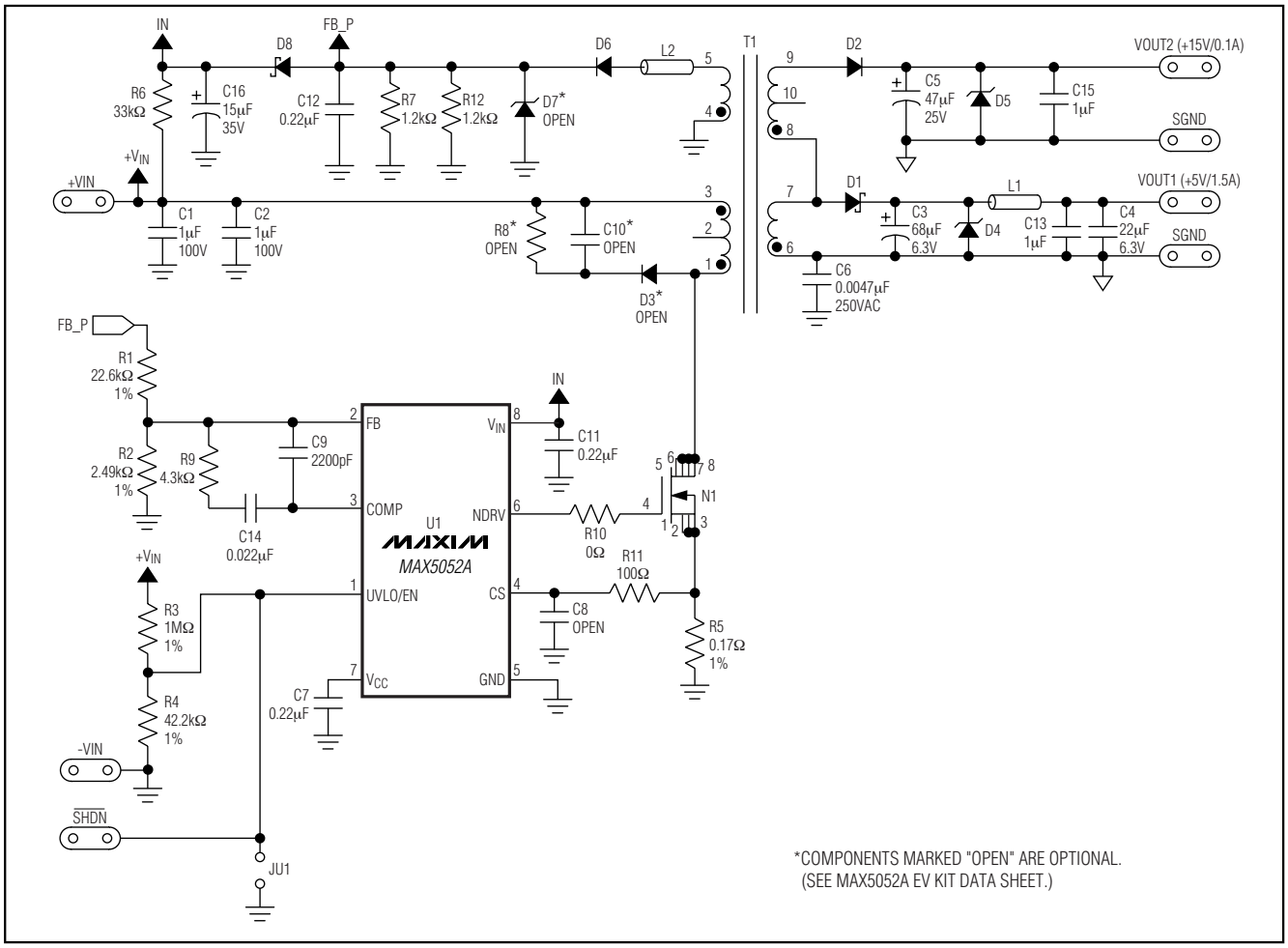


Figure 5. Primary Regulated, Dual-Output, Isolated Telecom Power Supply

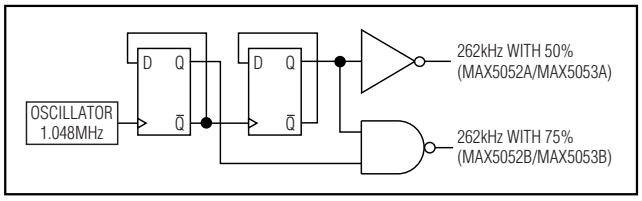


Figure 6. Internal Oscillator

Internal Error Amplifier

The MAX5052/MAX5053 include an internal error amplifier that can be used to regulate the output voltage in the case of a nonisolated power supply (see Figure 1) Calculate the output voltage using the following equation:

$$V_{OUT} = \left(1 + \frac{R5}{R6}\right) V_{REF}$$

where V_{REF} = 1.23V. The amplifier's noninverting input is internally connected to a digital soft-start circuit that gradually increases the reference voltage during start-up and is applied to this pin. This forces the output voltage to come up in an orderly and well-defined manner under all load conditions.

The error amplifier may also be used to regulate the tertiary winding output which implements a primary-side regulated, isolated power supply (see Figure 5). Calculate the output voltage using the following equation:

$$V_{OUT1} = \frac{N_S}{N_T}\left[\left(1 + \frac{R1}{R2}\right) V_{REF} + V_{D6}\right] - V_{D1}$$

where N_S is the number of secondary turns for V_{OUT1}, N_T is the number of tertiary winding turns, and both V_{D6} and V_{D1} are the diode drops at the respective outputs.

Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

Current Limit

The current-sense resistor (R_{CS}), connected between the source of the MOSFET and ground, sets the current limit. The CS input has a voltage-trip level (V_{CS}) of 291mV. Use the following equation to calculate the value of R_{CS}:

$$R_{CS} = \frac{V_{CS}}{I_{PRI}}$$

Where I_{PRI} is the peak current in the primary that flows through the MOSFET.

When the voltage produced by this current (through the current-sense resistor) exceeds the current-limit comparator threshold, the MOSFET driver (NDRV) quickly terminates the current ON-cycle, typically within 60ns. In most cases, a small RC filter is required to filter out the leading-edge spike on the sense waveform. Set the corner frequency at a few megahertz.

Applications Information

Primary Regulated, Isolated Telecom Power Supply

Figure 5 shows a complete design of a dual-output power supply with a telecom voltage range of 36V to 72V. An important aspect of this power supply is its primary-side regulation. This regulation, through the tertiary winding, also acts as bias winding for the MAX5052.

In the circuit of Figure 5, cross-regulation has been improved (tertiary and 5V outputs) by using chip inductors, L1 and L2, and R7||R2. R7||R2 presents enough loading on the tertiary winding output to allow ±5% load regulation on the 5V output over a load current range from 150mA to 1.5A.

Layout Recommendations

All printed circuit board traces carrying switching currents must be kept as short as possible, and the current loops they form must be minimized. The pins of the µMAX package have been placed to allow easy interfacing to the external MOSFET.

For universal AC input design, all applicable safety regulations must be followed. Offline power supplies may require UL, VDE, and other similar agency approvals. These agencies can be contacted for the latest layout and component rules.

Typically there are two sources of noise emission in a switching power supply: high di/dt loops and high dv/dt surfaces. For example, traces that carry the drain current often form high di/dt loops. Similarly, the heatsink of the MOSFET presents a dv/dt source, thus the surface area of the heatsink must be minimized as much as possible.

To achieve best performance, a star ground connection is recommended to avoid ground loops. For example, the ground returns for the power-line input filter, power MOSFET switch, and sense resistor should be routed separately through wide copper traces to meet at a single-system ground connection.

Chip Information

TRANSISTOR COUNT: 1449

PROCESS: BiCMOS

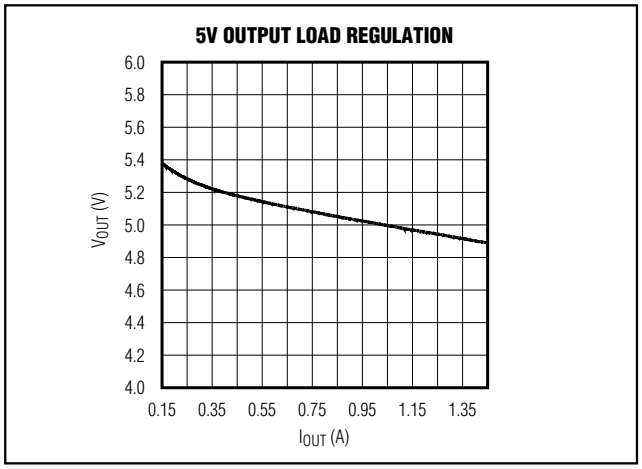


Figure 7. Output Voltage Regulation for the Figure 5 Circuit

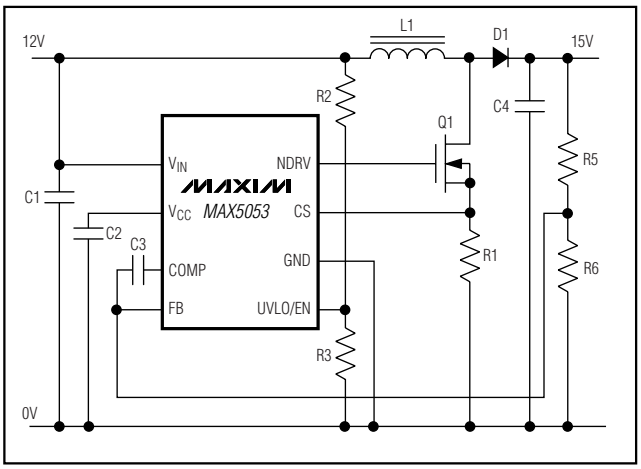
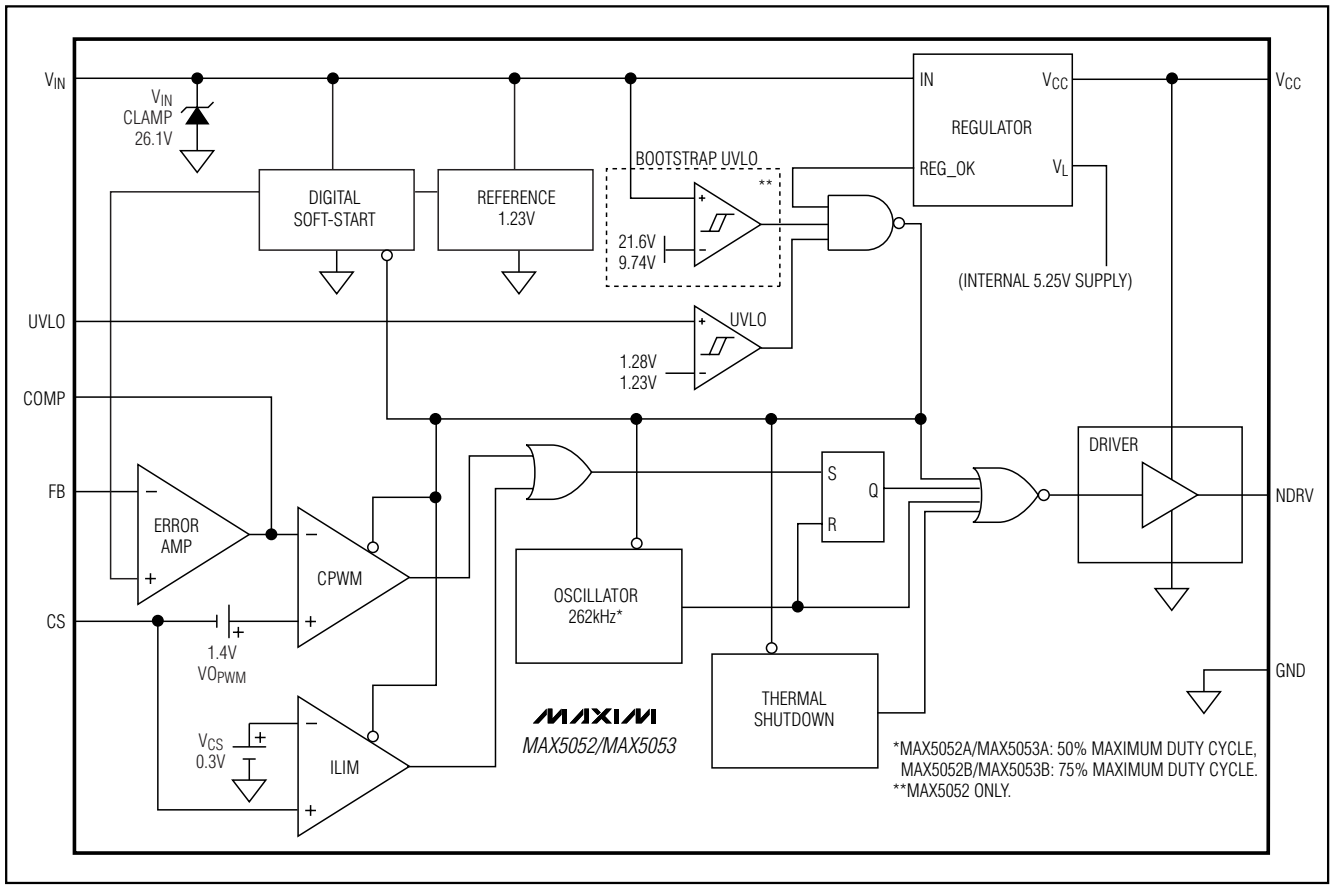


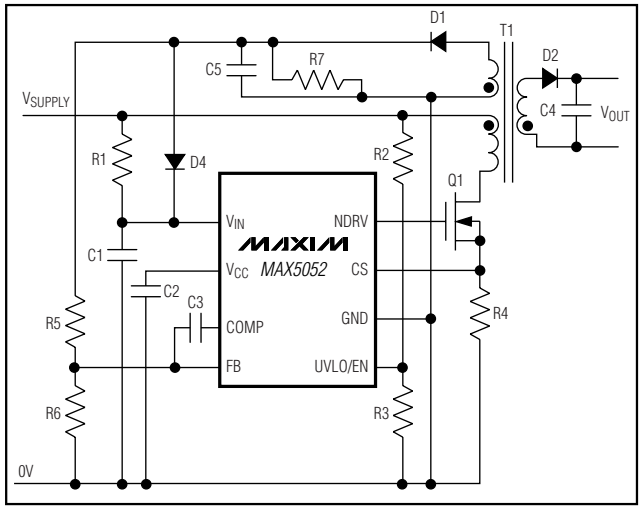
Figure 8. 12V to 15V Out Boost Regulator

Current-Mode PWM Controllers with an Error Amplifier for Isolated/Nonisolated Power Supplies

Functional Diagram



Typical Operating Circuit



Selector Guide

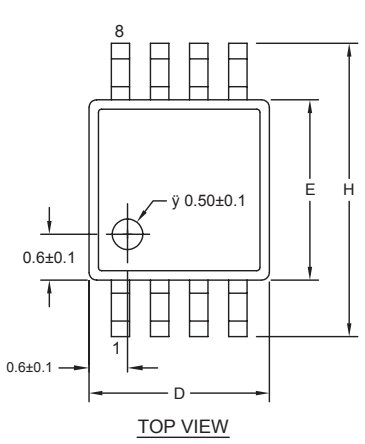
PART	BOOTSTRAP UVLO	STARTUP VOLTAGE	MAX DUTY CYCLE
MAX5052A	Yes	22V	50%
MAX5052B	Yes	22 V	75%
MAX5053A	No	10.8V*	50%
MAX5053B	No	10.8V*	75%

**The MAX5053 does not have an internal bootstrap UVLO. The MAX5053 starts operation as long as the V_{CC} pin is higher than 7V (the guaranteed output with a V_{IN} pin voltage of 10.8V) and the UVLO/EN pin is high.*

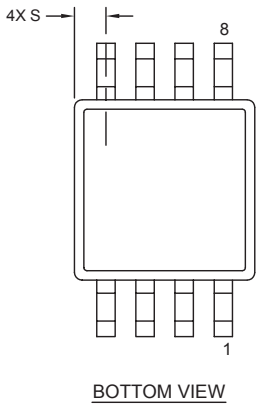
Package Information

(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**.)

8LUMAXD.EPS

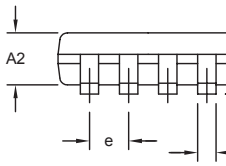


TOP VIEW

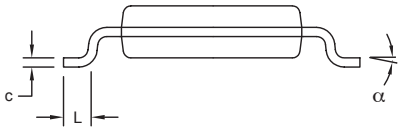


BOTTOM VIEW

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
b	0.010	0.014	0.25	0.36
c	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256 BSC		0.65 BSC	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0∞	6∞	0∞	6∞
S	0.0207 BSC		0.5250 BSC	



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. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187C-AA.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 8L uMAX/uSOP

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0036	J	1/1

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