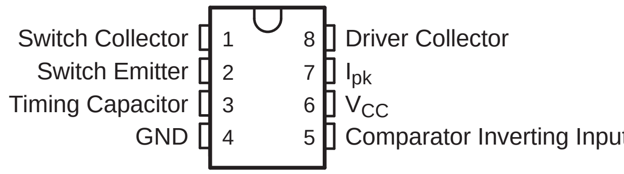
1.5-A PEAK BOOST/BUCK/INVERTING SWITCHING REGULATOR

FEATURES

- **Qualified for Automotive Applications**
- **Wide Input Voltage Range...3 V to 40 V**
- **High Output Switch Current...Up to 1.5 A**
- **Adjustable Output Voltage**
- **Oscillator Frequency...Up to 100 kHz**
- **Precision Internal Reference...2%**
- **Short-Circuit Current Limiting**
- **Low Standby Current**

D (SOIC) PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

The MC33063A is an easy-to-use IC containing all the primary circuitry needed for building simple dc-dc converters. The device primarily consists of an internal temperature-compensated reference, a comparator, an oscillator, a PWM controller with active current limiting, a driver, and a high-current output switch. Thus, the device requires minimal external components to build converters in the boost, buck, and inverting topologies.

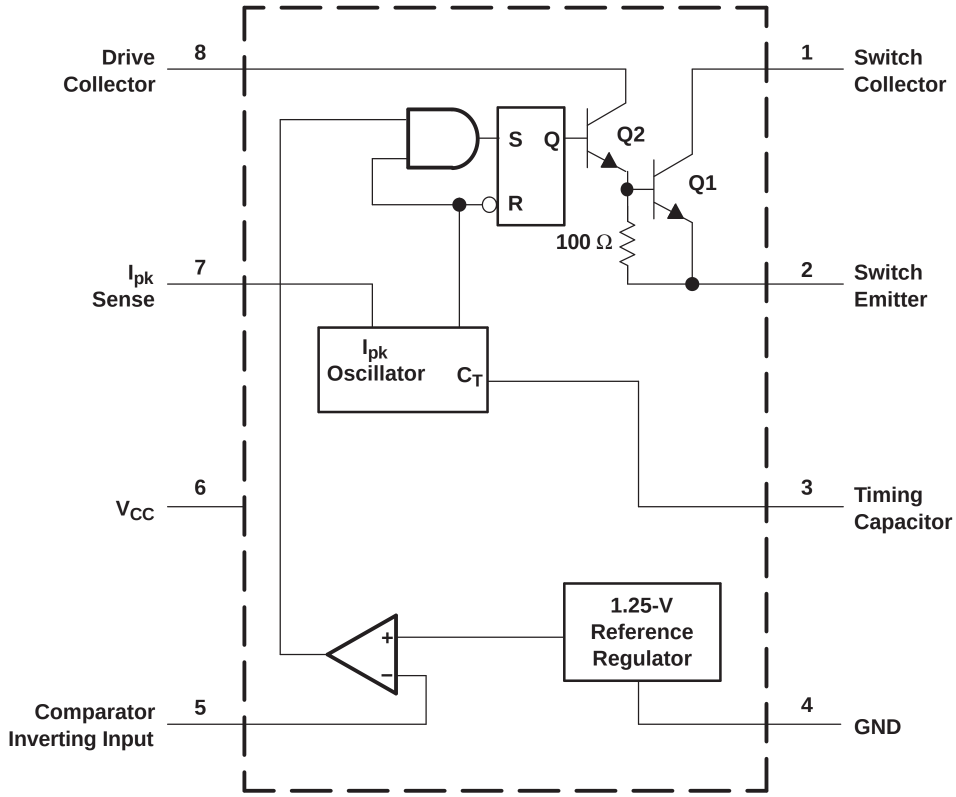
The MC33063A is characterized for operation from –40°C to 125°C.

ORDERING INFORMATION(1)

T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	SOIC – D	Reel of 2500	MC33063AQDRQ1	33063AQ

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

FUNCTIONAL BLOCK DIAGRAM



Absolute Maximum Ratings(1)

over operating free-air temperature range (unless otherwise noted)

V_{CC}	Supply voltage		40 V
V_{IR}	Comparator Inverting Input voltage range		–0.3 V to 40 V
$V_{C(switch)}$	Switch Collector voltage		40 V
$V_{E(switch)}$	Switch Emitter voltage	V_{PIN1} = 40 V	40 V
$V_{CE(switch)}$	Switch Collector to Switch Emitter voltage		40 V
$V_{C(driver)}$	Driver Collector voltage		40 V
$I_{C(driver)}$	Driver Collector current		100 mA
I_{SW}	Switch current		1.5 A
θ_{JA}	Package thermal impedance(2)(3)		97°C/W
T_J	Operating virtual junction temperature		150°C
T_{stg}	Storage temperature range		–65°C to 150°C

(1) 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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(3) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions

		MIN	MAX	UNIT
V_{CC}	Supply voltage	3	40	V
T_A	Operating free-air temperature	–40	125	°C

Electrical Characteristics

V_{CC} = 5 V, T_A = full operating range (unless otherwise noted) (see block diagram)

Oscillator

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
f_{osc}	Oscillator frequency	V_{PIN5} = 0 V, C_T = 1 nF	25°C	24	33	42	kHz
I_{chg}	Charge current	V_{CC} = 5 V to 40 V	25°C	24	35	42	µA
I_{dischg}	Discharge current	V_{CC} = 5 V to 40 V	25°C	140	220	260	µA
I_{dischg}/I_{chg}	Discharge-to-charge current ratio	$V_{PIN7} = V_{CC}$	25°C	5.2	6.5	7.5	
V_{Ipk}	Current-limit sense voltage	$I_{dischg} = I_{chg}$	25°C	250	300	350	mV

Output Switch(1)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
$V_{CE(sat)}$	Saturation voltage – Darlington connection	I_{SW} = 1 A, pins 1 and 8 connected	Full range		1	1.3	V
$V_{CE(sat)}$	Saturation voltage – non-Darlington connection(2)	I_{SW} = 1 A, R_{PIN8} = 82 Ω to V_{CC}, Forced β ~ 20	Full range		0.45	0.7	V
h_{FE}	DC current gain	I_{SW} = 1 A, V_{CE} = 5 V	25°C	50	75		
$I_{C(off)}$	Collector off-state current	V_{CE} = 40 V	Full range		0.01	100	µA

(1) Low duty-cycle pulse testing is used to maintain junction temperature as close to ambient temperature as possible.
(2) In the non-Darlington configuration, if the output switch is driven into hard saturation at low switch currents (≤300 mA) and high driver currents (≥30 mA), it may take up to 2 µs for the switch to come out of saturation. This condition effectively shortens the off time at frequencies ≥30 kHz, becoming magnified as temperature increases. The following output drive condition is recommended in the non-Darlington configuration:
Forced β of output switch = $I_{C,SW}$ / ($I_{C,driver}$ – 7 mA) ≥ 10, where ~7 mA is required by the 100-Ω resistor in the emitter of the driver to forward bias the V_{be} of the switch.

Comparator

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_{th}	Threshold voltage		25°C	1.225	1.25	1.275	V
			Full range	1.21		1.29	
ΔV_{th}	Threshold-voltage line regulation	V_{CC} = 5 V to 40 V	Full range		1.4	5	mV
I_{IB}	Input bias current	V_{IN} = 0 V	Full range		–20	–400	nA

Total Device

PARAMETER		TEST CONDITIONS	T_A	MIN	MAX	UNIT
I_{CC}	Supply current	V_{CC} = 5 V to 40 V, C_T = 1 nF, $V_{PIN7} = V_{CC}$, $V_{PIN5} > V_{th}$, V_{PIN2} = GND, All other pins open	Full range		4	mA

TYPICAL CHARACTERISTICS

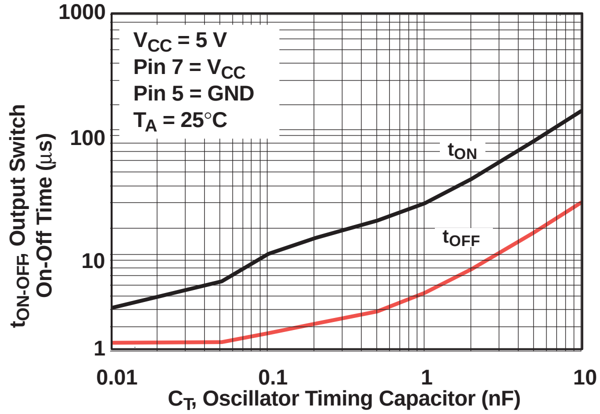


Figure 1. Output Switch On-Off Time vs Oscillator Timing Capacitor

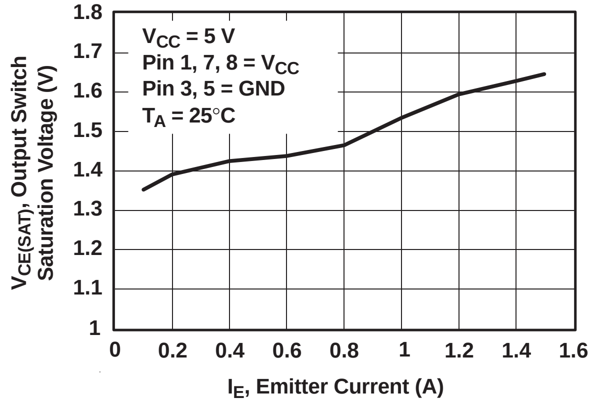


Figure 2. Output Switch Saturation Voltage vs Emitter Current (Emitter-Follower Configuration)

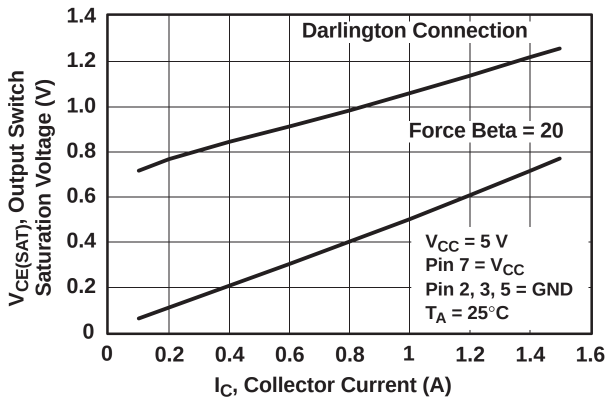


Figure 3. Output Switch Saturation Voltage vs Collector Current (Common-Emitter Configuration)

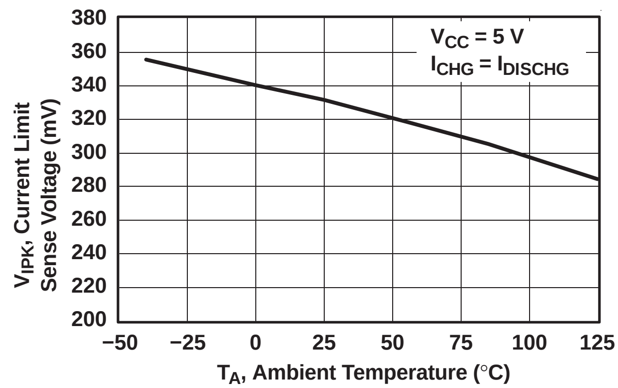


Figure 4. Current-Limit Sense Voltage vs Temperature

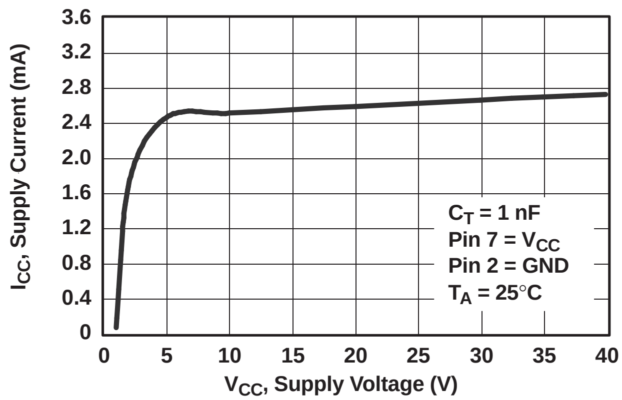


Figure 5. Standby Supply Current vs Supply Voltage

TYPICAL CHARACTERISTICS (continued)

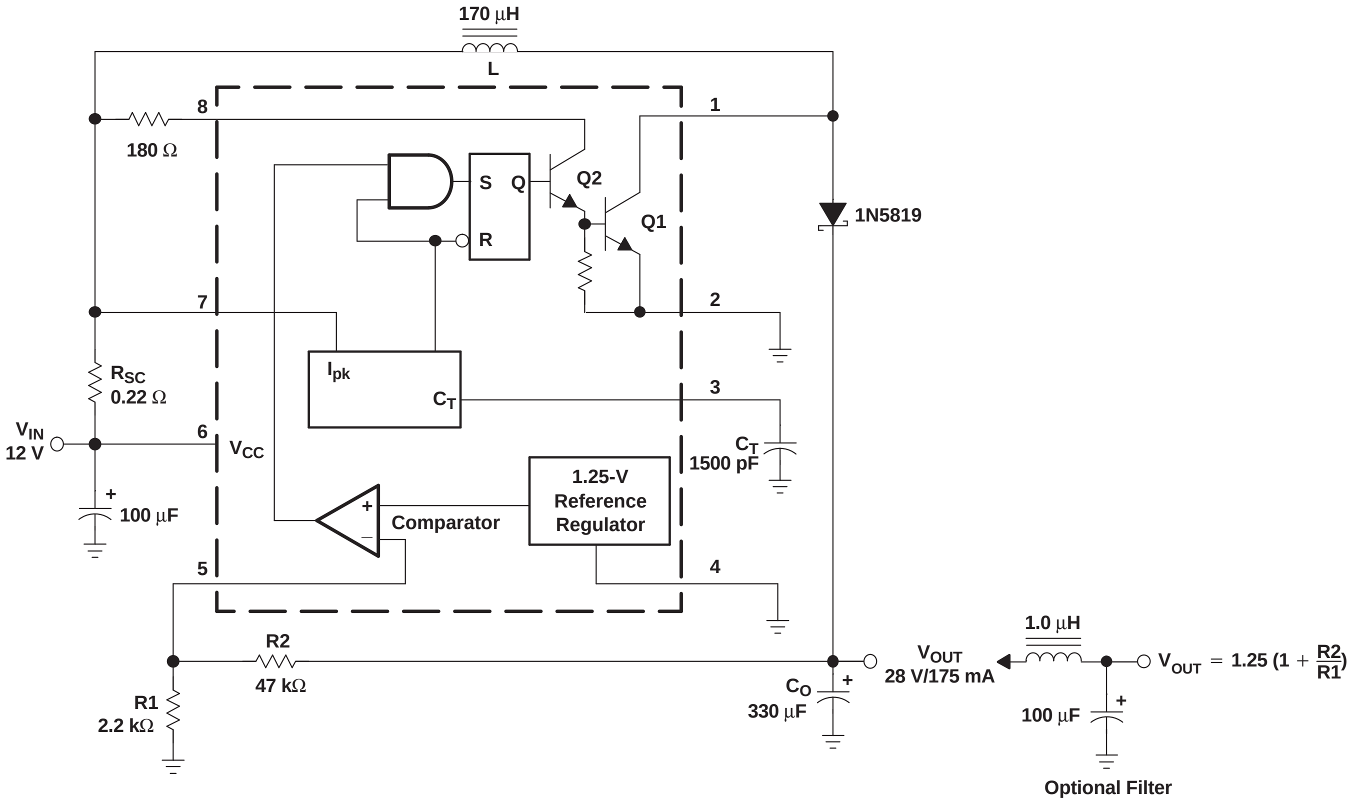
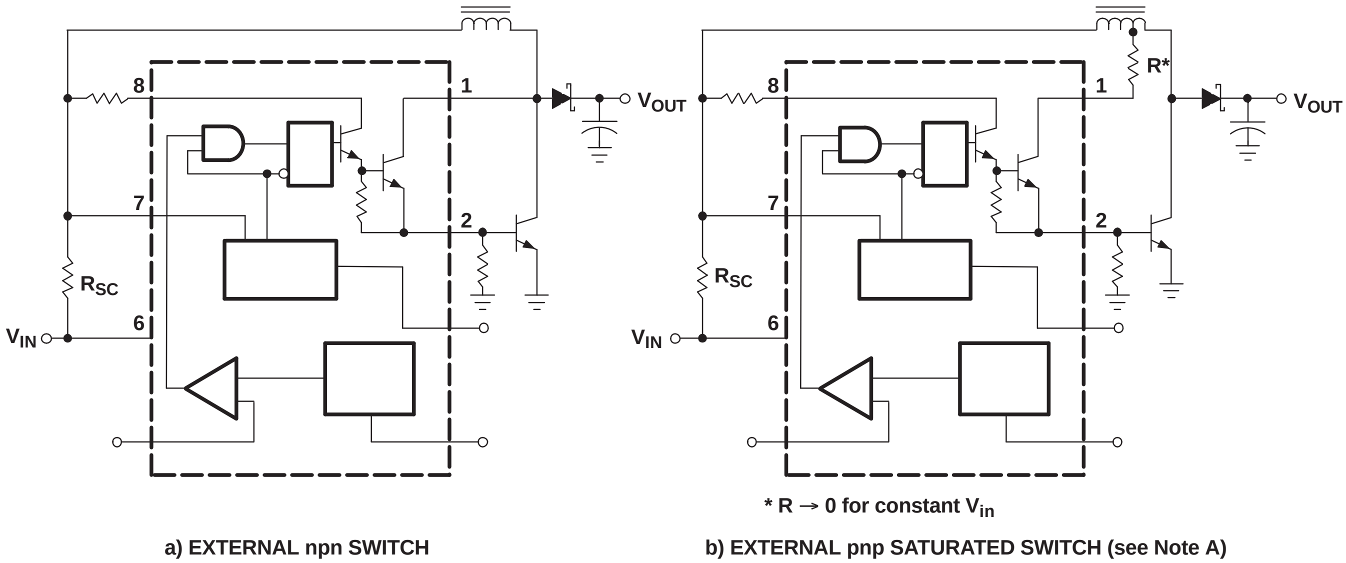


Figure 6. Step-Up Converter

TEST	CONDITIONS	RESULTS
Line regulation	V_{IN} = 8 V to 16 V, I_O = 175 mA	30 mV ± 0.05%
Load regulation	V_{IN} = 12 V, I_O = 75 mA to 175 mA	10 mV ± 0.017%
Output ripple	V_{IN} = 12 V, I_O = 175 mA	400 mV_{PP}
Efficiency	V_{IN} = 12 V, I_O = 175 mA	87.7%
Output ripple with optional filter	V_{IN} = 12 V, I_O = 175 mA	40 mV_{PP}



A. If the output switch is driven into hard saturation (non-Darlington configuration) at low switch currents (≤300 mA) and high driver currents (≥30 mA), it may take up to 2 µs to come out of saturation. This condition will shorten the off time at frequencies ≥30 kHz and is magnified at high temperatures. This condition does not occur with a Darlington configuration because the output switch cannot saturate. If a non-Darlington configuration is used, the output drive configuration in Figure 7b is recommended.

Figure 7. External Current-Boost Connections for I_C Peak Greater Than 1.5 A

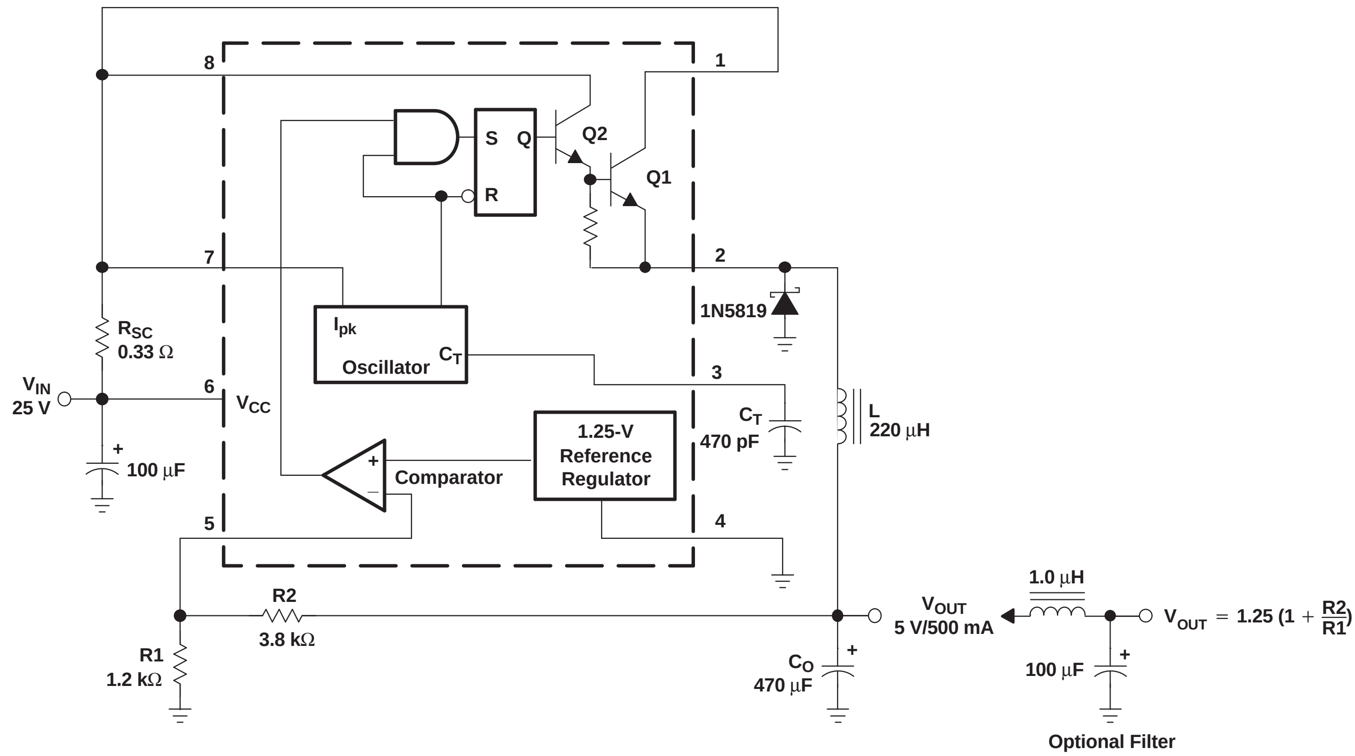
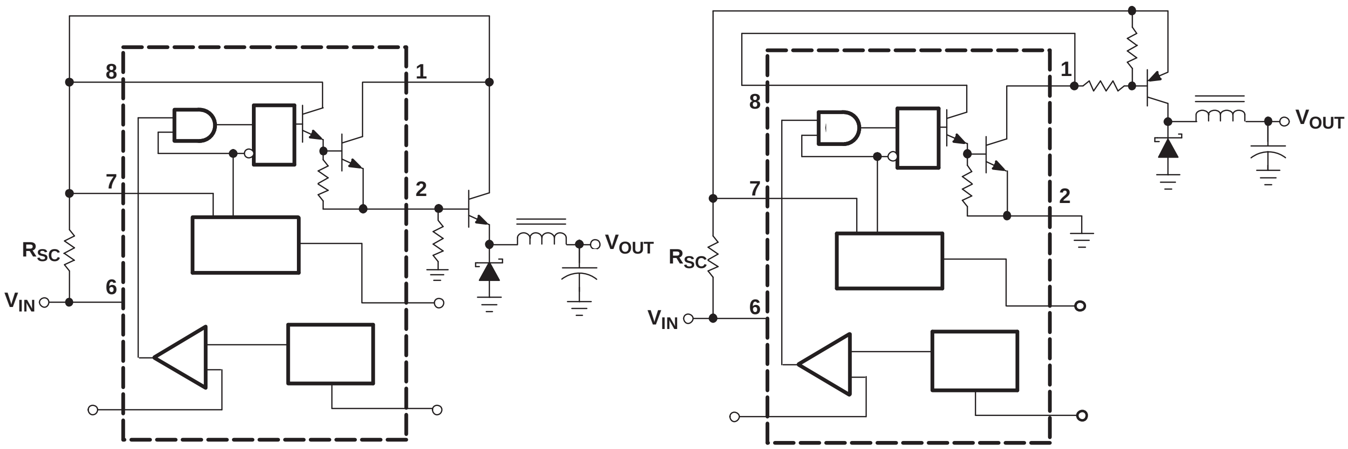


Figure 8. Step-Down Converter

TEST	CONDITIONS	RESULTS
Line regulation	V_{IN} = 15 V to 25 V, I_O = 500 mA	12 mV ± 0.12%
Load regulation	V_{IN} = 25 V, I_O = 50 mA to 500 mA	3 mV ± 0.03%
Output ripple	V_{IN} = 25 V, I_O = 500 mA	120 mV_{PP}
Short-circuit current	V_{IN} = 25 V, R_L = 0.1 Ω	1.1 A
Efficiency	V_{IN} = 25 V, I_O = 500 mA	83.7%
Output ripple with optional filter	V_{IN} = 25 V, I_O = 500 mA	40 mV_{PP}



a) EXTERNAL npn SWITCH

b) EXTERNAL pnp SATURATED SWITCH

Figure 9. External Current-Boost Connections for I_C Peak Greater Than 1.5 A

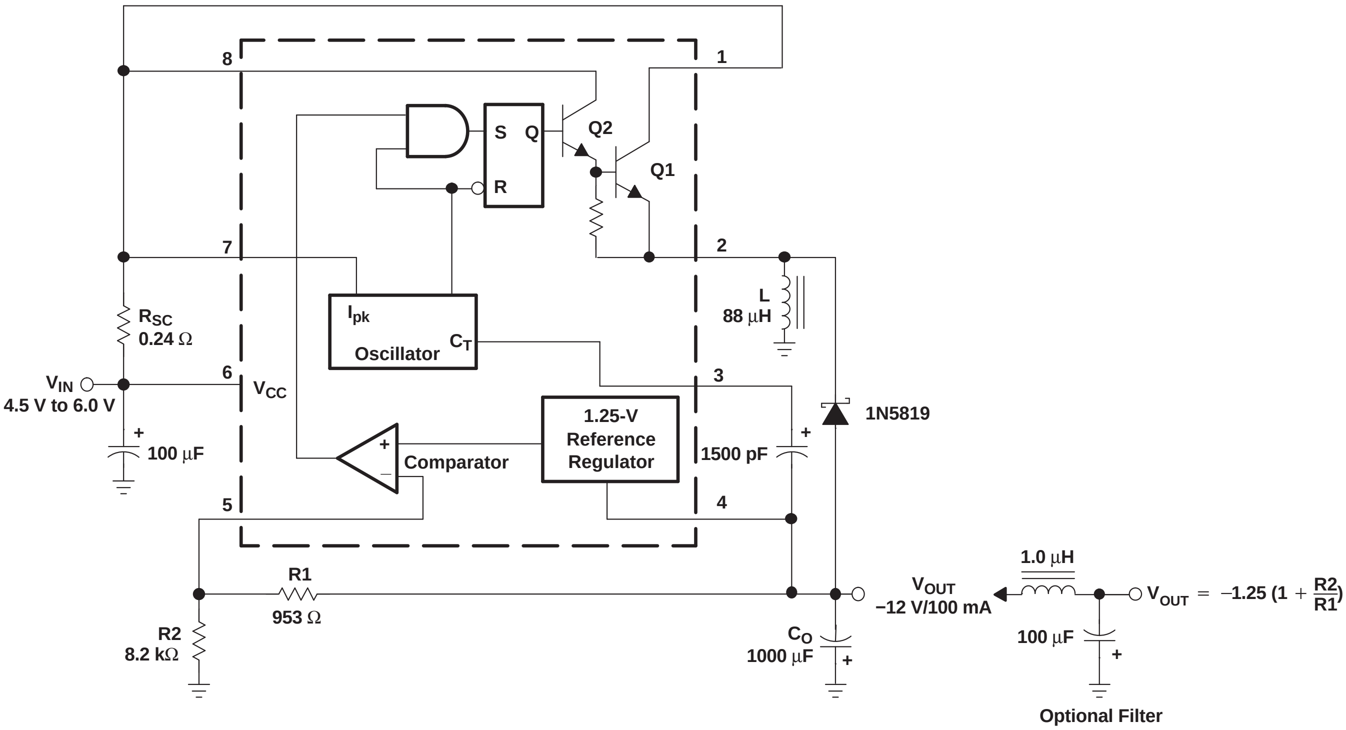
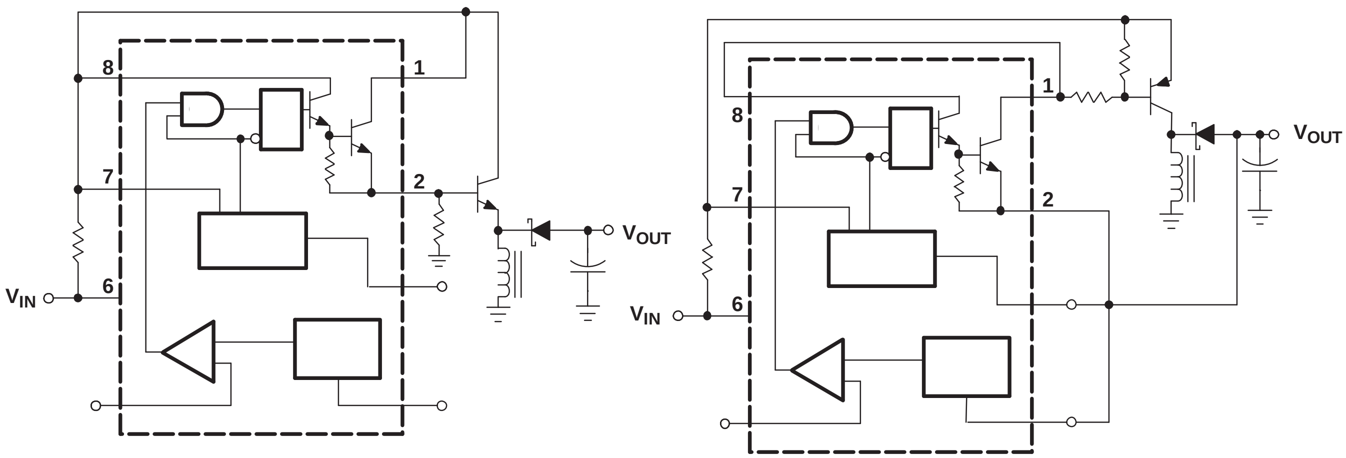


Figure 10. Voltage-Inverting Converter

TEST	CONDITIONS	RESULTS
Line regulation	V_{IN} = 4.5 V to 6 V, I_O = 100 mA	3 mV ± 0.12%
Load regulation	V_{IN} = 5 V, I_O = 10 mA to 100 mA	0.022 V ± 0.09%
Output ripple	V_{IN} = 5 V, I_O = 100 mA	500 mV_{PP}
Short-circuit current	V_{IN} = 5 V, R_L = 0.1 Ω	910 mA
Efficiency	V_{IN} = 5 V, I_O = 100 mA	62.2%
Output ripple with optional filter	V_{IN} = 5 V, I_O = 100 mA	70 mV_{PP}



a) EXTERNAL npn SWITCH

b) EXTERNAL pnp SATURATED SWITCH

Figure 11. External Current-Boost Connections for I_C Peak Greater Than 1.5 A

APPLICATION INFORMATION

CALCULATION	STEP UP	STEP DOWN	VOLTAGE INVERTING
t_{on}/t_{off}	$\frac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$	$\frac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$	$\frac{\lvert V_{out}\rvert + V_F}{V_{in} - V_{sat}}$
$(t_{on} + t_{off})$	$\frac{1}{f}$	$\frac{1}{f}$	$\frac{1}{f}$
t_{off}	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$
t_{on}	$(t_{on} + t_{off}) - t_{off}$	$(t_{on} + t_{off}) - t_{off}$	$(t_{on} + t_{off}) - t_{off}$
C_T	$4 \times 10^{-5}\ t_{on}$	$4 \times 10^{-5}\ t_{on}$	$4 \times 10^{-5}\ t_{on}$
$I_{pk(switch)}$	$2I_{out(max)}\left(\frac{t_{on}}{t_{off}} + 1\right)$	$2I_{out(max)}$	$2I_{out(max)}\left(\frac{t_{on}}{t_{off}} + 1\right)$
R_{SC}	$\frac{0.3}{I_{pk(switch)}}$	$\frac{0.3}{I_{pk(switch)}}$	$\frac{0.3}{I_{pk(switch)}}$
$L_{(min)}$	$\left(\frac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}}\right)t_{on(max)}$	$\left(\frac{(V_{in(min)} - V_{sat} - V_{out})}{I_{pk(switch)}}\right)t_{on(max)}$	$\left(\frac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}}\right)t_{on(max)}$
C_O	$9\ \frac{I_{out}t_{on}}{V_{ripple(pp)}}$	$\frac{I_{pk(switch)}(t_{on} + t_{off})}{8V_{ripple(pp)}}$	$9\ \frac{I_{out}t_{on}}{V_{ripple(pp)}}$

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
MC33063AQDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

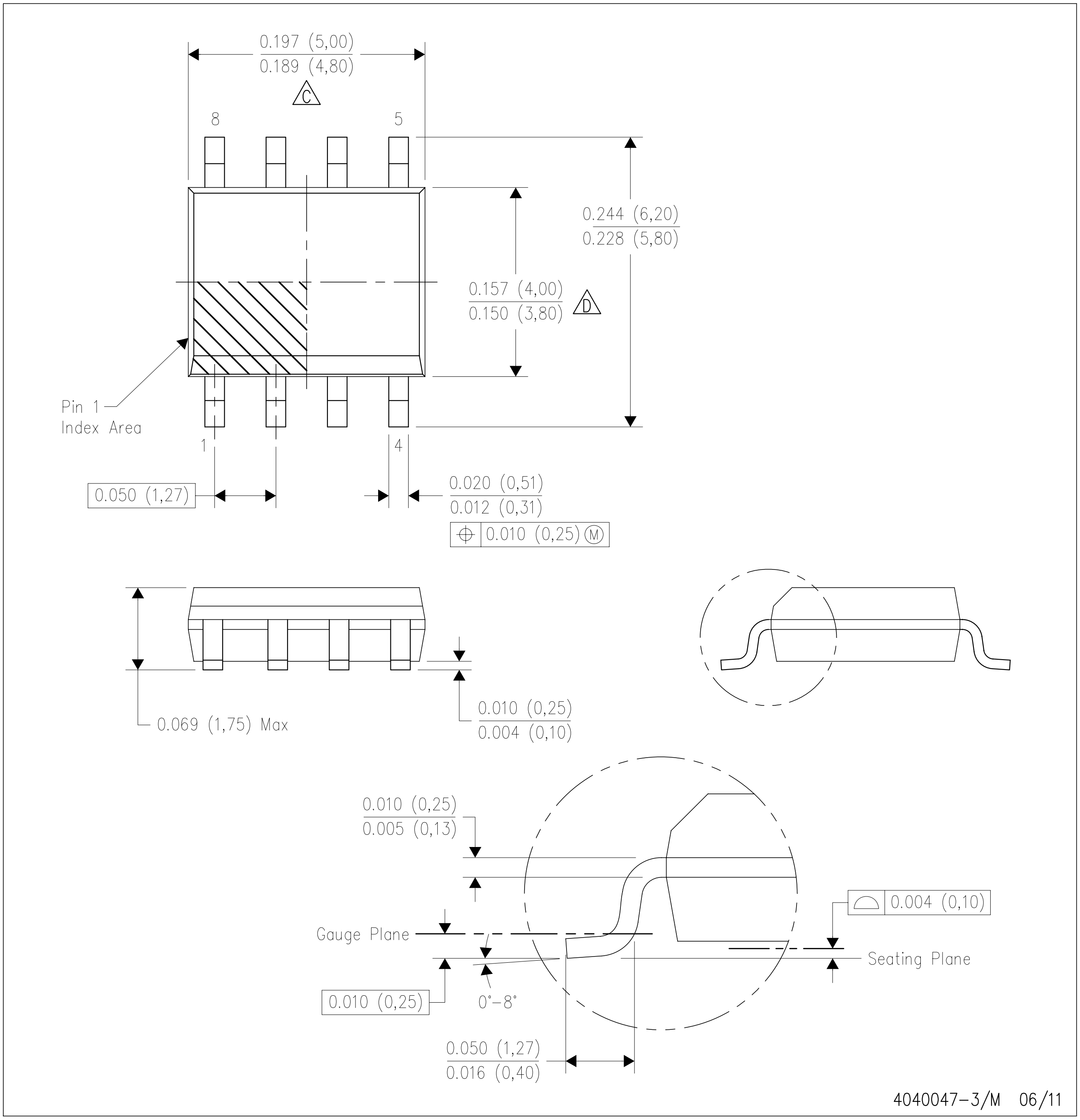
OTHER QUALIFIED VERSIONS OF MC33063A-Q1 :

- Catalog: MC33063A

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AA.