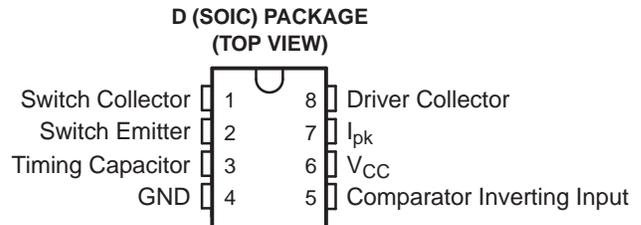


1.5-A PEAK BOOST/BUCK/INVERTING SWITCHING REGULATOR

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



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⁾

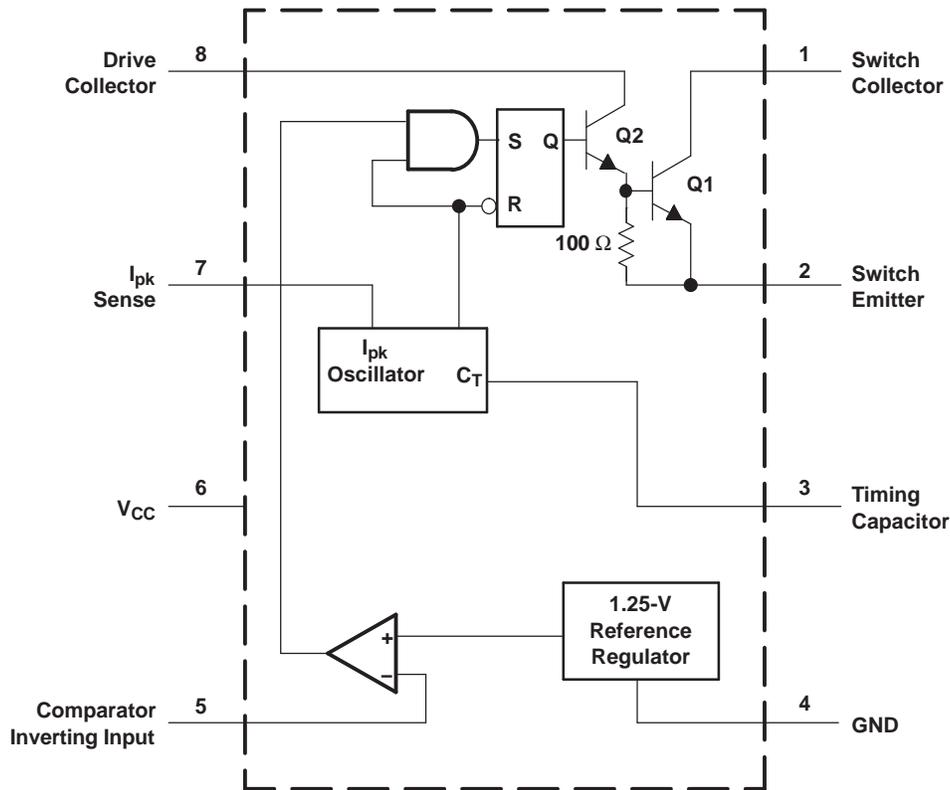
T_A	PACKAGE ⁽²⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 125°C	SOIC – D	Reel of 2500	MC33063AQDRQ1	33063AQ

- (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.



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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	$V_{PIN1} = 40 V$
$V_{CE(switch)}$	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

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

Oscillator

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
f_{osc}	Oscillator frequency	$V_{PIN5} = 0\text{ V}$, $C_T = 1\text{ nF}$	25°C	24	33	42	kHz
I_{chg}	Charge current	$V_{CC} = 5\text{ V to }40\text{ V}$	25°C	24	35	42	μA
I_{dischg}	Discharge current	$V_{CC} = 5\text{ V to }40\text{ V}$	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	$I_{SW} = 1\text{ A}$, pins 1 and 8 connected	Full range		1	1.3	V
$V_{CE(sat)}$	Saturation voltage – non-Darlington connection ⁽²⁾	$I_{SW} = 1\text{ A}$, $R_{PIN8} = 82\ \Omega$ to V_{CC} , Forced $\beta \sim 20$	Full range		0.45	0.7	V
h_{FE}	DC current gain	$I_{SW} = 1\text{ A}$, $V_{CE} = 5\text{ V}$	25°C	50	75		
$I_{C(off)}$	Collector off-state current	$V_{CE} = 40\text{ V}$	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 ($\leq 300\text{ mA}$) and high driver currents ($\geq 30\text{ mA}$), it may take up to $2\ \mu\text{s}$ for the switch to come out of saturation. This condition effectively shortens the off time at frequencies $\geq 30\text{ kHz}$, becoming magnified as temperature increases. The following output drive condition is recommended in the non-Darlington configuration:

Forced β of output switch = $I_{C,SW} / (I_{C,driver} - 7\text{ mA}) \geq 10$, where -7 mA is required by the $100\text{-}\Omega$ 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	$V_{CC} = 5\text{ V to }40\text{ V}$	Full range		1.4	5	mV
I_{IB}	Input bias current	$V_{IN} = 0\text{ V}$	Full range		-20	-400	nA

Total Device

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

TYPICAL CHARACTERISTICS

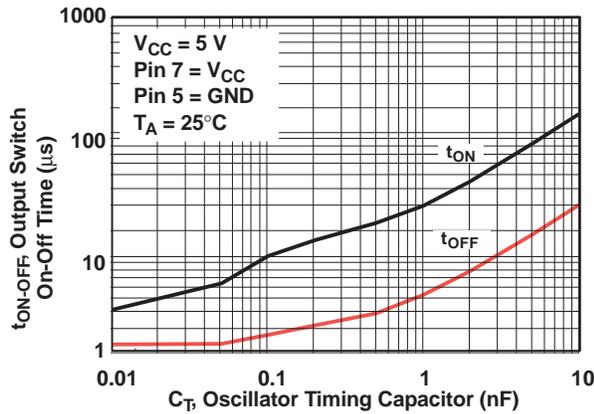


Figure 1. Output Switch On-Off Time vs Oscillator Timing Capacitor

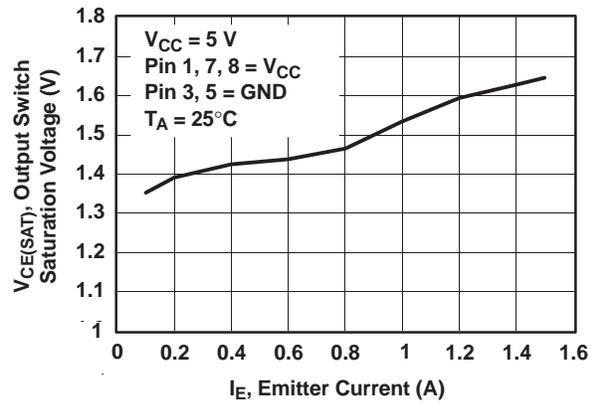


Figure 2. Output Switch Saturation Voltage vs Emitter Current (Emitter-Follower Configuration)

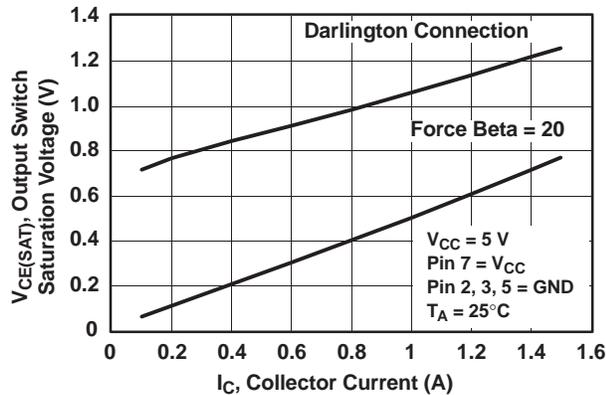


Figure 3. Output Switch Saturation Voltage vs Collector Current (Common-Emitter Configuration)

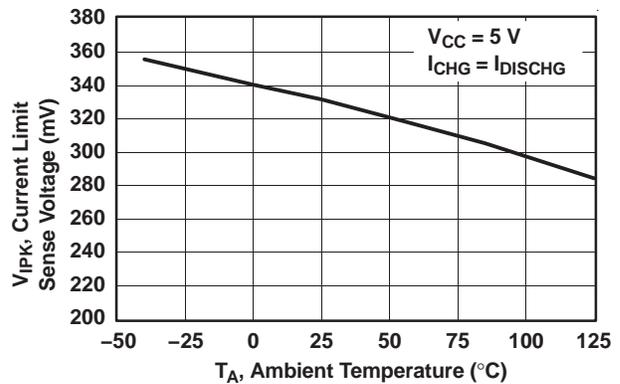


Figure 4. Current-Limit Sense Voltage vs Temperature

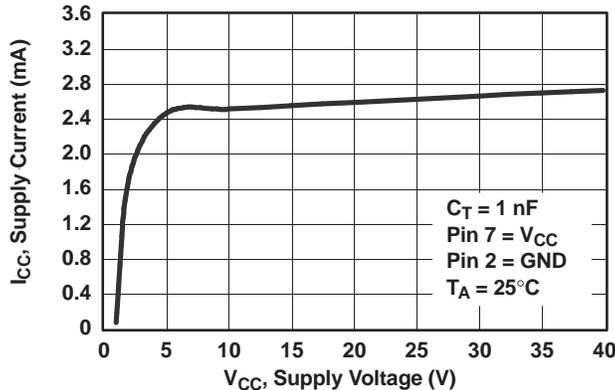


Figure 5. Standby Supply Current vs Supply Voltage

TYPICAL CHARACTERISTICS (continued)

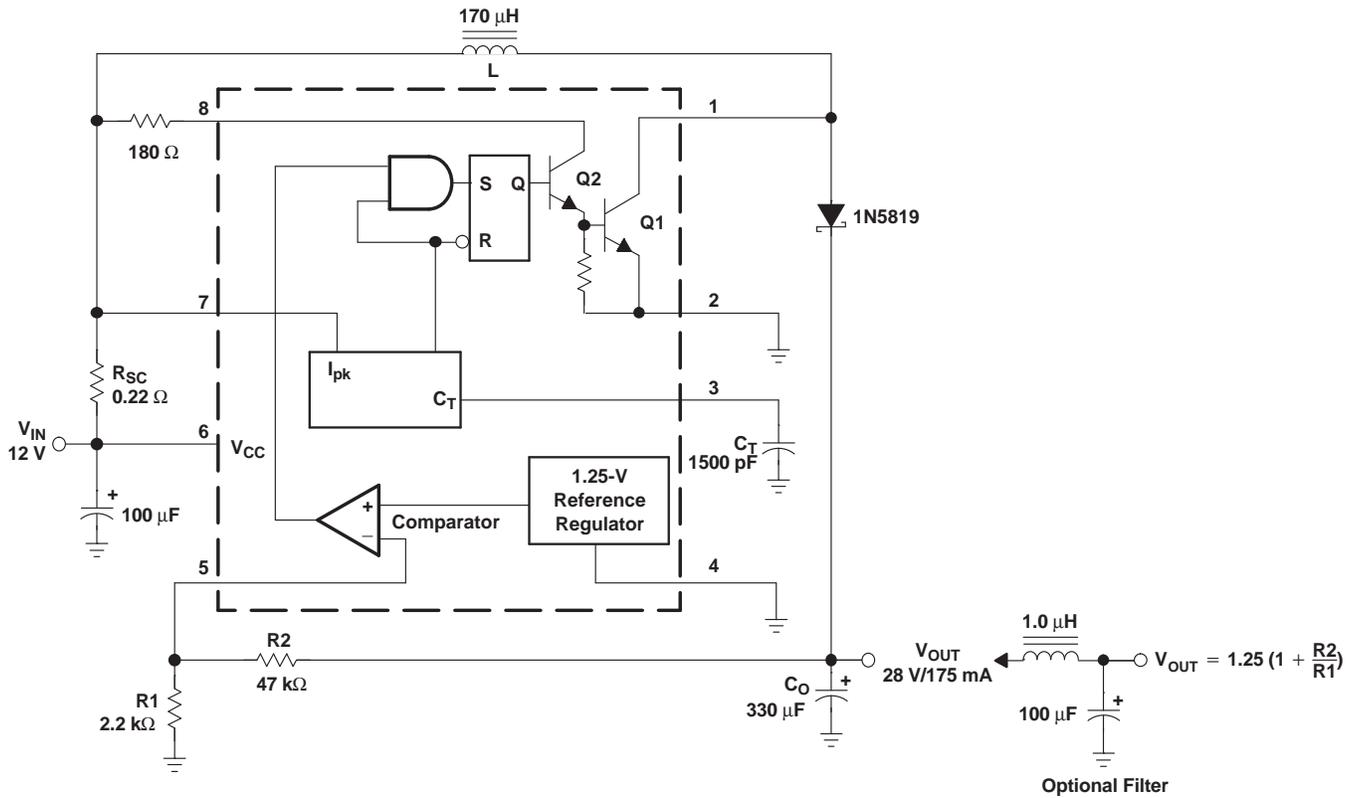
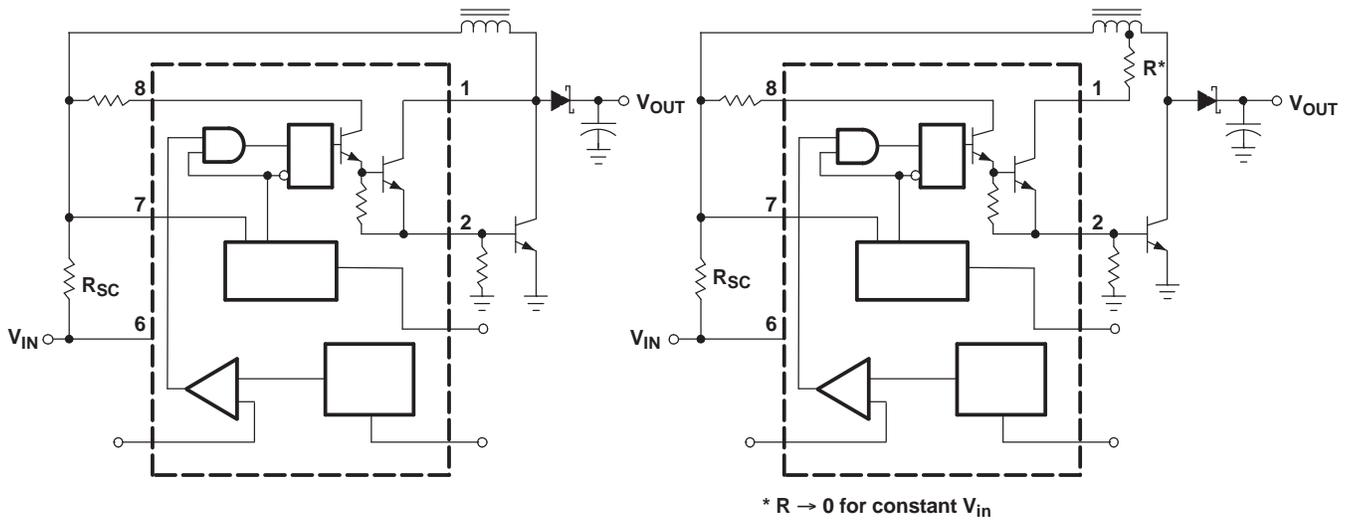


Figure 6. Step-Up Converter

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



a) EXTERNAL npn SWITCH

b) EXTERNAL pnp SATURATED SWITCH (see Note A)

- 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 $2 \mu\text{s}$ 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

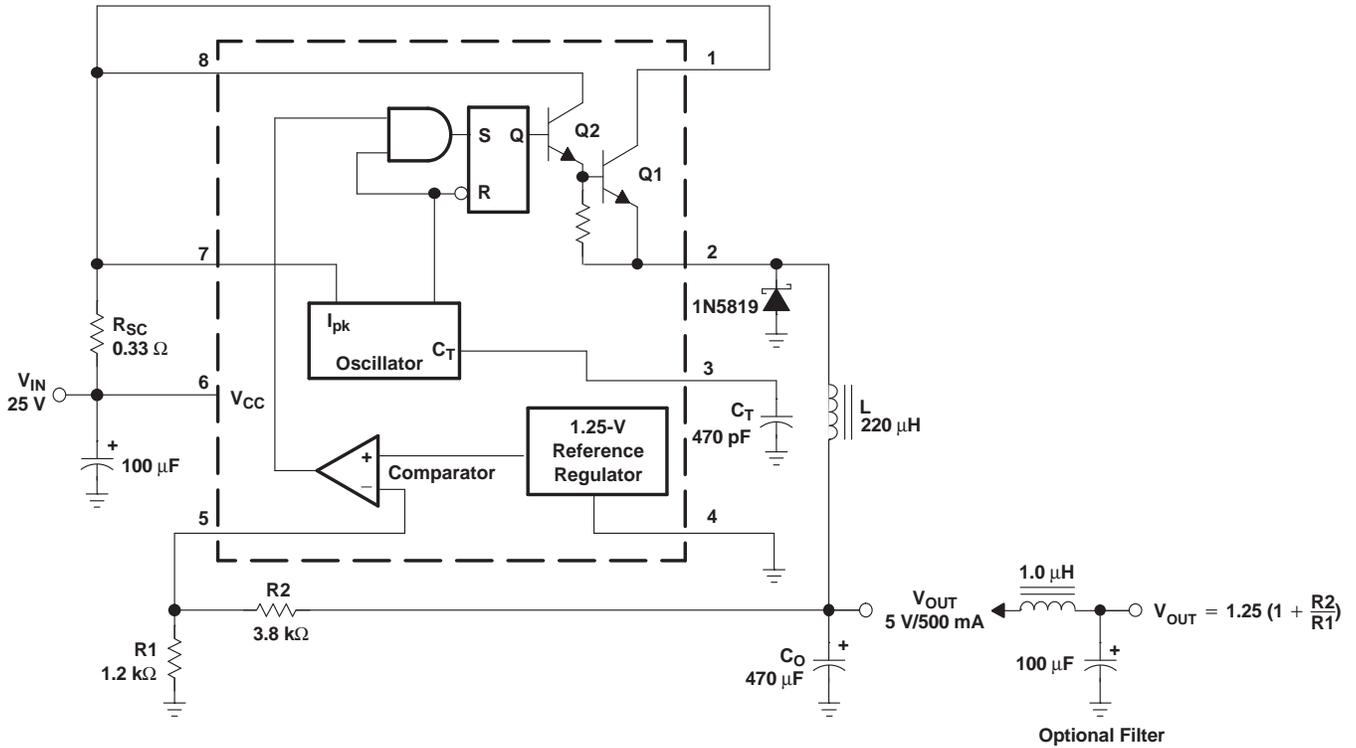


Figure 8. Step-Down Converter

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

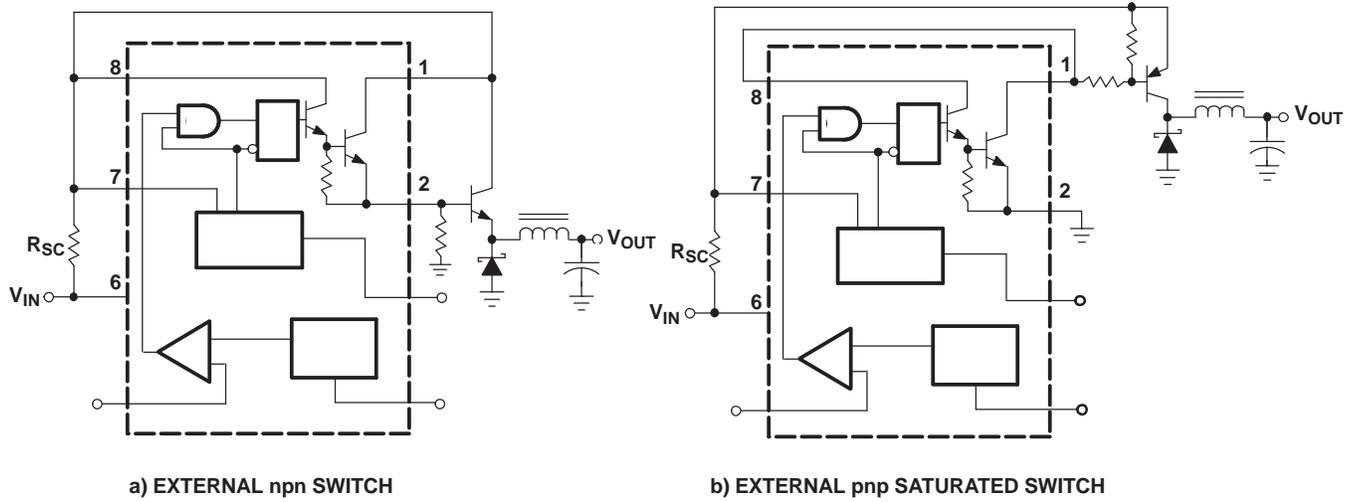


Figure 9. External Current-Boost Connections for I_C Peak Greater Than 1.5 A

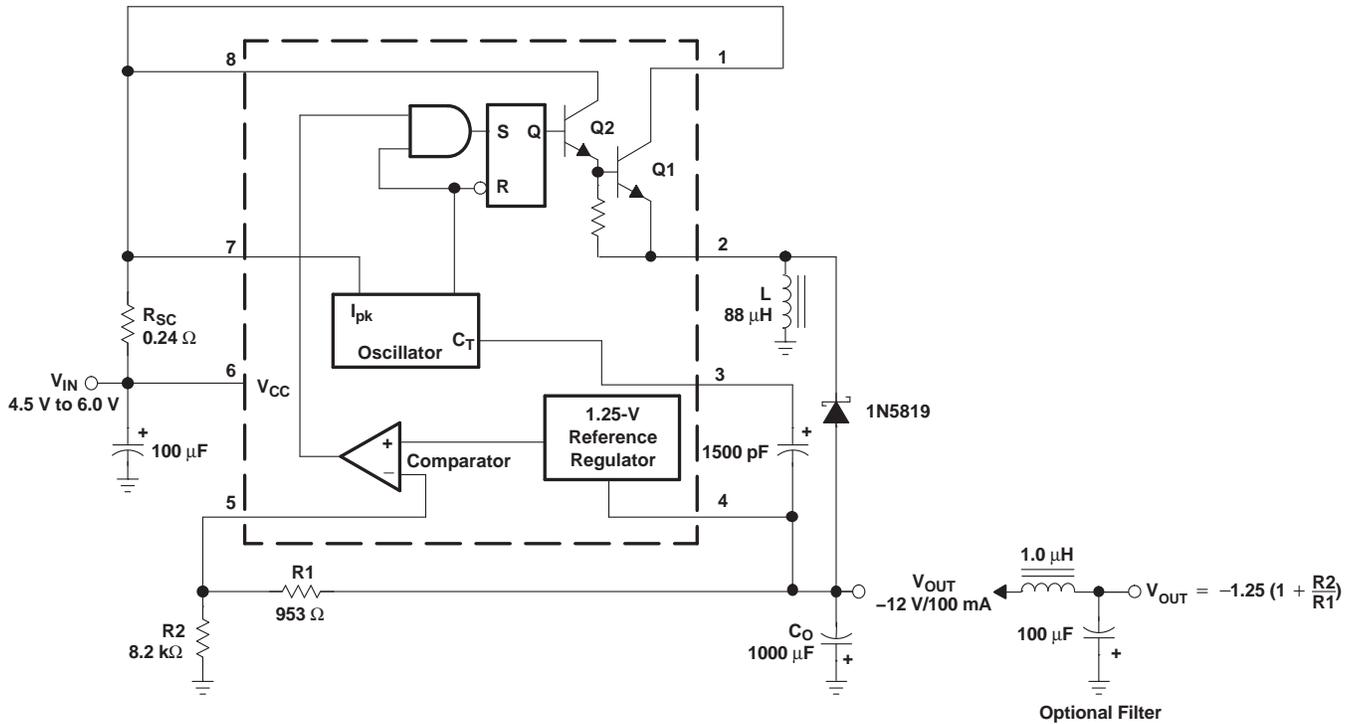


Figure 10. Voltage-Inverting Converter

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

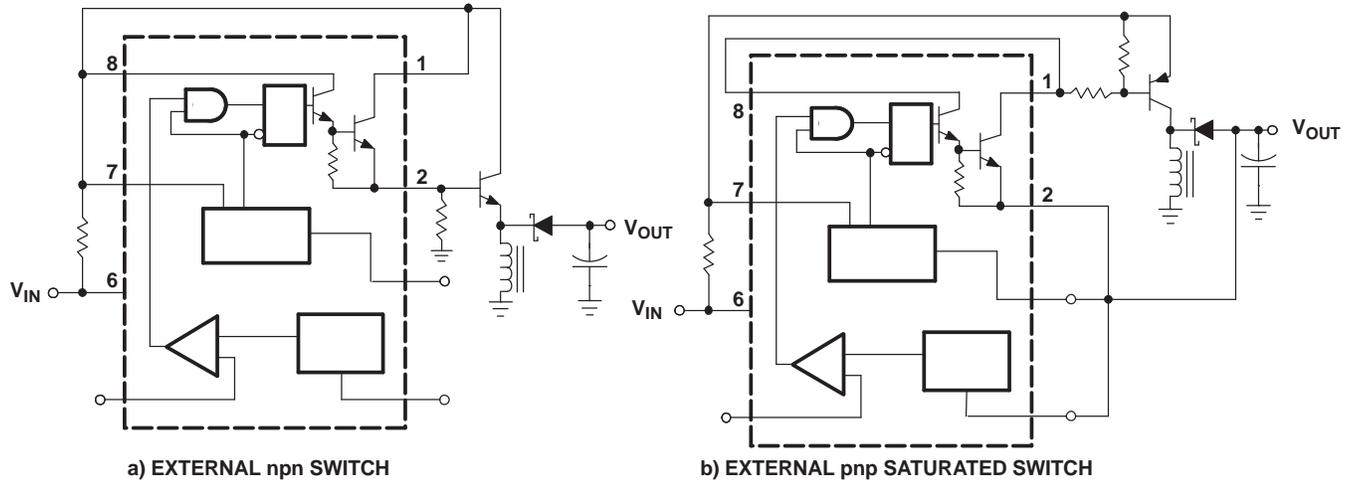


Figure 11. External Current-Boost Connections for I_C Peak Greater Than 1.5 A

APPLICATION INFORMATION

CALCULATION	STEP UP	STEP DOWN	VOLTAGE INVERTING
t_{on}/t_{off}	$\frac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$	$\frac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$	$\frac{ V_{out} + V_F}{V_{in} - V_{sat}}$
$(t_{on} + t_{off})$	$\frac{1}{f}$	$\frac{1}{f}$	$\frac{1}{f}$
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.

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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.

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- Catalog: [MC33063A](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

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