DC/DC Converter Control Circuits

FEATURES

- **Operation from 3.0V to 40V Input**
- **Low Standby Current**
- **Current Limiting**
- **Output Switch Current to 1.5A**
- **Output Voltage Adjustable**
- **Frequency Operation to 100kHz**
- **Precision 2% Reference**
- **Available in an 8-Pin PDIP and SOIC Package**

TYPICAL APPLICATIONS

- **Adapter Cards**
- **Set-Top Boxes**
- **Industrial Controllers**
- **Network Boxes**
- **Wireless Base Stations**

GENERAL DESCRIPTION

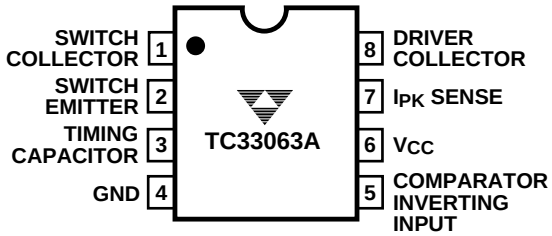
The TC33063A Series ia a monolithic control circuit containing the primary functions required for DC/DC converters. These devices consist of an internal temperature compensated reference, comparator, controlled duty cycle oscillator with an active current limit circuit, driver and high current output switch. This series was specifically designed to be incorporated in Step–Down and Step–Up and Voltage–Inverting applications with a minimum number of external components.

ORDERING INFORMATION

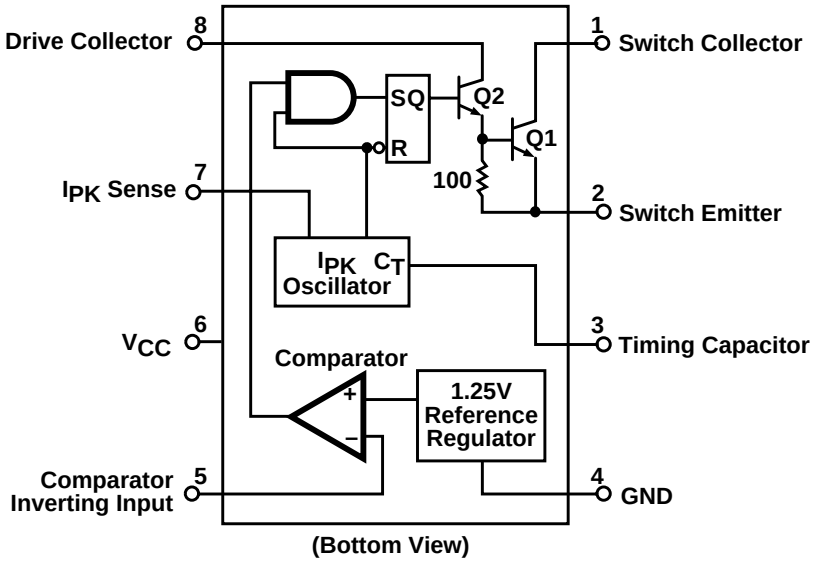
Part Number	Package	Temperature Range
TC33063AEPA	8-Pin PDIP	–40° to +85°C
TC33063AEOA	8-Pin SOIC	–40° to +85°C

PIN CONFIGURATIONS

8-Pin PDIP / SOIC



TYPICAL APPLICATION



(Bottom View)

This device contains 51 active transistors

TC33063A

ABSOLUTE MAXIMUM RATINGS*

Power Supply Voltage ..... V_{CC} = 40V_{DC}
Comparator Input Voltage Range ... V_{IR} = –0.3 to +40V_{DC}
Switch Collector Voltage ..... $V_{C(SWITCH)}$ = 40V_{DC}
Switch Emitter Voltage (VPin 1 = 40V) .. $V_{E(SWITCH)}$ = 40V_{DC}
Switch Collector to Emitter Voltage .. $V_{CE(SWITCH)}$ = 40V_{DC}
Driver Collector Voltage ..... $V_{C(DRIVER)}$ = 40V_{DC}
Driver Collector Current (Note 1) ..... $I_{C(DRIVER)}$ = 100mA
Switch Current ..... I_{SW} = 1.5A
Power Dissipation and Thermal Characteristics
PDIP Package
T_A = 25°C ..... P_D = 1.25W
Thermal Resistance ..... θ_{JA} = 100°C/W
SOIC Package
T_A = 25°C ..... P_D = 0.625W
Thermal Resistance ..... θ_{JA} = 160°C/W
Operating Junction Temperature ..... T_J =150°C
Operating Ambient Temperature Range
TC33063A ..... T_A = -40 to +85°C
Storage Temperature Range ..... T_{STG} = –65 to +150°C

*This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the operation section of the specifications is not implied. Exposure to absolute maximum ratings conditions for extended periods of time may affect device reliability.

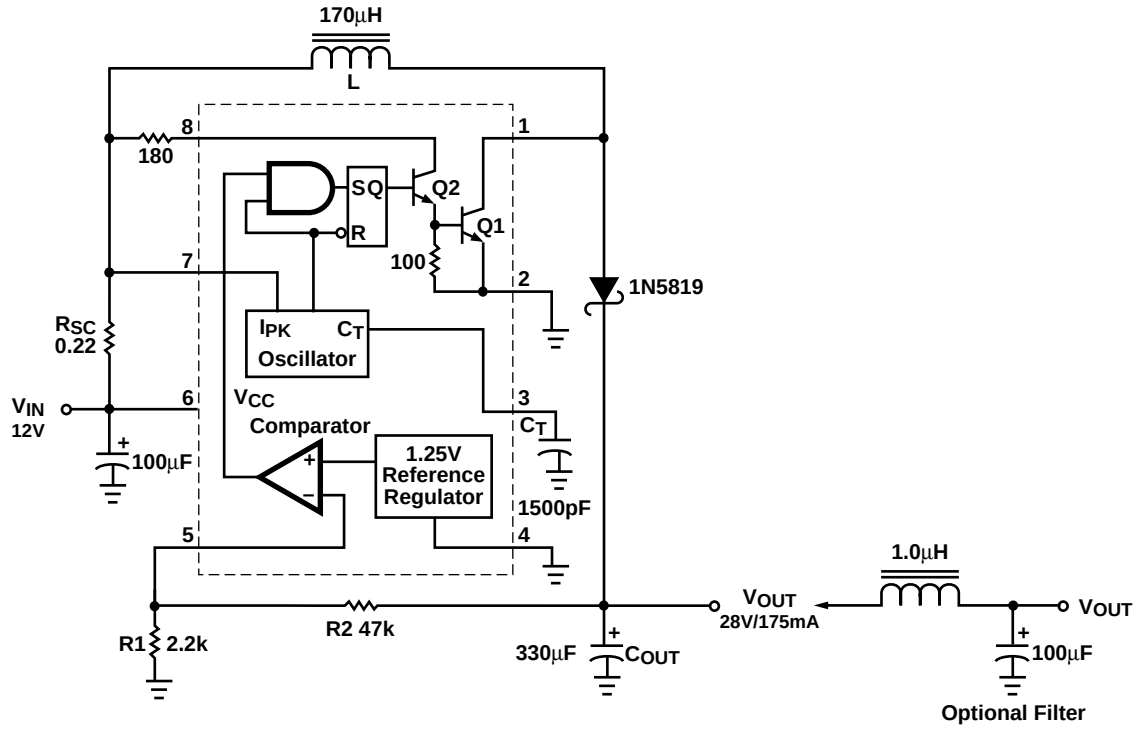
ELECTRICAL CHARACTERISTICS: V_{CC} = 5.0V, T_A = – 40°C to + 85°C [Note 3], unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
Oscillator						
f_{OSC}	Frequency (V_{PIN} 5 = 0V, C_T = 1.0nF, T_A = 25°C)		24	33	42	kHz
I_{CHG}	Charge Current (V_{CC} = 5.0V to 40V, T_A = 25°C)		24	35	42	µA
I_{DISCHG}	Discharge Current (V_{CC} = 5.0V to 40V, T_A = 25°C)		140	220	260	µA
I_{DISCHG}/I_{CHG}	Discharge to Charge Current Ratio (Pin 7 to V_{CC}, T_A = 25°C)		5.2	6.5	7.5	–
$V_{IPK(SENSE)}$	Current Limit Sense Voltage (I_{CHG} = I_{DISCHG}, T_A = 25°C)		250	300	350	mV
Output Switch						
$V_{CE(SAT)}$	Saturation Voltage, Darlington Connection (Note 4) (I_{SW} = 1.0A, Pins 1, 8 connected)		—	1.0	1.3	V
$V_{CE(sat)}$	Saturation Voltage, Darlington Connection (I_{SW} = 1.0A, R_{PIN} 8 = 82W to V_{CC}, Forced β ≈ 20)		—	0.45	0.7	V
h_{FE}	DC Current Gain (I_{SW} = 1.0A, V_{CE} = 5.0V, T_A = 25°C)		50	75	—	—
$I_{C(OFF)}$	Collector Off–State Current (V_{CE} = 40V)		—	0.01	100	µA
Comparator						
V_{TH}	Threshold Voltage	T_A = 25°C Over Operating Temperature	1.225 1.21	1.25 —	1.275 1..29	V
Reg_{LINE}	Threshold Voltage Line Regulation (V_{CC} = 3.0V to 40V)		—	1.4	5.0	mV
I_{IB}	Input Bias Current (V_{IN} = 0V)		—	–20	–400	nA
Total Device						
I_{CC}	Supply Current (V_{CC} = 5.0V to 40V, CT =1.0nF, Pin 7 = V_{CC}, VPin 5 > V_{TH}, Pin 2 = GND, Remaining Pins Open)		—	—	4.0	mA

NOTES: 1. Maximum package power dissipation limits must be observed.
2. ESD data available upon request.
3. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.
4. If the output switch is driven into hard saturation (non–Darlington configuration) at low switch currents (≤ 300mA) and high driver currents (≥ 30mA), it may take up to 2.0µsec for it to come out of saturation. This condition will shorten the off time at frequencies ≥ 30kHz, and is magnified at high temperatures. This condition does not occur with a Darlington configuration, since the output switch cannot saturate. If a non–Darlington configuration is used, the following output drive condition is recommended:

Forced b of output switch : $\frac{I_{C\ OUTPUT}}{I_{C\ DRIVER} - 7.0\ mA^*} \geq 10$

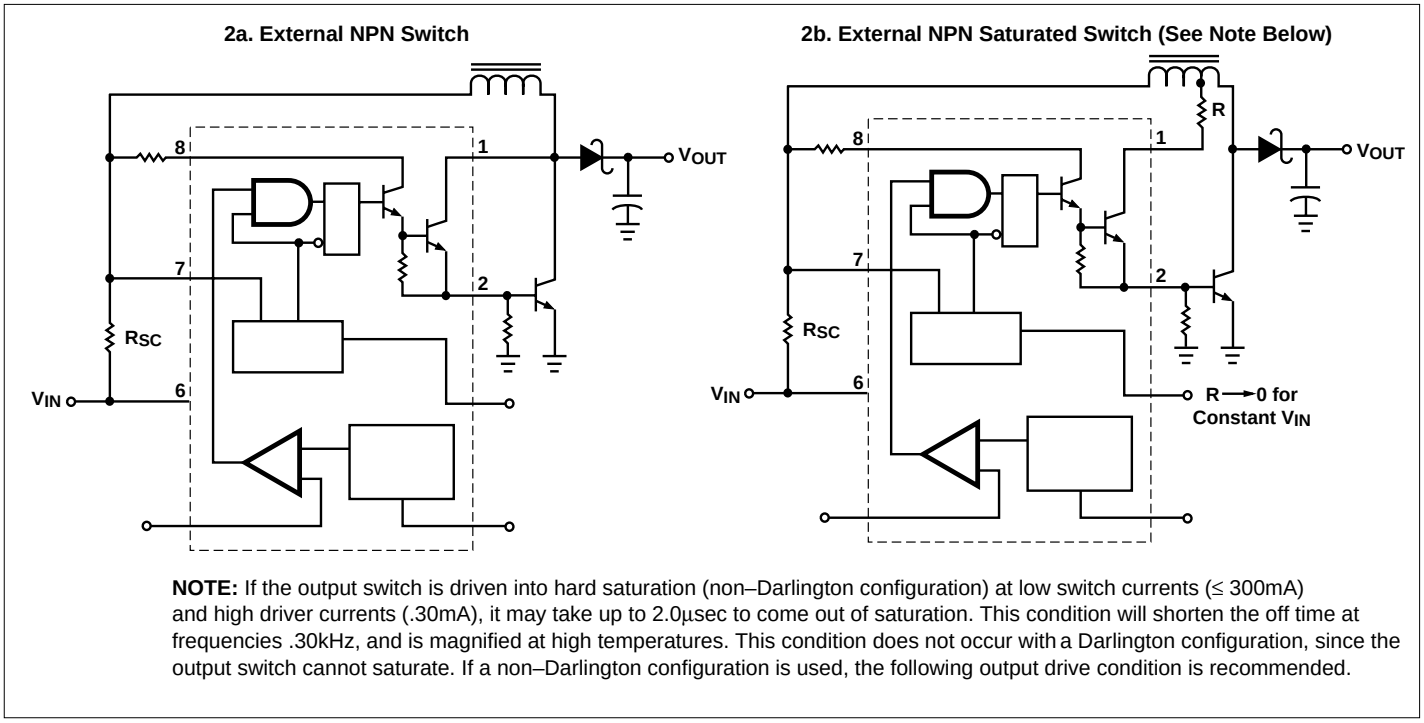
*The 100Ω resistor in the emitter of the driver device requires about 7.0mA before the output switch conducts.



Test	Conditions	Results
Line Regulation	V_{IN} = 8.0V to 16V, I_{OUT} = 175mA	30mV = ±0.05%
Load Regulation	V_{IN} = 12V, I_{OUT} = 75mA to 175mA	10mV = ±0.017%
Output Ripple	V_{IN} = 12V, I_{OUT} = 175mA	400mVpp
Efficiency	V_{IN} = 12V, I_{OUT} = 175mA	87.7%
Output Ripple With Optional Filter	V_{IN} = 12V, I_{OUT} = 175mA	40mVpp

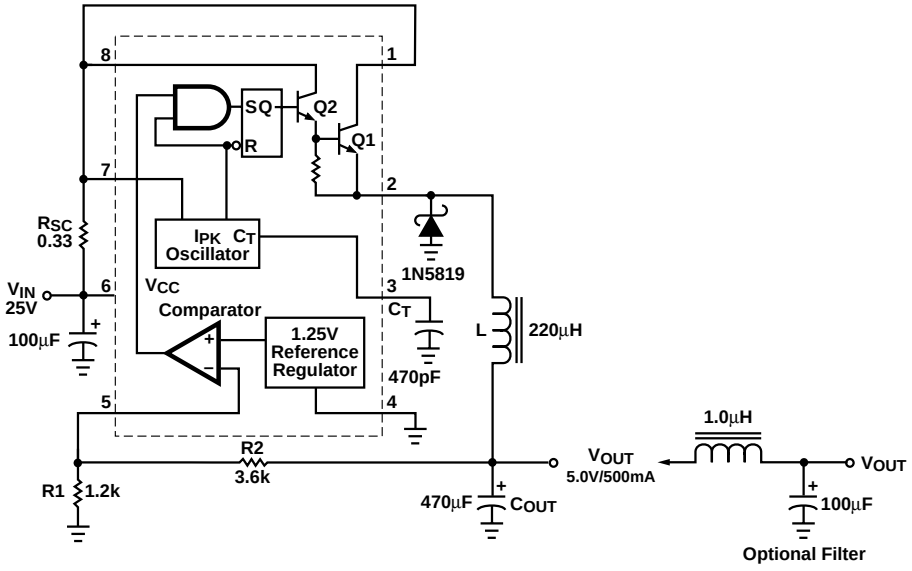
Figure 1. Step-Up Converter

TC33063A



NOTE: If the output switch is driven into hard saturation (non–Darlington configuration) at low switch currents (≤ 300mA) and high driver currents (.30mA), it may take up to 2.0µsec to come out of saturation. This condition will shorten the off time at frequencies .30kHz, and is magnified at high temperatures. This condition does not occur with a Darlington configuration, since the output switch cannot saturate. If a non–Darlington configuration is used, the following output drive condition is recommended.

Figure 2. External Current Boost Connections for IC Peak Greater than 1.5A



Test	Conditions	Results
Line Regulation	V_{IN} = 15V to 25V, I_{OUT} = 500mA	12mV = ±0.12%
Load Regulation	V_{IN} = 25V, I_{OUT} = 50mA to 500mA	3.0mV = ±0.03%
Output Ripple	V_{IN} = 25V, I_{OUT} = 500mA	120mVpp
Short Circuit Current	V_{IN} = 25V, R_L = 0.1Ω	1.1A
Efficiency	V_{IN} = 25V, I_{OUT} = 0.1Ω	83.7%
Output Ripple With Optional Filter	V_{IN} = 25V, I_{OUT} = 500mA	40mVpp

Figure 3. Step-Down Converter

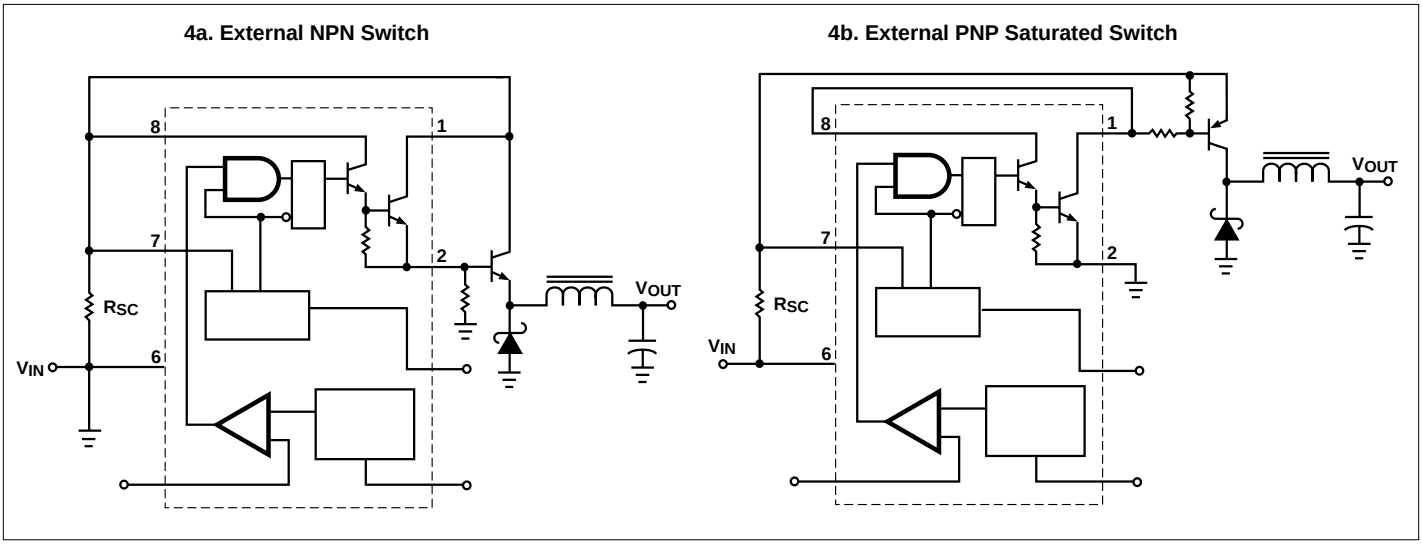
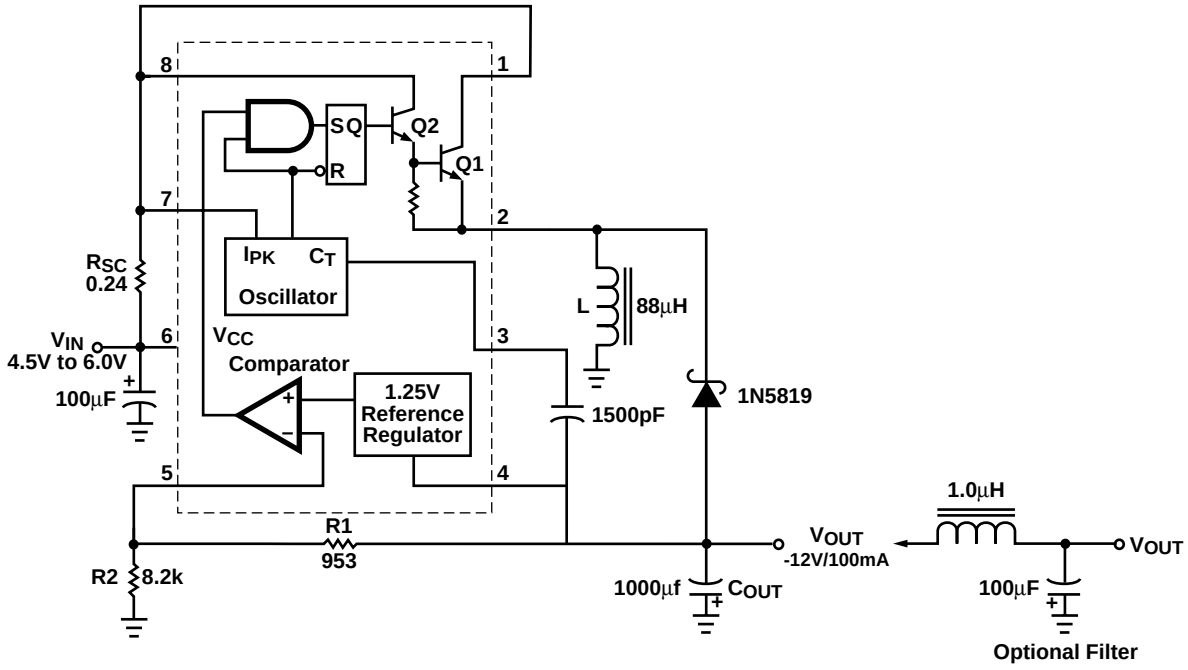


Figure 4. External Current Boost Connections for IC Peak Greater than 1.5A



Test	Conditions	Results
Line Regulation	V_{IN} = 4.5V to 6.0V, I_{OUT} = 100mA	3.0mV = ±0.012%
Load Regulation	V_{IN} = 5.0V, I_{OUT} =10mA to 100mA	0.022V = ±0.09%
Output Ripple	V_{IN} = 5.0V, I_{OUT} = 100mA	500mVpp
Short Circuit Current	V_{IN} = 5.0V, R_L = 0.1Ω	910mA
Efficiency	V_{IN} = 5.0V, I_{OUT} = 100mA	62.2%
Output Ripple With Optional Filter	V_{IN} = 5.0V, I_{OUT} = 100mA	70mVpp

Figure 5. Voltage Inverting Converter

TC33063A

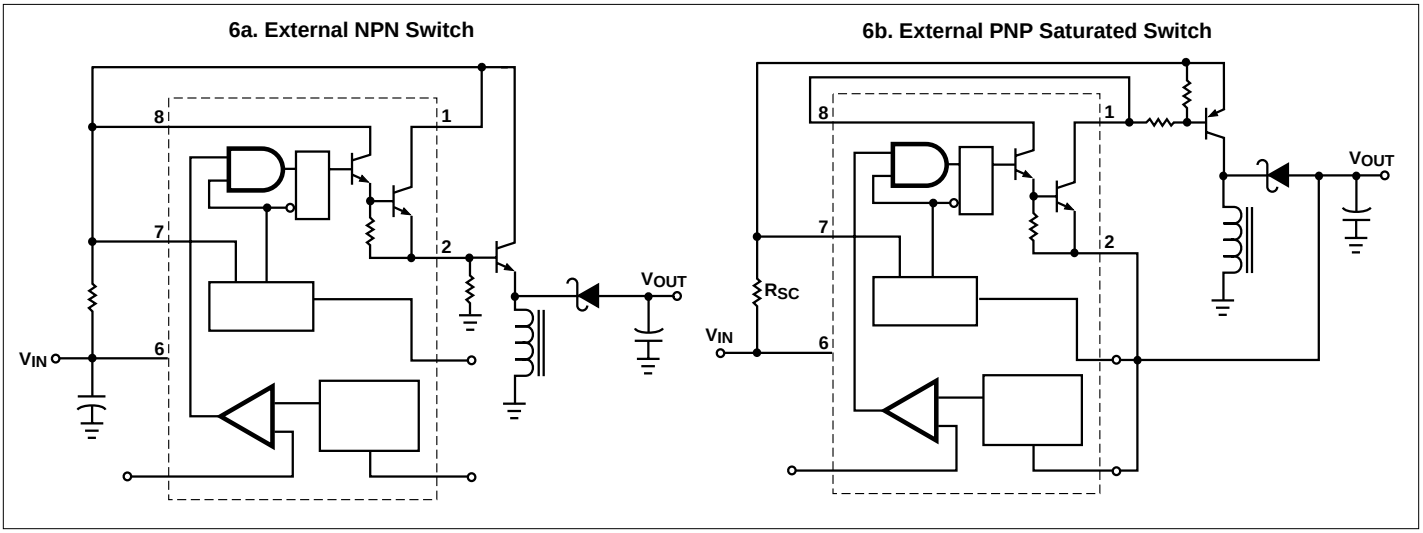


Figure 6. External Current Boost Connections for IC Peak Greater than 1.5A

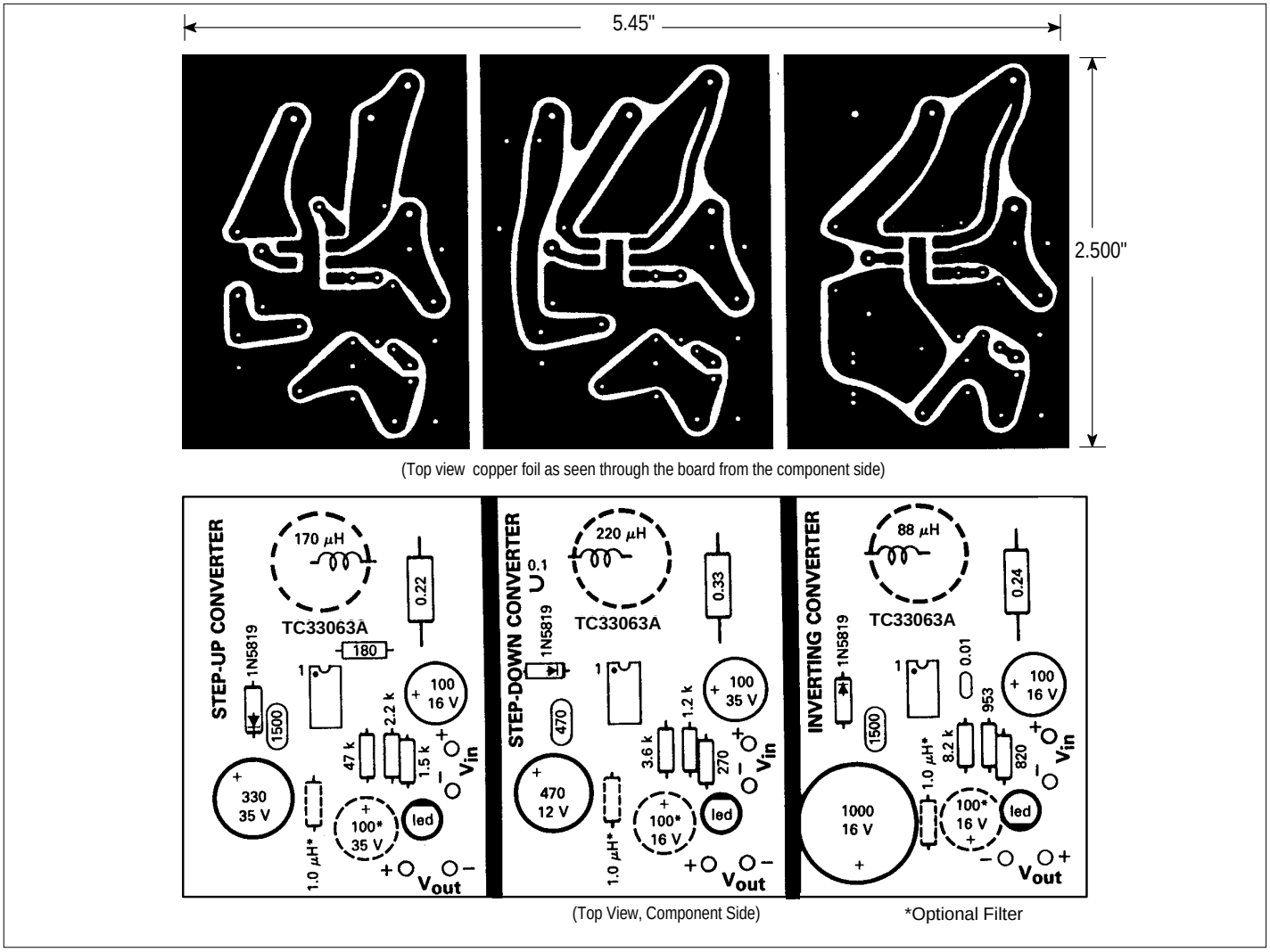


Figure 7. Printed Circuit Board and Component Layout (Circuits of Figures 1, 3, 5)

Inductor Data

Converter	Inductance (μH)	Turns/Wire
Step-Up	170	38 Turns of #22 AWG
Step-Down	220	48 Turns of #22 AWG
Voltage-Inverting	88	28 Turns of #22 AWG

All inductors are wound on Magnetic Inc. 55117 toroidal core.

Design Formula Table

Calculations	Step-Up	Step-Down	Voltage-Inverting
t_{ON} / t_{OFF}	$\frac{V_{OUT} + V_F - V_{IN(min)}}{V_{IN(min)} - V_{SAT}}$	$\frac{V_{OUT} + V_F}{V_{IN(min)} - V_{SAT} - V_{OUT}}$	$\frac{I\,V_{OUT}\,I + V_F}{V_{IN} - V_{SAT}}$
$(t_{ON} + t_{OFF})$	$\frac{1}{f}$	$\frac{1}{f}$	$\frac{1}{f}$
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	$4.0 \times 10^{-5}\, t_{ON}$	$4.0 \times 10^{-5}\, t_{ON}$	$4.0 \times 10^{-5}\, t_{ON}$
$I_{PK(SWITCH)}$	$2I_{OUT(max)} \left(\frac{t_{ON}}{t_{OFF}} + 1 \right)$	$2I_{OUT(max)}$	$2I_{OUT(max)} \left(\frac{t_{ON}}{t_{OFF}} + 1 \right)$
R_{SC}	$0.3/I_{PK(SWITCH)}$	$0.3/I_{PK(SWITCH)}$	$0.3/I_{PK(SWITCH)}$
$L_{(min)}$	$\left(\frac{V_{IN(min)} - V_{SAT}}{I_{PK(SWITCH)}} \right) t_{ON(max)}$	$\left(\frac{V_{IN(min)} - V_{SAT} - V_{OUT}}{I_{PK(SWITCH}} \right) t_{ON(max)}$	$\left(\frac{V_{IN(min)} - V_{SAT}}{I_{PK(SWITCH)}} \right) t_{ON(max)}$
C_O	$9\,\frac{I_{OUT} t_{ON}}{V_{RIPPLE(pp)}}$	$\frac{I_{PK(SWITCH)}(t_{ON} + t_{OFF})}{8V_{RIPPLE(pp)}}$	$9\,\frac{I_{OUT} t_{ON}}{V_{RIPPLE(pp)}}$

V_{SAT} = Saturation voltage of the output switch.
V_F = Forward voltage drop of the output rectifier.

The following power supply characteristics must be chosen:
V_{IN} – Nominal input voltage.
V_{OUT} – Desired output voltage, $IV_{OUT}I = 1.25 \left(1 + \frac{R2}{R1}\right)$
I_{OUT} – Desired output current.
f_{MIN} – Minimum desired output switching frequency at the selected values of V_{IN} and I_O .
$V_{RIPPLE(pp)}$ – Desired peak–to–peak output ripple voltage. In practice, the calculated capacitor value will need to be increased due to its equivalent series $V_{(pp)}$ – resistance and board layout. The ripple voltage should be kept to a low value since it will directly affect the line and load regulation.

TC33063A

TYPICAL CHARACTERISTICS

Figure 9. Output Switch On-Off Time vs. Oscillator Timing Capacitor

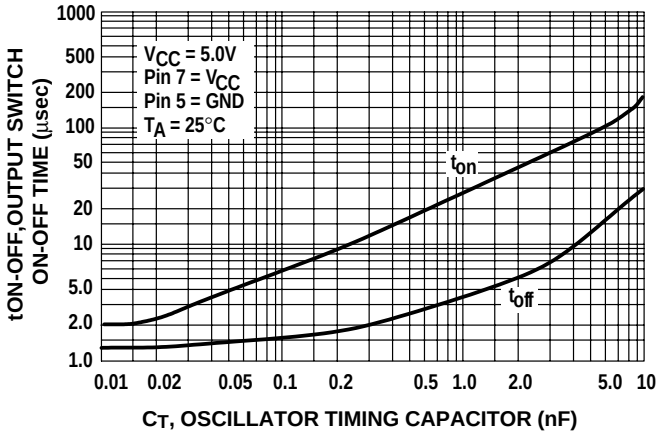


Figure 10. Timing Capacitor Waveform

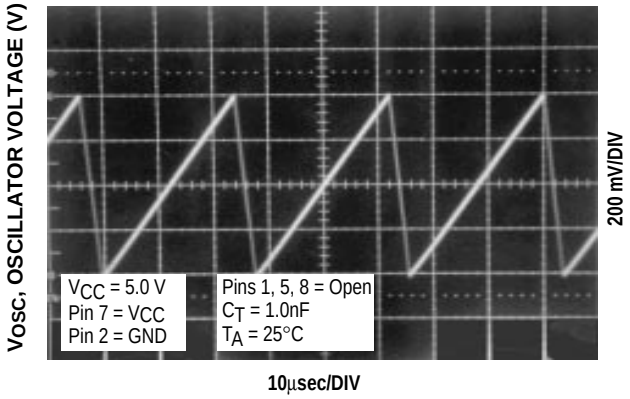


Figure 11. Emitter Follower Configuration Output Saturation Voltage vs. Emitter Current

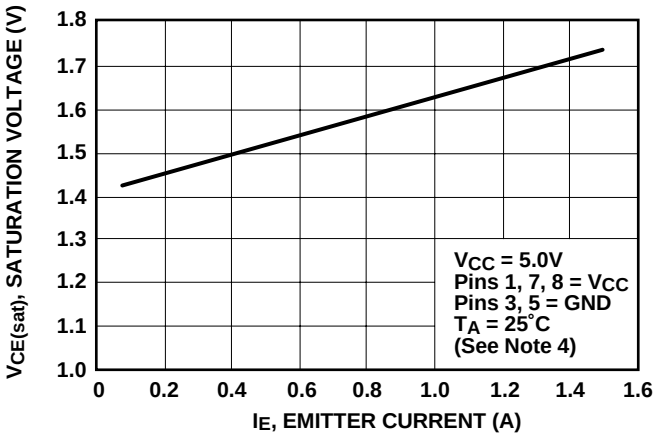


Figure 12. Common Emitter Configuration Output Switch Saturation Voltage vs. Collector Current

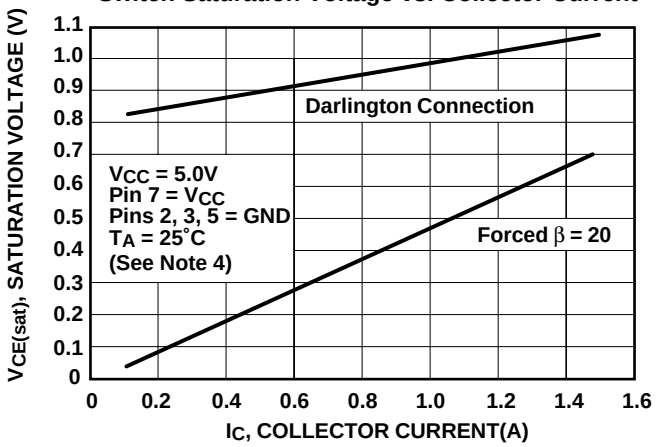


Figure 13. Current Limit Sense Voltage vs.Temperature

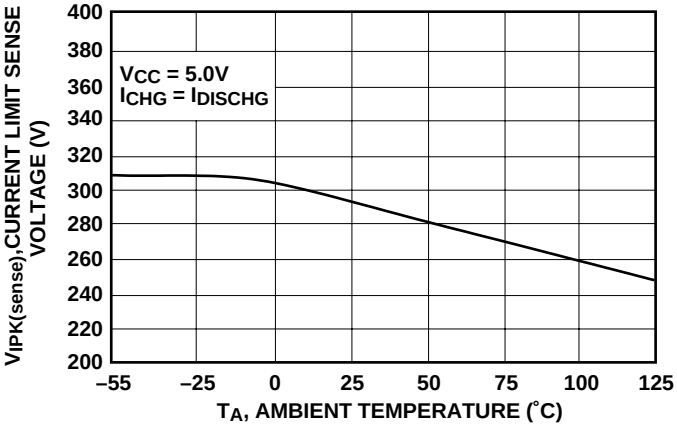
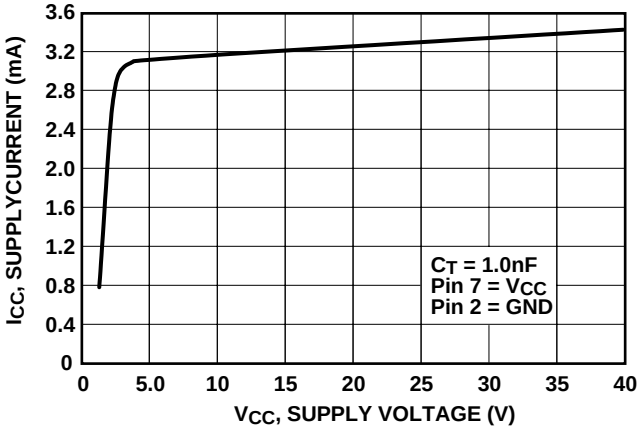


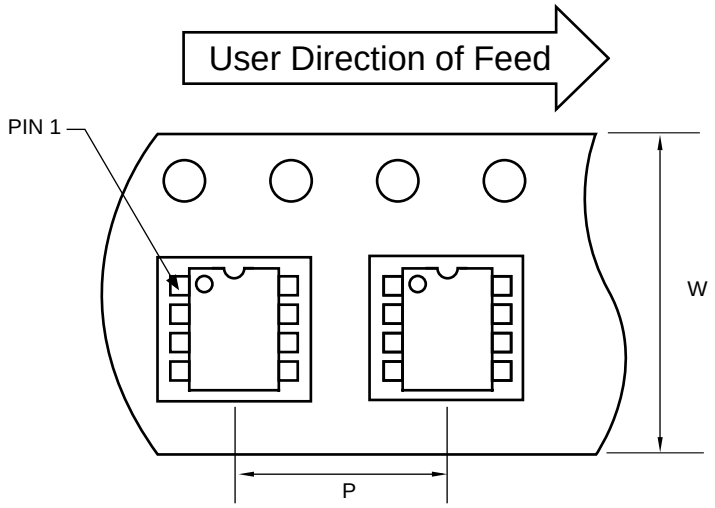
Figure 14. Standby Supply Current vs. Supply Voltage



NOTE: 4. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.

TAPE AND REEL SPECIFICATIONS

Component Taping Orientation for 8-Pin SOIC (Narrow) Devices



Standard Reel Component Orientation
for TR Suffix Device

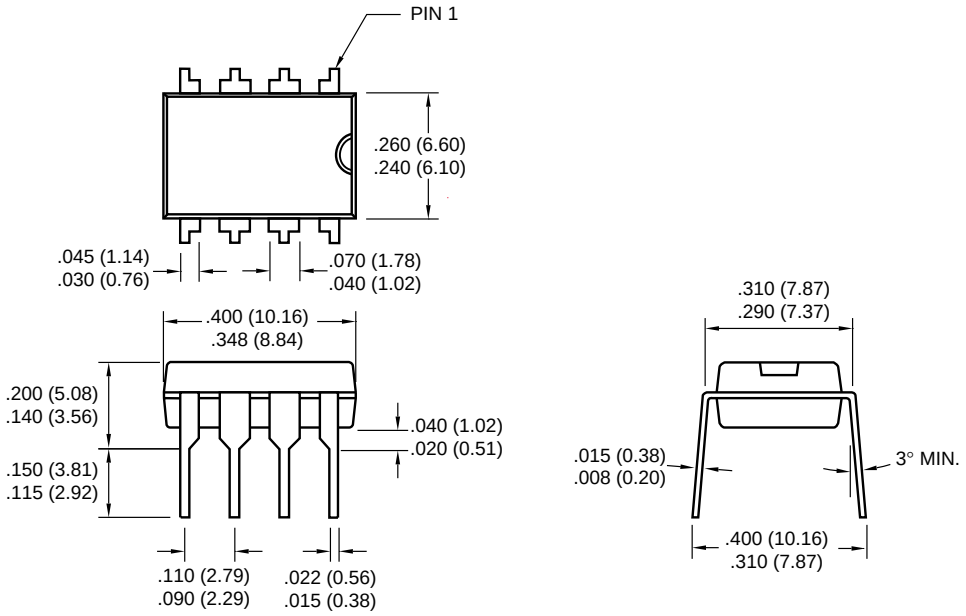
Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin SOIC (N)	12 mm	8 mm	2500	13 in

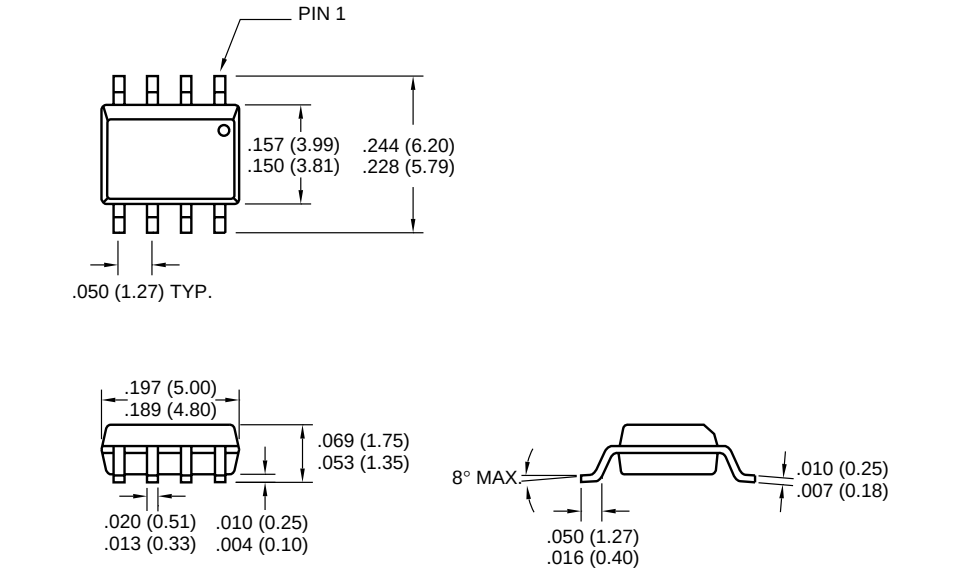
TC33063A

PACKAGE DIMENSIONS

8-Pin PDIP (Narrow)



8-Pin SOIC (Narrow)



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