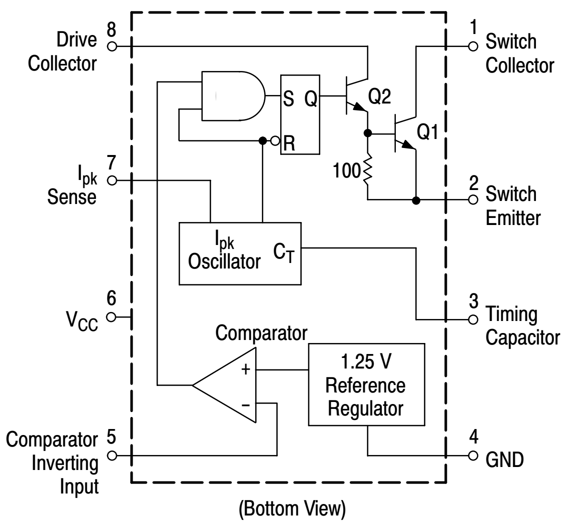
MC34063A, MC33063A, NCV33063A

1.5 A, Step-Up/Down/ Inverting Switching Regulators

The MC34063A Series is a monolithic control circuit containing the primary functions required for DC−to−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. Refer to Application Notes AN920A/D and AN954/D for additional design information.

Features

- Operation from 3.0 V to 40 V Input
- Low Standby Current
- Current Limiting
- Output Switch Current to 1.5 A
- Output Voltage Adjustable
- Frequency Operation to 100 kHz
- Precision 2% Reference
- Pb−Free Packages are Available



This device contains 51 active transistors.

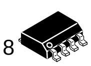
Figure 1. Representative Schematic Diagram

ON Semiconductor®

http://onsemi.com

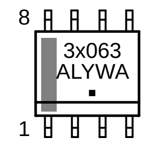
MARKING DIAGRAMS

8

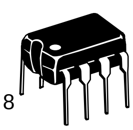


1

SOIC−8
D SUFFIX
CASE 751

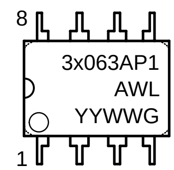


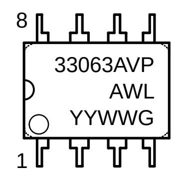
8



1

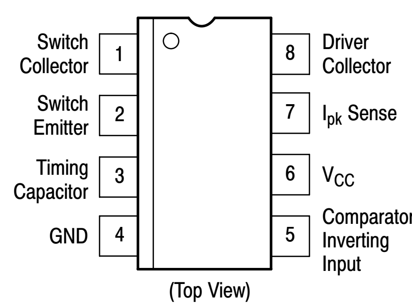
PDIP−8
P, P1 SUFFIX
CASE 626





x	=	3 or 4
A	=	Assembly Location
L, WL	=	Wafer Lot
Y, YY	=	Year
W, WW	=	Work Week
G or ▪	=	Pb−Free Package

PIN CONNECTIONS



ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 11 of this data sheet.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	40	Vdc
Comparator Input Voltage Range	V_{IR}	−0.3 to +40	Vdc
Switch Collector Voltage	$V_{C(switch)}$	40	Vdc
Switch Emitter Voltage ($V_{Pin\ 1}$ = 40 V)	$V_{E(switch)}$	40	Vdc
Switch Collector to Emitter Voltage	$V_{CE(switch)}$	40	Vdc
Driver Collector Voltage	$V_{C(driver)}$	40	Vdc
Driver Collector Current (Note 1)	$I_{C(driver)}$	100	mA
Switch Current	I_{SW}	1.5	A
Power Dissipation and Thermal Characteristics			
Plastic Package, P, P1 Suffix			
T_A = 25°C	P_D	1.25	W
Thermal Resistance	$R_{\theta JA}$	100	°C/W
SOIC Package, D Suffix			
T_A = 25°C	P_D	625	mW
Thermal Resistance	$R_{\theta JA}$	160	°C/W
Operating Junction Temperature	T_J	+150	°C
Operating Ambient Temperature Range	T_A		°C
MC34063A		0 to +70	
MC33063AV, NCV33063A		−40 to +125	
MC33063A		−40 to +85	
Storage Temperature Range	T_{stg}	−65 to +150	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Maximum package power dissipation limits must be observed.
2. This device series contains ESD protection and exceeds the following tests: Human Body Model 4000 V per MIL−STD−883, Method 3015. Machine Model Method 400 V.
3. NCV prefix is for automotive and other applications requiring site and change control.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, T_A = T_{low} to T_{high} [Note 4], unless otherwise specified.)

Characteristics	Symbol	Min	Typ	Max	Unit
OSCILLATOR					
Frequency ($V_{Pin\ 5}$ = 0 V, C_T = 1.0 nF, T_A = 25°C)	f_{osc}	24	33	42	kHz
Charge Current (V_{CC} = 5.0 V to 40 V, T_A = 25°C)	I_{chg}	24	35	42	μA
Discharge Current (V_{CC} = 5.0 V to 40 V, T_A = 25°C)	I_{dischg}	140	220	260	μA
Discharge to Charge Current Ratio (Pin 7 to V_{CC}, T_A = 25°C)	I_{dischg}/I_{chg}	5.2	6.5	7.5	−
Current Limit Sense Voltage (I_{chg} = I_{dischg}, T_A = 25°C)	$V_{ipk(sense)}$	250	300	350	mV
OUTPUT SWITCH (Note 5)					
Saturation Voltage, Darlington Connection (I_{SW} = 1.0 A, Pins 1, 8 connected)	$V_{CE(sat)}$	−	1.0	1.3	V
Saturation Voltage (Note 6) (I_{SW} = 1.0 A, $R_{Pin\ 8}$ = 82 Ω to V_{CC}, Forced $\beta \simeq 20$)	$V_{CE(sat)}$	−	0.45	0.7	V
DC Current Gain (I_{SW} = 1.0 A, V_{CE} = 5.0 V, T_A = 25°C)	h_{FE}	50	75	−	−
Collector Off−State Current (V_{CE} = 40 V)	$I_{C(off)}$	−	0.01	100	μA
COMPARATOR					
Threshold Voltage	V_{th}				V
T_A = 25°C		1.225	1.25	1.275	
T_A = T_{low} to T_{high}		1.21	−	1.29	
Threshold Voltage Line Regulation (V_{CC} = 3.0 V to 40 V)	Reg_{line}				mV
MC33063A, MC34063A		−	1.4	5.0	
MC33063AV, NCV33063A		−	1.4	6.0	
Input Bias Current (V_{in} = 0 V)	I_{IB}	−	−20	−400	nA
TOTAL DEVICE					
Supply Current (V_{CC} = 5.0 V to 40 V, C_T = 1.0 nF, Pin 7 = V_{CC}, $V_{Pin\ 5}$ > V_{th}, Pin 2 = GND, remaining pins open)	I_{CC}	−	−	4.0	mA

4. T_{low} = 0°C for MC34063A, −40°C for MC33063A, AV, NCV33063A
   T_{high} = +70°C for MC34063A, +85°C for MC33063A, +125°C for MC33063AV, NCV33063A
5. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.
6. 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 2.0 μs for it 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, since the output switch cannot saturate. If a non−Darlington configuration is used, the following output drive condition is recommended:

$$\text{Forced } \beta \text{ of output switch} : \frac{I_C \text{ output}}{I_C \text{ driver} - 7.0 \text{ mA}^*} \geq 10$$

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

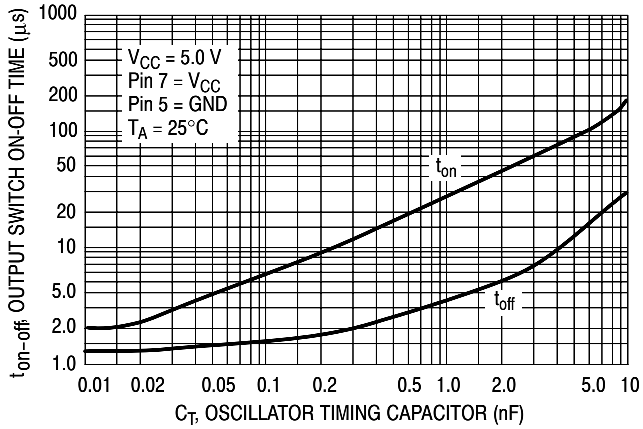


Figure 2. Output Switch On−Off Time versus Oscillator Timing Capacitor

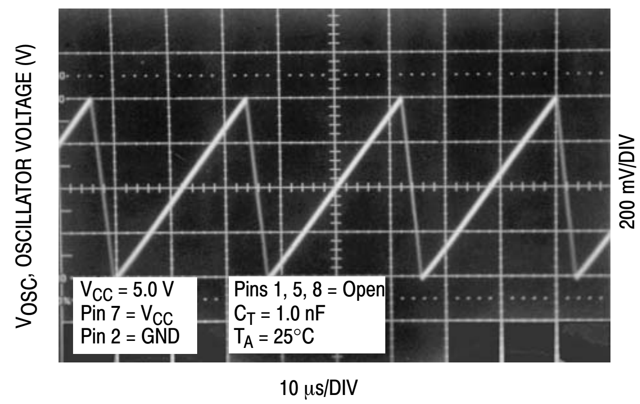


Figure 3. Timing Capacitor Waveform

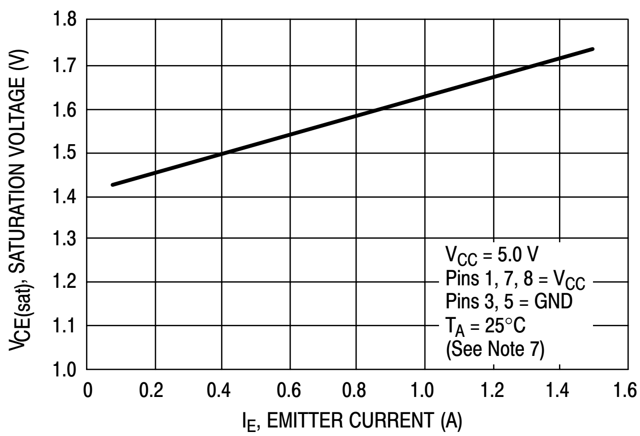


Figure 4. Emitter Follower Configuration Output Saturation Voltage versus Emitter Current

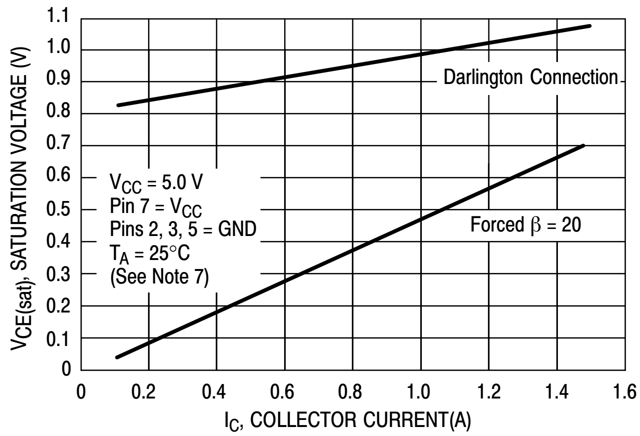


Figure 5. Common Emitter Configuration Output Switch Saturation Voltage versus Collector Current

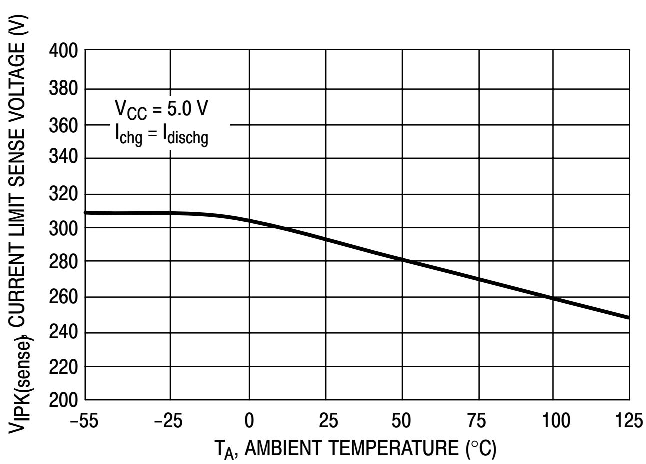


Figure 6. Current Limit Sense Voltage versus Temperature

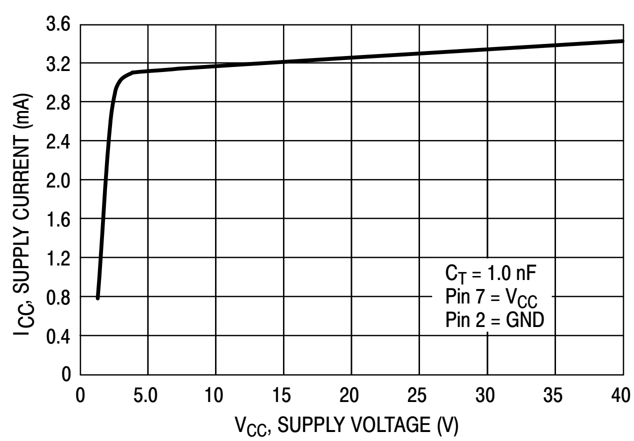
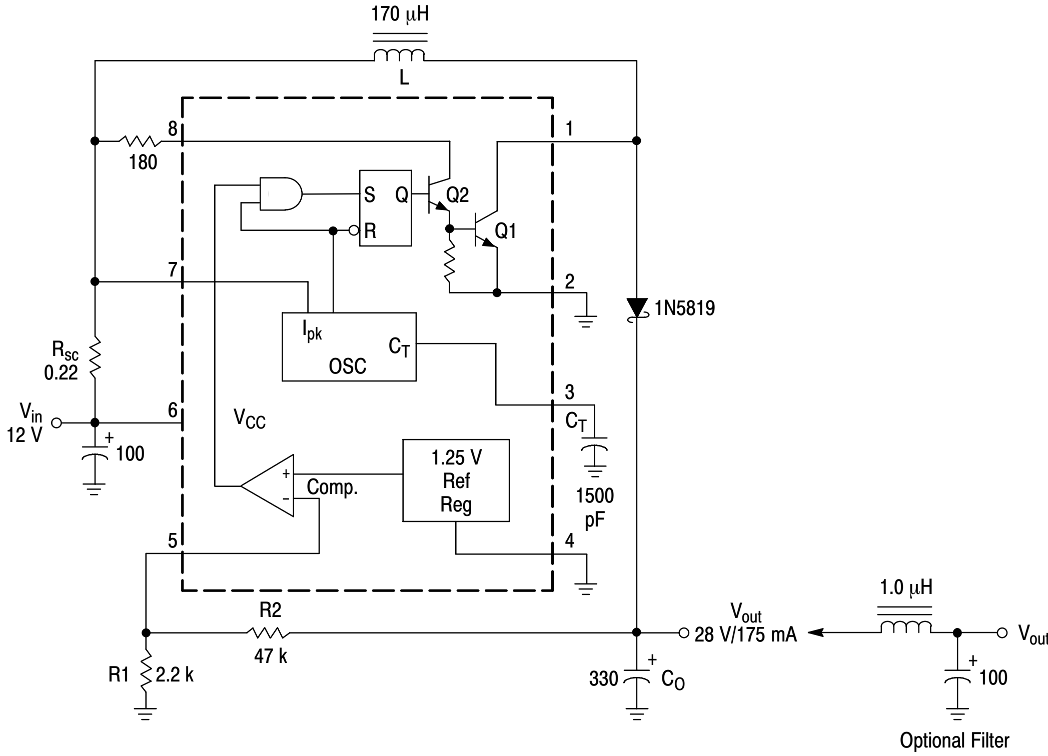


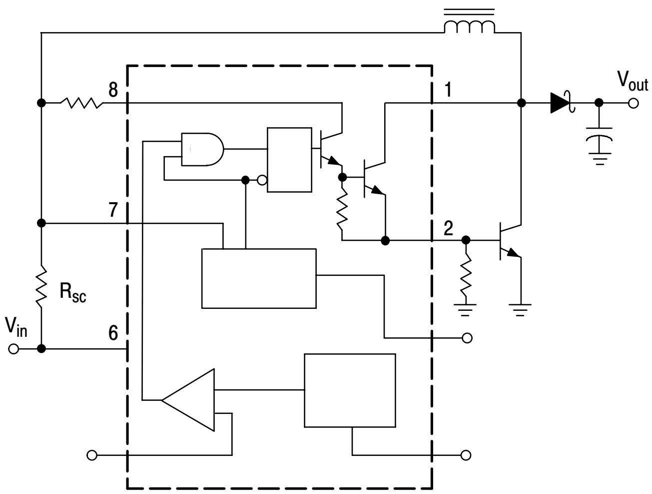
Figure 7. Standby Supply Current versus Supply Voltage

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



Test	Conditions	Results
Line Regulation	V_{in} = 8.0 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 mVpp
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 mVpp

Figure 8. Step−Up Converter



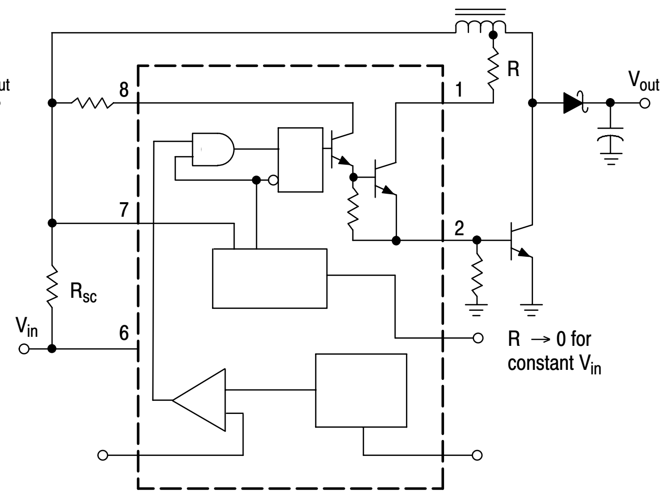
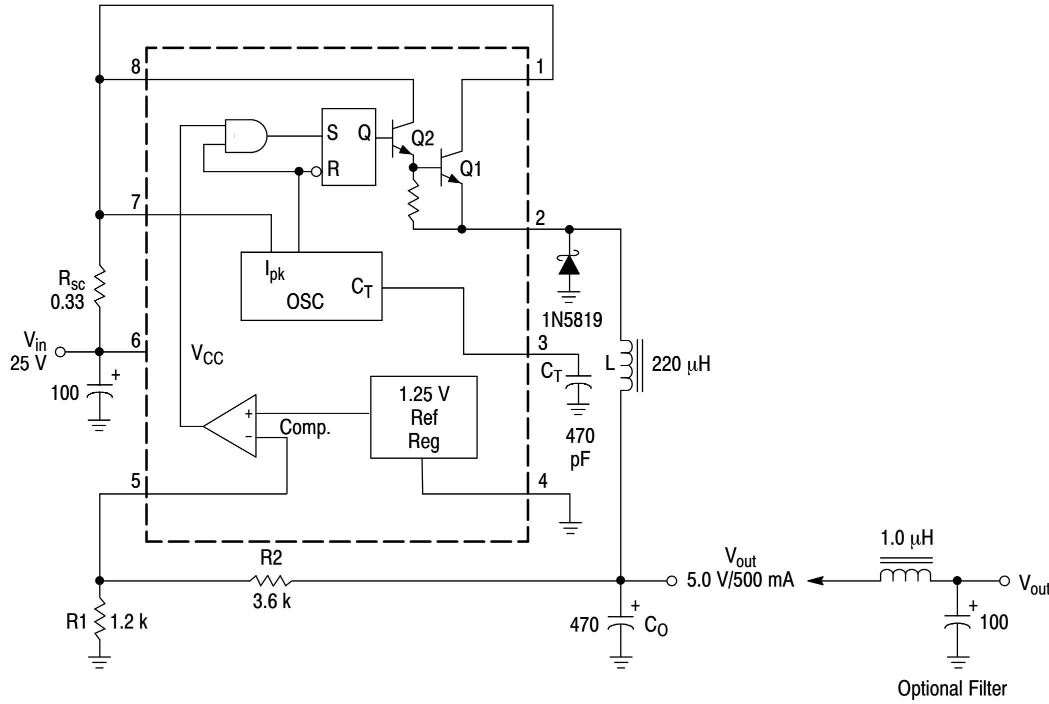


Figure 9. External Current Boost Connections for I_C Peak Greater than 1.5 A

9a. External NPN Switch

9b. External NPN Saturated Switch
(See Note 8)

8. 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 2.0 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, since the output switch cannot saturate. If a non−Darlington configuration is used, the following output drive condition is recommended.



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	3.0 mV = ±0.03%
Output Ripple	V_{in} = 25 V, I_O = 500 mA	120 mVpp
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 mVpp

Figure 10. Step−Down Converter

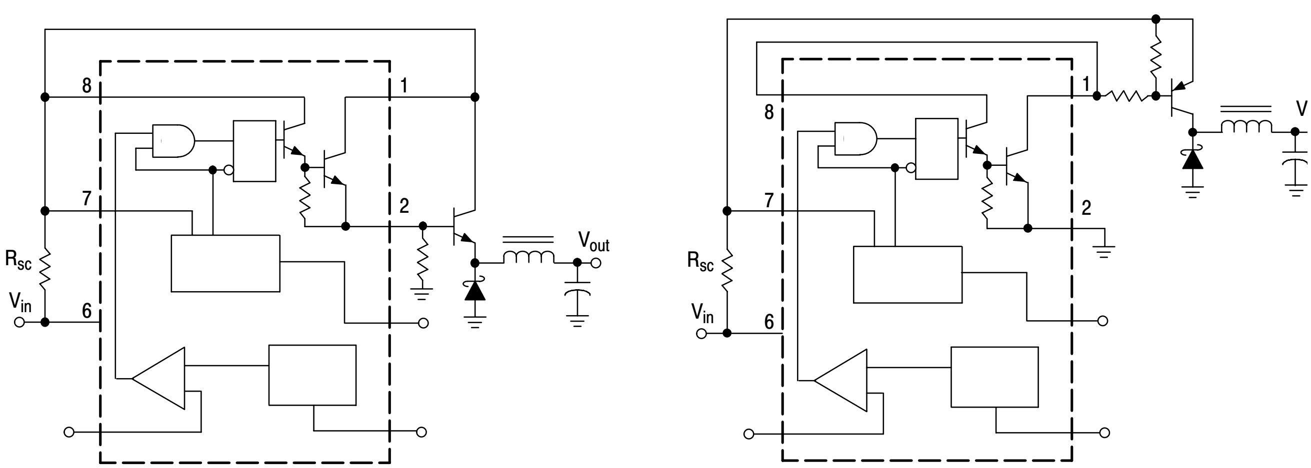
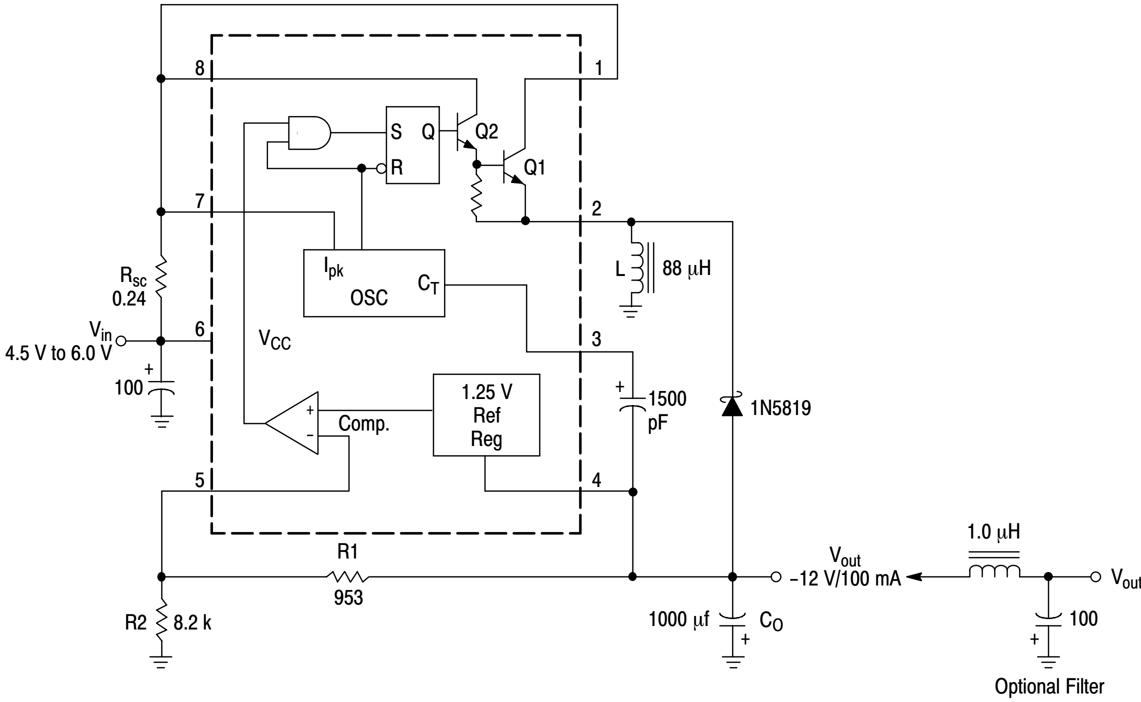


Figure 11. External Current Boost Connections for I_C Peak Greater than 1.5 A

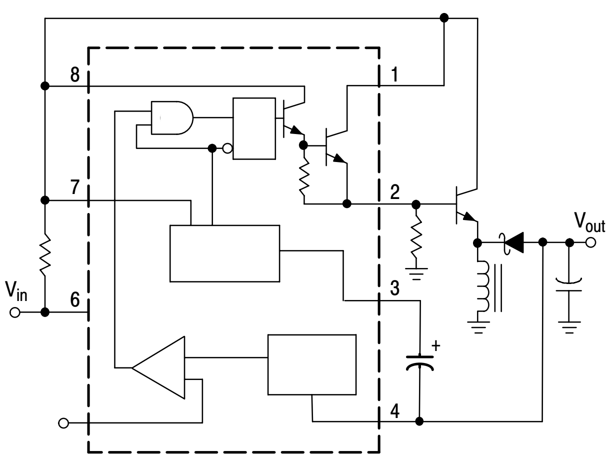
11a. External NPN Switch

11b. External PNP Saturated Switch



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

Figure 12. Voltage Inverting Converter



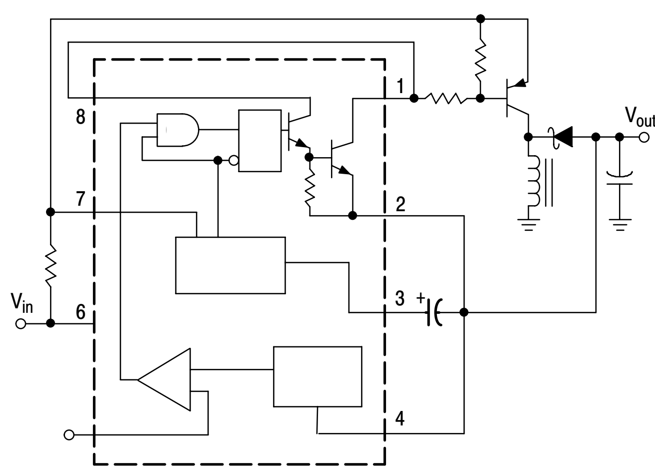
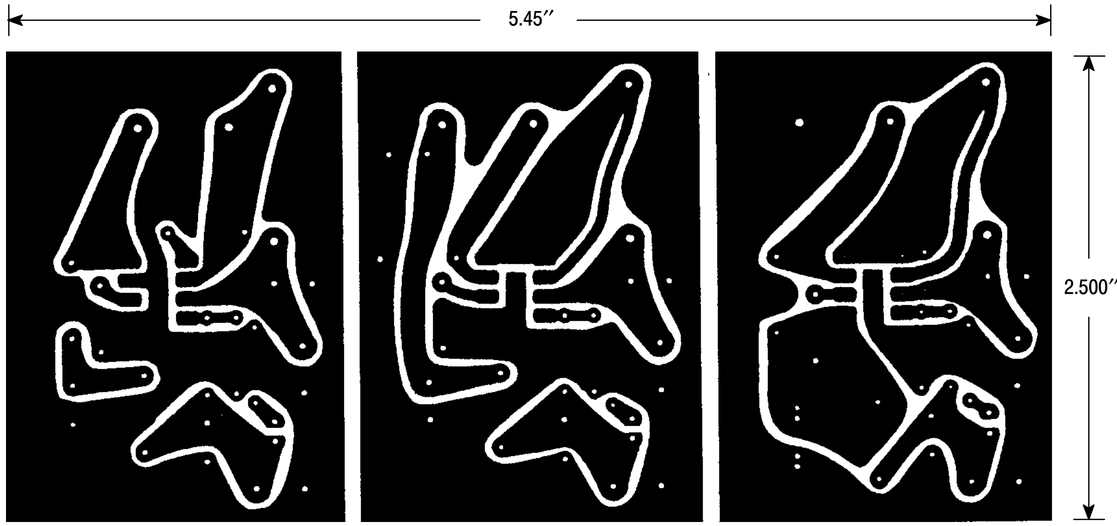
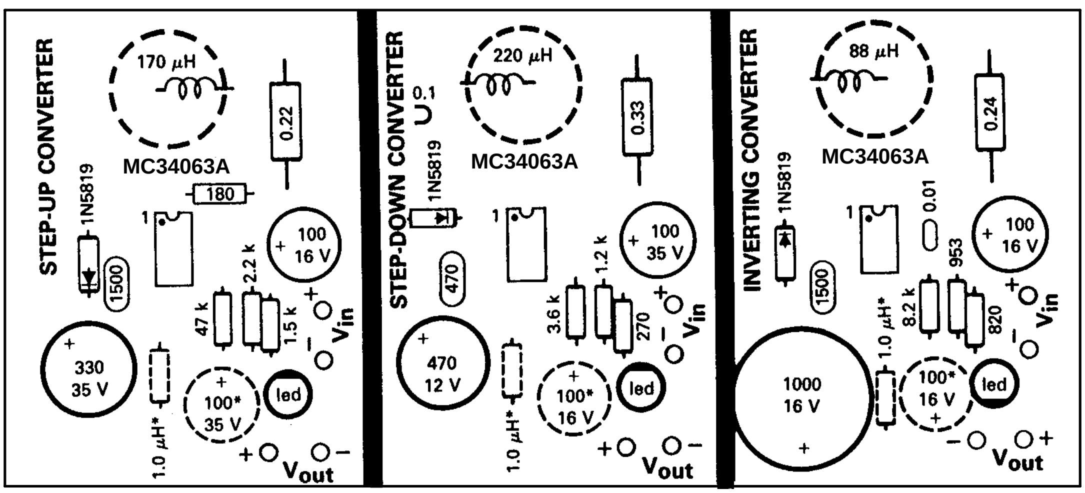


Figure 13. External Current Boost Connections for I_C Peak Greater than 1.5 A

13a. External NPN Switch **13b. External PNP Saturated Switch**



(Top view, copper foil as seen through the board from the component side)



(Top View, Component Side)

*Optional Filter.

Figure 14. Printed Circuit Board and Component Layout
(Circuits of Figures 8, 10, 12)

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 Magnetics Inc. 55117 toroidal core.

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	$4.0 \times 10^{-5}\ t_{on}$	$4.0 \times 10^{-5}\ t_{on}$	$4.0 \times 10^{-5}\ t_{on}$
$I_{pk(switch)}$	$2I_{out(max)}\left(\frac{t_{on}}{t_{off}} + 1\right)$	$2I_{out(max)}$	$2I_{out(max)}\left(\frac{t_{on}}{t_{off}} + 1\right)$
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, $\lvert V_{out}\rvert = 1.25\left(1 + \frac{R2}{R1}\right)$
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 resistance and board layout. The ripple voltage should be kept to a low value since it will directly affect the line and load regulation.

NOTE: For further information refer to Application Note AN920A/D and AN954/D.

Figure 15. Design Formula Table

ORDERING INFORMATION

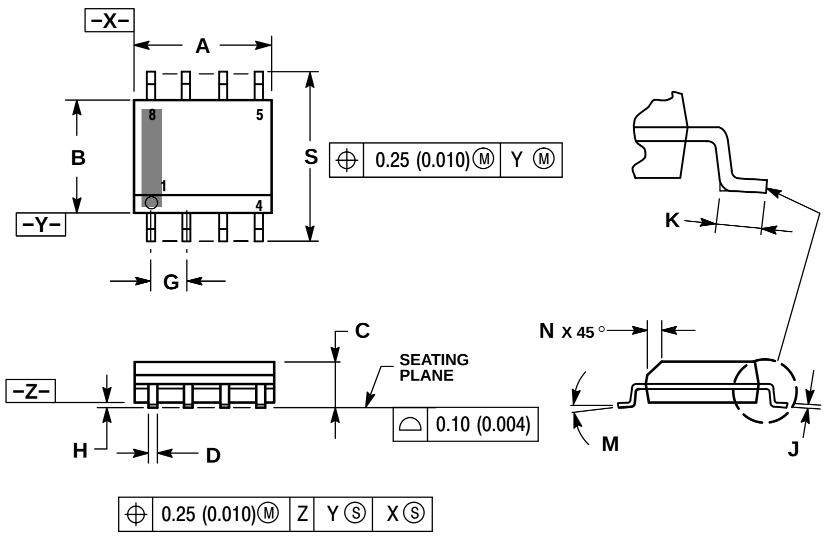
Device	Package	Shipping†
MC33063AD	SOIC−8	98 Units / Rail
MC33063ADG	SOIC−8 (Pb−Free)	98 Units / Rail
MC33063ADR2	SOIC−8	2500 Units / Tape & Reel
MC33063ADR2G	SOIC−8 (Pb−Free)	2500 Units / Tape & Reel
MC33063AP1	PDIP−8	50 Units / Rail
MC33063AP1G	PDIP−8 (Pb−Free)	50 Units / Rail
MC33063AVD	SOIC−8	98 Units / Rail
MC33063AVDG	SOIC−8 (Pb−Free)	98 Units / Rail
MC33063AVDR2	SOIC−8	2500 Units / Tape & Reel
MC33063AVDR2G	SOIC−8 (Pb−Free)	
NCV33063AVDR2*	SOIC−8	
NCV33063AVDR2G*	SOIC−8 (Pb−Free)	
MC33063AVP	PDIP−8	50 Units / Rail
MC33063AVPG	PDIP−8 (Pb−Free)	50 Units / Rail
MC34063AD	SOIC−8	98 Units / Rail
MC34063ADG	SOIC−8 (Pb−Free)	98 Units / Rail
MC34063ADR2	SOIC−8	2500 Units / Tape & Reel
MC34063ADR2G	SOIC−8 (Pb−Free)	2500 Units / Tape & Reel
MC34063AP1	PDIP−8	50 Units / Rail
MC34063AP1G	PDIP−8 (Pb−Free)	50 Units / Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

*NCV33063A: T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

PACKAGE DIMENSIONS

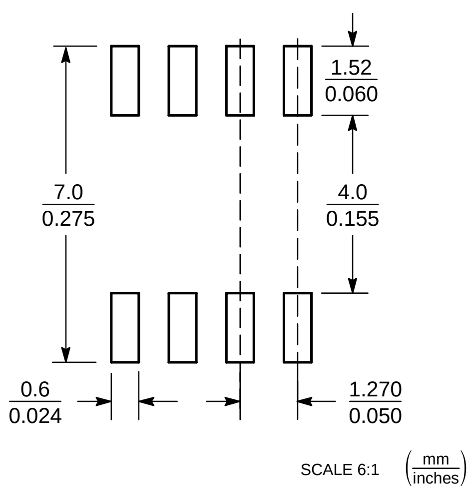
SOIC−8 NB
D SUFFIX
CASE 751−07
ISSUE AG



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751−01 THRU 751−06 ARE OBSOLETE. NEW STANDARD IS 751−07.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

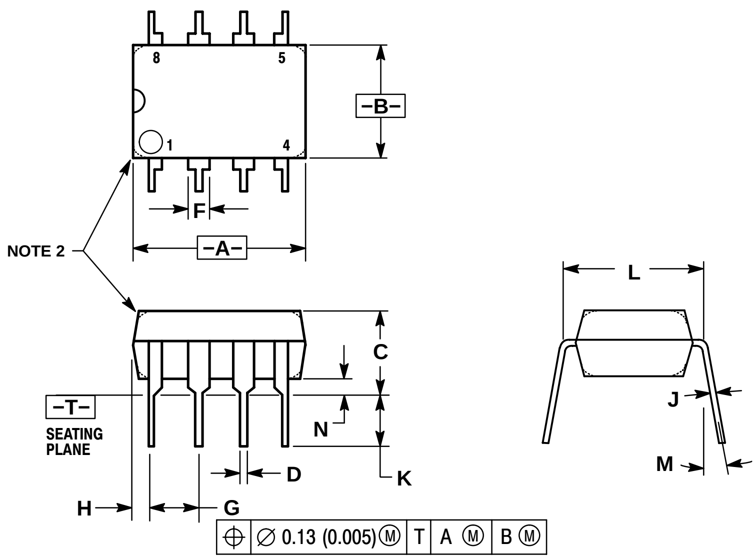
SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

PDIP−8
P, P1 SUFFIX
CASE 626−05
ISSUE L



NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	---	10°	---	10°
N	0.76	1.01	0.030	0.040

SENSEFET is a trademark of Semiconductor Components Industries, LLC.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
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