

# MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A

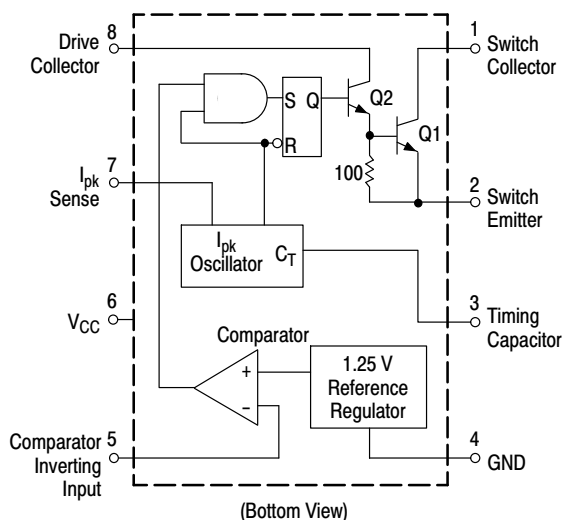
## Inverting Regulator - Buck, Boost, Switching

### 1.5 A

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
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant



This device contains 79 active transistors.

**Figure 1. Representative Schematic Diagram**



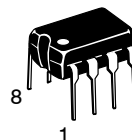
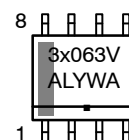
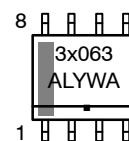
**ON Semiconductor®**

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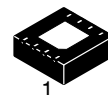
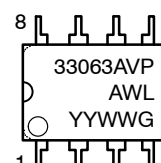
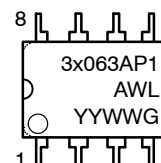
#### MARKING DIAGRAMS



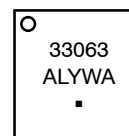
**SOIC-8  
D SUFFIX  
CASE 751**



**PDIP-8  
P, P1 SUFFIX  
CASE 626**



**DFN8  
CASE 488AF**



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

#### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 12 of this data sheet.

# MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A

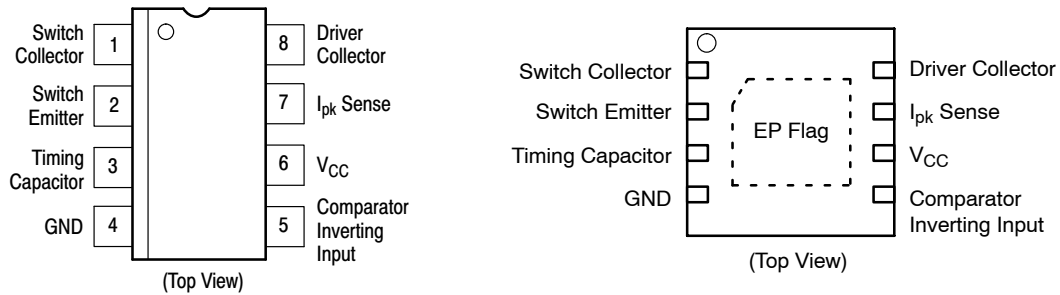


Figure 2. Pin Connections

## 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			
$T_A = 25^\circ C$	$P_D$	1.25	W
Thermal Resistance	$R_{\theta JA}$	115	$^\circ C/W$
SOIC Package, D Suffix			
$T_A = 25^\circ C$	$P_D$	625	mW
Thermal Resistance	$R_{\theta JA}$	160	$^\circ C/W$
Thermal Resistance	$R_{\theta JC}$	45	$^\circ C/W$
DFN Package			
$T_A = 25^\circ C$	$P_D$	1.25	mW
Thermal Resistance	$R_{\theta JA}$	80	$^\circ C/W$
Operating Junction Temperature	$T_J$	+150	$^\circ C$
Operating Ambient Temperature Range	$T_A$		$^\circ C$
MC34063A, SC34063A		0 to +70	
MC33063AV, NCV33063A		-40 to +125	
MC33063A, SC33063A		-40 to +85	
Storage Temperature Range	$T_{stg}$	-65 to +150	$^\circ C$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- Maximum package power dissipation limits must be observed.
- 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.
- NCV prefix is for automotive and other applications requiring site and change control.

# MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A

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

Characteristics	Symbol	Min	Typ	Max	Unit
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### OSCILLATOR

Frequency ( $V_{\text{Pin } 5} = 0\text{ V}$ , $C_T = 1.0\text{ nF}$ , $T_A = 25^\circ\text{C}$ )	$f_{\text{osc}}$	24	33	42	kHz
Charge Current ( $V_{CC} = 5.0\text{ V}$ to $40\text{ V}$ , $T_A = 25^\circ\text{C}$ )	$I_{\text{chg}}$	24	35	42	$\mu\text{A}$
Discharge Current ( $V_{CC} = 5.0\text{ V}$ to $40\text{ V}$ , $T_A = 25^\circ\text{C}$ )	$I_{\text{dischg}}$	140	220	260	$\mu\text{A}$
Discharge to Charge Current Ratio (Pin 7 to $V_{CC}$ , $T_A = 25^\circ\text{C}$ )	$I_{\text{dischg}}/I_{\text{chg}}$	5.2	6.5	7.5	–
Current Limit Sense Voltage ( $I_{\text{chg}} = I_{\text{dischg}}$ , $T_A = 25^\circ\text{C}$ )	$V_{\text{ipk(sense)}}$	250	300	350	mV

### OUTPUT SWITCH (Note 5)

Saturation Voltage, Darlington Connection ( $I_{\text{SW}} = 1.0\text{ A}$ , Pins 1, 8 connected)	$V_{\text{CE(sat)}}$	–	1.0	1.3	V
Saturation Voltage (Note 6) ( $I_{\text{SW}} = 1.0\text{ A}$ , $R_{\text{Pin } 8} = 82\ \Omega$ to $V_{CC}$ , Forced $\beta \approx 20$ )	$V_{\text{CE(sat)}}$	–	0.45	0.7	V
DC Current Gain ( $I_{\text{SW}} = 1.0\text{ A}$ , $V_{\text{CE}} = 5.0\text{ V}$ , $T_A = 25^\circ\text{C}$ )	$h_{\text{FE}}$	50	75	–	–
Collector Off-State Current ( $V_{\text{CE}} = 40\text{ V}$ )	$I_{\text{C(off)}}$	–	0.01	100	$\mu\text{A}$

### COMPARATOR

Threshold Voltage $T_A = 25^\circ\text{C}$ $T_A = T_{\text{low}}$ to $T_{\text{high}}$	$V_{\text{th}}$	1.225 1.21	1.25 –	1.275 1.29	V
Threshold Voltage Line Regulation ( $V_{CC} = 3.0\text{ V}$ to $40\text{ V}$ ) MC33063, MC34063 MC33063V, NCV33063	$\text{Reg}_{\text{line}}$	– –	1.4 1.4	5.0 6.0	mV
Input Bias Current ( $V_{\text{in}} = 0\text{ V}$ )	$I_{\text{IB}}$	–	–20	–400	nA

### TOTAL DEVICE

Supply Current ( $V_{CC} = 5.0\text{ V}$ to $40\text{ V}$ , $C_T = 1.0\text{ nF}$ , Pin 7 = $V_{CC}$ , $V_{\text{Pin } 5} > V_{\text{th}}$ , Pin 2 = GND, remaining pins open)	$I_{\text{CC}}$	–	–	4.0	mA
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Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

- $T_{\text{low}} = 0^\circ\text{C}$  for MC34063, SC34063;  $-40^\circ\text{C}$  for MC33063, SC33063, MC33063V, NCV33063  
 $T_{\text{high}} = +70^\circ\text{C}$  for MC34063, SC34063;  $+85^\circ\text{C}$  for MC33063, SC33063;  $+125^\circ\text{C}$  for MC33063V, NCV33063
- Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.
- If the output switch is driven into hard saturation (non-Darlington configuration) at low switch currents ( $\leq 300\text{ mA}$ ) and high driver currents ( $\geq 30\text{ mA}$ ), it may take up to  $2.0\ \mu\text{s}$  for it to come out of saturation. This condition will shorten the off time at frequencies  $\geq 30\text{ kHz}$ , 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:

$$\text{Forced } \beta \text{ of output switch : } \frac{I_{\text{C output}}}{I_{\text{C driver}} - 7.0\text{ mA}} \geq 10$$

\* The  $100\ \Omega$  resistor in the emitter of the driver device requires about  $7.0\text{ mA}$  before the output switch conducts.

# MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A

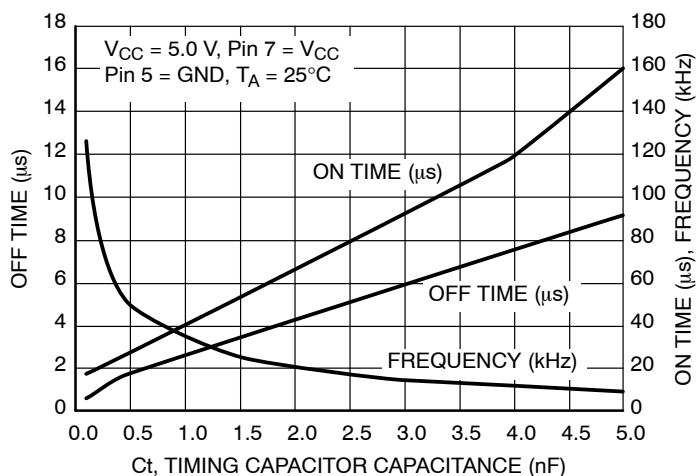


Figure 3. Oscillator Frequency

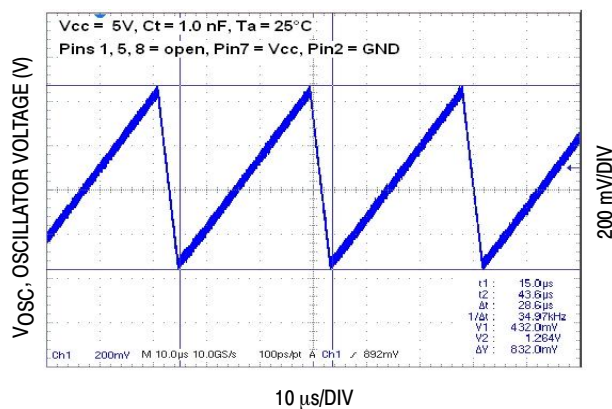


Figure 4. Timing Capacitor Waveform

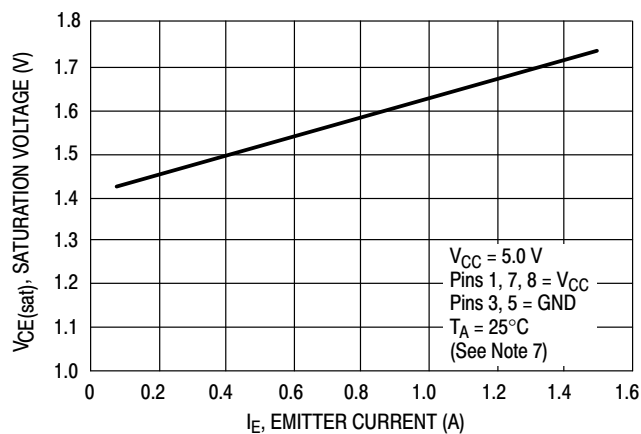


Figure 5. Emitter Follower Configuration Output Saturation Voltage versus Emitter Current

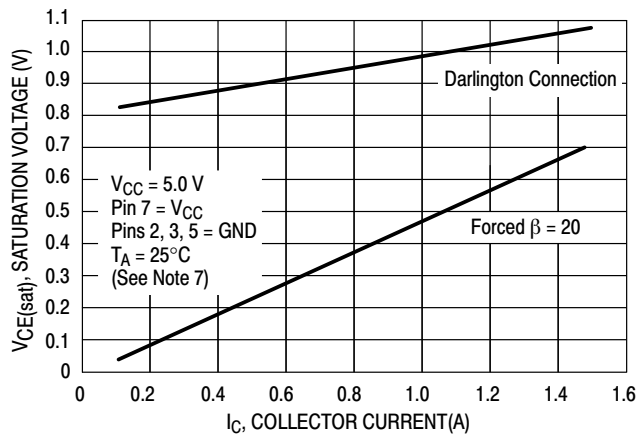


Figure 6. Common Emitter Configuration Output Switch Saturation Voltage versus Collector Current

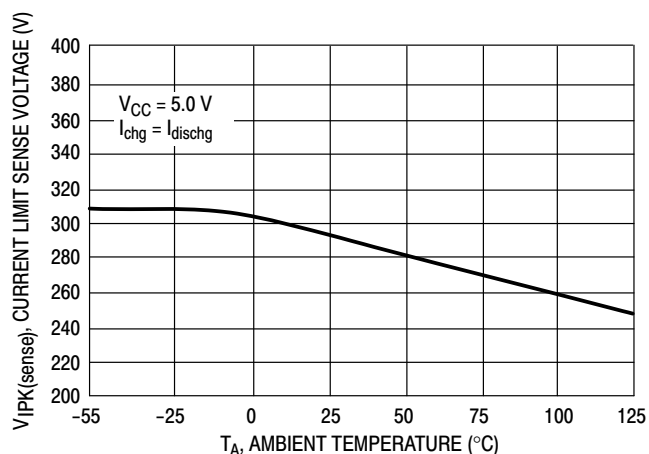


Figure 7. Current Limit Sense Voltage versus Temperature

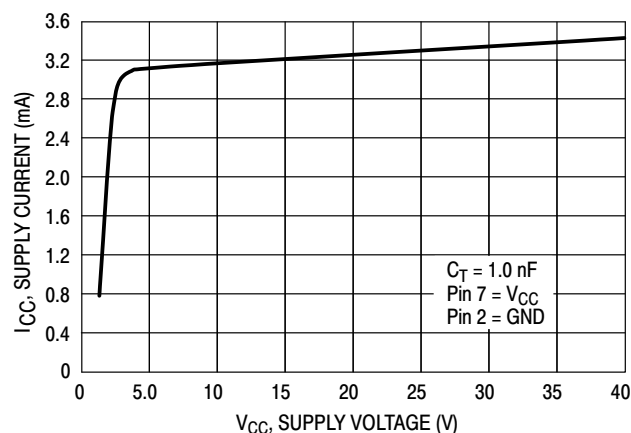
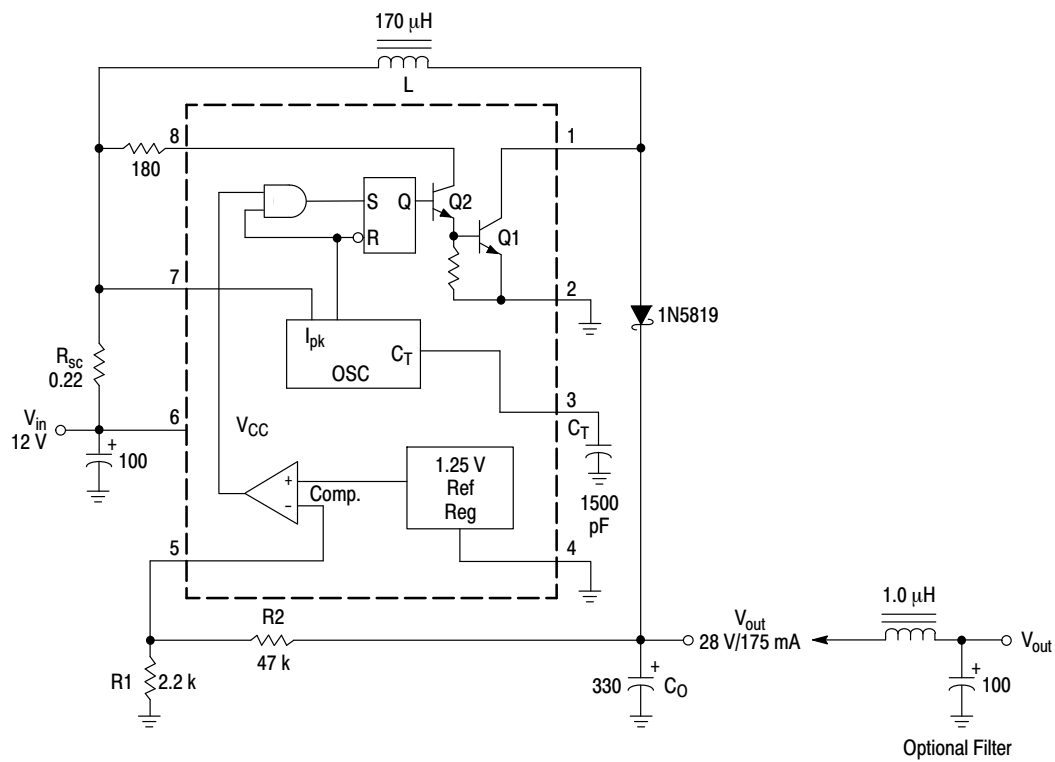


Figure 8. Standby Supply Current versus Supply Voltage

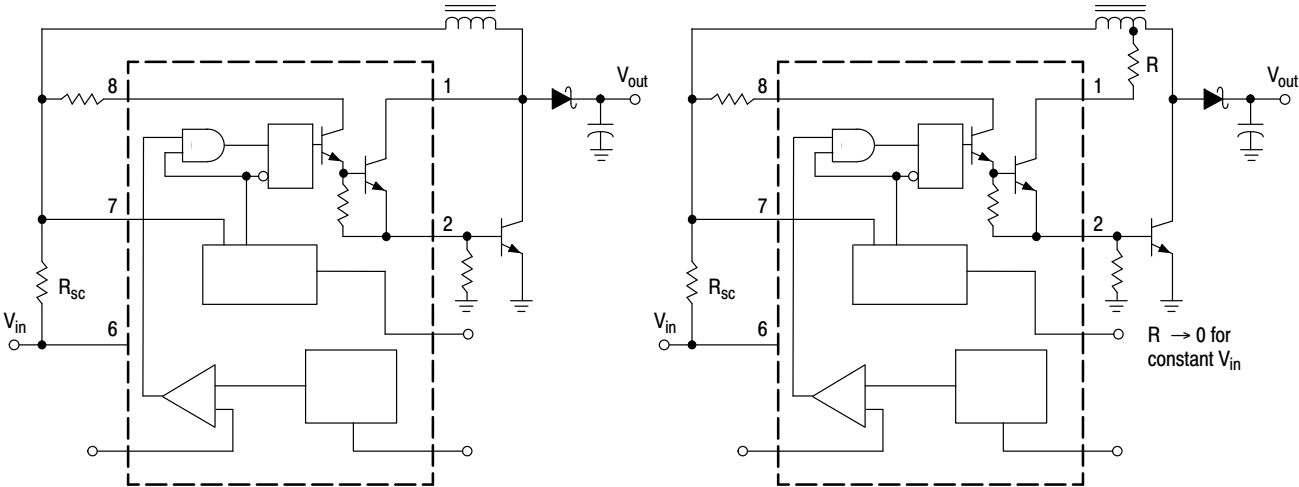
7. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.



Test	Conditions	Results
Line Regulation	$V_{in} = 8.0 \text{ V to } 16 \text{ V}$ , $I_O = 175 \text{ mA}$	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 mVpp
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 mVpp

Figure 9. Step-Up Converter

**MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A**



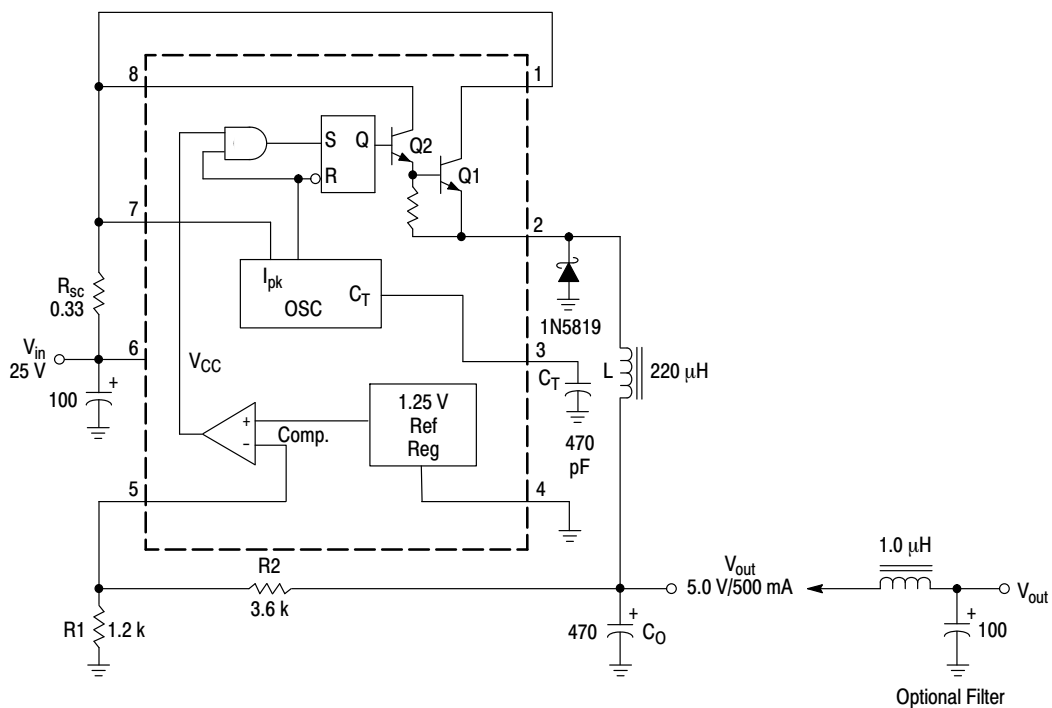
**Figure 10. External Current Boost Connections for  $I_C$  Peak Greater than 1.5 A**

### 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 ( $\leq 300$  mA) and high driver currents ( $\geq 30$  mA), it may take up to 2.0  $\mu$ s to come out of saturation. This condition will shorten the off time at frequencies  $\geq 30$  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	$V_{in} = 15\text{ V to } 25\text{ V}, I_O = 500\text{ mA}$	$12\text{ mV} = \pm 0.12\%$
Load Regulation	$V_{in} = 25\text{ V}, I_O = 50\text{ mA to } 500\text{ mA}$	$3.0\text{ mV} = \pm 0.03\%$
Output Ripple	$V_{in} = 25\text{ V}, I_O = 500\text{ mA}$	$120\text{ mVpp}$
Short Circuit Current	$V_{in} = 25\text{ V}, R_L = 0.1\ \Omega$	$1.1\text{ A}$
Efficiency	$V_{in} = 25\text{ V}, I_O = 500\text{ mA}$	$83.7\%$
Output Ripple With Optional Filter	$V_{in} = 25\text{ V}, I_O = 500\text{ mA}$	$40\text{ mVpp}$

Figure 11. Step-Down Converter

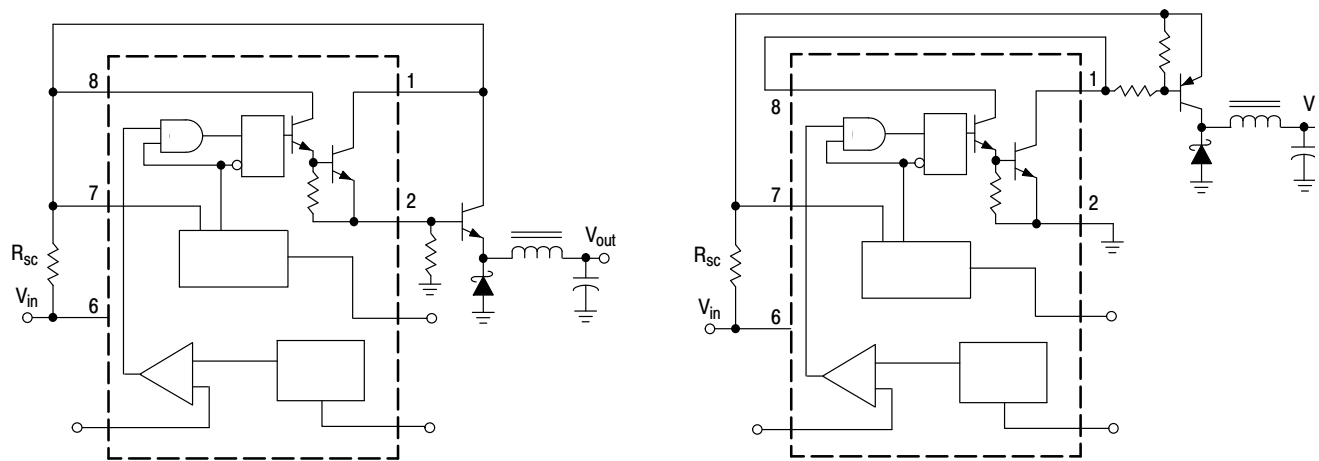
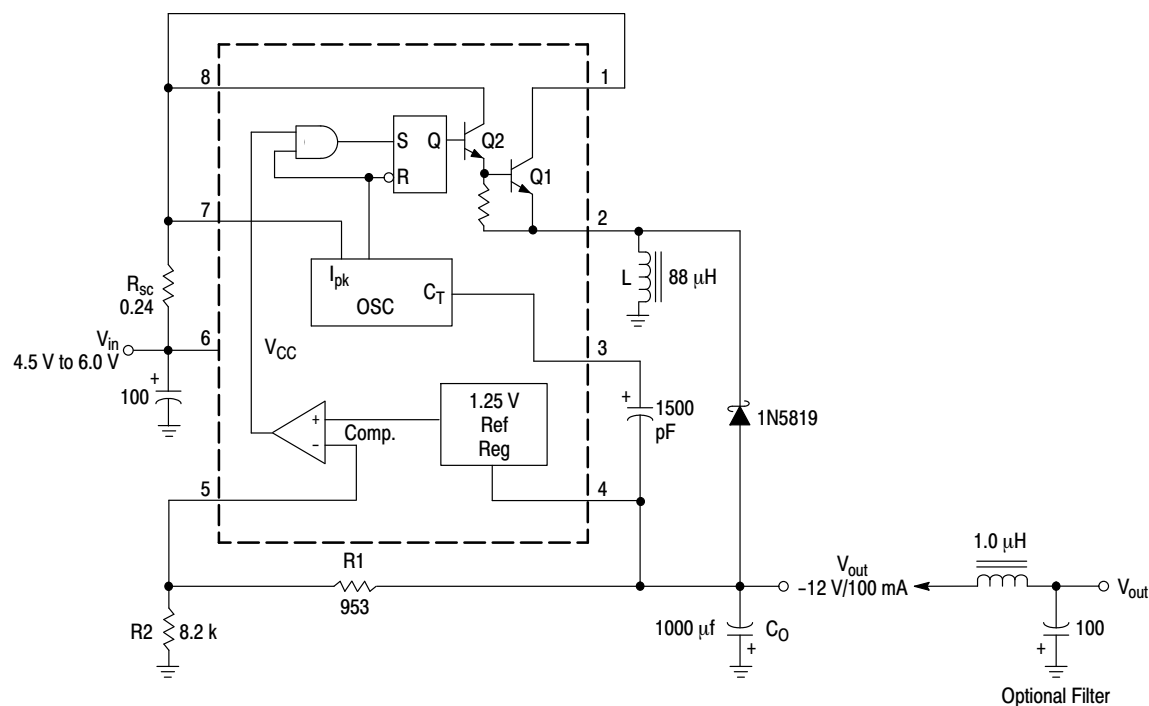


Figure 12. External Current Boost Connections for  $I_C$  Peak Greater than 1.5 A

11a. External NPN Switch

11b. External PNP Saturated Switch



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

Figure 13. Voltage Inverting Converter

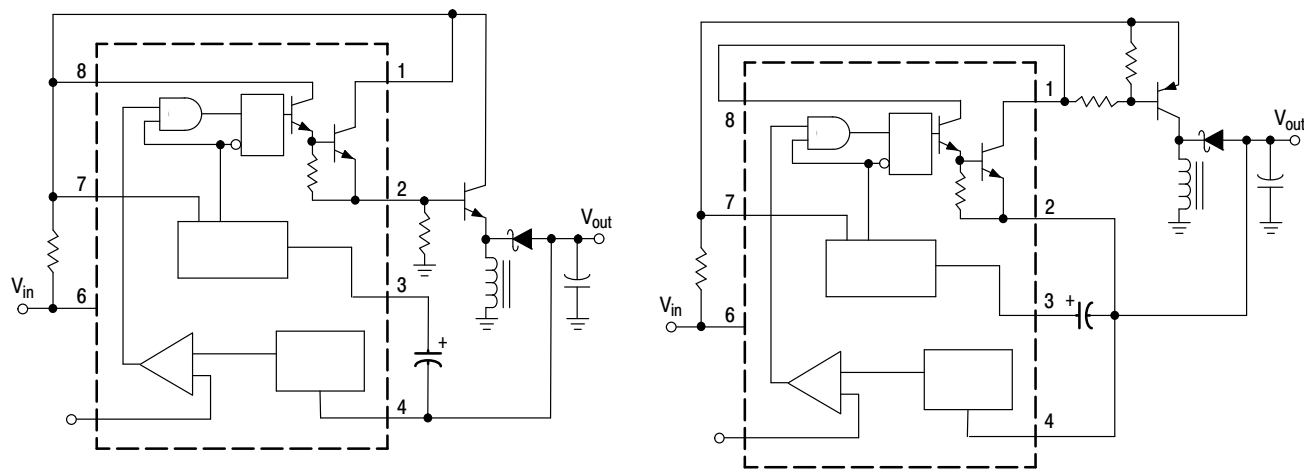
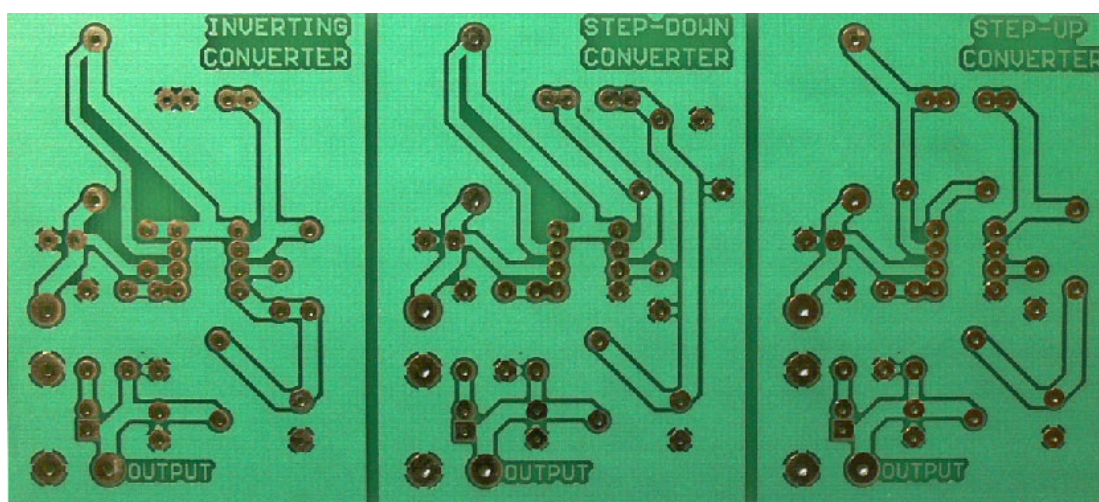


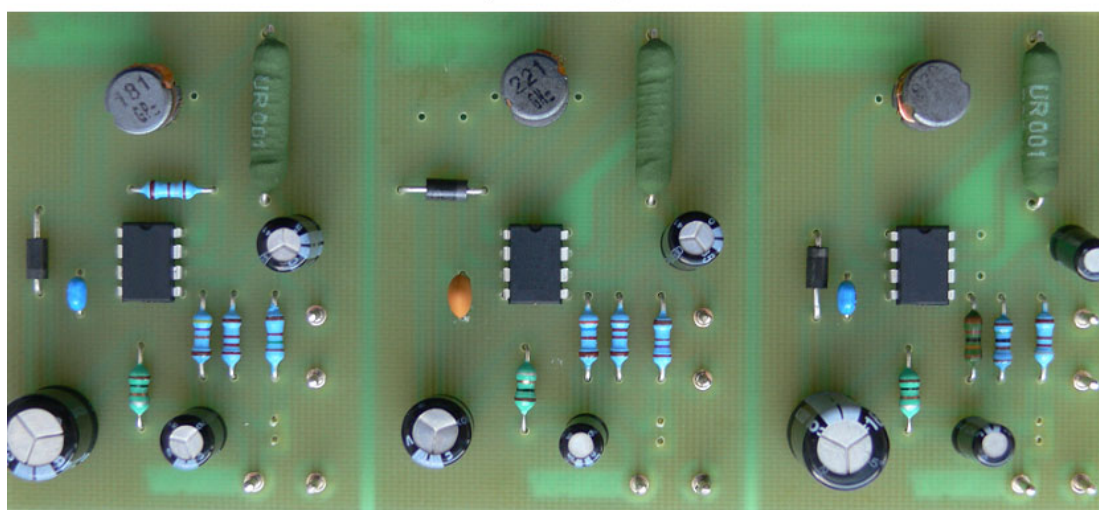
Figure 14. External Current Boost Connections for  $I_C$  Peak Greater than 1.5 A

13a. External NPN Switch

13b. External PNP Saturated Switch



(Bottom Side)



(Top View, Component Side)

**Figure 15. Printed Circuit Board and Component Layout**  
(Circuits of Figures 9, 11, 13)

#### INDUCTOR DATA

Converter	Inductance ( $\mu\text{H}$ )	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.

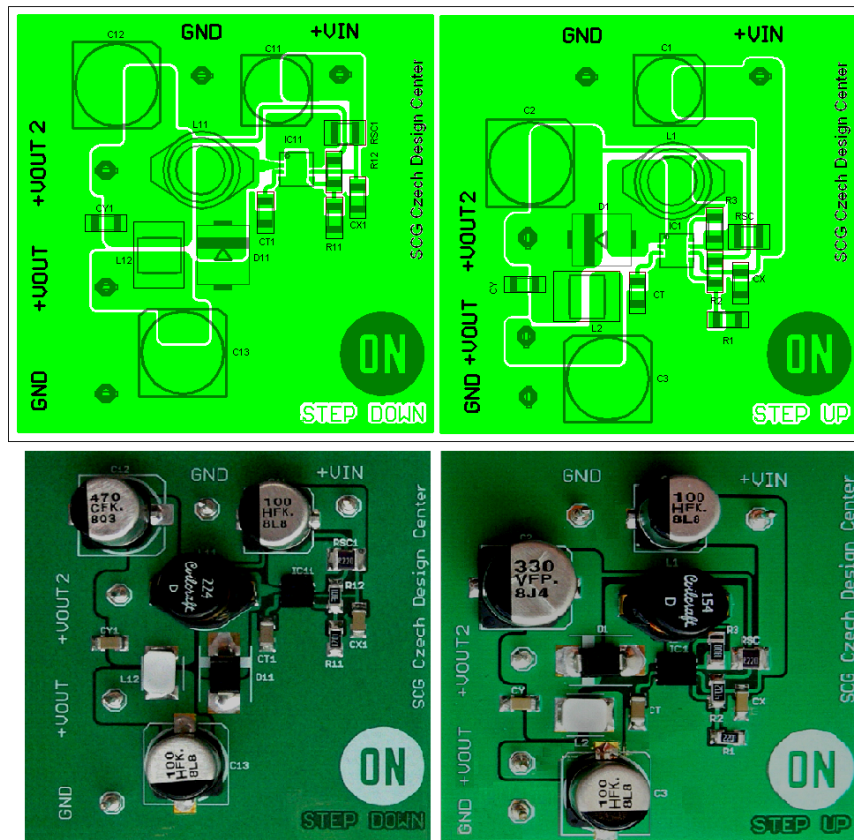


Figure 16. Printed Circuit Board for DFN Device

# MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A

Calculation	Step-Up	Step-Down	Voltage-Inverting
$t_{on}/t_{off}$	$\frac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$	$\frac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$	$\frac{ V_{out}  + V_F}{V_{in} - V_{sat}}$
$(t_{on} + t_{off})$	$\frac{1}{f}$	$\frac{1}{f}$	$\frac{1}{f}$
$t_{off}$	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$
$t_{on}$	$(t_{on} + t_{off}) - t_{off}$	$(t_{on} + t_{off}) - t_{off}$	$(t_{on} + t_{off}) - t_{off}$
$C_T$	$4.0 \times 10^{-5} t_{on}$	$4.0 \times 10^{-5} t_{on}$	$4.0 \times 10^{-5} t_{on}$
$I_{pk(switch)}$	$2I_{out(max)} \left( \frac{t_{on}}{t_{off}} + 1 \right)$	$2I_{out(max)}$	$2I_{out(max)} \left( \frac{t_{on}}{t_{off}} + 1 \right)$
$R_{sc}$	$0.3/I_{pk(switch)}$	$0.3/I_{pk(switch)}$	$0.3/I_{pk(switch)}$
$L_{(min)}$	$\left( \frac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}} \right) t_{on(max)}$	$\left( \frac{(V_{in(min)} - V_{sat} - V_{out})}{I_{pk(switch)}} \right) t_{on(max)}$	$\left( \frac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}} \right) t_{on(max)}$
$C_O$	$9 \frac{I_{out} t_{on}}{V_{ripple(pp)}}$	$\frac{I_{pk(switch)}(t_{on} + t_{off})}{8V_{ripple(pp)}}$	$9 \frac{I_{out} t_{on}}{V_{ripple(pp)}}$

$V_{sat}$  = 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,  $|V_{out}| = 1.25 \left( 1 + \frac{R_2}{R_1} \right)$

$I_{out}$  – 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 17. Design Formula Table**

# MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A

## ORDERING INFORMATION

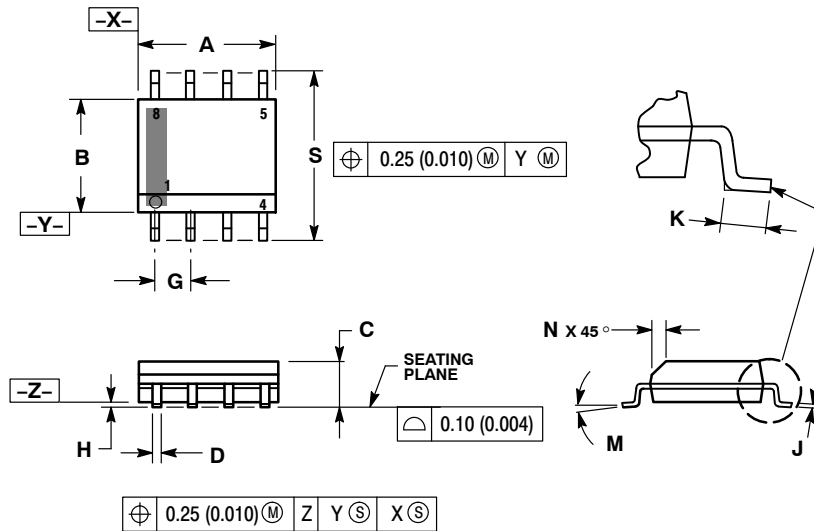
Device	Package	Shipping†
MC33063ADG	SOIC-8 (Pb-Free)	98 Units / Rail
MC33063ADR2G	SOIC-8 (Pb-Free)	2500 Units / Tape & Reel
SC33063ADR2G	SOIC-8 (Pb-Free)	2500 Units / Tape & Reel
MC33063AP1G	PDIP-8 (Pb-Free)	50 Units / Rail
MC33063AVDG	SOIC-8 (Pb-Free)	98 Units / Rail
MC33063AVDR2G	SOIC-8 (Pb-Free)	
NCV33063AVDR2G*	SOIC-8 (Pb-Free)	2500 Units / Tape & Reel
MC33063AVPG	PDIP-8 (Pb-Free)	50 Units / Rail
MC34063ADG	SOIC-8 (Pb-Free)	98 Units / Rail
MC34063ADR2G	SOIC-8 (Pb-Free)	2500 Units / Tape & Reel
SC34063ADR2G	SOIC-8 (Pb-Free)	2500 Units / Tape & Reel
MC34063AP1G	PDIP-8 (Pb-Free)	50 Units / Rail
SC34063AP1G	PDIP-8 (Pb-Free)	50 Units / Rail
MC33063MNTXG	DFN8 (Pb-Free)	4000 Units / Tape & Reel

†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:  $T_{low} = -40^{\circ}\text{C}$ ,  $T_{high} = +125^{\circ}\text{C}$ . Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

PACKAGE DIMENSIONS

SOIC-8 NB  
CASE 751-07  
ISSUE AK

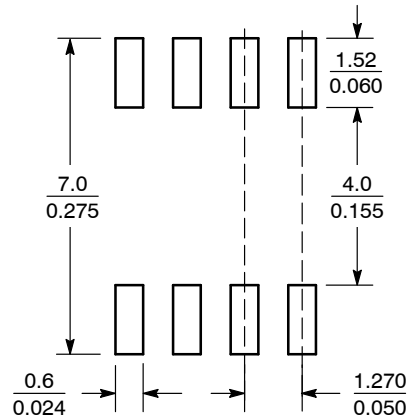


NOTES:

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.

DIM	MILLIMETERS		INCHES	
	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\*

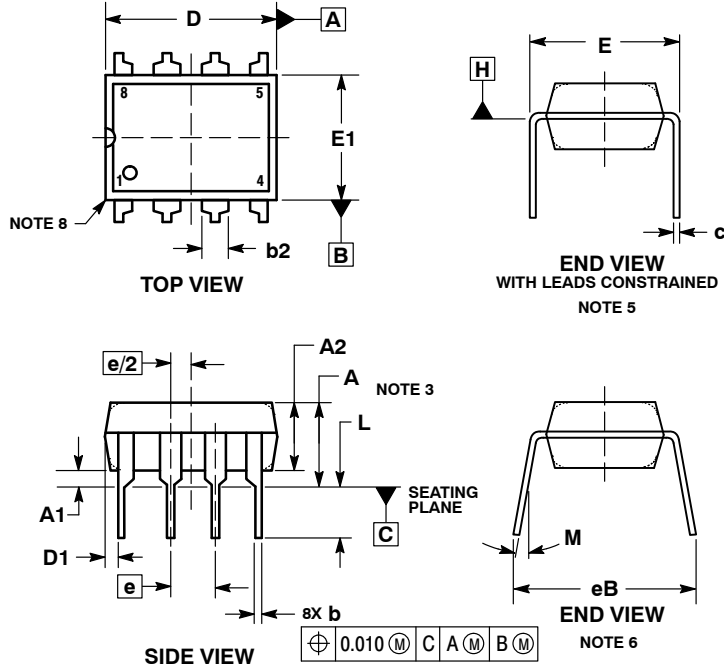


SCALE 6:1 ( $\frac{\text{mm}}{\text{inches}}$ )

\*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 P



## NOTES:

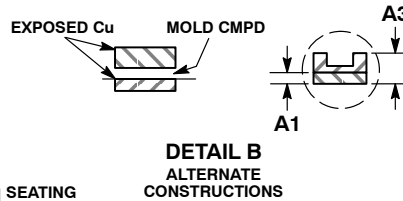
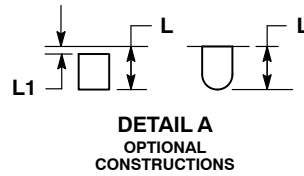
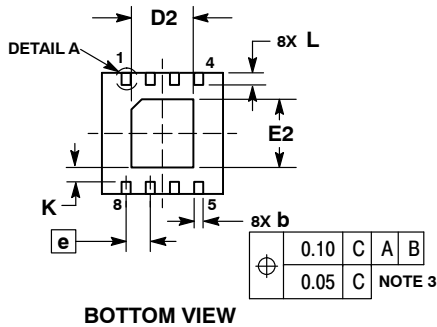
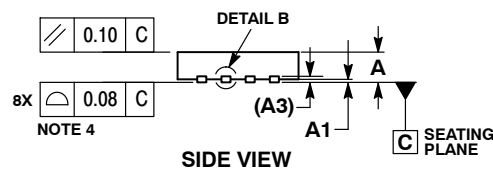
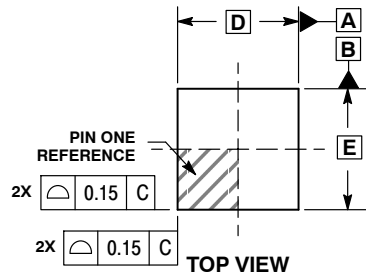
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	----	0.210	----	5.33
A1	0.015	----	0.38	----
A2	0.115	0.195	2.92	4.95
b	0.014	0.022	0.35	0.56
b2	0.060 TYP		1.52 TYP	
C	0.008	0.014	0.20	0.36
D	0.355	0.400	9.02	10.16
D1	0.005	----	0.13	----
E	0.300	0.325	7.62	8.26
E1	0.240	0.280	6.10	7.11
e	0.100 BSC		2.54 BSC	
eB	----	0.430	----	10.92
L	0.115	0.150	2.92	3.81
M	----	10°	----	10°

# MC34063A, MC33063A, SC34063A, SC33063A, NCV33063A

## PACKAGE DIMENSIONS

DFN8, 4x4  
CASE 488AF-01  
ISSUE C

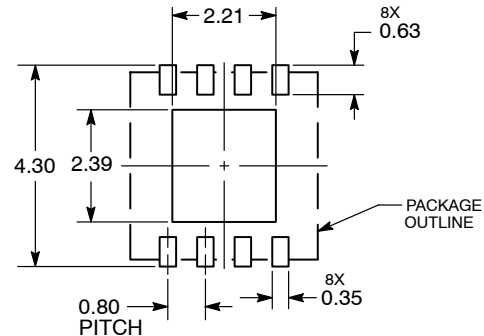


### NOTES:

1. DIMENSIONS AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30MM FROM TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. DETAILS A AND B SHOW OPTIONAL CONSTRUCTIONS FOR TERMINALS.

DIM	MILLIMETERS	
	MIN	MAX
A	0.80	1.00
A1	0.00	0.05
A3	0.20	REF
b	0.25	0.35
D	4.00	BSC
D2	1.91	2.21
E	4.00	BSC
E2	2.09	2.39
e	0.80	BSC
K	0.20	---
L	0.30	0.50
L1	---	0.15


### SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

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

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