

MC34063A, MC33063A

DC-to-DC Converter Control Circuits

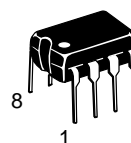
The MC34063A Series is a monolithic control circuit containing the primary functions required for DC-to-DC converters. These devices consist of an internal temperature compensated reference, comparator, controlled duty cycle oscillator with an active current limit circuit, driver and high current output 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.

- 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



ON Semiconductor

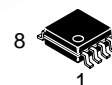
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PDIP-8
P, P1 SUFFIX
CASE 626



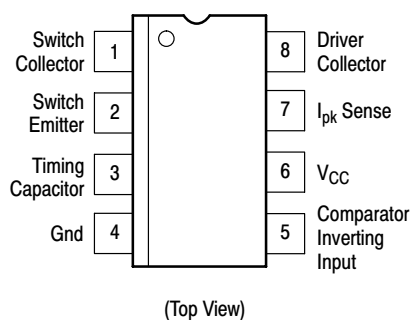
SO-8
D SUFFIX
CASE 751



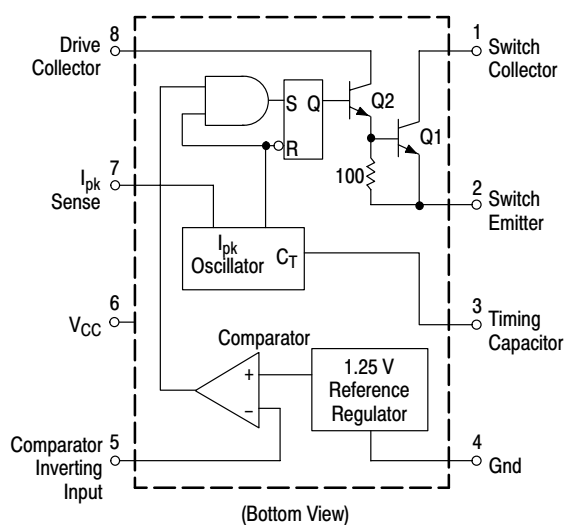
SOEIAJ-8
M SUFFIX
CASE 968

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PIN CONNECTIONS



Representative Schematic Diagram



This device contains 51 active transistors.

ORDERING INFORMATION

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

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 11 of this data sheet.

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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 ($V_{P_{in\ 1}} = 40\text{ V}$)	$V_{E(switch)}$	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			
$T_A = 25^\circ\text{C}$	P_D	1.25	W
Thermal Resistance	$R_{\theta JA}$	100	$^\circ\text{C/W}$
SOIC Package, D Suffix			
$T_A = 25^\circ\text{C}$	P_D	625	W
Thermal Resistance	$R_{\theta JA}$	160	$^\circ\text{C/W}$
Operating Junction Temperature	T_J	+150	$^\circ\text{C}$
Operating Ambient Temperature Range	T_A		$^\circ\text{C}$
MC34063A		0 to +70	
MC33063AV		-40 to +125	
MC33063A		-40 to +85	
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

1. Maximum package power dissipation limits must be observed.
2. ESD data available upon request.

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ELECTRICAL CHARACTERISTICS ($V_{CC} = 5.0\text{ V}$, $T_A = T_{low}$ to T_{high} [Note 3.], unless otherwise specified.)

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

OUTPUT SWITCH (Note 4.)

Saturation Voltage, Darlington Connection ($I_{SW} = 1.0\text{ A}$, Pins 1, 8 connected)	$V_{CE(sat)}$	–	1.0	1.3	V
Saturation Voltage (Note 5.) ($I_{SW} = 1.0\text{ A}$, $R_{Pin\ 8} = 82\ \Omega$ to V_{CC} , Forced $\beta \approx 20$)	$V_{CE(sat)}$	–	0.45	0.7	V
DC Current Gain ($I_{SW} = 1.0\text{ A}$, $V_{CE} = 5.0\text{ V}$, $T_A = 25^\circ\text{C}$)	h_{FE}	50	75	–	–
Collector Off–State Current ($V_{CE} = 40\text{ V}$)	$I_{C(off)}$	–	0.01	100	μA

COMPARATOR

Threshold Voltage $T_A = 25^\circ\text{C}$ $T_A = T_{low}$ to T_{high}	V_{th}	1.225 1.21	1.25 –	1.275 1.29	V
Threshold Voltage Line Regulation ($V_{CC} = 3.0\text{ V to }40\text{ V}$) MC33063A, MC34063A MC33363AV	Reg_{line}	– –	1.4 1.4	5.0 6.0	mV
Input Bias Current ($V_{in} = 0\text{ V}$)	I_{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} , $V_{Pin\ 5} > V_{th}$, Pin 2 = Gnd, remaining pins open)	I_{CC}	–	–	4.0	mA
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3. $T_{low} = 0^\circ\text{C}$ for MC34063A, -40°C for MC33063A, AV $T_{high} = +70^\circ\text{C}$ for MC34063A, $+85^\circ\text{C}$ for MC33063A, $+125^\circ\text{C}$ for MC33063AV
4. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.
5. 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:

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

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

MC34063A, MC33063A

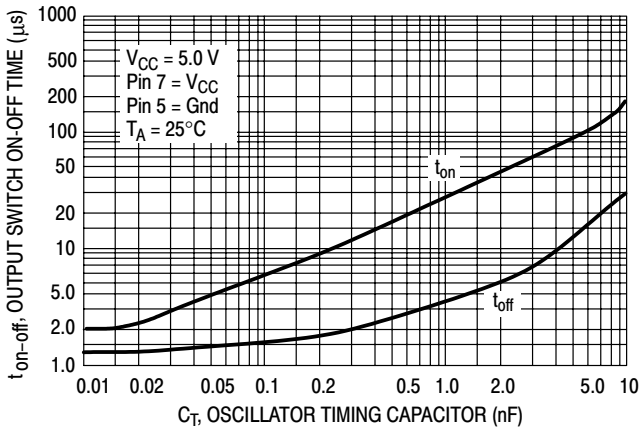


Figure 1. Output Switch On-Off Time versus Oscillator Timing Capacitor

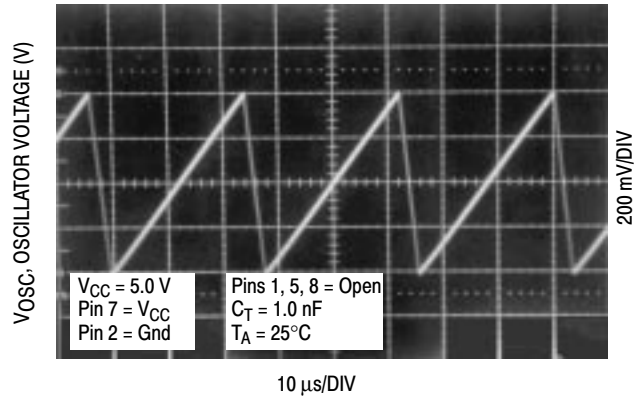


Figure 2. Timing Capacitor Waveform

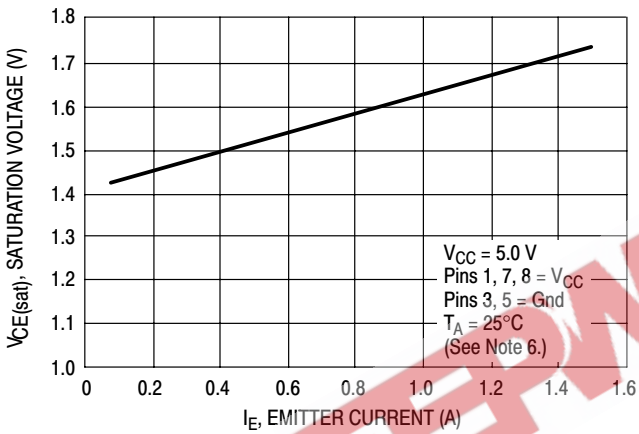


Figure 3. Emitter Follower Configuration Output Saturation Voltage versus Emitter Current

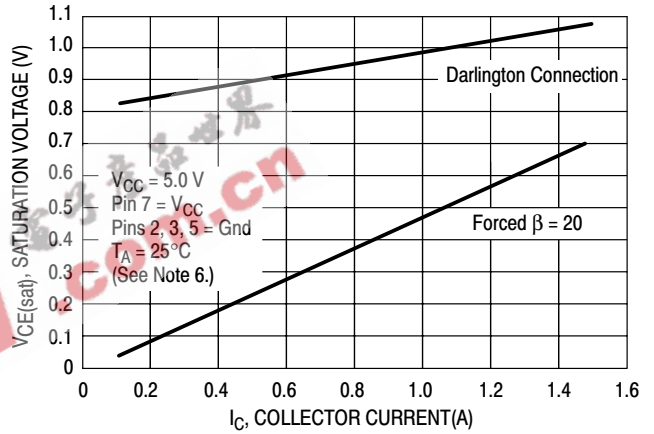


Figure 4. Common Emitter Configuration Output Switch Saturation Voltage versus Collector Current

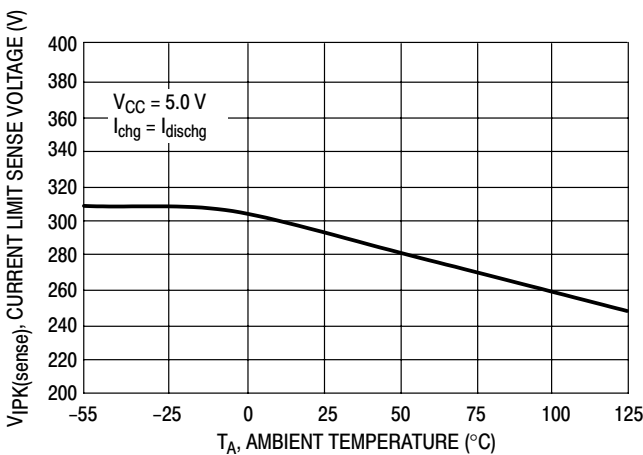


Figure 5. Current Limit Sense Voltage versus Temperature

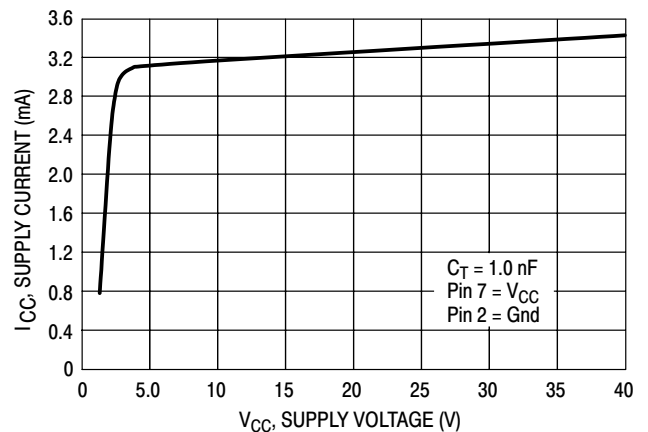
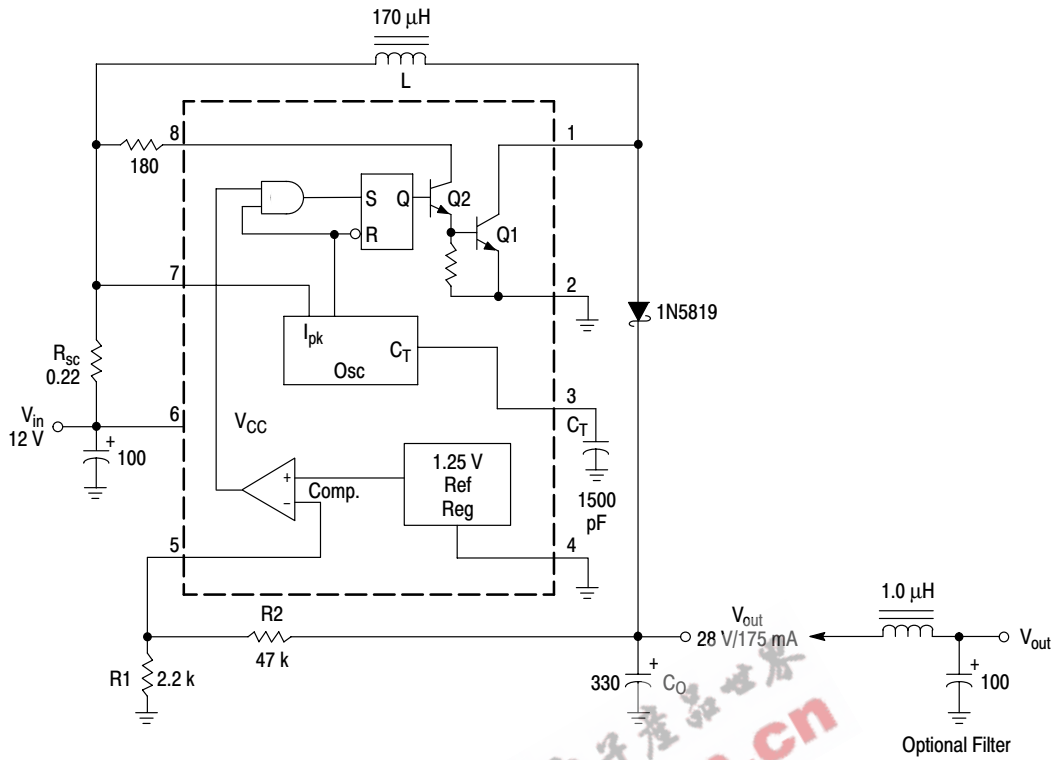


Figure 6. Standby Supply Current versus Supply Voltage

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

MC34063A, MC33063A



Test	Conditions	Results
Line Regulation	$V_{in} = 8.0\text{ V to }16\text{ V}, I_O = 175\text{ mA}$	$30\text{ mV} = \pm 0.05\%$
Load Regulation	$V_{in} = 12\text{ V}, I_O = 75\text{ mA to }175\text{ mA}$	$10\text{ mV} = \pm 0.017\%$
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 7. Step-Up Converter

MC34063A, MC33063A

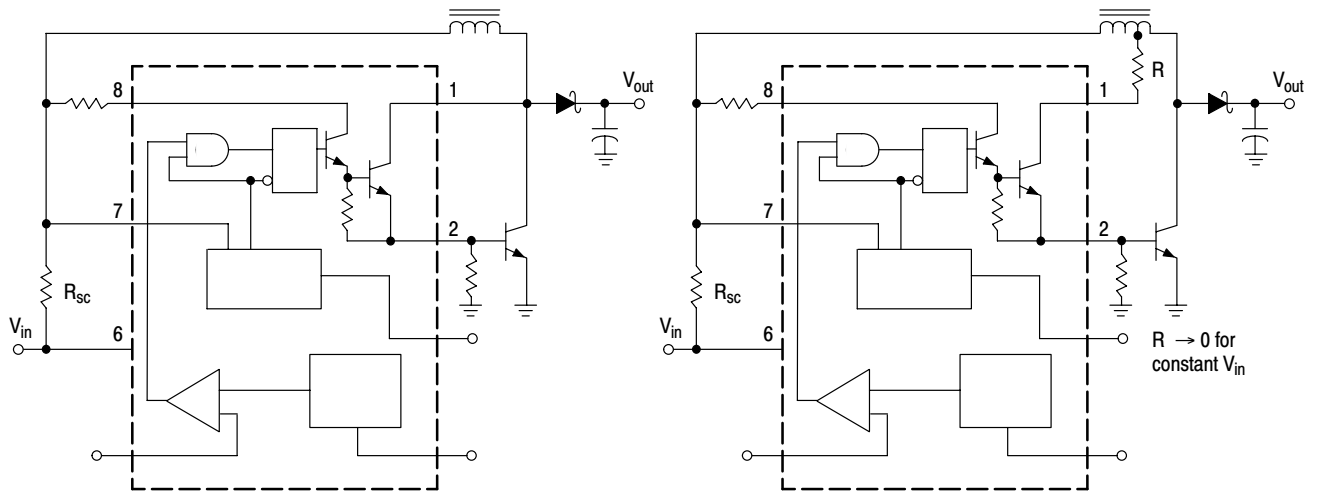


Figure 8. External Current Boost Connections for I_C Peak Greater than 1.5 A

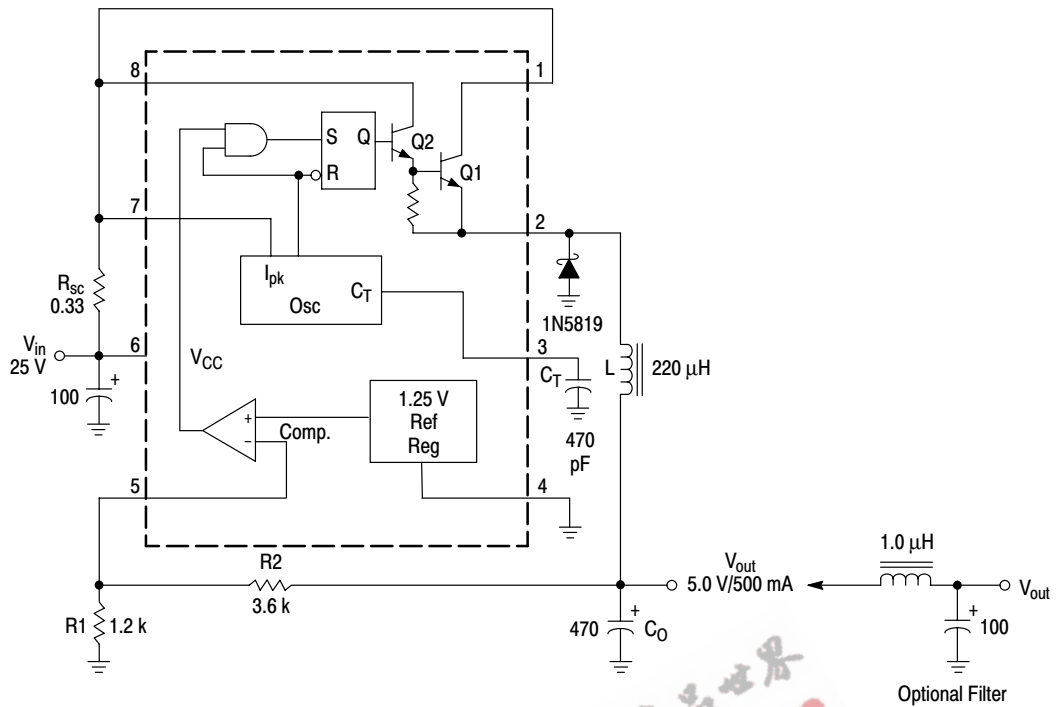
8a. External NPN Switch

8b. External NPN Saturated Switch

(See Note 7.)

7. 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 $2.0 \mu\text{s}$ 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, since the output switch cannot saturate. If a non-Darlington configuration is used, the following output drive condition is recommended.

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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 mVpp
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 mVpp

Figure 9. Step-Down Converter

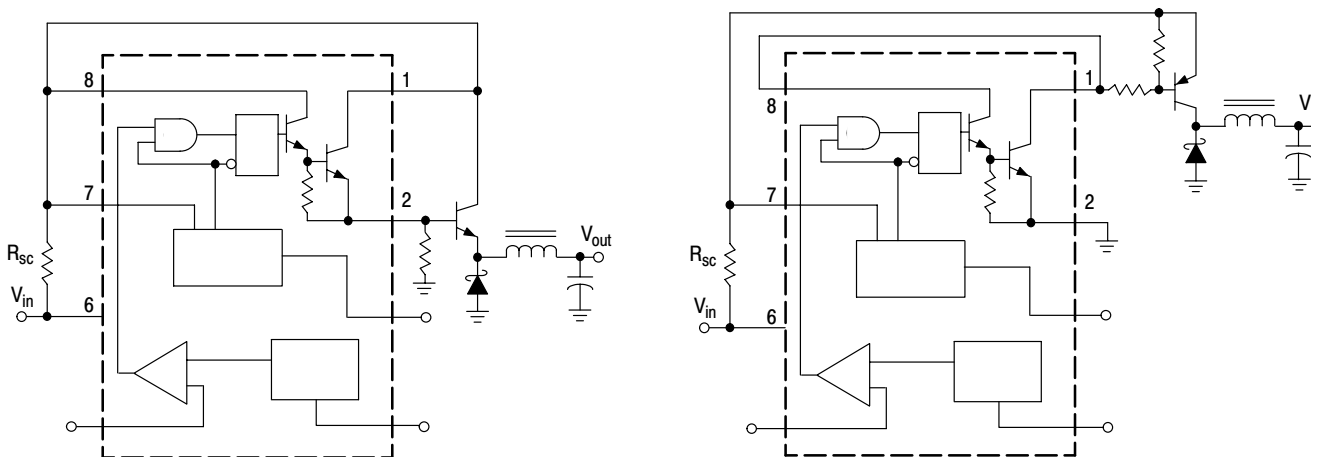
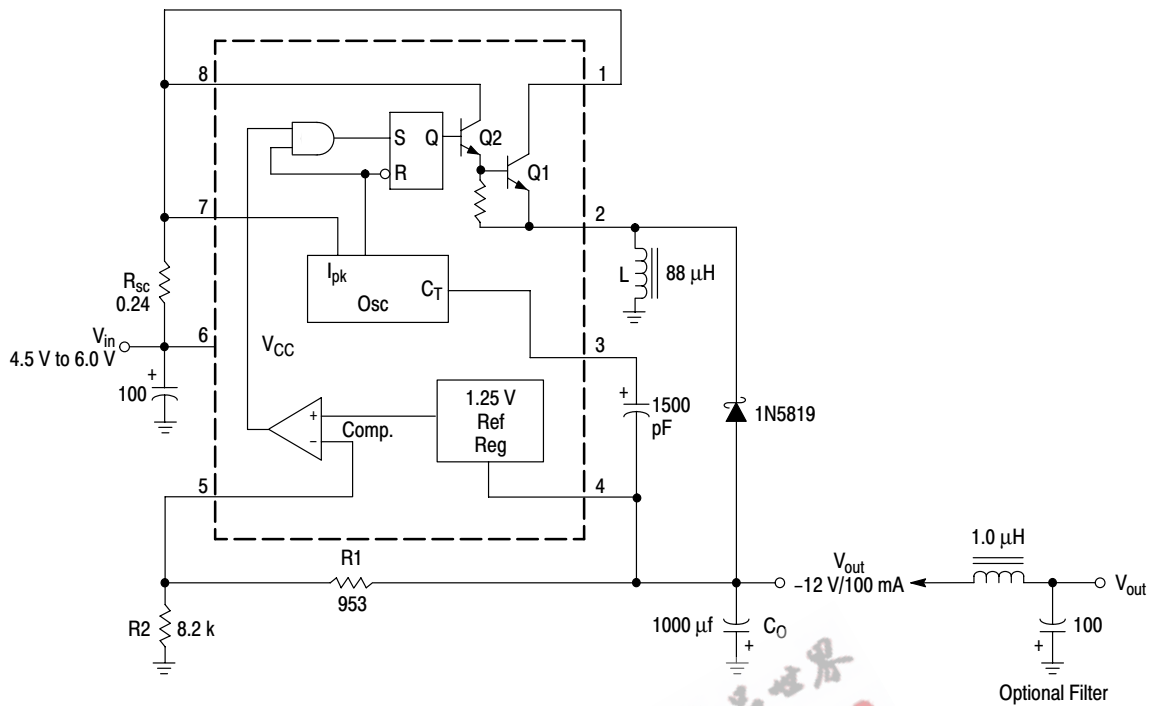


Figure 10. External Current Boost Connections for I_C Peak Greater than 1.5 A

10a. External NPN Switch

10b. External PNP Saturated Switch

MC34063A, MC33063A



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 mVpp
Short Circuit Current	$V_{in} = 5.0 \text{ V}, R_L = 0.1 \Omega$	910 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 mVpp

Figure 11. Voltage Inverting Converter

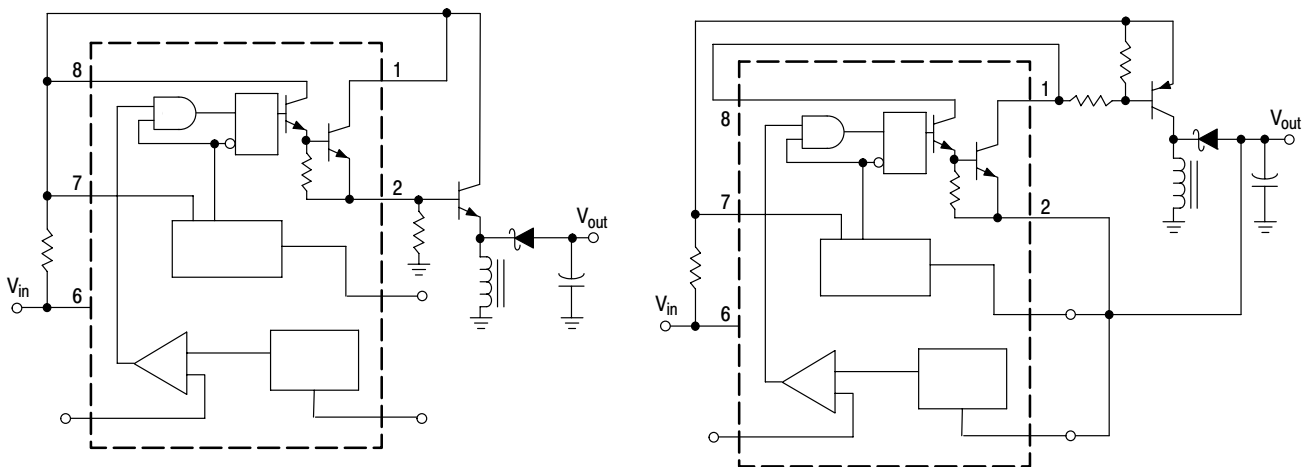
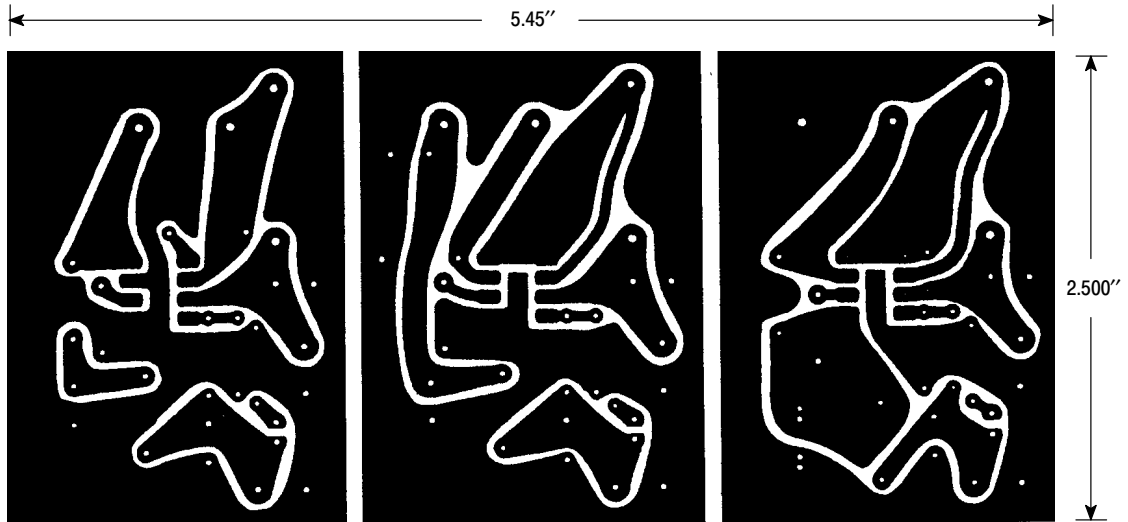


Figure 12. External Current Boost Connections for I_C Peak Greater than 1.5 A

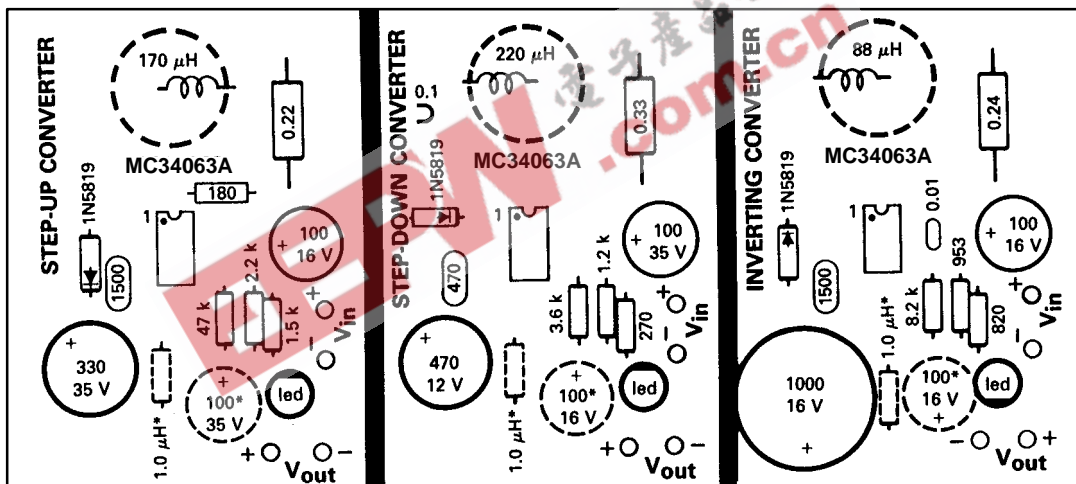
12a. External NPN Switch

12b. External PNP Saturated Switch

MC34063A, MC33063A



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



(Top View, Component Side)

*Optional Filter.

Figure 13. Printed Circuit Board and Component Layout

(Circuits of Figures 7, 9, 11)

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.

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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, $|V_{out}| = 1.25 \left(1 + \frac{R2}{R1} \right)$

I_{out} – Desired output current.

f_{min} – Minimum desired output switching frequency at the selected values of V_{in} and I_{out} .

$V_{ripple(pp)}$ – 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 14. Design Formula Table

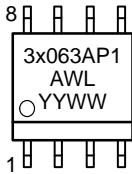
MC34063A, MC33063A

ORDERING INFORMATION

Device	Package	Shipping
MC33063AD	SO-8	98 Units / Rail
MC33063ADR2	SO-8	2500 Units / Tape & Reel
MC33063AP1	DIP-8	50 Units / Rail
MC33063AVD	SO-8	98 Units / Rail
MC33063AVDR2	SO-8	2500 Units / Tape & Reel
MC33063AVP	DIP-8	50 Units / Rail
MC34063AD	SO-8	98 Units / Rail
MC34063ADR2	SO-8	2500 Units / Tape & Reel
MC34063AP1	DIP-8	50 Units / Rail
MC34063BD	SO-8	98 Units / Rail
MC34063BDR2	SO-8	2500 Units / Tape & Reel
MC34063AM	SOEIAJ-8	94 Units / Rail
MC34063AMEL	SOEIAJ-8	1000 Units / Tape & Reel
MC34063AML1	SOEIAJ-8	1000 Units / Tape & Reel
MC34063AML2	SOEIAJ-8	2000 Units / Tape & Reel
MC34063AMR1	SOEIAJ-8	1000 Units / Tape & Reel
MC34063AMR2	SOEIAJ-8	2000 Units / Tape & Reel

MARKING DIAGRAMS

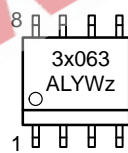
PDIP-8
P, P1 SUFFIX
CASE 626



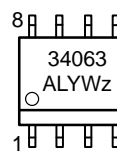
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P, P1 SUFFIX
CASE 626



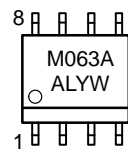
SO-8
D SUFFIX
CASE 751



SO-8
D SUFFIX
CASE 751



SOEIAJ-8
M SUFFIX
CASE 968

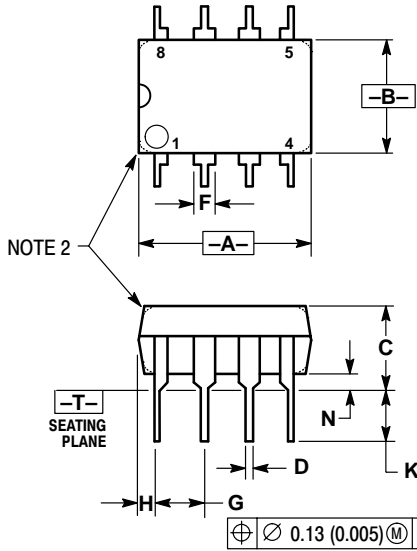


- x = 3 or 4
- z = A denotes AD suffix
J denotes BD suffix
- A = Assembly Location
- WL, L = Wafer Lot
- YY, Y = Year
- WW, W = Work Week

MC34063A, MC33063A

PACKAGE DIMENSIONS

PDIP-8
P, P1 SUFFIX
 PLASTIC PACKAGE
 CASE 626-05
 ISSUE K

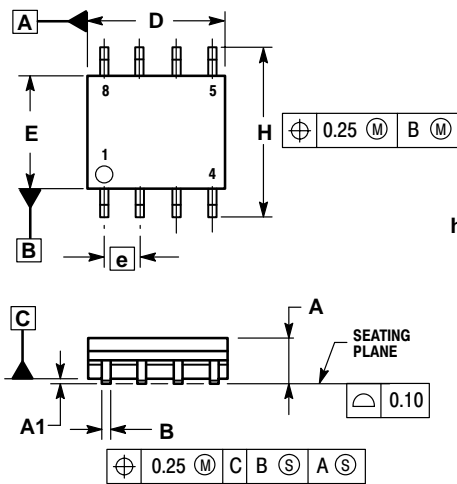


- NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
 2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
 3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

DIM	MILLIMETERS		INCHES	
	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

⊕ ∅ 0.13 (0.005) (M) T A (M) B (M)

SO-8
D SUFFIX
 PLASTIC PACKAGE
 CASE 751-06
 ISSUE T



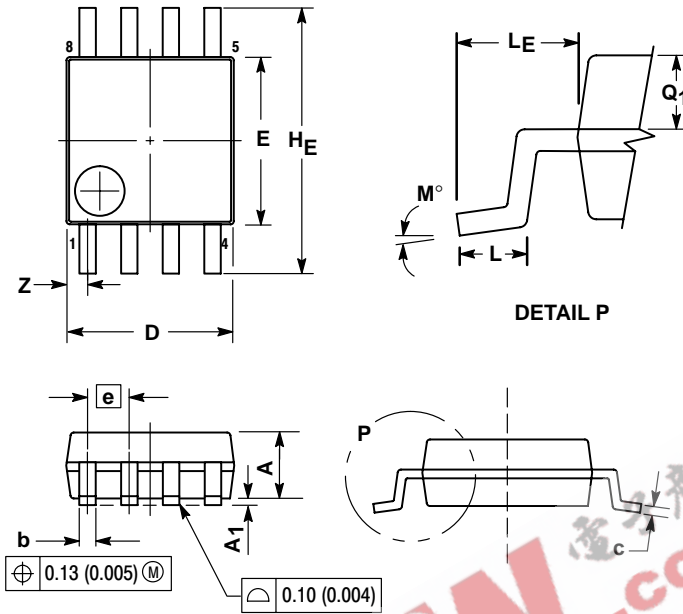
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
 2. DIMENSIONS ARE IN MILLIMETER.
 3. DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.
 4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
 5. DIMENSION B DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF THE B DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS	
	MIN	MAX
A	1.35	1.75
A1	0.10	0.25
B	0.35	0.49
C	0.19	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.25
θ	0°	7°

⊕ 0.25 (M) C B (S) A (S)

MC34063A, MC33063A

SOEIAJ-8
M SUFFIX
PLASTIC PACKAGE
CASE 968-01
ISSUE O



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER
3. DIMENSION D AND E DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS AND ARE MEASURED AT THE PARTING LINE. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
5. THE LEAD WIDTH DIMENSION (b) DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE LEAD WIDTH DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT MINIMUM SPACE BETWEEN PROTRUSIONS AND ADJACENT LEAD TO BE 0.46 (0.018).

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	---	2.05	---	0.081
A ₁	0.05	0.20	0.002	0.008
b	0.35	0.50	0.014	0.020
c	0.18	0.27	0.007	0.011
D	5.10	5.50	0.201	0.217
E	5.10	5.45	0.201	0.215
e	1.27 BSC		0.050 BSC	
HE	7.40	8.20	0.291	0.323
L	0.50	0.85	0.020	0.033
LE	1.10	1.50	0.043	0.059
M	0°	10°	0°	10°
Q ₁	0.70	0.90	0.028	0.035
Z	---	0.94	---	0.037

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Notes


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