

MC34063A/MC33063A

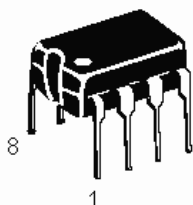
SMPS Controller

DC-to-DC Converter Control Circuits

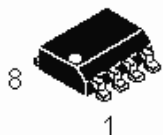
The MC34063A Series is a monolithic control circuit containing the primary functions required for DC-to-DC converters. These devices consist of an internal temperature compensated reference, comparator, controlled duty cycle oscillator with an active current limit circuit, driver and high current output 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 3.0V to 40V input
- Low Standby Current
- Current Limiting
- Output Switch Current to 1.5A
- Output Voltage Adjustable
- Frequency Operation to 100kHz
- Precision 2% Reference

DC-to-DC CONVERTER CONTROL CIRCUITS SEMICONDUCTOR TECHNICAL DATA

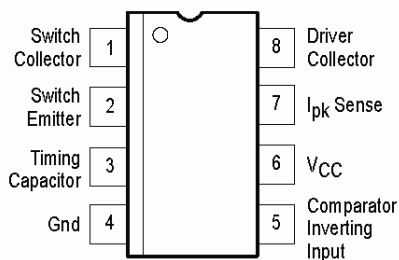


P, P₁ SUFFIX
PLASTIC PACKAGE
CASE 626



D SUFFIX
PLASTIC PACKAGE
CASE 751
(SO-8)

PIN CONNECTIONS

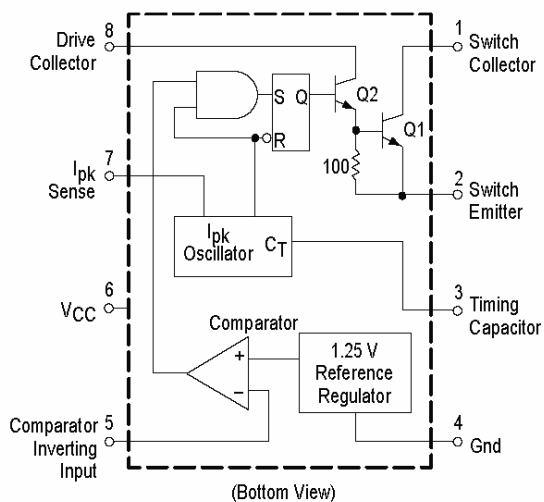


(Top View)

ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC33063AD	TA=-40° to +85°C	SO-8
MC33063AP1		Plastic DIP
MC34063AVD	TA=-40° to +125°C	SO-8
MC34063AVP		Plastic DIP
MC34063AD	TA=0° to +70°C	SO-8
MC34063APS		Plastic DIP

Representative Schematic Diagram



(Bottom View)

This device contains 51 active transistors.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V _{CC}	40	V dc
Comparator Input Voltage Range	V _{IR}	-0.3 to +40	V dc
Switch Collector Voltage	V _{C(switch)}	40	V dc
Switch Emitter Voltage (V _{PIN 1} =40V)	V _{E(switch)}	40	V dc
Switch Collector to Emitter Voltage	V _{CE(switch)}	40	V dc
Driver Collector Voltage	V _{C(driver)}	40	V dc
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 _{θJA}	100	°C/w
SOIC Package, D Suffix T _A =25°C	P _D	625	w
Thermal Resistance	R _{θJA}	160	°C/w
Operating Junction Temperature	T _J	+150	°C
Operating Ambient Temperature Range	T _A		°C
MC34063A		0 to +70	
MC33063AV		-40 to +125	
MC33063A		-40 to +85	
Storage Temperature Range	T _{stg}	-65 to +150	°C

NOTES: 1. Maximum package power dissipation limits must be observed.

2. ESD data available upon request.

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

Characteristics	Symbol	Min	Typ	Max	Unit
OSCILLATOR					
Frequency (V _{PIN 5} =0 V, C _T =10nF, T _A =25°C)	F _{OSC}	24	33	42	kHz
Charge Current (V _{CC} =5.0V to 40V, T _A =25°C)	I _{chg}	24	35	42	μA
Discharge Current (V _{CC} =5.0V to 40V, 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 4)

Saturation Voltage, Darlington Connection (Note 5) (I _{SW} = 1.0A, Pins 1,8 connected)	V _{CE(sat0)}	—	1.0	1.3	V
Saturation Voltage, Darlington Connection (I _{SW} = 1.0A, R _{PIN 8} = 82Ω to V _{CC} , Forced β ≥ 20)	V _{CE(sat)}	—	0.45	0.7	V
DC Current Gain (I _{SW} = 1.0A, V _{CE} = 5.0V, T _A =25°C)	h _{FE}	50	75	—	—
Collector Off-State Current (V _{CE} = 40V)	I _{C(off)}	—	0.01	0.01	μA

NOTES: 3. T_{LOW} = 0°C for MC34063A, -40°C for MC33063A, AV T_{high} = +70°C for MC34063A, +85°C for MC33063A, +125°C for MC33063V

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 (≤300mA) and high driver currents(≥30mA), it may take up to 2.0μs 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:

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

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

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

Characteristics	Symbol	Min	Typ	Max	Unit
OSCILLATO					
Threshold Voltage $T_A = 25^\circ C$ $T_A = T_{low}$ to T_{high}	V_{th}	1.225 1.21	1.25 —	1.275 1.29	V
Threshold Voltage Line Regulation ($V_{CC} = 3.0 V$ to $40V$) MC33063A, MC34063A MC33363V	Regline	— —	1.4 1.4	5.0 6.0	mV
Input Bias Current ($V_{in} = 0V$)	I_{IB}	—	-20	-400	nA

TOTAL DEVICE

Supply Current ($V_{CC} = 5.0V$ to $40V$, $C_T = 1.0nF$, Pin 7 = V_{CC} , $V_{Pin 5} > V_{th}$, Pin 2 = Gnd, remaining pins open)	I_{CC}	—	—	4.0	mA
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- NOTES:** 3. $T_{low} = 0^\circ C$ for MC34063A, $-40^\circ C$ for MC33063A, AV $T_{high} = +70^\circ C$ for MC34063A, $+85^\circ C$ for MC33063A, $+125^\circ C$ 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 ($\leq 300mA$) and high driver currents ($\geq 30mA$), it may take up to $2.0\mu s$ for it to come out of saturation. This condition will shorten the off time at frequencies $\geq 30kHz$, 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:

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

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

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

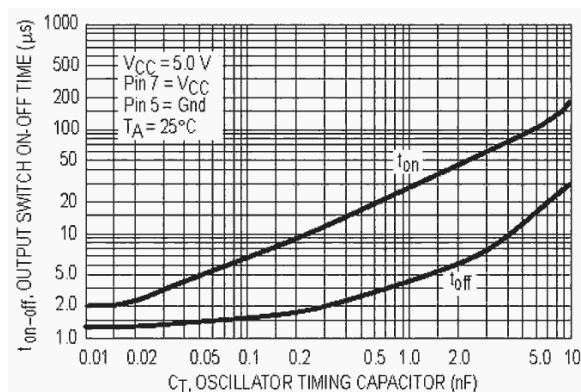


Figure 2. Timing Capacitor Waveform

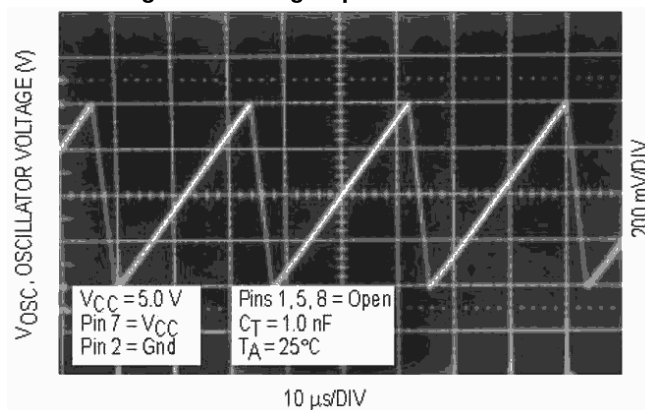


Figure 3. Emitter Follower Configuration Output Saturation Voltage Versus Emitter Current

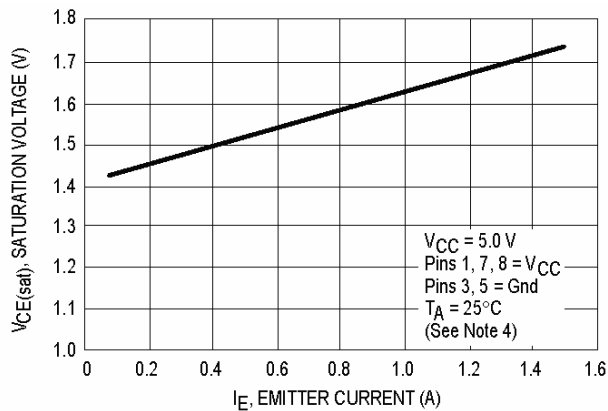


Figure 5. Current Limit Sense Voltage Versus Temperature

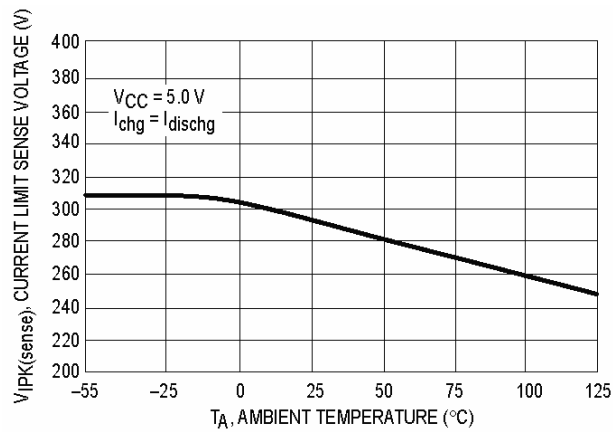


Figure 4. Common Emitter Configuration Output Switch Saturation Voltage versus Collector Current

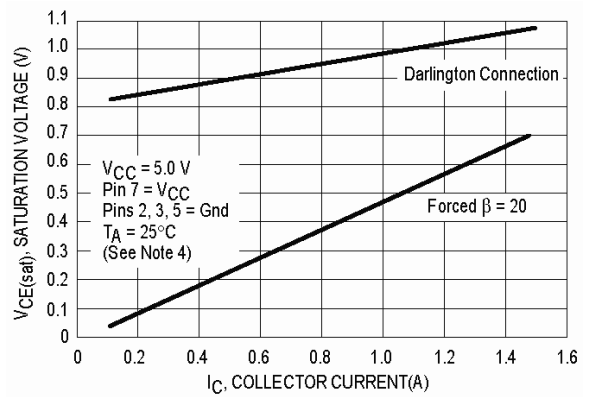
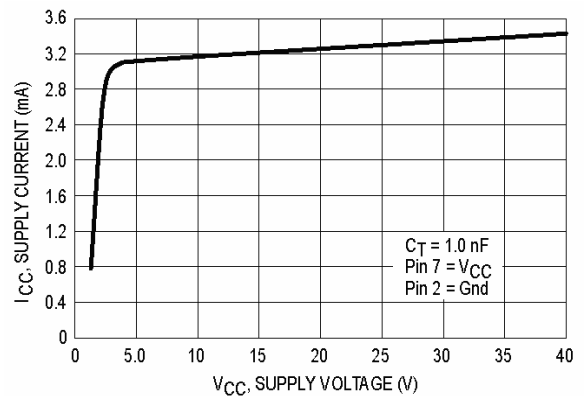
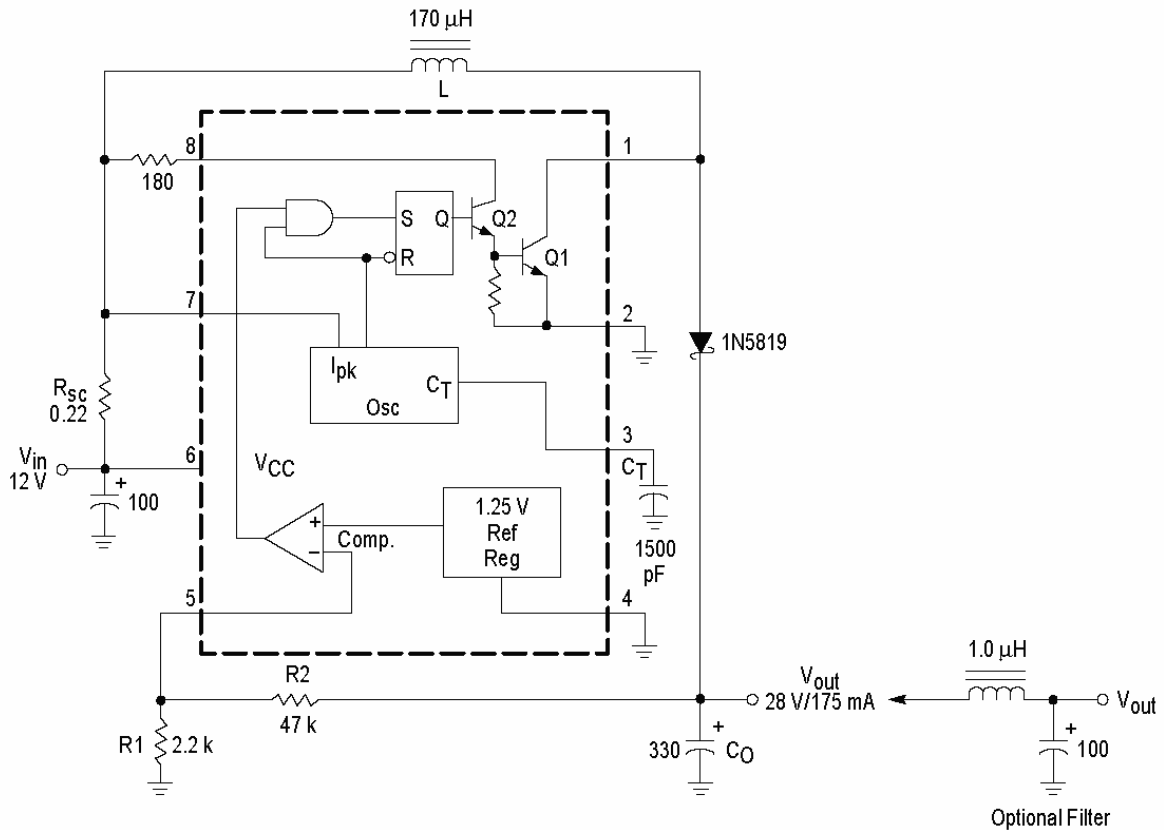


Figure 6. Standby Supply Current versus Supply Voltage



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

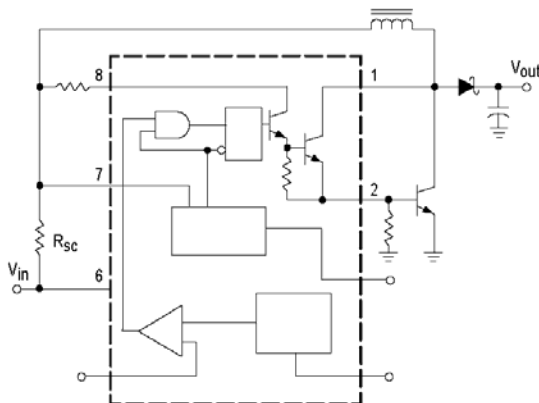
Figure 7. Step-Up Converter



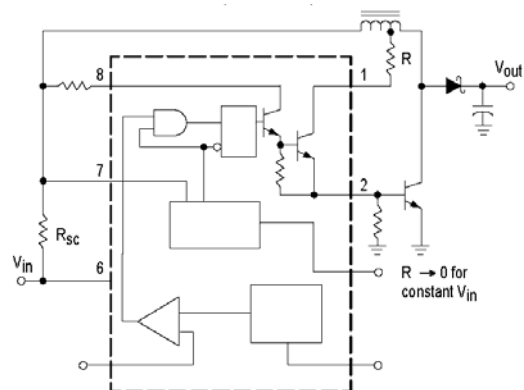
Test	Conditions	Results
Line Regulation	$V_{in}=8.0\text{V to }16\text{ V}$, $I_O = 175\text{mA}$	$30\text{mV} = \pm 0.05\%$
Load Regulation	$V_{in}=12\text{V}$, $I_O = 75\text{mA to }175\text{mA}$	$10\text{mV} = \pm 0.017\%$
Output Ripple	$V_{in}=12\text{V}$, $I_O = 175\text{mA}$	400mVpp
Efficiency	$V_{in}=12\text{V}$, $I_O = 175\text{mA}$	87.7%
Output Ripple With Optional Filter	$V_{in}=12\text{V}$, $I_O = 175\text{mA}$	40mVpp

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

8a. External NPN Switch

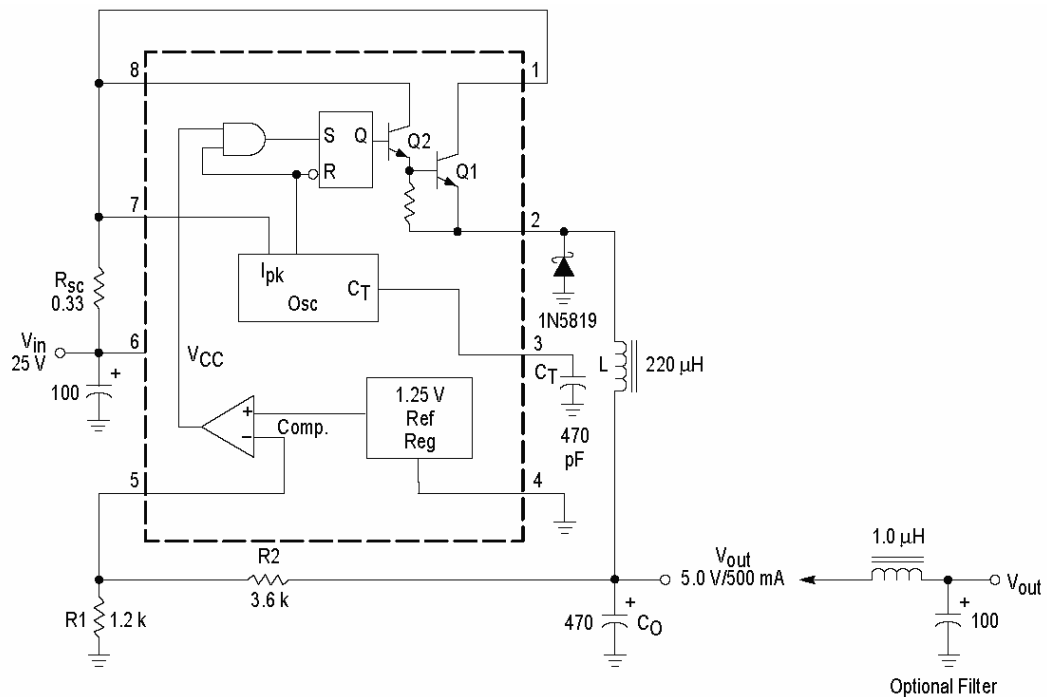


8b. External NPN Saturated Switch
(See Note 5)



NOTE: 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:

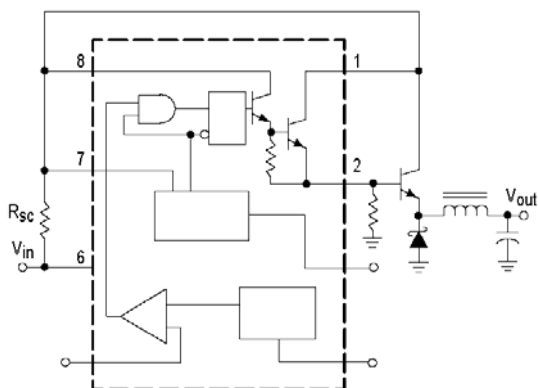
Figure 9. Step-Down Converter



Test	Conditions	Results
Line Regulation	$V_{in}=15V$ to $25V$, $I_O = 500mA$	$12mV = \pm 0.12\%$
Load Regulation	$V_{in}=25V$, $I_O = 50mA$ to $500mA$	$3.0mV = \pm 0.03\%$
Output Ripple	$V_{in}=25V$, $I_O = 500mA$	$120mV_{pp}$
Short Circuit Current	$V_{in}=25V$, $R_L = 0.1\Omega$	$1.1A$
Efficiency	$V_{in}=25V$, $I_O = 500mA$	83.7%
Output Ripple With Optional Filter	$V_{in}=25V$, $I_O = 500mA$	$40mV_{pp}$

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

10a. External NPN Switch



10b. External PNP Saturated Switch

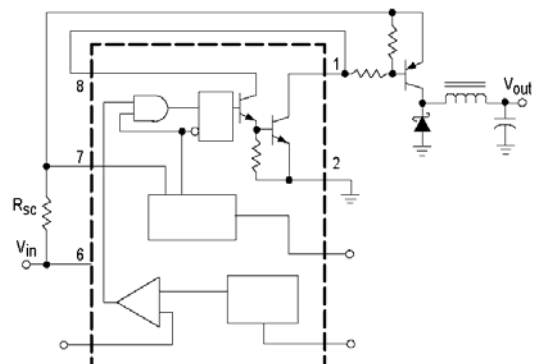
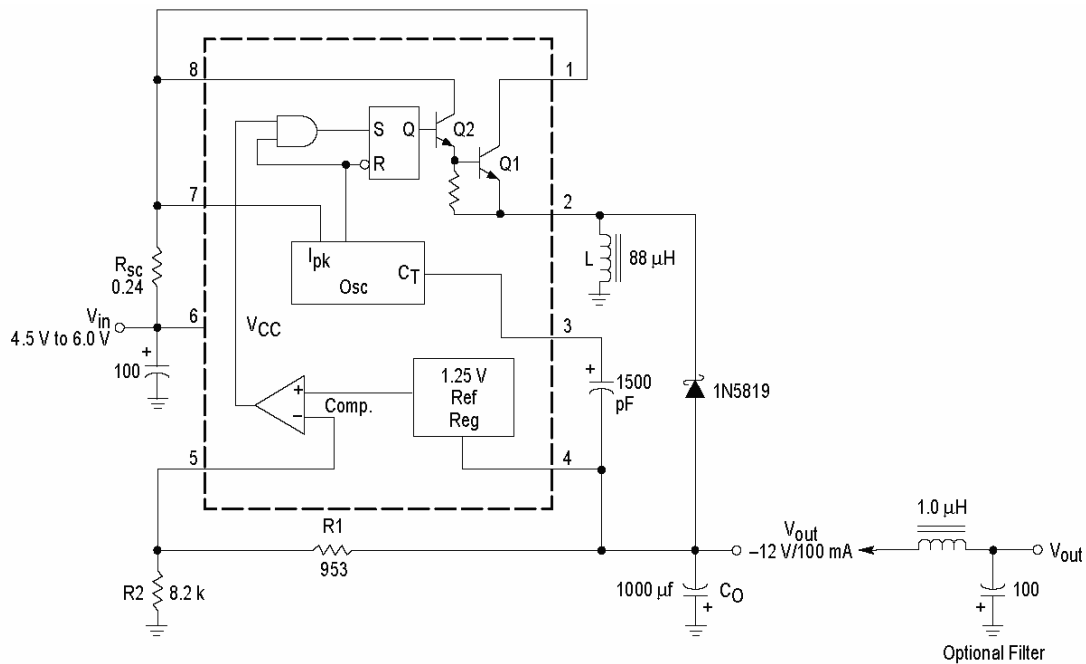


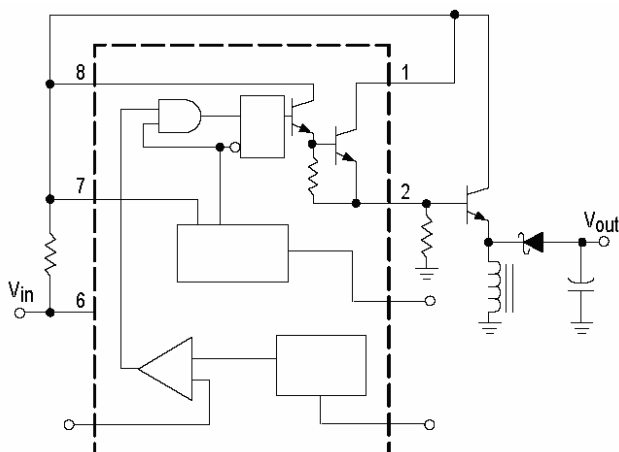
Figure 11. Voltage Inverting Converter



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

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

12a. External NPN Switch



12b. External PNP Saturated Switch

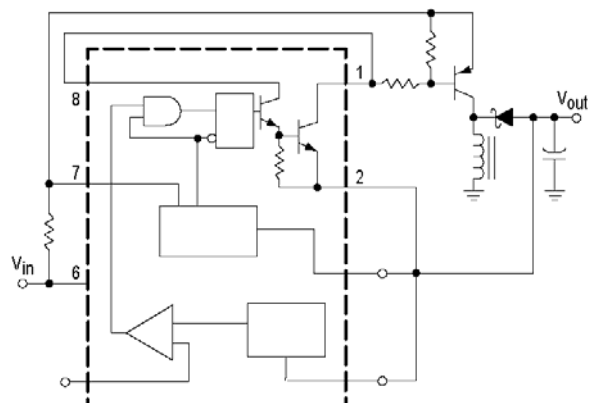
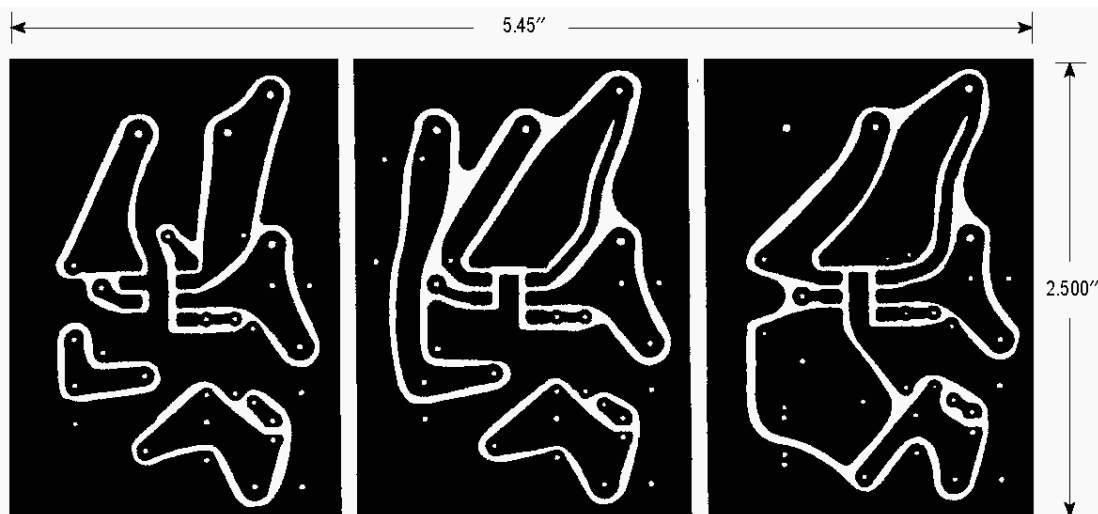
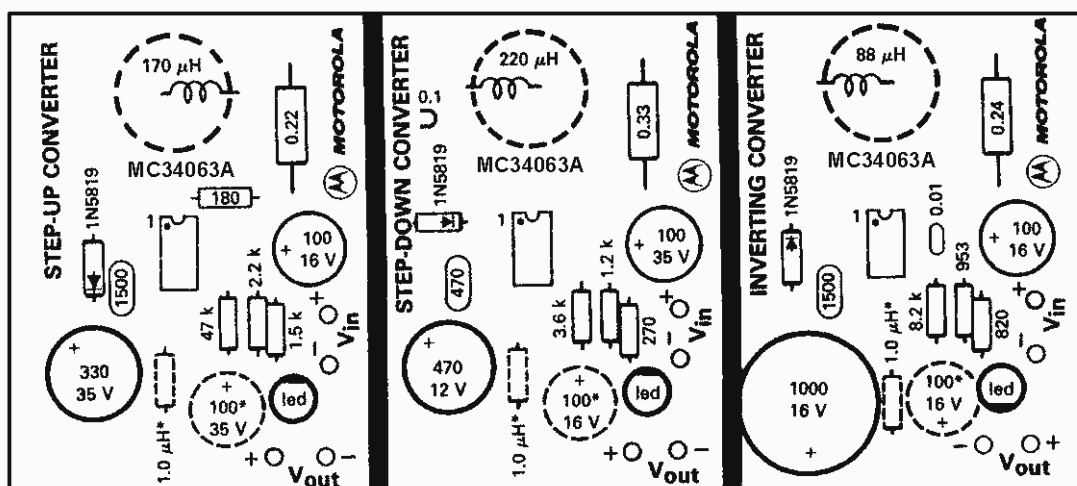


Figure 13. Printed Circuit Board and Component Layout

(Circuits of Figures 7,9,11)



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



(Top View, Component Side)

*Optional Filter.

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.

Figure 14. Design Formula Table

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, $|V_{out}| = 1.25 (1 + R_2/R_1)$

I_{out} – Desired output current.

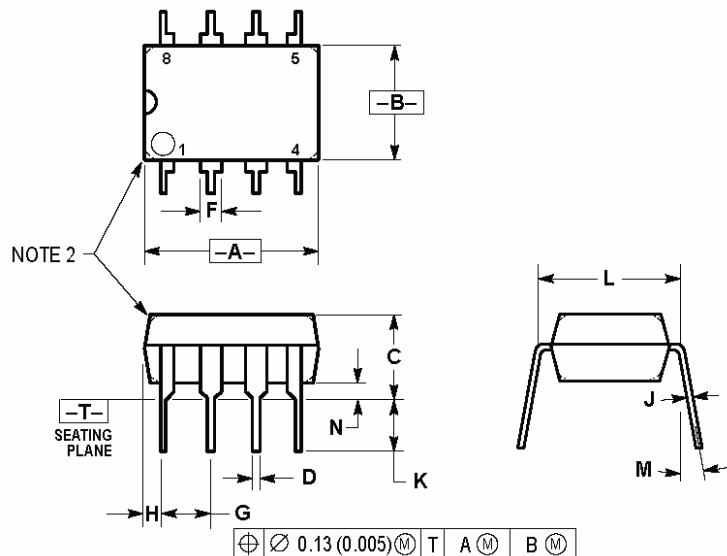
f_{min} – Minimum desired output switching frequency at the selected values of V_{in} and I_O .

$V_{ripple(pp)}$ – Desired peak-to-peak output ripple voltage. In practice, the calculated capacitor value will need to be increase 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.

OUTLINE DIMENSIONS

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

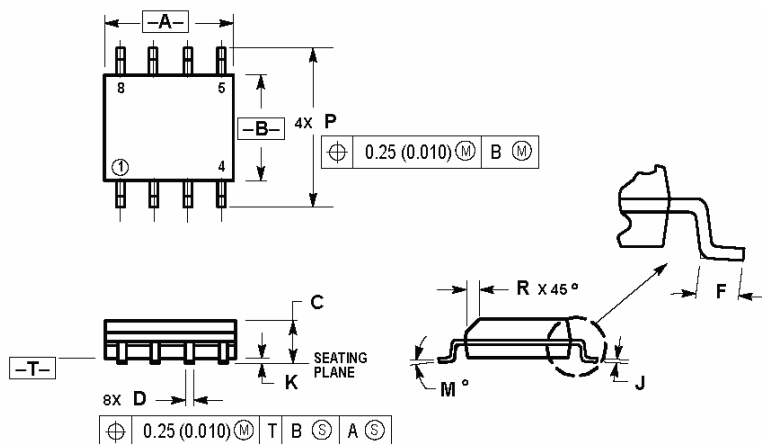


Note:

1. DIMENSIONL 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

D SUFFIX
PLASTIC PACKAGE
CASE 751-05
(SO-8)
ISSUE P



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS 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.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.18	0.25	0.007	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019