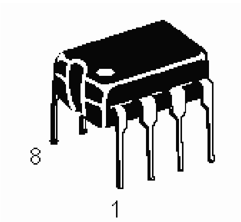
MC34063A/MC33063A
SMPS Controller

DC-to-DC Converter
Control Circuits

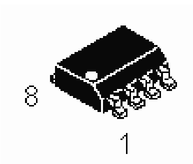
The MC34063A Series is a monolithic control circuit containing the primary functions required for DC-to-DC converters. These devices consist of an internal temperature compensated reference, comparator, controlled duty cycle oscillator with an active current limit circuit, driver and high current output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

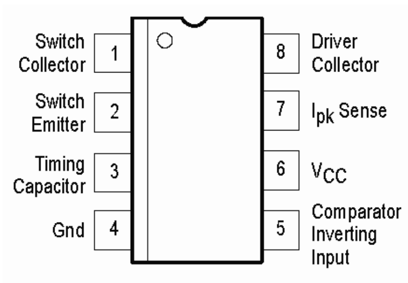


P, P$_1$ SUFFIX
PLASTIC PACKAGE
CASE 626



D SUFFIX
PLASTIC PACKAGE
CASE 751
(SO-8)

PIN CONNECTIONS

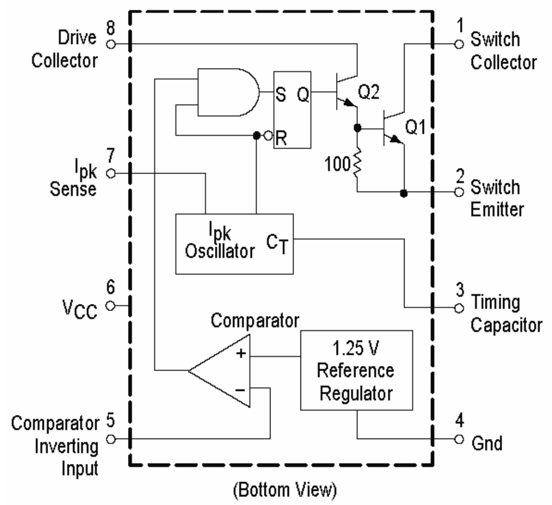


(Top View)

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
MC34603AVP		Plastic DIP
MC34063AD	TA=0° to +70°C	SO-8
MC34063APS		Plastic DIP

Representative Schematic Diagram



This device contains 51 active transistors.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	Vcc	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 TA=25°C Thermal Resistance SOIC Package, D Suffix TA=25°C Thermal Resistance	 P_D $R_{\theta JA}$ P_D $R_{\theta JA}$	 1.25 100 625 160	 W °C/w w °C/w
Operating Junction Temperature	T_J	+150	°C
Operating Ambient Temperature Range MC34063A MC33063AV MC33063A	T_A	 0 to +70 -40 to +125 -40 to +85	°C
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_{IOW} 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)

Characteristics	Symbol	Min	Typ	Max	Unit
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 ß≦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 Thigh = +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:

Forced ß 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, TA = T_{low} to T_{high} [Note 3], unless otherwise specified.)

Characteristics	Symbol	Min	Typ	Max	Unit
OSCILLATO					
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 40V)	Regline				mV
MC33063A, MC34063A		—	1.4	5.0	
MC33363V		—	1.4	6.0	
Input Bias Current (V_{in} = 0V)	I_{IB}	—	-20	-400	nA

TOTAL DEVICE

Characteristics	Symbol	Min	Typ	Max	Unit
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

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

Forced ß 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

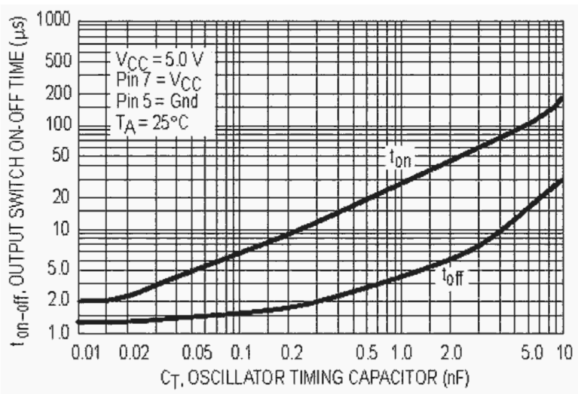


Figure 2. Timing Capacitor Waveform

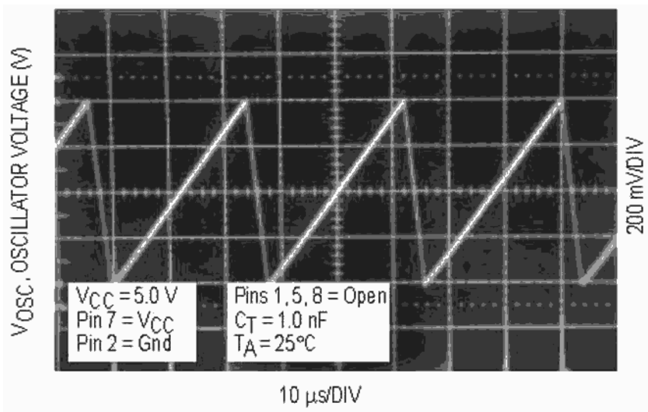


Figure 3. Emitter Follower Configuration Output Saturation Voltage Versus Emitter Current

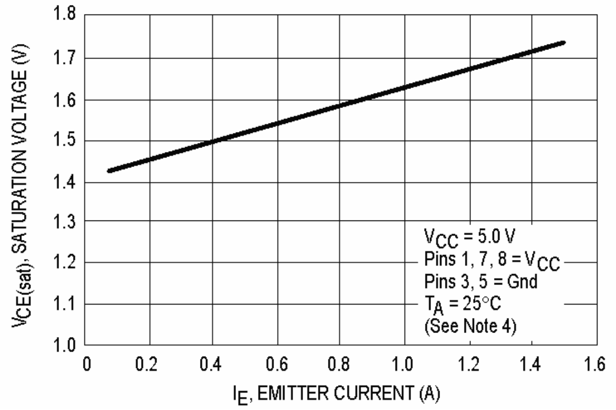


Figure 4. Common Emitter Configuration Output Switch Saturation Voltage versus Collector Current

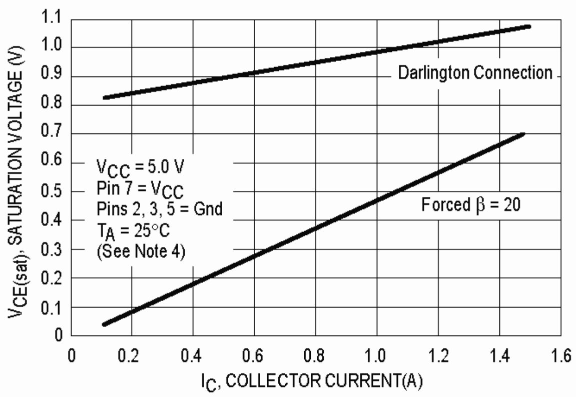


Figure 5. Current Limit Sense Voltage Versus Temperature

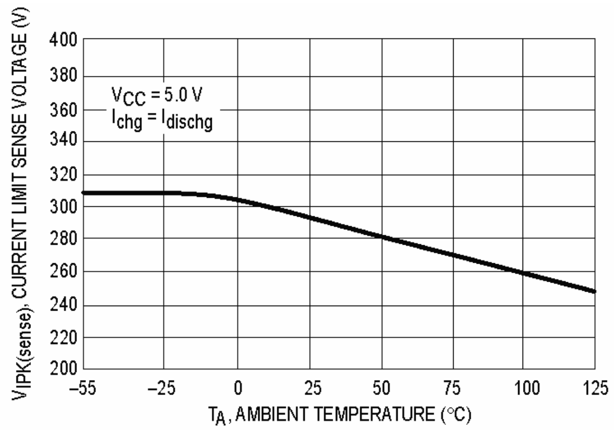
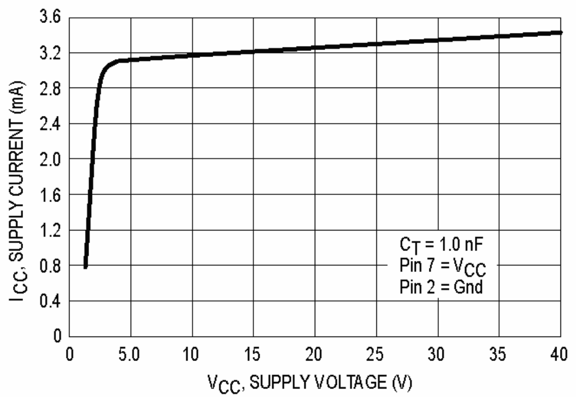
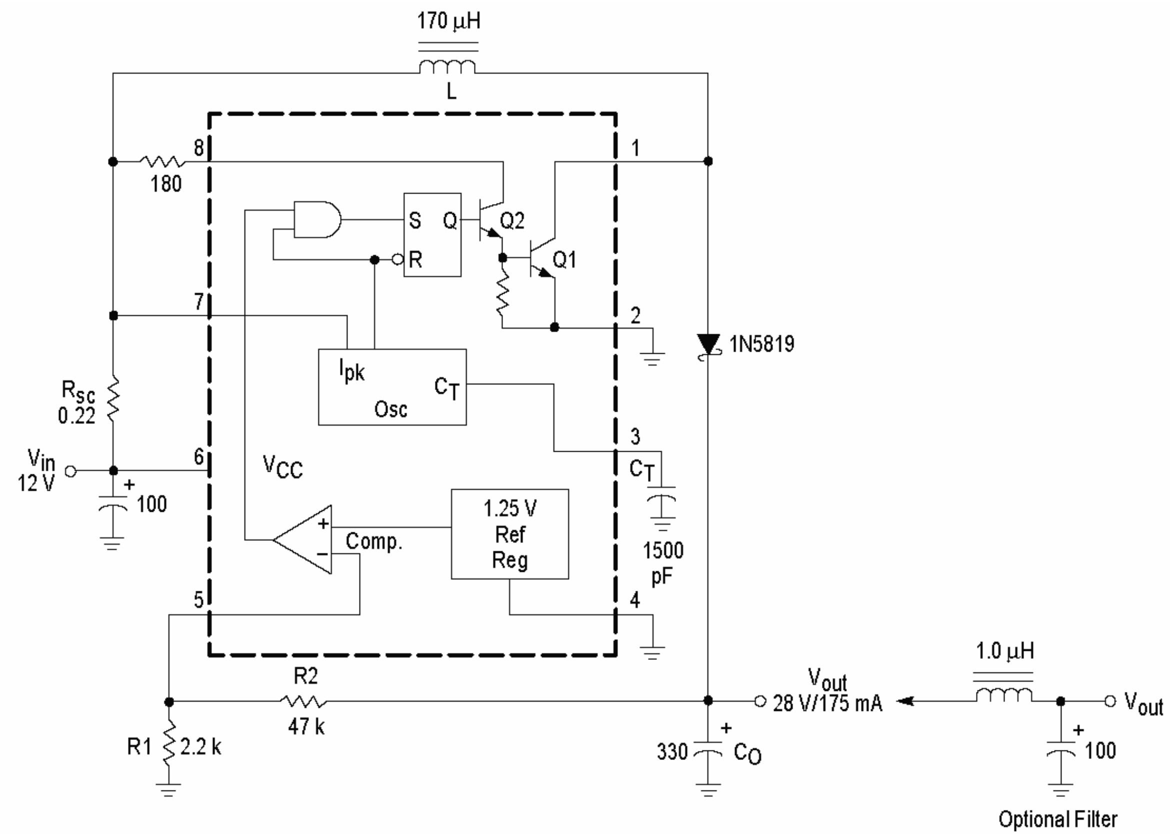


Figure 6. Standby Supply Current versus Supply Voltage



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

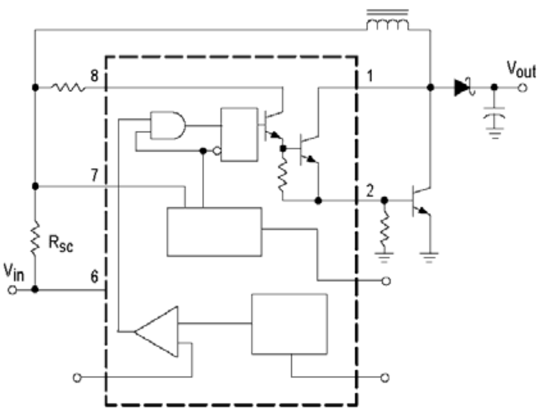
Figure 7. Step-Up Converter



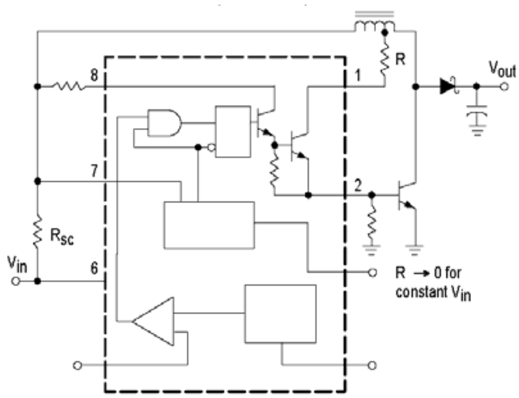
Test	Conditions	Results
Line Regulation	V_{in}=8.0V to 16 V, I_O = 175mA	30mV = ±0.05%
Load Regulation	V_{in}=12V, I_O = 75mA to 175mA	10mV =±0.017%
Output Ripple	V_{in}=12V, I_O = 175mA	400mVpp
Efficiency	V_{in}=12V, I_O = 175mA	87.7%
Output Ripple With Optional Filter	V_{in}=12V, I_O = 175mA	40mVpp

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

8a. External NPN Switch

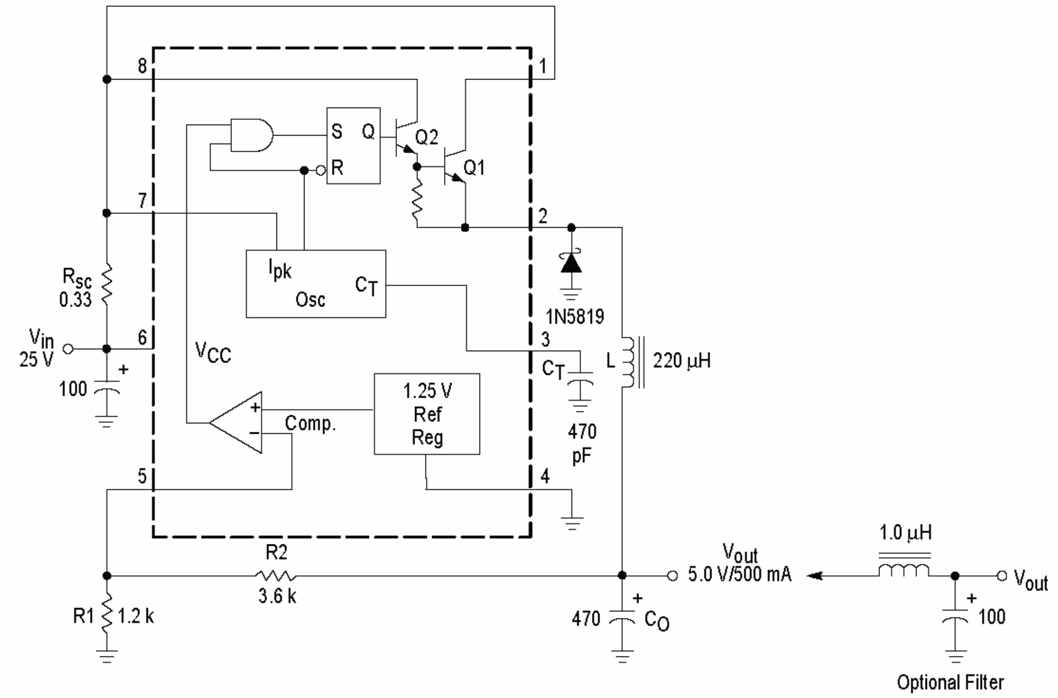


8b. External NPN Saturated Switch (See Note 5)



NOTE: 5. If the output switch is driven into hard saturation (non-Darlington configuration) at low switch currents (≤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:

Figure 9. Step-Down Converter



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

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

10a. External NPN Switch **10b. External PNP Saturated Switch**

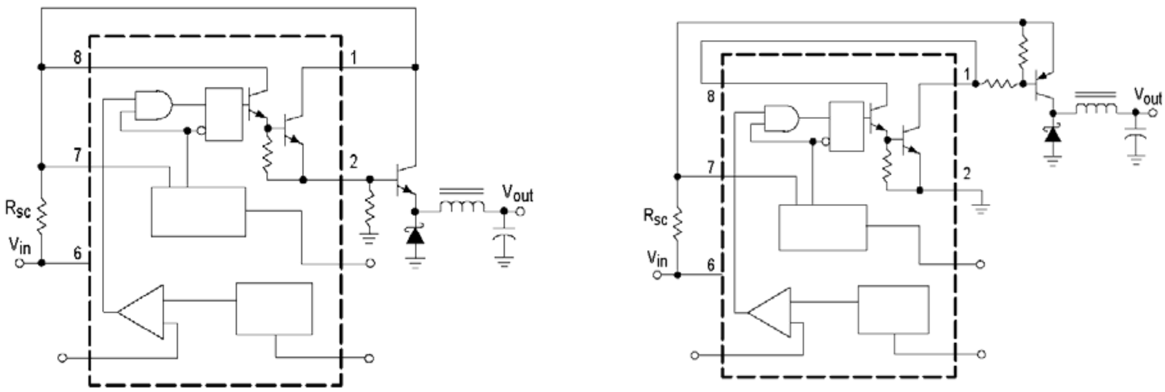
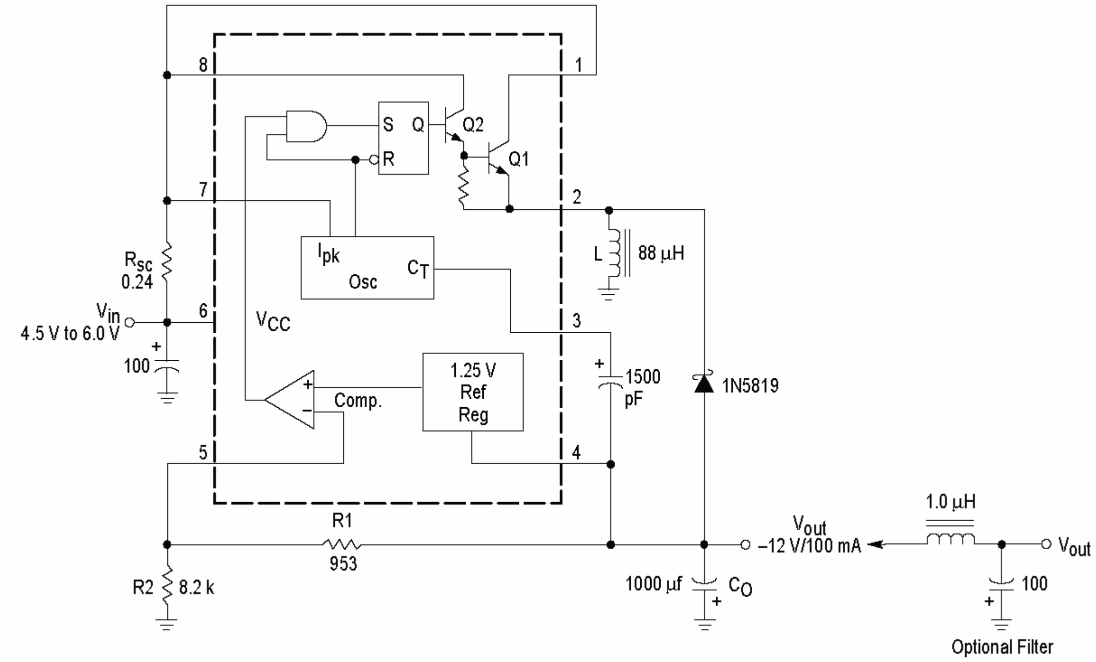


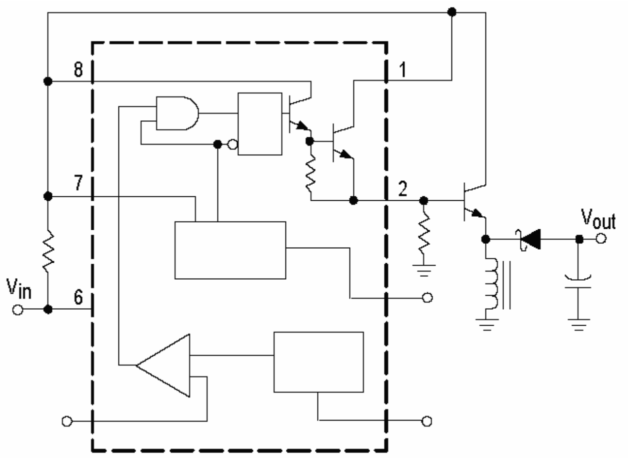
Figure 11.Voltage Inverting Converter



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

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

12a. External NPN Switch



12b. External PNP Saturated Switch

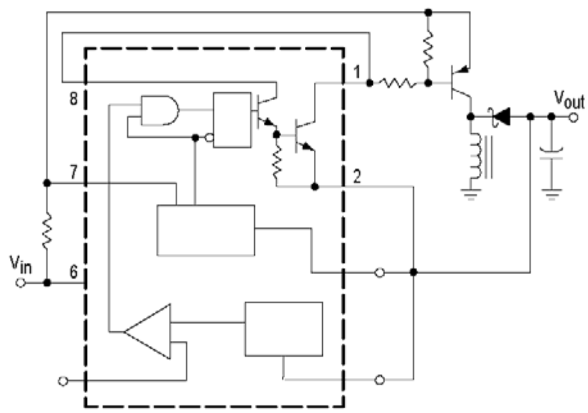
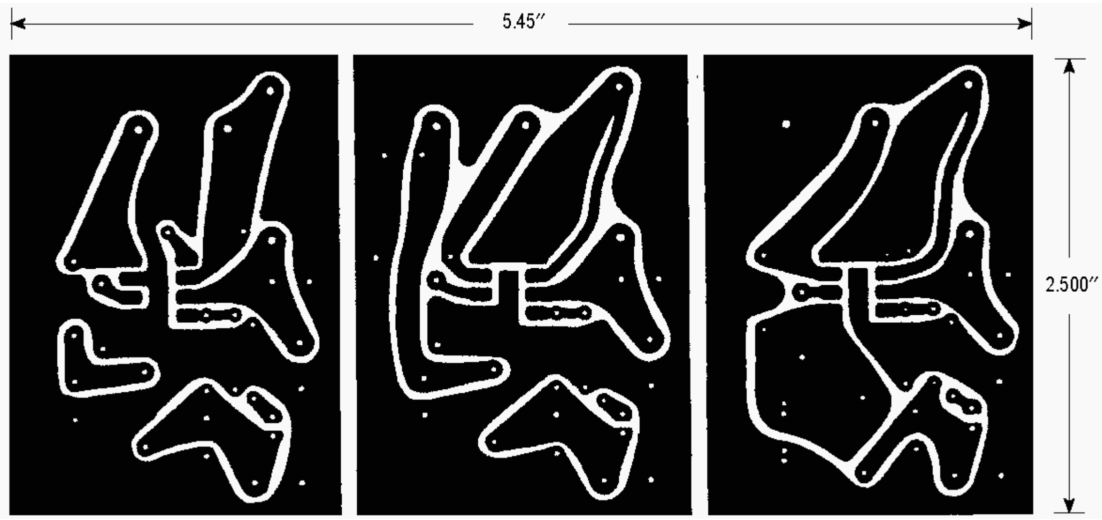
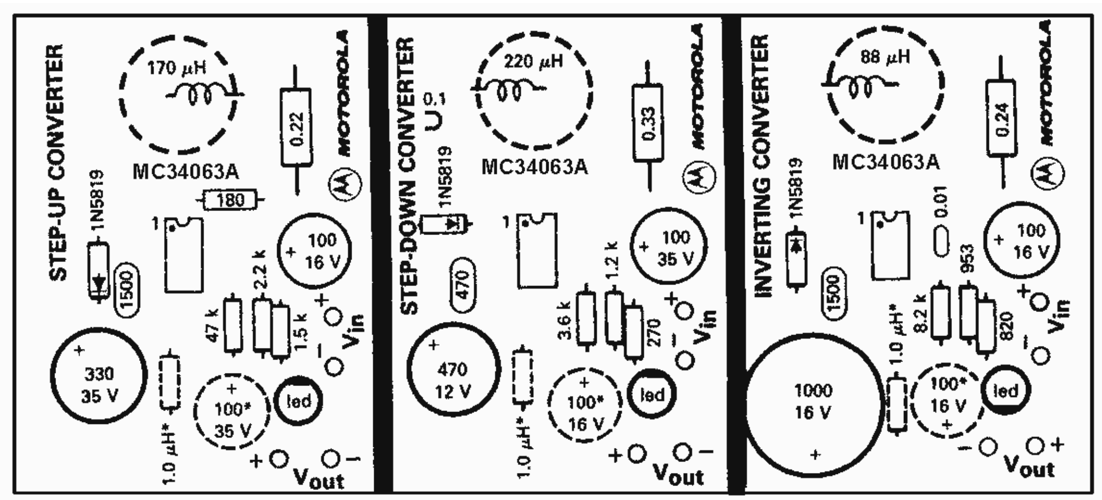


Figure 13. Printed Circuit Board and Component Layout
(Circuits of Figures 7,9,11)



(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

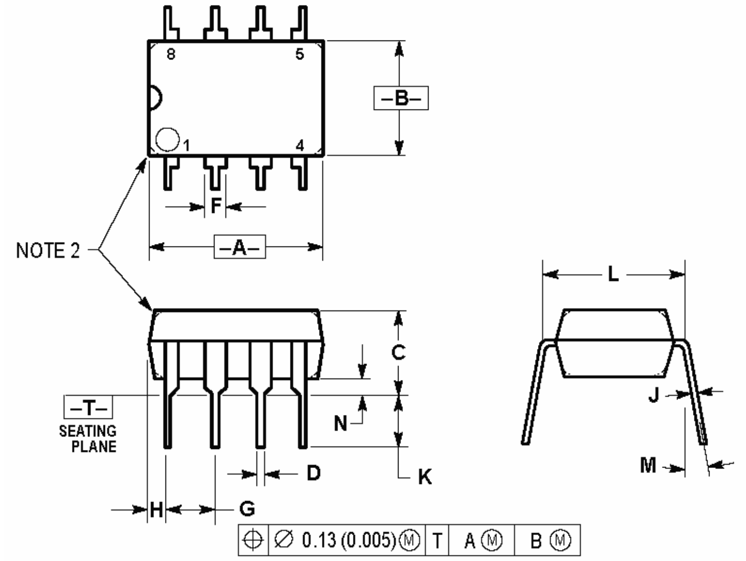
Calculation	Step–Up	Step–Down	Voltage–Inverting
t_{on}/t_{off}	$\frac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$	$\frac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$	$\frac{\|V_{out}\| + V_F}{V_{in} - V_{sat}}$
$(t_{on} + t_{off})$	$\frac{1}{f}$	$\frac{1}{f}$	$\frac{1}{f}$
t_{off}	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$
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 + R2/R1)
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

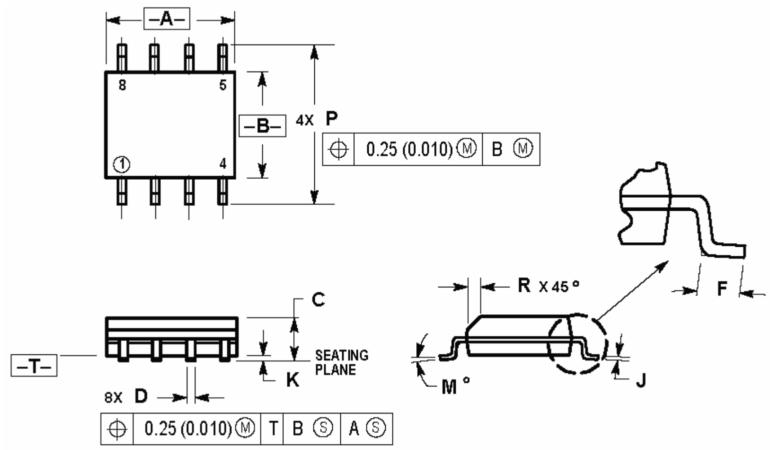


Note:

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 NOTINCLUDE MOLD PROTRUSION
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALLBE 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