# 1.5 A, Step-Up/Down/ Inverting Switching Regulators
(compatible to MC33063)

The HT83063A 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.
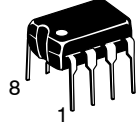
Features

- 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
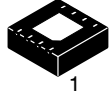- Precision 2% Reference
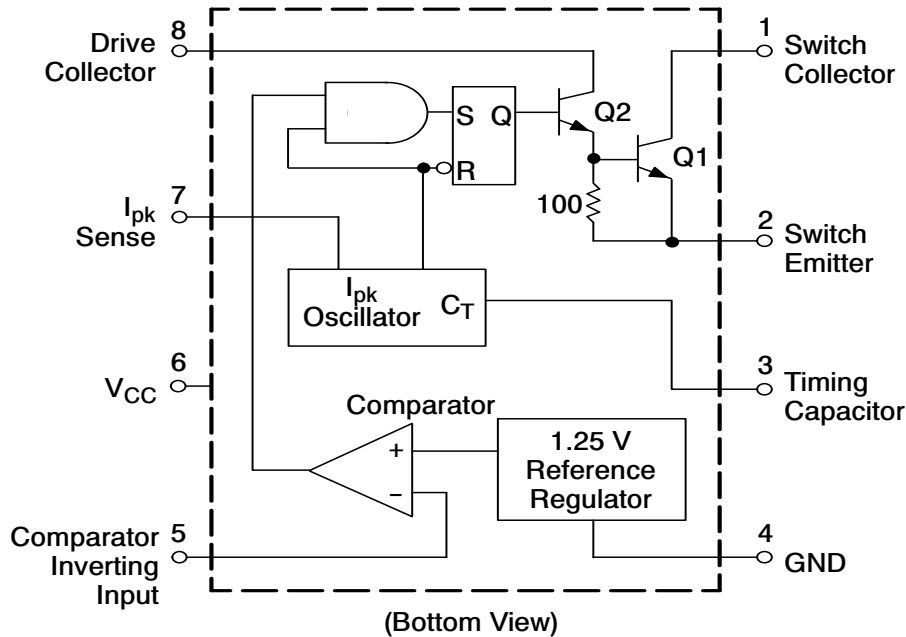- Pb−Free Packages are Available

ESOP−8

DIP−8

DFN8 4*4

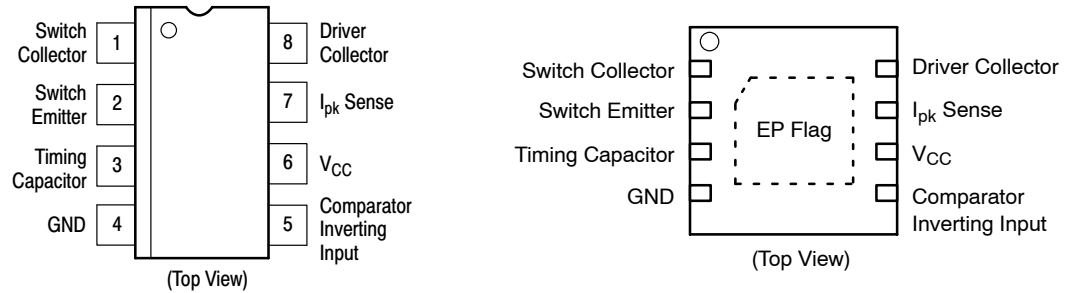**ORDERING INFORMATION**
HT83063AREZ ESOP8

HT83063ARDZ DFN8

HT83063ANZ DIP8

T_A = -40° to 85°C for all packages.

This device contains 79 active transistors.

Figure 1. Representative Schematic Diagram

(Top View)

(Top View)

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°C	P_D	1.25	W
Thermal Resistance	$R_{\theta JA}$	115	°C/W
SOIC Package, D Suffix			
T_A = 25°C	P_D	625	mW
Thermal Resistance	$R_{\theta JA}$	160	°C/W
DFN Package			
T_A = 25°C	P_D	1.25	mW
Thermal Resistance	$R_{\theta JA}$	80	°C/W
Operating Junction Temperature	T_J	+150	°C
Operating Ambient Temperature Range	T_A		°C
HT84063		0 to +70	
HT82063		−40 to +125	
HT83063		−40 to +85	
Storage Temperature Range	T_{stg}	−65 to +150	°C

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 T_A = 25°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 40 V) HT84064 HT83063	Reg_{line}	– –	1.4 1.4	5.0 6.0	mV
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

Forced β of output switch : $$\frac{I_C\ output}{I_C\ driver - 7.0\ mA\,*} \geq 10$$

* The 100 Ω resistor in the emitter of the driver device requires about 7.0 mA before the output switch conducts.
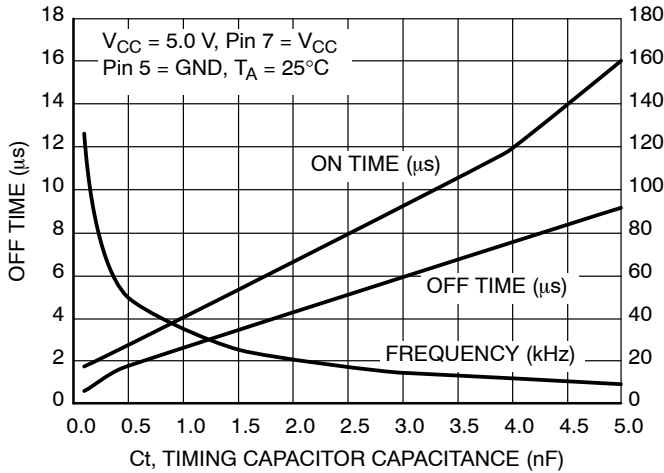
Figure 3. Oscillator Frequency
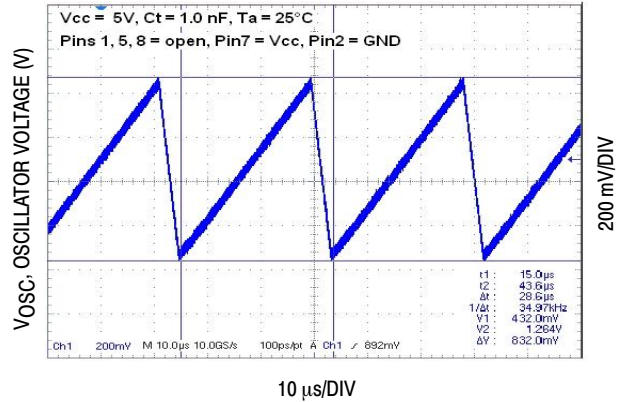
Figure 4. Timing Capacitor Waveform
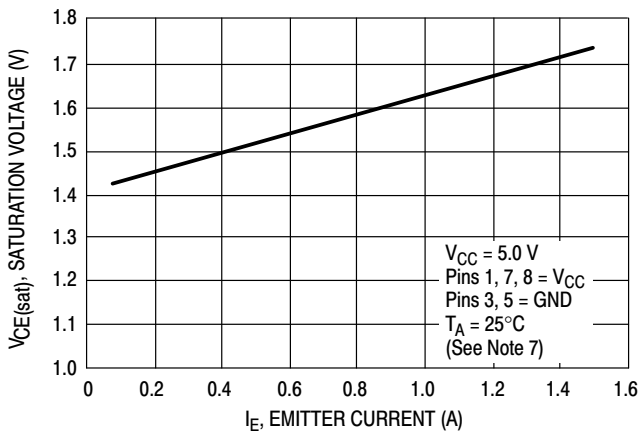
Figure 5. Emitter Follower Configuration Output Saturation Voltage versus Emitter Current
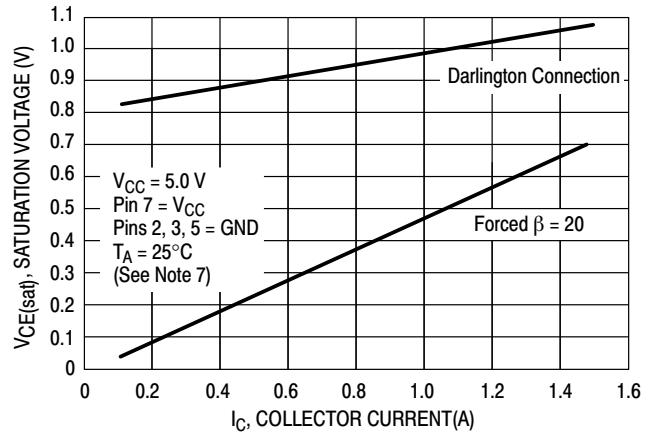
Figure 6. Common Emitter Configuration Output Switch Saturation Voltage versus Collector Current
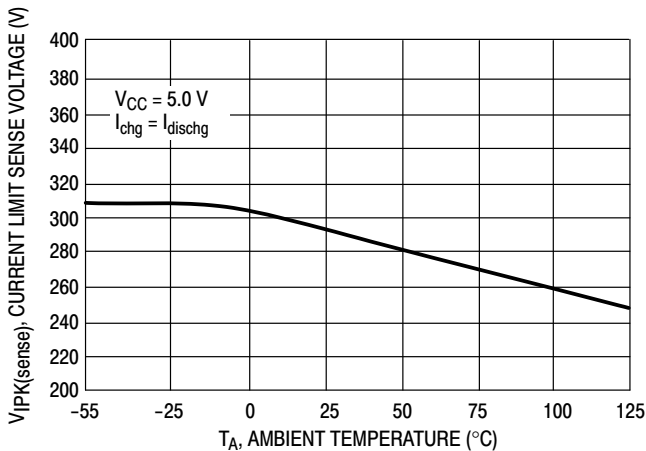
Figure 7. Current Limit Sense Voltage versus Temperature
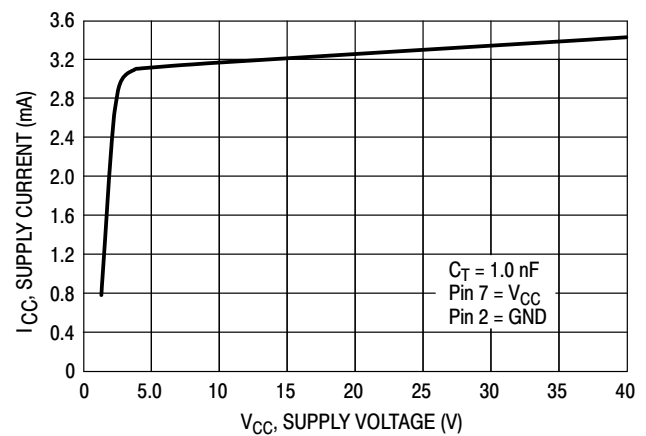
Figure 8. Standby Supply Current versus Supply Voltage

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

Figure 9. Step−Up Converter
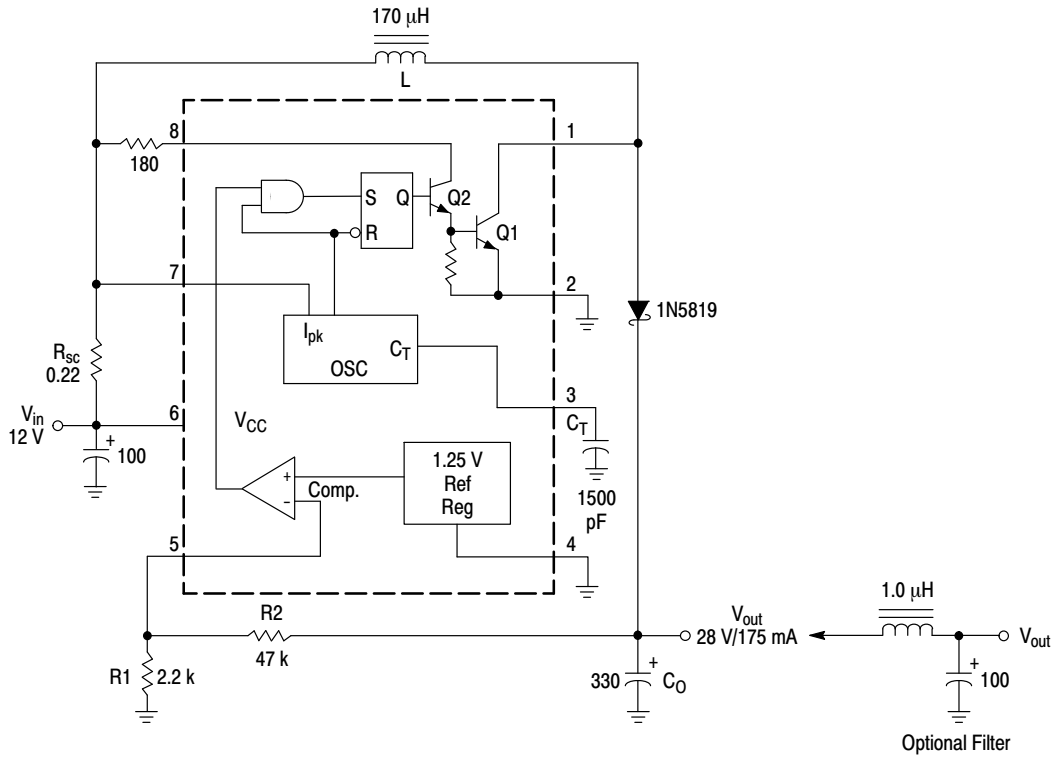
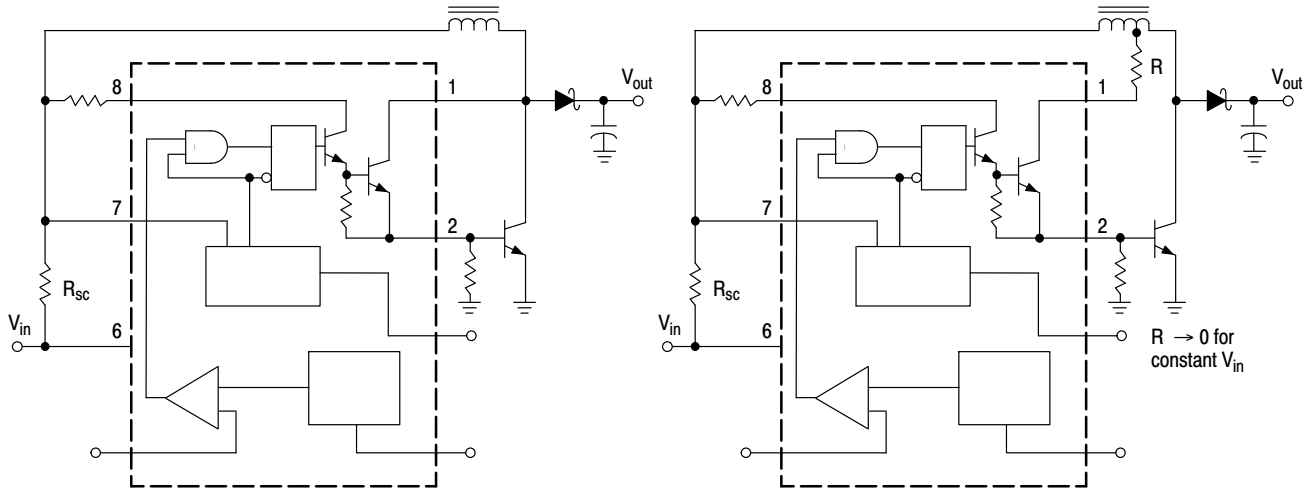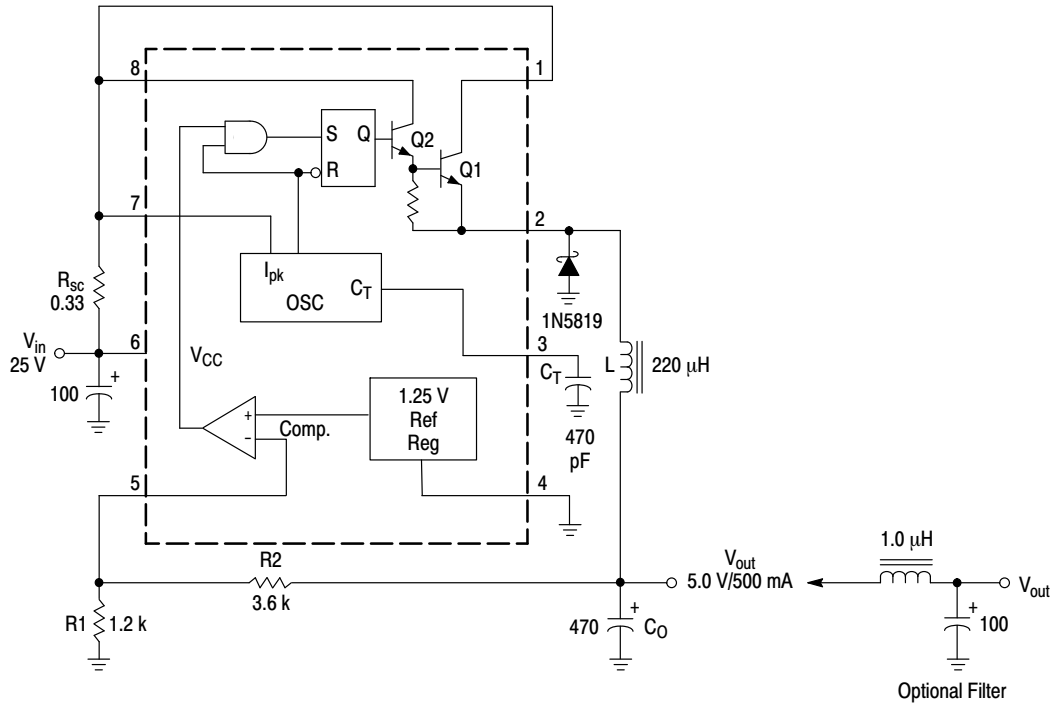| Test	Conditions	Results
Line Regulation	V_{in} = 8.0 V to 16 V, I_O = 175 mA	30 mV = ±0.05%
Load Regulation	V_{in} = 12 V, I_O = 75 mA to 175 mA	10 mV = ±0.017%
Output Ripple	V_{in} = 12 V, I_O = 175 mA	400 mVpp
Efficiency	V_{in} = 12 V, I_O = 175 mA	87.7%
Output Ripple With Optional Filter	V_{in} = 12 V, I_O = 175 mA	40 mVpp

Figure 10. External Current Boost Connections for I$_C$ Peak Greater than 1.5 A
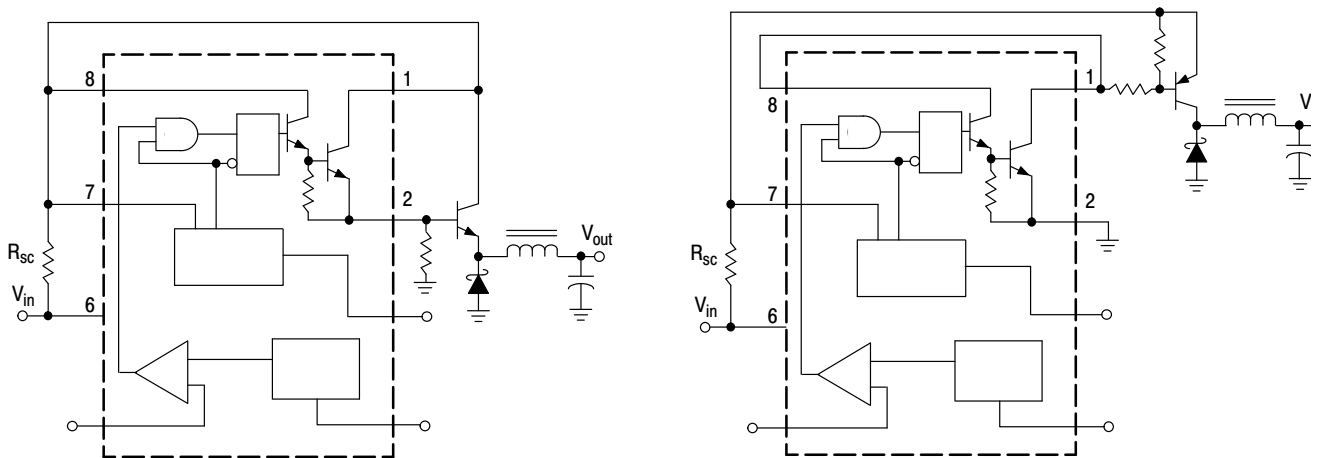
9a. External NPN Switch

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 (≤ 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.

Figure 11. Step−Down Converter

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

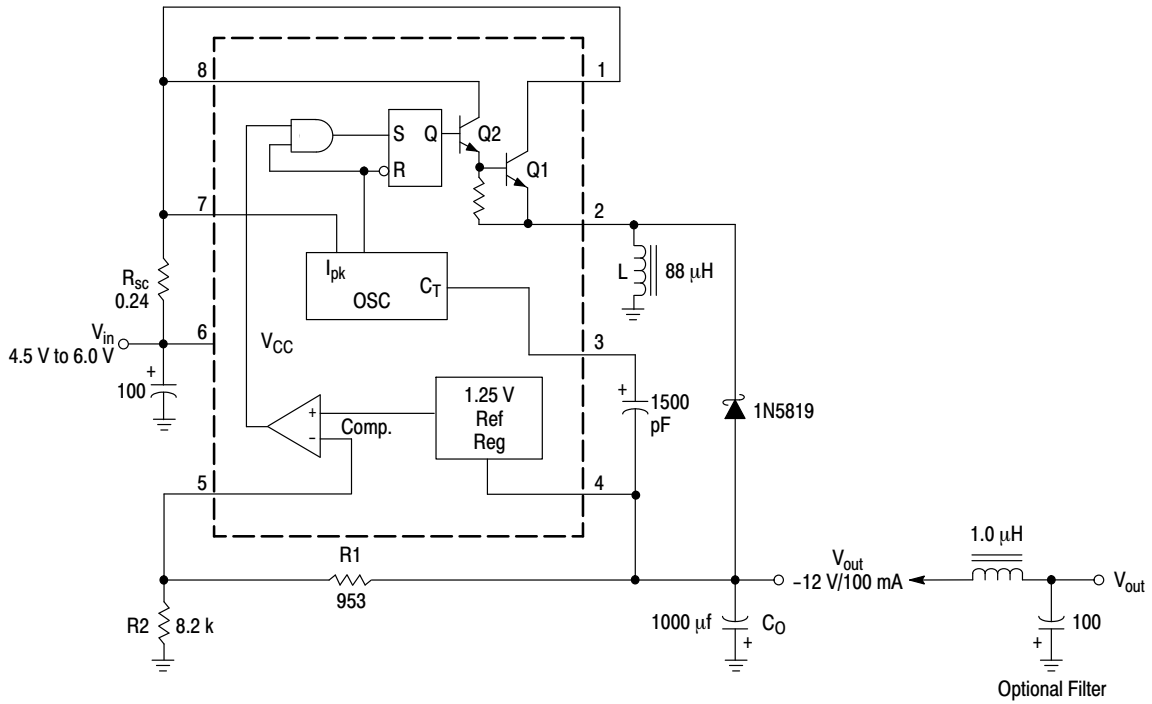**11a. External NPN Switch**   **11b. External PNP Saturated Switch**

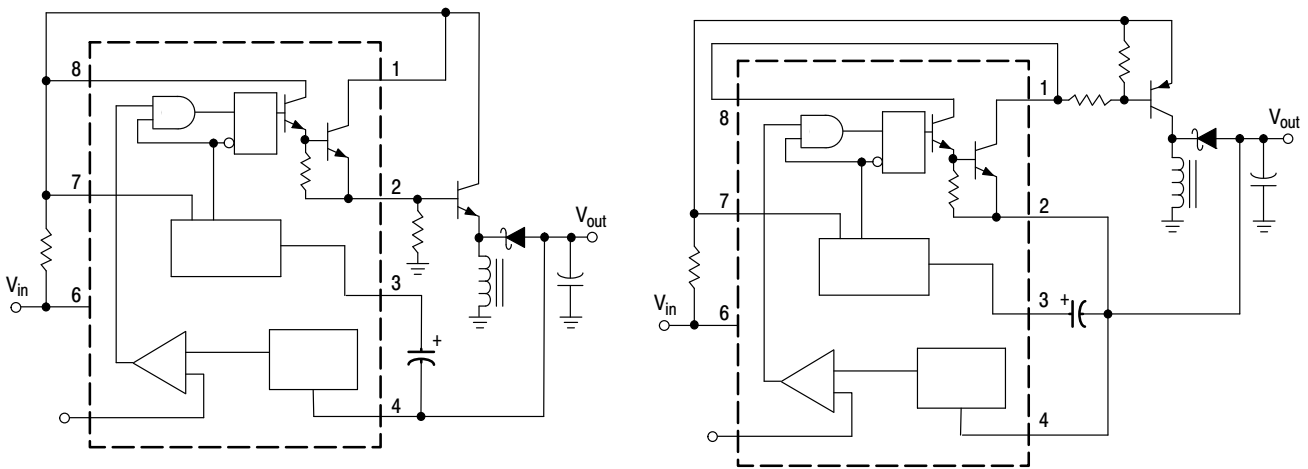| Test	Conditions	Results
Line Regulation	V_{in} = 4.5 V to 6.0 V, I_O = 100 mA	3.0 mV = ±0.012%
Load Regulation	V_{in} = 5.0 V, I_O = 10 mA to 100 mA	0.022 V = ±0.09%
Output Ripple	V_{in} = 5.0 V, I_O = 100 mA	500 mVpp
Short Circuit Current	V_{in} = 5.0 V, R_L = 0.1 Ω	910 mA
Efficiency	V_{in} = 5.0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

Figure 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**

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

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

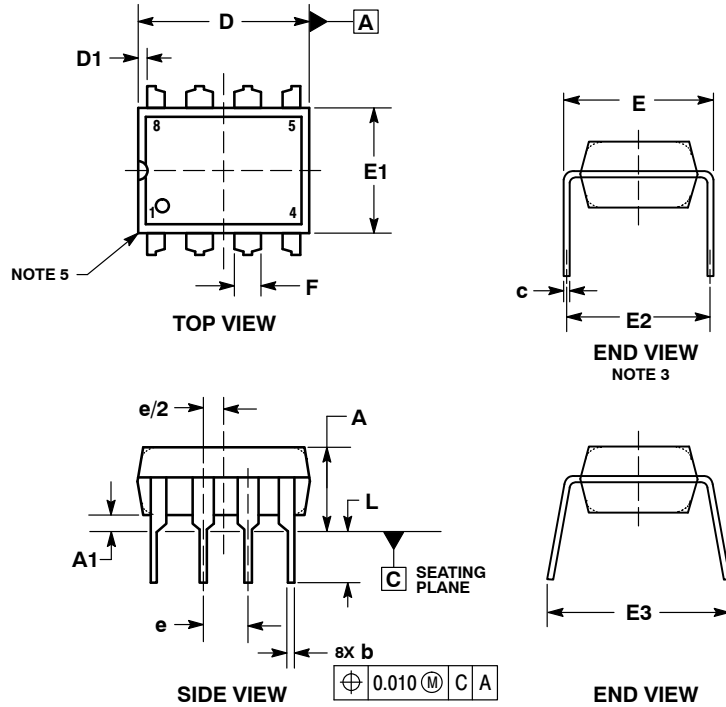**NOTE:** For further information refer to Application Note AN920A/D and AN954/D.
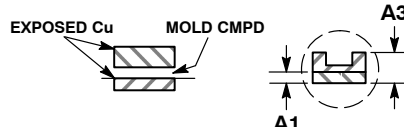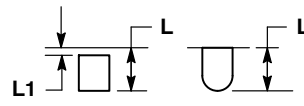
Figure 17. Design Formula Table

ESOP8
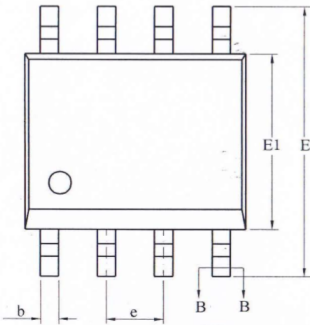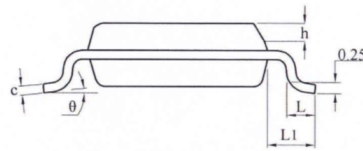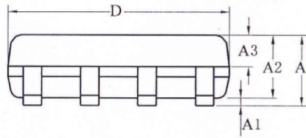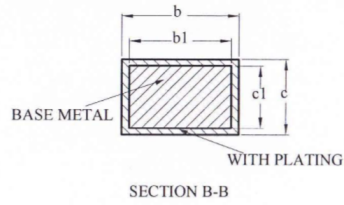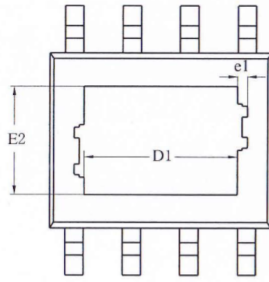
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.65
A1	0.05	—	0.15
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	—	0.47
b1	0.38	0.41	0.44
c	0.20	—	0.24
c1	0.19	0.20	0.21
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27BSC		
h	0.25	—	0.50
L	0.50	0.60	0.80
L1	1.05REF		
θ	0	—	8°

L/F Size Size(mm) (mil)	D1	E2	e1
90*90	2.09REF	2.09REF	0.16REF
95*130	3.10REF	2.21REF	0.10REF

BASE METAL

WITH PLATING

SECTION B-B

DIP−8

TOP VIEW

NOTE 5

END VIEW
NOTE 3

SIDE VIEW

⊕ | 0.010 Ⓜ | C | A

SEATING PLANE

END VIEW

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSION E IS MEASURED WITH THE LEADS RE-STRAINED PARALLEL AT WIDTH E2.
4. DIMENSION E1 DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

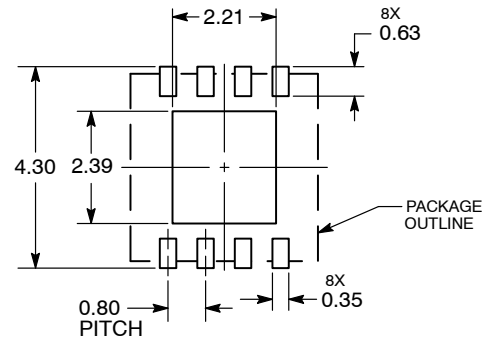| DIM	INCHES			MILLIMETERS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	----	----	0.210	----	----	5.33
A1	0.015	----	----	0.38	----	----
b	0.014	0.018	0.022	0.35	0.46	0.56
C	0.008	0.010	0.014	0.20	0.25	0.36
D	0.355	0.365	0.400	9.02	9.27	10.02
D1	0.005	----	----	0.13	----	----
E	0.300	0.310	0.325	7.62	7.87	8.26
E1	0.240	0.250	0.280	6.10	6.35	7.11
E2	0.300 BSC			7.62 BSC		
E3	----	----	0.430	----	----	10.92
e	0.100 BSC			2.54 BSC		
L	0.115	0.130	0.150	2.92	3.30	3.81

DFN8, 4x4

TOP VIEW

D

A
B

E

PIN ONE
REFERENCE

2X | ⌒ | 0.15 | C

2X | ⌒ | 0.15 | C

SIDE VIEW

/ | 0.10 | C

DETAIL B

8X | ⌒ | 0.08 | C
NOTE 4

A
(A3)
A1

C SEATING PLANE

DETAIL A
OPTIONAL CONSTRUCTIONS

L1

L

L

DETAIL B
ALTERNATE CONSTRUCTIONS

EXPOSED Cu   MOLD CMPD

A3

A1
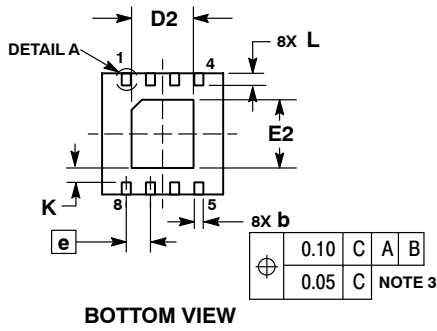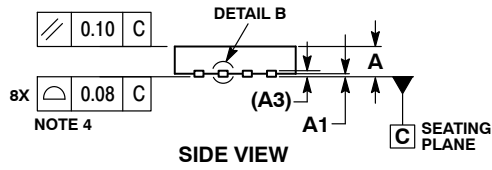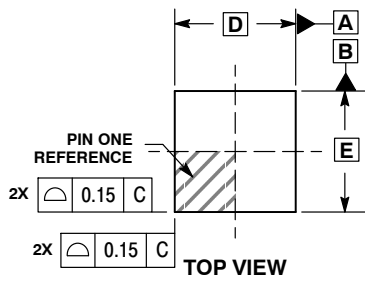
NOTES:
1. DIMENSIONS AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30MM FROM TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. DETAILS A AND B SHOW OPTIONAL 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

BOTTOM VIEW

DETAIL A

D2

8X L

E2

K

8X b

e

1   4

8   5

⊕ | 0.10 | C | A | B
  | 0.05 | C | NOTE 3

SOLDERING FOOTPRINT*

2.21

8X
0.63

4.30   2.39

0.80
PITCH

8X
0.35

PACKAGE
OUTLINE

DIMENSIONS: MILLIMETERS