MC34063A, MC33063A

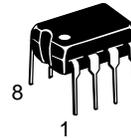## DC-to-DC Converter Control Circuits

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
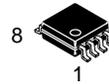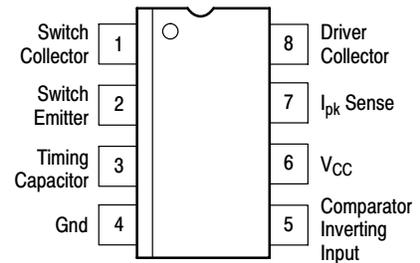- Precision 2% Reference

ON Semiconductor

http://onsemi.com

PDIP–8
P, P1 SUFFIX
CASE 626

8

1

SO–8
D SUFFIX
CASE 751

8

1

SOEIAJ–8
M SUFFIX
CASE 968

8

1

PIN CONNECTIONS

Switch Collector	1	○	8	Driver Collector
Switch Emitter	2		7	I_{pk} Sense
Timing Capacitor	3		6	V_{CC}
Gnd	4		5	Comparator Inverting Input

(Top View)

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.

Representative Schematic Diagram

8 Drive Collector
1 Switch Collector
S Q Q2
R Q1
100
7 I_{pk} Sense
I_{pk} Oscillator C_T
2 Switch Emitter
6 V_{CC}
Comparator
+
−
1.25 V Reference Regulator
3 Timing Capacitor
5 Comparator Inverting Input
4 Gnd

(Bottom View)
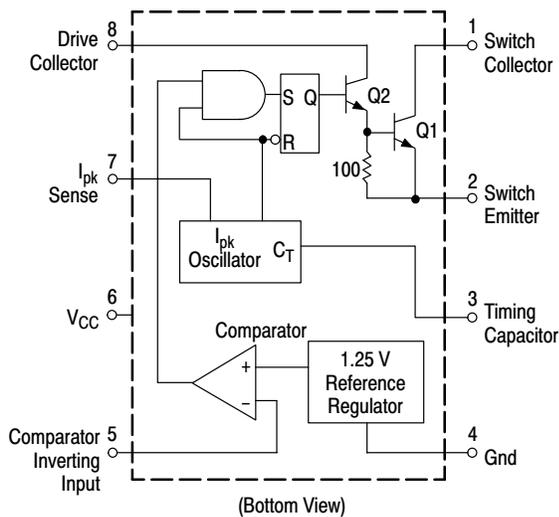
This device contains 51 active transistors.

1

Publication Order Number:
MC34063A/D

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
    Thermal Resistance
  SOIC Package, D Suffix
    T_A = 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

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

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 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 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 4.)					
Saturation Voltage, Darlington Connection (I_{SW} = 1.0 A, Pins 1, 8 connected)	$V_{CE(sat)}$	–	1.0	1.3	V
Saturation Voltage (Note 5.) (I_{SW} = 1.0 A, $R_{Pin\ 8}$ = 82 Ω to V_{CC}, Forced β ≃ 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) MC33063A, MC34063A MC33363AV	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

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

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

* The 100 Ω resistor in the emitter of the driver device requires about 7.0 mA before the output switch conducts.
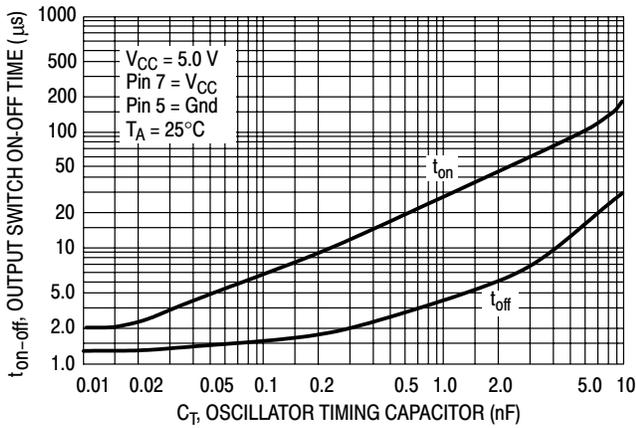
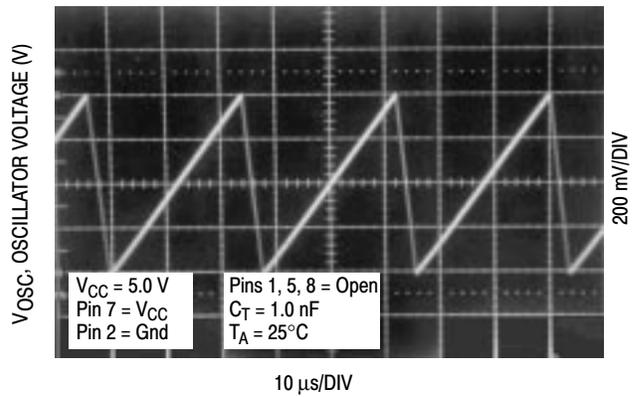Figure 1. Output Switch On–Off Time versus Oscillator Timing Capacitor
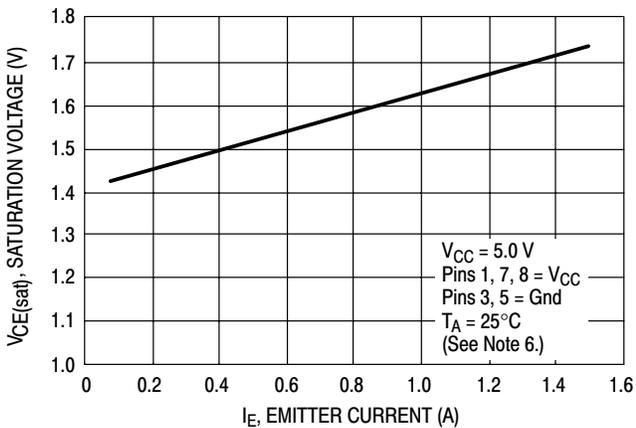

Figure 2. Timing Capacitor Waveform

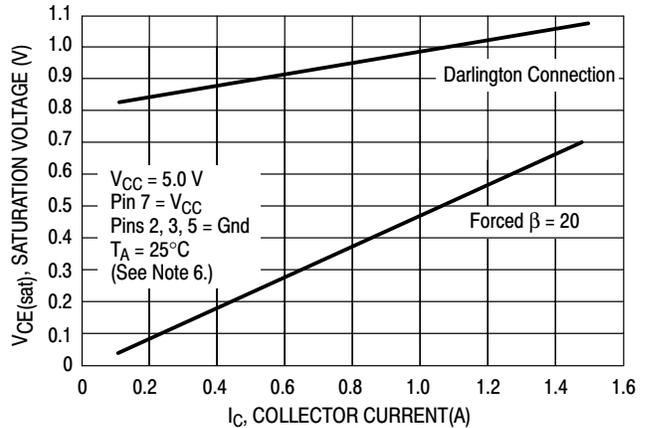Figure 3. Emitter Follower Configuration Output Saturation Voltage versus Emitter Current

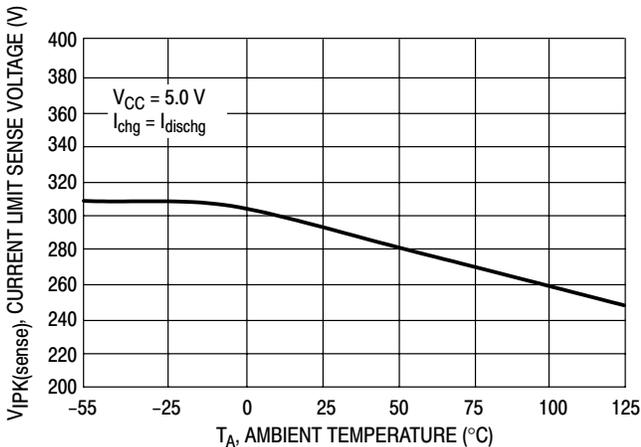Figure 4. Common Emitter Configuration Output Switch Saturation Voltage versus Collector Current

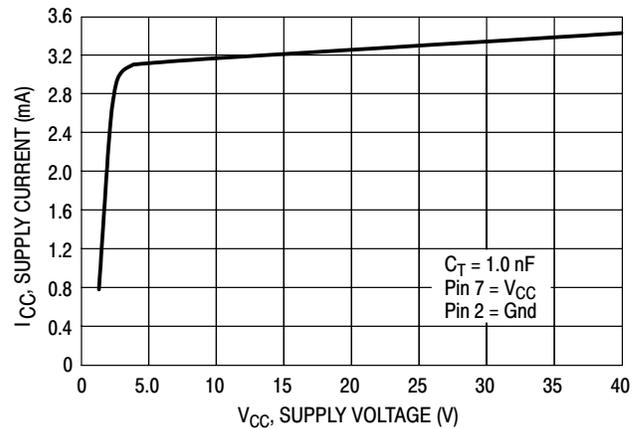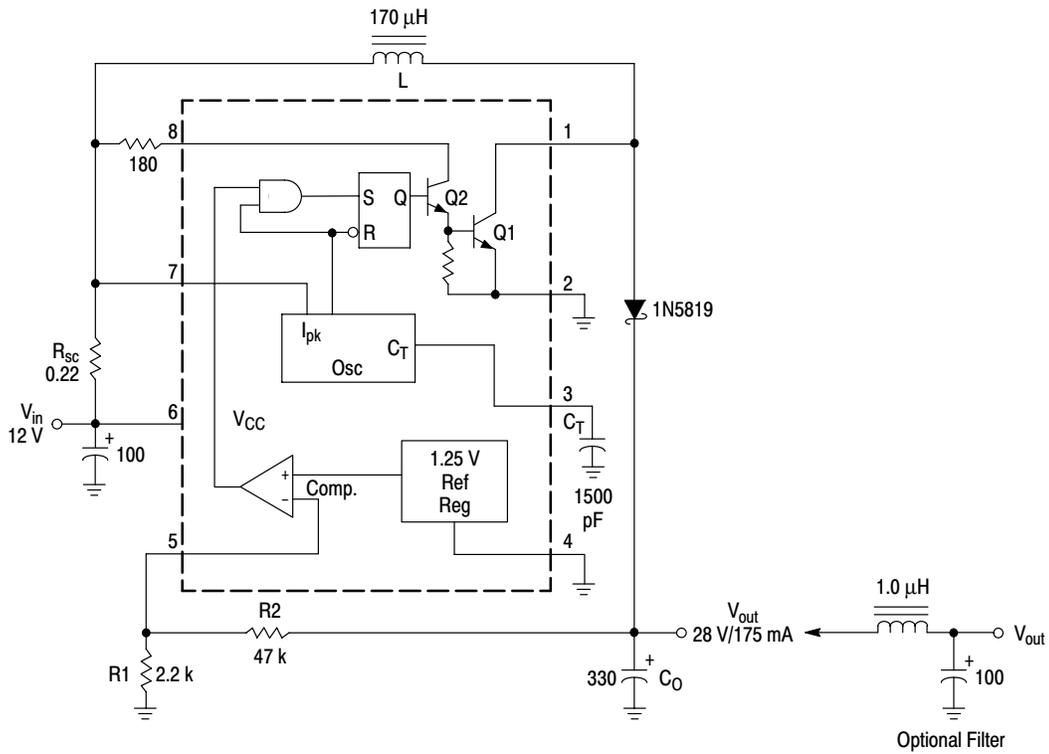

Figure 5. Current Limit Sense Voltage versus Temperature

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.

Figure 7. Step–Up Converter

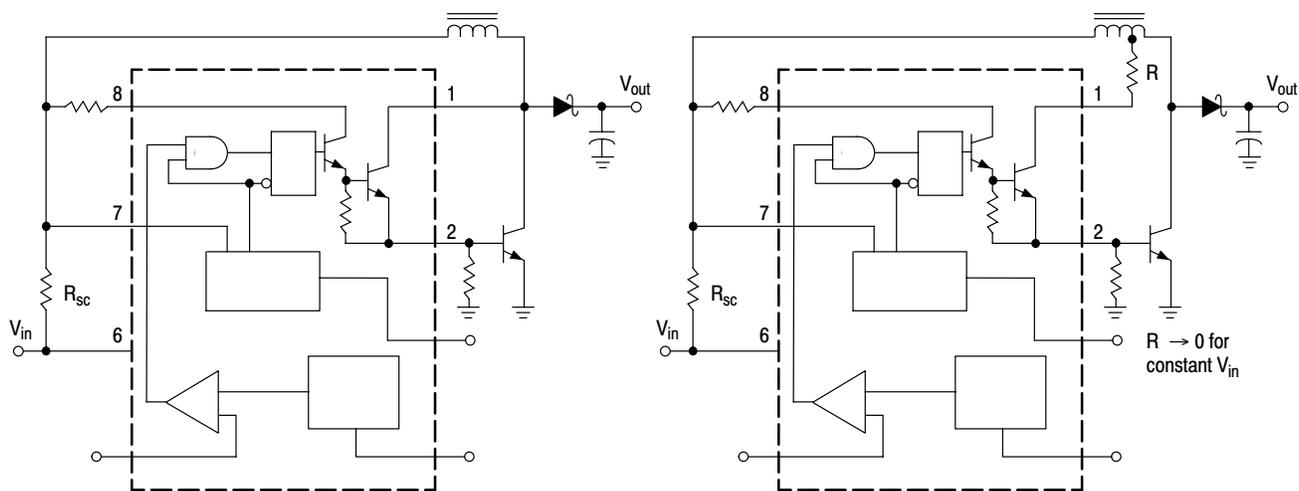| Test	Conditions	Results
Line Regulation	V_{in} = 8.0 V to 16 V, I_O = 175 mA	30 mV = ±0.05%
Load Regulation	V_{in} = 12 V, I_O = 75 mA to 175 mA	10 mV = ±0.017%
Output Ripple	V_{in} = 12 V, I_O = 175 mA	400 mVpp
Efficiency	V_{in} = 12 V, I_O = 175 mA	87.7%
Output Ripple With Optional Filter	V_{in}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

Figure 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 ($\leq$ 300 mA) and high driver currents ($\geq$ 30 mA), it may take up to 2.0 μs 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.
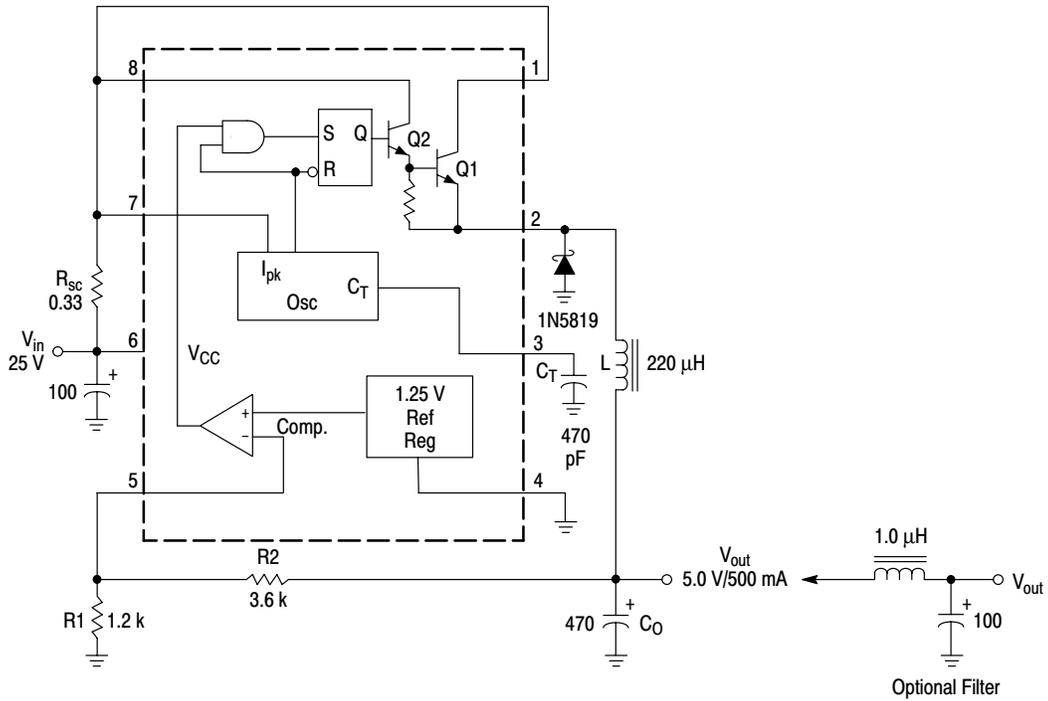
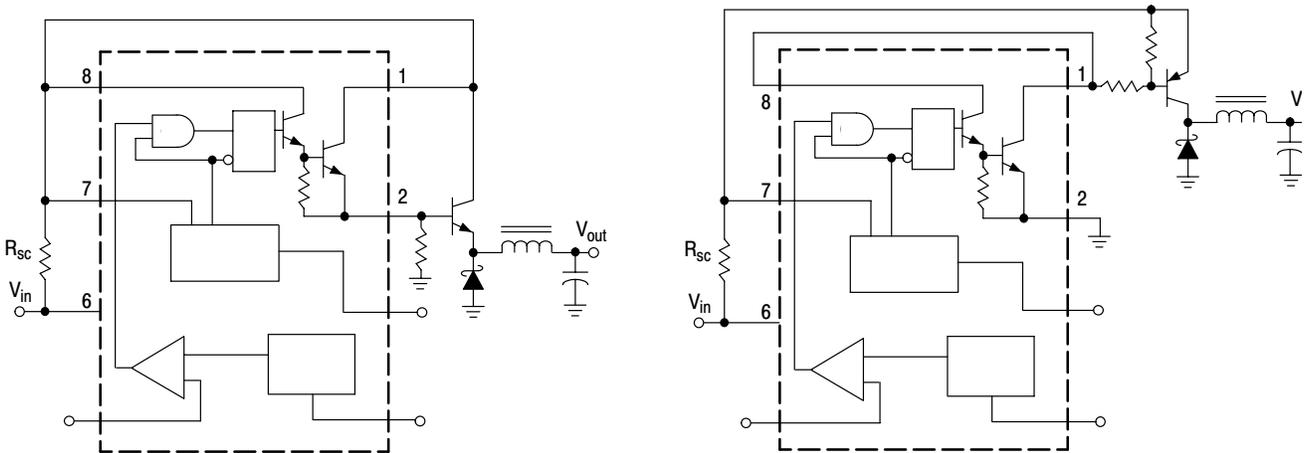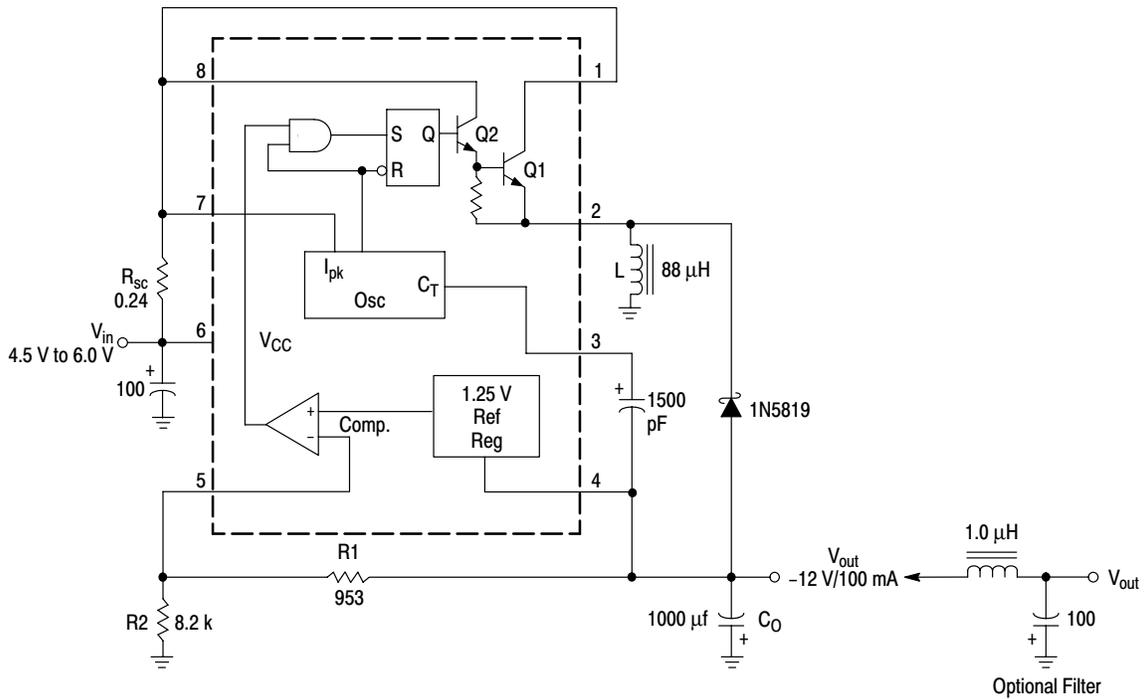| Test	Conditions	Results
Line Regulation	V_{in} = 15 V to 25 V, I_O = 500 mA	12 mV = ±0.12%
Load Regulation	V_{in} = 25 V, I_O = 50 mA to 500 mA	3.0 mV = ±0.03%
Output Ripple	V_{in} = 25 V, I_O = 500 mA	120 mVpp
Short Circuit Current	V_{in} = 25 V, R_L = 0.1 Ω	1.1 A
Efficiency	V_{in} = 25 V, I_O = 500 mA	83.7%
Output Ripple With Optional Filter	V_{in} = 25 V, I_O = 500 mA	40 mVpp

Figure 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**

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 11. Voltage Inverting Converter
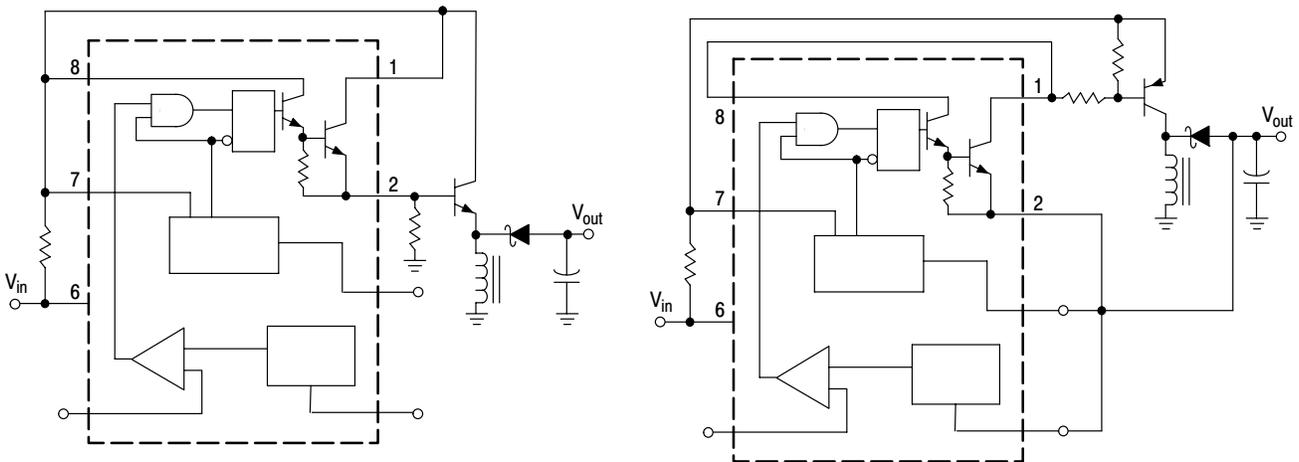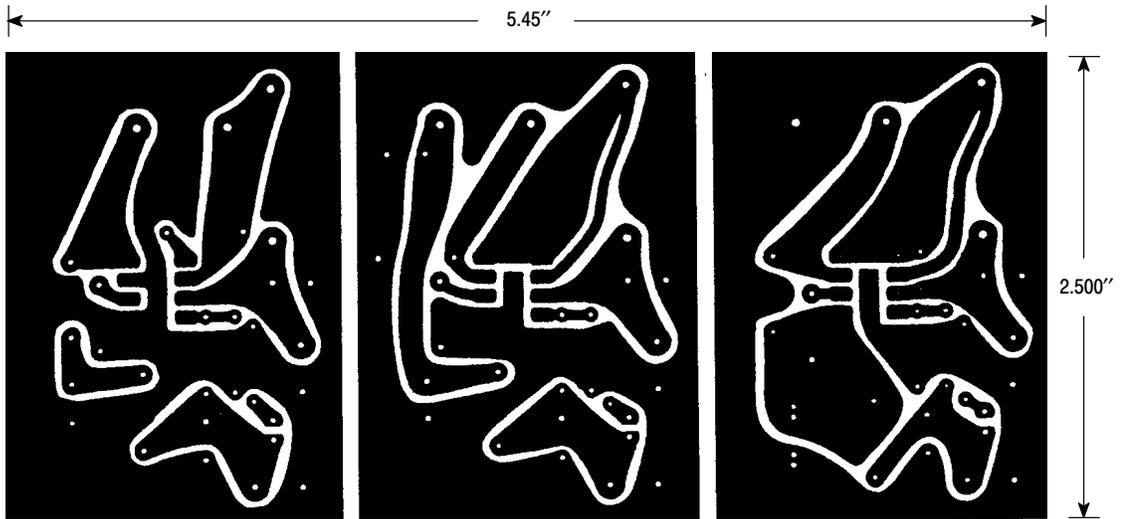

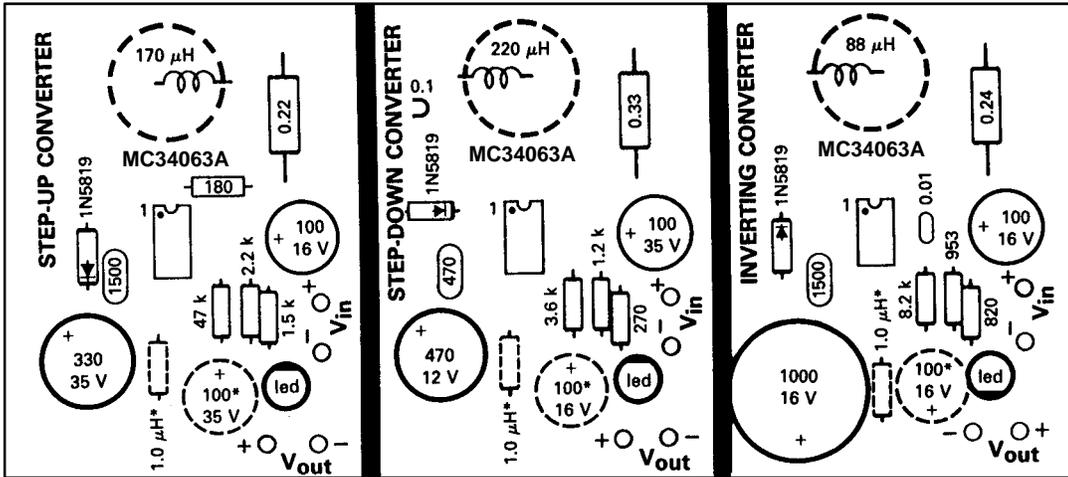**Figure 12. External Current Boost Connections for I_C Peak Greater than 1.5 A**

12a. External NPN Switch   **12b. External PNP Saturated Switch**

5.45″

2.500″

(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.

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.
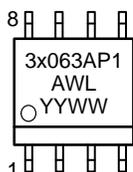
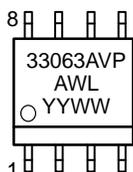**Figure 14. Design Formula Table**

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

8

3x063AP1
AWL
YYWW

1

PDIP–8
P, P1 SUFFIX
CASE 626

8

33063AVP
AWL
YYWW

1

SO–8
D SUFFIX
CASE 751

8

3x063
ALYWz

1

SO–8
D SUFFIX
CASE 751

8

34063
ALYWz

1

SOEIAJ–8
M SUFFIX
CASE 968

8

M063A
ALYW

1
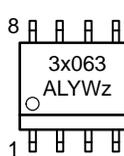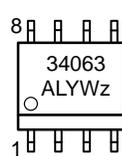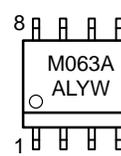
x	=	3 or 4
z	=	A denotes AD suffix
		J denotes BD suffix
A	=	Assembly Location
WL, L	=	Wafer Lot
YY, Y	=	Year
WW, W	=	Work Week

PACKAGE DIMENSIONS

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

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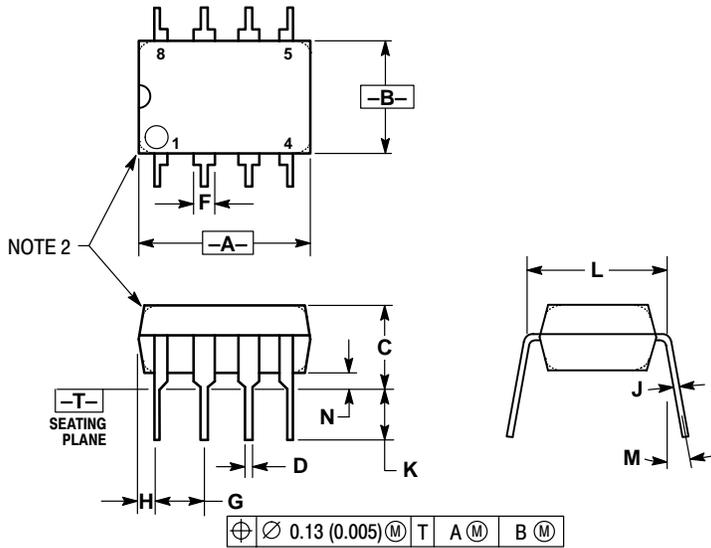
NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

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) Ⓜ T A Ⓜ B Ⓜ

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

⌖ 0.25 Ⓜ B Ⓜ

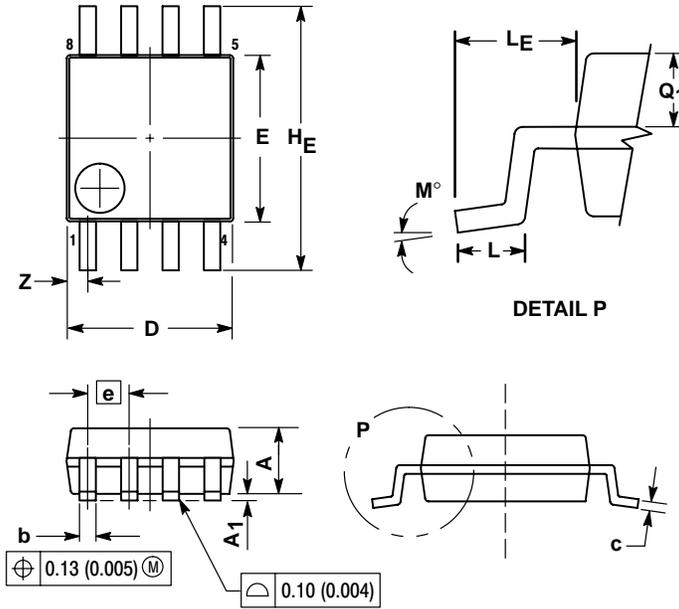h X 45°
θ

SEATING PLANE

◠ 0.10

⌖ 0.25 Ⓜ C B Ⓢ A Ⓢ
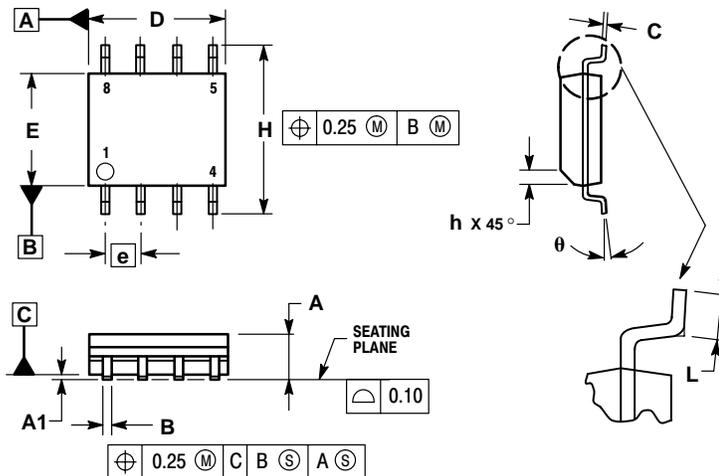
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. DIMENSIONS ARE IN MILLIMETER.
3. DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
5. DIMENSION B DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF 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°

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

DETAIL P

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 PROTUSION. 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
A1	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°
Q1	0.70	0.90	0.028	0.035
Z	---	0.94	---	0.037

Notes

Notes

PUBLICATION ORDERING INFORMATION

NORTH AMERICA Literature Fulfillment:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303–675–2175 or 800–344–3860 Toll Free USA/Canada
Fax: 303–675–2176 or 800–344–3867 Toll Free USA/Canada
Email: ONlit@hibbertco.com
Fax Response Line: 303–675–2167 or 800–344–3810 Toll Free USA/Canada

N. American Technical Support: 800–282–9855 Toll Free USA/Canada

EUROPE: LDC for ON Semiconductor – European Support
  German Phone: (+1) 303–308–7140 (Mon–Fri 2:30pm to 7:00pm CET)
      Email: ONlit–german@hibbertco.com
  French Phone: (+1) 303–308–7141 (Mon–Fri 2:00pm to 7:00pm CET)
      Email: ONlit–french@hibbertco.com
  English Phone: (+1) 303–308–7142 (Mon–Fri 12:00pm to 5:00pm GMT)
      Email: ONlit@hibbertco.com

EUROPEAN TOLL–FREE ACCESS*: 00–800–4422–3781
      *Available from Germany, France, Italy, UK, Ireland

CENTRAL/SOUTH AMERICA:
  Spanish Phone: 303–308–7143 (Mon–Fri 8:00am to 5:00pm MST)
      Email: ONlit–spanish@hibbertco.com

ASIA/PACIFIC: LDC for ON Semiconductor – Asia Support
  Phone: 303–675–2121 (Tue–Fri 9:00am to 1:00pm, Hong Kong Time)
      Toll Free from Hong Kong & Singapore:
      001–800–4422–3781
  Email: ONlit–asia@hibbertco.com

JAPAN: ON Semiconductor, Japan Customer Focus Center
  4–32–1 Nishi–Gotanda, Shinagawa–ku, Tokyo, Japan 141–0031
  Phone: 81–3–5740–2745
  Email: r14525@onsemi.com

ON Semiconductor Website: http://onsemi.com

For additional information, please contact your local
Sales Representative.