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DC/DC converter control circuits

Features

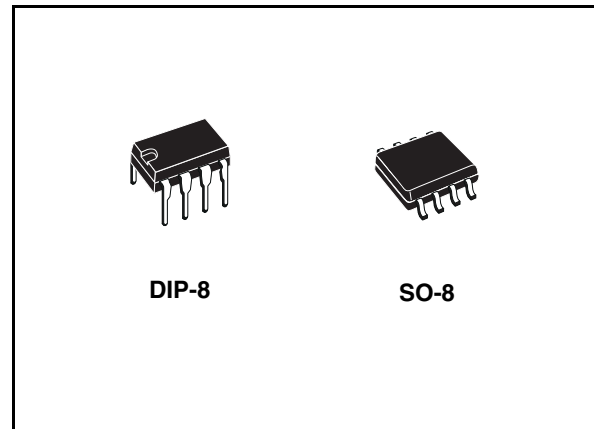
- Output switch current in excess of 1.5 A
- 2 % reference accuracy
- Low quiescent current: 2.5 mA (typ.)
- Operating from 3 V to 40 V
- Frequency operation to 100 kHz
- Active current limiting

Description

The MC34063A/E series is a monolithic control circuit delivering the main functions for DC/DC voltage converting.

The device contains an internal temperature compensated reference, comparator, duty cycle controlled oscillator with an active current limit circuit, driver and high current output switch. Output voltage is adjustable through two external resistors with a 2 % reference accuracy.

Employing a minimum number of external components the MC34063A/E devices series is



designed for step-down, step-up and voltage-inverting applications.

Table 1. Device summary

Order codes	
DIP-8	SO-8
MC34063ABN ⁽¹⁾	MC34063ABD-TR
MC34063ACN ⁽¹⁾	MC34063ACD-TR
MC34063EBN	MC34063EBD-TR
MC34063ECN	MC34063ECD-TR

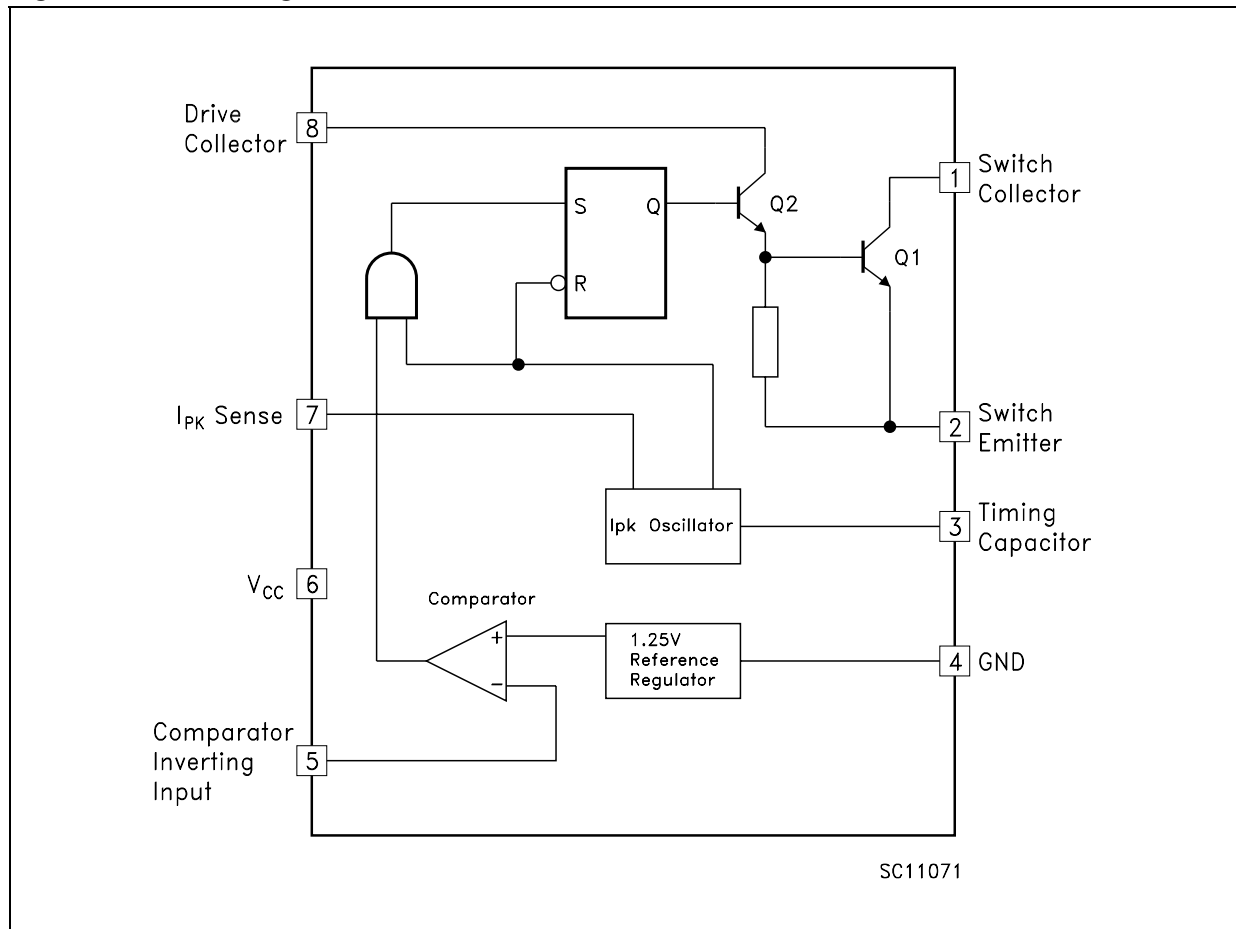
1. The "A" version is not recommended for new designs.

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1 Diagram

Figure 1. Block diagram



2 Pin configuration

Figure 2. Pin connections

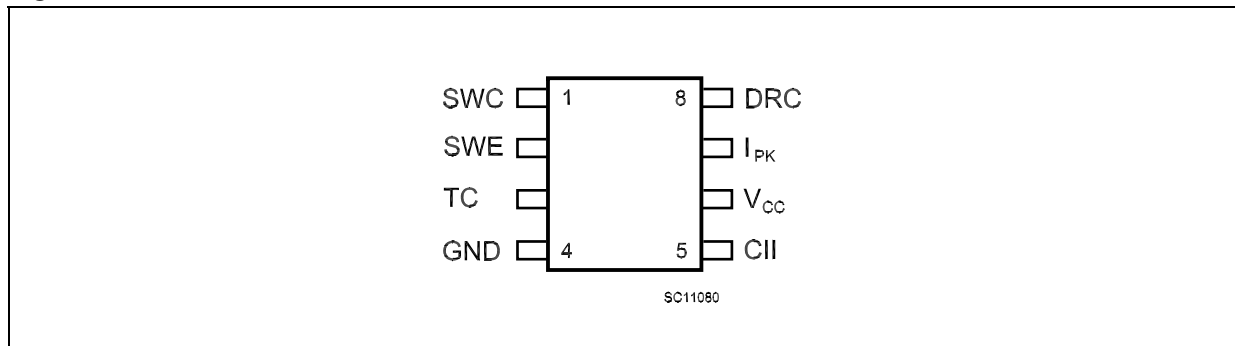


Table 2. Pin description

Pin n°	Symbol	Name and function
1	SWC	Switch collector
2	SWE	Switch emitter
3	TC	Timing capacitor
4	GND	Ground
5	CII	Comparator inverting input
6	V _{CC}	Voltage supply
7	I _{PK}	I _{PK} sense
8	DRC	Voltage driver collector

3 Maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter		Value	Unit
V_{CC}	Power supply voltage		50	V
V_{IR}	Comparator input voltage range		-0.3 to 40	V
V_{SWC}	Switch collector voltage		40	V
V_{SWE}	Switch emitter voltage ($V_{SWC} = 40V$)		40	V
V_{CE}	Switch collector to emitter voltage		40	V
V_{DC}	Driver collector voltage		40	V
I_{DC}	Driver collector current		100	mA
I_{SW}	Switch current		1.5	A
P_{TOT}	Power dissipation at $T_A = 25^\circ C$	for DIP-8	1.25	W
		for SO-8	0.625	
T_J	Operating junction temperature		150	$^\circ C$
T_{STG}	Storage temperature range		-40 to 150	$^\circ C$
T_{OP}	Operating ambient temperature range	for AC and EC series	0 to 70	$^\circ C$
		for AB series	-40 to 85	
		for EB series	-40 to 125	

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

Table 4. Thermal data

Symbol	Parameter	DIP-8	SO-8	Unit
R_{thJA}	Thermal resistance junction-ambient ⁽¹⁾	100	160	$^\circ C/W$
R_{thJC}	Thermal resistance junction-case	42	20	$^\circ C/W$

1. This value depends from thermal design of PCB on which the device is mounted.

4 Electrical characteristics

(Refer to the test circuits, $V_{CC} = 5\text{ V}$, $T_A = T_{LOW}$ to T_{HIGH} , unless otherwise specified, see [Note 2](#))

Table 5. Oscillator

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
f_{OSC}	Frequency	$V_{PIN5} = 0\text{ V}$, $C_T = 1\text{ nF}$, $T_A = 25^\circ\text{C}$	24	33	42	kHz
I_{CHG}	Charge current	$V_{CC} = 5\text{ to }40\text{ V}$, $T_A = 25^\circ\text{C}$	24	33	42	μA
I_{DISCHG}	Discharge current	$V_{CC} = 5\text{ to }40\text{ V}$, $T_A = 25^\circ\text{C}$	140	200	260	μA
I_{DISCHG}/I_{CHG}	Discharge to charge current ratio	$PIN\ 7 = V_{CC}$, $T_A = 25^\circ\text{C}$	5.2	6.2	7.5	μA
$V_{IPK(sense)}$	Current limit sense voltage	$I_{CHG} = I_{DISCHG}$, $T_A = 25^\circ\text{C}$	250	300	350	mV

Table 6. Output switch

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{CE(sat)}$	Saturation voltage, darlington connection	$I_{SW} = 1\text{ A}$, PIN 7, 8 connected		1	1.3	V
$V_{CE(sat)}$	Saturation voltage	$I_{SW} = 1\text{ A}$, $R_{PIN8} = 82\ \Omega$ to V_{CC} Forced $\beta \sim 20$		0.45	0.7	V
h_{FE}	DC current gain	$I_{SW} = 1\text{ A}$, $V_{CE} = 5\text{ V}$, $T_A = 25^\circ\text{C}$	50	120		
$I_{C(off)}$	Collector off-state current	$V_{CE} = 40\text{ V}$		0.01	100	μA

Table 7. Comparator

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{TH}	Threshold voltage	$T_A = 25^\circ\text{C}$	1.225	1.25	1.275	V
		$T_A = T_{LOW}$ to T_{HIGH}	1.21		1.29	
Reg_{line}	Threshold voltage line regulation	$V_{CC} = 3\text{ to }40\text{ V}$		1	5	mV
I_{IB}	Input bias current	$V_{IN} = 0\text{ V}$		-5	-400	nA

Table 8. Total device

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
I _{CC}	Supply current	V _{CC} = 5 to 40 V C _T = 1 nF PIN 7 = V _{CC} V _{PIN5} > V _{TH} PIN 2 = GND Remaining pins open	for MC34063A		2.5	4	mA
			for MC34063E		1.5	4	
V _{START-UP}	Start-up voltage (Note 4)	T _A = 25°C C _T = 1 μF, PIN 5 = 0	for MC34063A		2.1		V
			for MC34063E		1.5		

Note: 1 Maximum package power dissipation limit must be observed.

2 T_{LOW} = 0 °C, T_{HIGH} = 70 °C (AC and EC series); T_{LOW} = -40 °C, T_{HIGH} = 85 °C (AB series); T_{LOW} = -40 °C, T_{HIGH} = 125 °C (EB series).

3 If darlington configuration is not used, care must be taken to avoid deep saturation of output switch. The resulting switch-off time may be adversely affected. In a darlington configuration the following output driver condition is suggested:

$$\text{Forced } \beta \text{ of output current switch} = I_{\text{COUTPUT}} / (I_{\text{CDRIVER}} - 1 \text{ mA}^{(a)}) \geq 10$$

4 Start-up voltage is the minimum power supply voltage at which the internal oscillator begins to work.

a. Current less due to a built in 1 kΩ anti leakage resistor.

5 Typical performance characteristics

Figure 3. Emitter follower configuration output saturation voltage vs emitter current

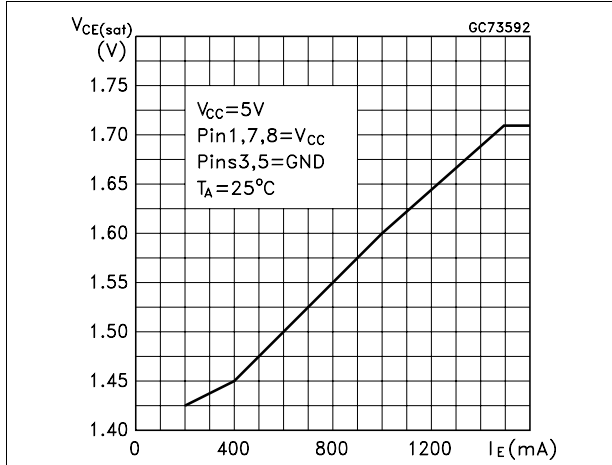


Figure 4. Output switch ON-OFF time vs oscillator timing capacitor

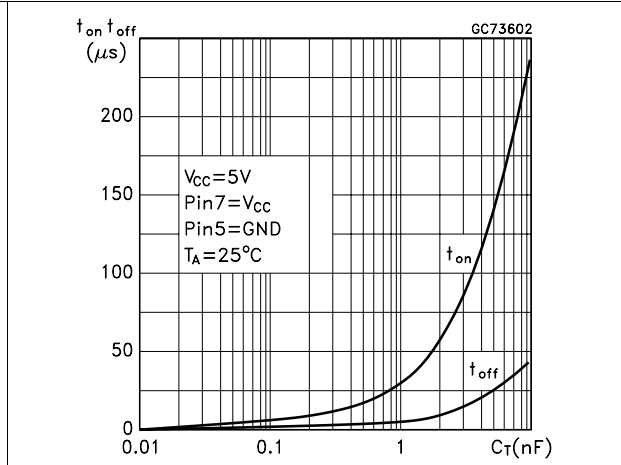


Figure 5. Common emitter configuration output switch saturation voltage vs collector current

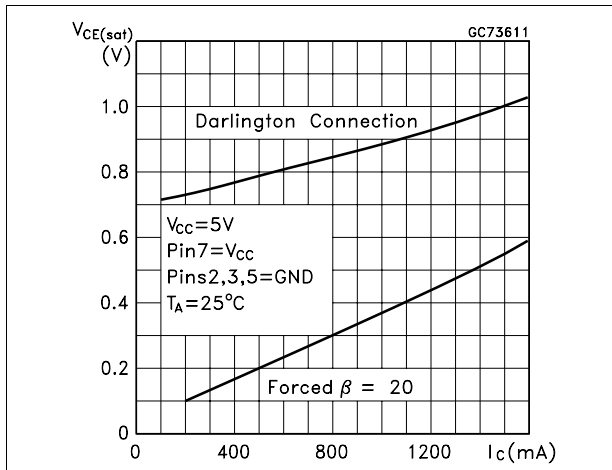


Figure 6. Darlington configuration collector emitter saturation voltage ($V_{CE(sat)}$) vs temperature

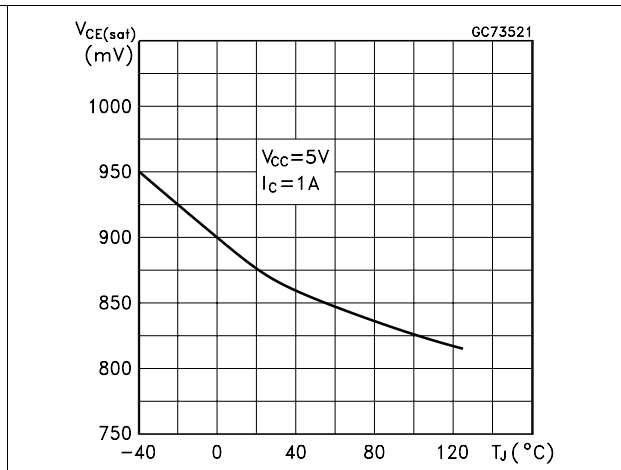


Figure 7. Power collector emitter saturation voltage (V_{CEsat}) vs temperature

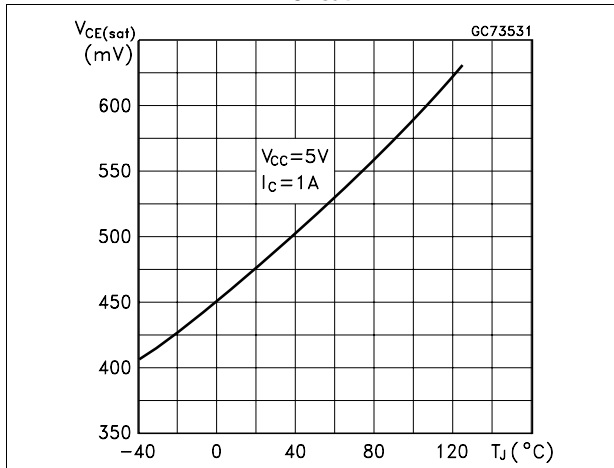


Figure 8. Current limit sense voltage (V_{IPK}) vs temperature

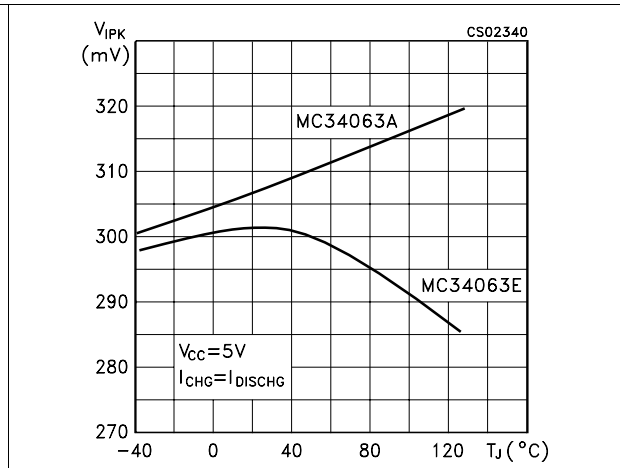


Figure 9. Reference voltage vs temperature

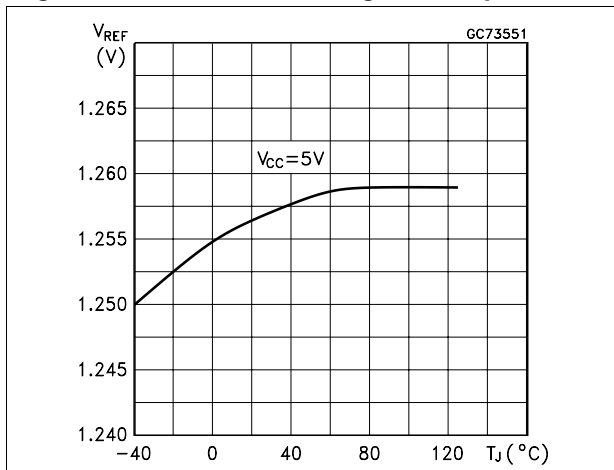


Figure 10. Bias current vs temperature

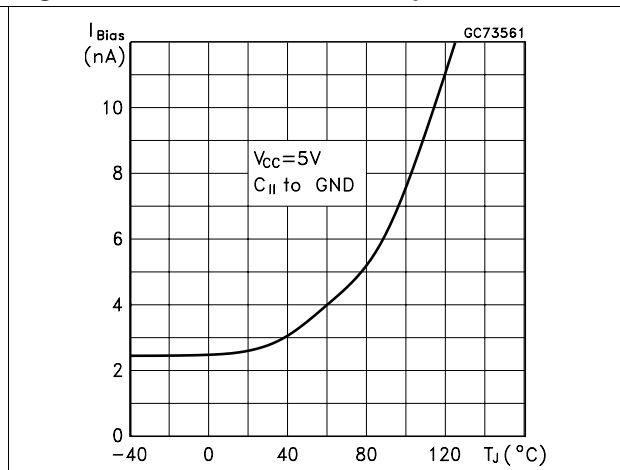


Figure 11. Supply current vs temperature

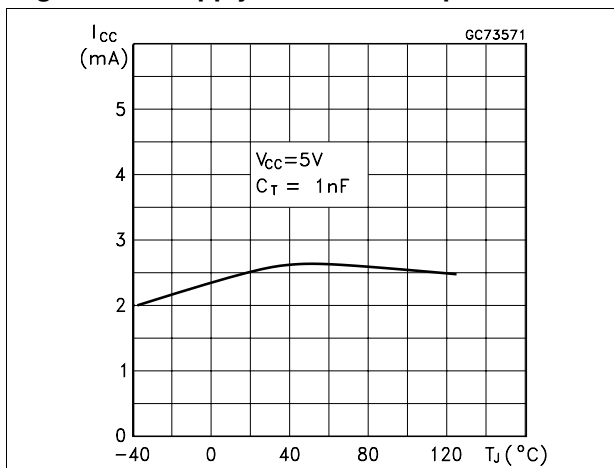
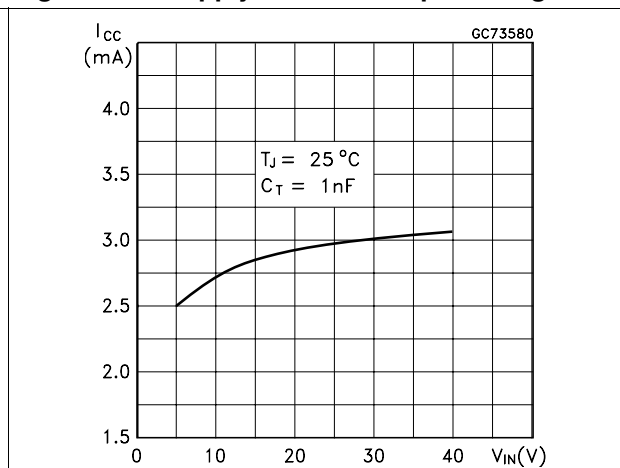


Figure 12. Supply current vs input voltage



6 Typical application circuit

Figure 13. Step-up converter

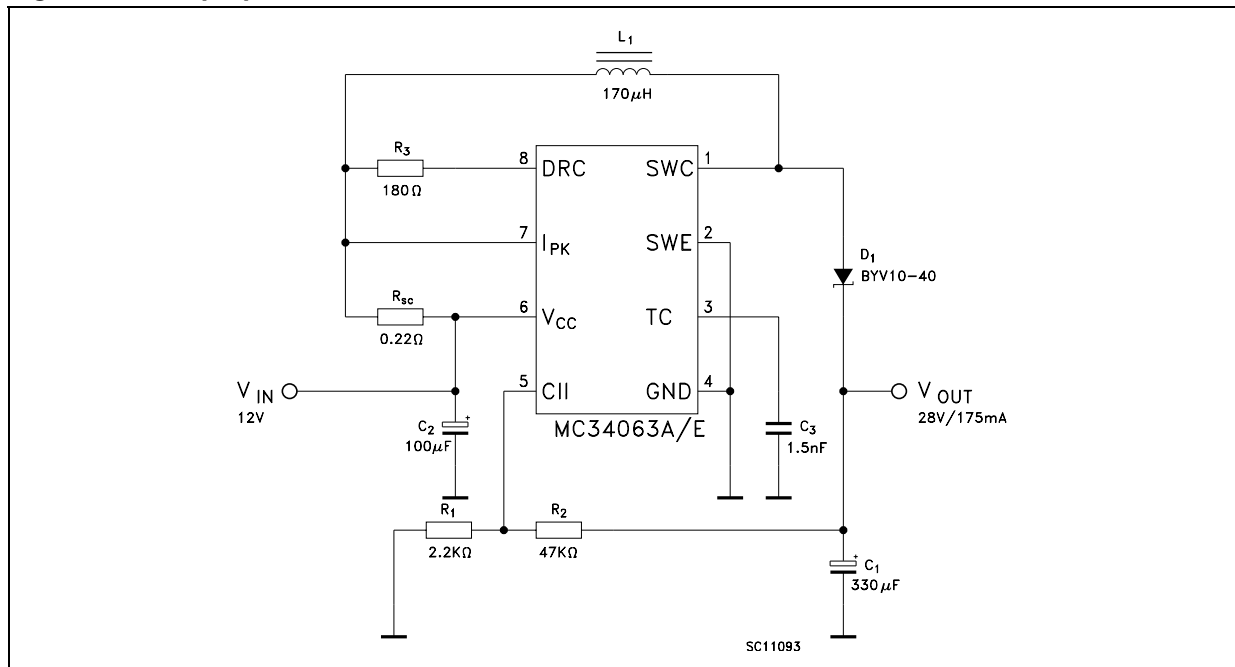


Figure 14. Printed evaluation board

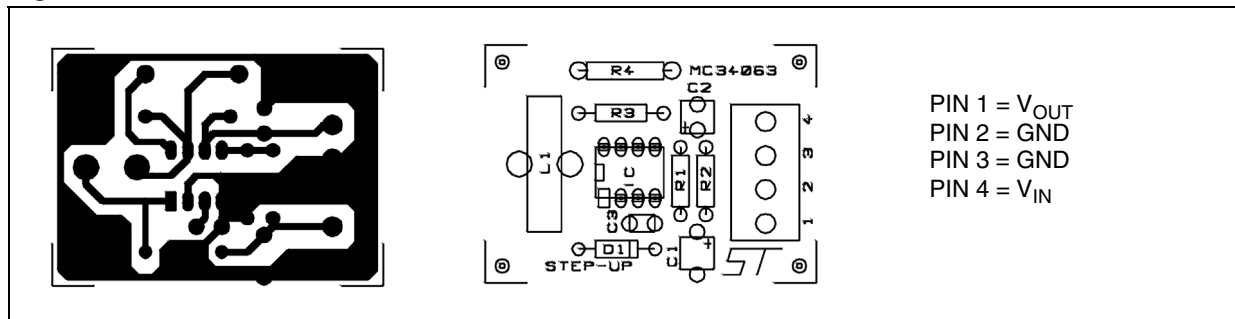


Table 9. Test condition ($V_{OUT} = 28\text{ V}$)

Test	Conditions	Value (Typ.)	Unit
Line Regulation	$V_{IN} = 8\text{ to }16\text{ V}$, $I_O = 175\text{ mA}$	30	mV
Load Regulation	$V_{IN} = 12\text{ V}$, $I_O = 75\text{ to }175\text{ mA}$	10	mV
Output Ripple	$V_{IN} = 12\text{ V}$, $I_O = 175\text{ mA}$	300	mV
Efficiency	$V_{IN} = 12\text{ V}$, $I_O = 175\text{ mA}$	89	%

Figure 15. Step-down converter

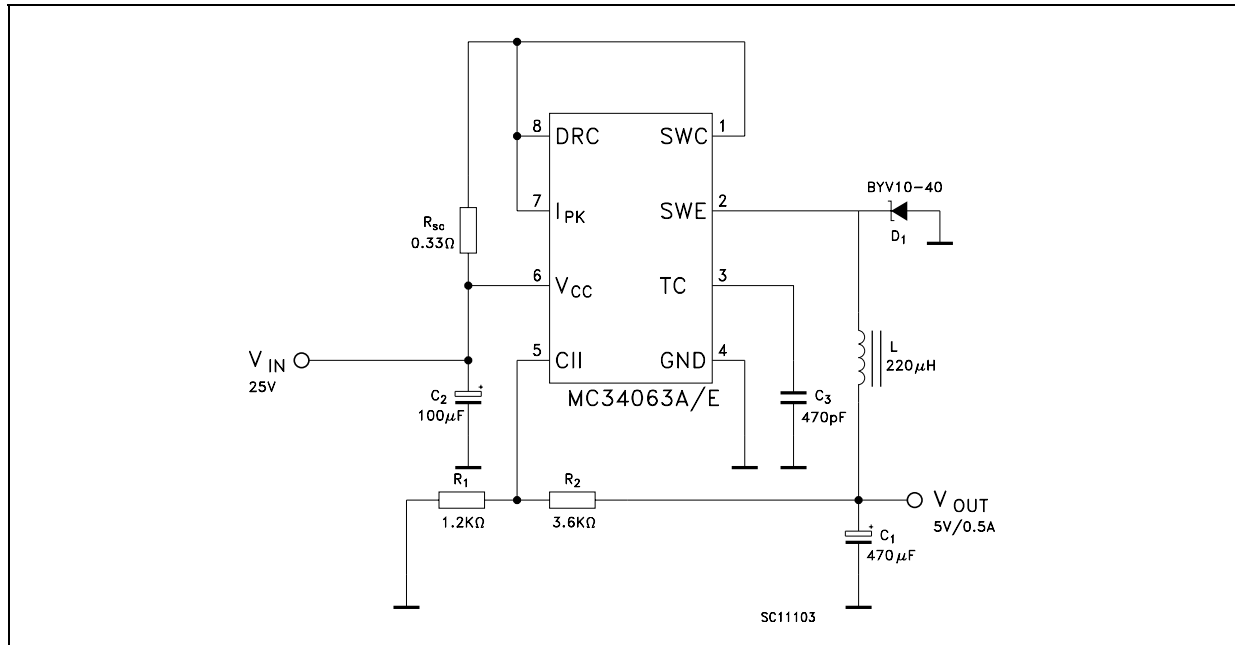


Figure 16. Printed evaluation board

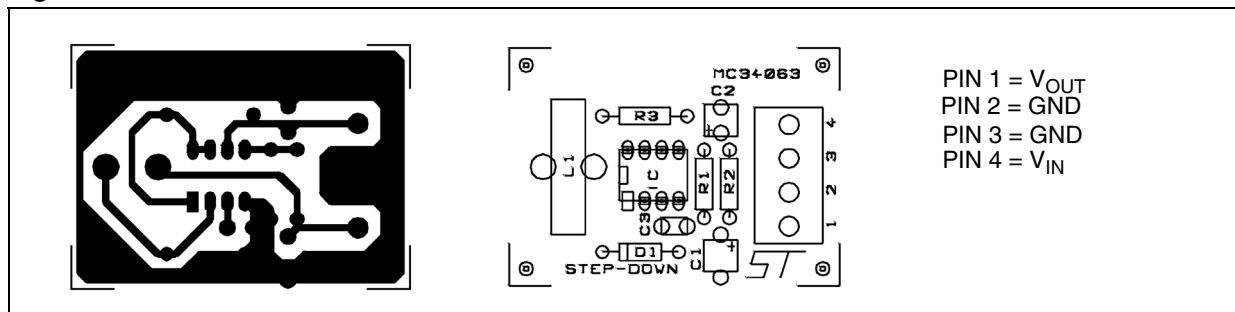


Table 10. Test condition ($V_{OUT} = 5\text{ V}$)

Test	Conditions	Value (typ.)	Unit
Line regulation	$V_{IN} = 15\text{ to }25\text{ V}$, $I_O = 500\text{ mA}$	5	mV
Load regulation	$V_{IN} = 25\text{ V}$, $I_O = 50\text{ to }500\text{ mA}$	30	mV
Output ripple	$V_{IN} = 25\text{ V}$, $I_O = 500\text{ mA}$	100	mV
Efficiency	$V_{IN} = 25\text{ V}$, $I_O = 500\text{ mA}$	80	%
I_{SC}	$V_{IN} = 25\text{ V}$, $R_{LOAD} = 0.1\ \Omega$	1.2	A

Figure 17. Voltage inverting converter

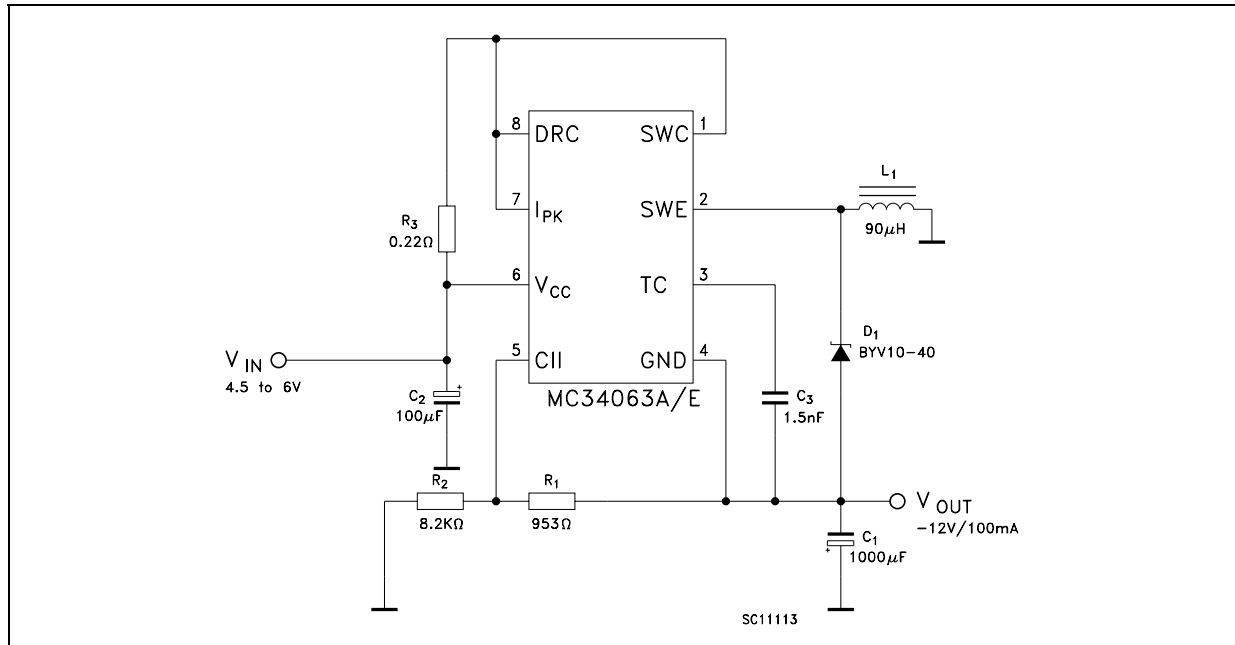


Figure 18. Printed evaluation board

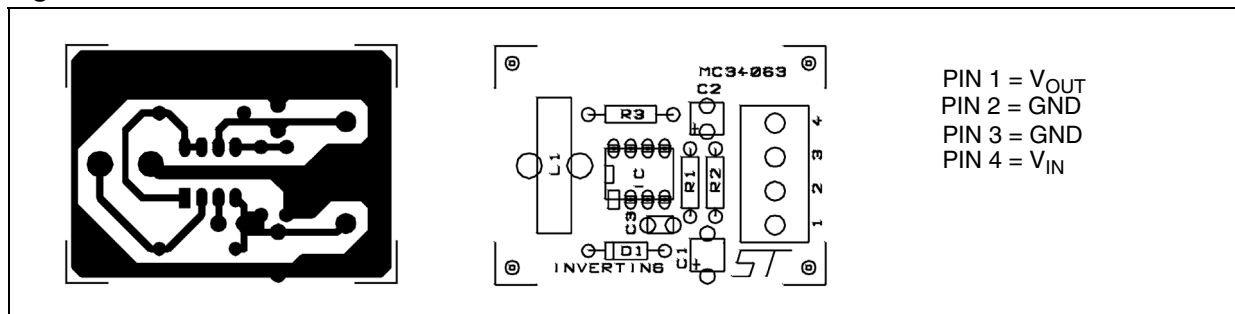


Table 11. Test condition ($V_{OUT} = 12\text{ V}$)

Test	Conditions	Value (typ.)	Unit
Line regulation	$V_{IN} = 4.5\text{ to }6\text{ V}$, $I_O = 100\text{ mA}$	15	mV
Load regulation	$V_{IN} = 5\text{ V}$, $I_O = 10\text{ to }100\text{ mA}$	20	mV
Output ripple	$V_{IN} = 5\text{ V}$, $I_O = 100\text{ mA}$	230	mV
Efficiency	$V_{IN} = 5\text{ V}$, $I_O = 100\text{ mA}$	58	%
I_{SC}	$V_{IN} = 5\text{ V}$, $R_{LOAD} = 0.1\ \Omega$	0.9	A

Table 12. Calculation

Parameter	Step-Up (Discontinuous mode)	Step-Down (Continuous mode)	Voltage Inverting (Discontinuous mode)
t_{on}/t_{off}	$\frac{V_{OUT} + V_F - V_{IN(mi)}}{V_{IN(min)} - V_{sat}}$	$\frac{V_{OUT} + V_F}{V_{IN(min)} - V_{sat} - V_{OL}}$	$\frac{ V_{OUT} + V_F}{V_{IN} - V_{sat}}$
$(t_{on} + t_{off}) \max$	$1/f_{min}$	$1/f_{min}$	$1/f_{min}$
C_T	$4.5 \times 10^{-5} t_{on}$	$4.5 \times 10^{-5} t_{on}$	$4.5 \times 10^{-5} t_{on}$
$I_{PK(switch)}$	$2I_{out(max)}[(t_{on}/t_{off})+1]$	$2I_{out(max)}$	$2I_{out(max)}[(t_{on}/t_{off})+1]$
R_{SC}	$0.3/I_{PK(switch)}$	$0.3/I_{PK(switch)}$	$0.3/I_{PK(switch)}$
C_O	$\frac{I_{out} t_{on}}{V_{ripple(p-p)}}$	$\frac{I_{PK(switch)}(t_{on} + t_{off})}{8V_{ripple(p-p)}}$	$\frac{I_{out} t_{on}}{V_{ripple(p-p)}}$
$L_{(min)}$	$\frac{V_{IN(min)} - V_{sat}}{I_{PK(switch)}} \times t_{on(mi)}$	$\frac{V_{IN(min)} - V_{sat} - V_{out}}{I_{PK(switch)}} \times t_{on()}$	$\frac{V_{IN(min)} - V_{sat}}{I_{PK(switch)}} \times t_{on(mi)}$

Note: 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} = Desired peak to peak output ripple voltage. In practice, the calculated capacitor value will and 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.

Figure 19. Step-up with external NPN switch

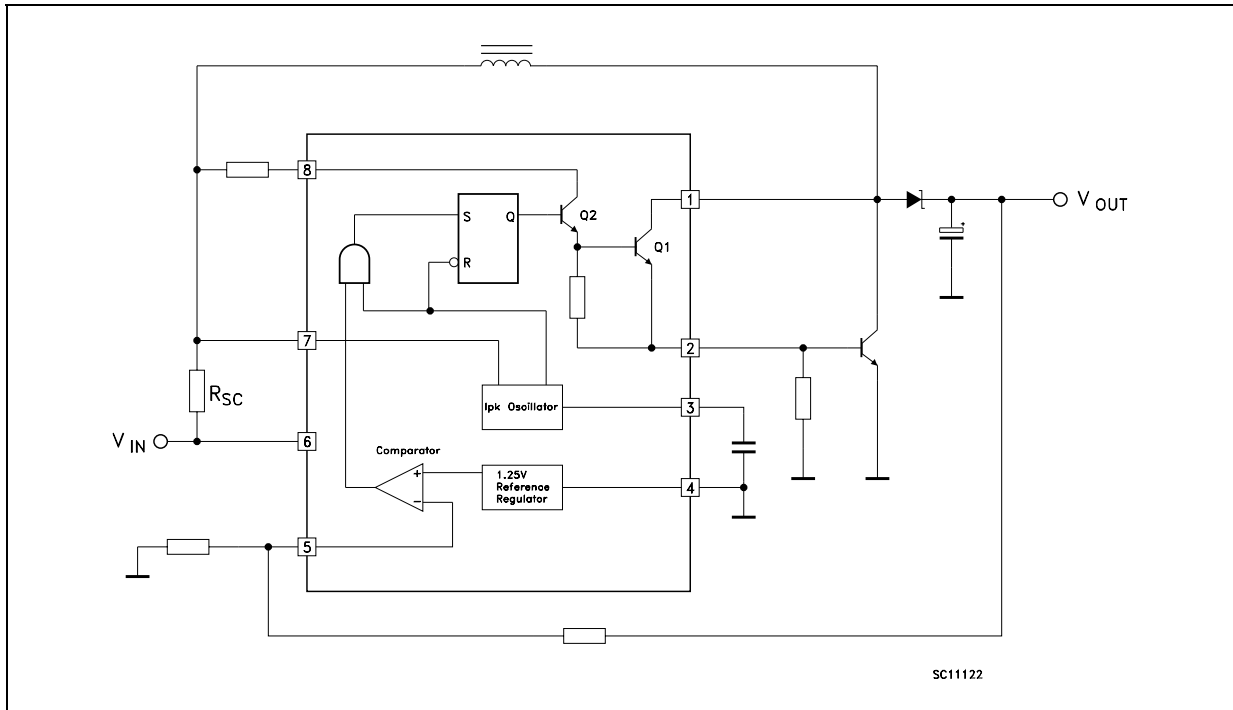


Figure 20. Step-down with external NPN switch

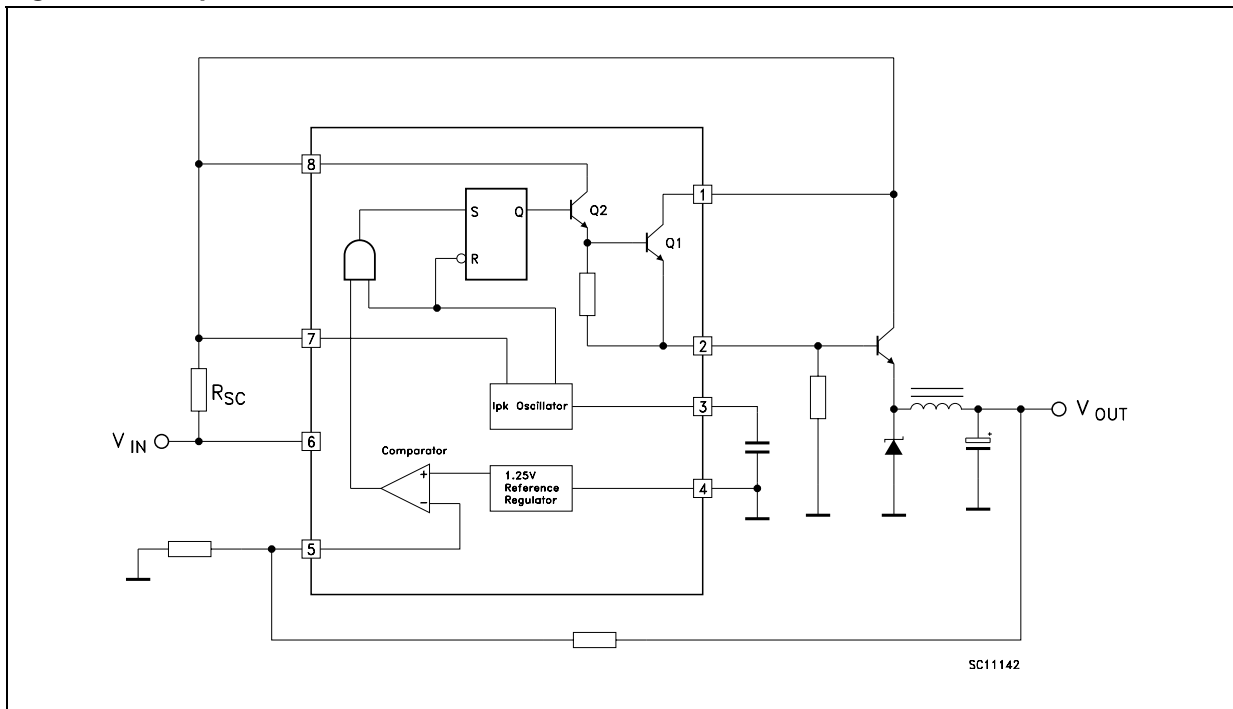


Figure 21. Step-down with external PNP switch

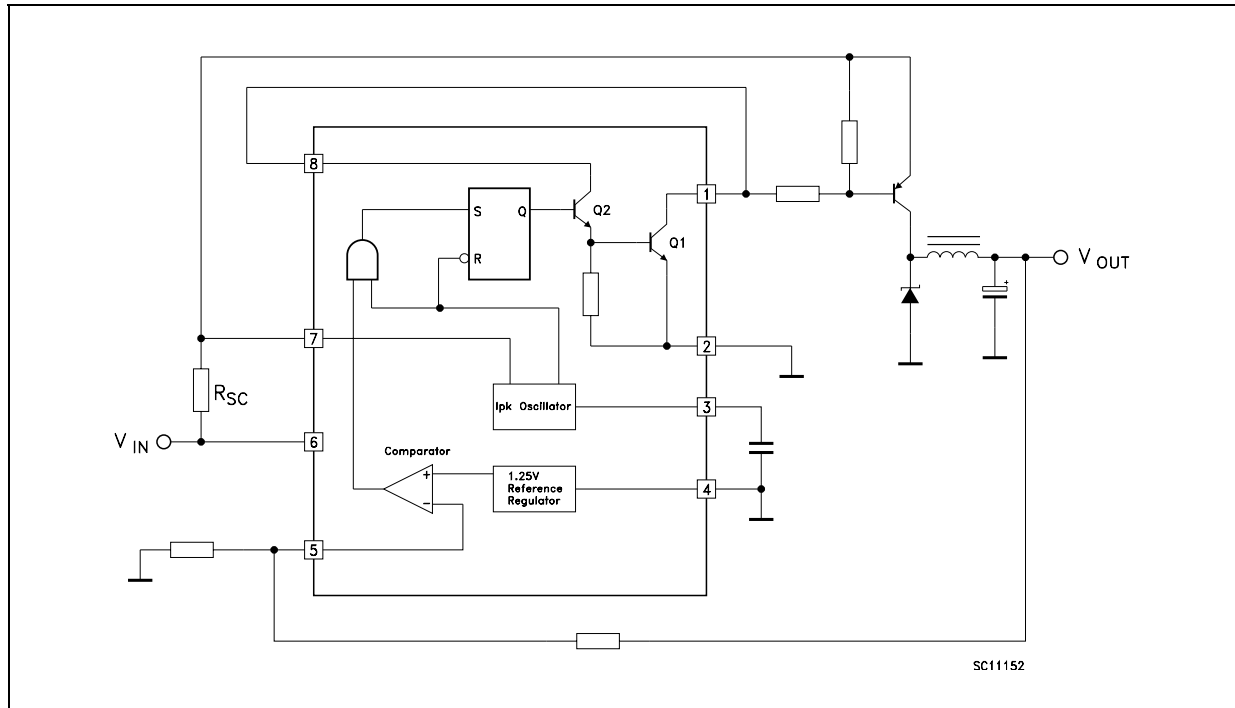


Figure 22. Voltage inverting with external NPN switch

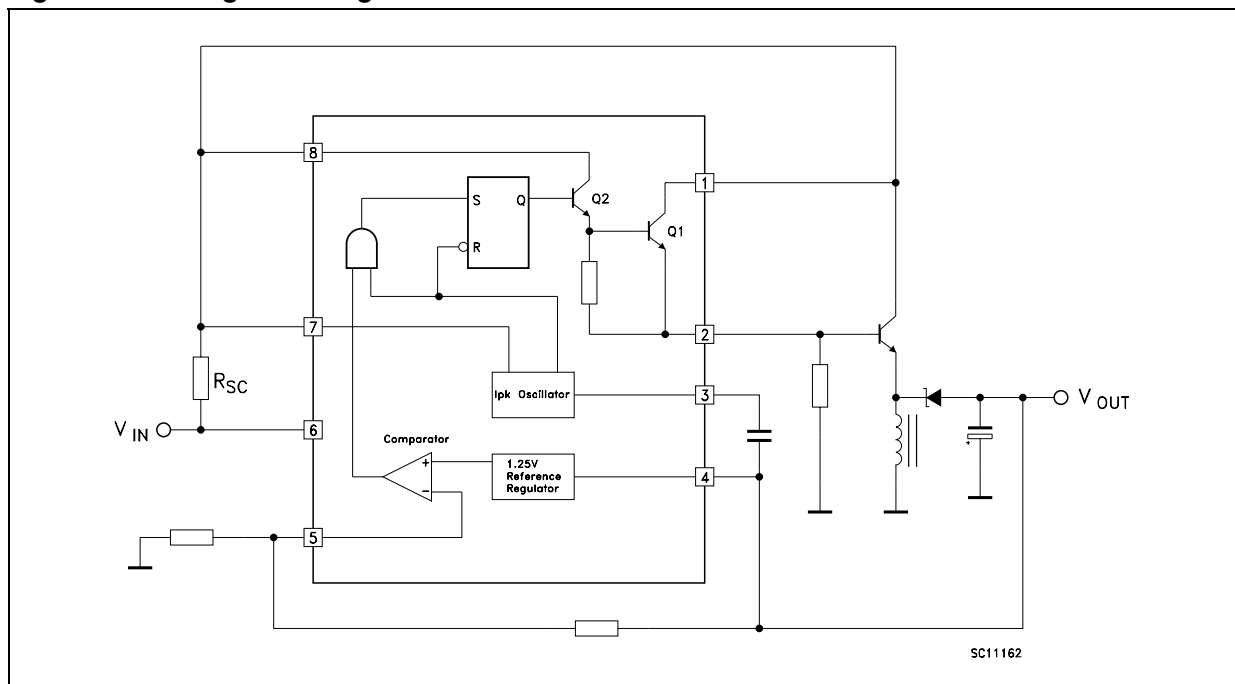


Figure 23. Voltage inverting with external PNP saturated switch

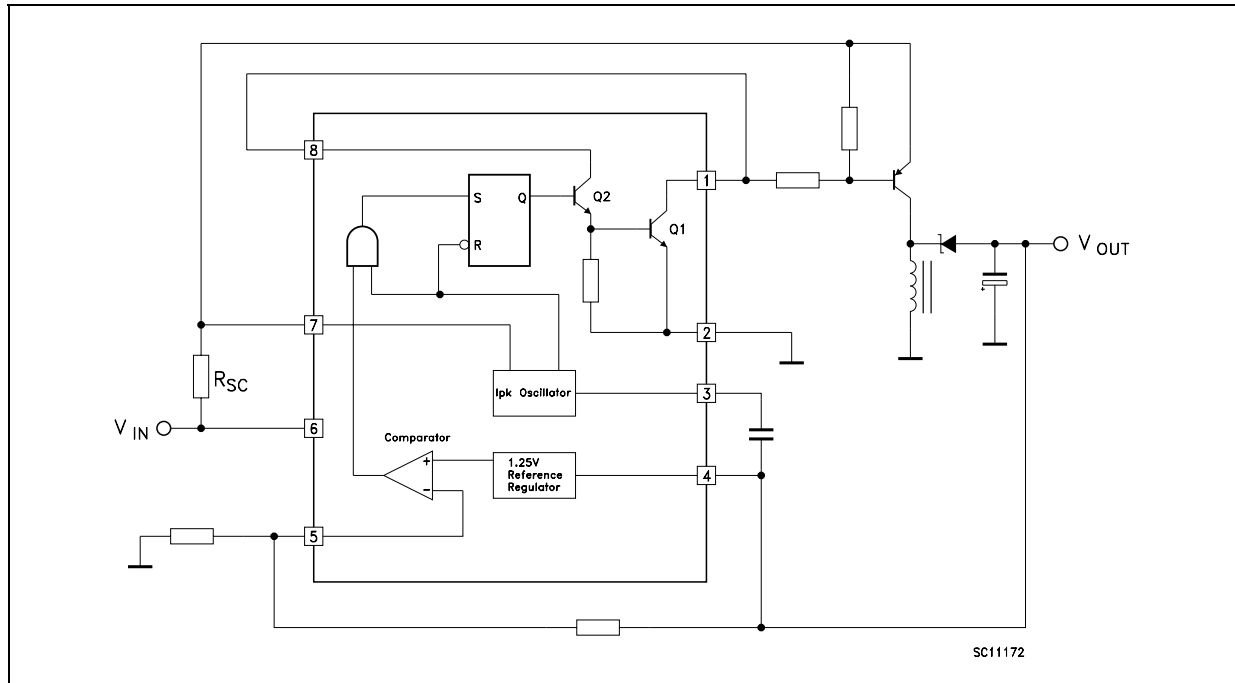


Figure 24. Dual output voltage

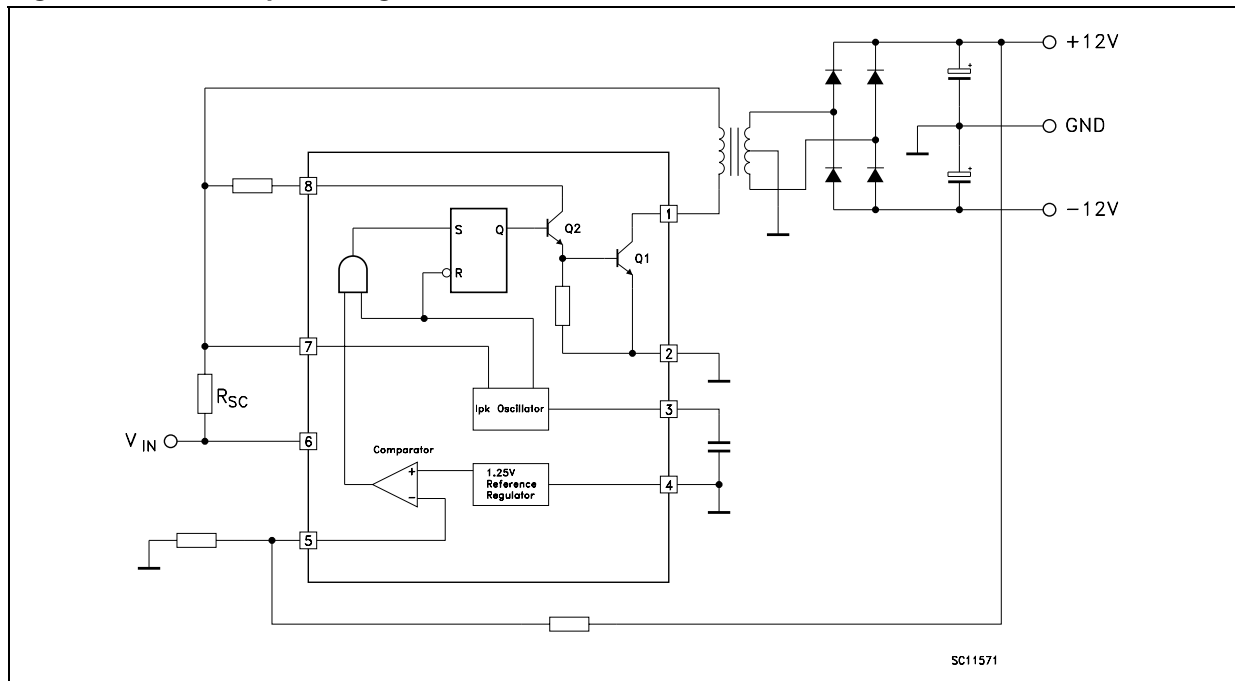
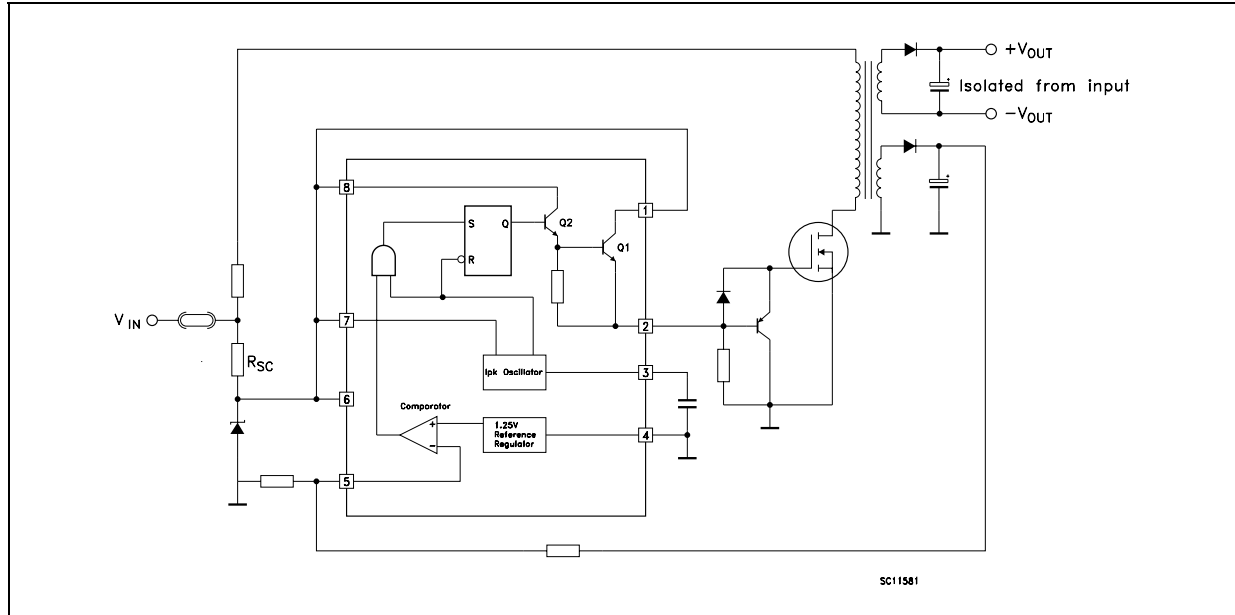


Figure 25. Higher output power, higher input voltage

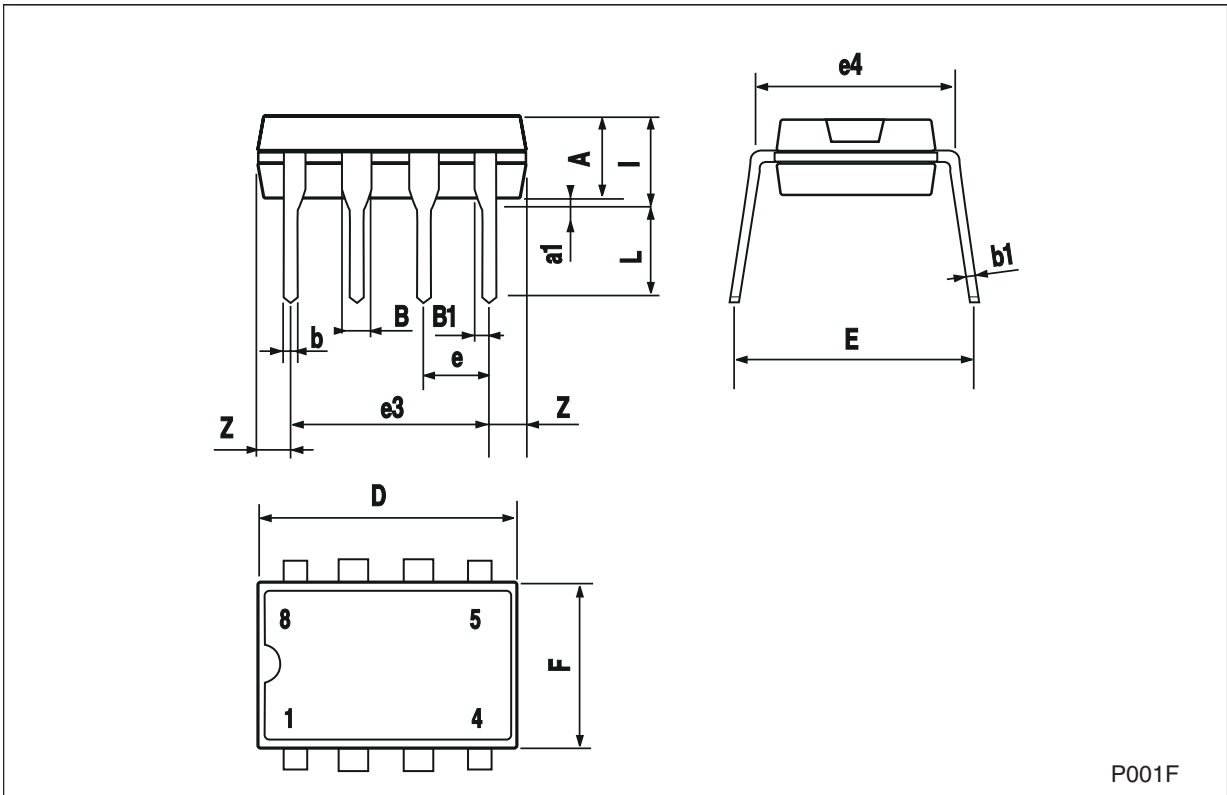


7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com

Plastic DIP-8 mechanical data

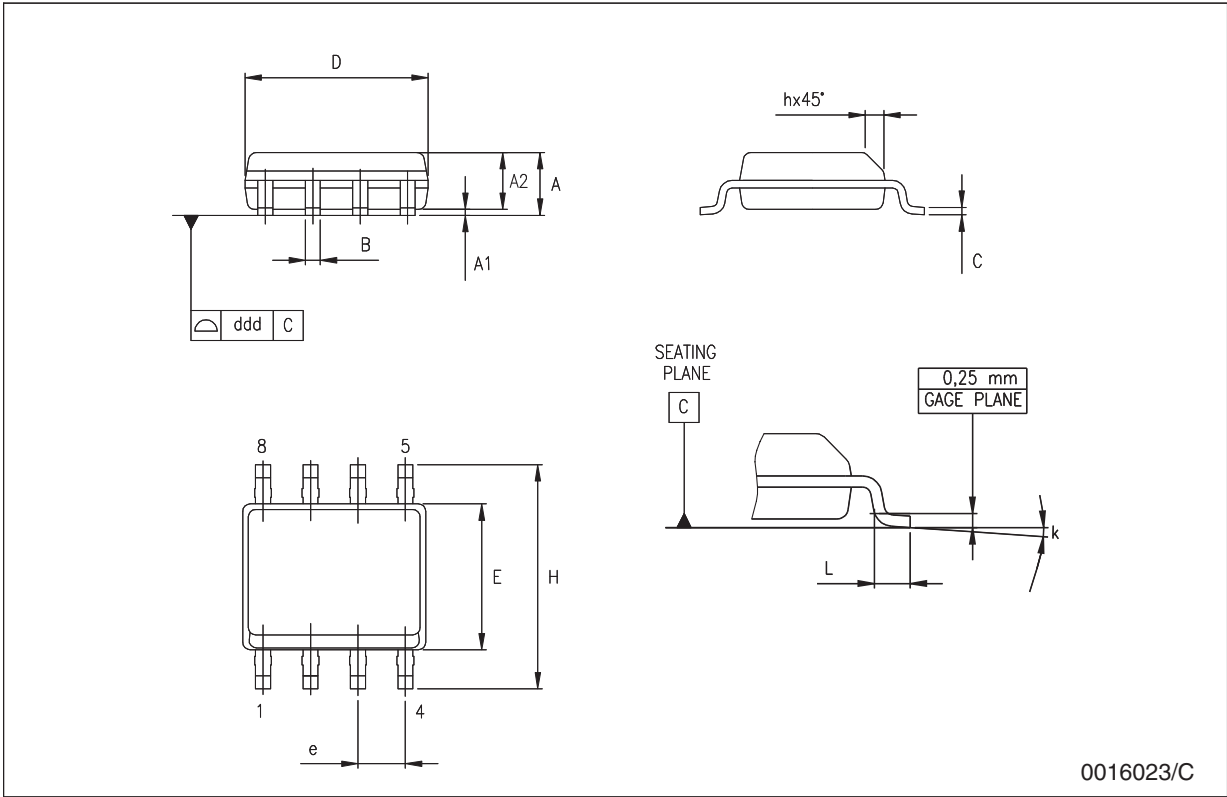
Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.3			0.130	
a1	0.7			0.028		
B	1.39		1.65	0.055		0.065
B1	0.91		1.04	0.036		0.041
b		0.5			0.020	
b1	0.38		0.5	0.015		0.020
D			9.8			0.386
E		8.8			0.346	
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			7.1			0.280
l			4.8			0.189
L		3.3			0.130	
Z	0.44		1.6	0.017		0.063



P001F

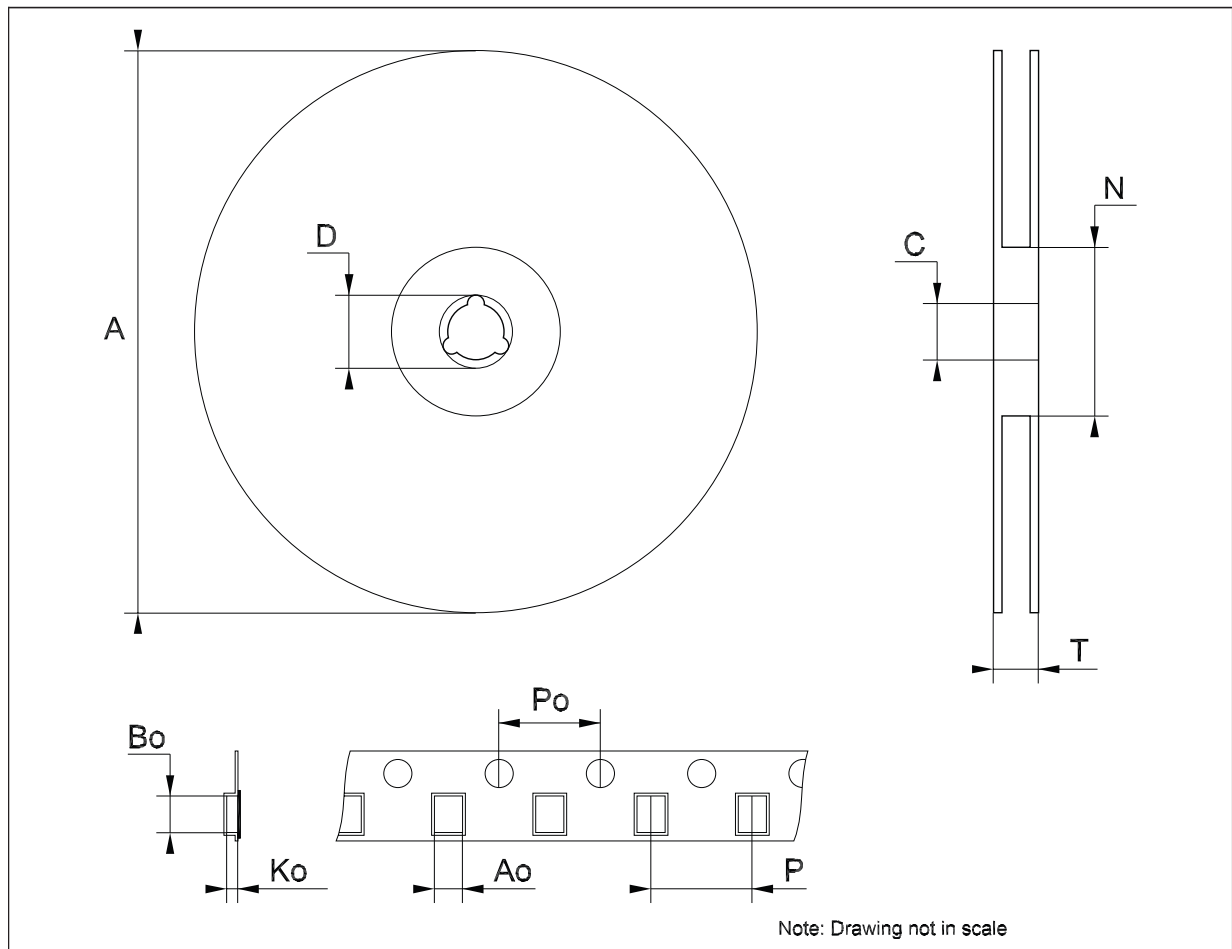
SO-8 mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	8° (max.)					
ddd			0.1			0.04



Tape & reel SO-8 mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			22.4			0.882
Ao	8.1		8.5	0.319		0.335
Bo	5.5		5.9	0.216		0.232
Ko	2.1		2.3	0.082		0.090
Po	3.9		4.1	0.153		0.161
P	7.9		8.1	0.311		0.319



8 Revision history

Table 13. Document revision history

Date	Revision	Changes
22-Jun-2004	9	
20-Nov-2007	10	Added Table 1 .

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