

DC-TO-DC CONVERTER CONTROL CIRCUITS

DESCRIPTION

The MC34063A is a monolithic control circuit containing the primary functions required for DC-to-DC converters. The device consists of an internal temperature compensated reference, comparator, controlled duty cycle oscillator with an active current limit circuit, driver and high current output switch. MC34063A is specifically designed to be incorporated in Step-Down, Step-Up and Voltage-Inverting applications with a minimum number of external components.

FEATURES

- 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

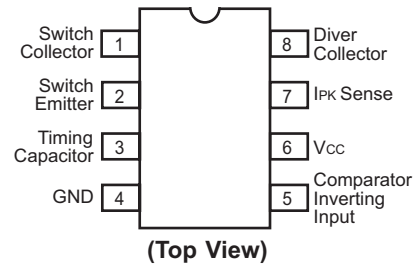
APPLICATION

- DC-DC Converter

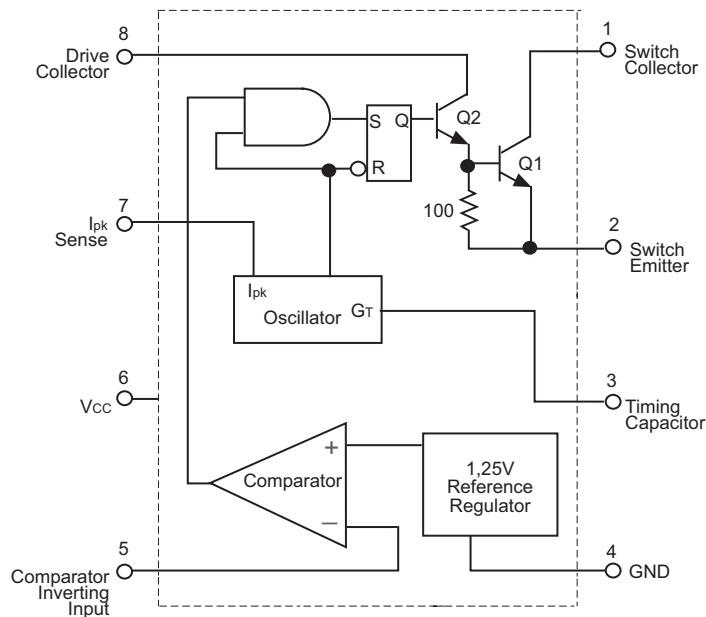
ORDERING INFORMATION

Temperature Range	Package		Orderable Device	Package Qty
0°C to +70°C	SOP8L	Pb-Free	MC34063AD	75Units/Tube
	SOP8L		MC34063ADR	2500Units/Tape
	DIP8L		MC34063AP	50Units/Tube

PIN CONFIGURATION



SCHEMATIC DIAGRAM



(Bottom View)

Figure 1. Representative Schematic Diagram

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	40	V
Comparator Input Voltage Range	V_{IR}	-0.3 to +40	V
Switch Collector Voltage	$V_{C(driver)}$	40	V
Switch Emitter Voltage ($V_{Pin1} = 40\text{ V}$)	$V_{E(switch)}$	40	V
Switch Collector to Emitter Voltage	$V_{CE(switch)}$	40	V
Driver Collector Voltage	$V_{C(driver)}$	40	V
Driver Collector Current (Note 1)	$I_{C(driver)}$	100	mA
Switch Current	I_{SW}	1.5	A
Power Dissipation, $T_A = 25^\circ\text{C}$	D Package	625	mW
	P Package	1.25	W
Thermal Resistance, $T_A = 25^\circ\text{C}$	D Package	160	$^\circ\text{C/W}$
	P Package	100	
Operating Junction Temperature	T_J	+150	$^\circ\text{C}$
Operating Ambient Temperature Range	T_A	0 to +70	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS

(V_{CC} = 5.0V, T_A=0 to +70°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
OSCILLATOR						
Frequency	f _{osc}	V _{Pin5} =0V, C _T =1.0nF, T _A = 25°C	24	33	42	kHz
Charge Current	I _{chg}	V _{CC} = 5.0V to 40V, T _A = 25°C	24	33	42	μA
Discharge Current	I _{dischg}	V _{CC} = 5.0V to 40V, T _A = 25°C	140	200	260	μA
Discharge to Charge Current Ratio	I _{dischg} /I _{chg}	Pin7 to V _{CC} , T _A =25°C	5.2	6.2	7.5	
Current Limit Sense Voltage	V _{lpk(sense)}	I _{chg} = I _{dischg} , T _A = 25°C	250	300	350	mV
OUTPUT SWITCH (Note 3)						
Saturation Voltage, Darlington Connection	V _{CE(sat)}	I _{SW} = 1.0A, Pins 1, 8 connected		1.0	1.3	V
Saturation Voltage	V _{CE(sat)}	I _{SW} = 1.0A, Forced β = 20 R _{Pin 8} = 82Ω to V _{CC}		0.45	0.7	V
DC Current Gain	h _{FE}	I _{SW} = 1.0A, V _{CE} =5.0V, T _A = 25°C	50	120		
Collector Off-State Current	I _{C(off)}	V _{CE} = 40V		0.01	100	μA
COMPARATOR						
Threshold Voltage	V _{th}	T _A = 25°C	1.225	1.25	1.275	V
		T _A = T _{low} to T _{high}	1.21		1.29	
Threshold Voltage Line Regulation	Reg _{line}	V _{CC} = 3.0V to 40V		1.4	5.0	mV
Input Bias Current	I _{IB}	V _{in} = 0V		-40	-400	nA
TOTAL DEVICE						
Supply Current	I _{CC}	V _{CC} = 5.0V to 40V, C _T = 10nF, V _{pin7} = V _{CC} , V _{Pin5} > V _{th} , Pin 2 = GND, Remaining pins open		2.5	4.0	mA

ELECTRICAL CHARACTERISTICS(CONTINUED)

(V_{CC} = 3.3V, T_A=0 to +70°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
OSCILLATOR						
Frequency	f _{osc}	V _{Pin5} =0V, C _T =1.0nF, T _A = 25°C	24	33	42	kHz
Charge Current	I _{chg}	V _{CC} = 5.0V to 40V, T _A = 25°C	24	33	42	μA
Discharge Current	I _{dischg}	V _{CC} = 5.0V to 40V, T _A = 25°C	140	200	260	μA
Discharge to Charge Current Ratio	I _{dischg} /I _{chg}	Pin7 to V _{CC} , T _A =25°C	5.2	6.2	7.5	
Current Limit Sense Voltage	V _{lpk(sense)}	I _{chg} = I _{dischg} , T _A = 25°C	250	300	350	mV
OUTPUT SWITCH (Note 3)						
Saturation Voltage, Darlington Connection	V _{CE(sat)}	I _{SW} = 1.0A, Pins 1, 8 connected		1.0	1.3	V
Saturation Voltage	V _{CE(sat)}	I _{SW} = 1.0A, Forced β = 20 R _{Pin 8} = 82Ω to V _{CC}		0.45	0.7	V
DC Current Gain	h _{FE}	I _{SW} = 1.0A, V _{CE} =5.0V, T _A = 25°C	50	120		
Collector Off-State Current	I _{C(off)}	V _{CE} = 40V		0.01	100	μA
COMPARATOR						
Threshold Voltage	V _{th}	T _A = 25°C	1.225	1.25	1.275	V
		T _A = T _{LOW} to T _{HIGH}	1.21		1.29	
Threshold Voltage Line Regulation	Reg _{line}	V _{CC} = 3.0V to 40V		1.4	5.0	mV
Input Bias Current	I _{IB}	V _{in} = 0V		-40	-400	nA
TOTAL DEVICE						
Supply Current	I _{CC}	V _{CC} = 5.0V to 40V, C _T = 10nF, V _{pin7} = V _{CC} , V _{Pin5} > V _{th} , Pin 2 = GND, Remaining pins open		2.5	4.0	mA

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

NOTE 2: Low duty cycle pulse techniques are used during test to maintain Junction temperature as close to ambient temperature as possible.

NOTE 3: 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 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.



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TYPICAL PERFORMANCE CHARACTERISTICS

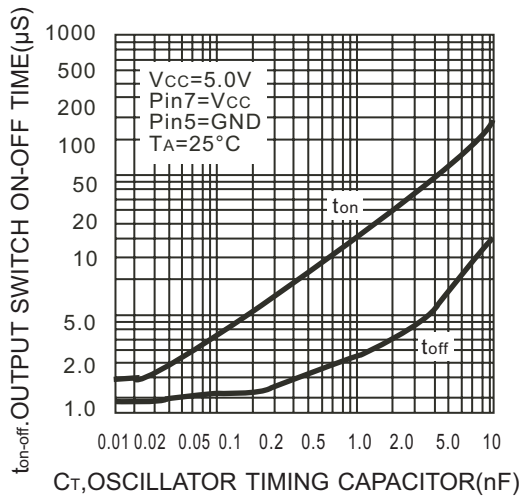


Figure 2. Output Switch On-Off Time vs. Oscillator Timing Capacitor

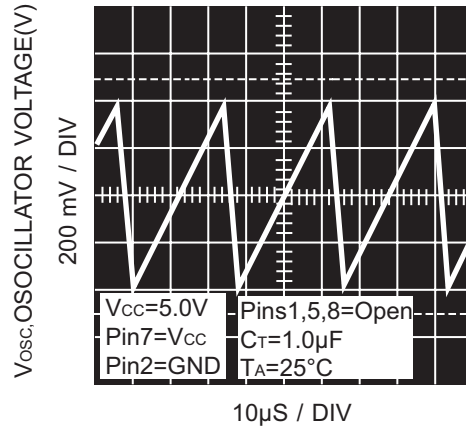


Figure 3. Timing Capacitor Waveform

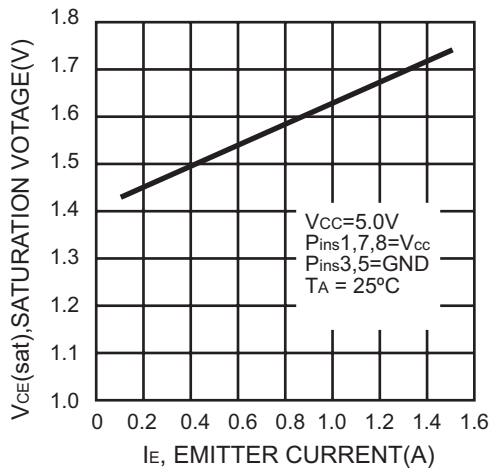


Figure 4. Emitter Follower Configuration Output Saturation Voltage vs. Emitter Current

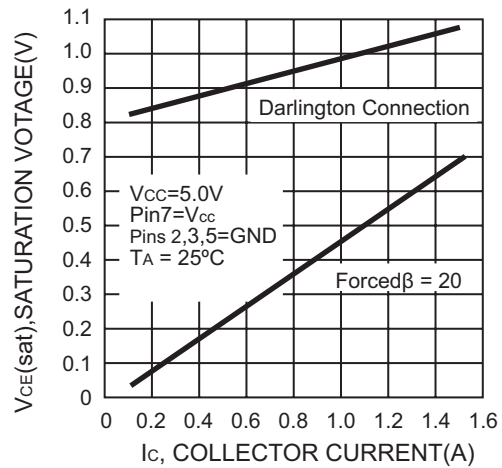


Figure 5. Common Emitter Configuration Output Switch Saturation Voltage vs. Collector Current

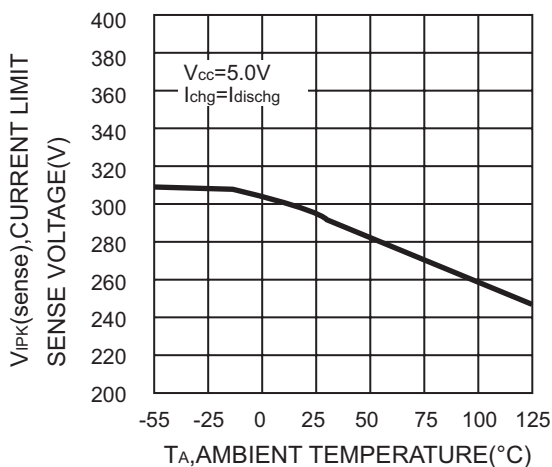


Figure 6. Current Limit Sense Voltage vs. Temperature

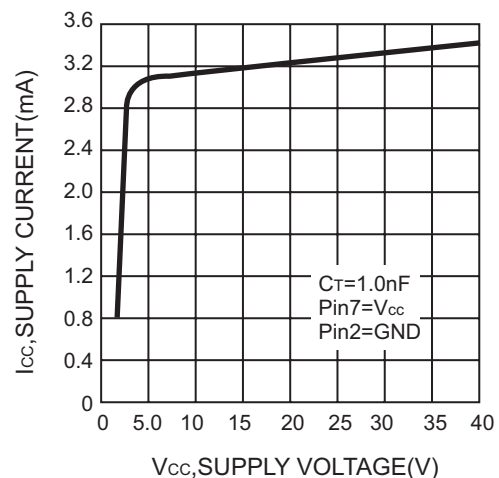


Figure 7. Standby Supply Current vs. Supply Voltage



TYPICAL APPLICATION

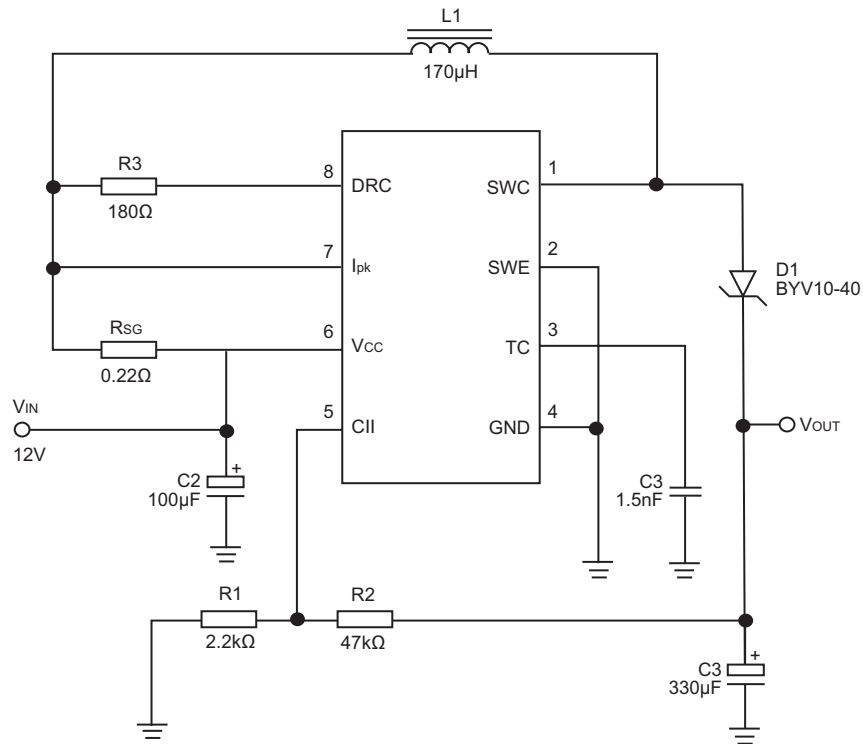


Figure 8. Step-Up Converter

For $V_{OUT}=28V$

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

TYPICAL APPLICATION(CONTINUED)

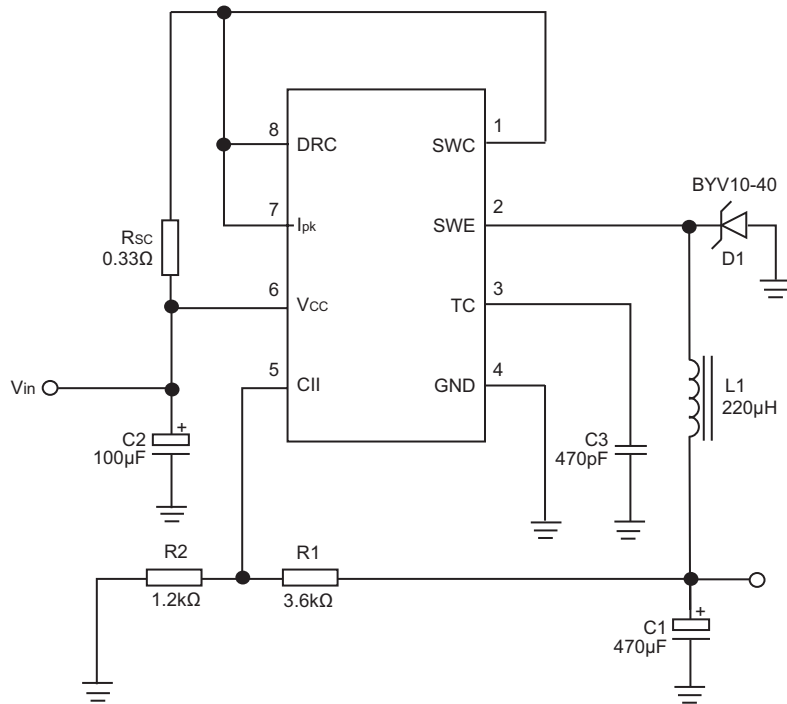


Figure 9. Step-Down Converter

For $V_{OUT} = 5V$

Parameter	Test Conditions	Result(Typ)	Unit
Line Regulation	$V_{IN} = 15$ to 25 V, $I_o = 500$ mA	5	mV
Load Regulation	$V_{IN} = 25$ V, $I_o = 50$ to 500 mA	30	mV
Output Ripple	$V_{IN} = 25$ V, $I_o = 500$ mA	100	mV
Efficiency	$V_{IN} = 25$ V, $I_o = 500$ mA	80	%
I_{sc}	$V_{IN} = 25$ V, $R_{load} = 0.1$ Ω	1.2	A

TYPICAL APPLICATION(CONTINUED)

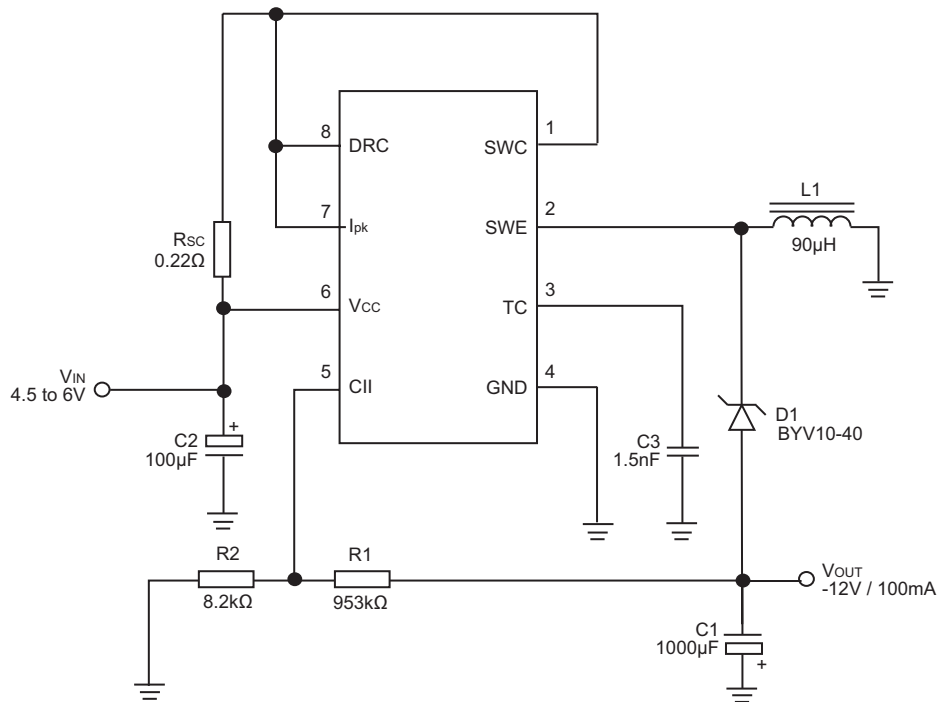


Figure 10. Voltage Inverting Converter

For $V_{OUT} = -12V$

Parameter	Test Conditions	Result(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

TYPICAL APPLICATION(CONTINUED)

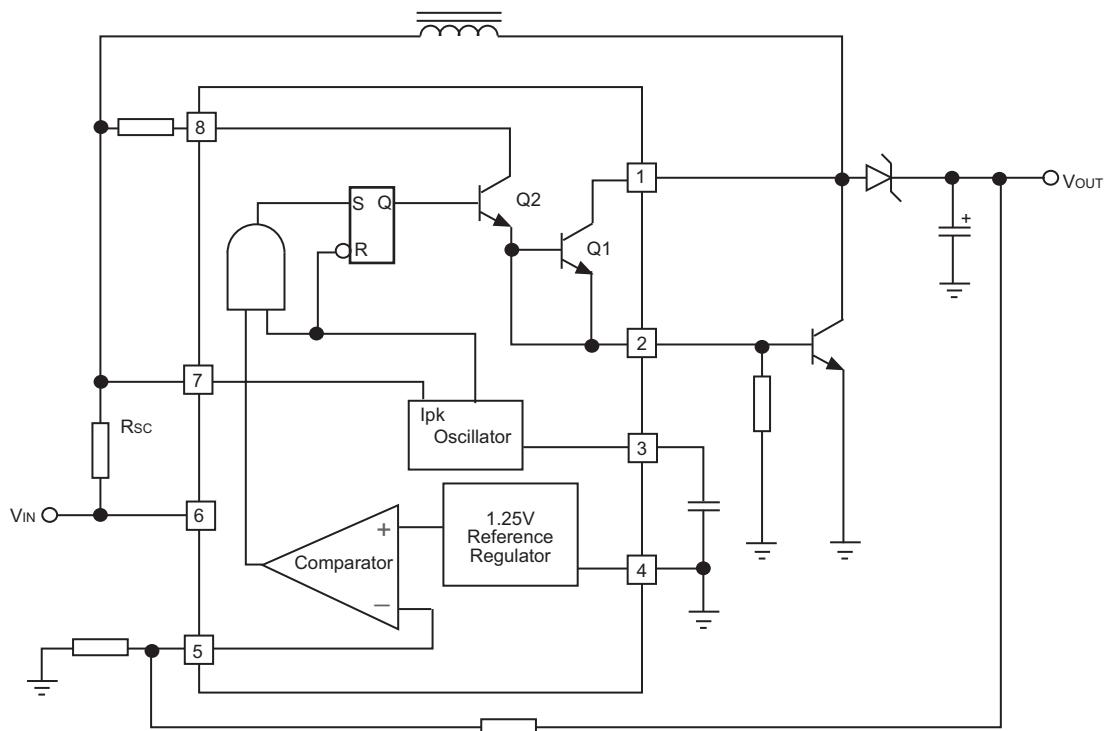


Figure 11. Step-up with External NPN Switch

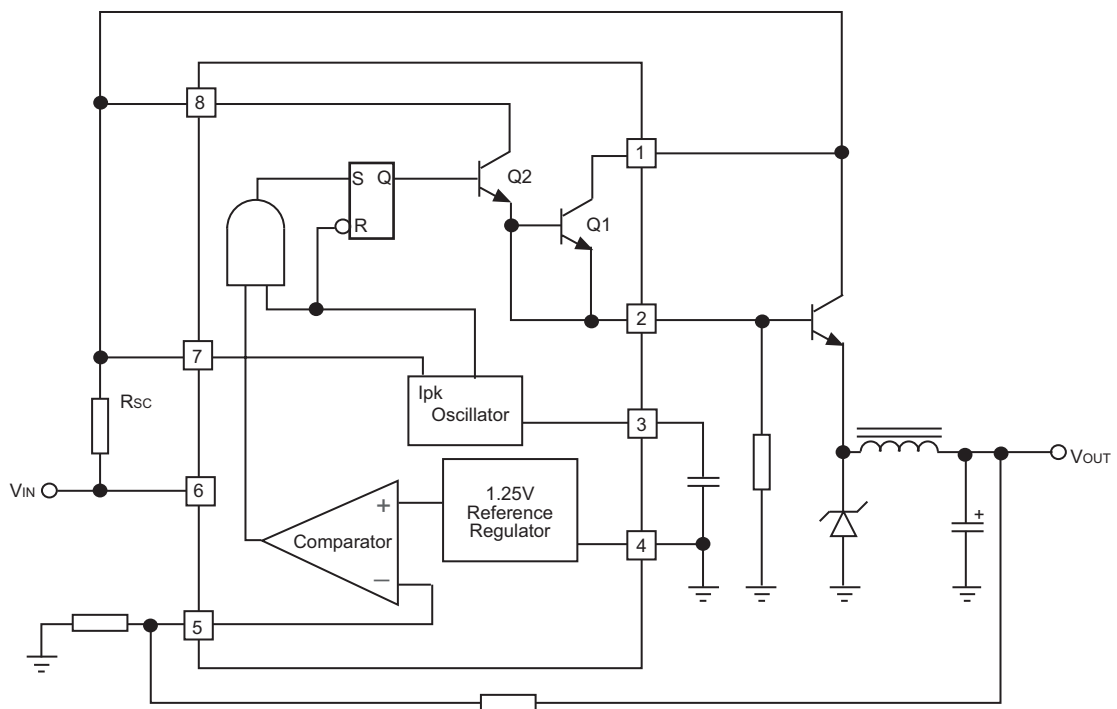


Figure 12. Step-down with External NPN Switch

TYPICAL APPLICATION(CONTINUED)

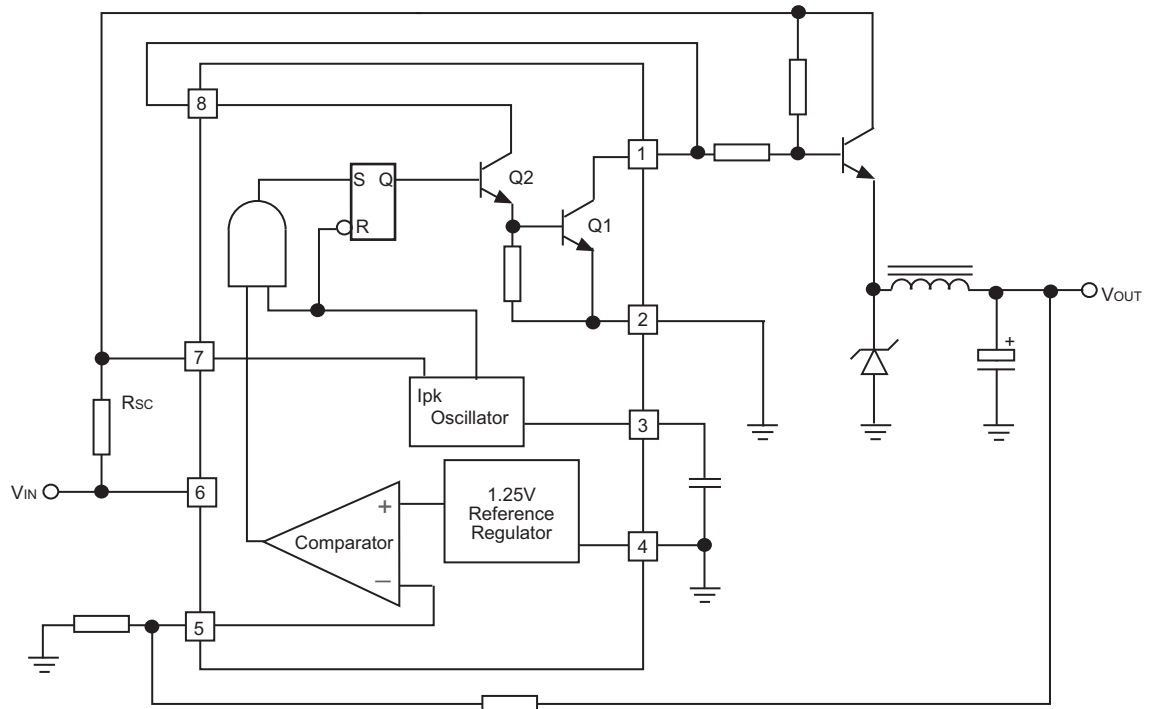


Figure 13. Step-down with External PNP Switch

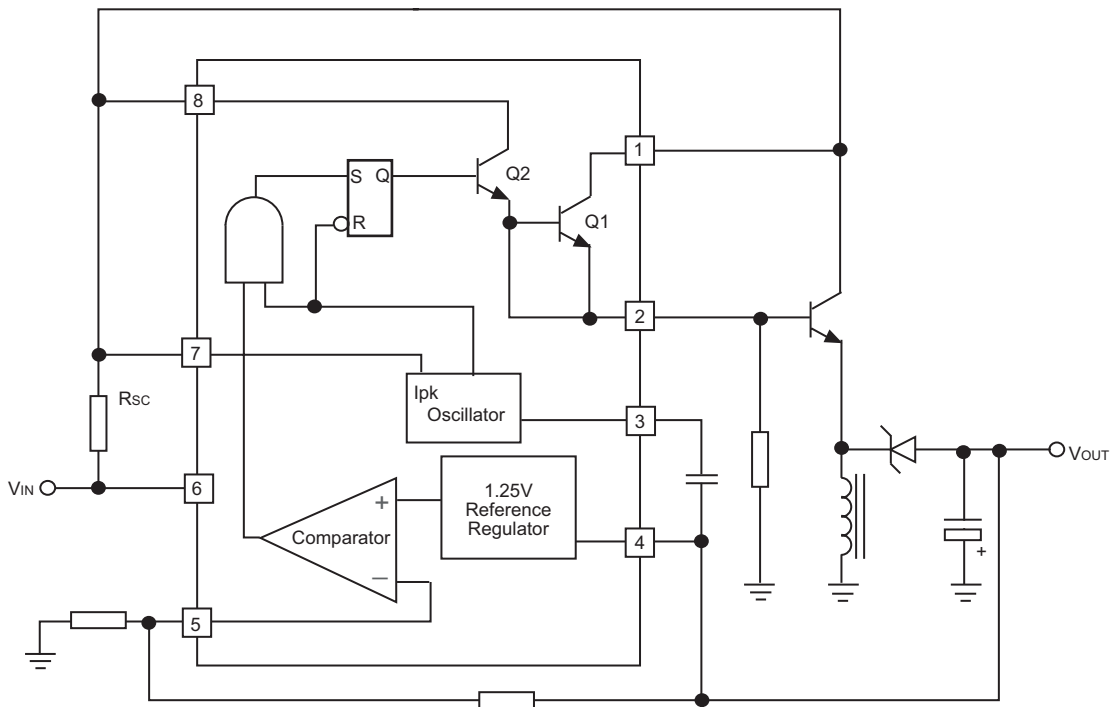


Figure 14. Voltage Inverting with External NPN Switch

TYPICAL APPLICATION(CONTINUED)

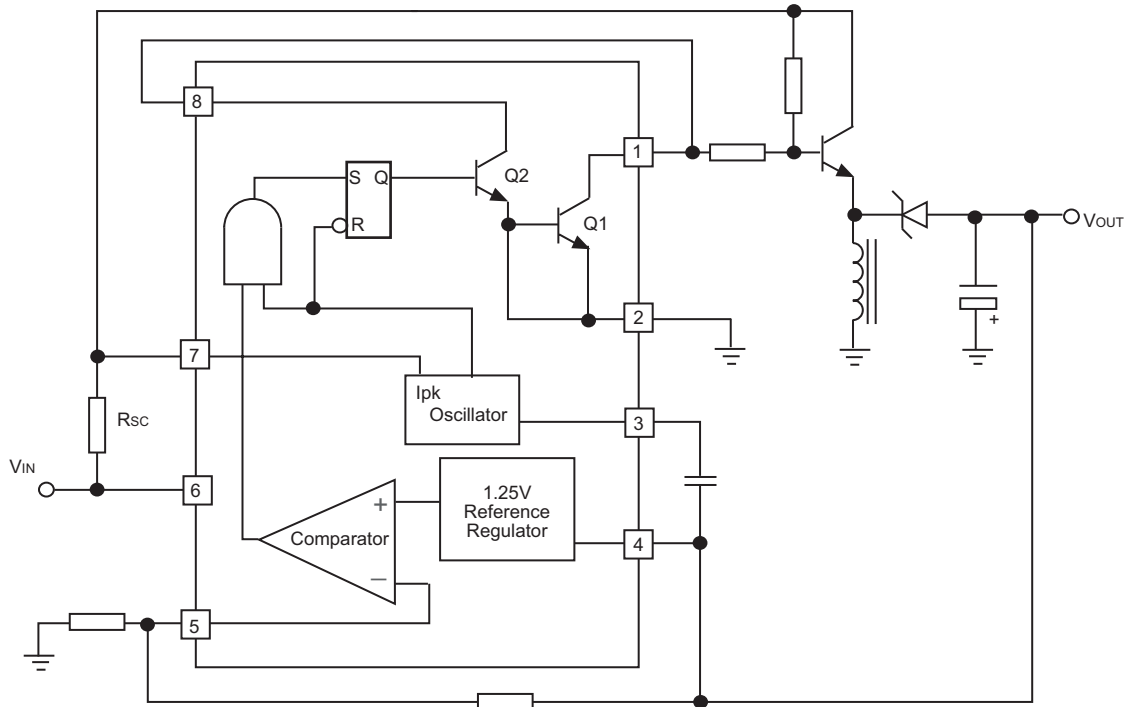


Figure 15. Voltage Inverting with External PNP Saturated Switch

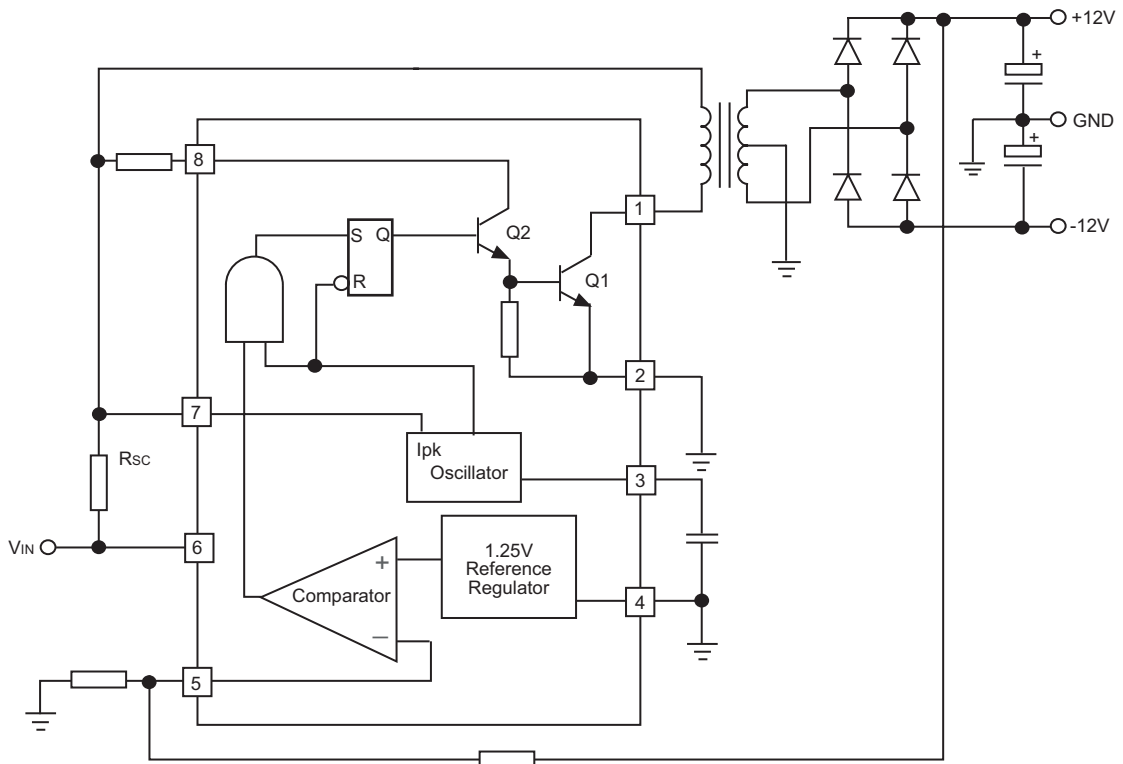


Figure 16. Dual Output Voltage

TYPICAL APPLICATION(CONTINUED)

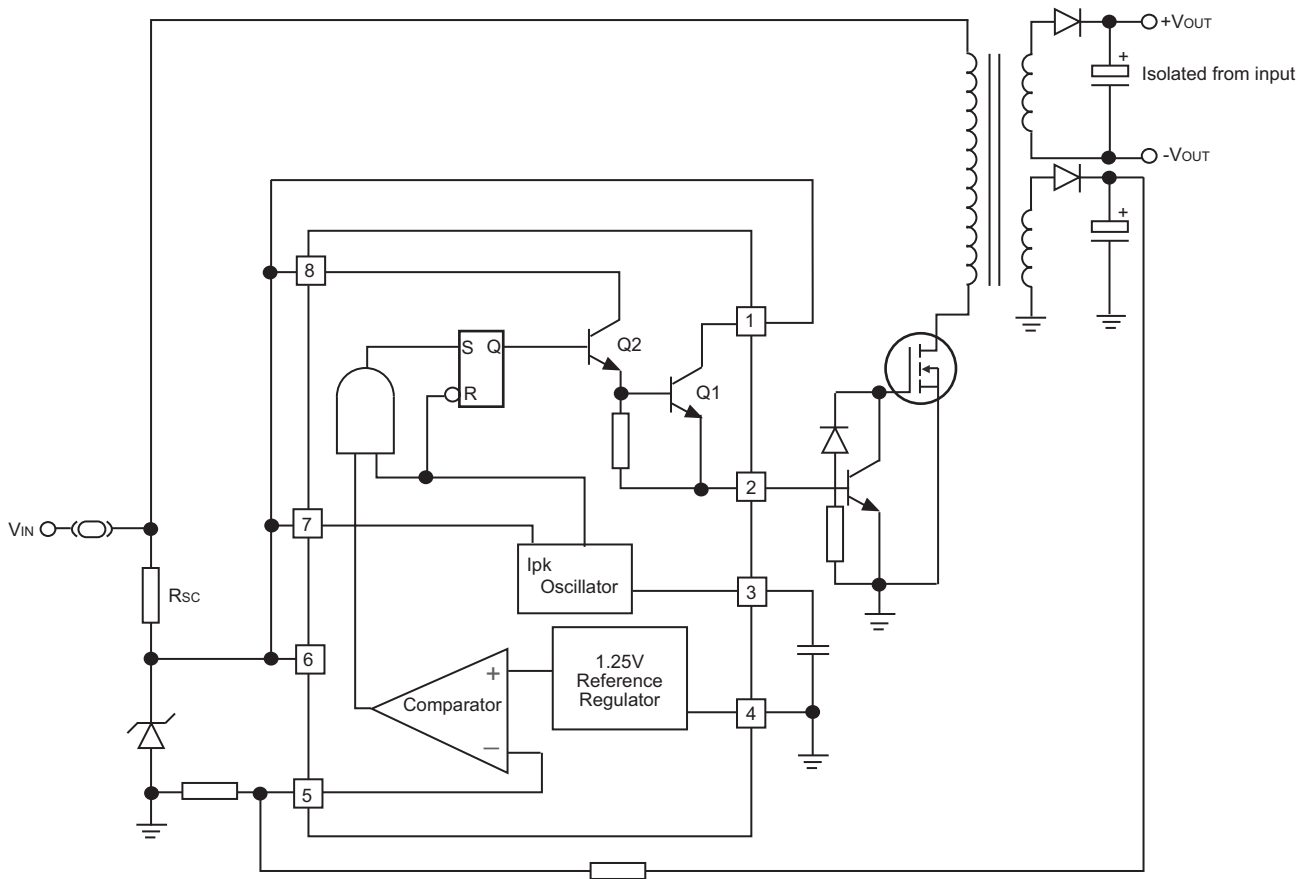


Figure 17. Higher Output Power, Higher Input Voltage

CALCULATION

Table 1 Design Formula Table

Calculation	Step-Up	Step-Down	Voltage-Inverting
t_{on}/t_{off}	$\frac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$	$\frac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$	$\frac{ V_{out} + V_F}{V_{in} - V_{sat}}$
$(t_{on}+t_{off})_{max}$	$\frac{1}{f}$	$\frac{1}{f}$	$\frac{1}{f}$
t_{off}	$\frac{t_{on} + t_{off}}{t_{on}/t_{off} + 1}$	$\frac{t_{on} + t_{off}}{t_{on}/t_{off} + 1}$	$\frac{t_{on} + t_{off}}{t_{on}/t_{off} + 1}$
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}	$\frac{0.3}{I_{PK(switch)}}$	$\frac{0.3}{I_{PK(switch)}}$	$\frac{0.3}{I_{PK(switch)}}$
$L_{(min)}$	$\frac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}} t_{on(max)}$	$\frac{(V_{in(min)} - V_{sat} - V_{out})}{I_{pk(switch)}} t_{on(max)}$	$\frac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}} t_{on(max)}$
C_o	$\approx \frac{I_{out} t_{on}}{V_{ripple(p-p)}}$	$\frac{I_{pk(switch)}(t_{on} + t_{off})}{8V_{ripple(p-p)}}$	$\approx \frac{I_{out} t_{on}}{V_{ripple(p-p)}}$

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.

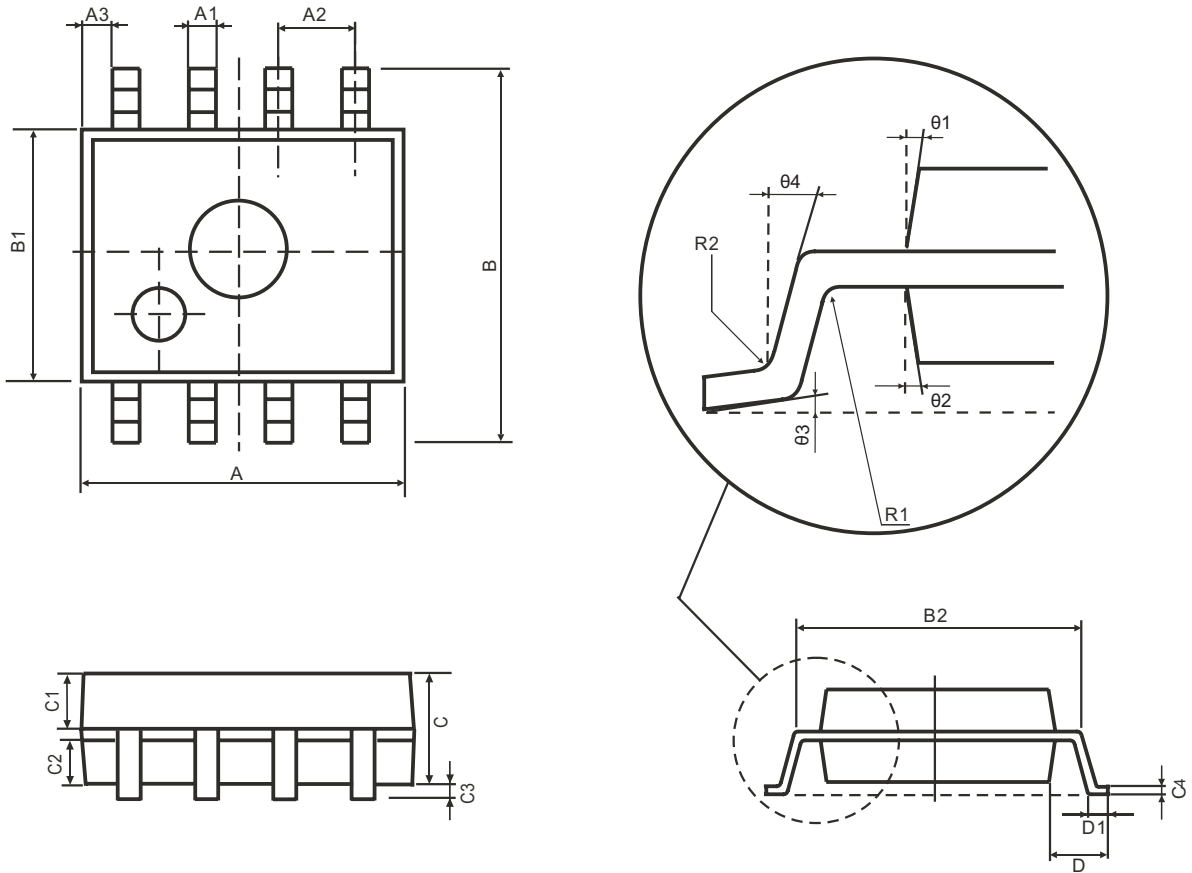
f_{min} =Minimum desired output switching frequency at the selected values of V_{in} and I_o

$V_{ripple(pp)}$ =Desired peak-to-peak output ripple voltage. In practice, the calculated capacitor value will need to be increased due to its equivalent series resistance and board layout.

The ripple should be kept to a low value since it will directly affect the line and load regulation.

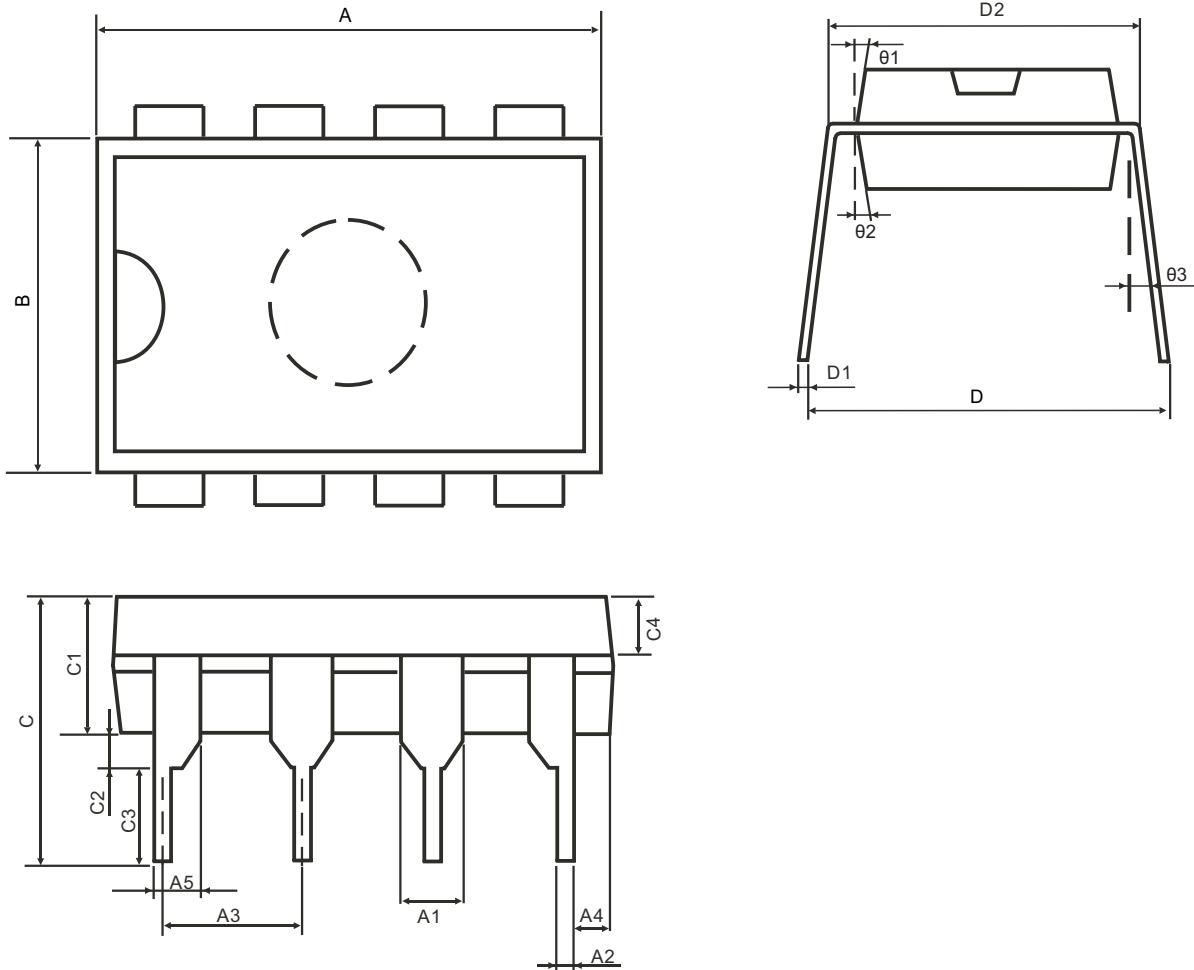


PHYSICAL DIMENSIONS SOP8L



Symbol	Dimension(mm)		Symbol	Dimension(mm)	
	Min	Max		Min	Max
A	4.95	5.15	C3	0.05	0.20
A1	0.37	0.47	C4	0.20(TYP)	
A2	1.27(TYP)		D	1.05(TYP)	
A3	0.41(TYP)		D1	0.40	0.60
B	5.80	6.20	R1	0.07(TYP)	
B1	3.80	4.00	R2	0.07(TYP)	
B2	5.0(TYP)		θ1	17°(TYP)	
C	1.30	1.50	θ2	13°(TYP)	
C1	0.55	0.65	θ3	4°(TYP)	
C2	0.55	0.65	θ4	12°(TYP)	

DIP8L



Symbol	Dimension(mm)		Symbol	Dimension(mm)	
	Min	Max		Min	Max
A	9.30	9.50	C2	0.5(TYP)	
A1	1.524(TYP)		C3	3.3(TYP)	
A2	0.39	0.53	C4	1.57(TYP)	
A3	2.54(TYP)		D	8.20	8.80
A4	0.66(TYP)		D1	0.20	0.35
A5	0.99(TYP)		D2	7.62	7.87
B	6.3	6.5	θ1	8°(TYP)	
C	7.20(TYP)		θ2	8°(TYP)	
C1	3.30	3.50	θ3	5°(TYP)	