



L296 L296P

HIGH CURRENT SWITCHING REGULATORS

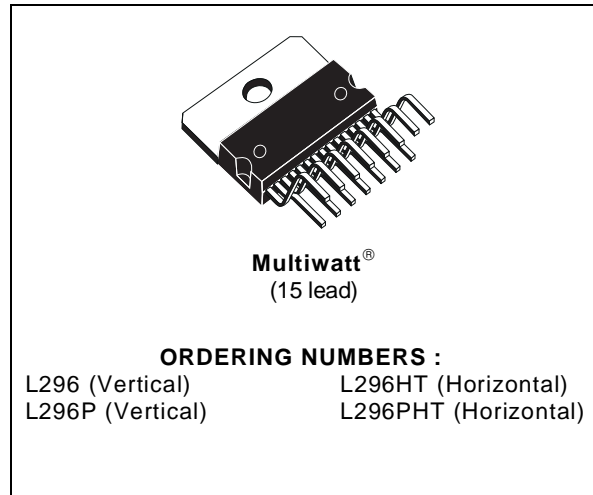
- 4 A OUTPUT CURRENT
- 5.1 V TO 40 V OUTPUT VOLTAGE RANGE
- 0 TO 100 % DUTY CYCLE RANGE
- PRECISE ($\pm 2\%$) ON-CHIP REFERENCE
- SWITCHING FREQUENCY UP TO 200 KHZ
- VERY HIGH EFFICIENCY (UP TO 90 %)
- VERY FEW EXTERNAL COMPONENTS
- SOFT START
- RESET OUTPUT
- EXTERNAL PROGRAMMABLE LIMITING CURRENT (L296P)
- CONTROL CIRCUIT FOR CROWBAR SCR
- INPUT FOR REMOTE INHIBIT AND SYNCHRONOUS PWM
- THERMAL SHUTDOWN

DESCRIPTION

The L296 and L296P are stepdown power switching regulators delivering 4 A at a voltage variable from 5.1 V to 40 V.

Features of the devices include soft start, remote inhibit, thermal protection, a reset output for microprocessors and a PWM comparator input for synchronization in multichip configurations.

The L296P includes external programmable limiting current.



The L296 and L296P are mounted in a 15-lead Multiwatt® plastic power package and requires very few external components.

Efficient operation at switching frequencies up to 200 KHz allows a reduction in the size and cost of external filter components. A voltage sense input and SCR drive output are provided for optional crowbar overvoltage protection with an external SCR.

PIN CONNECTION (top view)

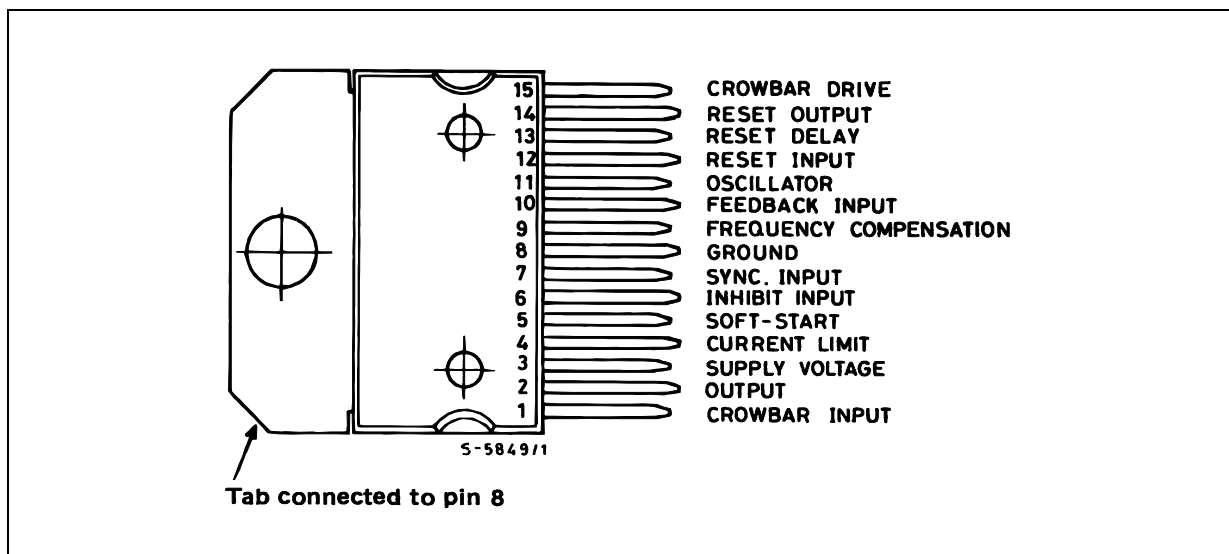


Figure 2 : Soft Start Waveforms

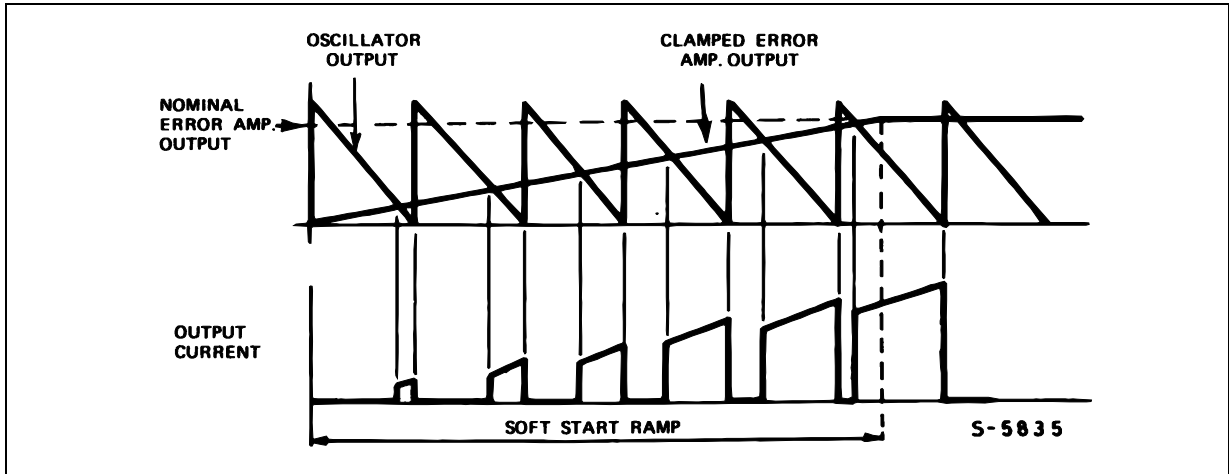
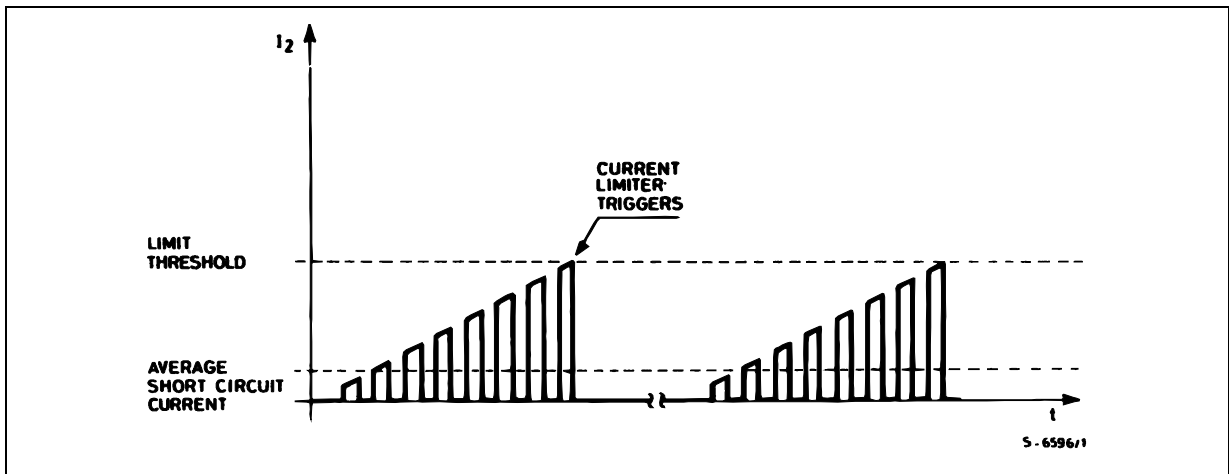


Figure 3 : Current Limiter Waveforms



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	Input Voltage (pin 3)	50	V
$V_i - V_2$	Input to Output Voltage Difference	50	V
V_2	Output DC Voltage Output Peak Voltage at $t = 0.1 \mu\text{sec}$ $f = 200\text{KHz}$	- 1 - 7	V V
V_1, V_{12}	Voltage at Pins 1, 12	10	V
V_{15}	Voltage at Pin 15	15	V
$V_4, V_5, V_7, V_9, V_{13}$	Voltage at Pins 4, 5, 7, 9 and 13	5.5	V
V_{10}, V_6	Voltage at Pins 10 and 6	7	V
V_{14}	Voltage at Pin 14 ($I_{14} \leq 1 \text{ mA}$)	V_i	
I_9	Pin 9 Sink Current	1	mA
I_{11}	Pin 11 Source Current	20	mA
I_{14}	Pin 14 Sink Current ($V_{14} < 5 \text{ V}$)	50	mA
P_{tot}	Power Dissipation at $T_{\text{case}} \leq 90 \text{ }^\circ\text{C}$	20	W
T_j, T_{stg}	Junction and Storage Temperature	- 40 to 150	$^\circ\text{C}$

THERMAL DATA

Symbol	Parameter	Value	Unit
$R_{th\ j-case}$	Thermal Resistance Junction-case	Max. 3	°C/W
$R_{th\ j-amb}$	Thermal Resistance Junction-ambient	Max. 35	°C/W

ELECTRICAL CHARACTERISTICS

(refer to the test circuits $T_j = 25^\circ\text{C}$, $V_i = 35\text{V}$, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit	Fig.
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DYNAMIC CHARACTERISTICS (pin 6 to GND unless otherwise specified)

V_o	Output Voltage Range	$V_i = 46\text{V}$, $I_o = 1\text{A}$	V_{ref}		40	V	4
V_i	Input Voltage Range	$V_o = V_{ref}$ to 36V, $I_o \leq 3\text{A}$	9		46	V	4
V_i	Input Voltage Range	Note (1), $V_o = V_{REF}$ to 36V $I_o = 4\text{A}$			46	V	4
ΔV_o	Line Regulation	$V_i = 10\text{V}$ to 40V, $V_o = V_{ref}$, $I_o = 2\text{A}$		15	50	mV	4
ΔV_o	Load Regulation	$V_o = V_{ref}$ $I_o = 2\text{A}$ to 4A $I_o = 0.5\text{A}$ to 4A		10 15	30 45	mV	4
V_{ref}	Internal Reference Voltage (pin 10)	$V_i = 9\text{V}$ to 46V, $I_o = 2\text{A}$	5	5.1	5.2	V	4
$\frac{\Delta V_{ref}}{\Delta T}$	Average Temperature Coefficient of Reference Voltage	$T_j = 0^\circ\text{C}$ to 125°C , $I_o = 2\text{A}$		0.4		mV/°C	
V_d	Dropout Voltage Between Pin 2 and Pin 3	$I_o = 4\text{A}$ $I_o = 2\text{A}$		2 1.3	3.2 2.1	V V	4 4
I_{2L}	Current Limiting Threshold (pin 2)	L296 - Pin 4 Open, $V_i = 9\text{V}$ to 40V, $V_o = V_{ref}$ to 36V	4.5		7.5	A	4
		L296P - $V_i = 9\text{V}$ to 40V, $V_o = V_{ref}$ Pin 4 Open $R_{lim} = 22\text{k}\Omega$	5 2.5		7 4.5	A	4
I_{SH}	Input Average Current	$V_i = 46\text{V}$, Output Short-circuited		60	100	mA	4
η	Efficiency	$I_o = 3\text{A}$ $V_o = V_{ref}$ $V_o = 12\text{V}$		75 85		%	4
SVR	Supply Voltage Ripple Rejection	$\Delta V_i = 2 V_{rms}$, $f_{ripple} = 100\text{Hz}$ $V_o = V_{ref}$, $I_o = 2\text{A}$	50	56		dB	4
f	Switching Frequency		85	100	115	kHz	4
$\frac{\Delta f}{\Delta V_i}$	Voltage Stability of Switching Frequency	$V_i = 9\text{V}$ to 46V		0.5		%	4
$\frac{\Delta f}{\Delta T_j}$	Temperature Stability of Switching Frequency	$T_j = 0^\circ\text{C}$ to 125°C		1		%	4
f_{max}	Maximum Operating Switching Frequency	$V_o = V_{ref}$, $I_o = 1\text{A}$	200			kHz	–
T_{sd}	Thermal Shutdown Junction Temperature	Note (2)	135	145		°C	–

DC CHARACTERISTICS

I_{3Q}	Quiescent Drain Current	$V_i = 46\text{V}$, $V_7 = 0\text{V}$, S1 : B, S2 : B $V_6 = 0\text{V}$ $V_6 = 3\text{V}$			66 30	85 40	mA
$-I_{2L}$	Output Leakage Current	$V_i = 46\text{V}$, $V_6 = 3\text{V}$, S1 : B, S2 : A, $V_7 = 0\text{V}$				2	mA

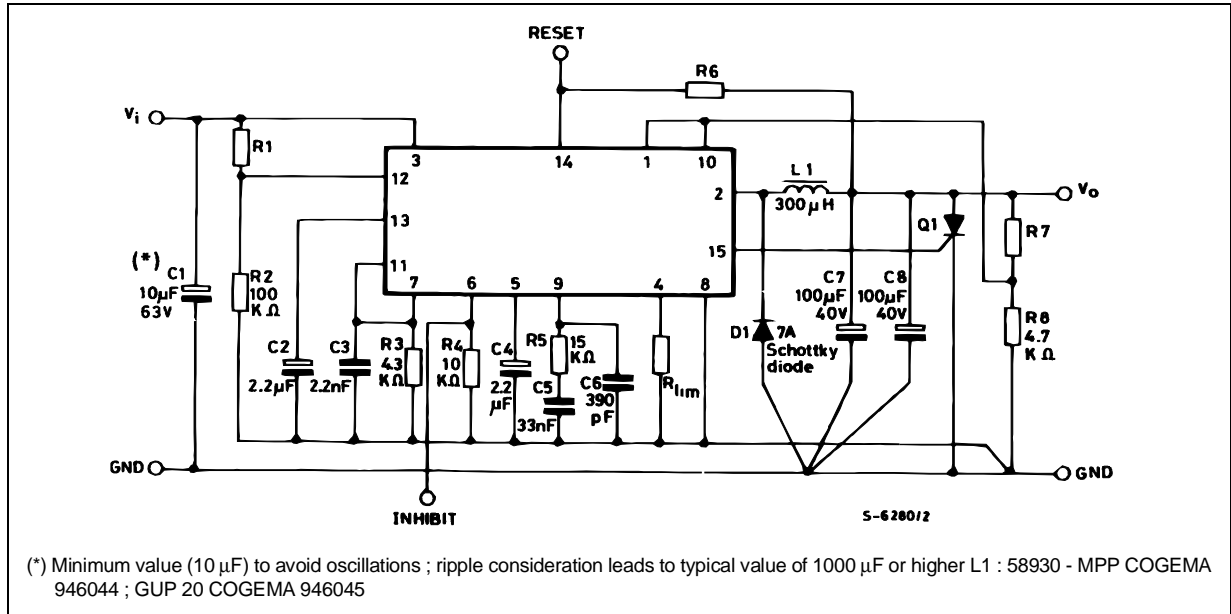
Note (1) : Using min. 7 A schottky diode.
(2) : Guaranteed by design, not 100 % tested in production.

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit	Fig.
SOFT START							
$I_{5\ so}$	Source Current	$V_6 = 0V, V_5 = 3V$	80	130	150	μA	6b
$I_{5\ si}$	Sink Current	$V_6 = 3V, V_5 = 3V$	50	70	120	μA	6b
INHIBIT							
V_{6L} V_{6H}	Input Voltage Low Level High Level	$V_i = 9V \text{ to } 46V, V_7 = 0V,$ $S1 : B, S2 : B$	-0.3 2		0.8 5.5	V	6a
- I_{6L} - I_{6H}	Input Current with Input Voltage Low Level High Level	$V_i = 9V \text{ to } 46V, V_7 = 0V,$ $S1 : B, S2 : B$ $V_6 = 0.8V$ $V_6 = 2V$			10 3	μA	6a
ERROR AMPLIFIER							
V_{9H}	High Level Output Voltage	$V_{10} = 4.7V, I_9 = 100\mu A,$ $S1 : A, S2 : A$	3.5			V	6c
V_{9L}	Low Level Output Voltage	$V_{10} = 5.3V, I_9 = 100\mu A,$ $S1 : A, S2 : E$			0.5	V	6c
$I_{9\ si}$	Sink Output Current	$V_{10} = 5.3V, S1 : A, S2 : B$	100	150		μA	6c
- $I_{9\ so}$	Source Output Current	$V_{10} = 4.7V, S1 : A, S2 : D$	100	150		μA	6c
I_{10}	Input Bias Current	$V_{10} = 5.2V, S1 : B$ $V_{10} = 6.4V, S1 : B, L296P$		2 2	10 10	μA μA	6c 6c
G_v	DC Open Loop Gain	$V_9 = 1V \text{ to } 3V, S1 : A, S2 : C$	46	55		dB	6c
OSCILLATOR AND PWM COMPARATOR							
- I_7	Input Bias Current of PWM Comparator	$V_7 = 0.5V \text{ to } 3.5V$			5	μA	6a
- I_{11}	Oscillator Source Current	$V_{11} = 2V, S1 : A, S2 : B$	5			mA	
RESET							
$V_{12\ R}$	Rising Threshold Voltage	$V_i = 9V \text{ to } 46V,$ $S1 : B, S2 : B$	V_{ref} -150mV	V_{ref} -100mV	V_{ref} -50mV	V	6d
$V_{12\ F}$	Falling Threshold Voltage		4.75	V_{ref} -150mV	V_{ref} -100mV	V	6d
$V_{13\ D}$	Delay Thershold Voltage		4.3	4.5	4.7	V	6d
$V_{13\ H}$	Delay Threshold Voltage Hysteresis	$V_{12} = 5.3V, S1 : A, S2 : B$		100		mV	6d
$V_{14\ S}$	Output Saturation Voltage	$I_{14} = 16mA, V_{12} = 4.7V, S1, S2 : B$			0.4	V	6d
I_{12}	Input Bias Current	$V_{12} = 0V \text{ to } V_{ref}, S1 : B, S2 : B$		1	3	μA	6d
- $I_{13\ so}$ $I_{13\ si}$	Delay Source Current Delay Sink Current	$V_{13} = 3V, S1 : A, S2 : B$ $V_{12} = 5.3V$ $V_{12} = 4.7V$	70 10	110	140	μA mA	6d
I_{14}	Output Leakage Current	$V_i = 46V, V_{12} = 5.3V, S1 : B, S2 : A$			100	μA	6d
CROWBAR							
V_1	Input Threshold Voltage	$S1 : B$	5.5	6	6.4	V	6b
V_{15}	Output Saturation Voltage	$V_i = 9V \text{ to } 46V, V_i = 5.4V,$ $I_{15} = 5mA, S1 : A$		0.2	0.4	V	6b
I_1	Input Bias Current	$V_1 = 6V, S1 : B$			10	μA	6b
- I_{15}	Output Source Current	$V_i = 9V \text{ to } 46V, V_1 = 6.5V,$ $V_{15} = 2V, S1 : B$	70	100		mA	6b

APPLICATION INFORMATION

Figure 34 : Typical Application Circuit.

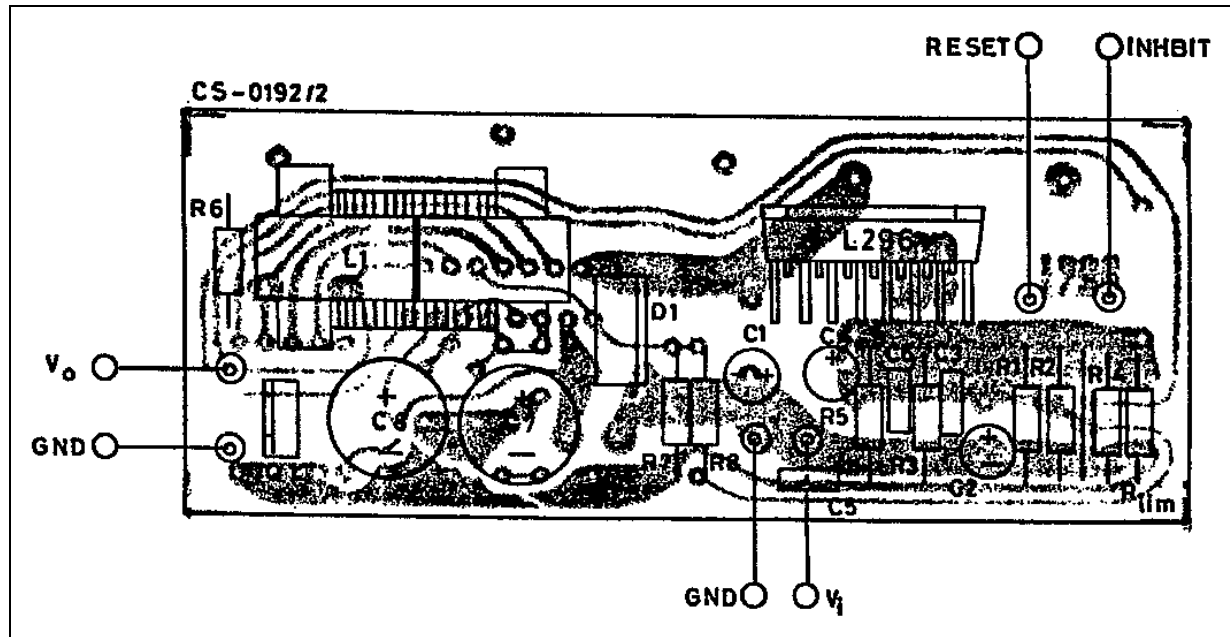


SUGGESTED INDUCTOR (L1)

Core Type	No Turns	Wire Gauge	Air Gap
Magnetics 58930 – A2MPP	43	1.0 mm	–
Thomson GUP 20 x 16 x 7	65	0.8 mm	1 mm
Siemens EC 35/17/10 (B6633& – G0500 – X127)	40	2 x 0.8 mm	–
VOGT 250 μH Toroidal Coil, Part Number 5730501800			

Resistor Values for Standard Output Voltages		
Vo	R8	R7
12 V	4.7 KΩ	6.2 KΩ
15 V	4.7 KΩ	9.1 KΩ
18 V	4.7 KΩ	12 KΩ
24 V	4.7 KΩ	18 KΩ

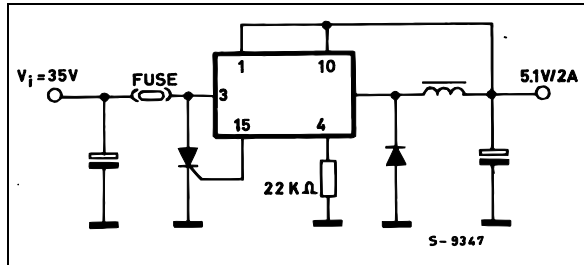
Figure 35 : P.C. Board and Component Layout of the Circuit of fig. 34 (1:1 scale)



SELECTION OF COMPONENT VALUES (see fig. 34)

Component	Recommended Value	Purpose	Allowed Range		Notes
			Min.	Max.	
R1 R2	– 100 k Ω	Set Input Voltage Threshold for Reset.	–	220k Ω	$R1/R2 = \frac{V_{i\min}}{5} - 1$ If output voltage is sensed R1 and R2 may be limited and pin 12 connected to pin 10.
R3	4.3 k Ω	Sets Switching Frequency	1 k Ω	100k Ω	
R4	10 k Ω	Pull-down Resistor		22k Ω	May be omitted and pin 6 grounded if inhibit not used.
R5	15 k Ω	Frequency Compensation	10k Ω		
R6		Collector Load For Reset Output	$\frac{V_o}{0.05A}$		Omitted if reset function not used.
R7 R8	– 4.7 k Ω	Divider to Set Output Voltage	– –	– 1k Ω	$R7/R8 = \frac{V_o - V_{REF}}{V_{REF}}$
R _{lim}	–	Sets Current Limit Level	7.5k Ω		If R _{lim} is omitted and pin 4 left open the current limit is internally fixed.
C1	10 μ F	Stability	2.2 μ F		
C2	2.2 μ F	Sets Reset Delay	–	–	Omitted if reset function not used.
C3	2.2 nF	Sets Switching Frequency	1 nF	3.3nF	
C4	2.2 μ F	Soft Start	1 μ F	–	Also determines average short circuit current.
C5	33 nF	Frequency Compensation			
C6	390 pF	High Frequency Compensation	–	–	Not required for 5 V operation.
C7, C8 L1	100 μ F 300 μ H	Output Filter	– 100 μ H	–	
Q1		Crowbar Protection			The SCR must be able to withstand the peak discharge current of the output capacitor and the short circuit current of the device.
D1		Recirculation Diode			7A Schottky or 35 ns t _r Diode.

Figure 43 : 5.1V/2A Power Supply using External Limiting Current Resistor and Crowbar Protection on the Supply Voltage (L296P only)

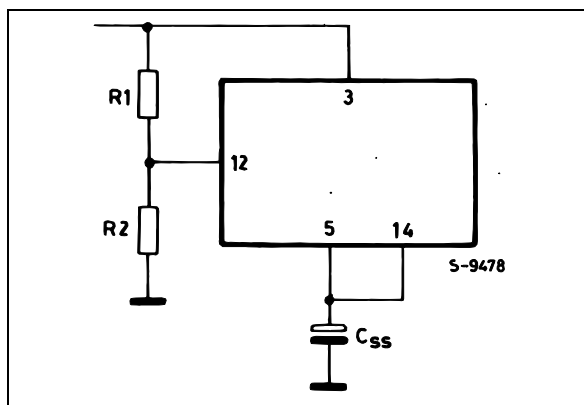


SOFT-START AND REPETITIVE POWER-ON

When the device is repetitively powered-on, the soft-start capacitor, C_{SS} , must be discharged rapidly to ensure that each start is "soft". This can be achieved economically using the reset circuit, as shown in Figure 44.

In this circuit the divider R1, R2 connected to pin 12 determines the minimum supply voltage, below which the open collector transistor at the pin 14 output discharges C_{SS} .

Figure 44



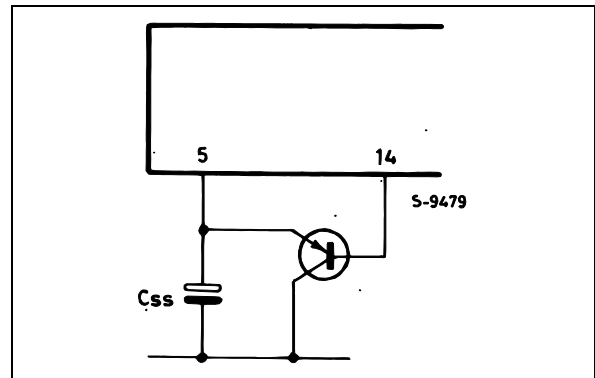
The approximate discharge times obtained with this circuit are :

CSS (μF)	tDIS (μs)
2.2	200
4.7	300
10	600

If these times are still too long, an external PNP tran-

sistor may be added, as shown in Figure 45 ; with this circuit discharge times of a few microseconds may be obtained.

Figure 45



HOW TO OBTAIN BOTH RESET AND POWER FAIL

Figure 46 illustrates how it is possible to obtain at the same time both the power fail and reset functions simply by adding one diode (D) and one resistor (R).

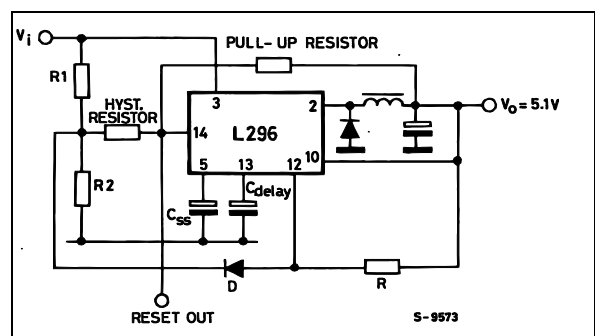
In this case the Reset delay time (pin 13) can only start when the output voltage is $V_O \geq V_{REF} - 100mV$ and the voltage across R2 is higher than 4.5V.

With the hysteresis resistor it is possible to fix the input pin 12 hysteresis in order to increase immunity to the 100Hz ripple present on the supply voltage.

Moreover, the power fail and reset delay time are automatically locked to the soft-start. Soft-start and delayed reset are thus two sequential functions.

The hysteresis resistor should be in the range of about 100kΩ and the pull-up resistor of 1 to 2.2kΩ.

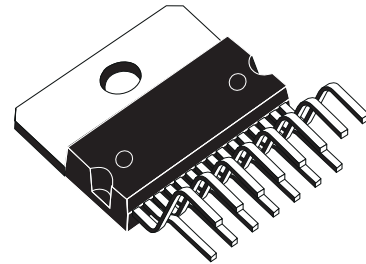
Figure 46



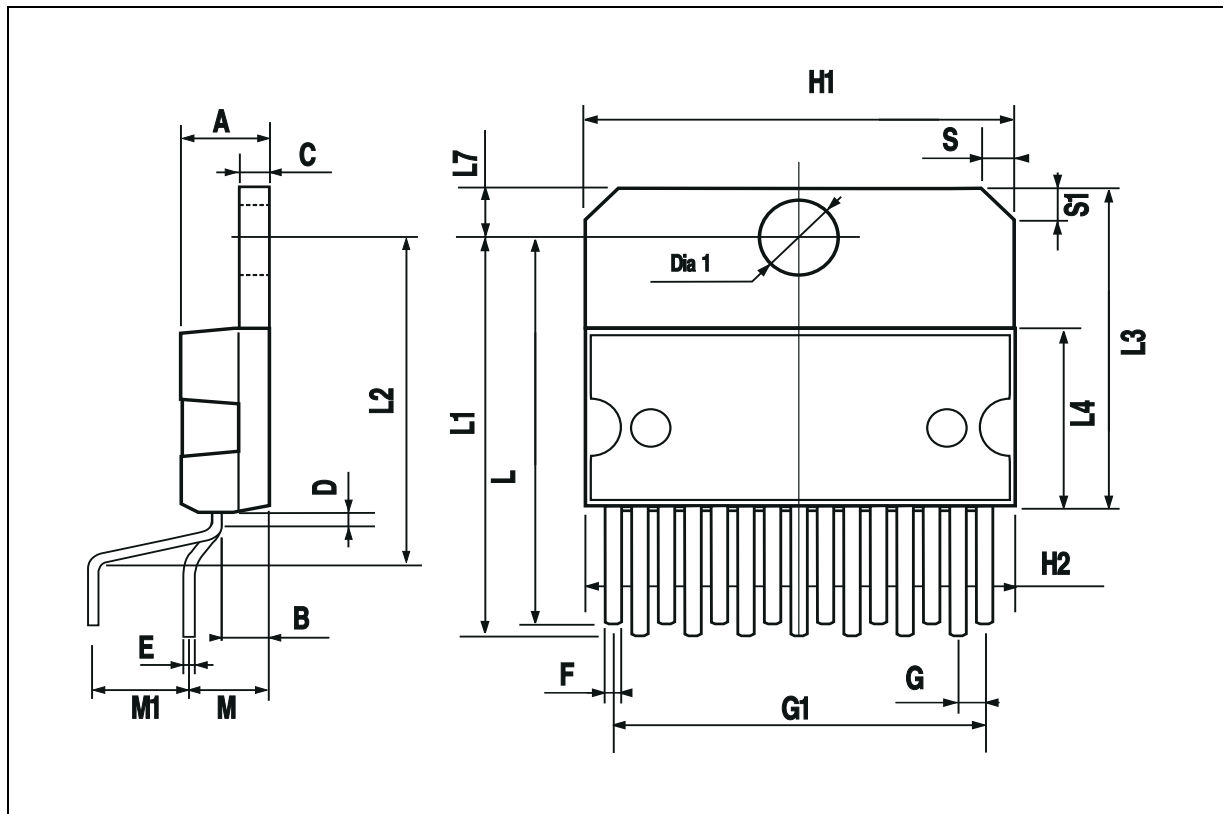
L296 - L296P

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
D		1			0.039	
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.02	1.27	1.52	0.040	0.050	0.060
G1	17.53	17.78	18.03	0.690	0.700	0.710
H1	19.6			0.772		
H2			20.2			0.795
L	21.9	22.2	22.5	0.862	0.874	0.886
L1	21.7	22.1	22.5	0.854	0.870	0.886
L2	17.65		18.1	0.695		0.713
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L7	2.65		2.9	0.104		0.114
M	4.25	4.55	4.85	0.167	0.179	0.191
M1	4.63	5.08	5.53	0.182	0.200	0.218
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA

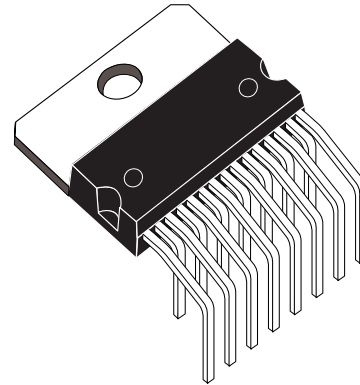


Multiwatt15 V



DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.14	1.27	1.4	0.045	0.050	0.055
G1	17.57	17.78	17.91	0.692	0.700	0.705
H1	19.6			0.772		
H2			20.2			0.795
L		20.57			0.810	
L1		18.03			0.710	
L2		2.54			0.100	
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L5		5.28			0.208	
L6		2.38			0.094	
L7	2.65		2.9	0.104		0.114
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA



Multiwatt15 H

