CM1581

5A LOW DROPOUT VOLTAGE REGULATOR

GENERAL DESCRIPTION

The CM1581 is a high performance low dropout regulator rated for 5A output current with fixed 1.8V/2.5V/3.3V/5.0V and adjustable output. It is designed for use in applications requiring low dropout characteristics over the rated current range.

When the second low-current input voltage is applied, the dropout voltage can be as low as 100mV at light loads and up to 500mV at maximum output current. On chip trimming adjusts the reference voltage to 1%. These features are ideal for low voltage microprocessor applications requiring a regulated 1.8V to 3.6V power supply.

In addition, the CM1581 provides the device protections including over current and thermal shutdown. The CM1581 series are ideal to the next generation microprocessor on motherboards where both 5V and 3.3V are available.

FEATURES

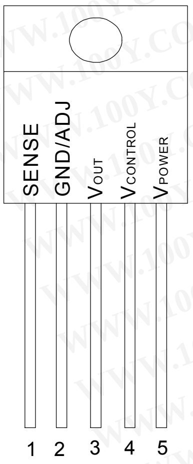
- Input-Output differential of typical 500mV at 5A and low quiescent current
- Output Current is excess of 5A
- Remote sense pin available
- Reverse battery protection
- Short Circuit Protection
- Internal Thermal Overload Protection
- 5L TO-220 and 5L TO-263 package available

APPLICATIONS

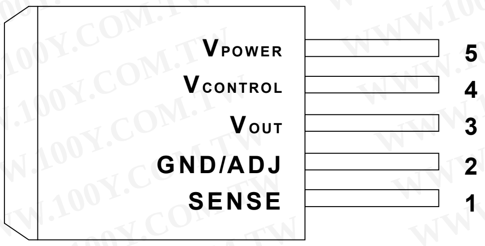
- Power Supplies
- Computer Add-On Cards
- Other Applications Requiring Low Dropout Voltage Over Rated Current

PIN CONFIGURATION

TO-220
Top View



TO-263
Top View



ORDERING INFORMATION

Package Type		Operating Temperature Range (T_A)	Output Voltage
TO-220	TO-263		
CM1581DCN220	CM1581DCN263	0℃ ~ +70℃	1.8V
CM1581KCN220	CM1581KCN263	0℃ ~ +70℃	2.5V
CM1581SCN220	CM1581SCN263	0℃ ~ +70℃	3.3V
CM1581ZJCN220	CM1581ZJCN263	0℃ ~ +70℃	5.0V
CM1581CN220	CM1581CN263	0℃ ~ +70℃	ADJ.

ABSOLUTE MAXIMUM RATINGS

Input Voltage (Vpower) ………………………………………………………. +13V
Input Voltage (Vcontrol) ………………………………………………….…… +13V
Operating Junction Temperature Range, T_J ……………..…. 0℃ to +150℃
Storage Temperature ……………………………………….….. -65℃ to +150℃
Lead Temperature (10 sec.) ……..………………………..………………... 300℃

POWER DISSIPATION TABLE

Package	Θ_{JA} (℃/W)	Derating factor (mW/℃) T_A >= 25℃	T_A <= 25℃ Power rating (mW)	T_A = 70℃ Power rating (mW)	T_A = 85℃ Power rating (mW)
TO-220	45	22.2	2775	1776	1443
TO-263	45	22.2	2775	1776	1443

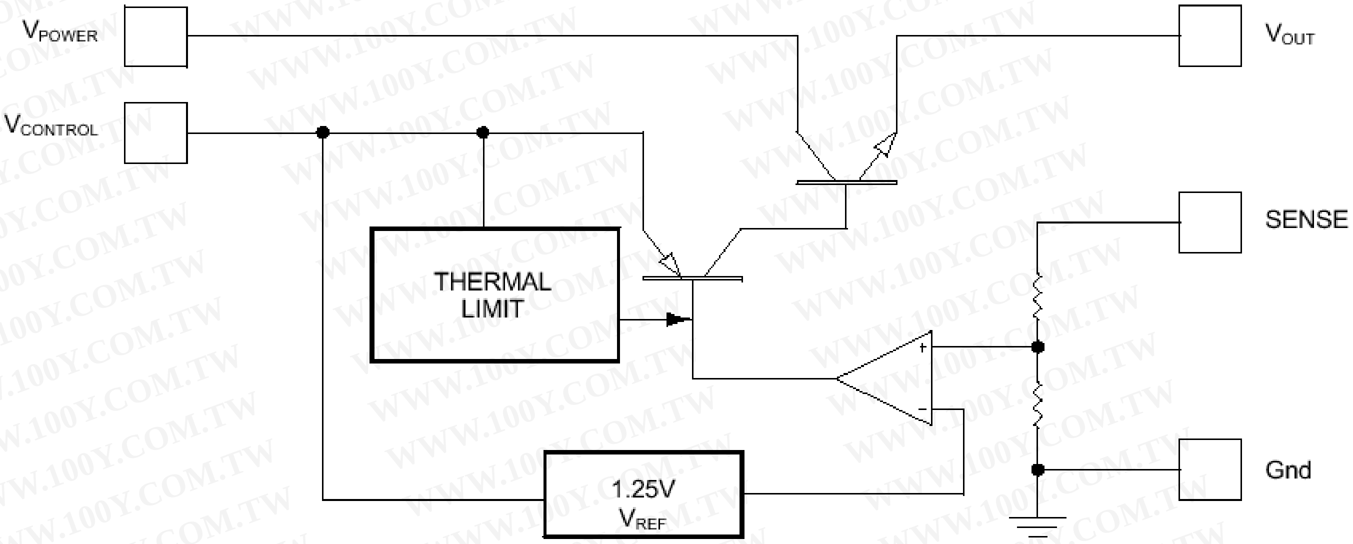
Note:

1. Θ_{JA} : Thermal Resistance-Junction to Ambient, D_F: Derating factor, P_O: Power consumption.
   Junction Temperature Calculation: $T_J = T_A + (P_D \times \Theta_{JA})$, $P_O = D_F \times (T_J - T_A)$
   The Θ_{JA} numbers are guidelines for the thermal performance of the device/PC-board system.
   All of the above assume no ambient airflow.
2. Θ_{JT} : Thermal Resistance-Junction to Ambient, T_C: case (Tab) temperature, $T_J = T_C + (P_D \times \Theta_{JC})$

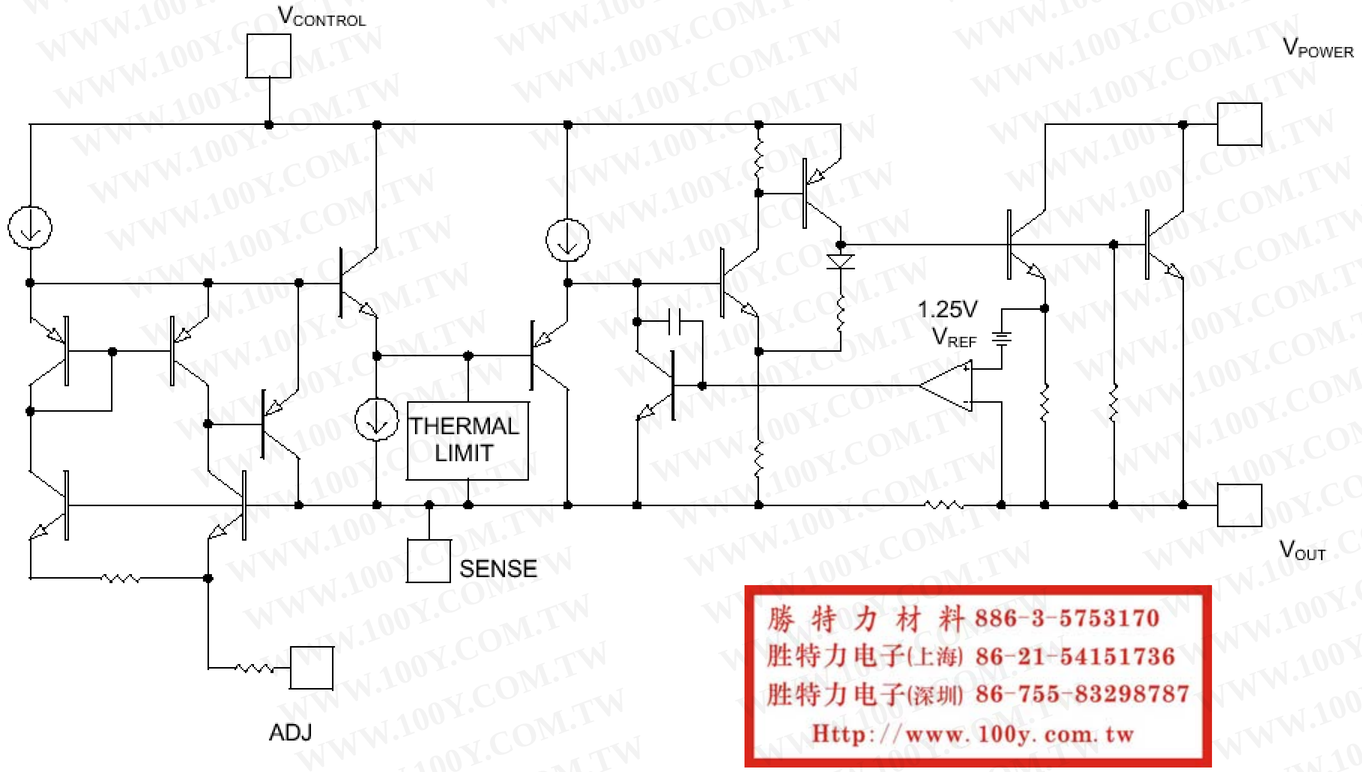
RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max	Units
Input Voltage (V_{IN})	V_{POWER}	2		7	V
	$V_{CONTROL}$	2.75		12	V
Load Current (with adequate heatsinking)	I_O	10			mA
Input Capacitor (V_{IN} to GND)		10			μF
Output Capacitor with ESR of 10Ω max. (V_{OUT} to GND)		33			μF

BLOCK DIAGRAM



CM1581 Fixed Output Voltage Block Diagram



CM1581 Adjustable Output Voltage block Diagram

ELECTRICAL CHARACTERISTICS

Electrical Characteristics at I_{OUT} = 0mA, and T_J = +25℃; unless otherwise noted

Parameter	Device	Test Conditions		CM1581			Unit
				Min.	Typ.	Max.	
Output Voltage	CM1581D	$V_{CONTROL}$ = 3.3V, V_{POWER} = 2.5V		1.792	1.800	1.818	V
	CM1581K	$V_{CONTROL}$ = 5.0V, V_{POWER} = 3.3V		2.474	2.500	2.525	V
	CM1581S	$V_{CONTROL}$ = 5.8V, V_{POWER} = 3.8V		3.267	3.300	3.333	V
	CM1581ZJ	$V_{CONTROL}$ = 7.5V, V_{POWER} = 5.5V		4.950	5.000	5.050	V
Output Voltage	CM1581D	$V_{CONTROL}$ = 3.3V, V_{POWER} = 2.5V	I_{OUT} = 5A	1.771	1.800	1.829	V
	CM1581K	$V_{CONTROL}$ = 5.0V, V_{POWER} = 3.3V		2.460	2.500	2.540	V
	CM1581S	$V_{CONTROL}$ = 5.0V, V_{POWER} = 4.1V		3.247	3.300	3.353	V
	CM1581ZJ	$V_{CONTROL}$ = 6.5V, V_{POWER} = 5.8V		4.920	5.000	5.080	V
Reference Voltage	CM1581(adj)	$V_{CONTROL}$ = 5.0V, V_{POWER} = 3.3V (note1)		1.238	1.250	1.262	V
		$V_{CONTROL}$ = (V_{OUT} + 1.5V) to 12V, V_{POWER} = (V_{OUT} + 0.8V) to 7V, I_{OUT} = 10mA to 5A		1.230	1.250	1.270	V
Line Regulator (note 2)		1.5V+ V_{OUT} <= $V_{CONTROL}$ <= 12V, 0.8V<= V_{POWER} - V_{OUT} <= 5.5V			0.04	0.20	%
Load Regulation (note 2)		$V_{CONTROL}$ = V_{OUT} + 2.5V, V_{POWER} = V_{OUT} + 0.8V, I_{OUT} = 10mA to 5A			0.08	0.3	%
Dropout Voltage (Note 3) $V_{CONTROL}$ - V_{OUT}		V_{POWER} = V_{OUT} + 0.8V	I_{OUT} = 10mA		1.00	1.15	V
			I_{OUT} = 5A		1.15	1.30	
Dropout Voltage (Note 3) V_{POWER} - V_{OUT}		$V_{CONTROL}$ = V_{OUT} + 2.5V	I_{OUT} = 10mA		0.10	0.17	V
			I_{OUT} = 5A		0.45	0.50	
Adjust Pin Current		$V_{CONTROL}$ = 2.75V, V_{POWER} = 2.05V, I_{OUT} = 10mA			50	120	µA
Control Pin Current		$V_{CONTROL}$ = V_{OUT} + 2.5V, V_{POWER} = V_{OUT} + 0.8V, I_{OUT} = 10mA to 5A			80	135	mA
Current Limit		(V_{IN} – V_{OUT}) = 1.5V		5.1	6.8		A
Minimum Load Current (Note 4)		$V_{CONTROL}$ = 5.0V, V_{POWER} = 3.3V			5	10	mA
Ripple Rejection (Note 5)		$V_{CONTROL}$ = V_{POWER} = V_{OUT} + 2.5V, V_{RIPPLE} = 1V_{PP}, I_{OUT} = 2.5A		60	80		dB
Thermal Regulation		T_A = 25℃			0.003		%/W

Note 1: Output voltage is set to be 2.5V.

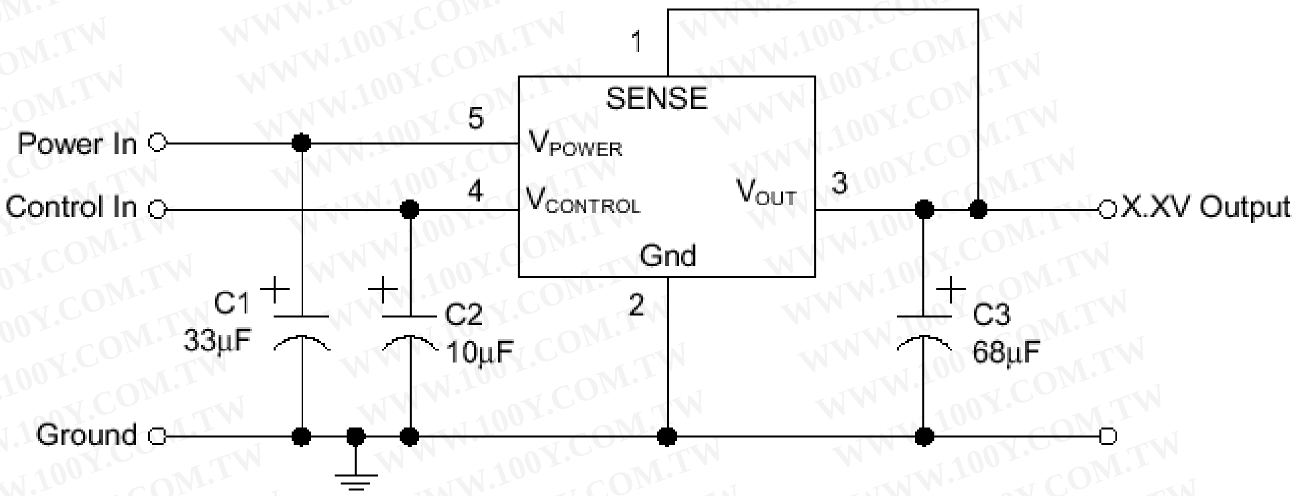
Note 2: Line and load regulations are guaranteed up to maximum power dissipation determined by input/output differential and the output current. However, the maximum power will not be available over the full input/output voltage range.

Note 3: The specifications represent the minimum input/output voltage required to maintain 1% regulation.

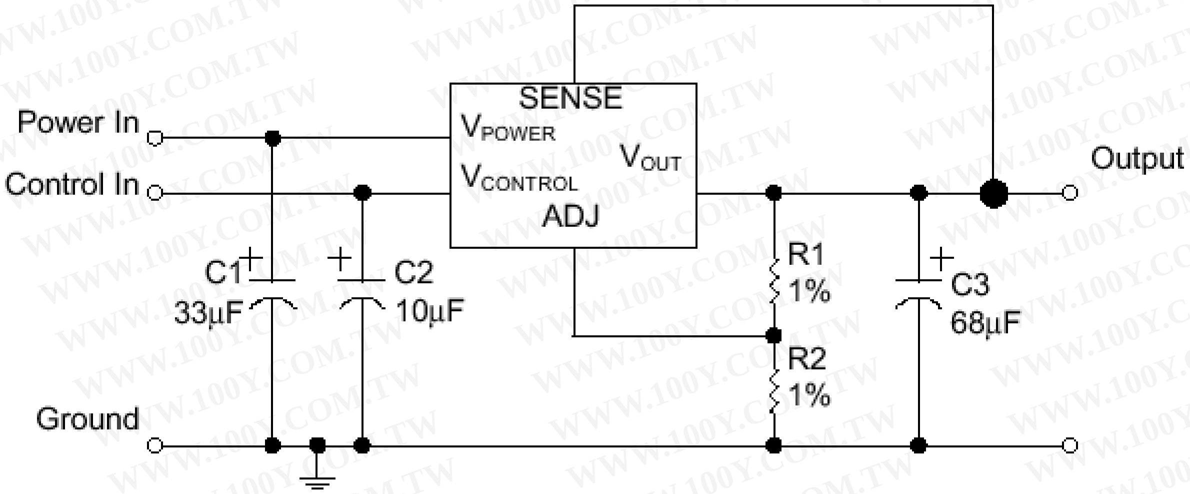
Note 4: The minimum load current is the minimum current required to maintain regulation. Normally the current in the resistor divider used to set the output voltage is selected to meet the minimum load current requirement.

Note 5: These parameters, although guaranteed, are not tested in production prior to shipment.

APPLICATION CIRCUIT



CM1581 Fixed Output Voltage Application Circuit



$$V_{OUT} = V_{REF}\,(1+(R2/R1)) + I_{ADJ}R2$$

CM1581 Adjustable Output Voltage Application Circuit

APPLICATION INFORMATION

General

The CM1581 series is designed to power the new generation of microprocessors. It is designed to make use of multiple power supplies, present in most systems, to reduce the dropout voltage. One of the advantages of the two-supply approach is maximizing the efficiency.

The second supply is at least 1V greater than output voltage and is providing the power for the control circuitry and supplies the drive current to the NPN output transistor. This allows the NPN output transistor to be driven into saturation. For the control voltage the current requirement is small, about 1% of the output current or approximately 50mA for a 5A load. This drive current becomes part of the output current. The maximum voltage on the Control pin is 13V. The maximum voltage at the Power pin is 7V. By trying the control and power inputs together the CM1581 can be operated as a single supply device. In single supply operation, the dropout voltage will be determined by the minimum the Control voltage.

The new generation of microprocessors cycle load current from several hundred milliampers to several amperes in tens of nanoseconds. Output voltage tolerances are tighter and include transient response as part of the specification. Designed to meet the fast current load step requirements of these microprocessors, the CM1581 also saves total cost by needing less output capacitance to maintain regulation.

The sense pin permits very accurate regulation of output voltage. As a result, over an output current range of 100mA to 5A, the typical load regulation is less than 1mV.

In addition to the enhancements mentioned, the reference accuracy has been improved a factor of two with a guaranteed initial tolerance of ±1% at 25℃ and 1.6% accuracy over the full temperature and load current load.

Typical applications for the CM1581 include 3.3V to 2.5V conversion with a 5V control supply, 5V to 4.2V conversion with a 12V control supply or 5V to 3.6V conversion with a 12V control supply. It is easy to obtain dropout voltages of less than 0.5V at 2.5A along with excellent static and dynamic specifications. The device is fully protected against over current and over temperature conditions.

Grounding and Output Sensing

The CM1581 adjustable voltage version allows true Kelvin sensing for both the high and low side of the load. As a result the voltage regulation at the load can be easily optimized. Voltage drops due to parasitic resistances between the regulator and the load can be placed inside the regulation loop. The advantages of remote sensing are illustrated in figures 1 through 3.

Figure 1 shows the device connected as a conventional 3 terminal regulator with the Sense lead connected directly to the output of the device. Rp is the parasitic resistance of the connections between the device and the load. Trace A of figure 3 illustrates the effect of Rp.

Figure 2 shows the device connected to take advantage of the remote sense feature. The Sense pin and the top of the resistor divider are connected to the top of the load; the bottom of the resistor divider is connected to the bottom of the load. The effect on the output regulation can be seen in trace B of figure 3.

It is important to note that the voltage drops due to Rp are not eliminated; they will add to the dropout voltage of the regulator regardless. The CM1581 adjustable can control the voltage at the load as long as the input-output voltage is greater than the total of the dropout voltage of the device plus the voltage drop across Rp.

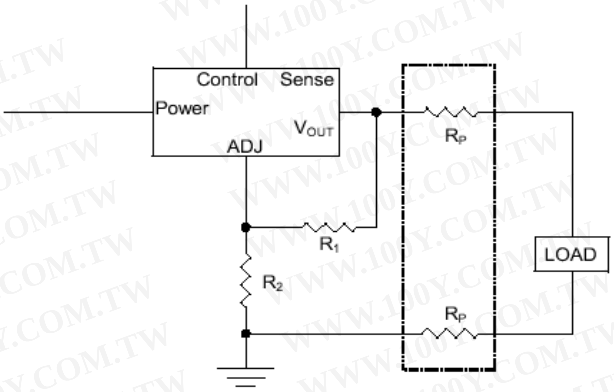


Figure 1. Conventional Load Sensing

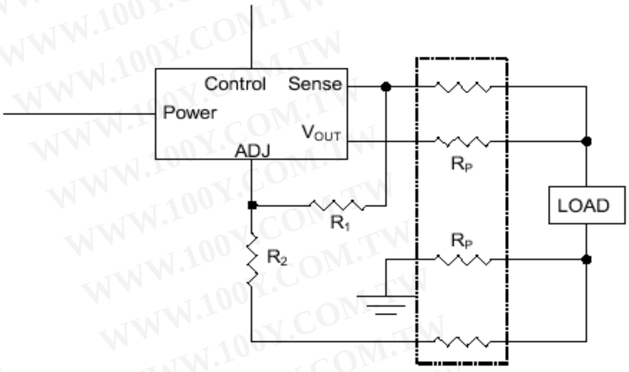


Figure 2. Remote Load Sensing

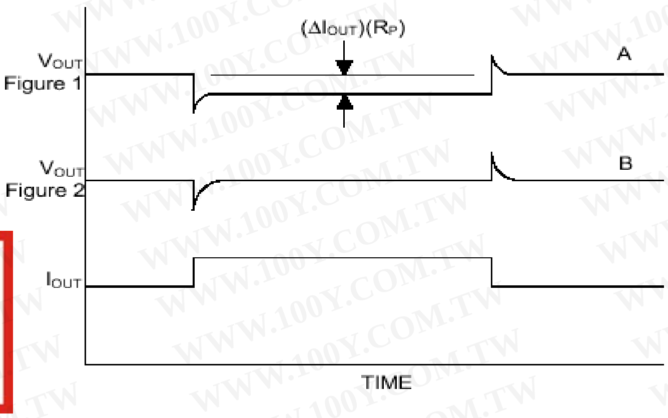


Figure 3. Remote Sensing Improves Load Regulation

Stability

The circuit design used in the CM1581 series requires the use of an output capacitor as part of the device frequency compensation. The addition of 150uF Aluminum electrolytic or a 22uF solid tantalum on the output will ensure stability for all operating conditions. In order to meet the transient performance of the processor larger value capacitors are needed. To limit the high frequency noise generated by the processor, high quality bypass capacitors must be used. In order to limit parasitic inductance (ESL) and resistance (ESR) in capacitors to acceptable limits, multiple small ceramic capacitor in addition to high quality solid tantalum capacitors are required.

When the adjustment terminal is bypassed to improve the ripple rejection, the requirement for an output capacitor increases. To further improve stability and transient response of these devices larger values of output capacitor can be used. The modern processors generate large high frequency current transients.

The load current step contains higher order frequency components than the output-coupling network must handle until the regulator throttles to the load current level. Because they contain parasitic resistance and inductance, capacitors are not ideal elements. These parasitic elements dominate the change in output voltage at the beginning of a transient load step change. The ESR of the output capacitors produces and instantaneous step in output voltage at the beginning of a transient load step change. The ESR of the output capacitors produces an instantaneous step in out voltage ΔV = ΔI(ESR). The ESL of the output capacitors produces a droop proportional to the rate of change of the output current ΔV = L(ΔI/Δt). The output capacitance produces a change in output voltage proportional to the time until the regulator an respond ΔV = Δt(ΔI/C). Figure 4 illustrates these transient effects.

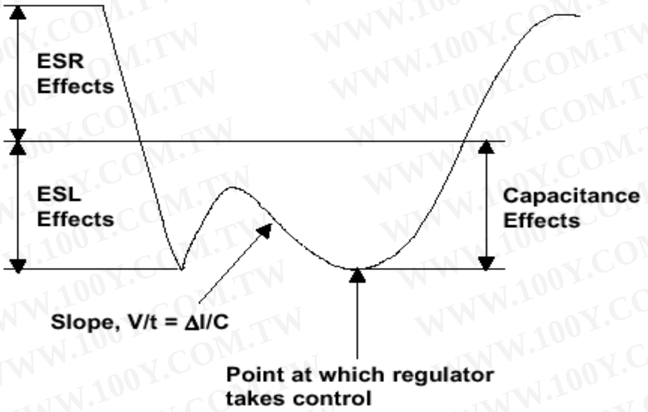


Figure 4.

Output Voltage

The CM1581 adjustable version develops a 1.25V reference voltage between the Sense pin and the Adjust pin (Figure 5). Placing a resistor between these two terminals causes a constant current to flow through R1 and down through R2 to set the output voltage. In general R1 is chosen so that this current is the specified minimum load current of 10mA. The current out of the Adjust pin is small, typically 50uA and it adds to the current for R1. For best regulation the top of the resistor divider should be connected directly to the Sense pin.

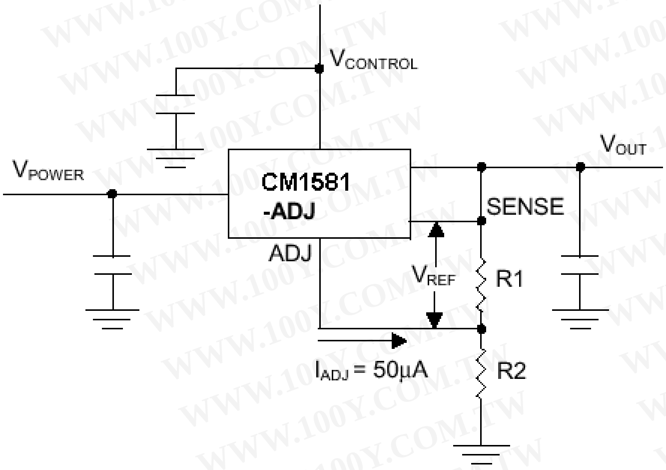


Figure 5 Setting Output Voltage

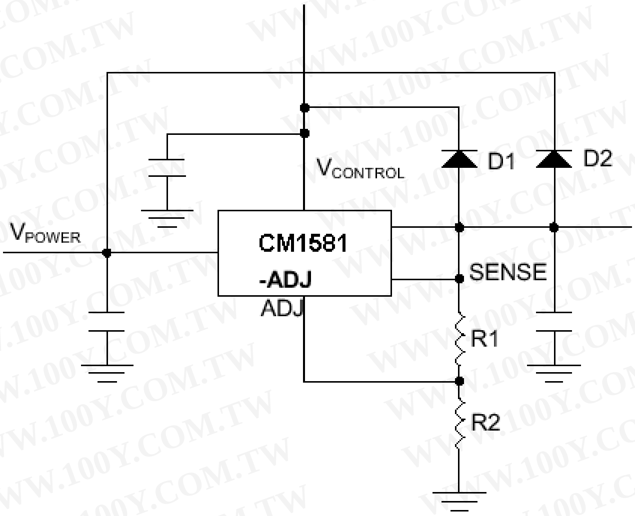


Figure 6. Optional Clamp Diodes Protect Against Input Crowbar Circuit

Protection Diodes

In normal operation, CM1581 family does not need any protection diodes between the adjustment pin and the output and from the output to the input to prevent die overstress. Internal resistors are limiting the internal current paths on the ADJ pin. Therefore even with bypass capacitors on the adjust pin no protection diode is needed to ensure device safety under short-circuit conditions. The Adjust pin can be driver on a transient basis ±7V with respect ti the output without any device degradation.

A protection diode between the Output pin and V_{POWER} pin is not usually needed. Microsecond surge currents of 50A to 100A can be handled by the internal diode between the Output pin and V_{POWER} pin of the device. In normal operations, it is difficult to get those values of surge currents even with the use of large output capacitances. Only with high value output capacitors, such as 1000uF to 5000uF and the VPOWER pin is instantaneously shorted to ground, damage an occur. A diode from output to input is recommended (Figure 6). If CM1581 is connected as single supply device with the control and power input pins shorted together the internal diode between the output and power input pin will protect the control input pin.

Thermal Consideration

The CM1581 adjustable version had internal power and thermal limiting circuitry (about 150℃) designed to protect the device under overload conditions. However, maximum junction temperature ratings should not be exceeded under continuous normal load conditions. Careful consideration must be given to all sources of thermal resistance from junction to ambient, including junction-to-case, case-to-heatsink interface and heatsink resistance itself.

Junction temperature of the Control section can run up to 125℃. Junction temperature rise in the power transistor will be greater than the temperature rise in the Control section making the thermal resistance lower in the Control section. At power levels below 12W, the temperature gradient will be lese than 25℃ and the maximum ambient temperature will be determined by the junction temperature of the Control section. This is due to the lower maximum junction temperature in the Control section. At power levels above 12W, the temperature gradient will be greater than 25℃ and the maximum ambient temperature will be determined by the Power section. In both cases, the junction temperature is determined by the total power dissipated in the device. For most low dropout applications the power dissipation will be less than 12W.

The power in the device us made up of two components: the power in the output transistor and the power in the control circuit.

The power in the control circuit is negligible, which is equal to: $P_{CONTROL} = (V_{CONTROL} – V_{OUT})/I_{CONTROL}$, where $I_{CONTROL}$ is equal to $I_{OUT}/100$(typ)

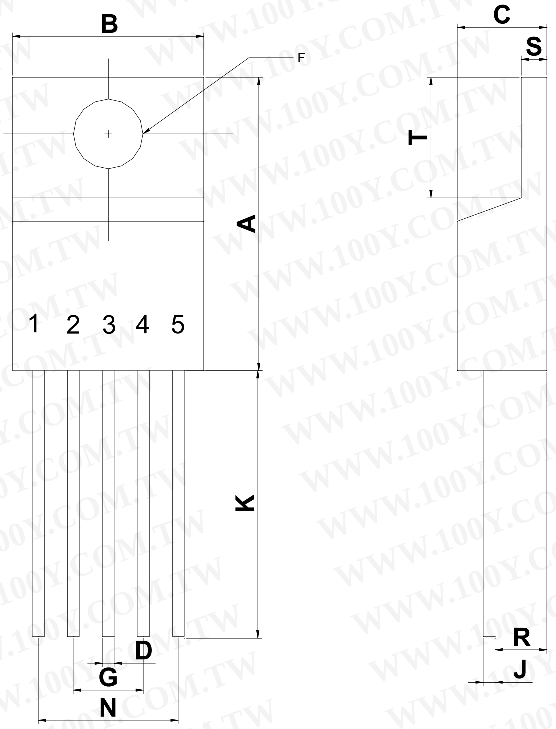
The power in the output transistor is equal to: $P_{OUTPUT} = (V_{POWER} – V_{OUT})/I_{OUT}$

The total power is equal to: $P_{CONTROL} + P_{OUTPUT}$

Junction-to-case thermal resistance is specified from the IC junction to the bottom of the case directly below the die. This is the lowest resistance path for the heat flow. In order to ensure the best possible thermal flow this area of the package to the heatsink proper mounting is required. Thermal compound at the case-to-heatsink interface is recommended. A thermally conductive spacer can be used, if the case of the device must be electrically isolated, but its added contribution to thermal resistance has to be considered.

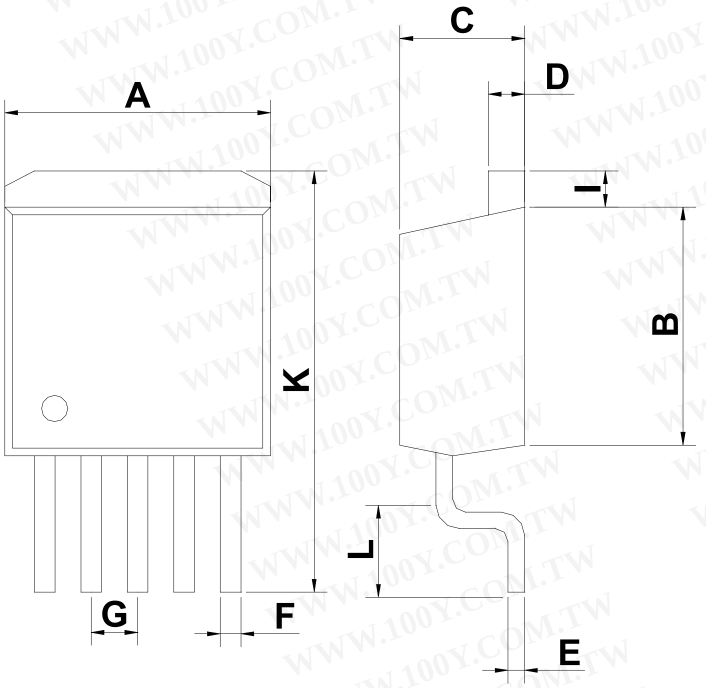
PACKAGE DIMENSION

TO-220 (N220)



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	14.23	---	16.51	0.560	---	0.650
B	9.66	---	10.66	0.380	---	0.420
C	3.56	---	4.82	0.140	---	0.190
D	0.46	---	0.89	0.018	---	0.035
F	3.56	---	4.06	0.140	---	0.160
G	3.40	---	---	0.134	---	---
J	0.31	---	1.14	0.012	---	0.045
K	12.70	---	14.70	0.500	---	0.580
N	---	6.80	---	---	0.268	---
R	2.04	---	2.92	0.080	---	0.115
S	1.14	===	1.39	0.045	===	0.055
T	5.85	---	6.85	0.230	---	0.270

TO-263 (N263)



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	10.03	---	10.67	0.395	---	0.420
B	8.25	---	9.17	0.325	---	0.361
C	4.34	---	4.59	0.171	---	0.181
D	1.14	---	1.40	0.045	---	0.055
E	0.33	---	0.432	0.013	---	0.017
F	0.737	---	0.889	0.029	---	0.035
G	1.57	---	1.83	0.062	---	0.072
I	---	---	1.65	---	---	0.065
K	14.60	---	16.13	0.575	---	0.635
L	2.29	---	2.79	0.090	---	0.110
V	1.14	---	1.40	0.045	---	0.055