1.5A Low Dropout Positive Regulators

Description

The LM1086 series of positive adjustable and fixed regulators are designed to provide 1.5A with high efficiency. All internal circuitry is designed to operate down to 1.5V input to output differential. On-chip trimming adjusts the reference voltage to 1%,LM1086 has internal overheat protection and current limiting circuit, which is applicable to all kinds of electronic products。

The LM1086 circuit includes a zener trimmed bandgap reference, current limiting, and thermal shutdown. Because the LM1086 regulator is floating and detects only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input-to-output differential is not exceeded. Exceeding the maximum input-to-output deferential will result in short-circuiting the output. By connecting a fixed resistor between the adjustment pin and output, the LM1086 can be also used as a precision current regulator.

Features

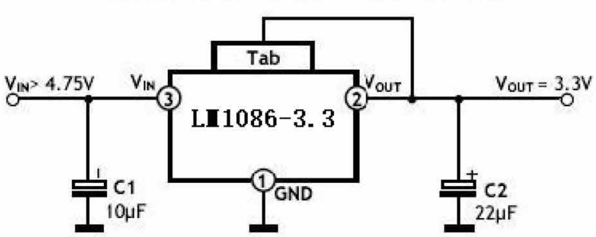
- Available in Fixed 1.8-V, 2.5-V, 3.3-V, 5-Vand Adjustable Versions
- Current Limiting and Thermal Protection
- Output Current 1.5 A
- Line Regulation 0.015% (Typical)
- Load Regulation 0.1% (Typical)
- Industrial Temperature Range −40°C to 125°C

Applications

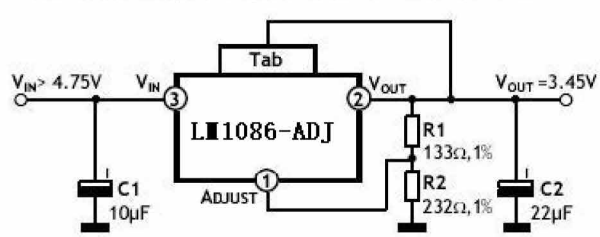
- Post Regulator for Switching DC-DC Converter
- High-Efficiency Linear Regulators
- Adjustable Power Supply
- Microprocessor Supplies
- Audio Amplifiers Supplies

Typical Application

FIXED VOLTAGE REGULATOR



ADJUSTABLE VOLTAGE REGULATOR



NOTES:
- C1 needed if device is far from filter capacitors
- C2 minimum value required for stability

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R2}{R1}\right) + I_{ADJ} \times R2$$

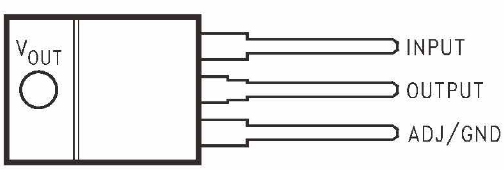
ORDERING INFORMATION

Part Number	Package	Packing	Temperature(TA)	Package Qty
LM1086CSX-3.3	TO-263-3	Reel	-40°C ~ 125°C	500
LM1086ISX-3.3	TO-263-3	Reel	-40°C ~ 125°C	500
LM1086CSX-5.0	TO-263-3	Reel	-40°C ~ 125°C	500
LM1086ISX-5.0	TO-263-3	Reel	-40°C ~ 125°C	500
LM1086CSX-ADJ	TO-263-3	Reel	-40°C ~ 125°C	500
LM1086ISX-ADJ	TO-263-3	Reel	-40°C ~ 125°C	500
LM1086CT-3.3	TO-220-3	Tube	-40°C ~ 125°C	450
LM1086IT-3.3	TO-220-3	Tube	-40°C ~ 125°C	450
LM1086CT-5.0	TO-220-3	Tube	-40°C ~ 125°C	450
LM1086IT-5.0	TO-220-3	Tube	-40°C ~ 125°C	450
LM1086CT-ADJ	TO-220-3	Tube	-40°C ~ 125°C	450
LM1086IT-ADJ	TO-220-3	Tube	-40°C ~ 125°C	450

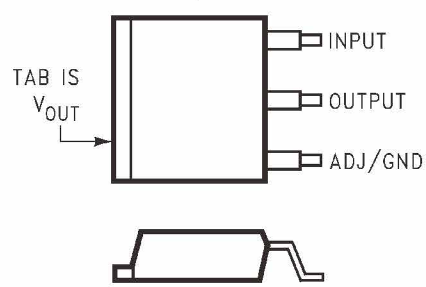
(1) 1.8V, 2.5V voltage is shutdown NAND

Pin Configuration and Functions

3-Pin
TO-220 Package
Top View



3-Pin
TO-263 Package
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
ADJ/GND	1	-	Adjust pin for the adjustable output voltage version. Ground pin for the fixed output voltage versions.
OUTPUT	2	O	Output voltage pin for the regulator.
INPUT	3	I	Input voltage pin for the regulator.

Absolute Maximum Ratings

		MIN	MAX	UNIT
Maximum Input to Output Voltage Differential	LM1086-ADJ		29	V
	LM1086-1.8		27	V
	LM1086-2.5		27	V
	LM1086-3.3		27	V
	LM1086-5.0		25	V
Power Dissipation		Internally Limited		
Junction Temperature (T_J)			150	°C
Lead Temperature			260, to 10 sec	°C
Storage temperature, T_{stg}		–65	150	°C

Recommended Operating Conditions

		MIN	MAX	UNIT
JUNCTION TEMPERATURE RANGE (T_J) (1)				
"C" Grade	Control Section	0	125	°C
	Output Section	0	150	°C
"I" Grade	Control Section	−40	125	°C
	Output Section	−40	150	°C

Thermal Information

THERMAL METRIC (1)		LM1086			UNIT
		KTT	NDE	NGN	
		3 PINS	3 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	40.8	23.0	35.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	42.3	16.1	24.2	
$R_{\theta JB}$	Junction-to-board thermal resistance	23.3	4.5	13.2	
ψ_{JT}	Junction-to-top characterization parameter	10.2	2.4	0.2	
ψ_{JB}	Junction-to-board characterization parameter	22.3	2.5	13.3	
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance: Control Section/Output Section	1.5/4.0	1.5/4.0	2.9	

Electrical Characteristics

Typicals and limits apply for T_J = 25°C unless specified otherwise.

PARAMETER		TEST CONDITIONS	T_J = 25°C			T_J over the entire range for operation (see *Recommended Operating Conditions*)			UNIT
			MIN	TYP	MAX	MIN (1)	TYP (2)	MAX (1)	
V_{REF}	Reference Voltage	LM1086-ADJ, I_{OUT} = 10 mA, $V_{IN} - V_{OUT}$ = 3 V, 10 mA ≤ $I_{OUT} \le I_{FULL\ LOAD}$, 1.5 V ≤ $V_{IN} - V_{OUT}$ ≤ 15 V (3)	1.238	1.250	1.262	1.225	1.250	1.270	V
V_{OUT}	Output Voltage (3)	LM1086-1.8, I_{OUT} = 0 mA, V_{IN} = 5 V, 0 ≤ $I_{OUT} \le I_{FULL\ LOAD}$, 3.3 V ≤ V_{IN} ≤ 18 V	1.782	1.8	1.818	1.764	1.8	1.836	V
		LM1086-2.5, I_{OUT} = 0 mA, V_{IN} = 5 V, 0 ≤ $I_{OUT} \le I_{FULL\ LOAD}$, 4.0 V ≤ V_{IN} ≤ 18 V	2.475	2.50	2.525	2.450	2.50	2.55	V
		LM1086-3.3, I_{OUT} = 0 mA, V_{IN} = 5 V, 0 ≤ $I_{OUT} \le I_{FULL\ LOAD}$, 4.75 V ≤ V_{IN} ≤ 18 V	3.267	3.300	3.333	3.235	3.300	3.365	V
		LM1086-5.0, I_{OUT} = 0 mA, V_{IN} = 8 V, 0 ≤ $I_{OUT} \le I_{FULL\ LOAD}$, 6.5 V ≤ V_{IN} ≤ 20 V	4.950	5.000	5.050	4.900	5.000	5.100	V
ΔV_{OUT}	Line Regulation (4)	LM1086-ADJ, I_{OUT} =10 mA, 1.5 V ≤ (V_{IN} - V_{OUT}) ≤ 15 V		0.015%	0.2%		0.035%	0.2%	
		LM1086-1.8, I_{OUT} = 0 mA, 3.3 V ≤ V_{IN} ≤ 18 V		0.3	6		0.6	6	mV
		LM1086-2.5, I_{OUT} = 0 mA, 4.0 V ≤ V_{IN} ≤ 18 V		0.3	6		0.6	6	mV
		LM1086-3.3, I_{OUT} = 0 mA, 4.5 V ≤ V_{IN} ≤ 18 V		0.5	10		1.0	10	mV
		LM1086-5.0, I_{OUT} = 0 mA, 6.5 V ≤ V_{IN} ≤ 20 V		0.5	10		1.0	10	mV

(1) All limits are specified by testing or statistical analysis.
(2) Typical Values represent the most likely parametric norm.
(3) $I_{FULL\ LOAD}$ is defined in the current limit curves. The $I_{FULL\ LOAD}$ Curve defines current limit as a function of input-to-output voltage. Note that 15W power dissipation for the LM1086 is only achievable over a limited range of input-to-output voltage.
(4) Load and line regulation are measured at constant junction temperature, and are specified up to the maximum power dissipation of 15W. Power dissipation is determined by the input/output differential and the output current. Ensured maximum power dissipation will not be available over the full input/output range.

Electrical Characteristics (continued)

Typicals and limits appearing in normal type apply for T_J = 25°C unless specified otherwise.

	PARAMETER	TEST CONDITIONS	T_J = 25°C MIN	T_J = 25°C TYP	T_J = 25°C MAX	T_J over the entire range for operation (see *Recommended Operating Conditions*) MIN(1)	TYP(2)	MAX(1)	UNIT
ΔV_{OUT}	Load Regulation(4)	LM1086-ADJ, (V_{IN}-V_{OUT}) = 3 V, 10 mA ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$		0.1%	0.3%		0.2%	0.4%	
		LM1086-1.8, 2.5, V_{IN} = 5 V, 0 ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$		3	12		6	20	mV
		LM1086-3.3, V_{IN} = 5 V, 0 ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$		3	15		7	25	mV
		LM1086-5.0, V_{IN} = 8 V, 0 ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$		5	20		10	35	mV
	Dropout Voltage(5)	LM1086-ADJ, 1.8, 2.5, 3.3, 5, ΔV_{REF}, ΔV_{OUT} = 1%, I_{OUT} = 1.5A					1.3	1.5	V
I_{LIMIT}	Current Limit	LM1086-ADJ, V_{IN} − V_{OUT} = 5 V, V_{IN} − V_{OUT} = 25 V				1.50	2.7		A
						0.05	0.15		
		LM1086-1.8,2.5, 3.3, V_{IN} = 8 V				1.5	2.7		A
		LM1086-5.0, V_{IN} = 10 V				1.5	2.7		A
	Minimum Load Current(6)	LM1086-ADJ, V_{IN} −V_{OUT} = 25 V					5.0	10.0	mA
	Quiescent Current	LM1086-1.8, 2.5, V_{IN} ≤ 18 V					5.0	10.0	mA
		LM1086-3.3, V_{IN} ≤ 18 V					5.0	10.0	mA
		LM1086-5.0, V_{IN} ≤ 20 V					5.0	10.0	mA
	Thermal Regulation	T_A = 25°C, 30ms Pulse		0.008	0.04				%/W
	Ripple Rejection	f_{RIPPLE} = 120 Hz, C_{OUT} = 25 µF Tantalum, I_{OUT} = 1.5 A							dB
		LM1086-ADJ, C_{ADJ} = 25 µF, (V_{IN}− V_O) = 3 V				60	75		
		LM1086-1.8, 2.5, V_{IN} = 6 V				60	72		dB
		LM1086-3.3, V_{IN}= 6.3 V				60	72		dB
		LM1086-5.0 V_{IN} = 8 V				60	68		dB
	Adjust Pin Current	LM1086		55				120	µA
	Adjust Pin Current Change	10 mA ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$, 1.5 V ≤ (V_{IN}−V_{OUT}) ≤ 15 V					0.2	5	µA
	Temperature Stability						0.5%		
	Long Term Stability	T_A = 125°C, 1000 Hrs		0.3%	1.0%				
	RMS Noise (% of V_{OUT})	10 Hz ≤ f≤ 10 kHz		0.003%					

(5) Dropout voltage is specified over the full output current range of the device.
(6) The minimum output current required to maintain regulation.

Typical Characteristics

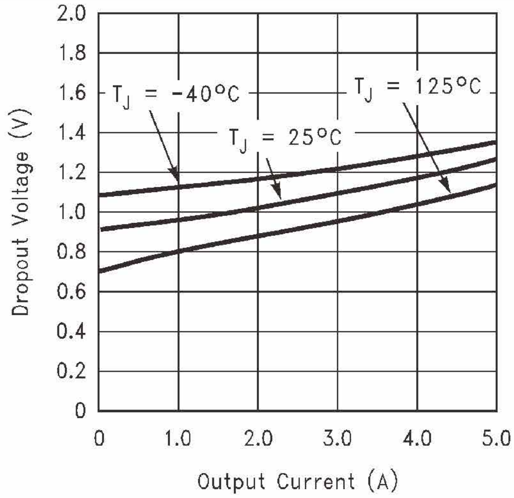


Figure 1. Dropout Voltage (V_{IN}−V_{OUT})

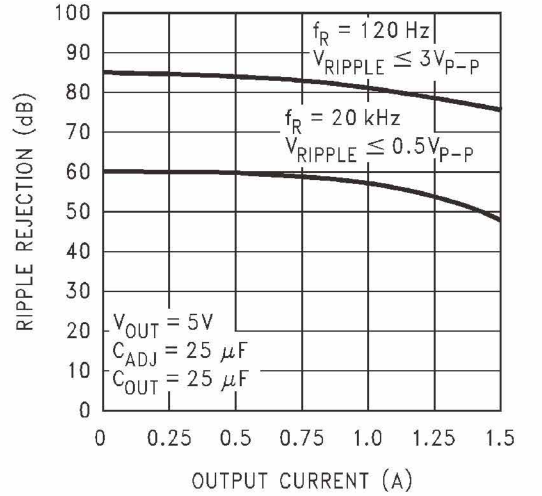


Figure 5. LM1086-ADJ Ripple Rejection vs Current

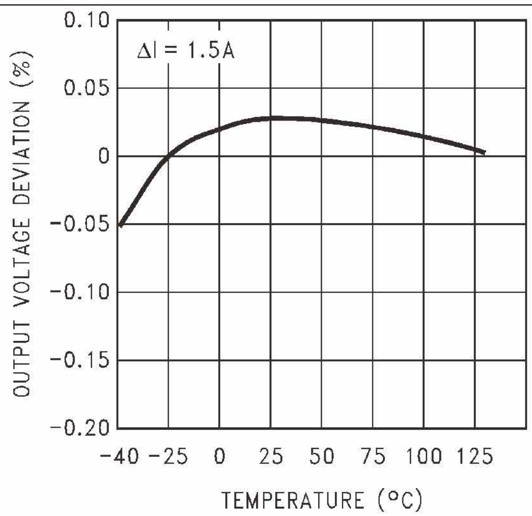


Figure 3. Load Regulation

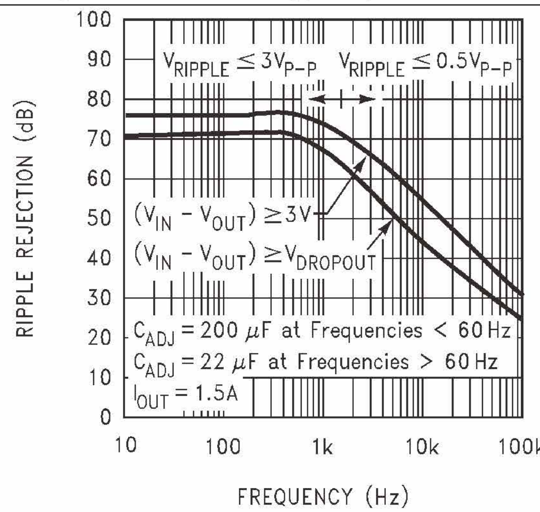
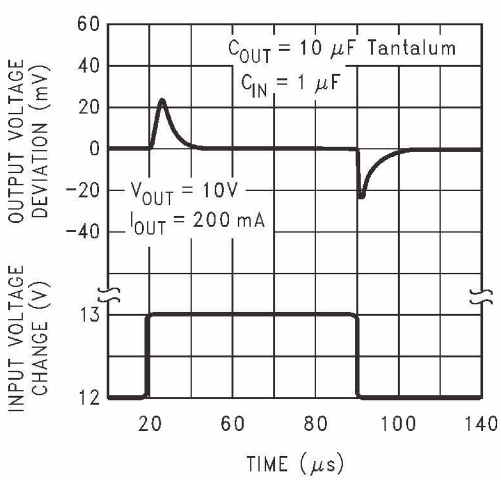
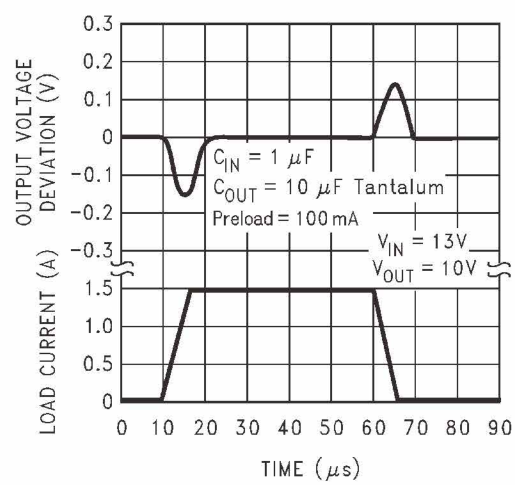


Figure 4. LM1086-ADJ Ripple Rejection



Line Transient Response



Load Transient Response

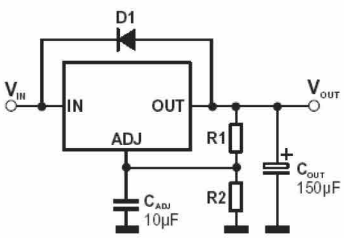
APPLICATION INFORMATION

The LM1086 series of adjustable and fixed regulators are easy to use and have all the protection features expected in high performance voltage regulators: short circuit protection and thermal shut-down.
Pin compatible with older three terminal adjustable regulators, these devices offer the advantage of a lower dropout voltage, more precise reference tolerance and improved reference stability with temperature.

STABILITY

The circuit design used in the LM1086 series requires the use of an output capacitor as part of the device frequency compensation. The addition of 150μF aluminum electrolytic or a 22μF solid tantalum on the output will ensure stability for all operating conditions.
When the adjustment terminal is bypassed with a capacitor to improve the ripple rejection, the requirement for an output capacitor increases. The value of 22μF tantalum or 150μF aluminum covers all cases of bypassing the adjustment terminal. Without bypassing the adjustment terminal smaller capacitors can be used with equally good results. To ensure good transient response with heavy load current changes capacitor values on the order of 100μF are used in the output of many regulators. To further improve stability and transient response of these devices larger values of output capacitor can be used.

PROTECTION DIODES



Unlike older regulators, the LM1086 family does not need any protection diodes between the adjustment pin and the output and from the output to the input to prevent over-stressing the die.

Internal resistors are limiting the internal current paths on the LM1086 adjustment pin, therefore even with capacitors on the adjustment pin no protection diode is needed to ensure device safety under short-circuit conditions.

Diodes between the input and output are not usually needed.

Microsecond surge currents of 50A to 100A can be handled by the internal diode between the input and output pins of the device. In normal operations it is difficult to get those values of surge currents even with the use of large output capacitances. If high value output capacitors are used, such as 1000μF to 5000μF and the input pin is instantaneously shorted to ground, damage can occur. A diode from output to input is recommended, when a crowbar circuit at the input of the LM1086 is used. Normal power supply cycling or even plugging and unplugging in the system will not generate current large enough to do any damage.

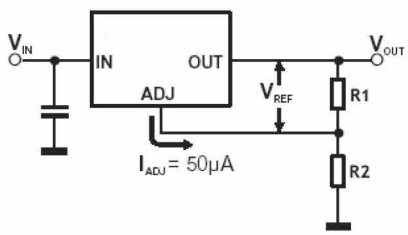
The adjustment pin can be driven on a transient basis ±25V, with respect to the output without any device degradation. As with any IC regulator, none the protection circuitry will be functional and the internal transistors will break down if the maximum input to output voltage differential is exceeded.

RIPPLE REJECTION

The ripple rejection values are measured with the adjustment pin bypassed. The impedance of the adjust pin capacitor at the ripple frequency should be less than the value of R1 (normally 100Ω to 120Ω) for a proper bypassing and ripple rejection approaching the values shown. The size of the required adjust pin capacitor is a function of the input ripple frequency. If R1=100Ω at 120Hz the adjust pin capacitor should be 25μF. At 10 kHz only 0.22 μF is needed.

The ripple rejection will be a function of output voltage, in circuits without an adjust pin bypass capacitor. The output ripple will increase directly as a ratio of the output voltage to the reference voltage (V_{OUT} / V_{REF}).

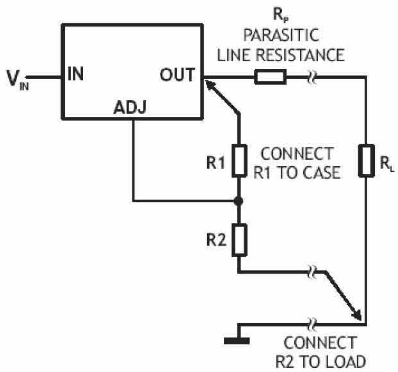
OUTPUT VOLTAGE



The LM1086 series develops a 1.25V reference voltage between the output and the adjust terminal. Placing a resistor between these two terminals causes a constant current to flow through R1 and down through R2 to set the overall output voltage.

This current is normally the specified minimum load current of 10mA. Because I_{ADJ} is very small and constant it represents a small error and it can usually be ignored.

LOAD REGULATION



True remote load sensing it is not possible to provide, because the LM1086 is a three terminal device. The resistance of the wire connecting the regulator to the load will limit the load regulation.

The data sheet specification for load regulation is measured at the bottom of the package. Negative side sensing is a true Kelvin connection, with the bottom of the output divider returned to the negative side of the load.

The best load regulation is obtained when the top of the resistor divider R1 is connected directly to the case not to the load. If R1 were connected to the load, the effective resistance between the regulator and the load would be:

$$\frac{R_P \times (R2 + R1)}{R1}, \quad R_P = \text{Parasitic Line Resistance}$$

Connected as shown , R_P is not multiplied by the divider ratio. Using 16-gauge wire the parasitic line resistance is about 0.004Ω per foot, translating to 4mV/ft at 1A load current. It is important to keep the positive lead between regulator and load as short as possible and use large wire or PC board traces.

THERMAL CONSIDERATIONS

The LM1086 series have internal power and thermal limiting circuitry 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-heat sink interface and heat sink resistance itself. To ensure safe operating temperatures and reflect more accurately the device temperature, new thermal resistance specifications have been developed. Unlike older regulators with a single junction-to-case thermal resistance specification, the data section for these new regulators provides a separate thermal resistance and maximum junction temperature for both the Control Section and the Power Transistor. Calculations for both temperatures under certain conditions of ambient temperature and heat sink resistance and to ensure that both thermal limits are met.

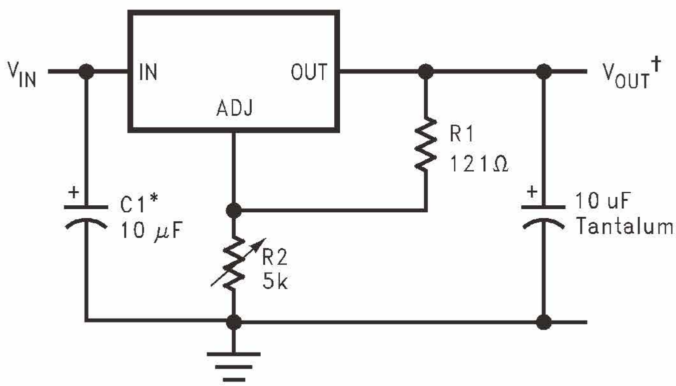
Junction-to-case thermal resistance is specified from the IC junction to the bottom of the case directly below the die. This is the lowest resistance path for the heat flow. In order to ensure the best possible thermal flow from this area of the package to the heat sink proper mounting is required. Thermal compound at the case-to-heat sink 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.

Application Information

The LM1086 is versatile in its applications, including uses in programmable output regulation and local on-card regulation. Or, by connecting a fixed resistor between the ADJUST and OUTPUT terminals, the LM1086 can function as a precision current regulator. An optional output capacitor can be added to improve transient response. The ADJUST terminal can be bypassed to achieve very high ripple-rejection ratios, which are difficult to achieve with standard three-terminal regulators. Please note, in the following applications, if ADJ is mentioned, it makes use of the adjustable version of the part, however, if GND is mentioned, it is the fixed voltage version of the part.

1.2-V to 15-V Adjustable Regulator

This part can be used as a simple low drop out regulator to enable a variety of output voltages needed for demanding applications. By using an adjustable R2 resistor a variety of output voltages can be made possible based on the LM1086-ADJ.



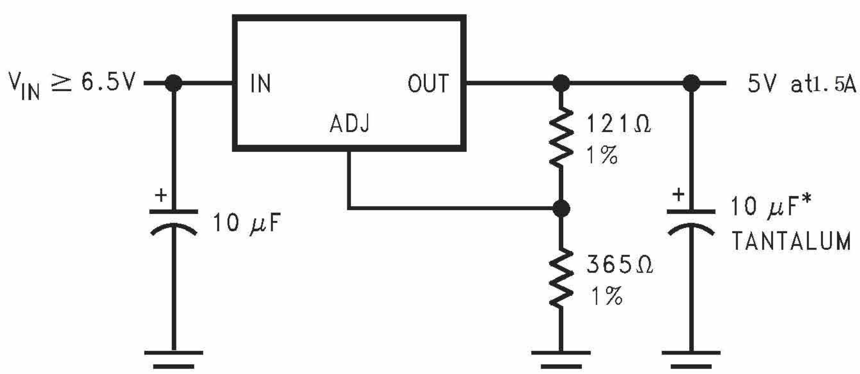
*NEEDED IF DEVICE IS FAR FROM FILTER CAPACITORS

$$^{\dagger}V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right)$$

Figure 16. 1.2-V to 15-V Adjustable Regulator

Adjustable at 5 V

The application outlines a simple 5 V output application made possible by the LM1086-ADJ. This application can provide 1.5 A at high efficiencies and very low drop-out.



*REQUIRED FOR STABILITY

Figure 17. Adjustable @ 5 V

5-V Regulator With Shutdown

A variation of the 5 V output regulator application with shutdown control is based on the LM1086-ADJ. It uses a simple NPN transistor on the ADJ pin to block or sink the current on the ADJ pin. If the TTL logic is pulled high, the NPN transistor is activated and the part is disabled, outputting approximately 1.25 V. If the TTL logic is pulled low, the NPN transistor is unbiased and the regulator functions normally.

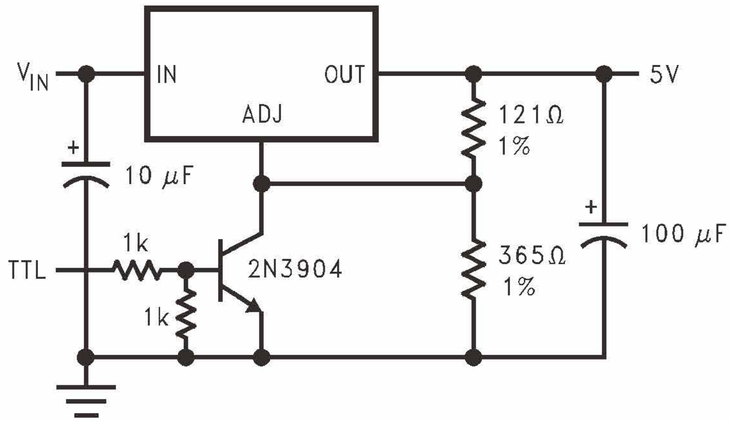
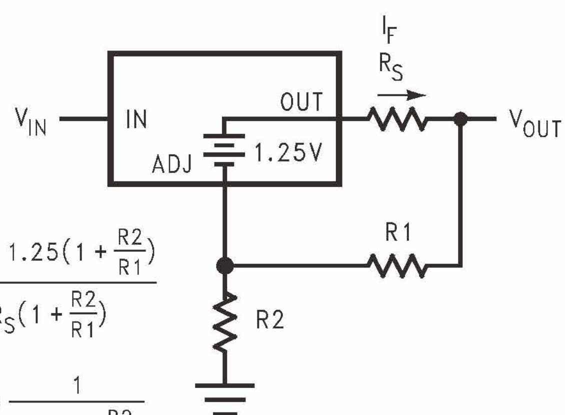


Figure 18. 5-V Regulator with Shutdown

Battery Charger

The LM1086-ADJ can be used as a battery charger to regulate the charging current required by the battery bank. In this application the LM1086 acts as a constant voltage, constant current part by sensing the voltage potential across the battery and compensating it to the current voltage. To maintain this voltage, the regulator delivers the maximum charging current required to charge the battery. As the battery approaches the fully charged state, the potential drop across the sense resistor, R_S,reduces and the regulator throttles back the current to maintain the float voltage of the battery.



$$I_F = \frac{V_{OUT} - 1.25(1 + \frac{R2}{R1})}{-R_S(1 + \frac{R2}{R1})}$$

$$\left(\frac{dI_F}{dV_{OUT}}\right) = \frac{1}{-R_S(1 + \frac{R2}{R1})}$$

Figure 19. Battery Charger

Ripple Rejection Enhancement

A very simple ripple rejection circuit is using the LM1086-ADJ. The capacitor C1 smooths out the ripple on the output by cleaning up the feedback path and preventing excess noise from feeding back into the regulator. Please remember X_{C1} should be approximately equal to R1 at the ripple frequency.

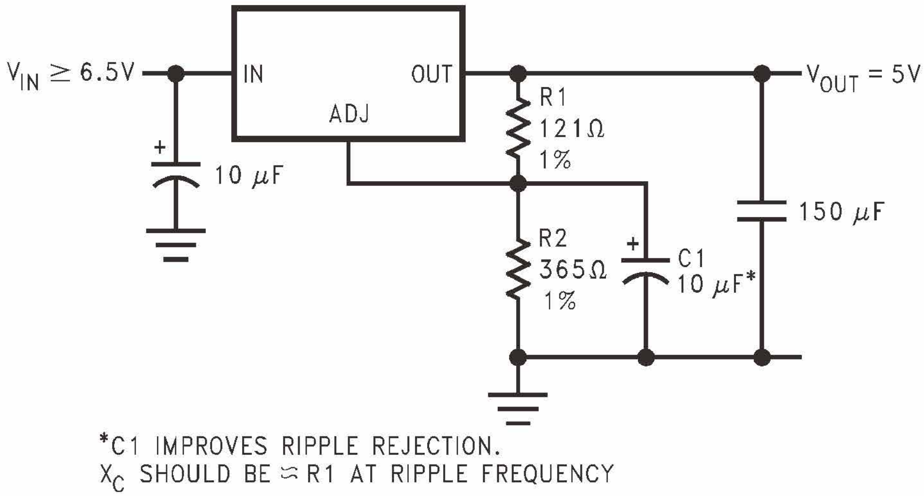


Figure 24. Ripple Rejection Enhancement

Automatic Light Control

A common street light control or automatic light control circuit is based on the LM1086-ADJ. The photo transistor conducts in the presence of light and grounds the ADJ pin preventing the lamp from turning on. However, in the absence of light, the LM1086 regulates the voltage to 1.25V between OUT and ADJ, ensuring the lamp remains on.

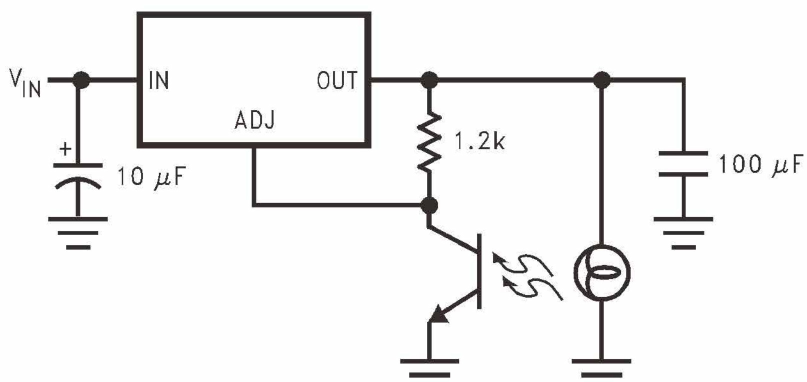
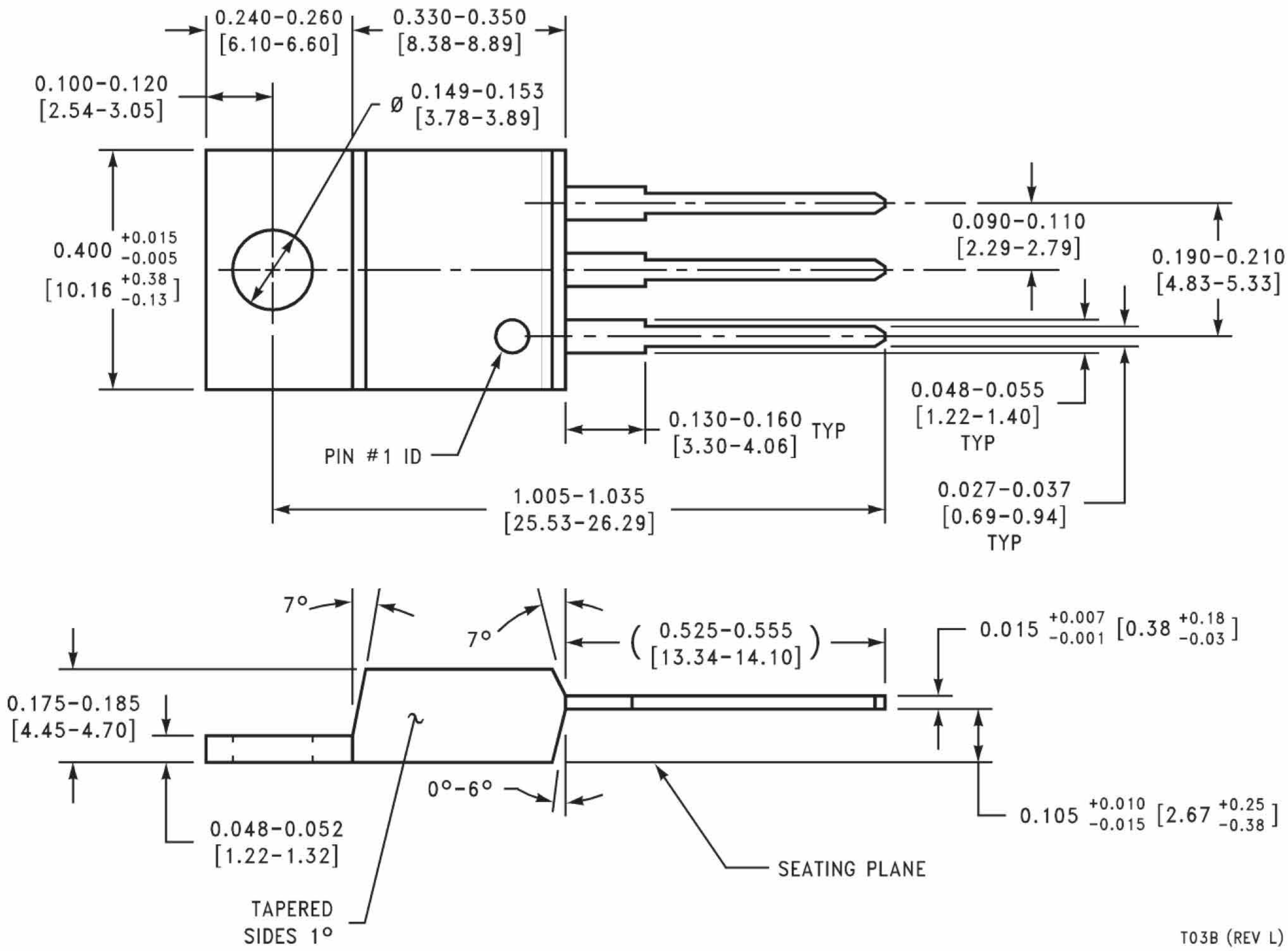


Figure 25. Automatic Light Control

TO-220 Package



TO-263 Package