800 mA Low Dropout Positive Voltage Regulator

MIK1117-XX   February 2000

Description

The MIK1117 series of positive adjustable and fixed regulators are designed to provide 800mA with higher efficiency than currently available devices. All internal circuitry is designed to operate down to 700 mV input to output differential and the dropout voltage is fully specified as a function of load current. Dropout voltage of the device is 100 mV at light loads and rising to 700 mV at maximum output current. A second low current input is required to achieve this dropout. The MIK1117 can also be used as a single supply device (3 pin version). On-chip trimming adjusts the reference voltage to 1%.

Features

- Adjustable or Fixed Output
- Output Current of 800mA
- Low Dropout, 700 mV at 800mA Output Current
- 0.015% Line Regulation
- 0.01% Load Regulation
- 100% Thermal Limit Burn-In
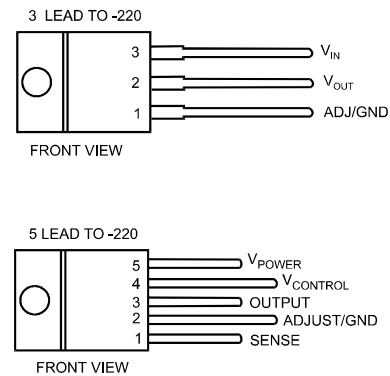- Fast Transient Response
- Remote Sense

Applications

- High Efficiency Linear Regulators
- Post Regulators for Switching Supplies
- Adjustable Power Supply

Typical application data 2.5V, 800mA regulator

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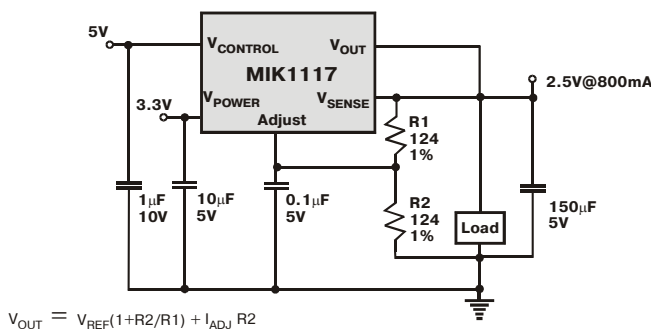
Package information

Absolute Maximum Ratings

Symbol	Parameter	Maximum	Units
P_D	Power Dissipation	Internally Limited	W
V_{IN}	Input Voltage		V
	Vpower	7	
	Vcontrol	13	
T_J	Operating Junction Temperature Range		^{o}C
	Control Section	0 to 125	
	Power Transistor	0 to150	
T_{STG}	Storage Temperature	-65 to 150	^{o}C
T_{LEAD}	Lead Temperature (Soldering, 10 sec)	300	^{o}C

Device Selection Guide (Note1)

Device	Output Voltage
MIK1117	Adj
MIK1117-1.5	1.5V
MIK1117-2.5	2.5V
MIK1117-2.85	2.85V
MIK1117-3.0	3.0V
MIK1117-3.3	3.3V
MIK1117-3.5	3.5V
MIK1117-5.0	5.0V

Note 1: Other fixed versions are available Vout = 1.5V to 5.0V

800 mA Low Dropout Positive Voltage Regulator

MIK1117-XX   February 2000

Electrical Characteristics (Note 1)

Electrical Characteristics at I_{LOAD} = 0 mA and T_J = +25°C unless otherwise specified.

Parameter	Device	Test Conditions		Min	Typ	Max	Units
Reference Voltage	MIK1117	$V_{CONTROL}$ = 2.75V, V_{POWER} = 2V, I_{LOAD} = 10mA		1.238	1.250	1.262	V
		$V_{CONTROL}$ = 2.7V to 12V, V_{POWER} = 3.3V to 5.5V, I_{LOAD} = 10mA to 800mA	*	1.230	1.250	1.270	
Output Voltage	MIK1117-1.5	$V_{CONTROL}$ = 4V, V_{POWER} = 2V		1.485	1.500	1.515	V
		$V_{CONTROL}$ = 3V, V_{POWER} = 2.3V, I_{LOAD} = 0mA to 800mA	*	1.475	1.500	1.525	
	MIK1117-2.5	$V_{CONTROL}$ = 5V, V_{POWER} = 3.3V		2.475	2.500	2.525	V
		$V_{CONTROL}$ = 4V, V_{POWER} = 3.3V, I_{LOAD} = 0mA to 800mA	*	2.460	2.500	2.540	
	MIK1117-2.85	$V_{CONTROL}$ = 5.35V, V_{POWER} = 3.35V		2.821	2.850	2.879	V
		$V_{CONTROL}$ = 4.4V, V_{POWER} = 3.7V, I_{LOAD} = 0mA to 800mA	*	2.805	2.850	2.895	
	MIK1117-3.0	$V_{CONTROL}$ = 5.5V, V_{POWER} = 3.5V		2.970	3.000	3.030	V
		$V_{CONTROL}$ = 4.5V, V_{POWER} = 3.8V, I_{LOAD} = 0mA to 800mA	*	2.950	3.000	3.050	
	MIK1117-3.3	$V_{CONTROL}$ = 5.8V, V_{POWER} = 3.8V		3.267	3.300	3.333	V
		$V_{CONTROL}$ = 4.8V, V_{POWER} = 4.1V, I_{LOAD} = 0mA to 800mA	*	3.247	3.300	3.353	
	MIK1117-3.5	$V_{CONTROL}$ = 6V, V_{POWER} = 4V		3.465	3.500	3.535	V
		$V_{CONTROL}$ = 5V, V_{POWER} = 4.3V, I_{LOAD} = 0mA to 800mA	*	3.445	3.500	3.555	
	MIK1117-5.0	$V_{CONTROL}$ = 7.5V, V_{POWER} = 5.5V		4.950	5.000	5.050	V
		$V_{CONTROL}$ = 6.5V, V_{POWER} = 5.8V, I_{LOAD} = 0mA to 800mA	*	4.920	5.000	5.080	
Line Regulation	All	I_{LOAD} = 10mA, (1.5V+ V_{OUT}) ≤ $V_{CONTROL}$ ≤ 12V, 0.8V ≤ (V_{POWER} - V_{OUT}) ≤ 5.5V	*		0.04	0.20	%
Load Regulation	All	$V_{CONTROL}$ = V_{OUT} +2.5V, V_{POWER} = V_{OUT} + 0.8V, I_{LOAD} = 10mA to 800mA	*		0.08	0.40	%
Minimum Load Current (Note 2)	MIK1117	$V_{CONTROL}$ = 5V, V_{POWER} = 3.3V, V_{ADJ} = 0V	*		1.7	5	mA
Control Pin Current (Note3)	All	$V_{CONTROL}$ = V_{OUT} +2.5V, V_{POWER} = V_{OUT} + 0.8V, I_{LOAD} = 10mA to 800mA	*		10	20	mA
Ground Pin Current	MIK1117-1.5/ -2.5/-2.85/ -3.0/-3.3/-3.5/- 5.0	$V_{CONTROL}$ = V_{OUT} +2.5V, V_{POWER} = V_{OUT} + 0.8V, I_{LOAD} = 10mA to 800mA	*		6	10	mA
Adjust Pin Current	MIK1117	$V_{CONTROL}$ = 2.75V, V_{POWER} = 2.05V, I_{LOAD} = 10mA	*		50	120	μA
Current Limit	All	$(V_{IN} - V_{OUT})$ = 3V	*	800	1100		mA
Ripple Rejection	All	$V_{CONTROL}$ = V_{POWER} = V_{OUT} + 2.5V, V_{RIPPLE} = 1V_{P-P}, I_{LOAD} = 400mA		60	75		dB
Thermal Regulation	MIK1117	T_A = 25°C, 30 ms pulse			0.003		%/W
Dropout Voltage		Note 4					
Control Input ($V_{CONTROL}$ - V_{OUT})	All	V_{POWER} = V_{OUT} +0.8V, I_{LOAD} = 10mA	*		1.00	1.15	V
		V_{POWER} = V_{OUT} + 0.8V, I_{LOAD} = 800mA	*		1.15	1.30	
Power Input (V_{POWER} - V_{OUT})	All	$V_{CONTROL}$ = V_{OUT} + 2.5V, I_{LOAD} = 800mA	*		0.55	0.70	V

The * denotes the specifications which apply over the full temperature range.

Note 1: Unless otherwise specified Vout = Vsense. For MIK1117 (adj) Vadj = 0V

Note 2: For the adjustable device 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 3: The control pin current is the drive current required for the output transistor. This current will track output current with a ratio of about 1:100.

Note 4: The dropout voltage for the MIK1117 is caused by either minimum control voltage or minimum power voltage. The specifications represent the minimum input/output voltage required to maintain 1% regulation.

800 mA Low Dropout Positive Voltage Regulator

MIK1117-XX   February 2000

Pin Functions (5-Lead)

Sense (Pin 1): This pin is the positive side of the reference voltage. With this pin it is possible to Kelvin sense the output voltage at the load.

Adjust (Pin 2): This pin is the negative side of the reference voltage. Adding a small bypass capacitor from the Adjust pin to ground improves the transient response. For fixed voltage devices the Adjust pin is also brought out to allow the user to add a bypass capacitor.

GND (Pin 2): For fixed voltage devices this is the bottom of the resistor divider that sets the output voltage.

VPOWER (Pin 5): This pin is the collector of the power transistor. The output load current is supplied through this pin. The voltage at this pin must be 0.7V greater than the output voltage for the device to regulate.

VCONTROL (Pin 4): This pin is the supply pin for the control circuitry. The current flow into this pin will be about 1% of the output current. The voltage at this pin must be 1.3V greater than the output voltage for the device to regulate.

Output (Pin 3): This is the power output of the device.

Block Diagram

800 mA Low Dropout Positive Voltage Regulator
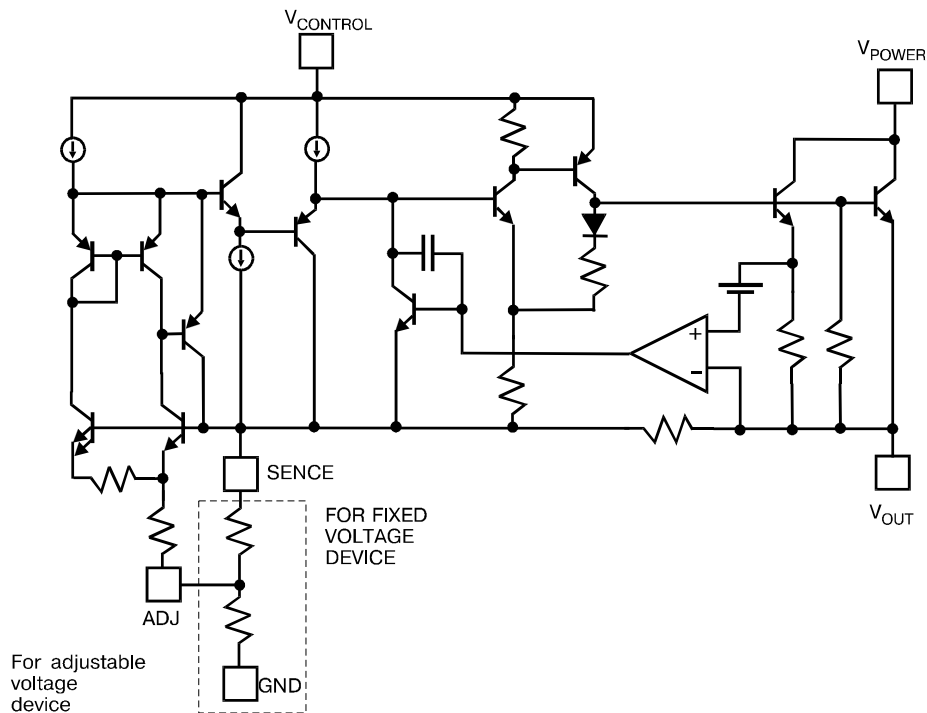
Application Information

The MIK1117 is designed to make use of multiple power supplies, 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 equal to about 1% of the output current. This drive current becomes part of the output current. The maximum voltage on the Control pin is 12V. The maximum voltage at the Power pin is 7V. By tying the control and power inputs together the MIK1117 can also be operated as a single supply device. In single supply operation the dropout will be determined by the minimum control voltage.

Both the fixed and adjustable versions have remote sense pins, permitting very accurate regulation of output voltage. As a result, over an output current range of 100mA to 800mA, the typical load regulation is less than 1mV. For the fixed voltages the adjust pin is brought out allowing the user to improve transient response by bypassing the internal resistor divider. Optimum transient response is provided using a capacitor in the range of 0.1µF to 1µF for bypassing the Adjust pin.

In addition to the enhancements mentioned, the reference accuracy has been improved a factor of two with a quaranteed initial tolerance of ±1% at 25^{0}C and 1.6% accuracy over the full temperature and load current range.
Typical applications for the MIK1117 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. The device is fully protected against overcurrent and overtemperature conditions.

Grounding and Output Sensing

The MIK1117 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. R_P 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 output regulation can be seen in trace B of figure 2.

It is important to note that the voltage drops due to R_P are not eliminated; they will add to the dropout voltage of the regulator regardless. The MIK1117 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 R_P.
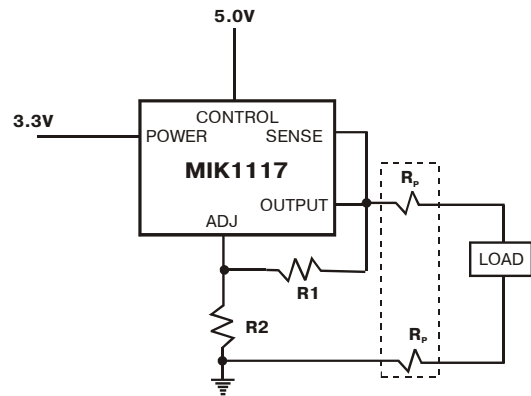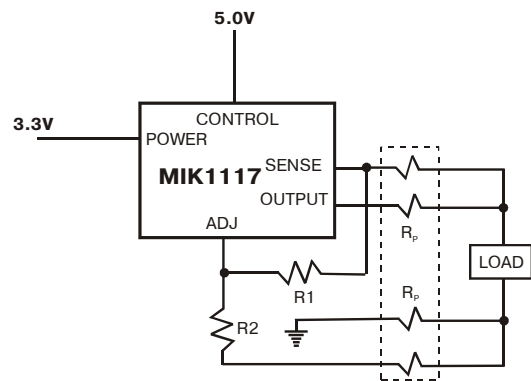

Figure 1. Conventional Load Sensing
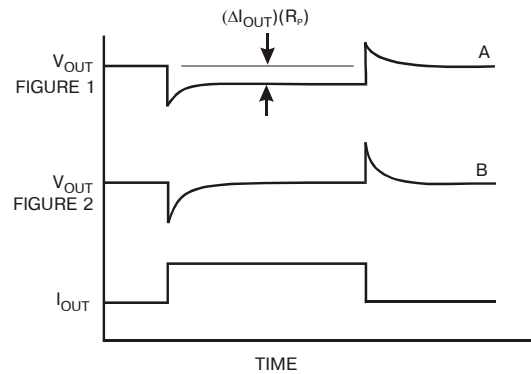

Figure 2. Remote Load Sensing

Figure 3. Remote Sensing Improves Load Regulation

Stability

The circuit design used in the MIK1117 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.

800 mA Low Dropout Positive Voltage Regulator

MIK1117-XX   February 2000

Output Voltage

The MIK1117 (adjustable version) develops a 1.25V reference voltage between the Sense pin and the Adjust pin (Figure 4). Placing a resistor between these two terminals causes a constant current to flow though R1 and down though R2 to set the output voltage. In general R1 is chosen so that this current is the specified minimum load current of 10 mA. The current out of the Adjust pin is small, typically 50µA and it adds to the current from R1. For best regulation the top of the resistor divider should be connected directly to the Sense pin.
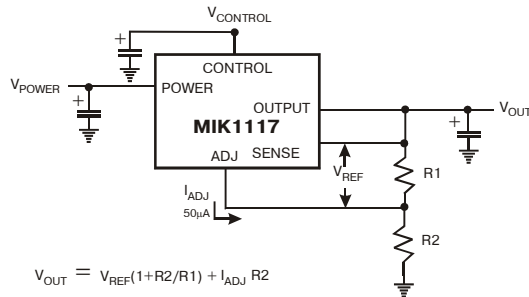
$$V_{OUT} = V_{REF}(1+R2/R1) + I_{ADJ}\, R2$$

Figure 4. Setting Output Voltage

Protection Diodes

In normal operation MIK1117 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 to 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 1000µF to 5000µF and the V_{POWER} pin is instantaneously shorted to ground, damage can occur. A diode from output to input is recommended (Figure 5).
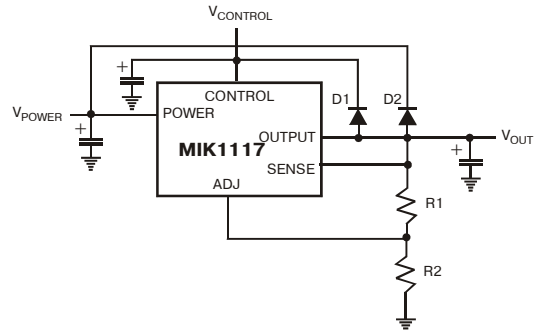

Figure 5. Optional Clamp Diodes Protect Against Input Crowbar Circuits

If MIK1117 is connected as a single supply device with the control and power input pins shorted together the internal diode between the output and the power input pin will protect the control input pin.

Thermal Considerations

The MIK1117 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.

Junction temperature of the Control section can run up to 125°C. Junction temperature of the Power section can run up to 150°C.

Pad Location MIK1117-XX
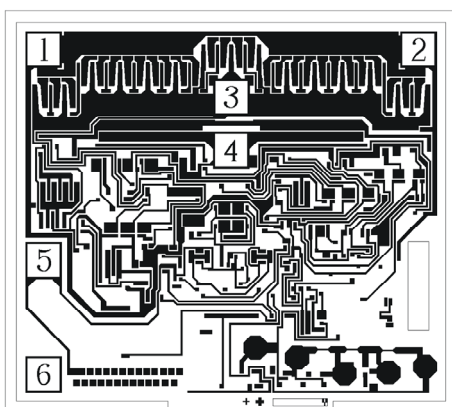
Chip size 2.0 mm x 1.78 mm

Pad Location Coordinates

N	Pad Name	Pad size (µm × µm)	Coordinates (µm)	
			X	Y
1	Output	140 × 140	100	1540
2	Output	140 × 140	1760	1540
3	V_{POWER} (Note1)	140 × 140	930	1325
4	$V_{CONTROL}$ (Note1)	140 × 140	930	1095
5	Sense (Note 1)	140 × 140	100	605
6	Adjust (adjustable output) GND (fixed output)	140 × 140	100	100

Note 1: For 3-lead version connect 3, 4 pad to V_{IN} and 5 pad to Output.