

**Overview**

Specifications such as efficiency, ripple and input voltage range are a function of output voltage settings. As the output voltage is trimmed down, efficiency goes down; ripple as a percent of  $V_{OUT}$  goes up and the input voltage range widens since input voltage dropout (loss of regulation) moves down. As the units are trimmed up, the reverse of the above effects occurs.

All converters have a fixed current limit. The overvoltage protection setpoint is also fixed; trimming the output voltage does not alter its setting. As the output voltage is trimmed down, the current limit setpoint remains constant. Therefore, in terms of output power, if the unit is trimmed down, available output power drops accordingly.

The output voltage of most Vicor converters can be trimmed +10%, -50%. Certain modules have restricted trim ranges. Consult the latest datasheet for details.

Do not attempt to trim the module output voltage more than +10%, as overvoltage shut down may occur. Do not exceed maximum rated output power when the module is trimmed up.

**Caution:** When trimming up VI-/MI-J00 converter modules, additional care should be taken as an improper component selection could result in module failure. Improper connection of the sense leads on VI-/MI-J00 converter modules can also result in an excessive overvoltage condition and module failure.

The following procedures describe methods for output voltage adjustment (-10 to +10% of nominal) of the VI-/MI-200, VI-/MI-J00, ComPAC/MI-ComPAC, FlatPAC and MegaMod/MI-MegaMod families.

Modules with nominal 3.3V outputs and above have the 2.5V precision reference and 10kΩ internal resistor. For trim resistor calculations on modules with 2.0V outputs use 0.97V in place of the 2.5V reference and substitute 3.88kΩ for the internal 10kΩ resistor.

Resistors are 0.25W. When trimming down any module, always maintain a minimum preload of at least 1% of rated output power and in some cases up to 10% may be required. For more specific information on trimming down a specific module, please consult the Vicor Applications Engineering Department at (800) 927-9474.

**Resistive Adjustment Procedure**

To achieve a variable trim range, an external resistor network must be added. (Figure 5.1)

**Example 1:** For trimming -10% to +10% with a standard off-the-shelf 10kΩ potentiometer (R7), values for resistors R6 and R8 need to be calculated.

Resistor R6 limits the trim down range. For a given percentage, its value is independent of output voltage. Refer to [Table 5.1](#), for limiting resistor values.

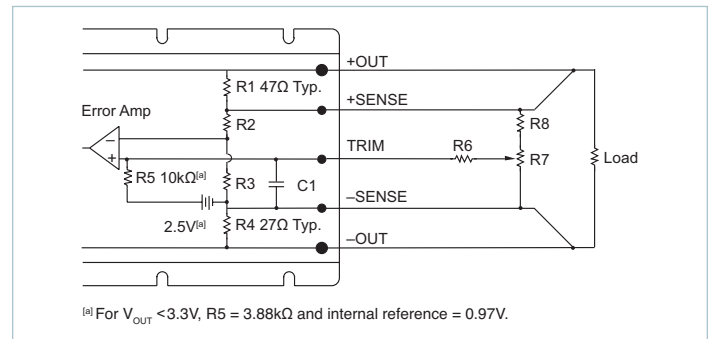


Figure 5.1 — External resistive network for variable trimming

**Trimming Down -10%**

A 10% drop of the 2.5V reference at the trim pin is needed to effect a 10% drop in the output voltage. (Figure 5.2)

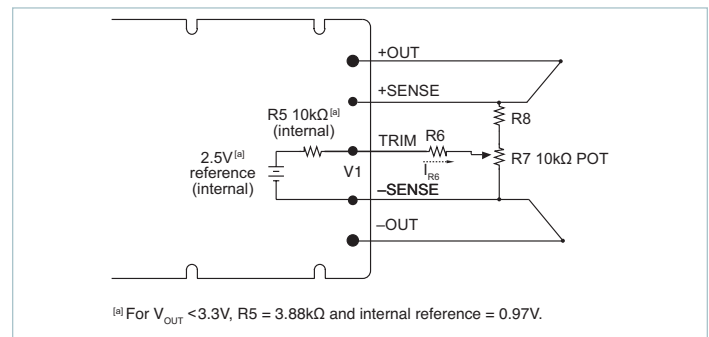


Figure 5.2 — Circuit diagram "Trim Down"

$$V_1 = 2.5V - 10\% = 2.25V$$

Therefore:

$$I_{R5} = \frac{(2.5V - 2.25V)}{10k\Omega} = 25\mu a$$

Since  $I_{R5} = I_{R6} = 25\mu A$ :

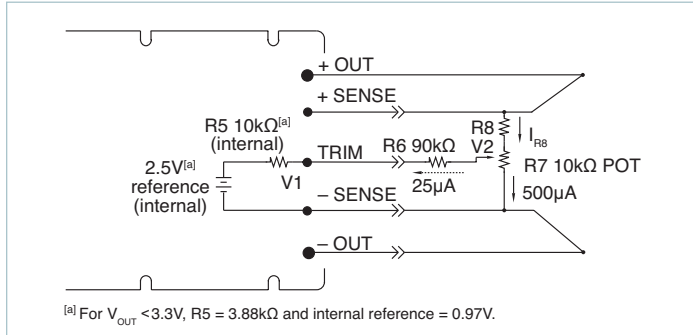
$$R6 = \frac{2.25V}{25\mu a} = 90k\Omega$$

This value will limit the trim down range to -10% of nominal output voltage.

**Trimming Up +10%**

To trim 10% above the nominal output voltage, the following calculations are needed to determine the value of R8. This calculation is dependent on the output voltage of the module. A 12V output will be used as an example. (Figure 5.3)

It is necessary for the voltage at the trim pin to be 10% greater than the 2.5V reference. This offset will cause the error amplifier to adjust the output voltage up 10% to 13.2V.



**Figure 5.3** — Circuit diagram “Trim Up”

$$V_i = 2.5V + 10\% = 2.75V$$

$$I_{R5} = \frac{(2.5V - 2.25V)}{10k\Omega} = 25\mu A$$

Since  $I_{R5} = I_{R6}$ , the voltage drop across R6 = (90kΩ) (25μA) = 2.25V.

Therefore,  $V_2 = 2.75V + 2.25V = 5V$ . The current through R7 (10kΩ pot) is:

$$I_{R7} = \frac{V_2}{R7} = \frac{5}{10k\Omega} = 500\mu A$$

Using Kirchoff’s current law:

$$I_{R8} = I_{R7} + I_{R6} = 525\mu A$$

Thus, knowing the current and voltage, R8 can be determined:

$$V_{R8} = (V_{OUT} + 10\%) - V_2 = 13.2V - 5V = 8.2V$$

$$R8 = \frac{(8.2V)}{525\mu A} = 15.6k\Omega$$

This resistor configuration allows a 12V output module to be trimmed up to 13.2V and down to 10.8V. Follow this procedure to determine resistor values for other output voltages.

**Fixed Trim**

Converters can be trimmed up or down with the addition of one external resistor, either  $R_U$  for programming up or  $R_D$  for programming down. (Figure 5.4)

**Example 2:** Fixed Trim Up (12V to 12.6V).

To determine  $R_U$ , the following calculation must be made:

$$2.5V + 5\% = 2.625V$$

$$V_{R5} = V_{TRIM} - V_{REF}$$

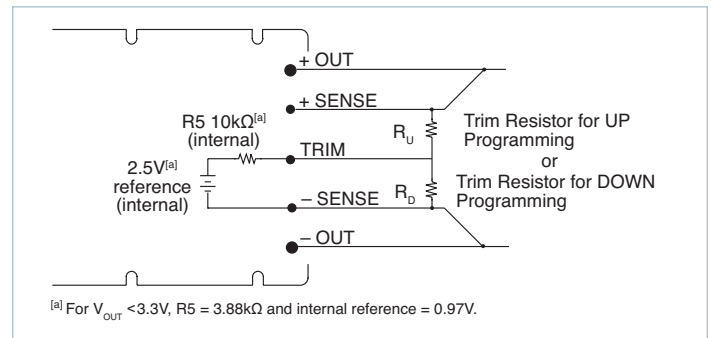
$$V_{R5} = 2.625 - 2.5 = 0.125V$$

Knowing this voltage, the current through R5 can be found:

$$I_{R5} = \frac{V_{R5}}{R5} = \frac{0.125}{10k\Omega} = 12.5\mu A$$

$$V_{Ru} = 12.6V - 2.625V = 9.975V$$

$$R_u = \frac{9.975}{12.5\mu A} = 798k\Omega$$



**Figure 5.4** — Fixed trimming

Connect  $R_U$  from the trim pin to the +SENSE. Be sure to connect the resistor to the +SENSE, not the +OUT, or drops in the positive output lead as a function of load will cause apparent load regulation problems.

**Example 3:** –25% Fixed Trim Down (24V to 18V).

The trim down methodology is identical to that used in Example 2, except that it is utilized to trim the output of a 24V module down 25% to 18V. The voltage on the trim pin must be reduced 25% from its nominal setting of 2.5V. This is accomplished by adding a resistor from the trim pin to –SENSE.

$$2.5V - 25\% = 1.875V$$

$$V_{R5} = V_{BANDGAP} - V_{TRIM}$$

$$= 2.5V - 1.875V = 0.625V$$

Knowing this voltage, the current through R5 can be found:

$$I_{R5} = \frac{V_{R5}}{R5} = \frac{0.625}{10k\Omega} = 62.5\mu a$$

The voltage across the resistor, R<sub>D</sub>, and the current flowing through it are known:

$$R_D = \frac{(2.5V - 0.625V)}{62.5\mu a} = 30k\Omega$$

Connect R<sub>D</sub> (Figure 5.4) from the TRIM pin to the –SENSE of the module. Be sure to connect the resistor to the SENSE, not the –OUT, or drops in the negative output lead as a function of load will cause apparent load regulation problems.

Values for Trim Down by Percentage	
Percent	Resistance
-5%	190kΩ
-10%	90kΩ
-15%	56.7kΩ
-20%	40kΩ
-25%	30kΩ
-30%	23.3kΩ
-35%	18.6kΩ
-40%	15kΩ
-45%	12.2kΩ
-50%	10kΩ

**Table 5.1** — Values for trim down by percentage (Refer to product data sheet for allowable trim ranges at vicorpower.com)

Fixed Trim Down		
V <sub>NOM</sub>	V (Desired)	Trim Resistor <sup>[a]</sup>
5V	4.5V	90.9kΩ
	3.3V	19.6kΩ
	2.5V	10.0kΩ
15V	13.8V	115kΩ
	20V	49.9kΩ
48V	40V	49.9kΩ
	36V	30.1kΩ

**Table 5.2a** — Values for fixed trim down by voltage

Fixed Trim Up		
V <sub>NOM</sub>	V (Desired)	Trim Resistor <sup>[a]</sup>
5V	5.2V	261kΩ
	5.5V	110kΩ
12V	12.5V	953kΩ
	13.2V	422kΩ
15V	15.5V	1.62MΩ
	16.5V	562kΩ
24V	25V	2.24MΩ
48V	50V	4.74MΩ

**Table 5.2b** — Values for fixed trim up by voltage

<sup>[a]</sup> Values listed in the tables are the closest standard 1% resistor values.

**Dynamic Adjustment Procedure**

Output voltage can also be dynamically programmed by driving the TRIM pin from a voltage or current source; programmable power supplies and power amplifier applications can be addressed in this way. For dynamic programming, drive the TRIM pin from a source referenced to the negative sense lead, and keep the drive voltage in the range of 1.25 – 2.75V. Applying 1.25 – 2.5V on the TRIM pin corresponds to 50 – 100% of nominal output voltage. For example, an application requires a +10, 0% (nominal), and a –15% output voltage adjustment for a 48V output converter. Referring to the table below, the voltage that should be applied to the trim pin would be as follows:

V <sub>TRIM</sub>	V <sub>OUT</sub>	Change from Nominal
2.125	40.8	-15%
2.5	48	0
2.75	52.8	+10%

The actual voltage range is further restricted by the allowable trim range of the converter. Voltages in excess of 2.75V (+10% over nominal) may cause overvoltage protection to be activated. For applications where the module will be programmed on a continuous basis the slew rate should be limited to 30Hz sinusoidal.

**Trimming on the Web (vicorpower.com)**

Trim values are calculated automatically. Design Calculators are available on the Vicor website in the PowerBench™ section at: [www.vicorpower.com/powerbench](http://www.vicorpower.com/powerbench).

Resistor values can be easily determined for fixed trim up, fixed trim down and for variable trimming applications.

In addition to trimming information, the website also includes design tips, applications circuits, EMC suggestions, thermal design guidelines and PDF data sheets for all available Vicor products.

