Output Voltage Trimming

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 all Vicor converters can be trimmed ±10%. Certain modules can be trimmed down to 50% of nominal output.

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

The following procedures describe methods for output voltage adjustment (–50 to +10% of nominal) of the VI-200, MI-200, VI-J00, MI-J00, ComPAC, FlatPAC and Mega Modules.

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

NOTE: Resistors are 1/4W. When trimming down any module, always maintain a preload of 1% of rated output power. For more specific information on trimming down a specific module, please consult Vicor's Applications Engineering Department.

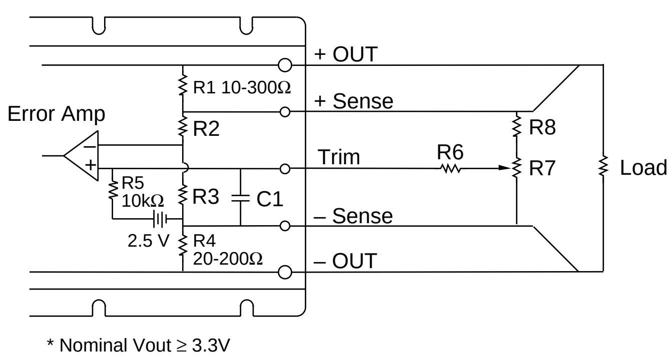
Resistive Adjustment Procedure

To achieve a variable trim range, an external resistor network must be added. Refer to Figure 1.

Example 1.
For trimming –20% to +10% with a standard off-the-shelf 10 kΩ 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 <u>independent</u> of output voltage. Refer to Table 1, page 5-4, for limiting resistor values.

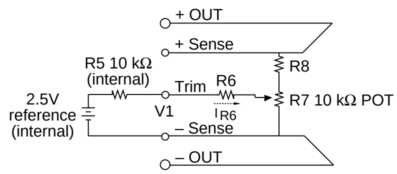
Figure 1. External Resistive Network for Variable Trimming



Trimming Down –20%

A 20% drop of the 2.5V reference at the trim pin is needed to effect a 20% drop in the output voltage. Refer to Figure 2.

Figure 2.
Circuit Diagram
"Trim Down"



$V_1 = 2.5V – 20\% = 2V$

Therefore:

$$I_{R5} = \frac{(2.5V - 2V)}{10\ k\Omega} = 50\ \mu A$$

Since $I_{R5} = I_{R6} = 50\ \mu A$:

$$R6 = \frac{2V}{50\ \mu A} = 40\ k\Omega$$

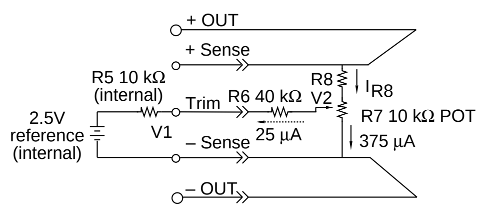
This value will limit the trim down range to –20% of nominal output voltage.

Trimming Up +10%

To trim +10% above 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. Refer to Figure 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 3.
Circuit Diagram
"Trim Up"



$V_1 = 2.5V + 10\% = 2.75V$

$$I_{R5} = \frac{(2.75V - 2.5V)}{10\ k\Omega} = 25\ \mu A$$

Since $I_{R5} = I_{R6}$, the voltage drop across R6 = (40 kΩ) (25 µA) = 1V.

Therefore, $V_2 = 2.75V + 1V = 3.75V$. The current through R7 (10 kΩ pot) is:

$$I_{R7} = \frac{V_2}{R7} = \frac{3.75}{10\ k} = 375\ \mu A$$

Trimming Up +10% (cont)

Using Kirchoff's current law:

$I_{R8} = I_{R7} + I_{R6} = 400\ \mu A$

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

$V_{R8} = (V_{out} + 10\%) – V_2 = 13.2V – 3.75V = 9.45V$

$$R8 = \frac{(9.45V)}{400\ \mu A} = 23.63\ k\Omega$$

This resistor configuration allows a 12V output module to be trimmed up to 13.2V and down to 9.6V. Follow this procedure to determine resistor values for other output voltages.

Fixed Trim

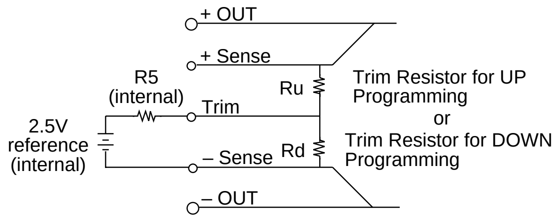
Converters can be trimmed up or down with the addition of one external resistor, either Ru for programming up or Rd for programming down. Refer to Figure 4 below.

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

To determine Ru, the following calculation must be made:

$2.5V + 5\% = 2.625V$
$V_{R5} = V_{trim} – V_{ref}$
$V_{R5} = 2.625 – 2.5 = 0.125V$

Figure 4.
Fixed Trimming



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

$$I_{R5} = \frac{V_{R5}}{R5} = \frac{.125V}{10\ k\Omega} = 12.5\ \mu A$$

$V_{Ru} = 12.6V – 2.625V = 9.975V$

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

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

Fixed Trim (cont)

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 negative sense.

2.5V – 25% = 1.875V
$V_{R5} = V_{bandgap} - V_{trim}$
= 2.5V – 1.875V = .625V

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

$$I_{R5} = \frac{V_{R5}}{R5} = \frac{.625V}{10\ k\Omega} = 62.5\ \mu A$$

The voltage across the resistor, Rd, and the current flowing through it are known:

$$Rd = \frac{(2.5V - .625V)}{62.5\ \mu A} = 30\ k\Omega$$

Connect Rd (Figure 4) from the trim pin to the negative sense of the module. Be sure to connect the resistor to the negative sense, not the negative output, or drops in the negative output lead as a function of load will cause apparent load regulation problems.

Table 1.
Values for Trim Down by Percentage

Percent	Resistance
–5%	190
–10%	90 kΩ
–15%	56.7 kΩ
–20%	40 kΩ
–25%	30 kΩ
–30%	23.3 kΩ
–35%	18.6 kΩ
–40%	15 kΩ
–45%	12.2 kΩ
–50%	10 kΩ

Tables 2a and 2b.
Values for Fixed Trim Down and Trim Up by Voltage

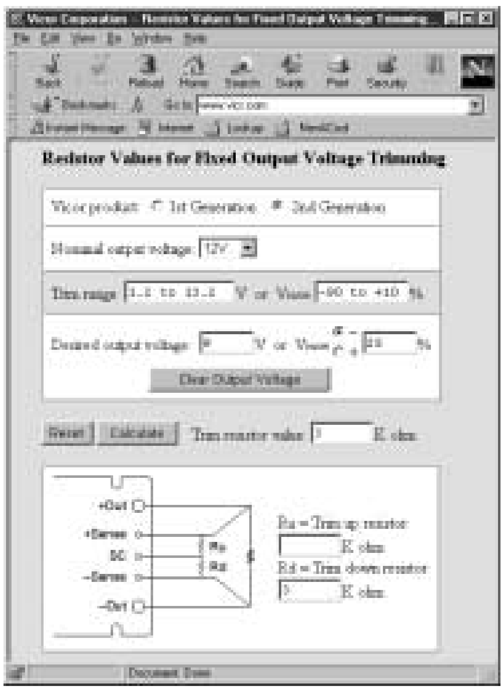
Fixed Trim Down		
Vnom	**V (Desired)**	**Trim Resistor**
5V	4.5V	90.9 kΩ
	3.3V	19.6 kΩ
	2V	6.65 kΩ
12V	10V	49.9 kΩ
15V	13.8V	115 kΩ
24V	20V	36.5 kΩ
48V	40V	49.9 kΩ
	36V	30.1 kΩ

Fixed Trim Up		
Vnom	**V (Desired)**	**Trim Resistor**
5V	5.2V	261 kΩ
	5.5V	110 kΩ
12V	12.5V	953 kΩ
	13.2V	422 kΩ
15V	15.5V	1.62 MΩ
	16.5V	562 kΩ
24V	25V	2.24 MΩ
48V	50V	4.74 MΩ

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 to 2.5V on the trim pin corresponds to 50% to 100% of nominal output voltage. 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 operating frequency should be limited to 30 Hz.

Trimming on the Web



Trim values calculated automatically:

Resistor trim calculators are available on Vicor’s web site at URL: www.vicr.com/tools.html or by requesting a copy of Vicor’s Applications Manual on a CD ROM.

Resistor values can be calculated for fixed trim up, fixed trim down and for variable trim up or down cases for both 1st and 2nd Generation DC/DC converters.

In addition to trimming information, the web site and the applications manual on CD ROM, also includes design tips, applications circuits, EMC suggestions, thermal design guidelines and PDF data sheets for all available Vicor products.