

## Design Idea

# Precision active load operates as low as 2V

Self-powered active load matches low-voltage sources.

By Joel Setton, Crolles, France; Edited by Brad Thompson and Fran Granville -- EDN, 8/4/2005

This Design Idea presents a self-powered, precision-active-load circuit that improves on a previously published design ([Reference 1](#)). Added features include a wider operating-voltage range of 2 to 50V or higher and several flexible current-setting modes. The circuit in [Figure 1](#) uses National Semiconductor's LM10, which suits this application. The LM10's reference section, IC<sub>1A</sub>, generates a precision 1.2V reference voltage, V<sub>S</sub>. Resistive divider R<sub>1</sub> and R<sub>2</sub> applies a fraction of V<sub>S</sub> to IC<sub>1A</sub>'s reference amplifier, which drives shunt regulator Q<sub>1</sub>.

Transistor Q<sub>3</sub> acts as a current mirror of transistor Q<sub>2</sub>'s collector current and supplies power to shunt regulator Q<sub>1</sub>. Resistors R<sub>9</sub> and R<sub>7</sub> set the current-mirror ratio, and the current through resistor R<sub>9</sub> depends on the current through R<sub>6</sub>, which V<sub>S</sub> establishes. As a result, Q<sub>3</sub>, which mirrors the collector current of Q<sub>2</sub>, provides power to the shunt regulator. V<sub>S</sub> sets R<sub>6</sub>, which determines the current through R<sub>9</sub>. Thus, the LM10's reference section regulates both its own power-supply voltage and the current that Q<sub>3</sub> provides.

At power-on, Q<sub>2</sub>, Q<sub>3</sub>, and Q<sub>4</sub> are all off. Resistor R<sub>10</sub> draws a small amount of start-up current, which Q<sub>3</sub> amplifies to start the current-mirror process. When sufficient current flows through R<sub>7</sub>, Q<sub>4</sub> saturates, and R<sub>9</sub> and R<sub>7</sub> then set the current-mirror ratio. The active load's power-handling section comprises the LM10's operational-amplifier section, IC<sub>1B</sub>, and power transistors Q<sub>6</sub> and Q<sub>8</sub>. A 10-turn precision potentiometer, P<sub>1</sub>, and range-selection switch, S<sub>1</sub>, set the load current as follows:

On Range A, the load current varies at 1A per turn of P<sub>1</sub>—that is, 10A maximum with P<sub>1</sub> set fully clockwise. On Range B, the load current varies at 100 mA per turn of P<sub>1</sub>—that is, 1A maximum with P<sub>1</sub> set fully clockwise. On Range C, an external voltage source that connects to R<sub>13</sub> controls the load current at a rate of 1A per volt with P<sub>1</sub> set fully clockwise. You can drive the external input with a function generator to test a power supply's transient response. On Range D, the load circuit emulates an adjustable power resistor with load current proportional to the voltage across the load's terminals. The equivalent resistance varies with P<sub>1</sub>'s setting—that is,  $R_{LOAD} = 100 \cdot V / I_{TURN}$ . Range E is similar to D, with a resistance of  $10 \cdot V / I_{TURN}$ .

To calibrate the circuit, connect it to a suitable power supply delivering any voltage from 2 to 50V. First, set P<sub>1</sub> to one turn—that is, one-tenth of full-scale—and S<sub>1</sub> to Range B. Adjust R<sub>17</sub> for a 100-mA output current. Then, rotate P<sub>1</sub> fully clockwise and adjust R<sub>20</sub> to set the output current to 1A. Repeat these two adjustments in sequence because they interact slightly. Current that IC<sub>1</sub> draws through Q<sub>3</sub> sets the minimum current through the load circuit at slightly less than 1 mA.

Because the circuit operates at 2 to 50V, it is suitable for testing the low-voltage outputs of a PC's power supply. You can extend the maximum voltage by selecting suitable transistors for Q<sub>2</sub>, Q<sub>3</sub>, and Q<sub>5</sub> through Q<sub>8</sub>; the LM10's

regulated power-supply voltage does not link to the external voltage. Note that when dissipating large amounts of power, transistors Q<sub>6</sub> and Q<sub>8</sub> require adequate cooling to maintain safe junction temperatures.

## Reference

1. Toffoli, Tommaso, "Self-powered dummy load checks out multiple power supplies," *Electronic Design*, April 17, 2000, pg 118.

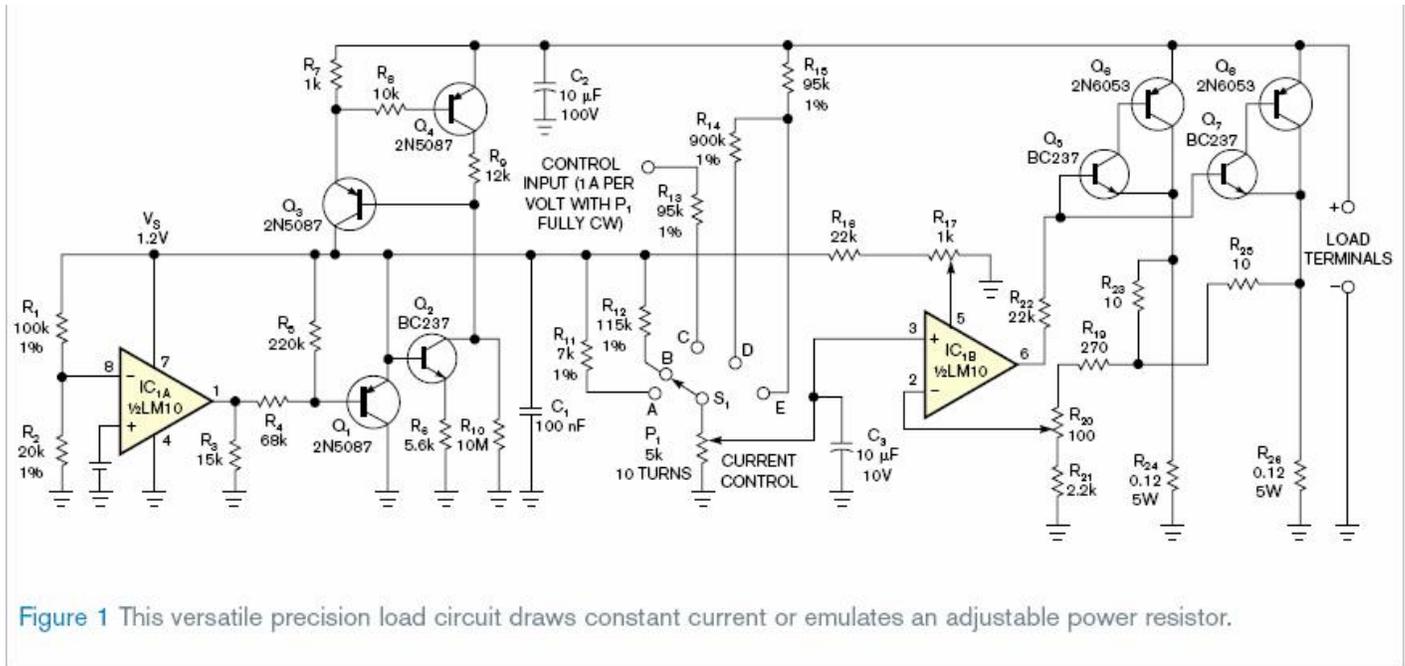


Figure 1 This versatile precision load circuit draws constant current or emulates an adjustable power resistor.