higher than that of an equivalently sized bipolar device. The Menegoli circuit also has a control device in series with the pass device which increases the overall output impedance, and while the power source for the error amplifier is not specified, the remaining control circuitry is powered by the potentially noisy input power supply.

[0016] FIG. **1**, from Roberts, John H., "Preeminent Preamp", *The Audio Amateur,* 3/1985, contains a schematic diagram of a prior art circuit that is bootstrapped, deriving the power for much of its internal circuitry from the regulated output rather than from the unregulated input. Using the regulated output voltage provides the advantage of isolating the reference and its associated circuitry from any noise present on the unregulated input voltage, noise being defined as any signal deviant from a perfect DC voltage. The Roberts circuit requires both a positive and a negative input and output voltage, thus cannot be simplified into a single supply circuit. Also VOUT (pos) and VOUT (neg) are the reference nodes for their opposite polarity outputs, allowing load induced transients from one polarity output to affect the other polarity output.

[0017] Prior art in FIG. **2** illustrates another bootstrapped circuit with error amplifier A**1** and reference REF**1** powered by the output signal. This circuit uses a zener diode to drop the voltage level at the output of A**1** to a value within the power supply range of the amplifier, that is, less than VOUT. An article describing this circuit [Jung, Walt "Improved Positive/Negative Regulators", *Audio Electronics,* 4/2000] notes problems with circuit startup, wherein the circuit has a valid stable state that does not yield the desired VOUT. FIG. **2** requires two resistors and a diode to generate a VIN referred bias current to control the output device. Modification of VOUT in FIG. **2** requires a change to either R**1** or R**2**, which changes the loop bandwidth, adversely affecting load regulation. Another prior art using a bootstrap power supply for some portion of a voltage regulator is seen in U.S. Pat. No. 6,198,266 B1, Mercer, 3/2001.

[0018] Reliability of voltage regulators is very important, and a common circuit known as a fold-back current limit is described in "New Developments in IC Voltage Regulators", Robert J. Widlar, *IEEE J. Solid-State Circuits*, vol. SC-6, pp. 2-7, February 1971. Fold-back current limiting uses a sense resistor in the path between regulator output and load to sense the current delivered by the regulator and limit the output current to a value that will prevent destruction of the regulator due to heat from excessive power dissipation. However, use of a fold-back sense resistor increases the output impedance of the regulator.

[0019] Thus a voltage regulator is desirable that provides high line and load rejection, low output impedance, low drop out, low device count, simple architecture, flexible usage, can be manufactured with discrete devices or in integrated form, has wide VOUT range that can be varied by changing a single component, with a means to limit output current without increasing output impedance.

SUMMARY OF THE INVENTION

[0020] The present invention provides a low dropout regulator with high line and load regulation and widely adjustable output voltage, low output impedance and output current limiting using a simple low element count architecture with floating reference and error correction elements, with output voltage value set via a single circuit element, and error loop bandwidth independent of output voltage.

DRAWINGS

Figures

[0021] FIG. **1** shows prior art of a voltage regulator with bootstrapped power to a portion of its circuitry.

[0022] FIG. **2** shows prior art of a voltage regulator with ground referenced bootstrapped power to a portion of its circuitry, using a zener diode to allow an error amplifier to operate within its power supply range.

[0023] FIG. **3** shows a simplified primary embodiment of the present invention, with floating reference and error amplifier.

[0024] FIG. **4** is a detailed primary embodiment of the present invention, with floating reference and error amplifier, having adjustable output voltage by modifying the value of a single resistor.

[0025] FIG. **5** is an extension of the primary embodiment showing a novel means to limit output current without increasing output impedance.

[0026] FIG. **6** is an extension of the embodiment of FIG. **5** showing a means to maintain low dropout voltage while allowing output current limit without increasing output impedance.

[0027] FIG. **7** is an extension of the primary embodiment wherein a constant current is generated from an additional voltage source by using a fixed resistor as a load.

[0028] FIG. **8** is an extension of the primary embodiment wherein the output voltage is modulated by a voltage source.

[0029] FIG. **9** is a negative output voltage embodiment of the primary embodiment of FIG. **4**.

DESCRIPTION

FIGS. **3** and **4**

Preferred Embodiment

[0030] The described invention uses a novel circuit configuration of standard devices to provide a voltage regulator with low output impedance, low dropout voltage, high line and load rejection. The invention can be assembled using existing individual circuit components or can be designed as a single integrated circuit. It can deliver any regulated output voltage value with a change in a single component, with constant loop bandwidth and no substantial difference in performance for one output voltage versus another. The invention makes use of a characteristic of depletion mode field effect transistors (FET) in which current is conducted when the gate voltage equals the source voltage (VGS=0) and current is gradually cut off as gate voltage decreases below (for N channel FET) or increases above (for P channel FET) the source voltage.

[0031] The embodiment of FIG. **3** comprises a reference voltage device REF**1**, an error amplifier A**1**, a feedback network R**8** plus R**9**, an offset voltage generator OFFSET, a load network LOAD, an N channel junction field effect driver transistor J**1** and an NPN bipolar output transistor Q**1**. All sections denoted by block **100** are powered by the output voltage from the emitter of Q**1**, giving the block a fixed and stable self-generated bootstrapped voltage source. The bootstrapped supply isolates the entire circuit excepting the two output devices J**1** and Q**1** from electrical noise on the VIN supply to provide high line regulation. The combination of