Keywords: voltage regulation, op amps, pnp transistors, linear regulators

APPLICATION NOTE 4405

# Spare Op Amp Generates Its Own Regulated Negative Supply

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*Abstract: This application note shows how to use a spare op amp to generate a regulated negative voltage supply, used to power the op amp itself as well as other low current circuitry. The regulated negative supply is generated from a regulated positive voltage and an unregulated negative voltage.*

This design idea appeared in the April 14, 2006 issue of *EE Times*.

For systems that require low current (100mA or less) and include a spare op amp along with unregulated positive and negative voltages, the circuit of **Figure 1** generates a regulated positive and negative supply voltage. The op amp then operates from the supply rails that it has helped to generate (±5V in this case). **Figure 2** shows the power-up response. The circuit achieves regulation regardless of which unregulated voltage is applied first.

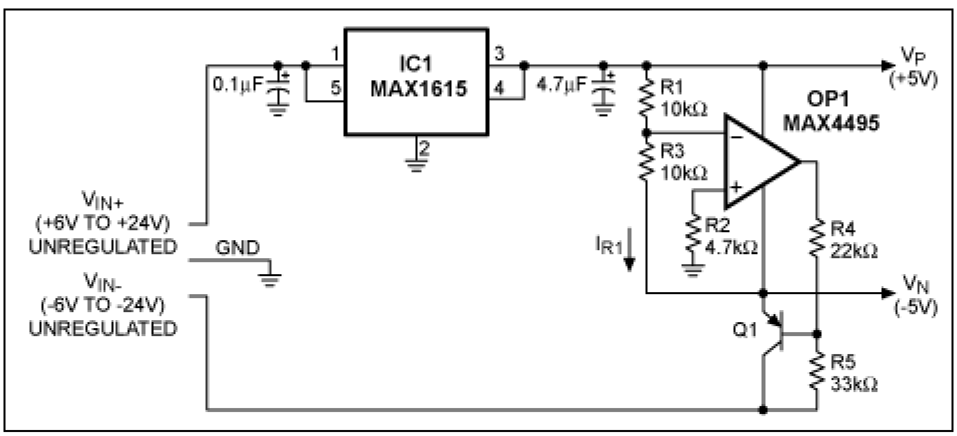


*Figure 1. This circuit derives a regulated ± voltage from ± unregulated input voltages.*

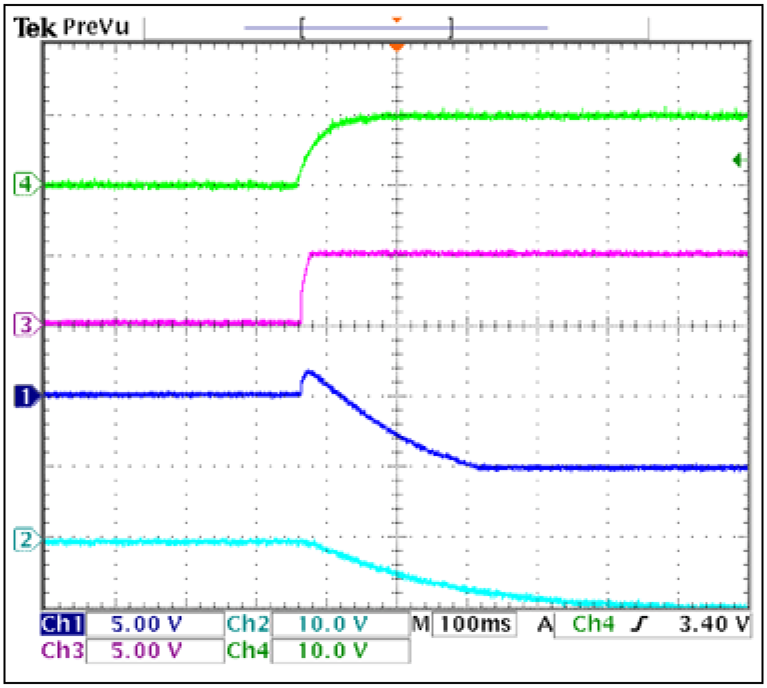


*Figure 2. The power-up response for the Figure 1 circuit.*
*CH1 = regulated -5V output*
*CH2 = negative supply voltage*
*CH3 = regulated +5V output*
*CH4 = positive supply voltage*

By controlling the base drive to Q1, the op amp maintains equilibrium at its inverting input, and thereby ensures that $V_N = -V_P(R3/R1)$. Resistor R5 provides the initial base current to Q1 until OP1 takes over. When that happens, OP1, Q1, and R1, R3, R4, and R5 form a negative feedback network that regulates $V_N$ to $-V_P(R3/R1)$:

$$V_{OP1+} = V_{OP1-}$$
$$V_{OP1+} = 0V$$

Using Superposition:

$$V_{OP1-'} = V_P(R3/(R3+R1)$$
$$V_{OP1-''} = (V_N(R1/(R1+R3)$$
$$V_{OP1-} = V_{OP1-'} + V_{OP1-''}$$
$$V_{OP1-} = V_P(R3/(R3+R1)) + V_N(R1/(R1+R3))$$
$$V_N = -V_P(R3/(R3+R1))((R1+R3)/R1)$$

Therefore:

$$V_N = -V_P(R3/R1)$$

Alternatively:

$$I_{R1} = V_P/R1$$

Therefore:

$V_N = -I_{R1} \times R3 = (-V_P/R1)R3$

The allowable range of the unregulated negative supply voltage is -6V to -24V. For a wider input-supply range, either replace Q1 with a higher gain transistor or lower the resistance of R4 and R5. $V_N$ can deliver up to 100mA without distortion, but $V_P$ is limited by the reference of IC1 to a maximum of 30mA, with a $V_P$ reduction at that level of ~0.3V. (For higher positive load currents you can substitute a different positive regulator.)

$I_{BIAS}$ is negligible for the op amp shown. To minimize the $I_{BIAS}$ error for other op amps, R2 should have the value R1||R3.

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