Keywords: pass transistor, linear regulator, LDO, increase LDO current, more load current Jan 24, 2003

APPLICATION NOTE 1861

Pass Transistor Boosts Current from Negative Linear Regulator

Abstract: The addition of a pass transistor to the circuit of Figure 1 allows the linear regulator (LDO) to deliver more current to the load. A detailed power dissipation analysis is included to assist circuit developers in choosing the proper power rating of each component. Furthermore, lab data shows that the device is stable across temperature, line, and load.

Adding four components to a negative linear regulator (U1 in **Figure 1**) increases the allowable load current by 60%. Cost for the components is less than $0.17 in 1k quantities.

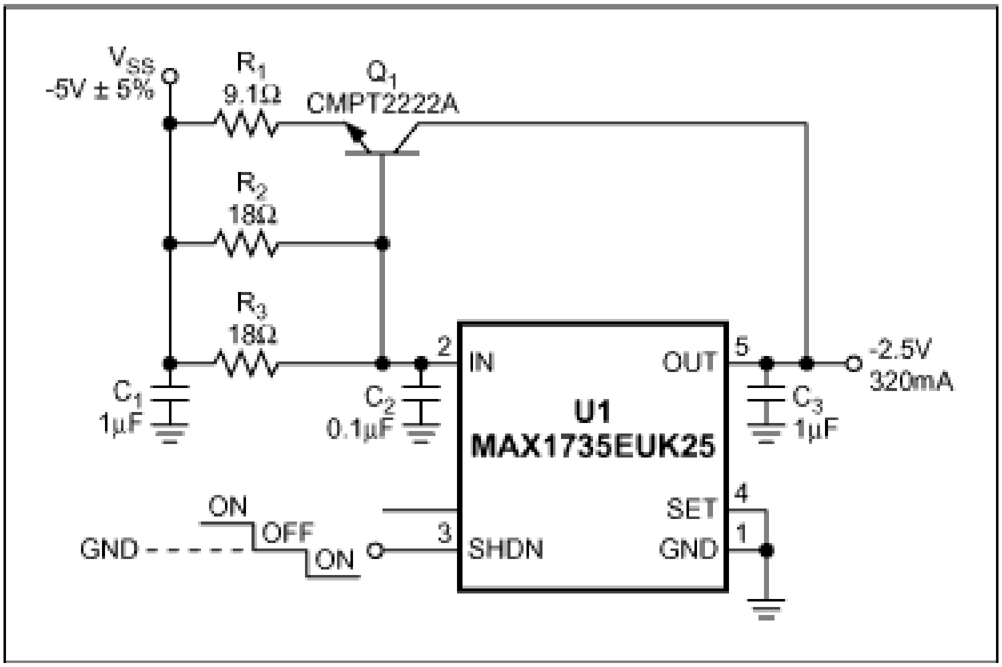

Figure 1. A pass transistor and associated resistors boosts load current in this negative linear regulator by 60%.

Connecting the SET terminal to ground sets U1's output voltage to -2.5V. U1's maximum load current is 200mA, and the extra components (Q_1, R_1, R_2, and R_3) draw another 120mA maximum from the load, producing (without degrading the output regulation) a total maximum load current of 320mA.

R_1 reduces the power dissipated in Q_1, prevents thermal runaway in Q_1, and provides momentary protection against short-circuited outputs. It also prevents oscillation by limiting gain in the Q_1 loop. Current flowing through U1 from OUT to V_{SS} produces a voltage drop of V_{R2} across R_2 and R_3, and thereby allows Q_1 to conduct load current as V_{R2} approaches the base-to-emitter threshold of Q_1. The threshold (V_{BE}) is approximately 0.7V at room temperature.

Choose the values of R_1, R_2, and R_3 to ensure that R_2, R_3 and Q_1 dissipate maximum power at the maximum load current (320mA in this case). At 320mA, U1 conducts 200mA and Q1 conducts 120 mA. Component power dissipation at maximum load is as follows:

$P_{R1} = I_{R1}^2 \times R_1 = 120mA^2 \times 9.1\Omega \approx 131mW$

$P_{Q1} = V_{Q1} \times I_{Q1} = (V_{SS} - V_{R1} - V_{OUT}) \times I_{Q1} = (5V - 1.1V - 2.5V) \times 120mA \approx 168mW$

$P_{R2} = I_{R2}^2 \times R_2 = 100mA^2 \times 18\Omega \approx 180mW$

$P_{R3} = I_{R3}^2 \times {}_{R3} = 100mA^2 \times 18\Omega \approx 180mW$

$P_{U1} = V_{U1} \times I_{U1} = (V_{SS} - V_{R2} - V_{OUT}) \times I_{U1} = (5V - 1.8V - 2.5V) \times 200mA \approx 140mW$

To provide higher load current, you can easily modify the circuit by increasing the power-dissipation ratings of R_1, R_2, R_3, and Q_1. **Table 1** details the components shown for 320mA load current. For power dissipation, the circuit board should have ample copper connected to the leads of power-dissipating components. Heat then conducts through the component leads to the circuit board, spreads into the copper areas, and is removed from the board by convection.

Table 1. Figure 1 Components

Component	Manufacturer Part Number Description	Package	Power Dissipation	Allowable Power Dissipation at +85°C
R_1	KAMAYA, INC. RMC18-9R1JB 9.1Ω ±5% Resistor	1206	250mW derate 4.55mW/°C above +70°C	181.75mW
R_2, R_3	KAMAYA, INC. RMC18-18RJB 18Ω ±5% Resistor	1206	250mW derate 4.55mW/°C above +70°C	181.75mW
Q_1	Central Semiconductor Corp. CMPT2222A NPN Transistor	SOT23-3	350mW derate 2.8mW/°C above +25°C	182mW
U_1	Maxim Integrated Products MAX1735EUK25 200mA Negative LDO	SOT23-5	571mW derate 7.1mW/°C above +70°C	464.5mW

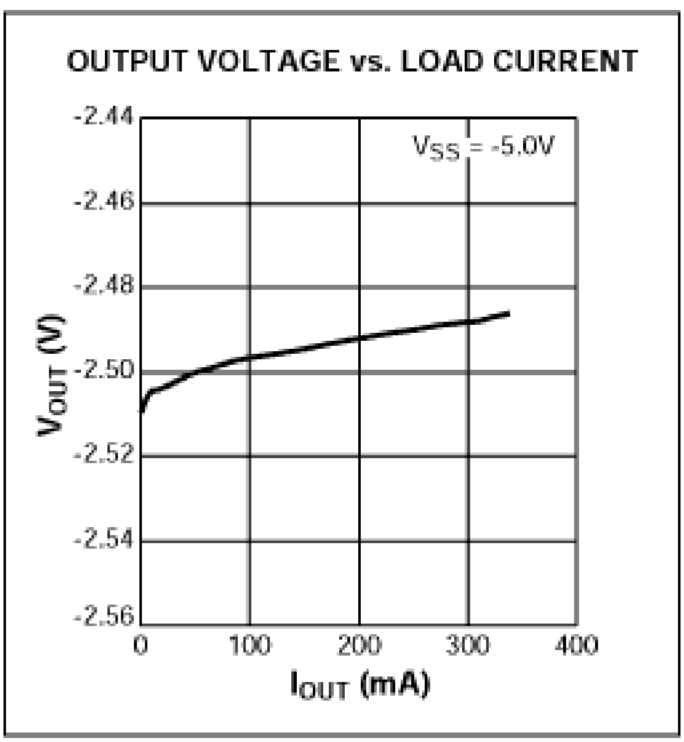

Figure 2a.

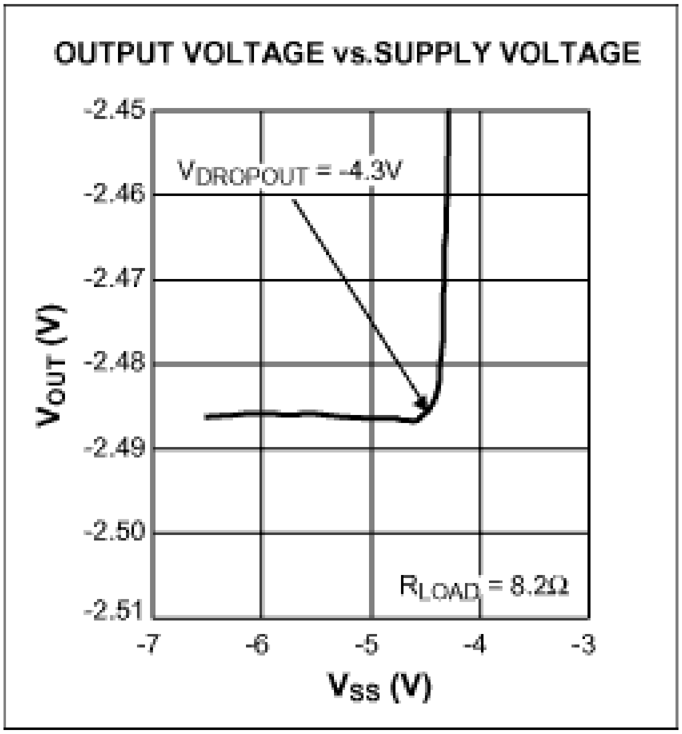

Figure 2b.

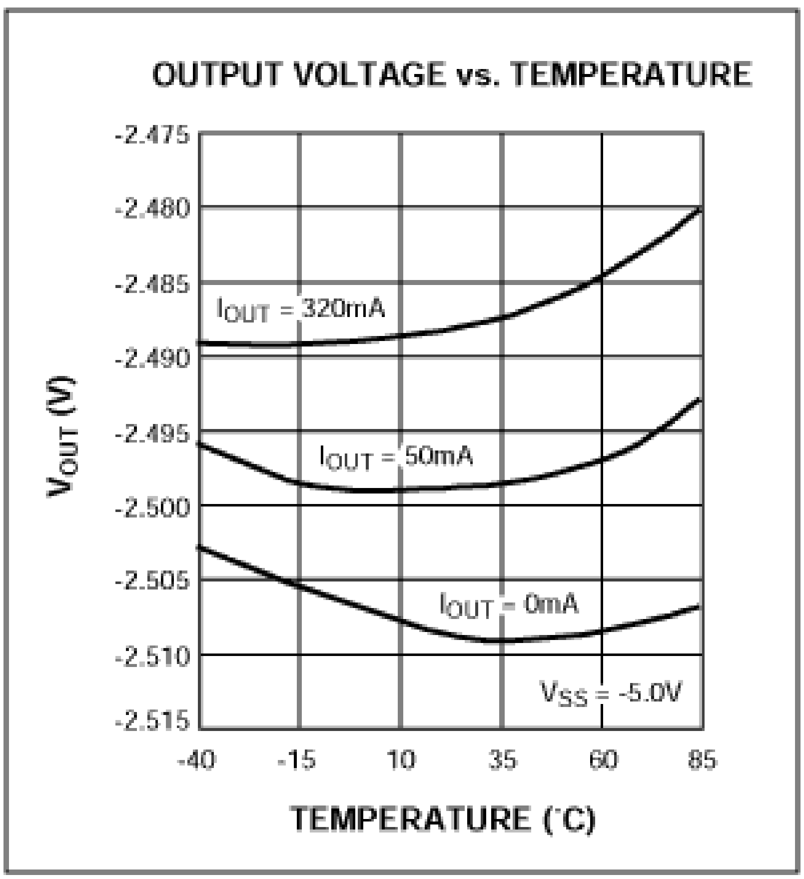

Figure 2c.

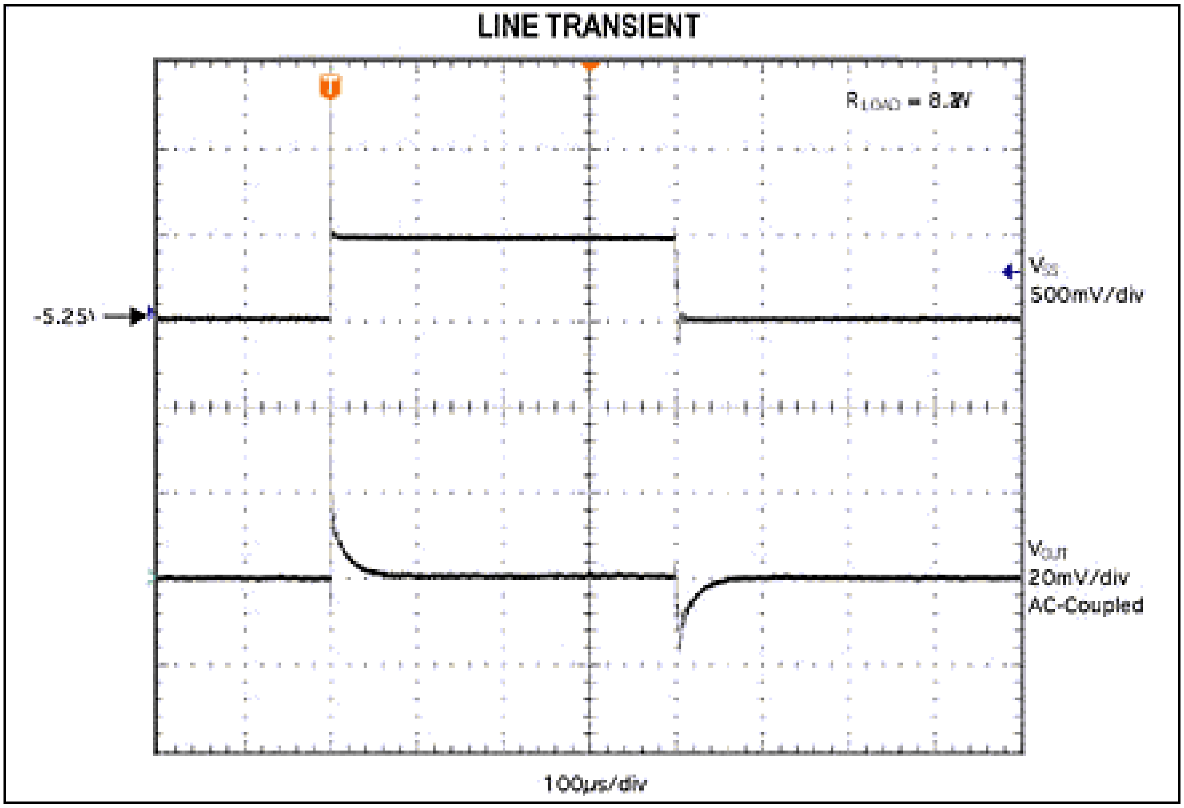

Figure 2d.

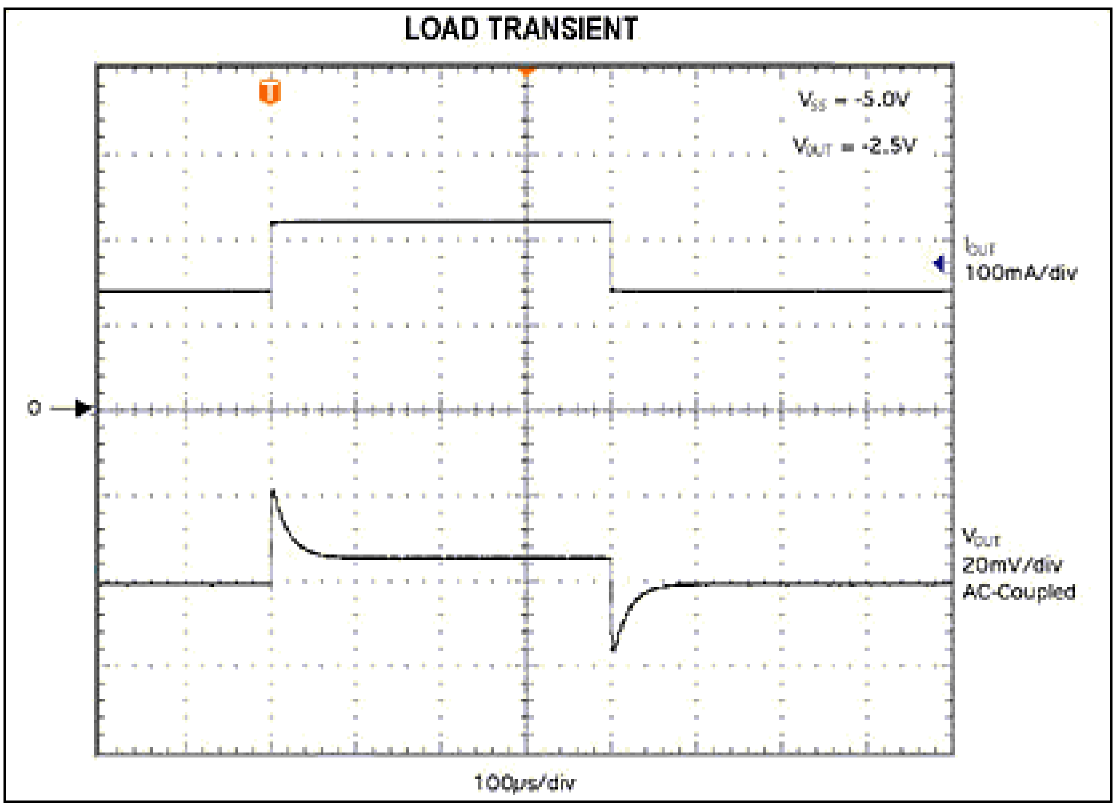

Figure 2e.

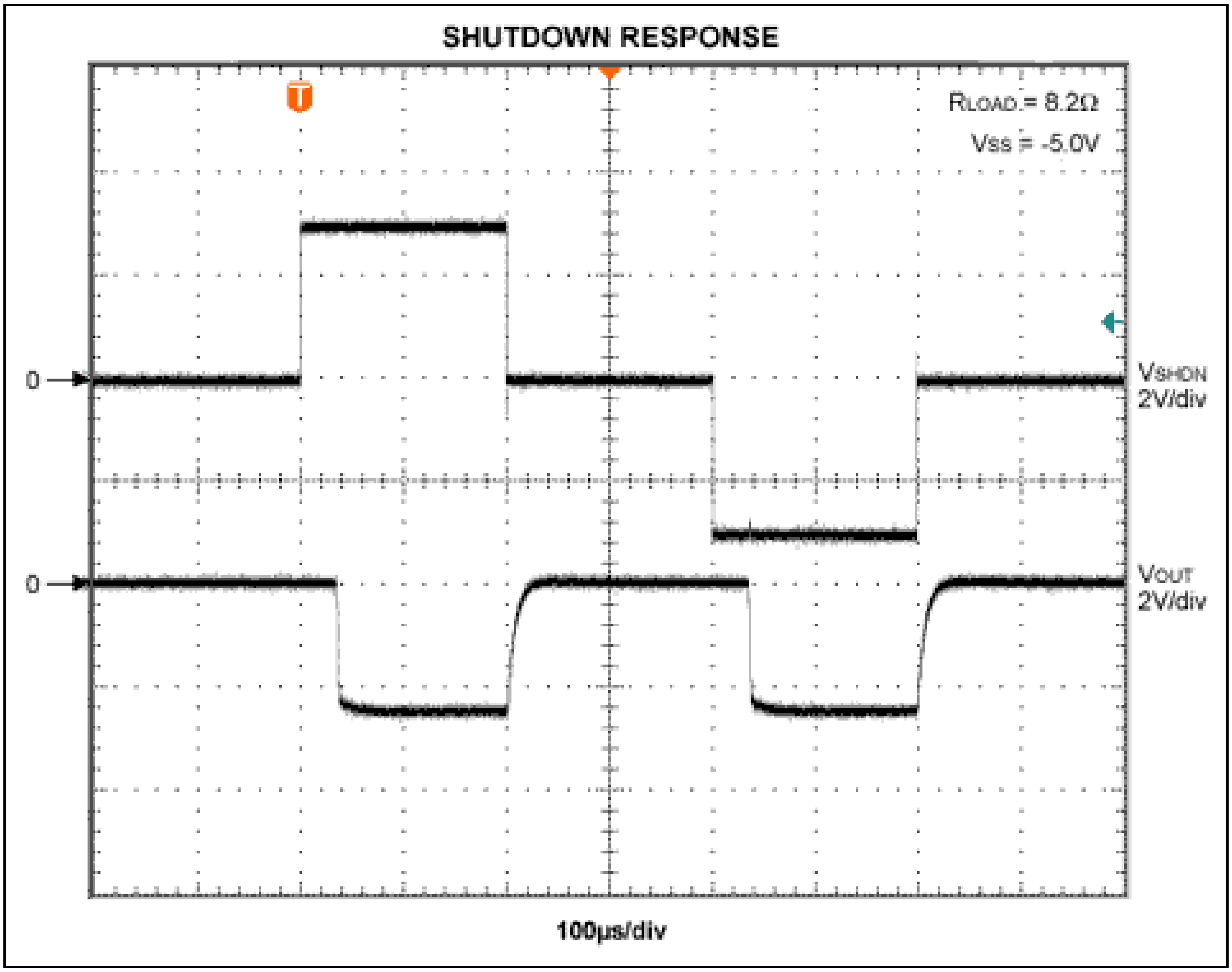

Figure 2f.

Figure 2. Curves and waveforms characterize the output of Figure 1: output voltage vs. load current (a), output voltage vs. supply voltage (b), output voltage vs. temperature (c), line transient response (d), load transient response (e), and shutdown response (f).

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