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APPLICATION NOTE 4280

Using the DS4424 to Margin the Output Voltage of a DC-DC Converter

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Abstract: A DS4424 adjustable-current DAC is used to adjust the margin of a DC-DC converter's output voltage. This article describes how to properly select the resistor values of a DC-DC converter's feedback divider network when the DS4424 is employed in the design.

Introduction

The DS4424 adjustable-current DAC is similar to the DS4404 adjustable-current DAC with two major differences. First, the DS4424 has 127 settings each for sink and source mode, while the DS4404 has 31 settings. Second, the DS4424's default I²C address is set to 20h, whereas the DS4404's default I²C address is 90h. Both devices' addresses are determined by the states of the A0 and A1 address pins.

This article focuses on the DS4424, which can be used to adjust the margin of a DC-DC converter's output voltage. The article explains how to properly select resistor values of the DC-DC converter's feedback divider network when the DS4424 is employed in the design.

The Adjustable Power Supply

The DS4424 contains four I²C adjustable current sources capable of sinking and sourcing current. A typical application for these DACs is margining the output voltage of a DC-DC converter (**Figure 1**).

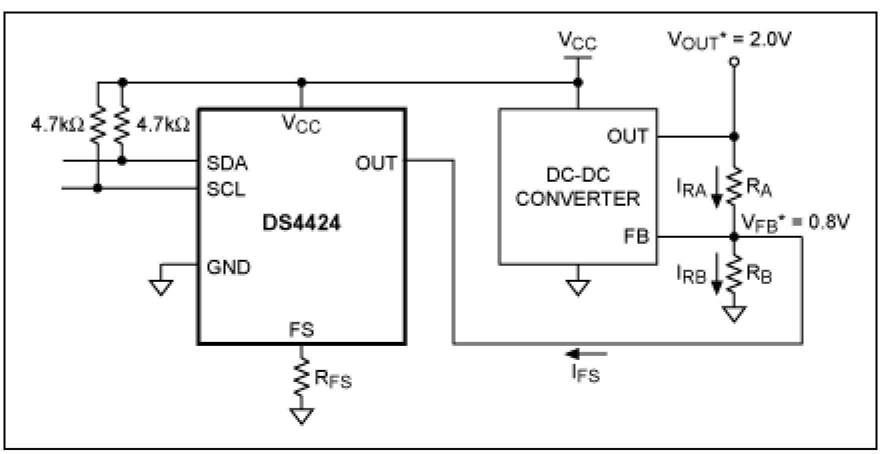

*Figure 1. DC-DC converter circuit with adjustable-current DACs used to margin the converter's output voltage. *V_{OUT} and V_{FB} values are determined by the DC-DC converter, and should not be confused with V_{OUT} and V_{RFS} of the DS4424.*

The DS4424 sinks and sources from its OUT pins. Valid full-scale current values range from 50µA to 200µA. The value of the full-scale current, I_{FS}, is determined by the size of the resistor connected to the DAC's FS pin of the corresponding OUT pin. The source/sink current generated by the DS4424 is commonly used to adjust the DC-DC converter's feedback voltage-divider.

Determining the Relationship Between V_{OUT} and I_{FS}

Choosing the right I_{FS} depends on how much margin is desired on the DC-DC converter's V_{OUT} pin. To determine this margin, we must discover the relationship between V_{OUT} and I_{FS}.

Summing currents into the V_{FB} node, we find that:

$$I_{RA} = I_{FS} + I_{RB} \qquad \text{(Eq. 1)}$$

Where:

$$I_{RB} = \frac{V_{FB}}{R_B} \qquad \text{(Eq. 2)}$$

And:

$$I_{RA} = \frac{V_{OUT} - V_{FB}}{R_A} \qquad \text{(Eq. 3)}$$

However, since R_B and V_{FB} are constant, there is no change in I_{RB}. Thus:

$$\Delta I_{RA} = \Delta I_{FS} \qquad \text{(Eq. 4)}$$

We are looking for the relationship between the margin on V_{OUT}, ΔV_{OUT}, and the selected range of I_{FS}, ΔI_{FS}. Since we know that the change in the I_{FS} current equals the change in the current across R_A, we can subtract one set of V_{OUT} and I_{RA} values from the other to determine the relationship between V_{OUT} and I_{FS}.

First, solving Equation 3 to find V_{OUT}, we determine that:

$$V_{OUT} = V_{FB} - I_{RA} \times R_A \qquad \text{(Eq. 5)}$$

Use Equation 5 to create two equations. For one equation, we choose the maximum margin on V_{OUT}, V_{OUTMAX}, and the maximum I_{RA} current, I_{RAMAX}. For the other equation, we choose the nominal values for V_{OUT} and I_{RA}, V_{OUTNOM} and I_{RANOM}. Subtracting the two equations, we get:

$$\begin{array}{l} V_{OUTMAX} = V_{FB} - I_{RAMAX} \times R_A \\ \underline{-\ (V_{OUTNOM} = V_{FB} - I_{RANOM} \times R_A)} \\ \Delta V_{OUT} = \Delta I_{RA} \times R_A \end{array} \qquad \text{(Eq. 6)}$$

Using Equation 4, Equation 6 translates into the relationship:

$$\Delta V_{OUT} = \Delta I_{FS} \times R_A \quad \text{(Eq. 7)}$$

Equation 7 shows that the relationship between the margin on V_{OUT} and I_{FS} is determined by the value of the resistor R_A.

Calculating the Right Resistor Value for the Margin on V_{OUT}

Now that we know the relationship between V_{OUT} and I_{FS}, we can select the correct value of R_A and, thus, R_B to generate the desired margin on V_{OUT}. Since the full-scale current sink/source range of the DS4424 is 50µA to 200µA, we select 100µA as the I_{FS} current for the DAC. To set this value, choose R_{FS} based on the following equation (also found on page 6 of the DS4424 data sheet):

$$R_{FS} = \frac{V_{RFS}}{I_{FS}} \times \frac{127}{16} \quad \text{(Eq. 8)}$$

With V_{RFS} = 0.976V, we solve Equation 8 and find that R_{FS} needs to be 80kΩ (77.47kΩ) to produce a 100µA full-scale current.

With the DS4424 I_{FS} selected, we must determine the size of R_A to achieve the desired margin on V_{OUT}. A 2.0V V_{OUT} with a 20% margin requires ±0.4V of change. Sinking and sourcing the settings of the DS4424 will manage the sign. The change in I_{FS} equals the I_{FS} value of 1mA, and the desired change in V_{OUT} is 0.4V. After substituting for ΔV_{OUT} and ΔI_{FS} in Equation 7, we solve for R_A and get R_A = 4.0kΩ.

Determining the Relationship Between R_A and R_B

The feedback network of the circuit in Figure 1 is a voltage-divider with resistors R_A and R_B. Looking at Figure 1 and assuming I_{FS} = 0A, we can create a simple voltage-divider equation:

$$V_{FB} = \frac{R_B}{R_A + R_B} \times V_{OUT} \quad \text{(Eq. 9)}$$

We assume that the desired nominal value for V_{OUT} is 2.0V, and that the DC-DC converter has a feedback voltage, V_{FB}, of 0.8V. Substituting the values for V_{OUT} and V_{FB}, the relationship between R_A and R_B is determined to be:

$$R_A = 1.5 \times R_B \quad \text{(Eq.10)}$$

We use Equation 10 to solve for R_B and get R_B = 2.67kΩ.

Conclusion

The resistive-feedback-divider network and the current-sinking/sourcing capabilities of the DS4424 DACs control the margin of V_{OUT} on a DC-DC converter. The relationship between the full-scale current, I_{FS}, to the margin on V_{OUT} is determined by the value of the resistor R_A. By choosing the correct I_{FS} value for your application, you can determine the correct resistor values for the feedback divider network, and achieve the desired margin on V_{OUT}.

Related Parts

DS4422	Two-/Four-Channel, I²C, 7-Bit Sink/Source Current DAC	Free Samples
DS4424	Two-/Four-Channel, I²C, 7-Bit Sink/Source Current DAC	Free Samples

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