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APPLICATION NOTE 4197

Using the DS4412 to Margin the Output Voltage of a DC-DC Converter

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Abstract: A DS4412 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 a DS4412 is employed in the design.

The Adjustable Power Supply

The DS4412 contains two 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. (See **Figure 1**.)

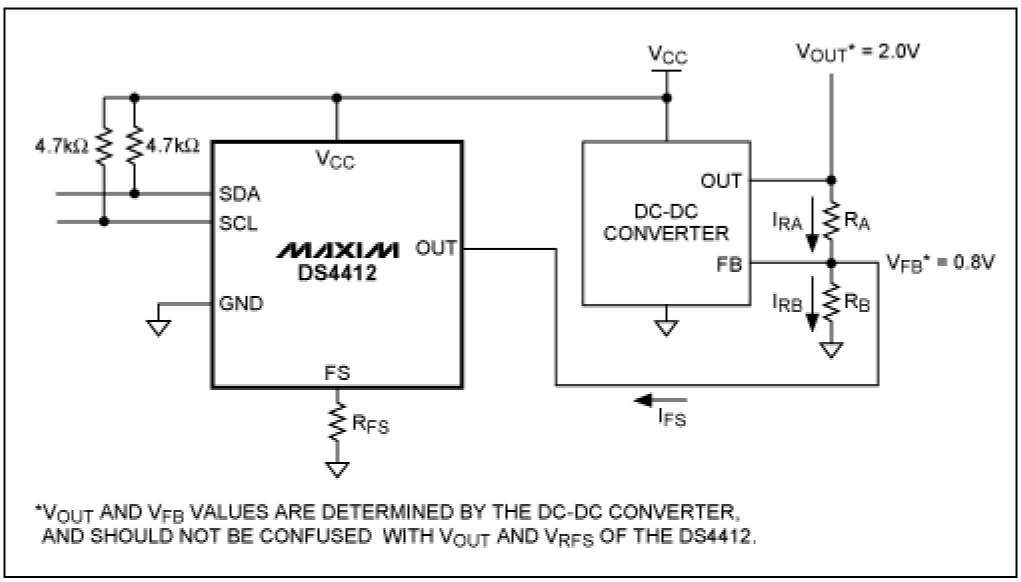

Figure 1. DC-DC converter circuit with adjustable-current DACs used to margin the converter's output voltage.

The DS4412 sinks and sources from its OUT pins. Valid full-scale current values range from 0.5mA to 2.0mA. 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 DS4412 is most 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 another to determine the relationship between V_{OUT} and I_{FS}.

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

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

Using Equation 4, Equation 6 translates into the relationship:

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

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 DS4412 is 0.5mA to 2.0mA, we select 1mA as the I_{FS} current for the DAC. To set this value, choose R_{FS} based on the following equation found on page 6 of the DS4412 datasheet:

$$R_{FS} = \frac{V_{RFS}}{I_{FS}} \times \frac{15}{1.974} \qquad \text{(Eq. 8)}$$

With V_{RFS} = 0.607V, we solve Equation 8 and find that R_{FS} needs to be 4.612kΩ to produce a 1mA full-scale current.

With the DS4412 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 settings of the DS4412 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 = 400Ω.

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.

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

We assume that the desired nominal value for V_{OUT} is 2.0V and 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

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

We use Equation 10 to solve for R_B and get R_B = 267Ω.

Conclusion

The resistive-feedback-divider network and the current-sinking/sourcing capabilities of the DS4412 DACs control the margin of V_{OUT} of 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		
DS4412	Dual-Channel, I²C Adjustable Sink/Source Current DAC	Free Samples

More Information
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For Samples: http://www.maximintegrated.com/samples