



APPLICATION NOTE 3608

## Using the DS3906 Digital Potentiometer with a Step-Up DC-DC Converter to Provide Fine Control of Output Voltage

*Abstract: When using DC-DC converters, designers confront a common problem: only standard output voltages are available. If calibration or adjustment of the output voltages is needed, high-precision nonstandard resistors are required. This application note shows how to use the DS3906 in the feedback loop of a step-up DC-DC converter to calibrate and/or adjust the output voltage. The DS3906 provides sub-ohm precision adjustments when used in parallel with external resistors.*

*Together with the DS3906, the example circuit uses a MAX5025 step-up DC-DC converter capable of generating up to 36V, 120mW (max).*

### Fixed Step-Up DC-DC Converter

The typical circuit from the MAX5025 data sheet is shown in **Figure 1**. In this circuit, the output voltage,  $V_{OUT}$ , is determined by the ratio of fixed resistors R1 and R2. These two resistors form a voltage divider that feeds a fraction of the output voltage back to the FB pin, thus creating a closed-loop system. The system is at equilibrium when  $V_{OUT}$  is generating the desired output voltage and the R1 and R2 voltage divider feeds back 1.25V to the FB pin. When  $V_{OUT}$  is lower than the desired output voltage (and, hence, the voltage fed back to FB ( $V_{FB}$ ) is below 1.25V), the DC-DC converter attempts to deliver additional power until FB reaches 1.25V. Solving equation 1, taken from the [MAX5025 data sheet](#), for  $V_{OUT}$  yields equation 2 where  $V_{REF}$ , the FB Set Point, is 1.25V for the MAX5025.

$$R1 = R2 \left( \frac{V_{OUT}}{V_{REF}} - 1 \right) \quad (\text{Eq 1})$$

$$V_{OUT} = V_{REF} \left( \frac{R1}{R2} + 1 \right) \quad (\text{Eq 2})$$

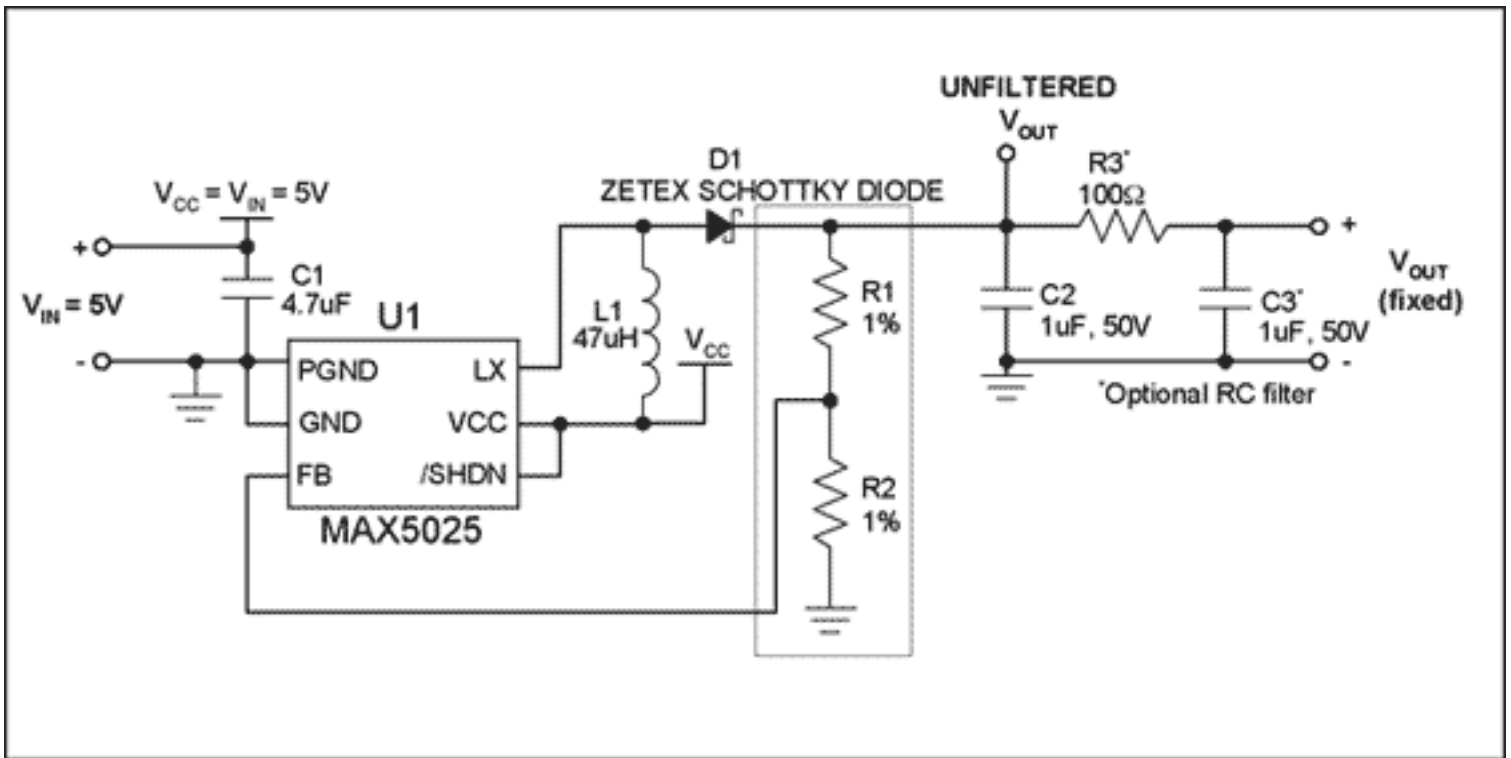


Figure 1. Circuit for a fixed, step-up DC-DC converter circuit.

## Adding a Digital Potentiometer to the Feedback Path

Although there are several ways to add a digital potentiometer to the circuit in Figure 1, this discussion focuses on the voltage-divider configuration shown in **Figure 2**.

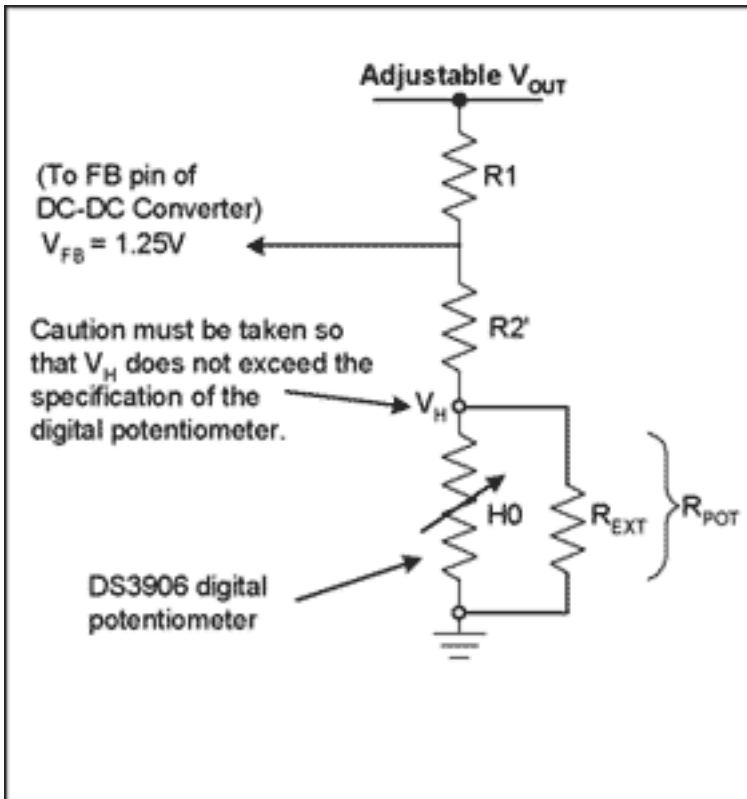


Figure 2. Illustration of the feedback path with a digital potentiometer.

The configuration in Figure 2 allows fine control of the DC-DC converter's output voltage around a desired value.

Equation 2 can be rewritten as:

$$V_{OUT} = V_{REF} \left( \frac{R1}{R2' + R_{POT}} + 1 \right) \quad (\text{Eq 3})$$

## Calculations

Several initial design assumptions were made: that  $V_{REF} = V_{FB} = 1.25V$ ; that the desired output voltage is 32V when the potentiometer is set in the mid position (position 20h); that the DS3906 is used with an external resistor which makes the response linear.

The application note [Resistor Calculator for the DS3906](#) and its associated [Excel spreadsheet](#) describe how to select an external resistor for the DS3906. For the application presented here in **Figure 3**, resistor H2 is used with an external resistance of 270Ω. The median resistance with this external resistor is about 200Ω, and is used in the calculation of R1 and R2 for the MAX5025.

Assuming that R2 is set to 9.8kΩ, we calculate the desired value of R1 based on equation 3. The calculated value of R1 is 246kΩ.

The spreadsheet associated with this application note helps calculate the range of voltages that can be programmed with this particular configuration. The spreadsheet shows that very fine adjustment of the output voltage is possible. The spreadsheet also allows the user to experiment with different values of R1, R2, and external resistance (in parallel with H2).

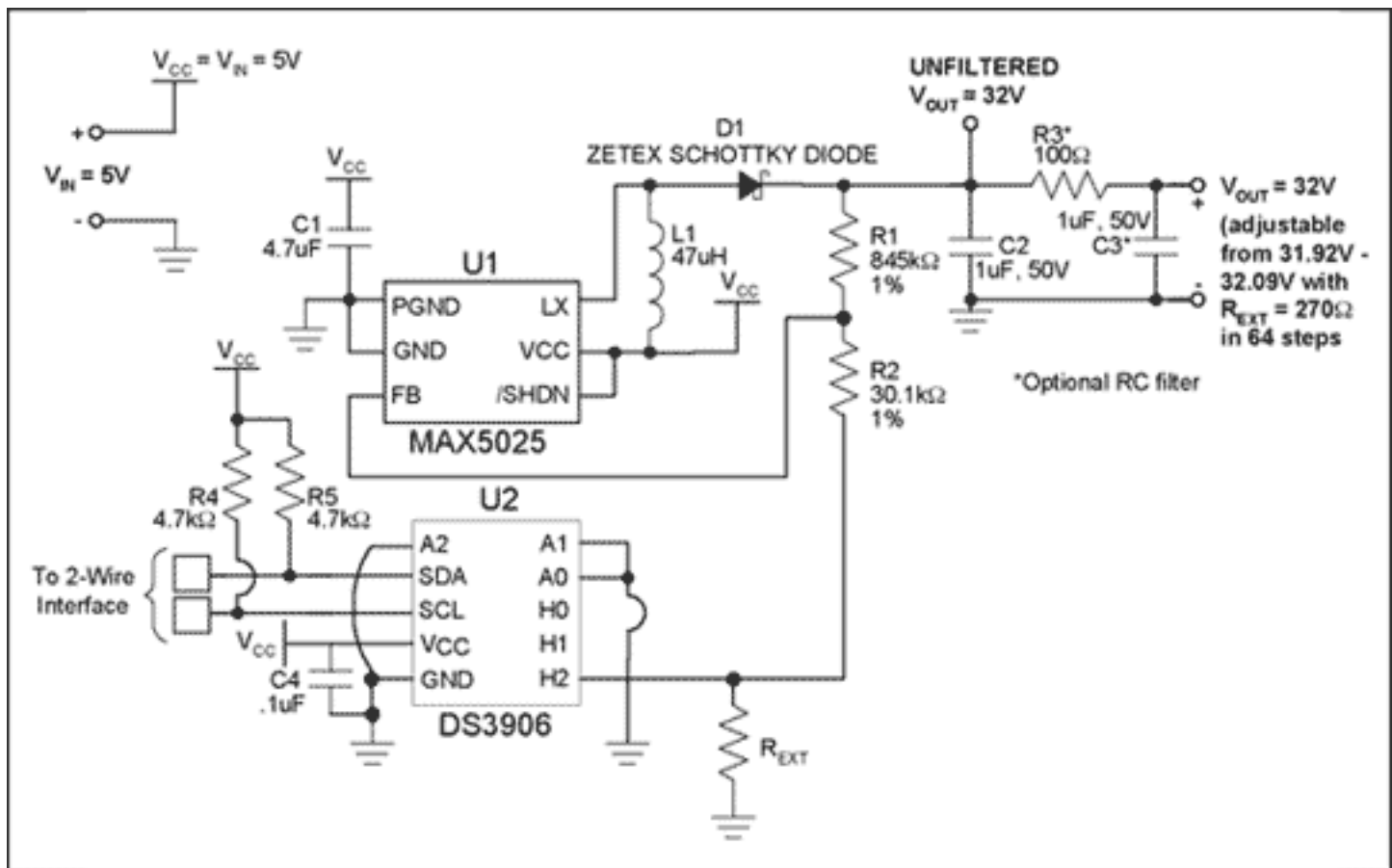


Figure 3. Final circuit using the DS3906.

## Conclusion

This application note shows how to use a digital potentiometer in the feedback loop of a step-up DC-DC converter to allow the output voltage to be calibrated. While this example specifically uses the MAX5025 and the DS3906 to generate 32V, the concepts presented here can be applied to other potentiometer/converter combinations and to other output voltages and power ratings.

Questions/comments/suggestions concerning this application note can be sent to: [MixedSignal.Apps@dalsemi.com](mailto:MixedSignal.Apps@dalsemi.com).

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Application Note 3608: [www.maxim-ic.com/an3608](http://www.maxim-ic.com/an3608)

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DS3906: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX5025: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

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