

Keywords: Initial accuracy, digital pots, potentiometer, end-to-end tolerance, resistance, voltage, dividers, ratiometric, ratio, steps, LSB, taps, error, temperature, coefficient, series resistor, noise, change, reference, buffer, amplifier

Sep 23, 2008

APPLICATION NOTE 4290

Ratiometric Design Overcomes the 25% Tolerance of a Digital Potentiometer

By: Bill Laumeister

Abstract: This application note explains how to eliminate the voltage change when a digital potentiometer is used as a voltage-divider in series with other resistors.

Introduction

Mechanical and electronic digital potentiometers tend to have loose end-to-end tolerances. Maxim digital pots typically have a 20% to 30% resistance tolerance. The resistance tolerance can be problematic when the digital pot is used as a voltage-divider in series with other resistors. That configuration will result in an unacceptable voltage change over tolerance.

This application note discusses a ratiometric method to convert that resistance tolerance into an acceptable current change. The proposed design also effectively removes the voltage change. In the circuit presented here the voltage output depends only on the ratio of the steps of the pot. The temperature coefficient is better controlled in the design.

Ratiometric Method for the Design

The design challenge is straightforward: a variable voltage between 3V and 4.5V with a tolerance of 3%. Start with the schematic in **Figure 1** and do the math. The digital pot is 50k Ω (25% tolerance); R1 is 16.5K (1%) and R2 is 100K (1%). The 25% tolerance of the pot's end-to-end resistance will dominate in this design.

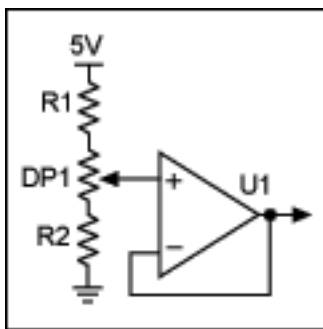


Figure 1. Basic schematic.

Now consider the same design with a different pot. If the pot is 37.5k Ω , the top of the pot is 4.46V and the bottom is 3.25V. Continuing on, if the pot is 62.5k Ω , the top of the pot is 4.54V and the bottom is 2.79V. This basic approach does not solve the changing voltage problem because the pot's end-to-end tolerance is in the circuit.

The next circuit in **Figure 2** only uses the pot's ratio.

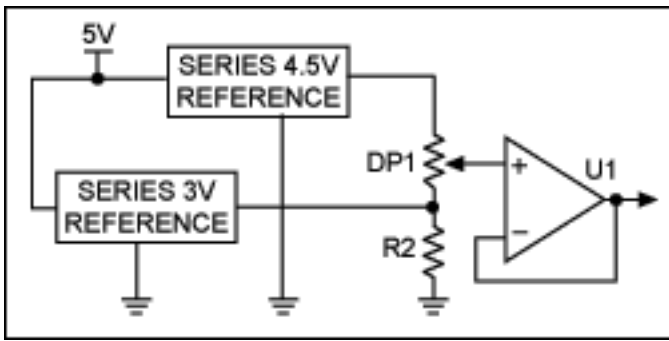


Figure 2. Alternate design features two voltage references.

By using two voltage references the tolerances and the temperature coefficient are controlled. The absolute end-to-end tolerance of the digital pot changes the current, but does not affect the voltage. The output voltage is ratiometric; the voltage out depends *only* on the ratio of the steps of the pot.

Both references use feedback to control the output voltage. R2 (~25K to 50K) ensures that both references source current. Bypass capacitors are discussed in the data sheet for each Maxim digital pot. Some capacitors may be required, depending on the board layout.

Ultimately, an application dictates the system's requirements. Device temperature coefficients can be predicted from the respective digital pot data sheets. The pots also offer a choice of noise specifications. Maxim's complete list of [digital pots](#) and [voltage references](#) is available on the website.

Application note 4290: www.maxim-ic.com/an4290

More Information

For technical support: www.maxim-ic.com/support

For samples: www.maxim-ic.com/samples

Other questions and comments: www.maxim-ic.com/contact

Automatic Updates

Would you like to be automatically notified when new application notes are published in your areas of interest? [Sign up for EE-Mail™](#).

Related Parts

- DS1805: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX5160: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX5161: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX5400: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX5463: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX5464: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX5465: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX6023: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX6029: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX6045A: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX6045B: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)
- MAX6063A: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6063B: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6067B: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6103: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6107: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6145: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

AN4290, AN 4290, APP4290, Appnote4290, Appnote 4290

Copyright © by Maxim Integrated Products

Additional legal notices: www.maxim-ic.com/legal