Perform Coarse and Fine Correction with Less Costly Dual DCPs

AN1689
Rev 0.00
November 2, 2011

Digitally Controlled Potentiometers (DCPS) find uses in a wide variety of systems for setting bias currents, variable reference voltages, and calibration settings. In industrial control and automation applications, high accuracy is a must. DCPs with 1024 taps are available, but for a few dollars instead of tens of cents. A dual, 32-tap, 50kΩ DCP is available for 64 cents (1k unit price). Can we use both of the DCPs in the package and reach similar performance to the 1024 tap?

Using the dual 32-tap DCP, the first inclination might be to simply stack one atop the other. This only doubles the effective resolution, and many DCPs aren't configured to allow that type of connection. By the way, it's common practice to span a DCP over a smaller voltage range to increase its resolution, but that's not the optimum solution here.

However, both DCPs can be used simultaneously. In fact, instead of a linear gain of 2 in resolution, it's possible to increase the resolution by 322, or 1024. Both DCPs will stretch between ground and the power supply. One will give coarse adjustment and the second will give fine adjustment. In other words, one provides the most significant 5 bits and the other provides the least significant 5 bits. The critical components are the weighted resistors within the summing circuit.

Referencing Figure 1, resistor RFINE needs to be 32 times the value of RCOARSE (in our 32-tap potentiometer example). For various DCP tap values, the resistance needs to scale so that: RFINE = RCOARSE × (number of taps).

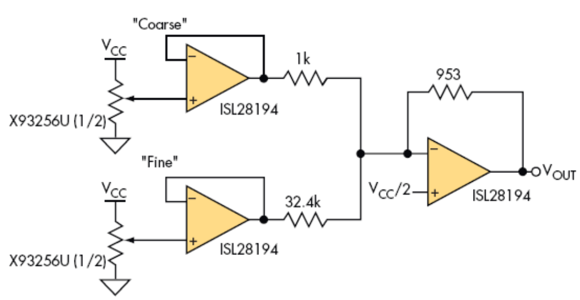

FIGURE 1. A DUAL 32-TAP DCP CAN PERFORM COARSE AND FINE TUNING. ALSO OFFERS A LESS EXPENSIVE SOLUTION TO THE 1024-TAP DCP

The feedback resistor of the summing op amp has a value of 953Ω (1% resistor value). This is the closest approximation below the parallel combination of 1kΩ and 32kΩ.

Realize that the resolution will not always increase by the square of the number of taps, as in this example. Aforementioned DCPs have 1024 taps. This coarse/fine setup should theoretically give a resolution equal to 20-bits, or 1,048,576 taps. On a 5V supply, the LSB would be equal to 4.7µV. Are op amps this accurate?

If we need absolute accuracy to DC, then the parameter of interest is offset voltage. For the ISL28194, the typical offset is 0.1mV (or 100µV), since it's a precision op amp. This will limit our achievable accuracy. If a more typical amp is chosen, the offset voltage might range from 5mV to 25mV. Because op amps are readily available with 5mV offsets, it follows that the maximum number of taps commercially available is 1024.

Note that the output will be the inversion of the sum of the two inputs. Figure 2 presents the output voltage data. An ideal circuit would show a linear response across all 1024 taps. While the circuit does exhibit some nonlinearities at the ends of the voltage spectrum, the linear range extends from about 100 to 900 taps in the coarse/ fine spectrum. Those 800 taps translate to 9.6 bits-a respectable output for a dual 32-tap DCP-and it definitely rivals the more expensive 1024-tap, 10-bit DCP solution.

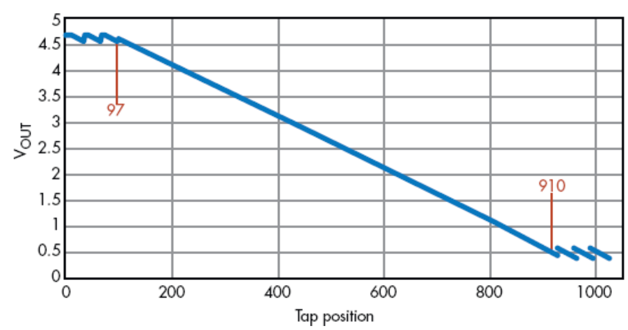

FIGURE 2. OUTPUT VOLTAGE VERSUS TAP VOLTAGE SHOWS 9.6 BITS OF ACCURACY

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(Rev.4.0-1 November 2017)

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