



## Improving the Resolution of Digitally Programmable Potentiometer (DPP™) Applications

Chuck Wojslaw, Director of Applications Engineering

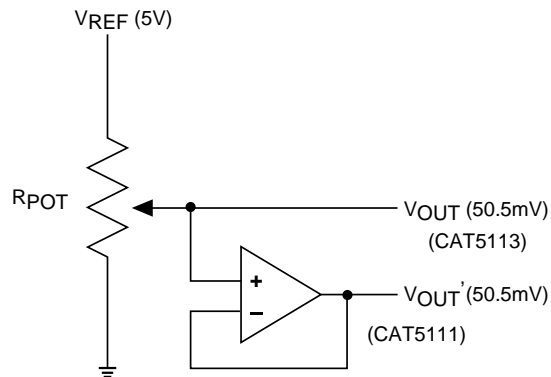
**ABSTRACT:** Resolution is the ability to discern one of many. In application circuits using digitally programmable potentiometers, resolution is both a function of the potentiometer and the circuit design. The objective of this design note is to illustrate a few basic device and circuit ideas on resolution. This design note focuses on resolving voltage.

There are millions of applications of the potentiometer, however, the most common one is the programmable voltage divider shown in Figure 1. For a potentiometer with  $n$  taps (remember two of the taps are used for the bottom and top of the resistive array), the resolution of the potentiometer is given as

$$V_{OUT} \text{ (smallest)} = \frac{V_{REF}}{n-1}$$

$$0V \leq V_{OUT} \leq V_{REF}$$

The output of the circuit is the wiper voltage which may be buffered ( $V_{OUT}'$ ) or not ( $V_{OUT}$ ). The amount of loading of the wiper will determine whether to use the buffered or unbuffered version of the DPP. For example, the resolution is 50.5mV for a 100 tap pot and a 5V reference. The number of taps of Catalyst's DPPs vary from 32 to 256.



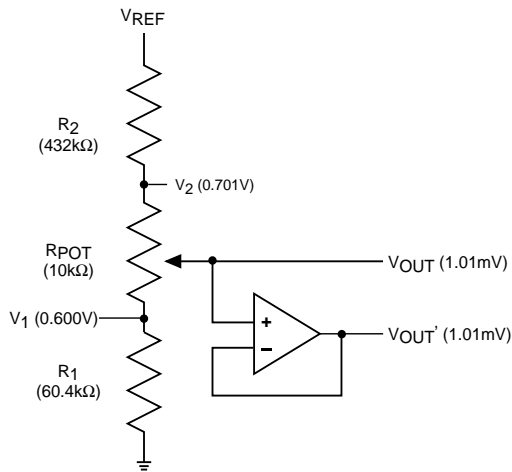
**Figure 1. Programmable Voltage Divider**

If the range of the programmed voltage can be restricted in the application, the pot can be inserted in a voltage divider as shown in Figure 2. Resistors  $R_1$ ,  $R_2$ , and the end-to-end resistance of the potentiometer,  $R_{POT}$ , define the voltage range and the number of pot taps defines the voltage resolution within this range.

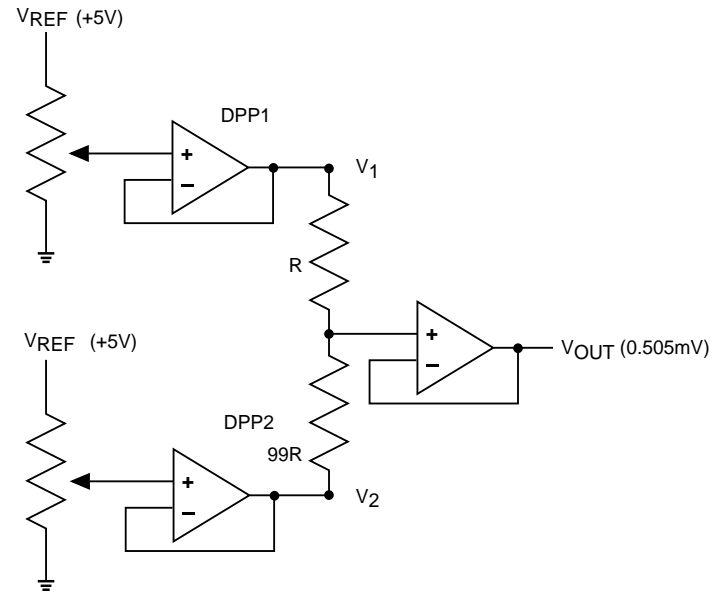
$$V_{OUT} \text{ (smallest)} = \frac{V_{REF}}{n-1} \cdot \frac{R_{POT}}{R_{POT} + R_1 + R_2}$$

$$V_1 \leq V_{OUT} \leq V_2$$

For example, if the voltage range is restricted from 0.601V to 0.701V, the resolution is for the tap pot 1.01mV over this range.



**Figure 2. Differential Voltage Divider**



**Figure 3. High Resolution Voltage Divider**

An amplifier and a few discrete resistors can extend the resolution to satisfy any application requirement. The circuit in Figure 3 consists of two buffered digitally controlled, 100 tap, potentiometers and a summing amplifier circuit with weighted-value, input resistors. For this circuit,

$$V_{OUT} = \frac{99 V_1}{100} + \frac{V_2}{100}$$

$$V_{OUT} \text{ (smallest)} = \frac{V_{1,2}}{n - 1} \frac{1}{100}$$

The output of this circuit example varies from 0 to 5V in half-millivolt steps and is the equivalent to a 13+ binary bit DAC (with memory!!). The use of summing amplifier (inverting and noninverting) circuits, weighted-value input resistors, and DPPs can extend the resolution to any required level.



**CATALYST**

Catalyst Semiconductor, Inc.  
Corporate Headquarters  
1250 Borregas Avenue  
Sunnyvale, CA 94089  
Phone: 408.542.1000  
Fax: 408.542.1200  
www.catalyst-semiconductor.com

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