Digital Control Potentiometers Offer Hidden Benefits for Many Designs

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Digital Control
I^2C, SPI, Up/Down
Push-button

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Resistor Ladder
Resolution: 4-bit to 10-bit
R_{TOTAL}: 1kΩ to 100kΩ

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Register Store
Non-volatile: E^2PROM
Volatile: RAM

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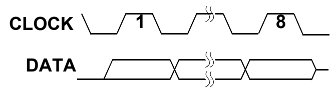
DCP
TSSOP, SC-70
SOT-23, µTQFN

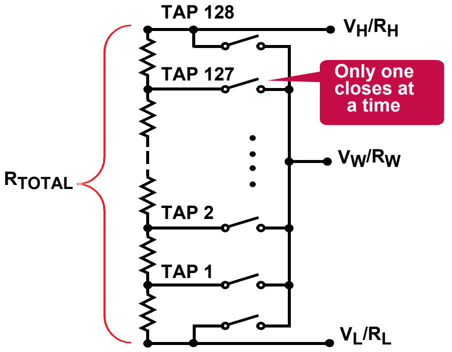
Digital Control

Digital control allows the user to select each switch in a “make-before-break” mode, transferring the potential to the wiper.



Resistor Ladder

The resistor array is comprised of individual resistors connected in series. There are electronic switches (taps) at each resistor junction, which have a common output node called a wiper (VW/RW). Each physical end of the array is described as a terminal and referred to as VGH/RH and VL/RL, and the resistance between the terminals is referred to as R_{TOTAL}.



Register Store

DCP wiper position is stored in a register. When power is reset, a volatile DCP typically sets the wiper position to midscale or zero-scale at power-up. When the power is cycled for a nonvolatile DCP, the last value stored in the EEPROM register is recalled, which loads the initial wiper value during power-up.

ACCESS CONTROL REGISTER (ACR)

VOL	SHDN	WIP	0	0	0	0	0

DCP = Digitally Controlled Potentiometer
Tap = Switch position on resistor string
R_{TOTAL} = Total Resistance
Wiper (VW/RW) = DCP output node

Just about any application you can name these days needs ICs that are smaller, highly integrated, and less expensive. Innovations and advancements in digital control potentiometers (DCPs) fit right into these requirements. DCPs are now ideal design choices for controlling backlighting in video products, or for volume control in audio products, among other applications because they now deliver significant flexibility at lower costs than ever. Even better, DCP manufacturers have taken advantage of process technology improvements to deliver temperature performance improvements and integrated on-chip non-volatile memory.

All these improvements make DCPs an alternative to DACs in many handheld and portable applications. DACs provide fixed resolutions in 8-bit through 24-bit versions where output voltages span between the supply voltages in known increments. DCPs, while limited in the number of total taps at 1024 (or 10 bits) offer a different kind of benefit. It's a little bit 'hidden,' but worth looking at.

The benefit is the flexibility. A DCP allows you to set the voltage on the ends of the potentiometer. If the voltage is set on the rails, then the resolution of the output is equal to the number of taps. On the other hand, if the ends are set to a span of half the supply, then the output resolution benefits by the same factor of two. In effect, you add resistance in series, and as a result improve the resolution of the DCP for a specific application, depending on its requirements. Flexibility is a big plus here, varying the voltage across the fixed resistance mean. For example, the DCP can be used in the feedback path of an amplifier.

Some DCPs also incorporate charge pumps so the output can swing between dual supplies, while the input remains between ground and a single supply. Additionally, there are DCPs that operate on a single ±5V or ±15V supply.

Adding memory is another feature that makes DCPs attractive. The typical solution has been to add an external EEPROM to hold onto critical information in case of a power failure or interruption. DCPs with added non-volatile memory can conveniently store basic information such as wiper position. Identification, calibration and other data also can now be stored right there with the DCP simply by choosing a DCP with more EEPROM cells.

Another improvement we are seeing from DCPs is stable temperatures. Temperature performance used to be a limitation for DCPs, but is no longer. Process technology improvements let DCPs provide 50ppm/degrees Centigrade of change in end-to-end resistance.

Since most DCPs are used as voltage dividers, it makes sense to look at resistances as relative, so the meaningful comparison is relative differences versus temperature. In this comparison, the temperature performance is approximately 4ppm/°C. Basically, the performance limitation is gone.

As DCP features have improved, designers of consumer electronics equipment or telecommunications systems have been able to consider using DCPs in place of DACs. The decision involves comparing the temperature performance, memory (or lack of it), and flexibility, or rigidity, of a DCP compared with a DAC. Those comparisons are blurring now that the performance of DCPs is improving so much. For example, both provide linear steps, but the DCP also can use logarithmic steps, therefore it's an excellent choice for an application like an audio system. Secondly, outputs of either DACs or DCPs can be found with an output buffer to drive impedance loads, but it's more usual to find a DCP with a simple resistance at the output.

Control interfaces are another issue. A DCP can provide push-button controls or up-down controls, I^2C and/or SPI interfaces, whereas DACs typically only support serial and parallel inputs.

DACs do have some fundamental advantages in some applications, where absolute precision is an overarching objective. DCPs can store their own calibration information, directly set the gate bias for proper functioning in an application like a base station, and dynamically adjust to include data from other sources, such as temperature sensors.

Top uses for DCPs now: in pressure, temperature and laser sensors; to trim voltages on voltage regulators; in power supply modules to regulate voltage; and for adjusting analog signals for digital systems.

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