Dynamic Power Control (DPC) Minimizes Power Loss, Maximizes Temperature Range

by David Rice, applications engineer, Analog Devices, Inc.

Digital-to-analog converters (DACs) in industrial systems may be expected to drive a wide range of loads. If the DAC is powered by a fixed supply, this can lead to significant power dissipated on-chip, particularly if the load is small or short circuited to ground.

The power dissipated on-chip can increase temperatures beyond recommended operating limits and can be a major concern for systems with large channel density or with higher ambient temperatures.

For example, an ideal DAC needs to supply up to 20 mA to a user defined load in the 100 Ω to 1 kΩ range. In this case, the minimum supply voltage must be 20 V. The maximum power generated by the DAC is V × I = 20 V × 20 mA = 0.4 W. If a 1 kΩ load is used, all of the power is consumed by the load, resulting in no power lost. When 20 mA flows through a 100 Ω load, only 0.04 W is consumed. This means that 0.36 W is wasted or dissipated on chip. In some cases, a 0 Ω load is also a valid condition, resulting in all power being dissipated on-chip.

In a 64-pin LFCSP package, the maximum ambient temperature cannot exceed 125° C. With four channels each dissipating 0.4 W, the total power dissipated is 1.6 W. The thermal impedance of a 64-pin LFCSP package is 28° C/W. In the previous example, the temperature rise is $P_D \times \theta_{JA}$ = 1.6 W × 28° C/W = 44.8° C. Therefore, the maximum safe ambient temperature is only 80.2° C. Heat sinks can be added to overcome this problem, but this may not be viable due to the required space and cost.

Dynamic power control (DPC) directly addresses this issue. A dc-to-dc converter boosts a 5 V supply to create a 7.5 V to 29.5 V supply. This boosted supply powers the DAC current output driver, which delivers the required power to the load. With a 0 Ω load, the output of the dc-to-dc converter is 7.5 V, its lowest value. The maximum power dissipated in the DAC is only 7.5 V × 20 mA = 0.15 W, saving 0.25 W compared to the original solution.

With DPC, the maximum power dissipated by four channels (each short circuited to ground) is 0.6 W. The temperature rise is $P_D \times \theta_{JA}$ = 0.6 W × 28° C/W = 16.8° C. Therefore, the maximum safe operating temperature increases to 108.2° C. DPC provides the most benefit in systems having a wide, undefined load range, high channel density, and high temperatures that leave little room for large power losses.

The AD5755 four-channel, 16-bit, digital-to-analogue converter provides voltage and current outputs for programmable logic controllers (PLCs), distributed control systems (DCSs), and other industrial process control applications. Dynamic power control regulates the voltage on the output driver, minimizing power dissipation with low value load resistors and easing thermal management. Each channel can be configured to provide:

- Voltage output, with 0 V to 5 V, 0 V to 10 V, ±5 V, or ±10 V full-scale range and ±0.04% total unadjusted error (TUE).
- Current output, with 0 mA to 20 mA, 4 mA to 20 mA, or 0 mA to 24 mA full-scale range and ±0.05% TUE.

Offset and gain can be individually programmed for each channel. The devices can be used with the on-chip 5 V, ±5 ppm/°C reference, or an external reference. Available in a 9 × 9 × 0.85 mm 64-lead LFCSP package, it is specified from –40° C to +105° C and priced at $13.65 in 1000s.

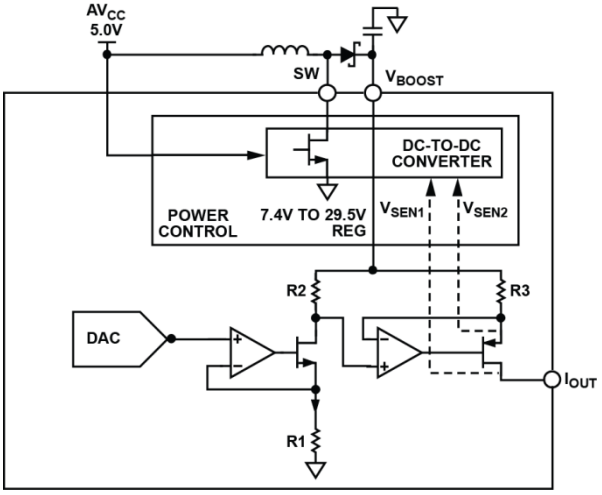

Figure 1. AD5755 with Dynamic Power Control

The figure shows its current output circuitry, dc-to-dc converter, and power controller. When the current output is enabled, V_{DS} of the output FET is sensed. This voltage controls the MOSFET in the power control block to regulate V_{BOOST}, which in turn controls V_{DS} as determined by the

output current requirement. With the MOSFET switched on, the inductor charges to a value determined by the difference in the actual value of V_{DS} and the required value. When switched off, the inductor discharges into the capacitor and V_{BOOST} pin. This process repeats on each clock cycle. There is one dc-to-dc converter per channel. For more information on the AD5755 family, please visit:

http://www.analog.com/en/digital-to-analog-converters/da-converters/ad5755/products/product.html

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