Design Note

Precision Solutions with Protection and Robustness for Analog Outputs in Process Control

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In industrial processes, there is a need for accurate and robust control of actuators that manage process parameters such as flow, temperature, and pressure. Precision analog output modules, known as programmable logic controllers (PLCs) or distributed control systems (DCS), produce voltage or current outputs used to govern such actuators. These modules need to deliver robust, reliable, and precise outputs in harsh industrial environments.

The combination of the AD5423 single-channel, 16-bit I/V output DAC and ADG5401F overvoltage protected SPST switch from Analog Devices align with these control needs and are suited to the requirements for analog output modules.

Precision

Precision is a key feature of the AD5423. In voltage out mode, TUE is as low as ±0.01% at 25°C (±0.05% across temperature) with typical output drift of 0.35 ppm FSR/°C. In current out mode, TUE is also ±0.01% at 25°C with typical output drift of 2 ppm FSR/°C. Differential nonlinearity (DNL) in all output modes is ±1 LSB and guaranteed monotonic.

The ADG5401F precision switch has an on-resistance (R_{ON}) specification of 6 Ω and has an integrated secondary feedback channel that is used to connect the channel I_{OUT}/V_{OUT} to the $+V_{SENSE}$ input on the AD5423; this removes any error associated with the variation in on resistance of the ADG5401F. The maximum on leakage of the ADG5401F across temperature is 40 nA. This leakage accounts for less than 1 LSB on a 16-bit, 4 mA to 20 mA current output DAC maintaining precision in the output signal chain and maximizing dynamic range.

Robustness

The ADG5401F overvoltage protected SPST switch is used on the analog output of the AD5423 DAC to protect against overvoltage conditions in both the powered and unpowered state. The ADG5401F can tolerate up to ±60 V overvoltage on the source (S) and source feedback (SFB) pins. This will protect precision analog output nodes that are vulnerable to damage caused by loss of system power, miswiring, power supply sequencing issues, etc. Figure 1 details how the AD5423 and the ADG5401F should be connected in an analog output module.

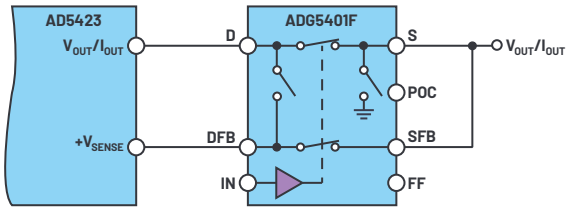

Figure 1. AD5423 and ADG5401F configuration.

The ADG5401F power supplies set the overvoltage fault threshold, so if the voltage on the source pins (S or SFB) goes above the ADG5401F supply voltage, this is considered a fault and the main switch channel and the secondary feedback channel will automatically open.

When the switch channels are open during a fault, any large fault currents are prevented from flowing back into the DAC output and into the system power supply. With no large fault currents flowing during an overvoltage event, the system power dissipation is no longer constrained by the power dissipation during a fault, thereby reducing the design effort required for the system power supplies. The ADG5401F allows the system to remove current limiting resistors in the output signal path that can cause headroom issues in some applications.

The ADG5401F includes an integrated open-loop prevention switch. If the V_{OUT}/I_{OUT} node is subjected to an overvoltage signal up to ±60 V, the ADG5401F will implement its overvoltage protection mode, and the main channel and secondary feedback channel switches will open. At the same time, the internal open-loop prevention switch, an internal connection between D and DFB, will close. This open-loop prevention switch keeps the DAC output feedback loop intact and prevents the DAC from driving the output to the rails.

To achieve protection from high voltage transients, such as IEC 61000-4-2 ESD, IEC 61000-4-4 electrical fast transient (EFT), and IEC 61000-4-5 surge, implement a circuit such as the one shown in Figure 2 by using discrete resistors and a transient voltage suppression (TVS) device. Place the resistors inside the feedback loop of the system so that the resistors do not add any error to the system output.

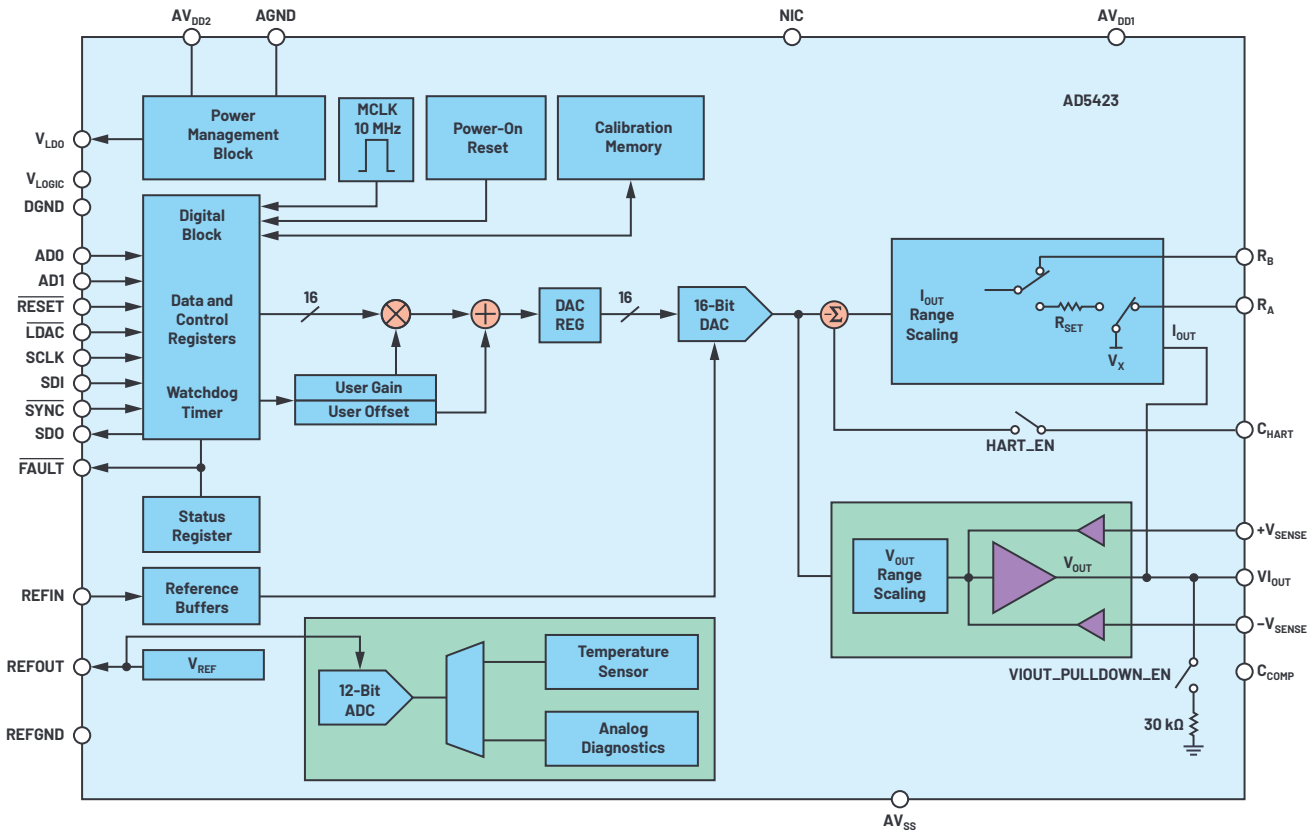

Figure 3. AD5423 functional block diagram.

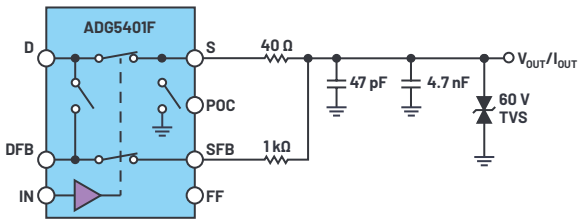

Figure 2. ADG5401F circuit diagram.

Table 1. High Voltage Transient Protection

IEC 61000-4 Transient	Protection Level (kV)
ESD (Contact)	±6
EFT	±4
Surge	±4

Diagnostics

The AD5423 contains a 12-bit internal diagnostic ADC that provides diagnostic information on user-selectable inputs such as supplies, grounds, internal die temperatures, and references.

On-board diagnostic registers contain flags that indicate various fault situations, as well as a FAULT pin that triggers for any fault. In voltage out mode, short-circuit detection is monitored while in current out mode, open-circuit detection is monitored. The AD5423 also offers a cyclic redundancy check (CRC), which performs a check on the received data and triggers the FAULT pin if the current data package appears to be incorrect. Temperature monitoring is also available, which registers a fault if the die temperature exceeds a programmed limit.

Conclusion

Together, the AD5423 and the ADG5401F offer the precision and robustness required by industrial process applications. The AD5423's 16-bit I/V output provides the accurate control signals required for modern analog output modules, while the ADG5401F maintains that precision and provides robust protection against external stresses in harsh environments.

About the Author

David Forde joined Analog Devices, Inc. as a layout engineer in 2006 after graduating from Carlow Institute of Technology with a B.Sc. in integrated circuit design. In 2011, he graduated from the University of Limerick with a M.Eng. in VLSI systems and in 2015 he joined the Instrumentation and Precision Technology Group as an applications engineer supporting the analog switch and multiplexer product portfolio. He can be reached at david.forde@analog.com.

Claire Croke joined Analog Devices in 1999 and currently works as a marketing engineer in the Precision Switches and Multiplexers Group in Ireland. In her previous role at Analog Devices, Claire worked in the Precision Converter Applications Team. She graduated with a B.Eng. in electronic engineering from University of Limerick, Ireland. She can be reached at claire.croke@analog.com.

Jean McAdam is a strategic marketing manager for Process Control and Automation at Analog Devices. Prior to this role, she led the marketing activities for ADI's platform customer evaluation solutions and held roles as a software systems engineer and software developer. She holds a B.Eng. in electronic and computer engineering from the University of Limerick. She can be reached at jean.mcadam@analog.com.