

How Software Configurable Hardware Helps for Flexibility in Industrial I/O Modules

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Whether used for a process control installation or an industrial automation system, an I/O module or a field junction box has a variety of unique challenges in the whole product life cycle. Product management faces decisions on how many channels and which combinations will be necessary for each product. Electronic designers must decide how to implement the best performance and cost-efficient system for various analog or digital signals in the projects. Installation technicians can be overwhelmed by all the different products and numerous wiring schemes. Wouldn't life be easier if we could design a system with the ultimate flexibility against such difficulties? Analog Devices' new product family of software configurable input/output (SWIO) ICs achieve this goal by supporting literally any function and any combination on any pin at any time.

For an industrial programmable logic controller (PLC) or distributed control system (DCS) in process control or factory automation, end-customers and applications have differing requirements. For product managers to define the correct product, strategy and optimization is a huge task. One end-customer may require more analog output channels, such as 4 mA to 20 mA, while another one asks for more digital inputs. Or the same customer can ask for more analog channels for one platform, whereas the other platform requires more digital channels. Examples of this dilemma are shown in Figure 1. As Industry 4.0 rises, manufacturers need flexible systems that can quickly and easily adapt to changing requirements, all driven by shifts in consumer behavior and demand. As a result, they can no longer rely on fixed, large-scale systems designed for

mass-market products and predictable demand. Instead, flexible systems that can be reconfigured quickly with minimal downtime and capital investment are required.

SWIO components enable their channels to be programmed, not only as input or output, but also as analog or digital. Furthermore, they can be efficiently set up for reading 2- or 3-wire RTDs or thermocouples.

Software configurable I/O also acts as a bridge to Ethernet-based control networks, as it can further be applied to brownfield installations requiring updates to 10BASE-T1L Industrial Ethernet systems. It enables the development of standardized, configurable field I/O units capable of translating between existing HART®-enabled 4 mA to 20 mA sensors and actuators and 10BASE-T1L or 100 meter fiber backhaul.

Figure 2 shows the [AD74413R](#), a quad-channel SWIO device designed to meet process control, factory automation, or building control applications (this article focuses on industrial applications). The device is a fully integrated monolithic solution for industrial input and output operation. The AD74413R features a 16-bit, sigma-delta ($\Sigma\Delta$) ADC and four 13-bit DACs and is packaged in a 9 mm × 9 mm, 64-lead LFCSP that supports a -40°C to +105°C operating temperature range. Each of the four channels are configured by writing to the configuration registers over an SPI bus whose clock can go up to 24 MHz. Users can refine the default configurations of each operation mode via the AD74413R register map.

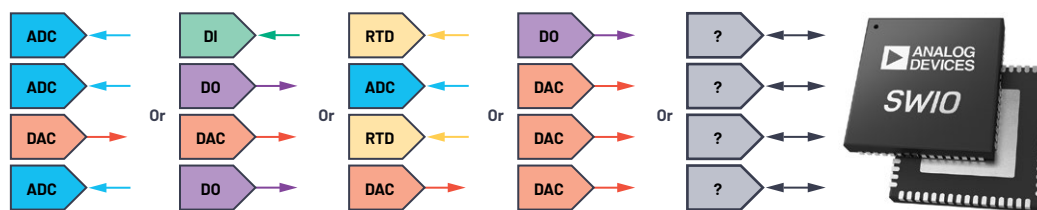


Figure 1. Channel number and configuration possibilities.

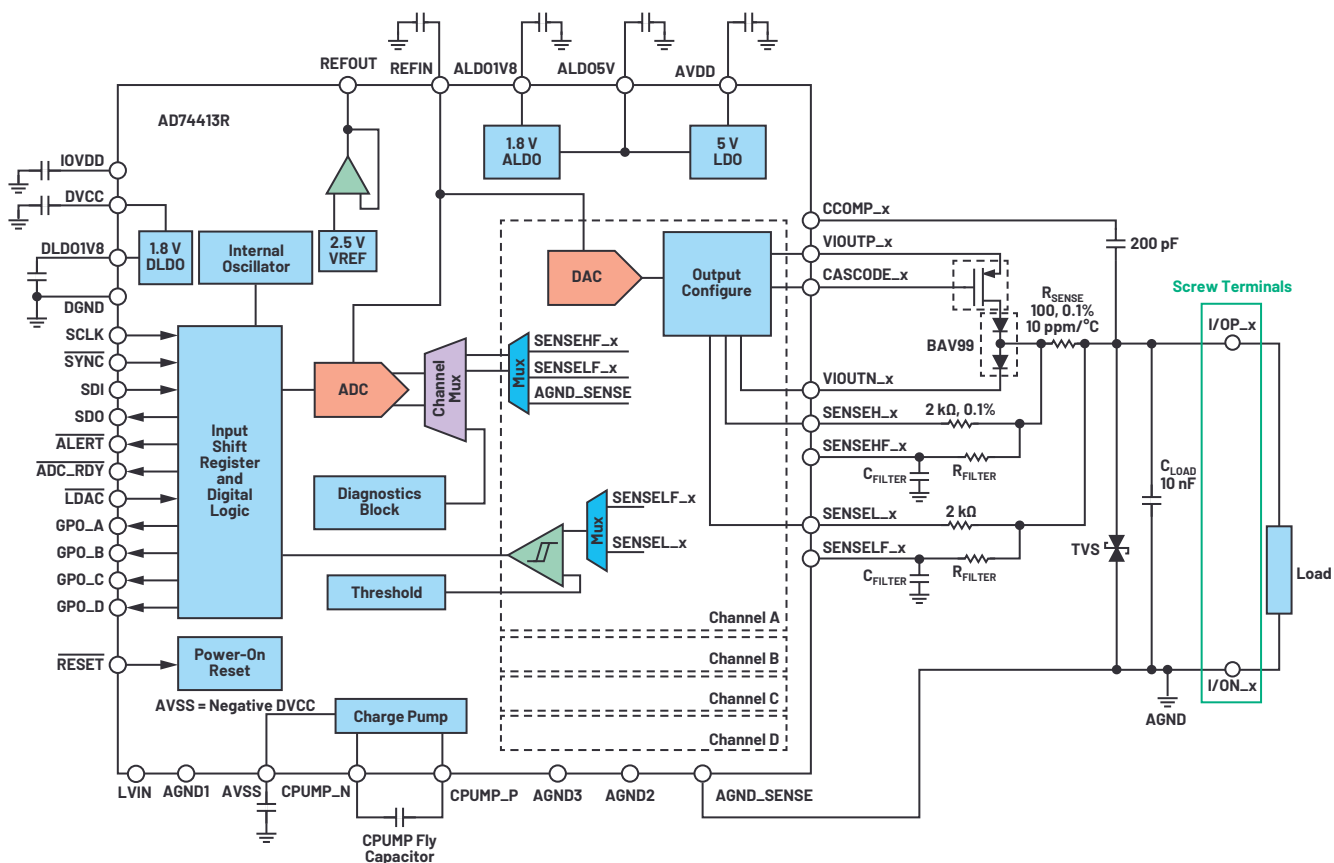


Figure 2. SW configurable I/O component and a typical application example.

The AD74413R's 16-bit, sigma-delta ADC can measure either current or voltage on one or more of the four channels and up to four diagnostic inputs via a single conversion request. The conversion rate is up to 4.8 kSPS, and optional 50 Hz and 60 Hz rejection filters are available.

The per channel 13-bit R-string DACs are inherently monotonic and linear. These DACs support current outputs up to 25 mA and have open-circuit detection capability for fault diagnostics. Similarly, they can provide voltage outputs with true 0 V to 11 V range.

AD74413R has a highly accurate internal reference to drive DACs and ADCs in cost-sensitive applications, while an external reference may be used when the highest performance is required.

Possible Functions and Operating Modes

Each channel's function overview can be seen in Table 1. The component can support voltage output, current output, voltage input, current input (externally powered), current input (loop powered), external RTD measurement, digital input logic, and loop-powered digital input. There is also high impedance mode as a default function after power-up or a device reset.

Table 1. Possible Function Selections

Channel Function (Programmed via the CH_FUNC_SETUPx Registers)	Example Feature(s)
High Impedance	Optional pull down
Voltage Output	Short-circuit protection
Current Output	Open-circuit detection
Voltage Input	Optional pull down, thermocouple measurement mode
Current Input (Externally Powered)	Short-circuit protection, HART-compatible mode
Current Input (Loop Powered)	Short-circuit protection, HART-compatible mode
Resistance Measurement	Ratiometric measurement, 2-wire or potentially 3-wire RTDs
Digital Input Logic	Filtered or unfiltered voltage measurements, debounce function
Digital Input, Loop Powered	Filtered or unfiltered voltage measurements, debounce function

The voltage output amplifier can generate unipolar voltages up to 11 V. An internal low voltage charge pump allows the amplifier to generate a true zero output voltage. In this mode, an external sense resistor provides current feedback (force voltage measure current FVM approach) while negative feedback over the SENSEL_x pin regulates the correct voltage level.

slew rate control. Moreover, it has seven low power digital isolation channels—four for SPI and three for general-purpose communication.

Another typical need in I/O modules is driving relays or lamps. AD74413R has the GPOs, which may also be programmed as special digital outputs (DOs). With an external PMOS and [ADM1270](#) current limiting controller, this pin can regulate a few hundred milliamperes for driving relays or lamps. ADM1270 provides inrush current limiting and overcurrent protection for such inductive or resistive loads. A typical application example can be found on the evaluation board of the AD74413R.

When HART modulation is required, an [AD5700](#) can provide modem functionality for AD74413R-based systems.

Since the scope of this article encompassed industrial applications, we mainly discussed the AD74413R. There is also a lighter version, called [AD74412R](#), that is targeted to building control applications. It has a reduced operating temperature range of -40°C to $+85^{\circ}\text{C}$, more relaxed current input and output accuracies, and supply voltages up to 26.4 V.

Conclusion

With the right SWIO ICs, manufacturers can develop a platform that replaces multiple aging fixed function I/O modules. Moreover, they can use this technology across multiple end applications where the I/O dynamically changes with each installation. For systems traditionally reliant on control cabinets with multiple I/O modules and specified wiring for each channel type, the need for hardware disappears as end users can now install a single module programmable from the control room, helping to decrease product management, logistic, manufacturing, and support costs. SWIO technology also acts as a bridge to Ethernet-based control networks, since it can be applied to already available installations.

References

¹ Bela G. Liptak. *Instrument Engineers' Handbook, Volume II: Process Control and Optimization*. CRC Press, September 2005.

² [HART Communication Protocol](#). FieldComm Group.

About the Author

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