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Increase Switch Channel Density with Advanced Packaging and Route Through Pins

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Abstract

This article introduces a groundbreaking precision switch product that aims to revolutionize the challenges faced in printed circuit board (PCB) design and electronic measurement systems that require high channel density and precision. With its innovative copackaging approach for passive components and the inclusion of a route through pins feature, this switch not only offers significant benefits in terms of PCB space utilization but also greatly enhances switch channel density. In addition, the very low switch resistance improves measurement accuracy and reduces power dissipation, which aids thermal management at a system level.

Introduction

The core innovation of this switch lies in its unique integration of passive components and independently controlled switches with a serial peripheral interface (SPI). By incorporating resistors and capacitors directly into the switch package, designers can achieve unprecedented space-saving benefits. This design architecture results in a remarkable reduction of up to 80% in board area, making it an ideal solution for applications where space limitations are a critical concern.

The route through pins feature offers a game-changing solution for PCB designers. By enabling efficient routing of SPI and power supply traces directly through the switch, this feature eliminates the need for additional vias or complex routing configurations. This simplification not only reduces design complexity but also leads to substantial improvements in switch channel density, enabling the creation of more compact and high-performance designs.

In addition to its space-saving attributes, this switch has a low switch resistance of approximately 0.5 Ω. This characteristic is crucial for improving measurement accuracy and minimizing heat generation when handling high currents. By reducing switch resistance, it provides superior signal integrity and precision in a wide range of applications, including automated test equipment and precision measurement and control systems. Furthermore, the low switch resistance improves thermal resistance, ensuring reliable and consistent performance even in varying environmental conditions.

Challenges When Maximizing Channel Count

When designing a system with the goal of maximizing channel count, board space becomes a valuable resource. Switches play a crucial role in increasing channel count in a system, but as the number of switches grows, board space is not only occupied by the switches themselves but also by the logic control lines and associated passive components required for correct operation. Consequently, the achievable channel count is compromised due to the space taken up by the additional components needed to control the switches.

Traditional Switch Solution

One commonly employed solution to enhance channel density is to use switches controlled by an SPI logic interface, such as the ADG1414, an octal SPI switch. This architecture offers a significant advantage over a parallel interface, as it only requires four GPIO lines for implementation and utilizes just one SPI port of a standard microcontroller. For systems containing numerous switches, the daisy-chain feature available on the device can be used to control all the devices simultaneously. Figure 1 illustrates an example where 25 ADG1414 devices configured in daisy-chain mode control 200 LEDs. In addition, three decoupling capacitors and one pull-up resistor are required for proper operation. This implementation requires the placement of 125 components, occupying a board area of approximately 2600 mm^2.

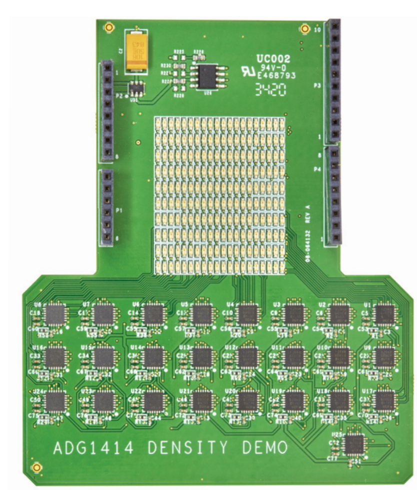

Figure 1. PCB layout example showing 25 ADG1414 devices.

Advanced Packaging

By integrating passive components directly into the switch package as shown in Figure 2, designers can achieve unparalleled space-saving benefits. The ADGS2414D has integrated decoupling capacitors for the V_{DD}, V_{SS}, and RESET/V_L power supply pins. Therefore, the need for external decoupling capacitors is eliminated. The pull-up resistor for the SDO pin is also integrated. Combined with multidie stacking of the switch circuitry, the total system footprint of this switch is significantly reduced and available in a 4 mm × 5 mm LGA package.

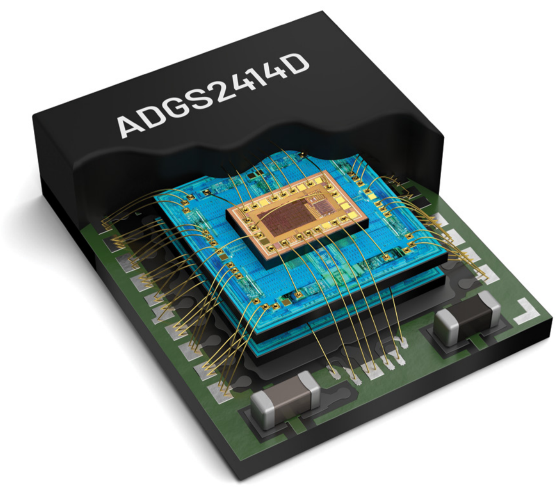

Figure 2. ADI's innovative stacked triple-die solution.

Route Through Pins

When multiple devices are used in a system, the route through pins feature allows for a more compact layout with increased channel density. This feature facilitates the seamless passage of power supplies and digital lines between devices. The V_{DD}, RESET/V_L, and GND power lines, as well as the SCLK, CS, SDI, and SDO digital lines, are available on both the top and bottom pins of the package. These route through pins simplify PCB routing and reduce the need for vias when connecting multiple devices. Figure 3 shows an example PCB layout where the route through pins on four ADGS2414D devices configured in daisy-chain mode are used to minimize the overall size of the layout.

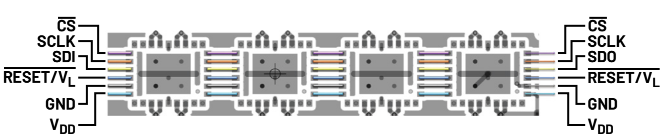

Figure 3. PCB layout example of using the route through pins feature.

ADI Switch Solution

As mentioned earlier, the common switch solution shown in Figure 1 requires the placement of 125 components occupying a board area of approximately 2600 mm^2. With the innovative copackaging of passive components and the route through pins feature of the octal switch, a new PCB design with significantly higher density becomes achievable. Figure 4 showcases the same scenario of 200 LEDs controlled by 25 ADGS2414D switches. Again, the daisy-chain feature can be used to control all the devices simultaneously. Notably, the layout lacks passive components, allowing the switches to be placed in close proximity with a typical spacing of 1 mm between each device on both sides. This design requires the placement of only 25 devices on a board area of approximately 800 mm^2, resulting in a 70% reduction in the board area. In addition to the board area savings, there is a reduction of 100 passive components, leading to significant cost savings in manufacturing, as well as improvements in product quality and reliability.

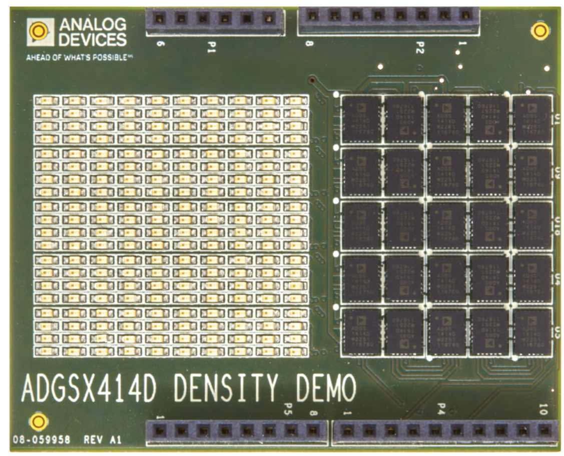

Figure 4. PCB layout example showing 25 devices.

Low Switch Resistance

In addition to its space-saving benefits, the ADGS2414D boasts an impressively low switch on resistance of typically 0.5 Ω. This low resistance minimizes voltage drops (I × R) within a measurement signal chain, resulting in enhanced overall accuracy at the system level. In applications with high channel density, improved accuracy translates to reduced channel-to-channel variation and fewer calibration cycles, leading to cost savings and increased product test yield.

This switch can handle significantly higher switching currents, with a specification of up to 850 mA per channel. This capability is particularly valuable when dealing with high current switching scenarios. However, it's important to manage the heat generated by power loss in the switch, especially in high channel density applications where thermal management can be a challenge. Once again, the low switch on resistance plays a crucial role in reducing power loss (I^2 × R) as heat. This feature ensures temperature stability within the system and helps prevent overheating issues.

Daisy-Chain Mode

The ADGS2414D supports the connection of multiple devices in a daisy-chain configuration, as shown in Figure 5. In this setup, all devices share the same CS, SCLK, and V_L lines. The SDO of one device forms a connection to the SDI of the next device, creating a shift register. One single 16-bit SPI frame is used to command all the devices in the chain to enter daisy-chain mode. In this mode, SDO is an 8-cycle delayed version of SDI, so the desired switch configuration can be passed from one device to the next device in the chain.

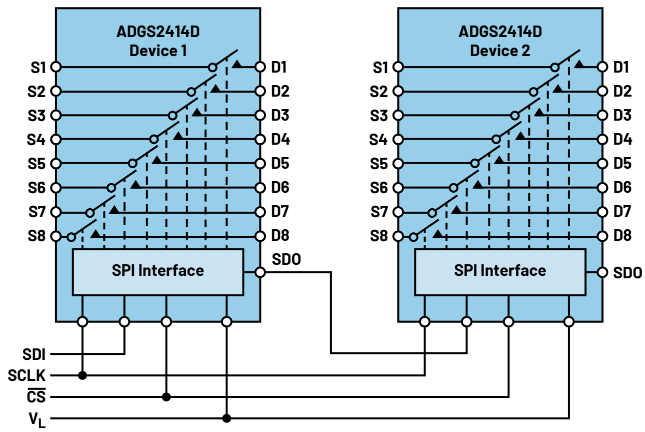

Figure 5. Two ADGS2414D devices in a daisy-chain configuration.

Error Detection Function

Protocol and communication errors on the SPI are detectable. There are three error detection features: incorrect SCLK count error detection, invalid read/write address error detection, and CRC error detection. Each of these error detection features can be enabled or disabled using corresponding enable bits in the error configuration register. In addition, there is an error flag bit in the error flags register for each of these error detection features.

Conclusion

The ADGS2414D offers a groundbreaking solution in PCB design and electronic measurement technology. Its innovative copackaging of passive components, the route through pins feature, SPI interface, and low switch resistance contribute to significant reductions in board area, increased channel density, and improved measurement accuracy. The same industry-leading switch performance seen in Analog Devices' current switch offerings is maintained due to the multidie packaging used. With the introduction of this device, a new innovative precision switch solution is presented that enables a significant increase in switch channel density.

About the Authors

Brendan Somers is a product marketing engineer in the Instrumentation Business Unit at Analog Devices, Ireland. He graduated from the University of Bolton in 1993 with a B.Eng. honors degree in electrical and electronic engineering. Brendan joined the company in 2012 supporting precision converters and recently joined the Switches and Multiplexer Technology Group. Prior to joining ADI, he worked as an electronics design engineer for more than 15 years within the automotive industry and product manufacturing sector.

Edwin Omoruyi is a senior product applications engineer in the Instrumentation Business Unit at Analog Devices, Ireland. He graduated from the Limerick Institute of Technology in 2007 with a B.Eng. honors degree in electronics systems engineering, and from the University of Limerick in 2010 with an M.Eng. honors degree in very large scale integration (VLSI). Edwin rejoined ADI in 2023 after he previously worked in the Automotive and Cabin Electronics Business Unit as an applications engineer from 2010 to 2018. Outside of ADI, he worked as a system architect on AD/ADAS sensing applications in the automotive industry and manufacturing sector.

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