Application Note

Improving Energy Efficiency in Appliances and Industrial Applications using the ISO6163 Digital Isolator With Automatic Enable

TEXAS INSTRUMENTS

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ABSTRACT

To reduce the environmental impact from energy consumption, various governments and certifying bodies are making the power consumption requirements for house hold appliances (white goods) and other industrial applications more stringent. The ISO6163 is a 6-channel digital isolator with 4 high-speed communication channels and 2 low-speed control channels. The low-speed control channels have an integrated automatic enable which provides a bi-directional wake-up capability controlling the low-power STANDBY state of the device even across the isolation barrier. In appliances and other applications where high-speed data communication is not required all the time, this device helps reduce system power consumption to turning off the high-speed channels and allowing control of both sides of the isolation barrier to power down and wake-up entire sub-systems within the appliance or application.

This application note introduces several use cases of the device: MCU to SPI peripheral, MCU to MCU, and MCU to bus.

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1 Introduction

The ISO6163 device is a high-performance, six-channel digital isolator designed for high energy efficiency systems where part or all of the system is transitioned to low-power mode for portions of operation with fast wake-up capability. Many applications do not require high-speed communication all the time. This device helps save energy by turning off the high-speed isolation channels when not needed, thus lowering the current consumption of the isolation device.

The ISO6163 device is optimized with low quiescent current and bi-directional automatic enable of the high-speed data channels for use in high energy efficiency applications such as appliances, battery monitoring, metering and grid.

The ISO6163 device has three forward channels and three reverse-direction channels. This device provides two low-speed data channels with bi-directional automatic enable control functionality. The low-speed control channels automatically enable the high-speed channels when needed or turn them off (outputs high impedance) to further reduce power consumption when high-speed data transfer is not needed by the system.

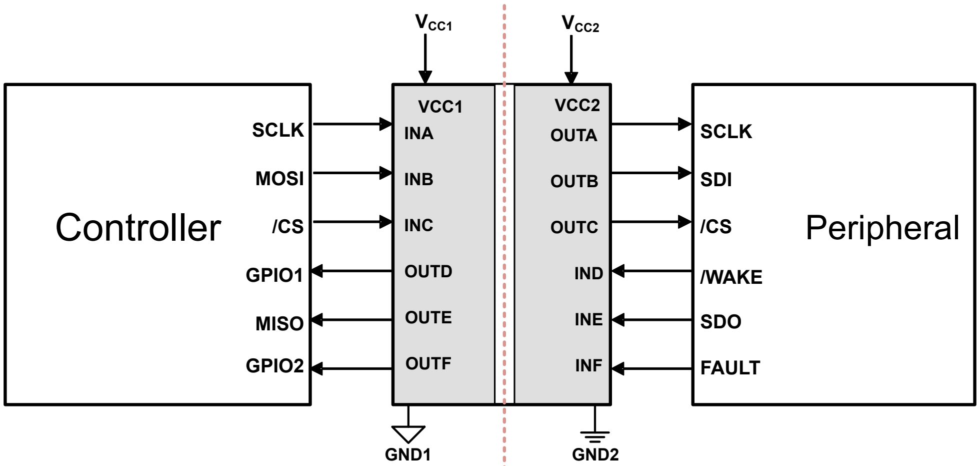

Figure 1-1. Simplified Example Application

For details on the High-Speed Data Channels (A, B, E, and F), Low-Speed Control Channels with Automatic Enable (C and D), the timing requirements on the Low-Speed Control Channels for entering and exiting the low-power STANDBY state and the functional modes of the device, please refer to the *ISO6163 Low-Power, High-Speed Six-Channel Digital Isolator With Automatic Enable*. The high-speed data channels (A,B, E, and F) support up to 50Mbps and are described in section 7.2 of the data sheet. The low-speed control channels (C and D) support up to 4Mbps and are described in section 7.3 of the data sheet. The timing and level details of Automatic Enable for the low-speed control channels (C and D) are described in section 7.3.1 of the data sheet.

When using 5V supplies, the ISO6163 reduces the power in STANDBY state with respect to ACTIVE state with 50Mbps communication by 52.3mW (typical) for a 93% reduction in isolation power consumption. With 25Mbps communication by the power is reduced by 31.25mW (typical) for a 90% reduction in isolation power consumption.

Similarly when using 3.3V supplies, the ISO6163 reduces the power in STANDBY state with respect to ACTIVE state with 50Mbps communication by 43.7mW (typical) for a 93% reduction in isolation power consumption. With 25Mbps communication by the power is reduced by 27mW (typical) for a 88% reduction in isolation power consumption.

Significantly higher power saving at a system level is possible using the low-speed control channels to turn off additional circuitry on one or both sides of the isolation barrier when the circuits are not needed.

The following sections of this application note shows the device used in various application use cases where the system can be partially powered down while retaining the capability to wake-up and return to full operation and communication automatically.

2 Using the ISO6163 in Energy Efficient Applications

This section highlights several use cases of the ISO6163: MCU (microcontroller) to SPI peripheral, MCU to MCU, and MCU to bus. The concepts described here can be adapted for other use case scenarios for the device.

2.1 MCU to SPI Peripheral Communication With Bi-Directional Wake-up

These application use cases show MCU to SPI peripherals with bi-directional wake-up from the MCU side or the peripheral side.

Figure 2-1 example shows MCU to SPI peripheral with bi-directional wake up. When both sides idle the communication by returning both INC and IND to HIGH, the isolator transitions to STANDBY state and turns off the high-speed data channels. When the MCU wants to communicates, the MCU pulls INC LOW (nCS) and the isolator wakes-up, turns on the high-speed channels and pulls OUTC LOW. The SPI peripheral uses the input from OUTC as a wake-up interrupt or equivalent to wake-up and prepare for the high-speed communication. Similarly, if the system is in low-power mode and the peripheral issues a wake-up request, the peripheral pulls IND (nWAKE) LOW. The isolator wakes-up, and turns on the high-speed channels and asserts OUTD LOW. The MCU uses an interrupt IO or equivalent on OUTD to wake-up and prepare for the high-speed communication.

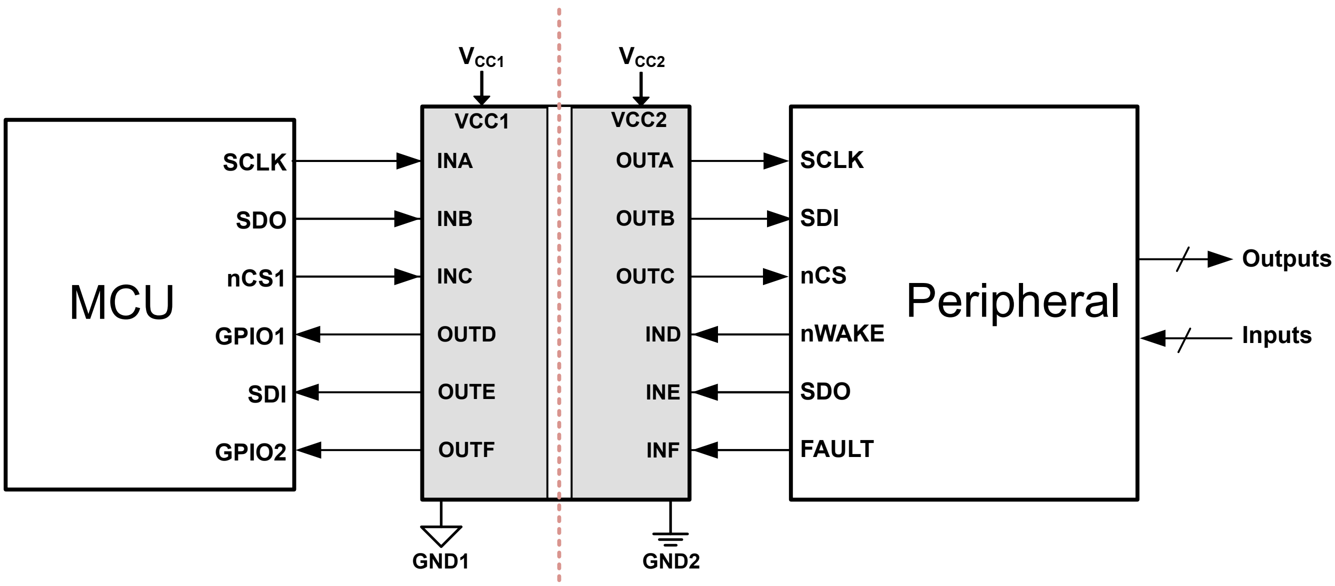

Figure 2-1. 6-Channel MCU to SPI Peripheral With Bi-directional Wake-up From MCU to Peripheral or Peripheral to MCU

The next example, Figure 2-2, is similar to Figure 2-1 however this example uses multiple SPI peripherals in a point to point SPI architecture.

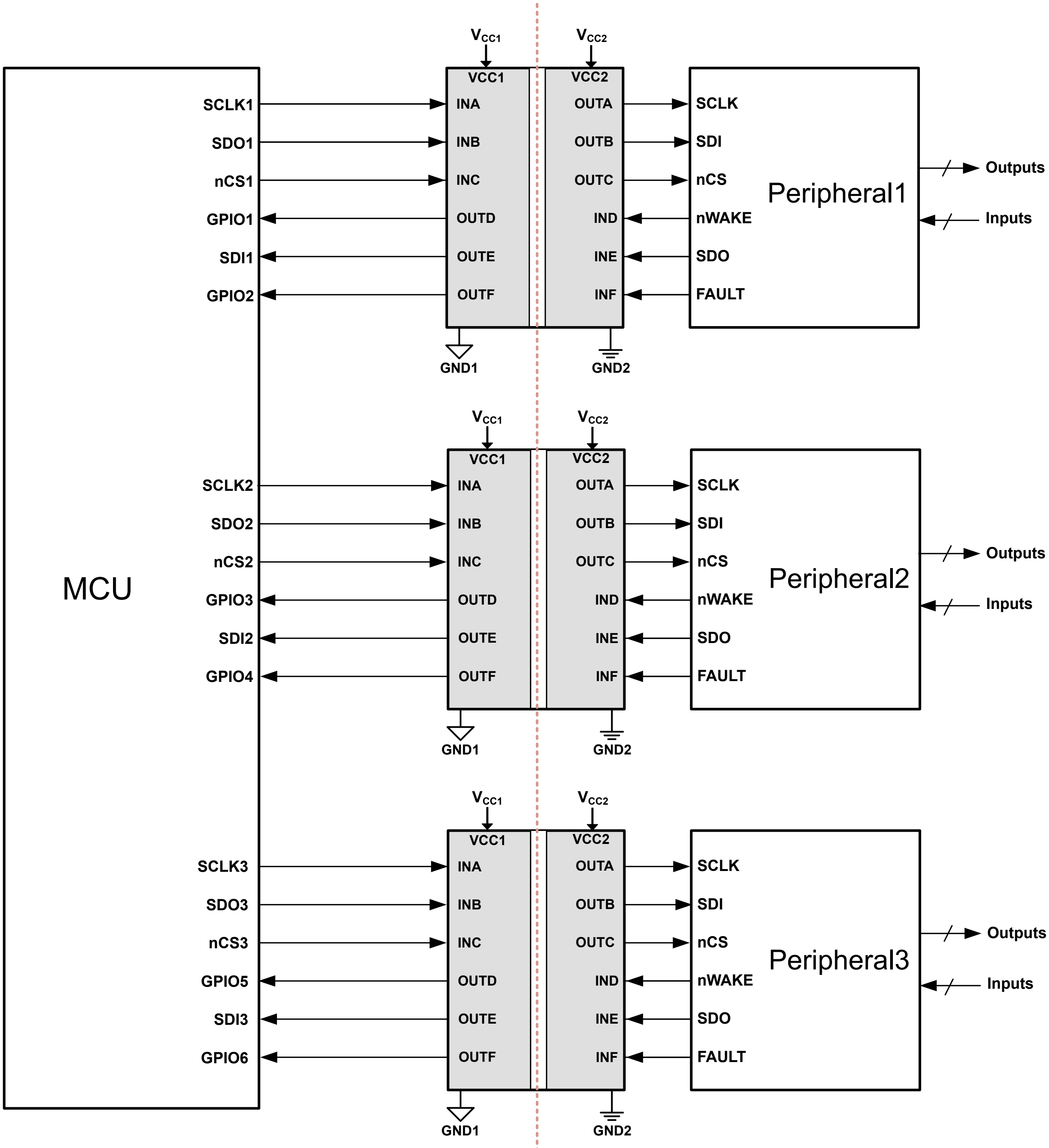

Figure 2-2. 6-Channel MCU to Multiple SPI Peripherals With Bi-directional Wake-up From MCU to Peripheral or Peripheral to MCU

2.2 MCU to Communication Bus Transceiver with Bi-Directional Wake-up

This application use case shows MCU (microcontroller) to communication bus transceiver with bi-directional wake-up from the MCU side or the communication bus side.

Figure 2-3 example shows MCU to communication bus transceiver with bi-directional wake-up. When both the MCU and bus communication are idle and return both INC and IND to HIGH, the isolator transitions to STANDBY state and turns off the high-speed data channels after the STANDBY state enable delay time, t_{LP_EN}. When the MCU wants to communicates, the MCU pulls INC LOW (nCS) and the isolator wakes-up, turns on the high-speed channels and pulls OUTC LOW waking up the SPI to Bus Transceiver device preparing for communication with other nodes of the network. The SPI to Bus Transceiver uses the input from OUTC as a wake-up request to prepare for the high-speed communication. Similarly, if the system is in low-power mode and the communication bus issues a wake-up request, the SPI to Bus Transceiver processes the request and pulls IND (nWAKE) LOW. The isolator wakes-up, and turns on the high-speed channels and asserts OUTD LOW. The MCU uses an interrupt IO or equivalent on OUTD to wake-up and prepare for the high-speed communication.

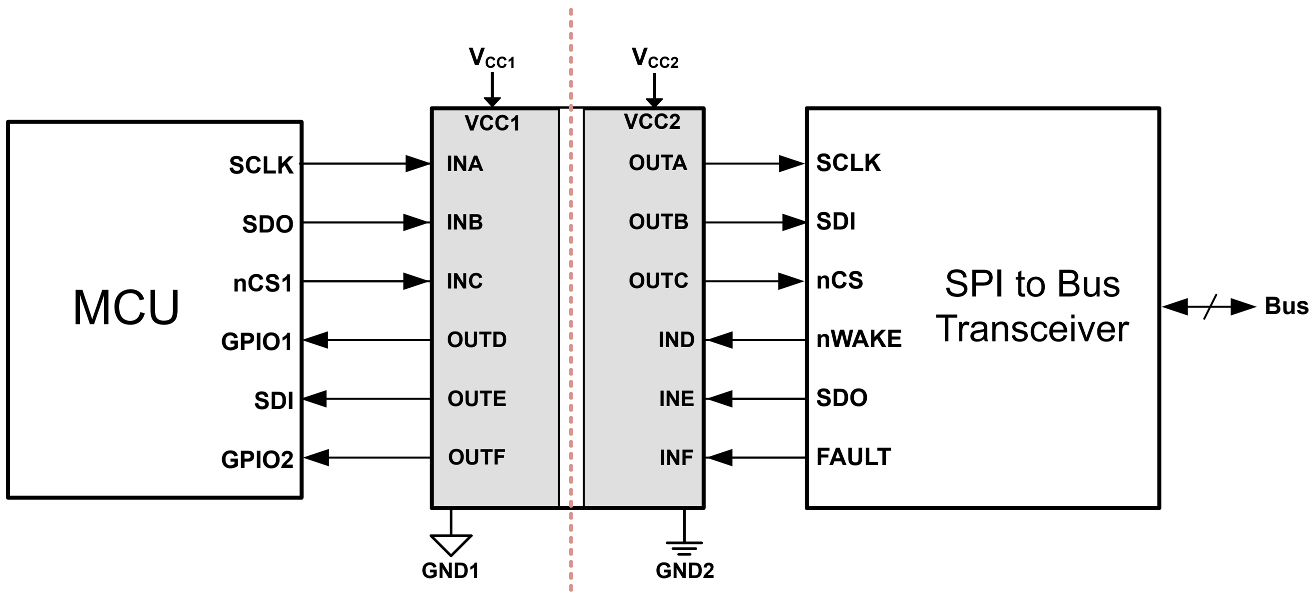

Figure 2-3. 6-Channel MCU to Communication Bus Transceiver With Bi-directional Wake-up From MCU to Bus or From Bus to MCU

2.3 MCU to SPI Peripheral Communication With Single Direction Wake-up

These application use cases show MCU (microcontroller) to SPI peripherals with single direction wake-up from the MCU side.

Figure 2-4 shows a MCU to SPI peripheral with single direction wake-up from the host MCU. When the host MCU idles the communication by pulling INC HIGH, the isolator transitions to STANDBY state after the STANDBY state enable delay time, t_{LP_EN}, and turns off the high-speed data channels since IND is wired HIGH. To initiate communication again, the MCU pulls nCS LOW (INC), the isolator transitions to ACTIVE state turning on the high-speed channels and pulls OUTC LOW. The SPI peripheral uses the input from OUTC as a wake-up interrupt or equivalent to wake-up and prepare for high-speed communication.

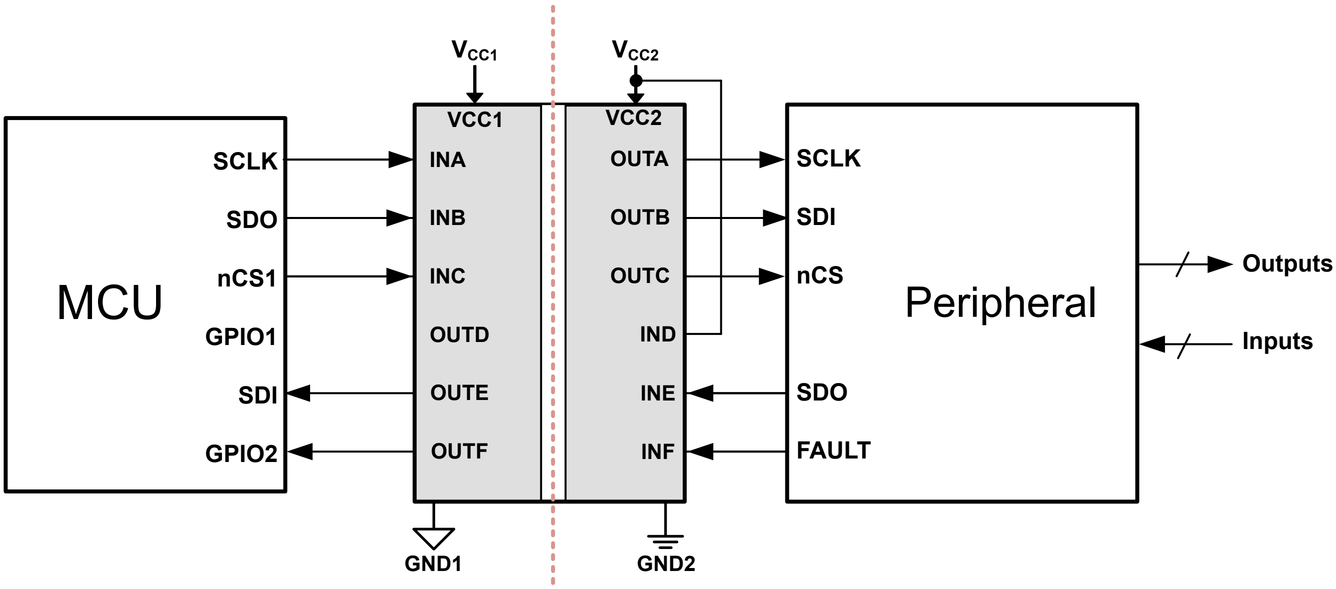

Figure 2-4. 5-Channel MCU to SPI Peripheral With Single Direction Wake-up From MCU to Peripheral

The next example, Figure 2-5, is similar to Figure 2-4 however this example uses a single channel opto-emulator, ISO8710, as the nCS for the second peripheral.

The MCU must control INC of the ISO6163 isolator since INC controls the wake-up and state of the ISO6163 and the chip select to peripheral 1. To keep the ISO6163 in ACTIVE state while the MCU is communicating with Peripheral2 (nCS2 LOW and nCS1 HIGH), the communication to Peripheral2 must be completed before, t_{LP_EN} and the ISO6163 transitions to STANDBY state after INC (nCS1) is HIGH for the STANDBY state enable delay time. The STANDBY state transition timing is explained in the *ISO6163 Low-Power, High-Speed Six-Channel Digital Isolator With Automatic Enable*, data sheet, section 7.3.1 Low-Speed Control Channels: Timing and Level Details for Automatic Enable.

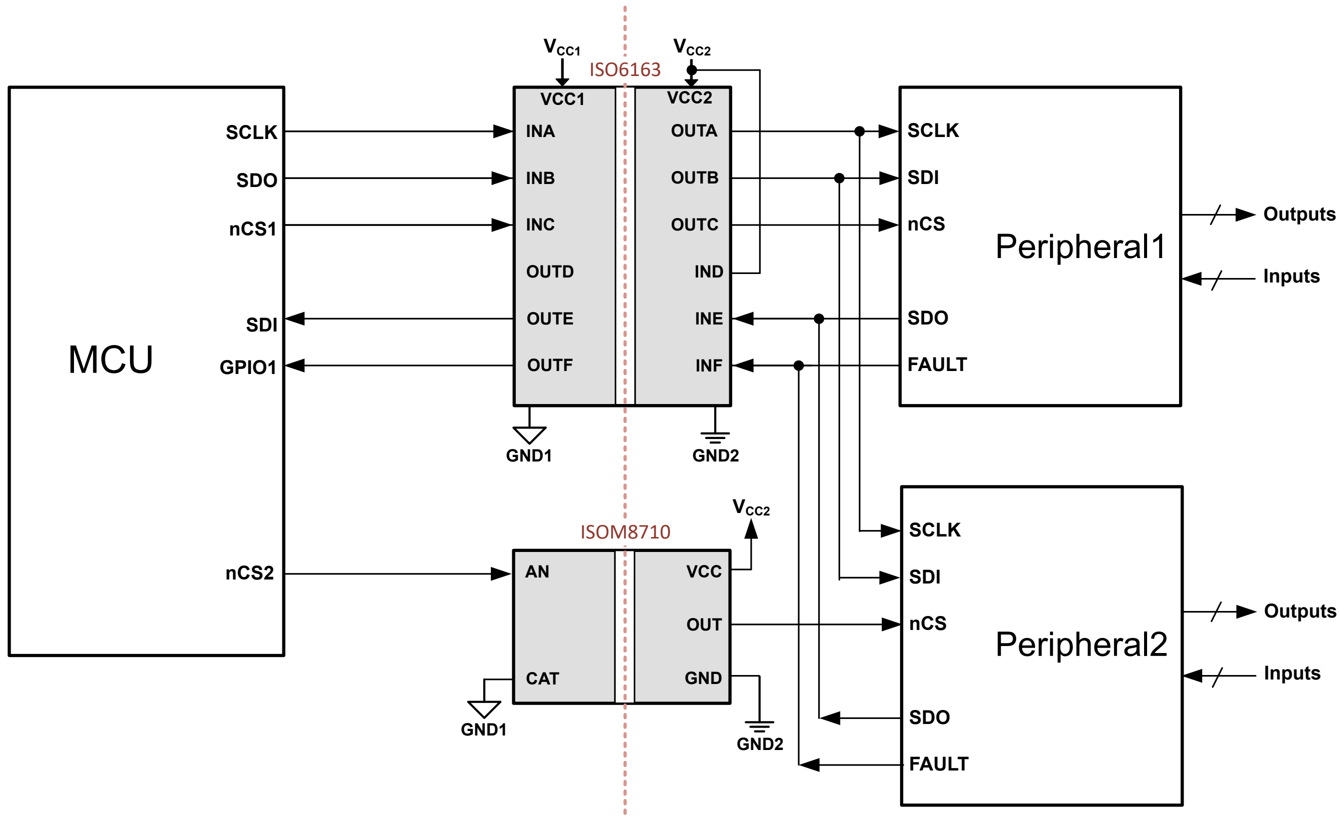

Figure 2-5. 5-Channel MCU to Multiple SPI Peripheral Bus With Single-Direction Wake-up From MCU to Peripheral With ISOM8710 Opto-emulator for 2nd nCS Channel

2.4 MCU to MCU Communication with Bi-Directional Wake-up

These application use cases show possible MCU to MCU communication.

Figure 2-6 example shows MCU to MCU communication with SPI. When both sides idle the communication by raising both INC and IND HIGH for longer than the STANDBY state enable delay time, t_{LP_EN}, the isolator transitions to STANDBY state and turns off the high-speed data channels. MCU1 can re-initiate communication by pulling INC (nCS) LOW, waking-up the isolator, turning on the high-speed channels and pulling OUTC LOW. MCU2 wakes-up because of OUTC falling LOW and generates an interrupt or equivalent to wake-up MCU2 to prepare for the high-speed communication.

Similarly, when MCU2 has data ready to communicate, MCU2 pulls IND (nDR) LOW, waking-up the isolator, turning on the high-speed channels and pulling OUTD LOW. MCU1 wakes-up because of OUTD falling LOW and generates an interrupt or equivalent to wake-up MCU1 to prepare for the high-speed communication.

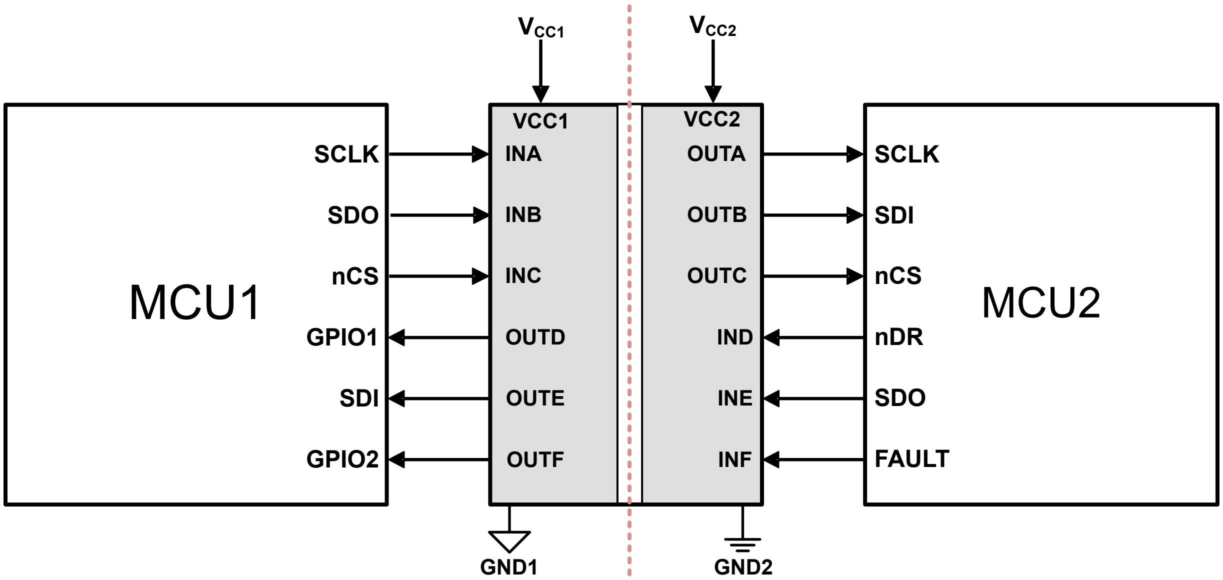

Figure 2-6. 6-Channel MCU to MCU Communication Through SPI

Figure 2-7 example shows MCU to MCU communication with a dedicated data bus in each direction. When both sides idle the communication the isolator transitions to STANDBY state and turns off the high-speed data channels. When MCU1 communicates by pulling INC LOW for a data enable signal and the isolator wakes-up and turns on the high-speed channels. MCU2 uses an interrupt IO or equivalent on OUTC to wake-up and prepare for high-speed communication. Similarly, when MCU2 has data ready to communicate, MCU2 pulls IND LOW for data enable and the isolator wakes-up and turns on the high-speed channels. MCU1 uses an interrupt IO or equivalent on OUTD to wake-up and prepare for high-speed communication.

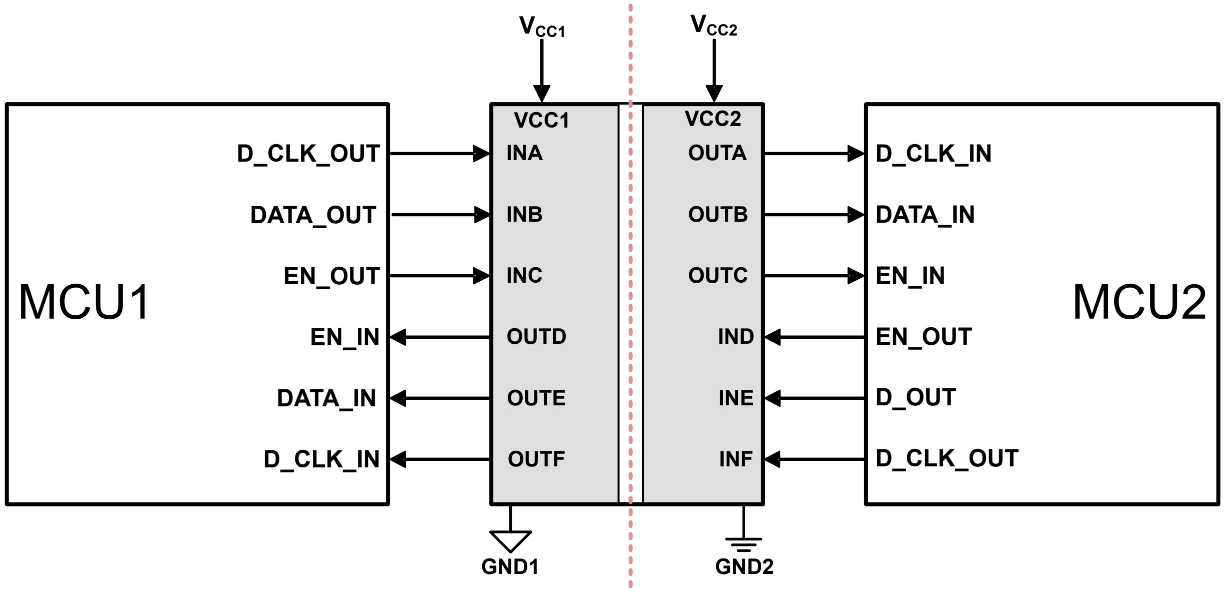

Figure 2-7. 6-Channel MCU to MCU Communication Through Dedicated Serial Data Bus

3 Summary

The ISO6163 digital isolator helps reduce energy consumption in house hold appliances (white goods) and other industrial applications. The ISO6163 automatic enable feature provide low-power STANDBY state reducing the current consumption in the isolator and providing signals that can control additional system circuitry reducing energy outside of the isolator. The flexibility in the use cases of the device provide benefits under many use case scenarios.

This device helps system designers meet energy efficiency requirements from various governments and certifying bodies.

When using 5V supplies, the ISO6163 reduces the power in STANDBY state with respect to ACTIVE state with 50Mbps communication by 52.3mW (typical) for a 93% reduction in isolation power consumption. With 25Mbps communication by the power is reduced by 31.25mW (typical) for a 90% reduction in isolation power consumption.

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4 References

- Texas Instruments, *ISO6163 Low-Power, High-Speed Six-Channel Digital Isolator With Automatic Enable*, data sheet.
- Texas Instruments, *Digital Isolator Design Guide*, application note.
- Texas Instruments, *Isolation Glossary*, application note.
- Texas Instruments, *How to Use Isolation to Improve ESD, EFT, and Surge Immunity in Industrial Systems*, analog applications journal.

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