Application Note

Using SPI Controlled MUX To Increase Channel Density

Nir Gilgur

ABSTRACT

Most multiplexers use GPIO signals to switch between input and output connections. Other more unique methods use different protocols; such as I2C, MIPI, SPI, and so on. In this application note we focus on a SPI controlled multiplexer and how the features and capabilities can benefit different designer systems.

Table of Contents

Trademarks

All trademarks are the property of their respective owners.

1 Introduction

One of the biggest concerns when designing a system is having enough board space. Multiplexers with high channel count can have a large footprint. As channel count increases, often you are left with a trade off of limited functionality for controlling all the switches. For example, an 8-channel 1:1 can only have the functionality to control all the switches on/off with one or two control pins. If controlling all the switches individually is crucial, then the pin count needs to be increased, and in turn the size by adding extra GPIOS to be able to control all the switches independently. If there is a need for an 8-channel 1:1 with switches controlled independently; before, it would be a multi-chip design. With the SPI Multiplexer it can be done with a single chip. Instead of GPIOS, it has an internal SPI (as shown in Figure 1-1) allowing for independently controlling the switches, resulting in a smaller footprint design.

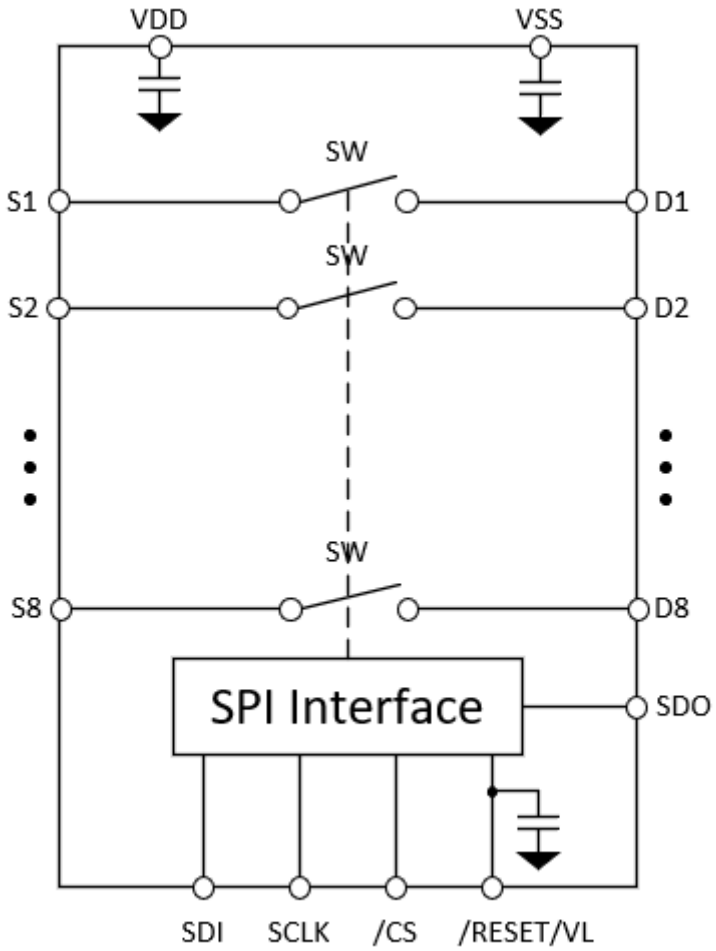

Figure 1-1. SPI Controlled Multiplexer

2 Device Details

The TMUXS7614D is a 1:1, single-pole, single-throw (SPST) 8-channel SPI controlled multiplexer with high precision performance. The TMUXS7614D has a low internal resistance of 1.35Ω and Ron flatness of 0.01Ω, as well as low current leakage of 50pA (typical). These specifications allow the TMUXS7614D to reliably work and provide accurate measurements in precision applications.

Moreover, the TMUXS7614D configuration is capable of passing eight different signals which can be done with a smaller system board footprint than using photomos relays as shown in Figure 2-1.

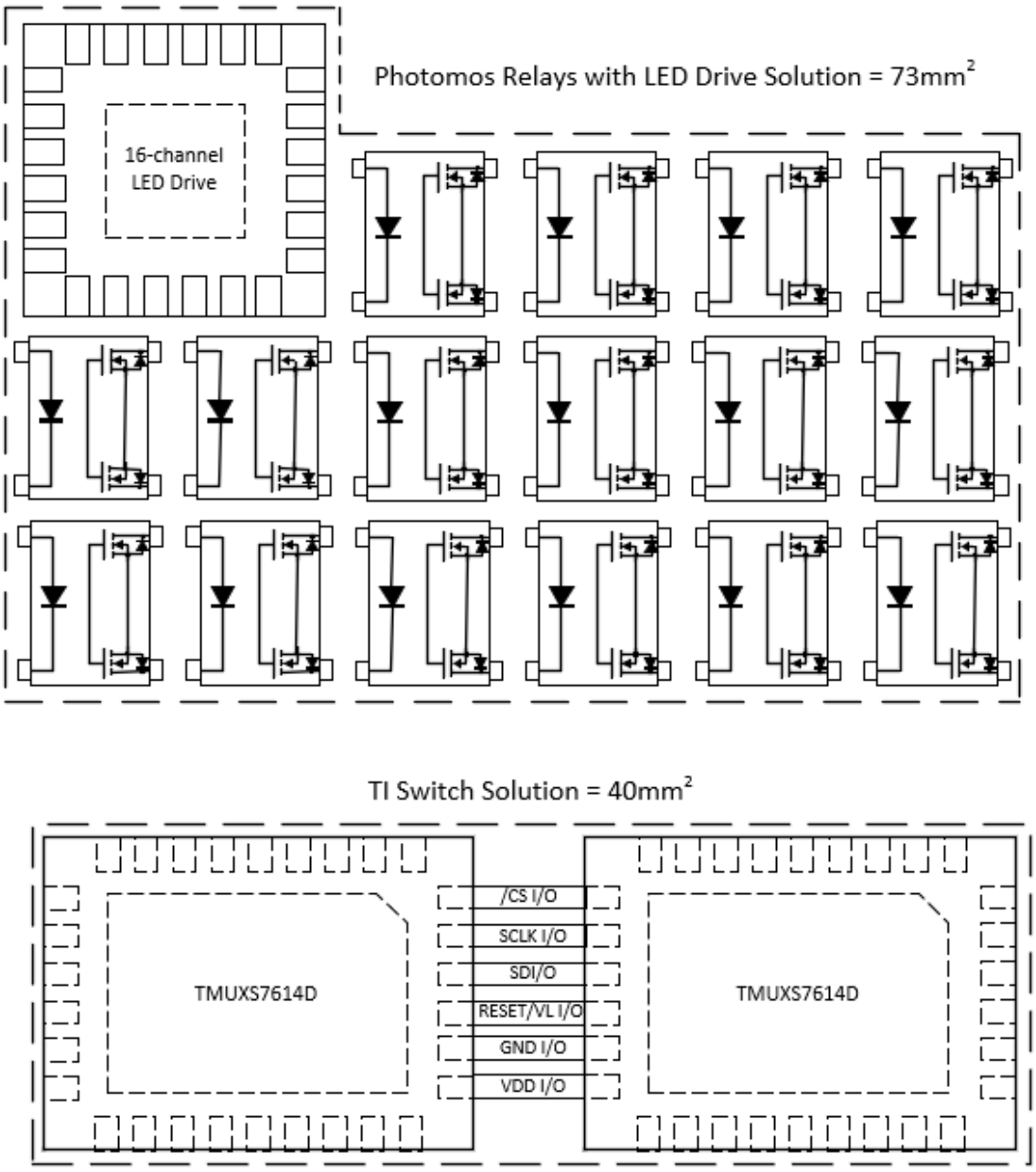

Figure 2-1. Photomos Relays With LED Driver and the TMUXS7614D Footprint Comparison

3 Daisy Chain Mode

One unique feature of the TMUXS7614D is the ability to go into Daisy Chain mode, which allows to connect multiple devices in a chain and send SPI signals to open and close selected individual switches. A single SPI signal can be sent and passed through, to control all the channels across the entire system of multiplexers.

The TMUXS7614D device has eight independent SPST (single-pole, single-throw) switches, controlled through the SPI. The layout is simple; due to the capability to operate without any external components. This is because 0.1µF decoupling capacitors are integrated into the device for VDD, VSS, and VL. When in daisy chain mode, multiple TMUXS7614D devices are connected together and can be controlled independently from each other. Meaning each channel on each mux can be controlled individually, depending on the SPI command sent to the mux. This is depicted in Figure 3-1, where there are three devices on three different EVM boards connected in daisy chain and communicating to each other using SPI signals. Notice how the last device on the chain (device 3) communicates back to the MCU.

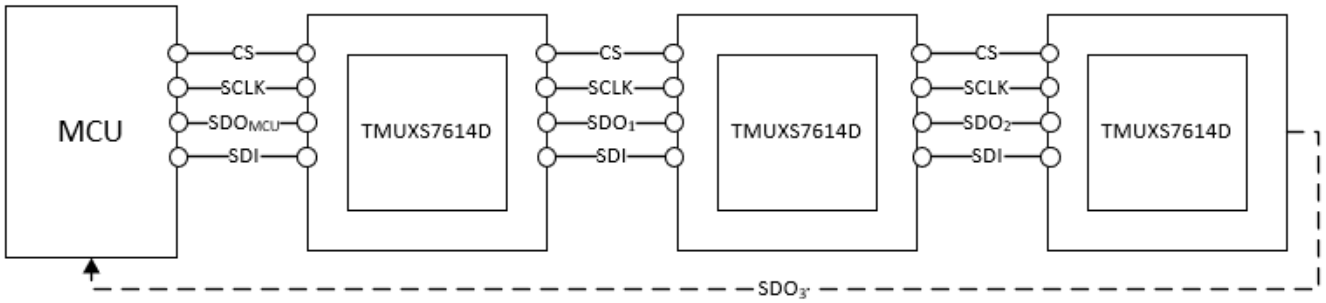

Figure 3-1. TMUXS7614D in Daisy Chain Mode Communicating Using SPI Signals Sent by the MCU

4 SPI Signal Modes

4.1 Address Mode

The SPI signal communication is defaulted to address mode. In that mode the registers of the mux are accessed by a 16-bit SPI command bounded by the chip select line (/CS). Other than address mode the device can operate in burst and daisy chain modes. The SPI pins are SDI, SDO, SCLK, and /CS. To send a SPI signal, CS has to be held low while the data is being captured on the SDI line when SCLK is on the rising edge. The data is sent out on the SDO line on the falling edge of SCLK. The SPI signal lanes are shown in Figure 4-1.

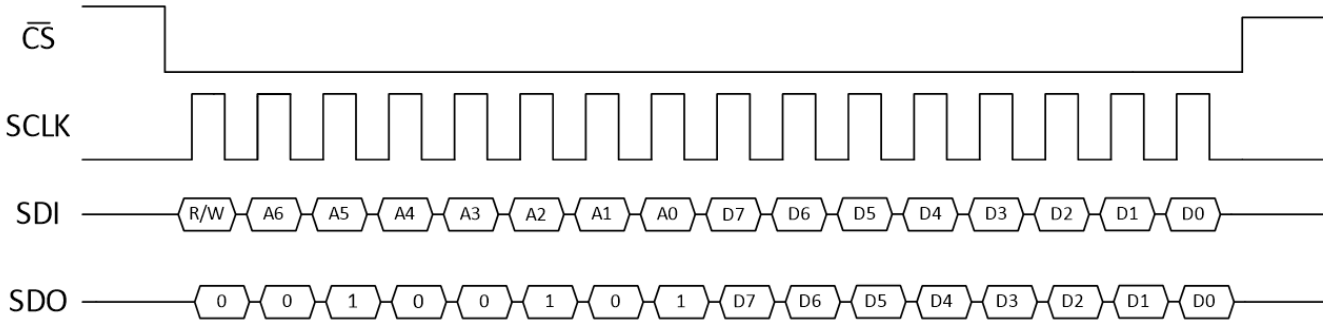

Figure 4-1. SPI Address Mode Signal

The first bit on the SDI line indicates whenever the bit is a read or write command. If the bit is 1, it is a read. If the bit is 0 then it is a write. The next seven bits are correlated to the target register address. The remaining eight bits are the data bits. The data bits contain the data being sent on the SPI signal during a write command. In a read command, the last eight bits are ignored. During the clock cycles, the SDO line sends out the data contained in the target address register. The data stored in the target register is sent out in the last eight bits on the SDO line during SCLK falling edges when the SPI reads. The SPI command can extend to a 24-bit command if the user enables CRC error detection.

4.2 Burst Mode

Burst mode is enabled through the burst enable register. Burst mode allows the SPI to accept consecutive commands without the need to deassert the /CS line. Burst mode uses the same 16-bit command structure as the address mode to communicate with the device. The SDO line also operates similarly as in address mode.

4.3 Daisy Chain Mode

The TMUXS7614D can enter daisy chain mode by sending a 16-bit SPI command of 0x2500. Daisy chain mode allows to connect several devices in a daisy chain configuration. Providing the capability to turn on or off individual switches on each device on the chain. All devices share the same /CS, SCLK, and VL lines. Each SDO line is connected to the SDI line of the next device on the chain, except the SDO line of the last device which is connected back to the MCU. To exit daisy chain mode a hardware reset is required. SPI signals in daisy chain are shown in Figure 4-2.

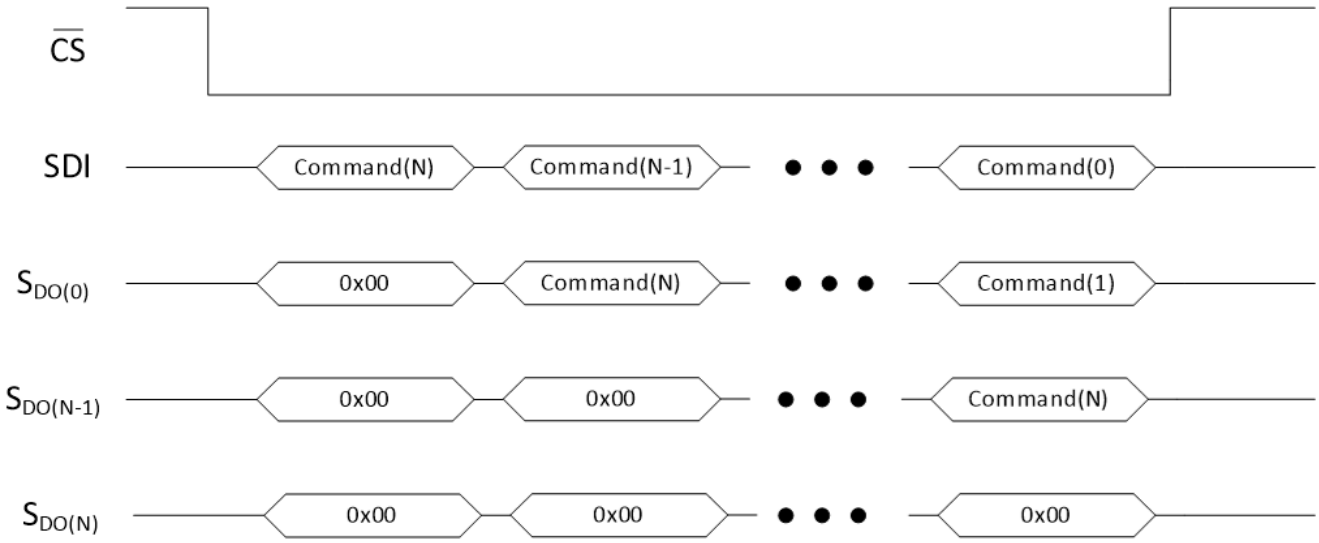

Figure 4-2. Daisy Chain Mode Signal

5 Summary

To conclude, the TMUXS7614D is a SPI controlled precision multiplexer that can be used to save footprint areas in many designer systems due to the capability of switching using the SPI protocol. TMUXS7614D can be used as relay replacements to save board space. Additionally, TMUXS7614D has high precision performance, which allows the TMUXS7614D to have the capability to be implemented in test and measurement applications as well. Lastly, TMUXS7614D has the daisy chain feature, letting multiple TMUXS7614D devices to be controlled using SPI signals to turn switches on or off on each device independently.

6 References

- Texas Instruments, *Analog Switches and Muxes*, selection guide

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265