Application Note

Compact 128-Channel Switch Design for Ultrasound Application

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ABSTRACT

Ultrasound systems use piezo-electric transducer elements to generate ultrasound beams that are used for imaging. Modern day ultrasound systems have 128-512 piezo-electric transducers arranged in an array, which are excited to high voltage (up to ±100V). This can call for an equal number of transmitters and receiver modules to be added to the system. This can be costly and can lead to an increased design size. To overcome this, often high-voltage multiplexers are used to reduce the number of transmitters and receiver modules. Since each channel needs independent control, the number of HV switches needed in the system can go as high as 512. With such a high number of switches, the area occupied by switches in the system becomes critical, especially in ultrasound probes and hand-held systems which are compact in size. This application note focuses on TI's 32 channel HV switch design, TMUX9832, which is the smallest in the market with a unique pinout that simplifies board layout . This document highlights on how using 4 x TMUX9832 is still simpler compared to 2 x 64 channel competitor devices.

Table of Contents

Trademarks

1 Introduction

As the imaging technology is improving in ultrasound systems, there has been an increasing demand to fit more transducer elements along with HV switches in ultrasound probes, while keeping the same form factor. This need has driven to develop switches with high channel density which can be laid out compactly on the PCB with minimal effort.

To understand the use case better, look at how HV multiplexers and switches fit into a present-day ultrasound system. In this context, the multiplexer is responsible for connecting the transmit and receive circuitry to the transducers. The channels of the multiplexer are activated in turn to drive sequential sections of the probe elements. Each multiplexer channel passes the transmitter's ±100V pulses to each piezoelectric element. When an element subsequently receives the return signal from the subject of imaging, the multiplexer also passes this signal back to the receiver circuitry for amplification, digital conversion, processing, and display.

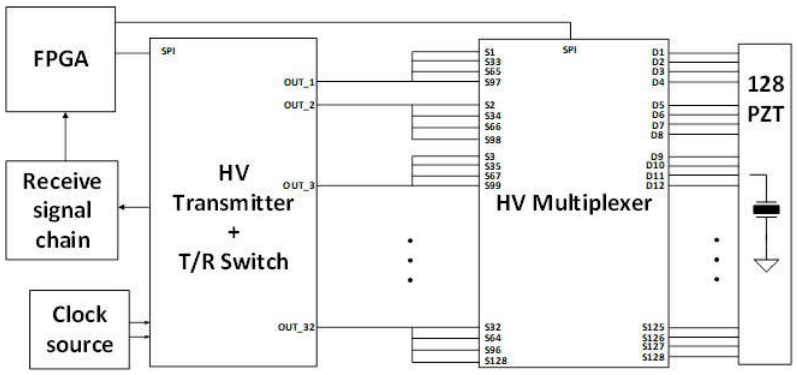


Figure 1-1. Typical Block Diagram for 128 Channel Ultrasound System

For this application, TI recommends the TMUX9832 device, which is the latest beyond the supply 1:1 32 channel switch.

2 TMUX9832

TMUX9832 is a 32-channel low resistance single pole single throw SPST analog switch IC. TMUX9832 does not need any high voltage bias, but works on +5V supply, while still being able to support ±110V analog signals. This device is the most designed for ultrasound applications.

Since the device works at low supply voltage, TMUX9832 reduces the power consumption significantly. This is very beneficial for battery powered applications, like ultrasound smart probes. Low power consumption also leads to less heat generation. This enables fitting more devices in a smaller form factor without compromising the temperature of the probes, which otherwise can cause discomfort to the patients.

Additionally, the low bias voltage nature of the device eliminates the need to have high voltage isolation in the system to protect the user form ±100V high voltage DC supplies. This helps reducing the system size and cost.

3 TMUX9832 vs Existing Design

Similar to TMUX9832, there are other designs available which can work in a similar way. This application note compares TMUX9832 with two such designs:

Table 3-1. TMUX9832 vs Available Alternatives

	4 x TMUX9832	2 x Alternative A	2 x Alternative B
No. of channel	32	64	64
Package size	7.5mm x 7.5mm	15mm x 15mm	10mm x 10mm
Channel density	1.76mm^2/ch	3.52mm2/ch	1.56mm^2/ch
Input Voltage Range	± 110V	± 100V	± 90V
Logic Level	1.8V to 5V	1.8V to 5V	3V to 5V
Flow through layout	Yes	Yes	No

4 Design Size

As shown previously, TMUX9832 offers high channel density while maintaining the quality of performance. The size of 2 TMUX9832 combined is still half of alternative A size and almost comparable to alternative B. Besides, TMUX9832 offers a flow through pinout, which makes the process easy to route multiple units together to design higher channel count design.

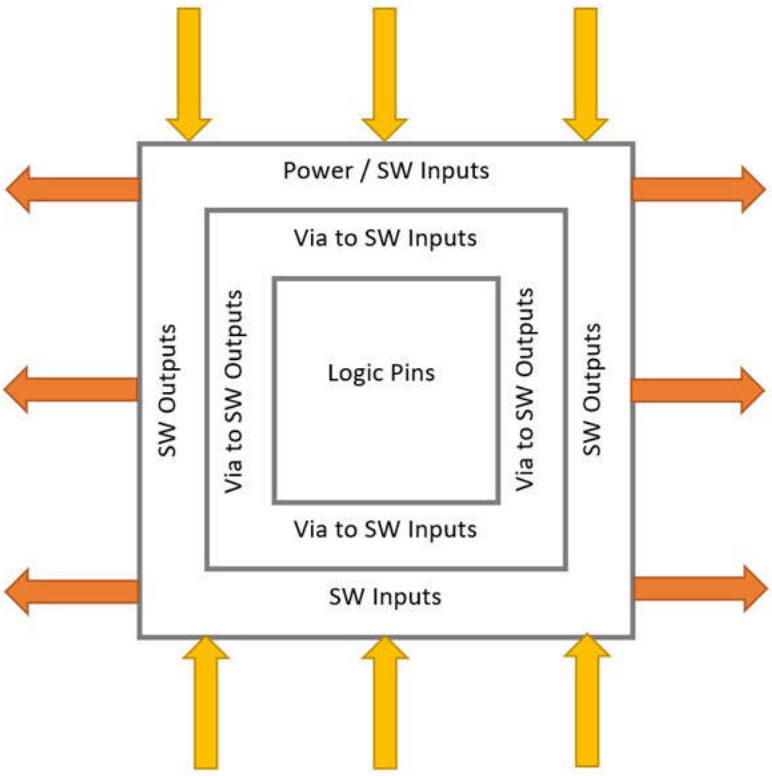
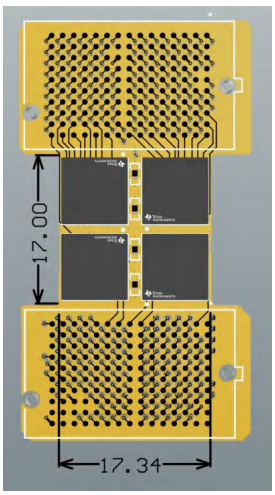
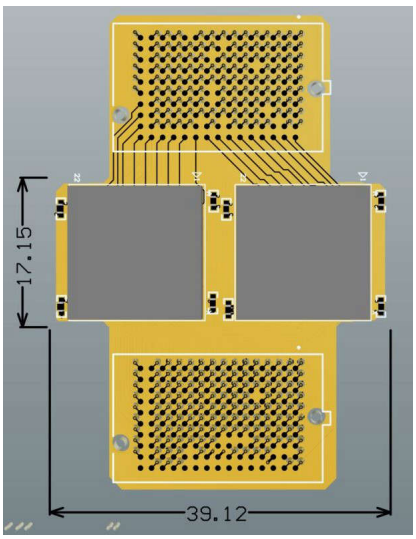
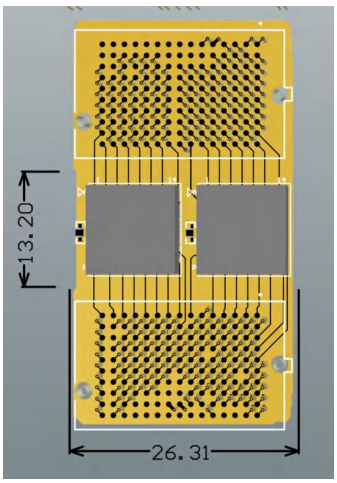


Figure 4-1. TMUX9832 Pin Arrangement

Table 4-1 is an example layout for all three devices.

Table 4-1. Layout for the Three Designs

4 x TMUX9832	2 x Alternative A	2 x Alternative B
		

Four of the TMUX9832 ICs can be fit in almost half of the area taken by two alternative A devices.

Coming to alternative B, even if the device size is comparable to TMUX9832, because of the flow through layout, the total design size for TMUX9832 is lower. Furthermore, TMUX9832 outperforms alternative B in terms of ON resistance and the switch capacitance values.

For an easy comparison of the performance of the three designs, we can define a Figure of Merit (FOM) as:

$$FOM = \frac{Channel\ \ count \times 1000}{Total\ \ PCB\ \ Area \times On\ \ Resistance \times (On\ \ Capacitance + Off\ \ Capacitance)} \quad (1)$$

A higher FOM implies better performance in smaller size.

Table 4-2 summarizes the total design size, packing efficiency and channel density for the three devices for 128 channel ultrasound application:

Table 4-2. Comparison Between the Three Designs

	TMUX9832	2 x Alternative A	2 x Alternative B
No. of channels	32	64	64
No. of devices used	4	2	2
1 device package size	56.25mm^2	225mm^2	100mm^2
Total Package Area	1.76mm^2/ch	3.52mm^2/ch	1.56mm^2/ch
Total PCB Area	2.3mm^2/ch	5.24mm^2/ch	2.72mm^2/ch
Figure of Merit	2.15	0.70	0.46

5 Summary

This application note discussed a few competitor devices and how TI's design with TMUX9832 is the best for high-channel count ultrasound applications. Not only the devices are available in the smallest form factor, but the unique pinout makes the process easy to lay them out on PCBs very efficiently. Improved channel density combined with layout offering high packaging density, enables to make the ultrasound design more compact.

6 References

- Texas Instruments, *Multiplexers and Signal Switches Glossary*, application note.
- Texas Instruments, *Selecting the Correct Texas Instruments Signal Switch*, application note.

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