Application Note

Achieving Fast VGS Switching in RF Power Amplifiers in Aerospace and Defense Applications

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ABSTRACT

The AMC7924 is a highly integrated analog monitor and control device designed for high-density, general purpose monitor and control systems. The TMUX6234 is a multi-channel CMOS switch with low on-resistance, low leakage current, and fast switching. This application note details how the two devices used in series provide a robust, highly versatile application for LDMOS and GaN power amplifier control in wireless infrastructure, aerospace, and defense applications.

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Trademarks

1 Device Overview

The AMC7924 features twenty four 12-bit digital to analog converters (DACs), twenty four 12-bit analog to digital converter inputs (ADC), and six general purpose input/outputs (GPIO). The device supports positive and negative DAC output ranges, up to 10-V full-scale range. The DACs are separated into two groups with dedicated voltage supplies, allowing the device to operate with two independent output ranges. This gives the flexibility to support multiple LDMOS and GaN power amplifiers (PAs) with one device.

The TMUX6234 is a four channel multiplexer 2:1 switch with a wide supply range and low on-resistance. The device has an operating range of ±18 V and a maximum continuous current load of 400 mA, making the TMUX6234 fully compatible with LDMOS and GaN PA control. The TMUX6234 has a fast switch on or off time of max 260 ns. The digital pins can handle voltages from 1.8 V to V_{DD}, allowing for a wide range of inputs to toggle the switches.

Both devices can operate with 1.8 V logic. This minimizes external circuitry required for operating the two devices.

2 Application

Figure 2-1 shows an example application of the AMC7924 and TMUX6234. The 24 DACs, DAC banks with different output voltages, and wide supply range of the TMUX6234 allow for multiple circuit implementations. In the application, the first two switches supply negative voltage for GaN PAs, and the last two switches supply positive voltage for LDMOS PAs.

The first switch shows DAC_A0 providing the GaN *on* voltage, and DAC_A1 providing the *pinch-off* voltage. The second switch shows the *pinch-off* voltage being provided by the negative supply. The third switch shows DAC_B0 providing the LDMOS *on* voltage, and DAC_B1 providing the *pinch-off* voltage. The last switch shows the *pinch-off* voltage being provided by ground.

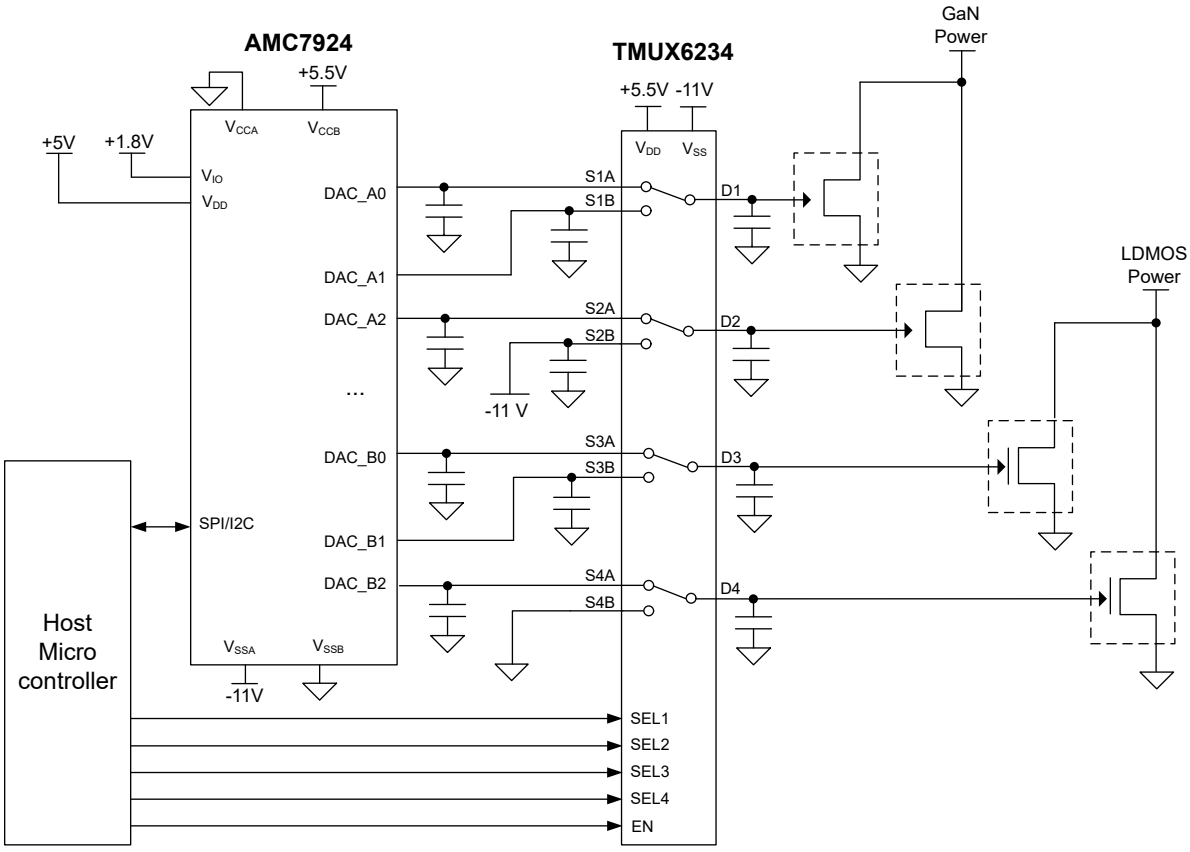

Figure 2-1. AMC7924 and TMUX6234 Application

The fast switching of the TMUX6234 allows for the PA to turn off quickly when not being used. This stops PA from drawing current and thus saves significant system power. This functionality is also desirable in wireless infrastructure that implements time division duplex. Fast switching allows for less *downtime* where the antenna cannot receive or transmit information, thus improving system functionality and efficiency.

In addition, the 24 ADCs can be used to monitor the output voltages, the input supplies, and GaN and LDMOS current with the use of a current shunt monitor (CSM). All 24 ADCs have user-programmable high and low limits that can trigger alarms in the device. Furthermore, the AMC7924 has a dedicated GPIO pin that can function as an $\overline{\text{ALARMOUT}}$ indicator, giving the host a signal when the AMC has detected an alarm condition. Figure 2-2 shows some examples of possible monitor circuits.

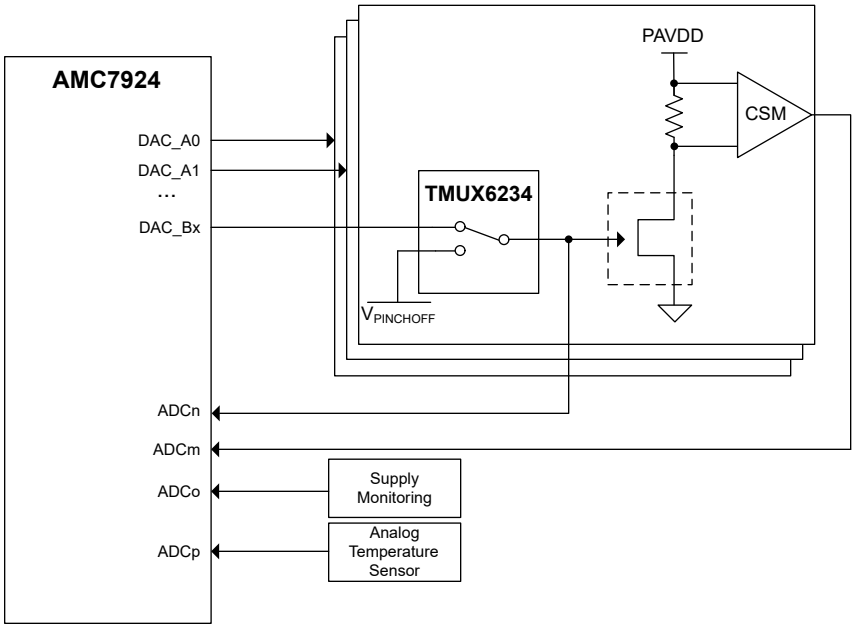

Figure 2-2. AMC7924 ADC Implementations

3 Switch Timing Capabilities

Figure 3-1 shows the output of the TMUX6234 with a 1 MHz signal on the SEL pin. The *pinch-off* voltage is the AMC7924 –8-V V_{SS} supply.

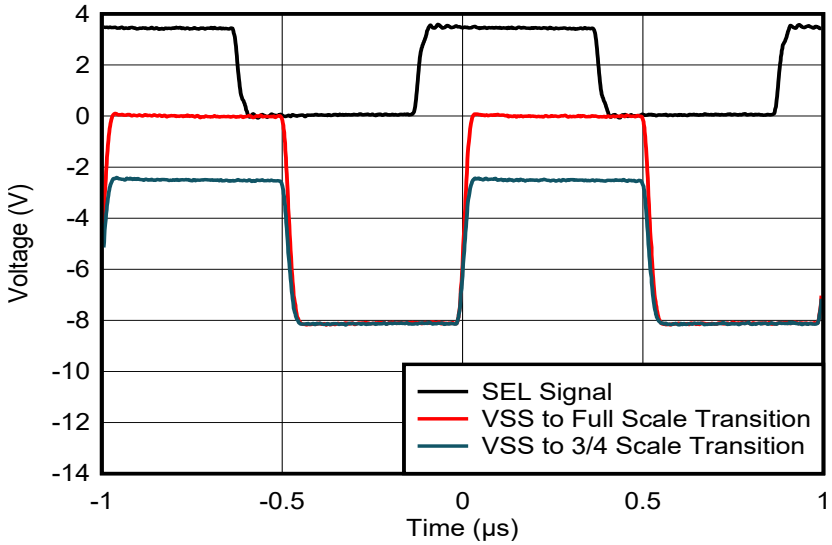

Figure 3-1. TMUX6234 Output Switching Plot

Large capacitors on the DAC and V_{SS} supplies and a small capacitor on the TMUX output are imperative for fast voltage switching. These large capacitors dump stored current into the smaller output capacitor, enabling the output to quickly charge up to the designed for voltage. Figure 3-2 shows the recommended capacitors for fast switching.

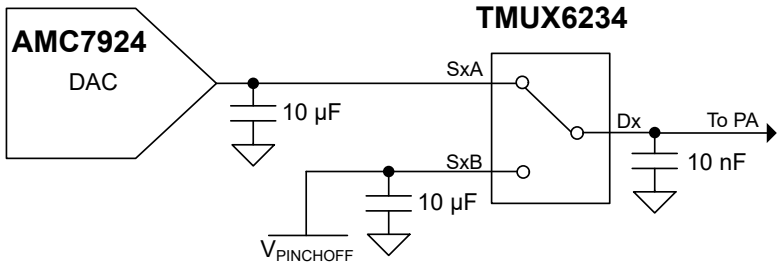

Figure 3-2. Recommended Output Switching Capacitors

4 Summary

In many applications, multiple voltage biasing controllers are required to bias the multiple power amplifiers. With the twenty four DAC outputs, the AMC7924 cuts down on the number of discrete controllers needed, simplifying board layout and micro-controller programming. The addition of the TMUX6234 allows for fast PA gate switching and significant flexibility when choosing *pinch-off* biasing voltages. The AMC7924 and TMUX6234 together make a robust PA control and monitor design that can be implemented in a variety applications.

5 References

- Texas Instruments, *TMUX6234 36 V, Low Ron, 2:1, 4 Channel Precision Switches with 1.8 V Logic*, data sheet
- Texas Instruments, *AMC7924 24-Channel, 12-Bit, Analog Monitor and Controller with Multichannel ADC, Bipolar DACs, Temperature Sensor, and GPIO Ports*, device product page

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