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Generating Secondary Fault Supplies for Fault Protected Switches

by Paul O'Sullivan

INTRODUCTION

The new range of fault protected switches from Analog Devices, Inc., (ADG5462F, ADG5243F, ADG5248F, and ADG5249F) allow for user defined fault protection levels. Two secondary power supplies on the device, POSFV and NEGFV, are the required secondary power supplies that set the level at which the overvoltage protection is engaged. POSFV can be supplied from 4.5 V up to V_{DD}, and NEGFV can be supplied from V_{SS} to 0 V. If a secondary supply is not available, these pins (POSFV and NEGFV) must be connected to V_{DD} (POSFV) and V_{SS} (NEGFV). In that case, the overvoltage protection then engages at the primary supply voltages. When the voltages at the source inputs exceed POSFV or NEGFV by a threshold voltage, V_T, the channel turns off or, if the device is unpowered, the channel remains off. The source input remains high impedance while the channel is off.

The secondary supplies (POSFV and NEGFV) provide the current required to operate the fault protection and, therefore, must be low impedance supplies. For that reason, they cannot be generated from a resistor divider off the main supply rails. This application note describes some of the options for generating the secondary supply rails depending on the system requirements, and the advantages and disadvantages of each of the supply configuration options.

FAULT PROTECTION OVERVIEW

Internal circuitry enables the switch to detect overvoltage inputs by comparing the voltage on the source pins with POSFV and NEGFV. A signal is considered overvoltage if it exceeds the secondary supply voltages by the voltage threshold (V_T). The threshold voltage is typically 0.7 V, but it ranges from 0.8 V at −40°C down to 0.6 V at +125°C.

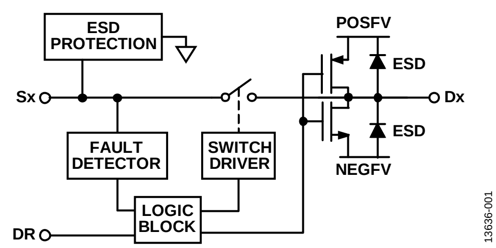

Figure 1. Switch Channel and Control Function

When an overvoltage condition is detected on a source pin (Sx), the switch automatically opens and the source pin becomes high impedance and ensures that no current flows through the switch. The drain pin is then either pulled to the supply that was exceeded or goes open circuit, depending on the device and the configuration of the DR pin, when available.

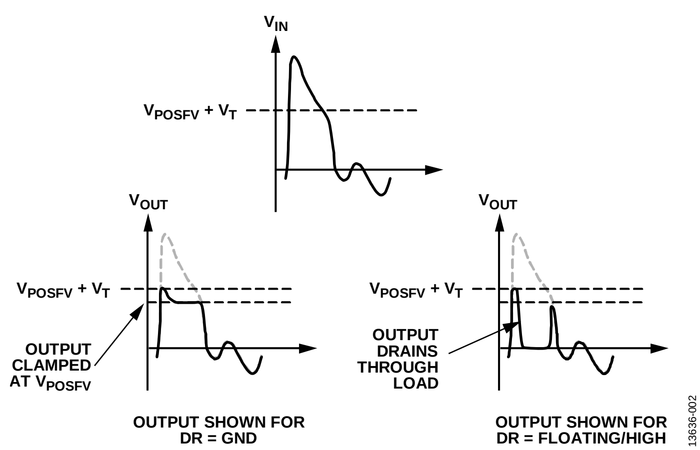

Figure 2. ADG5462F Drain Output Response During Fault Condition

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REVISION HISTORY

12/15—Revision 0: Initial Version

DATA ACQUISITION SIGNAL CHAIN USING THE ADG5462F CHANNEL PROTECTOR

Figure 3 shows an example of a portion of a data acquisition signal chain where the ADG5462F channel protector is used. The PGA uses ±15 V supply rails to achieve optimal analog performance and the ADC downstream has an input signal range of 0 V to 5 V.

The channel protector sits between the programmable gain amplifier (PGA) and the analog-to-digital converter (ADC), allowing the signal to pass through in normal operation, but protecting the ADC by clamping any overvoltage outputs from the PGA to between 0 V and 5 V.

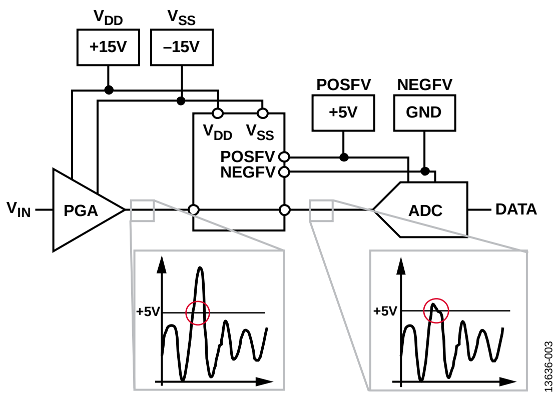

Figure 3. ADG5462F Channel Protector Application Example

Figure 4 highlights the advantage of using separate primary and secondary supply voltages on the ADG5462F channel protector. The ADC signal range in this example is 0 V to 5 V. Using a switch with a 5.5 V single supply results in a large variation in the on resistance (R_{ON}) of the switch across the signal range, causing a detrimental impact on system performance specifications such as THD + N. Utilizing the flat R_{ON} region of the switch with a ±15 V primary supply optimizes the system performance. The ADC is then protected by the thresholds set by the secondary supply rails.

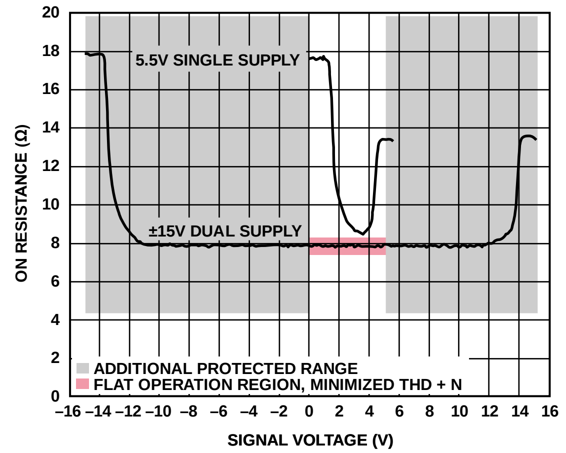

Figure 4. Flat R_{ON} Range of Operation

POSFV/NEGFV CONFIGURATION OPTIONS

There are a number of ways in which the POSFV and NEGFV fault supplies can be configured. The main considerations are as follows:

- Analog switch performance required: sets the requirements for primary supply rails
- Fault protection levels required by downstream components: sets voltage requirement for secondary rails
- Availability of other system supply rails: determines the requirement for generating POSFV/NEGFV supplies

A number of different options are detailed in the following sections.

TYING POSFV TO V_{DD} AND NEGFV TO V_{SS} (OR GND)

Tying POSFV to V_{DD} and NEGFV to V_{SS} (or GND) is the simplest configuration and sets the fault thresholds at the same voltage as the primary supply rails. In the case of a fault, the drain pin clamps to V_{DD} + 0.7 V or V_{SS} − 0.7 V.

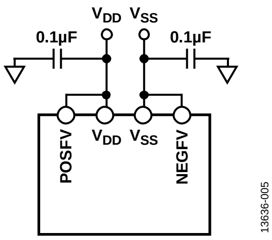

Figure 5. Primary Supplies Shorted to Secondary Supplies

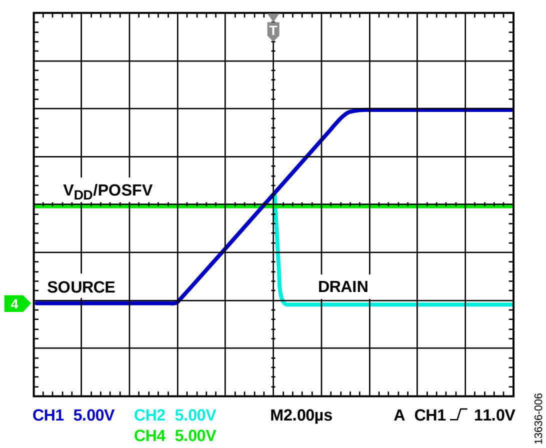

Figure 6. Drain Output Response to Positive Overvoltage (POSFV Tied to V_{DD})

There are both advantages and disadvantages to consider when using this configuration.

Advantages to Tying the Supplies

This is the simplest configuration; no additional supply rails or discrete components are required.

Disadvantages to Tying the Supplies

If the V_{DD}/V_{SS} range is reduced to meet the protection voltage requirements, then R_{ON} performance is not optimized compared to setting a wider V_{DD}/V_{SS} range. In addition, the drain pin clamps to ~0.7 V above V_{DD}/POSFV during a fault condition before the switch turns off; therefore, there is a small overshoot above V_{DD} for a short duration (~500 ns) that is seen by downstream devices. This amount of energy, however, is more benign than a 1 kV ESD pulse and should not cause any concerns in a system, as shown in the scope plot in Figure 7.

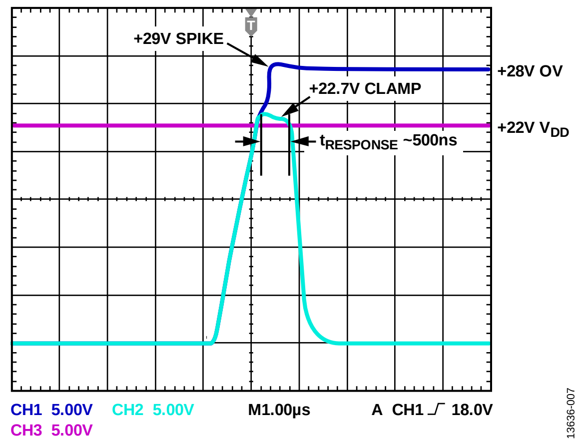

Figure 7. Overshoot During Fault Condition

USING SEPARATE LOW IMPEDANCE POWER SUPPLIES FOR POSFV/NEGFV

Using separate low impedance power supplies for POSFV and NEGFV is the default mode of operation in many applications. In the example described previously in the Data Acquisition Signal Chain Using the ADG5462F Channel Protector, there were already suitable supply rails available for the user, for example, ±15 V supplies for the PGA and +5 V/GND supplies for the ADC. In such a case, the wider supply range is used for optimal analog performance and the secondary supplies protect downstream components from overvoltage faults above the expected signal range.

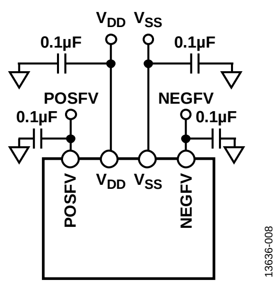

Figure 8. Separate Low Impedance Secondary Supply Rails

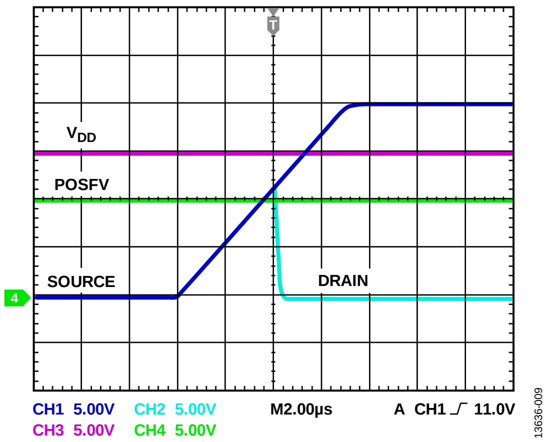

Figure 9. Drain Output Response to Positive Overvoltage (Dedicated POSFV Supply Rail)

There are both advantages and disadvantages to consider when using this configuration.

Advantages to Separate Supplies

Using separate supplies provides optimum R_{ON} performance. In addition, the user sets fault thresholds according to specific protection requirements of downstream components.

Disadvantages to Separate Supplies

An important consideration is that separate low impedance power supply rails are required for this configuration. If these are not available in the system, they must be generated from a dc-to-dc converter or from a buffered resistor divider from the primary supplies.

ADDING A DIODE FROM THE PRIMARY SUPPLY RAIL TO THE SECONDARY SUPPLY RAIL

There may be cases where downstream components are very sensitive to overvoltage stresses above the primary supply rails. In these cases, the drain pin clamping to V_{DD} + 0.7 V for 500 ns following a fault may not be acceptable. One option to reduce the clamp voltage to the approximate V_{DD} voltage level is to add a diode between V_{DD} and POSFV. With POSFV at a diode drop below V_{DD}, the fault threshold and the clamp voltage are approximately equal to the V_{DD} voltage.

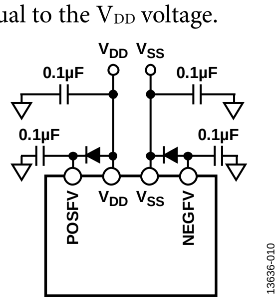

Figure 10. Diodes Configured Secondary Supply Rails

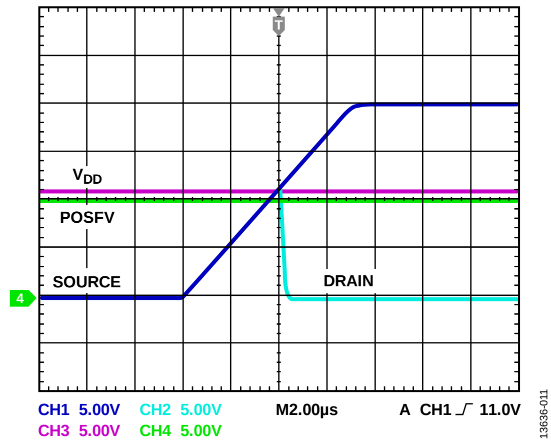

Figure 11. Drain Output Response to Positive Overvoltage (Diode from V_{DD} to POSFV)

Because the internal drain clamp diodes are referenced to the secondary supplies and because the secondary supply is not driven by a low impedance source, this solution is only suitable for situations where the source pin goes into fault rapidly. If the source pin is brought into fault at a slow ramp rate, the POSFV or NEGFV pin can pull with the fault and remain a diode drop below the fault voltage. This can cause a scenario where the overvoltage event is not detected. If the ramp rate into a fault condition is slow, then a larger POSFV/NEGFV stabilization capacitor is helpful.

There are both advantages and disadvantages to consider when using this configuration.

Advantages to Adding a Diode

Adding a diode from the primary supply rail to the secondary supply rail limits overshoot above V_{DD} to sensitive downstream circuitry. In addition, this configuration sets a custom fault threshold without generating additional system rails.

Disadvantages to Adding a Diode

Additional discrete components (that is, two diodes) are required to generate the POSFV/NEGFV rails. There is also the possibility of a slightly reduced signal range (if internal and external diode drops do not match, the fault detector may trip inside the primary supply rails). This configuration is also not suitable for fault conditions with a slow ramp rate.

USING REVERSE BREAKDOWN VOLTAGE OF ZENER DIODE TO CONFIGURE POSFV/NEGFV

In cases where additional custom supply rails are not available, the POSFV and NEGFV supplies need to be generated by the system designer. One option to achieve this is to use a Zener diode between the primary supply rail and the secondary supply rail, and then utilize the reverse breakdown voltage due to the POSFV/NEGFV supply current (Zener voltage) to configure the secondary rails.

Zener diodes are readily available with breakdown voltages of 2 V and above, so any POSFV/NEGFV voltage can be generated using this method.

The drain response is similar to having a dedicated secondary supply rail, as shown in Figure 9. There may be some variation in Zener voltage across different devices, and the Zener voltage also varies over temperature. Therefore, the POSFV/NEGFV voltage (and, hence, the fault threshold voltage) is not as well regulated as a dedicated supply rail. However, it is a cheap and simple way to configure a secondary supply rail if the fault threshold tolerance is sufficient for the application.

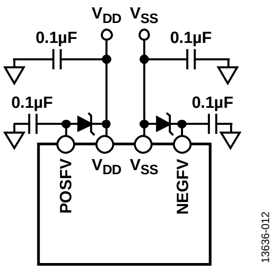

Figure 12. Zener Diode Configured Secondary Supply Rails

There are both advantages and disadvantages to consider when using this configuration.

Advantages for Using a Zener Diode

Using a Zener diode configuration sets the custom fault threshold without generating additional system rails.

Disadvantages for Using a Zener Diode

The Zener diode configuration requires additional discrete components to generate POSFV/NEGFV rails. Consequently, variations in Zener voltage across devices and temperature directly impact fault threshold accuracy. The Zener diode configuration is not suitable for fault conditions with a slow ramp rate (similar to the previous diode configuration).

SUMMARY

The fault protected switches allow the user to set a specific fault threshold at which the switch turns off. The ability to set a wide primary supply voltage enables the switch to achieve optimum analog performance (for example, flatter, lower R_{ON}). If a lower fault threshold voltage is required, then POSFV and NEGFV require separate low impedance supplies to generate those thresholds.

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