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APPLICATION NOTE 4207

Making the MAX1452/MAX1455 Signal Conditioners Tolerant of Supply Limitations

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Abstract: The MAX1452/MAX1455 are high-precision, low-cost signal conditioners that can be operated in digital mode for system-level manufacturing and in analog mode for normal operation. In application circuits, depending on the driving capability of the power supply utilized to supply the V_{DD} pin, there is the possibility of (a) the device starting up in digital mode, when intended to start in analog mode, (b) excessive output noise, and (c) not having enough voltage on V_{DDF} for reliable EEPROM operations. The following application note suggests adding a single component to the application circuit to address these concerns, improving both manufacturing yield and product reliability.

Description

The MAX1452/MAX1455 are high-precision, low-cost signal conditioners that can be operated in two modes: digital mode for system-level manufacturing and analog mode for normal operation. The MAX1452/MAX1455 contain a power-on reset (POR) circuit to ensure that the on-chip digital logic and state machines initialize to the proper conditions at power-up and after brownout events. This POR senses the supply voltage and holds the logic in the initialization state until the supply voltage reaches the required operating level. The MAX1452/MAX1455 operate from two supply inputs: (1) V_{DD}, which powers the internal logic and the analog circuits, and (2) V_{DDF}, which powers the on-chip EEPROM memory circuits. At the system level, V_{DD} and V_{DDF} are tied together either directly or through a resistor (as described below).

In a typical application circuit, there is an RC circuit on the V_{DDF} pin (R between V_{DD} and V_{DDF}, and C between V_{DDF} and GND). The RC filter is required because, due to cost and space constraints, the chosen V_{DD} supply normally has limited driving capability and the V_{DD} level cannot be maintained during EEPROM operations. As a result of this limited drive capability, potential issues can arise during manufacturing and/or operation. One of these issues is starting up in the wrong mode—if a problem occurs, the output will start in digital mode instead of starting in analog mode. This generally happens because V_{DDF} will grossly lag V_{DD} and causes unreliable reading of the Control Location in the flash memory. A second issue is the output noise caused by ripples on V_{DD} that can couple through to the output. Finally, EEPROM cell charging can be compromised after a WRITE operation. In applications where a V_{DD} supply with adequate current capability is selected, none of these issues will be present.

Background

The MAX1452/MAX1455 contain an integrated EEPROM to store calibration coefficients and device configuration information. Depending on the EEPROM operation performed, the current drawn from the V_{DDF}

supply is 7mA to 25mA. When active, the EEPROM has three operational modes: Read, Write, and Erase. Both Write and Erase operations are used during module manufacturing for calibration and testing (in digital mode). After manufacturing, the device is locked (switched to analog mode) and only the Read operation is performed. It is important to note that the high current levels for Write and Erase operations occur only during manufacturing, and there is no requirement to account for them in the application circuit design.

In manufacturing, the EEPROM operations can draw about 25mA from V_{DDF} during calibration and testing. The Erase operation draws 25mA for 1μs, followed by a 16mA current draw for 5ms. The Write operation draws 25mA for 1μs, followed by a 16mA current draw for 80μs.

During normal operation, there are 10 EEPROM Read operations every 1ms to load or refresh the coefficient and configuration registers. Each Read operation draws a current of 7mA for 1μs and no current for 1μs. The result is a burst of 10 closely spaced Read operations that occurs every 1ms, resulting in a low effective average current draw on V_{DDF}.

In MAX1452/MAX1455 applications, the V_{DD} supply must be properly sized to supply the currents required for EEPROM operations (especially in the case of a 4-20mA application). Without sufficient current sourcing, the V_{DDF} and V_{DD} voltages may drop below the minimum guaranteed operating voltage of 4.5V.

When the internal EEPROM performs a Read operation during the MAX1452/MAX1455's normal operating mode, voltage ripples on V_{DDF} may occur. In the case of a weak V_{DD} supply, these voltage ripples could couple onto V_{DD}, creating undesired output noise. The chip's separate V_{DD} and V_{DDF} supply pins allow user applications to incorporate external RC filtering on the V_{DDF} supply pin to reduce unwanted noise coupling. However, there are many considerations to be made when choosing the RC filter values. The value of R must be large enough to prevent current spikes on V_{DD} during EEPROM operations. R must also be small enough to allow V_{DDF} to closely track the V_{DD} voltage during initial startup to prevent any startup problems. Of course, the selection of C is also of great importance, and there is an optimal mix of R and C values. However, the optimal values in this case may not address all concerns.

Add a Diode to Address Issues Caused by a Weak V_{DD} Supply

To utilize an RC filter on V_{DDF} for output noise improvement without being subjected to undesirable consequences, one can add a Schottky diode between the V_{DD} and V_{DDF} in parallel with R of the RC filter (**Figure 1**). The forward voltage of this Schottky diode must be smaller than the forward voltage of the parasitic diode between V_{DD} and GND, and also large enough such that it does not conduct at the maximum operating temperature of the product. A BAT54 Schottky diode, with a forward voltage of 300mV at +25°C, has been tested and proved suitable for this application. Such a diode between the V_{DD} and V_{DDF} results in the following improvements:

- **Resolution of the startup problem**. This diode allows V_{DDF} to track the V_{DD} voltage very closely—only one diode drop (< 300mV) apart. Consequently, when the POR signal is released, the V_{DDF} voltage is at the proper level to correctly read the Control Location in the EEPROM, thereby starting in correct operating mode.

- **Decreased output noise**. Adding the diode, it is possible to use much larger values of C (a minimum of 0.47μF is required to maintain the V_{DDF} level during high current draw in Read operation) and R (typically 1kΩ). Larger RC values may be used without causing a concern at startup. Regardless of the RC-filter time constant, V_{DD} and V_{DDF} are always only one diode drop (< 300mV) apart. Without the diode, during the Read operation, too large a C value causes a large delay in V_{DDF} ramp and could result in a startup problem. Also, too small a C value causes larger V_{DD} spikes that propagate through the output, causing unwanted output noise.

- **Improved EEPROM cell charging when writing to the EEPROM**. This improvement occurs because the V_{DDF} level remains above the minimum required 4.5V (V_{DD} = 5V) at all times.
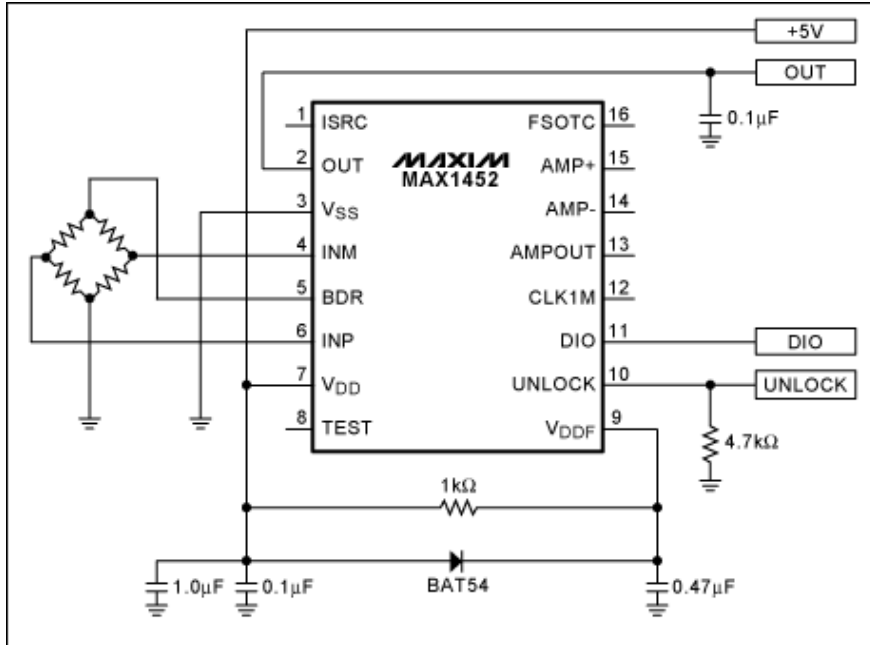
Figure 1. This typical MAX1452 application circuit also includes a Schottky diode to address V_{DD} supply drive limitations.

Related Parts		
MAX1452	Low-Cost Precision Sensor Signal Conditioner	Free Samples
MAX1455	Low-Cost Automotive Sensor Signal Conditioner	Free Samples

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