

## 1 Introduction

The Analog-to-Digital Converter (ADC) available on some DE-Series boards allow for analog circuitry - such as sensors, microphones or amplifiers - to be connected to the digital electronics of the FPGA. Table 1 lists the DE-Series boards that contain an ADC.

<b>Board</b>	<b>Input Voltage Range</b>	<b>Number of Input Channels</b>
DE0-Nano	0V - 3.3V	8
DE1-SoC	0V - 5V	8
DE10-Standard	0V - 5V	8
DE10-Nano	0V - 5V	8
DE10-Lite	0V - 5V	6

## 2 Examples of Analog Sensors

Some examples of analog sensor circuits that can be connected to the ADC are shown below. This list is not all-inclusive; any analog signal with voltages within the input voltage range of the ADC can be connected.

The circuits below contain a voltage source with voltage  $V_{dd}$ .  $V_{dd}$  should be set to the maximum of the ADC's input voltage range (3.3 V for the DE0-Nano's ADC, 5 V for the other board's ADC). While it is acceptable for  $V_{dd}$  to be lower than the maximum input voltage, doing so will limit the ADC's ability to detect smaller voltage fluctuations as the input voltage will be compressed to a smaller range. In most cases, you can use a 3.3 V or 5.0 V output voltage pin of the board as the  $V_{dd}$  voltage source.

### 2.1 Photoresistor (Light sensor)

A photoresistor acts as a variable resistor, with resistance proportional to the amount of light contacting its surface. As the amount of light decreases, the resistance of the device will increase. When placed in a resistor divider with a constant resistor – as shown in Figure 1 – the output voltage can be used to measure the level of ambient light.

Tested with a RB-Spa-350 Photoresistor and a 5.1 kΩ resistor.

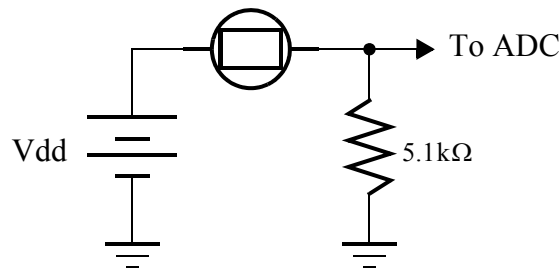


Figure 1. Circuit including a photoresistor.

### 2.2 Potentiometer (Variable Resistor)

Potentiometers are variable resistors which are controlled by a knob or dial. When placed in a resistor divider network, they can be used to control the output voltage.

Tested with a RB-Dfr-44 Potentiometer and a 5.1 kΩ resistor.

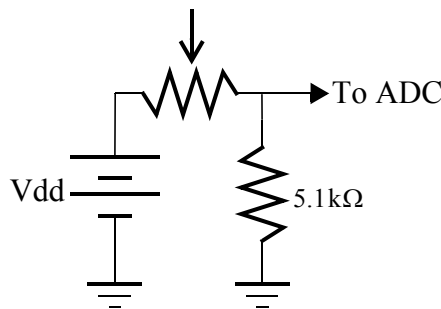


Figure 2. Circuit using a potentiometer.

### 2.3 Simple Switch

A Single-Pole Single-Throw (SPST) Switch is a simple on-off switch. When off, it is equivalent to an open circuit, and creates a short circuit when on. The circuit in Figure 3 detects at state of the switch. The large resistor in parallel with the switch will drive the output low when the switch is open, but will connect the output to  $V_{DD}$  when closed.

Tested with a RB-Inn-08 Bumper Switch, a 10 kΩ and a 1 MΩ resistor.

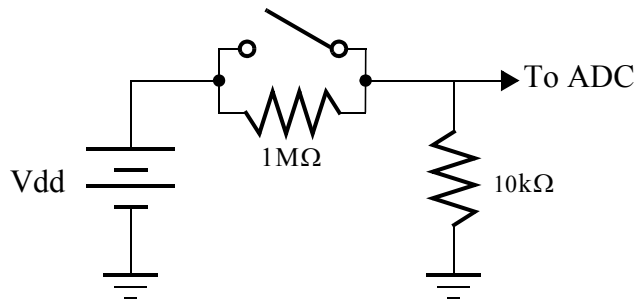


Figure 3. Circuit including a SPST switch.

### 2.4 Magnetic Induction Sensor

A Magnetic Induction sensor can be used to detect strong magnetic fields. Simple models function as a magnetically-controlled switch, producing a low voltage in the presence of a magnetic field, and a high voltage otherwise.

Using a DFR0033 Magnetic Induction sensor, connect Port 3 to Ground, Port 2 to a 3.3V source and Port 1 to the ADC, as shown in Figure 4.

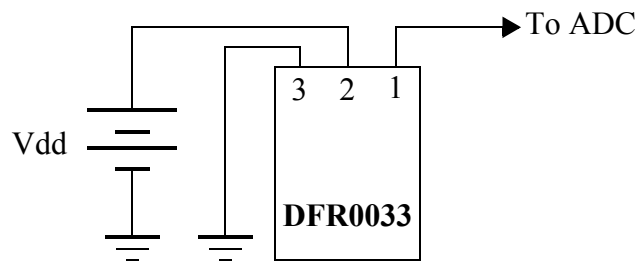


Figure 4. Circuit using a DFR0033 Magnetic Induction sensor.

## 2.5 Capacitive Touch Sensor

A Capacitive Touch sensor functions as a button which is sensitive to touch. When touched, the capacitance of the sensor changes, which changes the voltage on the output terminal.

Using a DFR0030 Capacitive Touch sensor, connect Port 3 to Ground, Port 2 to a 3.3V source and Port 1 to the ADC, as shown in Figure 5.

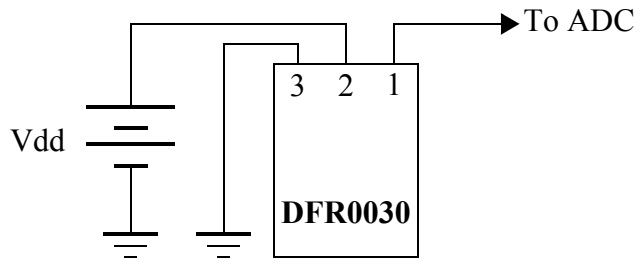


Figure 5. Circuit using a DFR0030 Capacitive Touch sensor.

## 2.6 Flame Sensor

A Magnetic Induction sensor can be used to sources of heat, such as open flames. The sensor uses a photodiode sensitive to infrared radiation (light with wavelengths in the 760 nm - 1100 nm range) to generate a current across the resistor.

Using a DFR0033 Magnetic Induction sensor, connect Port 3 to a 3.3V source, Port 2 to ground and Port 1 to the ADC, as shown in Figure 6.

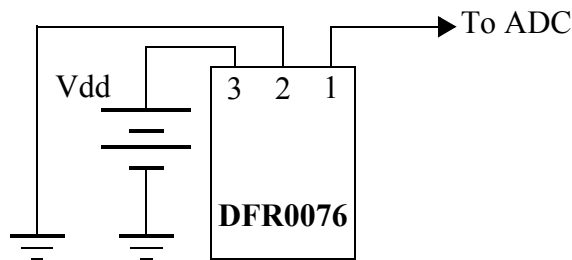


Figure 6. Circuit using a DFR0076 Flame sensor.

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