

# StudentZone—July 2017

## Linear Regulators with Negative Voltages

By **Frederik Dostal**

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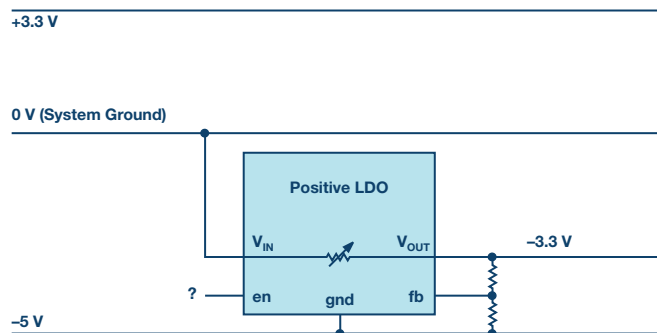
What are negative voltages? With voltages, everything is relative. Between different electrical conductors, there can be different electric potentials. This means that one voltage can be higher than another voltage. In such a case, one would not choose the description “negative voltage.” By negative voltage, we mean that one voltage is lower than a system’s ground potential. Figure 1 shows an example with a supply voltage of 3.3 V and a system ground potential of 0 V. In such a system, the signals of a sensor shall be measured and recorded. These signals may be between +2.5 V and –2.5 V. For sensing these signals, we are using an operational amplifier that requires a positive supply voltage of +3.3 V and a negative supply voltage of –3.3 V.

For the positive voltages, +3.3 V are already available in the system. For the necessary negative voltage of –3.3 V, an available support voltage of –5 V may be utilized. This voltage rail may come from a transformer-based power supply. Typically, such voltages are not regulated very accurately. For accurate –3.3 V generation, we want to use a linear regulator.

There is a very large selection of linear regulators available on the market suited for positive voltages. Can such a positive linear regulator be used in applications where negative voltages need to be converted?

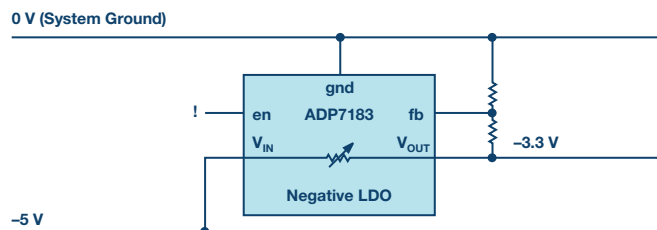
Figure 1 shows a linear regulator used in such an application. The problem with using a typical linear regulator that is intended for positive output voltages is that it can only source current and not sink current. If we were to select a positive linear regulator that can source and sink currents, there would still be an issue with this setup. The adjustable resistor stands for the pass element of a linear regulator. The voltage relationship between  $V_{IN}$ ,  $V_{OUT}$ , and GND connectors are exactly the same for this linear regulator IC, just like if it was used in a positive voltage application. However, there are several disadvantages to using a positive linear regulator in such an environment. The circuit will use the resistive divider to regulate the output voltage based on the –5 V rail and not based on the 0 V rail, system ground. This causes disturbances and noise on the –5 V rail to couple directly onto the generated –3.3 V rail. Also, the regulation accuracy is rather poor. When the –5 V supply voltage only has an accuracy of  $\pm 10\%$ , this inaccuracy will also couple onto the –3.3 V generated output voltage.

A second negative about such a use case for a positive linear regulator is that the I/O pins of the linear regulator device, such as an enable pin, will be referenced to –5 V. If some sequencing amongst different voltages needs to be observed in the system, some sort of level shifting might be necessary.



*Figure 1. A positive linear regulator for generating a negative voltage will not usually work due to the direction of current flow.*

In Figure 2, the same system is shown, but a linear regulator is used that was specifically designed to step down negative voltages. These ICs are specifically called negative linear regulators. The new **ADP7183** negative linear regulator from Analog Devices was specifically designed for the lowest noise and highest power supply rejection ratio (PSRR). This makes the part very useful for filtering applications to power sensitive nodes.



*Figure 2. A negative linear regulator for generating a negative voltage.*

If a negative linear regulator, like the one shown in Figure 2, is being used, the generated  $-3.3\text{ V}$  is being regulated in relation to the  $0\text{ V}$  ground voltage. This yields a very low noise and accurate output voltage. Also, the I/O pins are referenced to the system ground of  $0\text{ V}$  and, by this, the effort of level shifting can be omitted.

This makes special negative linear regulators very necessary when converting negative voltages or when filtering negative voltages. Generally there is only a limited supply of negative linear regulators available on the market. New products such as the ADP7183 (300 mA) and [ADP7185](#) (500 mA) increase the available portfolio for designers.

### Quiz:

By the way—why an LDO regulator? You are still using the standard 7805 to get a stable  $5\text{ V}$  output? Well you need  $7\text{ V}$  (minimum) input voltage for the 7805. Let's say we need  $100\text{ mA}$  output current.

Which efficiency will you get from the 7805 vs. an LDO regulator like the ADP150?

Tip: Check the data sheet of the [ADP150](#).

Find the answer at [StudentZone](#).

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