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2.7 - DAC [U6 Datasheet]

DAC Overview

There are two DACs (digital-to-analog converters or analog outputs) on the U6. Each DAC can be set to a voltage between about 0.02 and 5 volts with 12-bits of resolution.

Although the DAC values are based on an absolute reference voltage, and not the supply voltage, the DAC output buffers are powered internally by Vs and thus the maximum output is limited to slightly less than Vs.

The analog output commands are sent as raw binary values (low level functions). For a desired output voltage, the binary value can be approximated as:

Bits(uncalibrated) = (Volts/4.86)*65536

For a proper calculation, though, use the calibration values (Slope and Offset) stored in the internal flash on the Control processor (Section 5.4):

Bits = (Slope * Volts) + Offset

The DACs appear both on the screw terminals and on the DB37 connector. These connections are electrically the same, and the user must exercise caution only to use one connection or the other, and not create a short circuit.

The power-up condition of the DACs can be configured by the user. From the factory, the DACS default to enabled at minimum voltage (~0 volts). Note that even if the power-up default for a line is changed to a different voltage or disabled, there is a delay of about 100 ms at power-up where the DACs are in the factory default condition.

The analog outputs can withstand a continuous short-circuit to ground, even when set at maximum output.

Voltage should never be applied to the analog outputs, as they are voltage sources themselves. In the event that a voltage is accidentally applied to either analog output, they do have protection against transient events such as ESD (electrostatic discharge) and continuous overvoltage (or

undervoltage) of a few volts.

There is an accessory available from LabJack called the LJTick-DAC that provides a pair of 14-bit analog outputs with a range of ±10 volts. The LJTick-DAC plugs into any digital I/O block, and thus up to 10 of these can be used per U6 to add 20 analog outputs. The LJTick-DAC has various differences compared to the built-in DACs on the U6:

- Range of +10.0 to -10.0 volts. (~0-5 volts for the U6 DACs)
- Range includes 0.0 volts. (Typical minimum of 0.04 volts for the U6 DACs)
- Resolution of 14-bits. (Spread across 20V span, so voltage resolution is the same)

2.7.1 - Typical Analog Output Connections [U6 Datasheet]

2.7.1.1 - High Current Output [U6 Datasheet]

The DACs on the U6 can output quite a bit of current, but have 50 Ω of source impedance that will cause voltage drop. To avoid this voltage drop, an op-amp can be used to buffer the output, such as the non-inverting configuration shown in Figure 2.6-1. A simple RC filter can be added between the DAC output and the amp input for further noise reduction. Note that the ability of the amp to source/sink current near the power rails must still be considered. A possible op-amp choice would be the TLV246x family (ti.com).

2.7.1.2 - Different Output Ranges [U6 Datasheet]

Consider using an LJTick-DAC rather than the built-in DACs. The LJTDAC provides +/-10 volt outputs with 14-bit resolution across that span.

The typical output range of the DACs is about 0.04 to 4.95 volts (assuming Vs=5.0V). For other **unipolar output ranges**, an op-amp in the non-inverting configuration (Figure 2.6-1 in Section 2.6.3.5) can be used to provide the desired gain. Connect Vin in Figure 2-3 to the DACx terminal, connect -V to GND, connect +V to a voltage source greater than the max desired output, and set R1 & R2 to control the gain. Example: Unipolar 0-10 volt output. Use R1=93.1kΩ and R2=100kΩ to provide a gain of about x1.07, and use Vm+ to provide up to 2.5mA of 12V power

to the LT1490A op-amp. This will provide a nominal output range of 0.08 to 10.3 volts.

For **bipolar output ranges**, such as ±10 volts, a similar op-amp circuit can be used to provide gain and offset, and of course the op-amp must be powered with supplies greater than the desired output range (depending on the ability of the op-amp to drive it's outputs close to the power rails). For example, the Vm+/Vm- supplies available from the U6 are typically ±13 volts. If these supplies are used to power the LT1490A op-amp (linear.com), which has rail-to-rail capabilities, the outputs could be driven very close to ±13 volts.

For bipolar ranges a reference voltage is also required to provide the offset/level-shifting. In the following circuit, DAC1 is used to provide a reference voltage. The actual value of DAC1 can be adjusted such that the circuit output is 0 volts at the DAC0 mid-scale voltage, and the value of R1 can be adjusted to get the desired gain. A fixed reference (such as 2.5 volts) could also be used instead of DAC1.

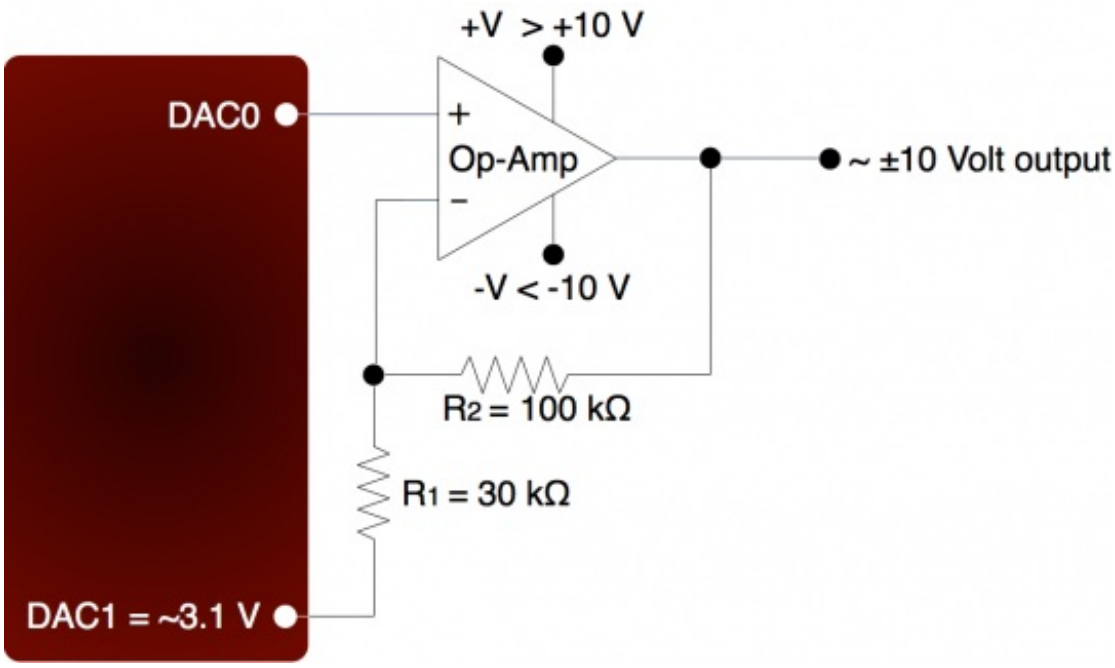

Figure 2.7.1.2-1. ±10 Volt DAC Output Circuit

A two-point calibration should be done to determine the exact input/output relationship of this circuit. Refer to application note SLOA097 from ti.com for further information about gain and offset design with op-amps.