Eight 16-Bit, Low INL, V_{OUT} DACs in a 4mm × 5mm QFN Package: Unparalleled Density and Flexibility

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While 16-bit V_{OUT} DACs are not uncommon, the combination of low INL (±4 LSB) and high density (eight DACs in a 4mm × 5mm QFN package) allows the LTC2656 to fit an unparalleled range of sockets. Space-saving features also include a built-in 2ppm/°C reference, with performance typically reserved for external references. These characteristics, along with superior offset and gain error specifications, make the LTC2656 a powerful device housed in a tiny package.

Although the LTC2656 is a formidable standalone device, it can be readily combined with other Linear Technology products to produce uniquely high performance solutions.

A DIGITALLY CONTROLLED POWER SUPPLY USING THE LT3080 1.1A REGULATOR

Another noteworthy product in the Linear Technology portfolio is the LT3080. The LT3080 is a 1.1A low dropout linear regulator that can be paralleled to increase output current or spread heat on surface mounted boards. Typically the output voltage of the LT3080 is adjusted by a resistor at the SET pin of the part (Figure 1). A fixed current of 10µA flows out of the SET pin through the resistor and the resulting voltage drop programs the output of the regulator.

The LTC2656 can be combined with the LT3080 to create a digitally controlled power supply. If the output of the DAC is connected to the SET pin of the regulator (Figure 2), the LT3080 acts as a unity gain buffer. The DAC simply sinks the 10µA from the internal current source and directly controls the output of the regulator creating a digitally controlled power supply. Should more than 1.1A be needed, multiple LT3080s can be paralleled to provide more output current.

The LTC2656's 16 bits of resolution yield finer tuning of the LT3080's output than that of a digital potentiometer. Typical digital potentiometers have resolutions of only 8 bits; high resolution digital pots are at 10 bits. The ±4 LSB INL of the LTC2656 is far superior to the INL of typical digital pots. The LTC2656-L combined with an LT3080 results in a power-supply with an adjustable range of 0V–2.5V, while using the LTC2656-H produces a power supply with an adjustable range of 0V–4.096V.

Figure 1. Simple variable output voltage 1.1A supply

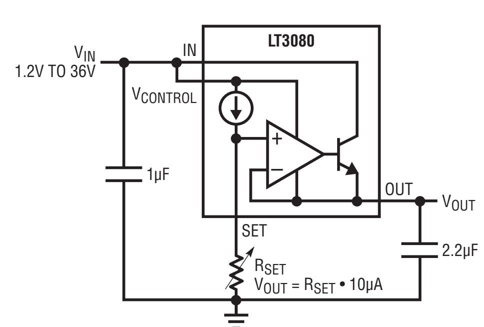
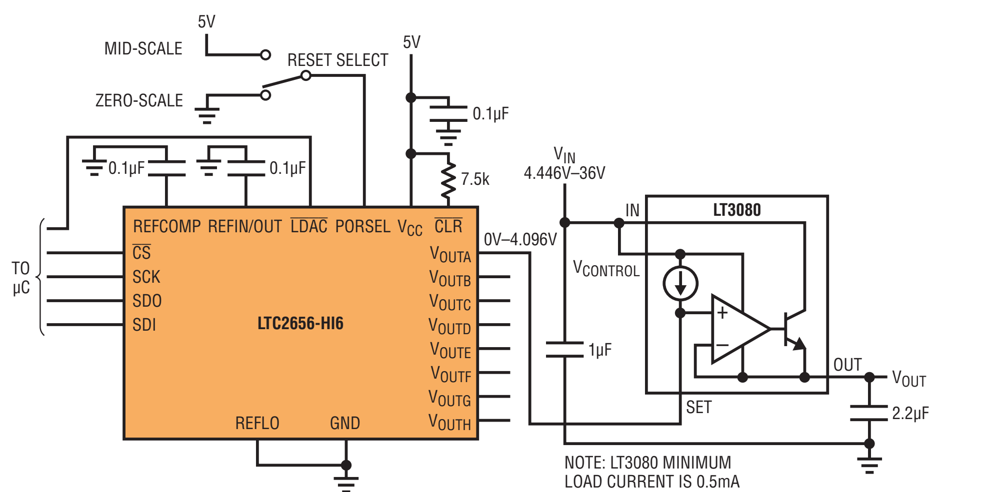


Figure 2. Digitally controlled version of the power supply in shown in Figure 1 with a 0V–4.096V output range. For a 0V–2.5V output range use the LTC2656-LI.



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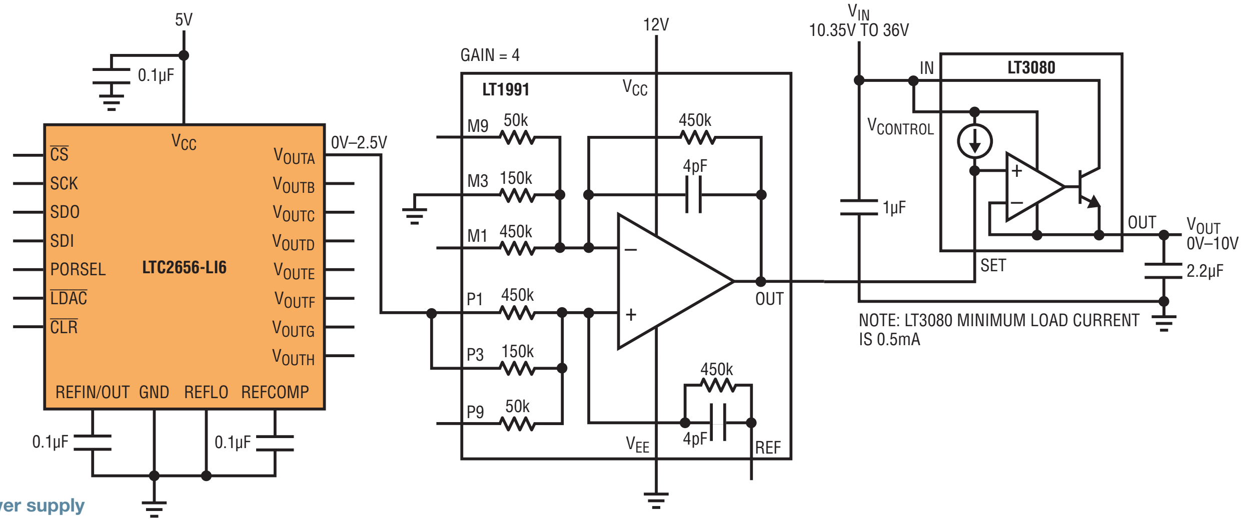


Figure 3. Expanding the power supply output range to 0V–10V

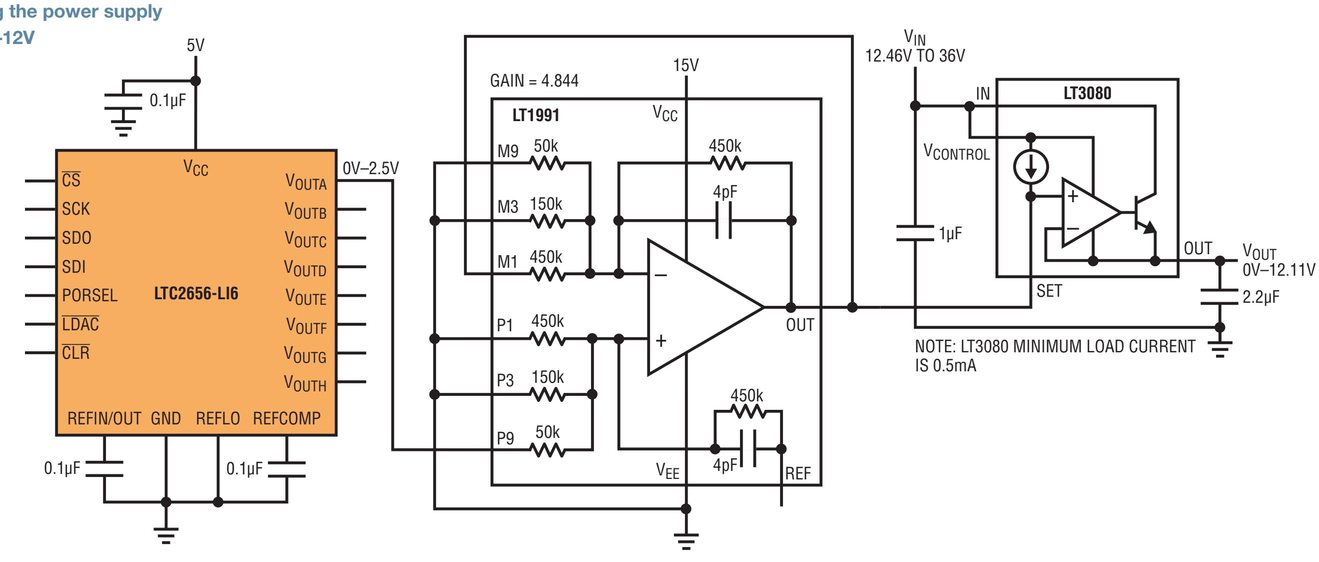
The two Linear Technology parts complement each other very well. The LT3080 has a max offset of 2mV in the DFN package, while the LTC2656 has a max offset of ±2mV. This means that there will only be a slight degradation in offset performance when combining these two parts. This circuit can also be easily replicated at each of the DAC outputs in order to create an 8-channel adjustable power supply.

ADDING THE LT1991 TO ADJUST OUTPUT RANGE

The LTC2656-H combined with an LT3080 provides a nice digitally controlled 1.1A power supply with an output range from 0V to 4.096V. However, should the user need a wider output range than what that particular circuit offers, there is an LTC part that provides an easy solution.

The LT1991 is a micropower precision gain selectable amplifier. It combines a precision op amp with eight precision matched resistors in a small package. Using the

Figure 4. Expanding the power supply output range to 0V–12V



LT1991 eliminates the need for any expensive external precision gain setting resistors. Gain can be set by simply changing how the input pins are connected, which in turn changes how the internal precision resistors set the gain of the op amp.

The limiting factor in output range of the LTC2656-LT3080 circuit is the output range of the LTC2656. The LT3080 is fully capable of going all the way up to 36V, however the DAC output at the SET pin is limited to 4.096V which in turn limits the output of the regulator. This hurdle is easily overcome by adding an LT1991 between the output of the LTC2656 and the SET pin of the LT3080. The LT1991 expands the output range of the DAC, which in turn sets the output range of the LT3080.

The LT1991 standard grade has 0.08% gain accuracy and 100μV offset, so there should be no degradation in performance of the DAC. With a maximum gain of 13 and a supply range of 40V, the LT1991 can stretch the DAC output range to match that of the LT3080. Typical output ranges such as 0V–10V (Figure 3) and 0V–12V (Figure 4) are easily achieved.

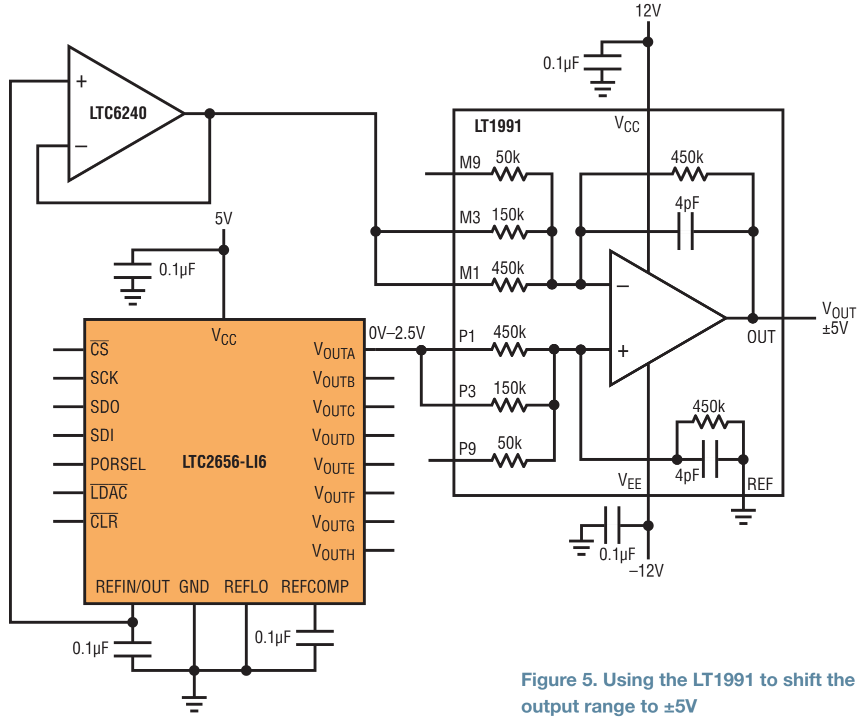


Figure 5. Using the LT1991 to shift the LTC2656 output range to ±5V

USING THE LT1991 TO GO BIPOLAR

While the LTC2656 does come in two flavors, neither one is capable of a bipolar output. This again is a situation where the LT1991 proves its mettle. Using a combination of gain and offset, the LT1991 can be combined with the LTC2656 to form circuits that provide a ±5V output (Figure 5), a ±10V output (Figure 6) and a variety of other bipolar voltages.

As stated before, the LT1991 has the advantage of not requiring expensive external precision gain set resistors. While some users might balk at using a multichip solution in order to achieve a

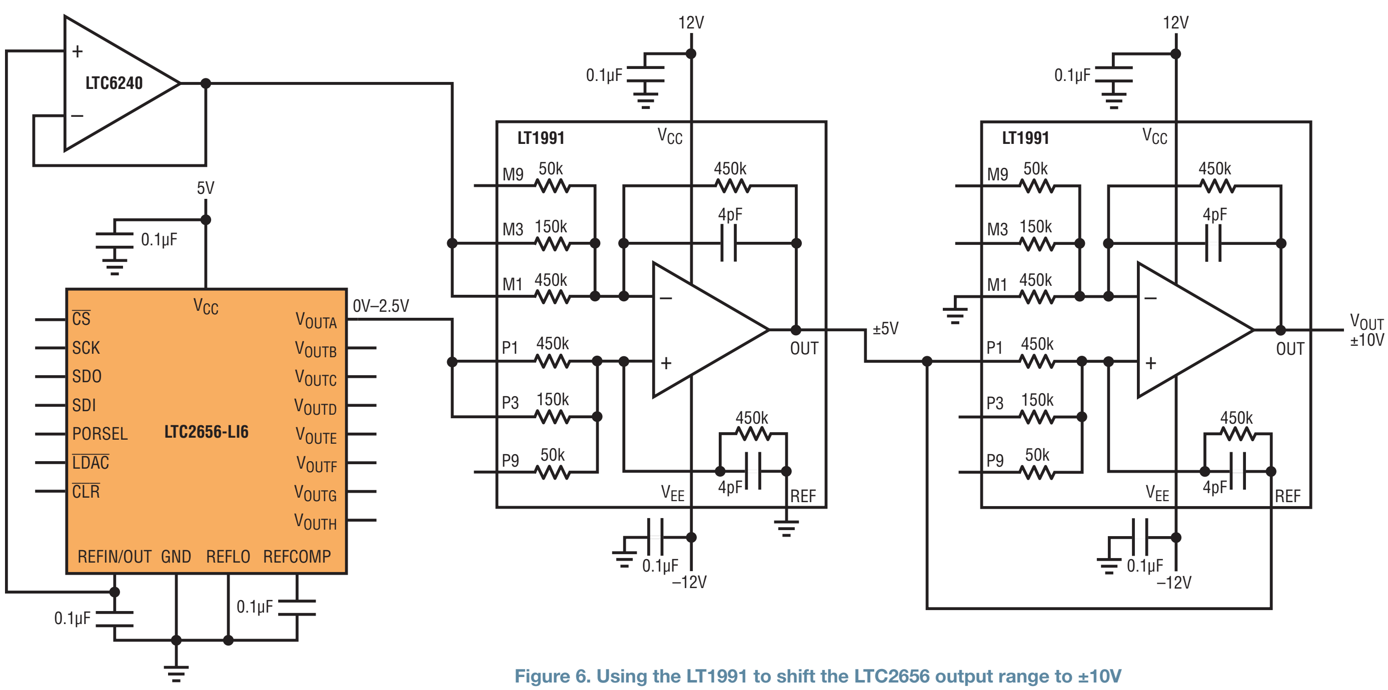


Figure 6. Using the LT1991 to shift the LTC2656 output range to ±10V

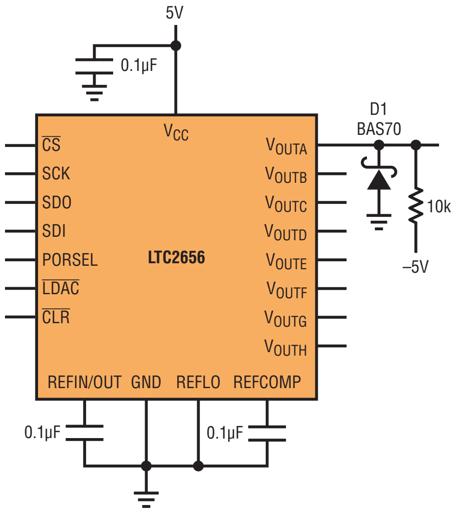


Figure 7. Achieving true rail-to-rail performance with the LTC2656

bipolar output, it is worth pointing out that the LTC2656 already saves space by eliminating the need for an external reference. Also, many bipolar DACs require an external op amp to convert a current output to a voltage anyway, so in the end, the LT1991 adds little to the board space equation while likely producing significant performance improvements.

GOING ALL THE WAY TO GROUND

The LTC2656 has unmatched offset performance, and its ouput can swing within 3mV of ground. For applicatons requiring the outputs to go completely to the lower supply rail, some additional circuitry, in the form of a Schottky diode and pull-down resistor, must be added (Figure 7).

The pull-down resistor forces the amplifier's pull-up stage to turn on. With the pull-up stage turned on on, the output loop is correctly closed, putting the amplifier back into regulation. The Schottky diode prevents the output from being driven far below ground during power-up or when the DAC is placed into shutdown.

LINKING MULTIPLE LTC2656s TO THE SAME REFERENCE

When a design calls for more than the eight channels available in a single LTC2656, the SPI interface of the DAC allows for easy expansion.

When the application demands high precision matching between all analog outputs, it is possible to drive all of the LTC2656 from a single internal reference. This is accomplished by tying the REFCOMP pin low on all but one of the DACs while also issuing the internal reference shutdown command through the digital interface. The one DAC with REFCOMP not tied to GND becomes the master reference, the REFIN/REFOUT pin of this DAC feeds into the REFIN/REFOUT pin on all the other DACs. All of the DACs on the board are thus driven from a single internal reference, avoiding variances in the respective reference outputs.

It is important to have the correct bypass capacitors in place at each of the reference inputs (Figure 8). The master reference should be treated similarly to a discrete reference during board layout and design.

CONCLUSION

The LTC2656 offers superior accuracy, precision and DAC density without the need for an external reference, thus reducing overall part count and footprint. It can be easily inserted into a wide variety of applications to solve otherwise intractable problems. ■

Figure 8. Driving multiple LTC2656s with a single internal reference