# EXTERNAL CONTROL OF DC/DC CONVERTERS USING A D/A CONVERTER

In an increasing number of hand-held and portable designs there is a need for external control of the output voltage of a DC/DC converter. Many of these applications, including PDAs, MP3 players and mobile phones, incorporate a D/A converter within their design and this D/A converter can be simply and effectively used to vary the output of a DC/DC converter. Here Torex Semiconductor, one of world's leading suppliers of DC/DC converters, looks at how this is done.

The examples below show how circuits incorporating a voltage outputting D/A converter can be connected via a direct interface to a CPU. In each case the 'FB' version of the DC/DC converter is used, where the output voltage is set by external resistors. All the circuits are applicable to both step-down and step-up applications and with an FB voltage of either 1 or 0.9V.

The subject of the first example is Torex's XC6366B105MR which is a 500kHz step-down PFM/PWM switching DC/DC Controller. Figure 1 shows the complete reference design circuit. The TC1320 D/A converter has an 8-bit resolution with 1LSB accuracy at 10mV. The D/A converter's full scale is 255 and its operating voltage is 0 to 2.5V. Output voltage can be externally adjusted between 0.5 and 3V. To achieve an output voltage of 0.5V the D/A is set to 255. For an output voltage of 3V the D/A converter is set to 0.

The basic circuit is shown in Figure 2. Here the output voltage of the D/A converter is passed through a resistor so that current is added at the FB pin to vary the output voltage of the DC/DC converter. A constant-voltage power supply is used as the reference voltage to the D/A converter.

Figure 1

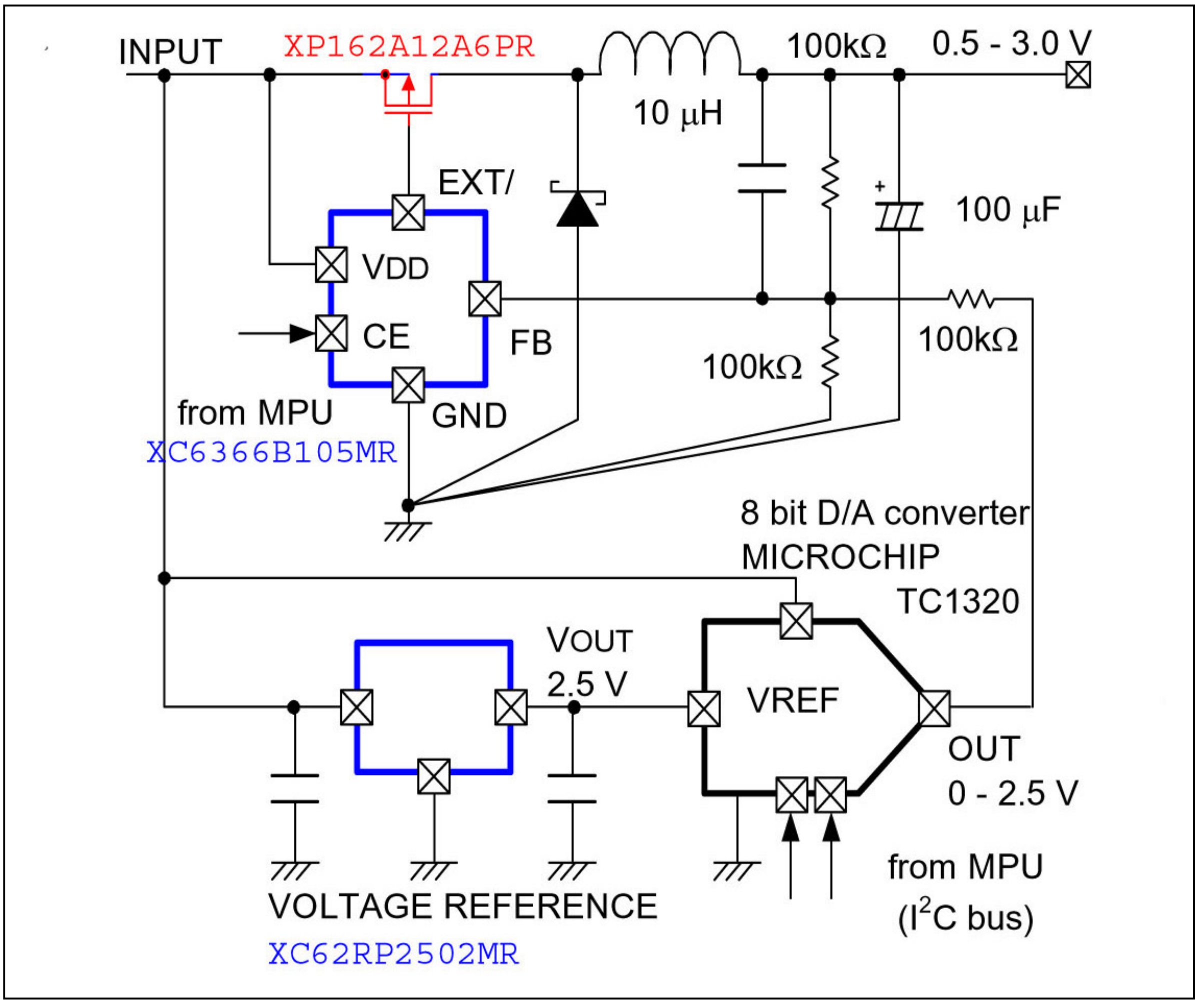
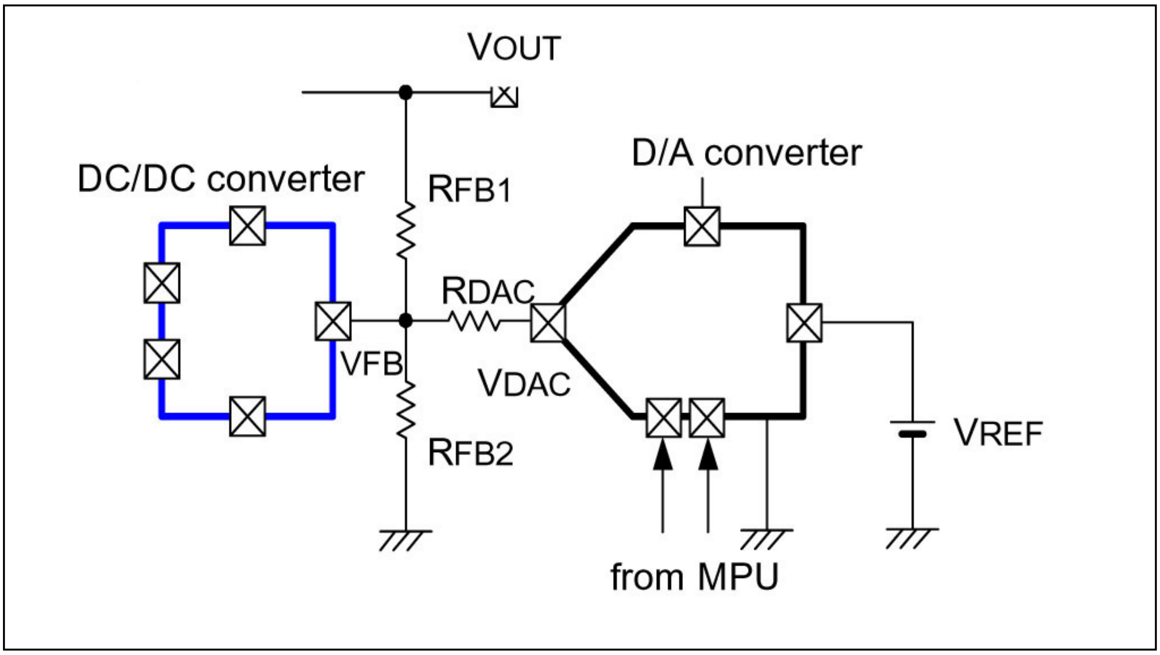



Figure 2 Basic Circuit

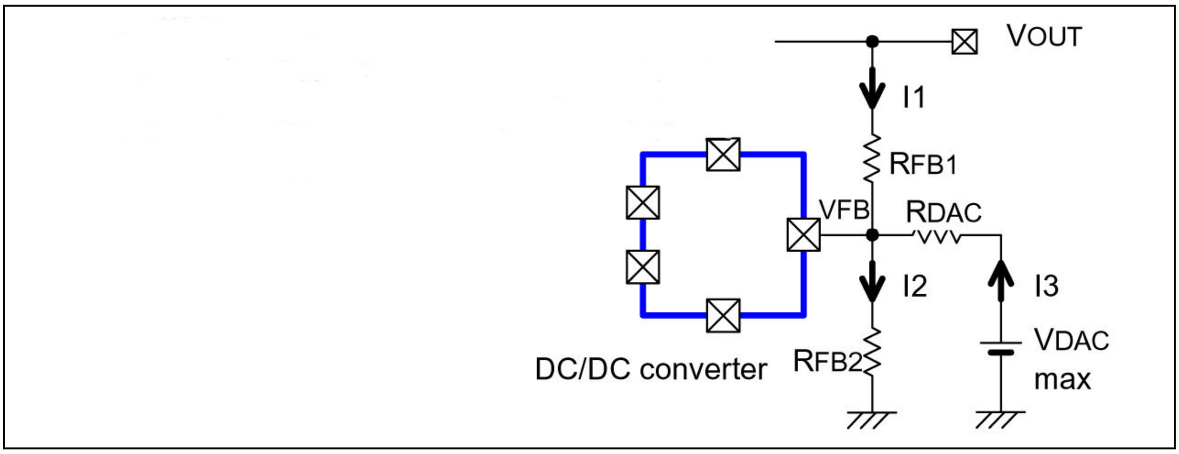


The principle of operation is shown in Figure 3 and Figure 4. In Figure 3, the output voltage, VOUT, decreases if current flows into the FB pin from the output voltage of the D/A converter, VDAC. The output voltage, VOUT, is inversely proportional to the output voltage of the D/A converter, VDAC.

Given, I1 = I2-I3, then, VOUT = (I1 x RFB1) + (I2 x RFB2)

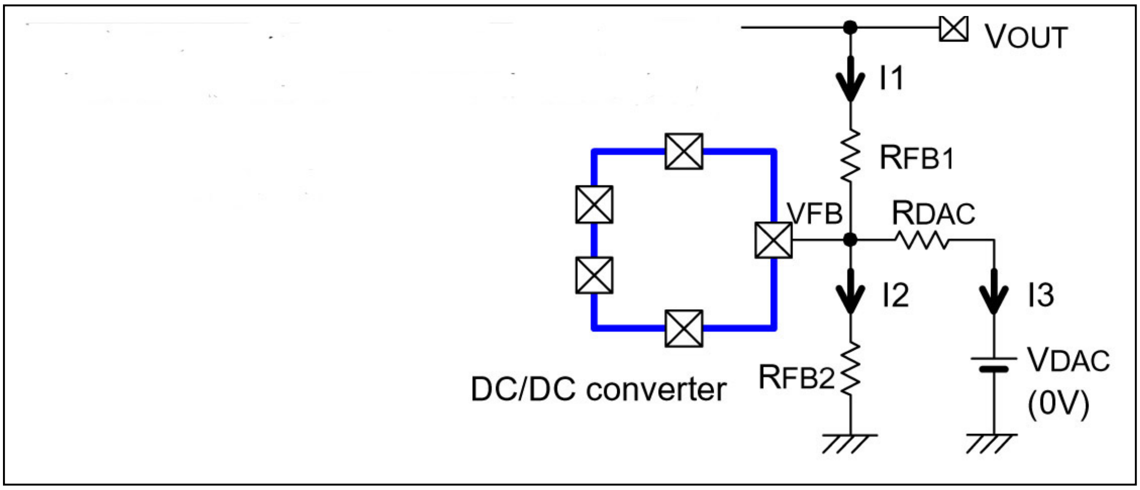
When the D/A converter output voltage is at a maximum, the DC/DC converter output is at a minimum as shown in Figure 3.

Figure 3




In Figure 4 when the output voltage of the D/A converter, VDAC, is lower than the voltage at the FB pin, current flows from the FB pin to GND. When the output voltage of the D/A converter, VDAC, is zero, the output voltage becomes the maximum (VOUTmax).

Figure 4



Given the principle of operation shown in Figures 3 and 4, the maximum and minimum output voltages are calculated from the following:

$$V_{OUTmax} = \left\{ \left[ \frac{R_{FB1}}{R_{FB2}} + \frac{R_{FB1}}{R_{DAC}} \right] + 1 \right\} \text{ x } V_{FB}$$

$$V_{OUTmin} = \left\{ \left[ \frac{R_{FB1}}{R_{FB2}} + 1 \right] \text{ x } V_{FB} \right\} - \left\{ \frac{R_{FB1}}{R_{DAC}} \text{ x } (V_{DACmax} - V_{FB}) \right\}$$

Thus for the first example:

$$V_{OUTmax} = \left\{ \left[ \frac{100}{100} + \frac{100}{100} \right] + 1 \right\} \text{ x } 1.0 = 3V$$

and

$$V_{OUTmin} = \left\{ \left[ \frac{100}{100} + 1 \right] \text{ x } 1.0 \right\} - \left\{ \frac{100}{100} \text{ x } (2.5 - 1.0) \right\}$$

$$V_{OUTmin} = 0.5V$$

Now let us consider another example this time based on Torex's XC9103/4/5 series of step-up DC/DC converters which has an adjustable output voltage range of 3 to 8V. The D/A converter in this example has a 10-bit resolution with 1LSB accuracy at 5mV. The D/A converter's full scale is 1024 and its output voltage can be externally adjusted between 0 and 2V. To achieve an output voltage of 3V the D/A is set to 1023. For an output voltage of 8V the D/A converter is set to 0.

In order to calculate the resistances used in the basic circuit we have to consider the following pair of equations:

$$\frac{1}{R_{FB2}} = \left( \frac{\frac{V_{OUTmax}}{V_{FB}} - 1}{R_{FB1}} \right) - \frac{1}{R_{DAC}}$$

$$R_{DAC} = \frac{V_{DAC}\text{ variation}}{V_{OUT}\text{ variation}} \times R_{FB1}$$

An arbitrary value for RFB2 is chosen as the first step in the calculation. In this case we will set RFB2 at 50kΩ. VFB this time is 0.9V

From the parameters we can see that

$$R_{DAC} = \frac{2}{5} \times R_{FB1}$$

so

$$\frac{1}{50} = \left( \frac{\frac{8}{0.9} - 1}{5/2\ R_{DAC}} \right) - \frac{1}{R_{DAC}}$$

gives $R_{DAC} = 108\ k\Omega$

and as $R_{FB1} = R_{DAC} \times 2.5$

then $R_{FB1} = 270\ k\Omega$

Feeding these values into our equations for VOUTmax and VOUTmin:

$$V_{OUTmax} = \left\{ \left[ \frac{270}{50} + \frac{270}{108} \right] + 1 \right\} \text{ x } 0.9 = 8V$$

and

$$V_{OUTmin} = \left\{ \left[ \frac{270}{50} + 1 \right] \text{ x } 0.9 \right\} - \left\{ \frac{270}{108} \text{ x } (2 - 0.9) \right\}$$

$$V_{OUTmin} = 3V$$

Thus with the careful selection of a small number of resistors it can be seen that a D/A converter can be simply and effectively used to vary the output of a DC/DC converter.