Output Adjustment of ARG3000 Series

SINGLE OUTPUT 0VDC TO 200VDC

Referring to the output stage diagram (Figure 1), note that $-V_{OUT}$ (Pin 7) is connected to the system ground and the load is connected between $+V_{OUT}$ (Pin 5) and $-V_{OUT}$ (Pin 7). Also note that $V_{OUT}/2$ (Pin 6) can be used for additional output filtering. By connecting capacitors from $+V_{OUT}$ to $V_{OUT}/2$ and from $V_{OUT}/2$ to $-V_{OUT}$. This will allow the designer to use higher capacitance with lower voltage rating than that which will be required if a single capacitor was used from $+V_{OUT}$ to $-V_{OUT}$. To set V_{OUT} for a specific output voltage range when the input control voltage range is known, the ARG3000 provides two access points: the Inverting (overall) input (Pin 8) and the Non-Inverting (NI) (Pin 9).

From Eq #2, we can calculate the required VA for the given range of V_{OUT}/V_{IN}. Then by solving two equations, the reference voltage VB and any external resistor in series with R3 will be calculated to generate the required VA range.

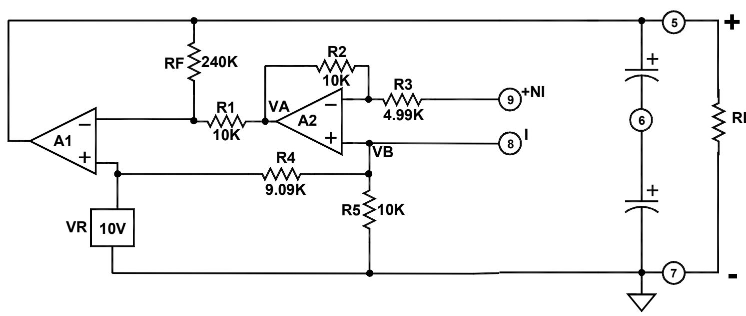

FIGURE 1. Output stage

$$V_O = VR\left(1 + \frac{R2}{R3}\right) - \frac{R2}{R3}VA \qquad \text{Eq \#1}$$

$$VA\Big|_{\text{Pin 8 open}} = VB\left(1 + \frac{R2}{R3}\right) - \frac{R2}{R3}V_{IN} \qquad \text{Eq \#2}$$

$$VA\Big|_{\text{Pin 9 = 0 (Shorted to Pin 7)}} = V_{IN} = VB = \left(1 + \frac{R2}{R3}\right) \qquad \text{Eq \#3}$$

EXAMPLE 1

The required output V_{OUT} (Pin 5) needs to be adjusted from 0Vdc to 200Vdc from a control voltage source of 0Vdc to 5Vdc.

By setting $V_O = 0$ in Eq #1 and solving for:

$$VA = VR\left(R1 + \frac{RF}{R1}\right)\frac{R1}{RF} = VR\left(\frac{R1}{RF} + 1\right)$$

Then substituting the resistor values in Figure X:

$$VA = 10(0.04167 + 1) = 10.4167$$

Then setting $V_O = 200 = VR\left(1 + \frac{RF}{R1}\right) - \frac{RF}{R1}VA$

$$\Rightarrow 200 = 10(1+24) - 24VA$$

$$250 - 200 = 24VA$$

$$VA = 2.08V$$

Repeating the above steps with Eq #2, we need to get 10.4167 at VA with $V_{IN}=0$ (Pin 9):

$$10.4167 = VB\left(1 + \frac{R2}{R3}\right) - \frac{R2}{R3}*0$$

$$10.4167 = VB(1+K)$$

$$K = \frac{R2}{R3}$$

$$VB = \frac{10.4167}{K+1}$$

$$2.08 = VB(1+K) - K*5 \;\Rightarrow\; 2.08 = \frac{10.4167}{K+1}(1+K) - 5K$$

$$K = \frac{10.4167 - 2.08}{5} = 1.667K = \frac{R2}{R3}$$

$$R3 = \frac{10K}{1.667K} = 5.998K$$

$$VB = \frac{10.4167}{1+1.667} = 3.905V$$

The external resistor required to be connected from Pin 9 (NI) to the control voltage source is given as:

RX = 5.998 - 4.99K = 1.008K ≈ 1K 1% resistor

To set VB (Pin 8) to 3.905V, a resistor must be connected from Pin 8 to Pin 7 (GND) in parallel with R5, the parallel combination of R5 and R external (we'll call it R5') is:

$$VB = \frac{R5' * 10}{R4 + R5'} = 3.905$$

$$10(R5') - 3.905(R5') = 3.905(R4)$$

$$\Rightarrow 6.095(R5') = 3.905(9.09)$$

$$R5' = \frac{35.496}{6.095} = 5.824$$

$$\text{then } \frac{R5*R_{EXT}}{R5+R_{EXT}} = 5.824$$

$$10(R_{EXT}) - 5.824(R_{EXT}) = 10*5.824 \Rightarrow 13.95K \text{ or } 14K\ 1\%$$

Thus by connecting a 1K 1% resistor from Pin 9 to controlling source and a 14K 1% resistor from Pin 8 to Pin 7, the ARG3000 will provide $0V_{OUT}$ at $0V_{IN}$ and $200V_{OUT}$ at $5V_{IN}$.

DUAL OUTPUT

When the ARG3000 is used as a dual output adjustable converter, $V_O/2$ (Pin 6) is connected to the system ground while Pin 5 provides the positive V_{OUT} and Pin 7 provides the negative V_{OUT}. All the output controls and signals, such as 5V reference sign and the inputs to A2 are referenced to $-V_{OUT}$ (Pin 7).

When the controlling voltage source is referenced to system ground, a voltage level shift is required. The circuit in Figure 2 can be used to provide the required current and voltage shift. The current (I) required to be injected into Pin 9 (NI) is generated by the current source (A1, Q1, R_{CS}), while A2 is used to set the required gain. The drain voltage of Q1 (V_{DS}) must be higher than the maximum $-V_{OUT}$ voltage. With I = 0 through the current source, the voltage at Pins 8 or 9 can be as high as 5.3V, therefore a voltage higher than 5.3V is required for Q2 to operate properly. +10V is selected in Figure 2.

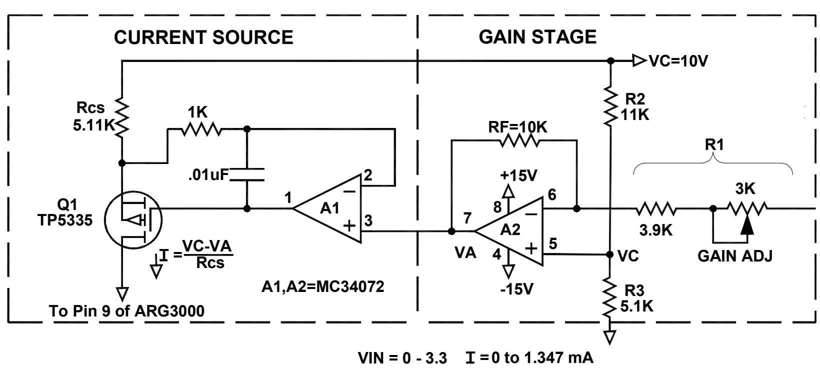

FIGURE 2. Voltage to current converter for ARG3000 dual output models

EXAMPLE 2

A D/A converter with an output voltage from 0V to 3.3V will be used to adjust the ARG3000 from 0V to ±75V, or 0V to 150V between Pin 5 and Pin 7. From Example 1, we calculated VA for $0V_{OUT}$ to be VA = 10.4167.

$$\text{For } 150V_{OUT},\ VA = \frac{250 - 150}{24} = 4.1667$$

VB = 5.238 voltage at Pin 8

With Pin 9 connected through an external resistor to $-V_{OUT}$ (Pin 7) and I through Q1 = 0, VA = 10.4167 or:

$$10.4167 = VB(1+\frac{R2}{R3+RX}) \quad \text{(See Figure 3)}$$

$$\Rightarrow \frac{10.4167}{5.238} -1 = \frac{R2}{R3+RX} = 0.9887$$

$$RX+R3 = \frac{R2}{0.9887} = 10.114$$

$$RX = 10.114 - 4.99 = 5.12$$

Therefore, use a 5.11K 1% standard resistor.

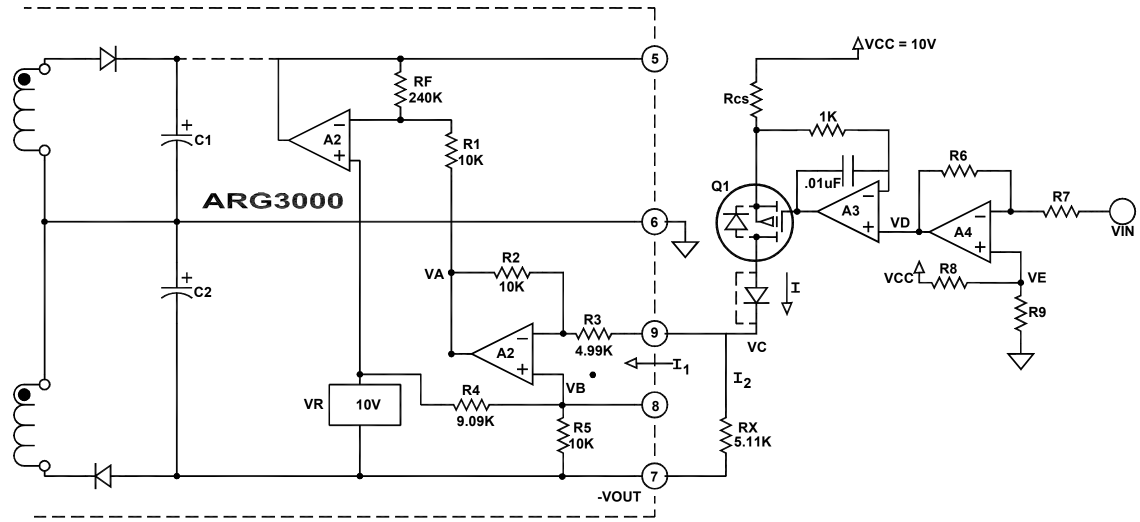

FIGURE 3. Output adjustment with a high voltage current source for ARG3000 dual output models

EXAMPLE 2 Continued

Next, we calculate the current required to be applied at Pin 9. Referring to Figure 3, the current I from the current source will split into two parts. One will go through RX = 5.11K and the other will go through R2 and R3. We'll refer to the voltage at Pin 9 as VC and sum the current around A2 as follows:

$$I_1 = \frac{VC - VB}{R3} = \frac{VB - VA}{R2} \quad \text{and} \quad I_2 = \frac{VC}{RX}$$

$$\frac{VC}{R3} = VB\left(\frac{1}{R3} + \frac{1}{R2}\right) - \frac{VA}{R3} \quad \Rightarrow \quad VC = VB\left(1+\frac{R3}{R2}\right) - \frac{R3}{R2}VA$$

From above VB = 5.238, VA for V_O = 150 is VA = 4.167.

Then:

$$VC = 5.238\left(1+\frac{4.99}{10}\right) - \frac{4.99}{10}(4.1667) = 7.852 - 2.079 = 5.773$$

$$I_1 = \frac{5.773-5.238}{4.99K} = 1.072 \times 10^{-4} \quad I_2 = \frac{5.773}{5.11K} = 1.13 \times 10^{-3}$$

and I = 1.237×10^{-3}A or 1.237mA.

The current source must allow 1.237mA when V_{IN} = 3.3V and 0mA when V_{IN} = 0V. The output VD of A4 when V_{IN} = 0 must be 10V to provide I = 0mA and it must be greater than VB (>5.238V). If we set R_{CS} = 2.26K 1% standard, then VD for I = 1.237mA = 10 - VD $\Rightarrow$ 10 - 2.26(1.237) = 10 - 2.792 = 7.208V.

Then the gain ratio and offset can be calculated by:

$$\mathbf{VD = VE\left(1+\frac{R6}{R7}\right) - \frac{R6}{R7}V_{IN} \qquad K = \frac{R6}{R7}}$$

For V_{IN}=0, 10 = VE(1+K)

and V_{IN}=3.3, VD = 7.208 $\Rightarrow$ 7.208 = VE(1+K) - 3.3K

$$7.208 = \frac{10}{1+K}(1+K) - 3.3K \Rightarrow 10 - 7.208 = 3.3K, \ K = 0.846$$

Solving for VE:

$$VE = \frac{10}{1+0.846} = 5.417 \qquad K = \frac{R6}{R7} = 0.846$$

for R7 = 10K, R6 = 8.46K or 8.45K 1% standard resistor and if R9 is set to R9 = 5.11K, then R8 = 4.32K.

Other current sources can be used as long as they are stable over temperature. In high switching current environments such as DC/DC converters, OPAMs with a high power supply rejection ratio are recommended. Also note that in all the circuitry given above, single supply OPAMs, such as MC34072, can be used as long as the output is not forced to either $+V_{CC}$ or $-V_{CC}$ (always allow a margin of $+V_{CC}$-2V and $-V_{CC}$+2V). The same circuits can be adopted for adjusting any DC/DC or AC/DC converter even though most standard DC/DC converters only offer a ±10% V_{OUT} Adjust range.