MARS HV Power Supply Control

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The MARS shoreside high-voltage power supply previously output up to 7500 V to feed power to the seafloor node. That voltage must now be reduced because of concerns about the condition of the underwater connecter that connects the subsea cable to the seafloor node. The new node will operate at 1500 V nominal, and the mini node will operate at 800–900 V. The voltage is set by a control input on the HV power supply which causes the supply to output 1500 V of output for every 1 V of input. We must modify the control circuitry to limit the power supply to output a maximum of 1500 V.

There's an op-amp buffer in the control circuitry whose gain can be set with resistors. However, the minimum gain is 1, which would cause the power supply to output too much voltage at maximum setting. Instead, we must modify the circuit to use a resistive divider at the output of the op-amp buffer. These calculations will find the values of the resistors in the divider.

Max desired power supply output voltage

```
Vpsoutmax = 1500
```

```
1500
```

Gain of the power supply from programming input to output in volts per volt

```
Gps = 1500
```

```
1500
```

Reference voltage feeding the DAC

```
Vref = 2.5
```

```
2.5
```

Input voltage to power supply to produce max output voltage

$$\text{Vpsinmax} = \frac{\text{Vpsoutmax}}{\text{Gps}} \text{ // N}$$

```
1.
```

Divider ratio to produce Vpsinmax from Vref

$$\text{Drat} = \frac{\text{Vpsinmax}}{\text{Vref}}$$

0.4

Define a resistive divider with R1 on top and R2 on the bottom that divides by the ratio we just found.

$$\text{eqn1} = \frac{\text{R2}}{\text{R1} + \text{R2}} == \text{Drat}$$

$$\frac{\text{R2}}{\text{R1} + \text{R2}} == 0.4$$

We also require that the output impedance of the network is less than 1 kΩ, so we'll set it to 500 Ω. Therefor, the parallel combination of the two resistors must equal 500 Ω.

$$\text{eqn2} = \frac{\text{R1 R2}}{\text{R1} + \text{R2}} == 500$$

$$\frac{\text{R1 R2}}{\text{R1} + \text{R2}} == 500$$

Find the two resistors that meet these criteria.

```
soln = Solve[{eqn1, eqn2}, {R1, R2}] // First
```

Solve: Solve was unable to solve the system with inexact coefficients. The answer was obtained by solving a corresponding exact system and numericizing the result.

{R1 → 1250., R2 → 833.333}

The closest standard 1% resistor values are 1240 Ω and 825 Ω. Find the HV power supply maximum output with these values.

$$\text{Vpsoutmaxactual} = \text{Vref} \frac{825}{1240 + 825} \text{Gps}$$

1498.18

Find the current that the OP196 op-amp must produce to drive this divider at Vref. This current must be less than 4 mA.

$$\text{Iopampout} = \frac{\text{Vref}}{\text{R1} + \text{R2}} \text{ /. soln}$$

0.0012

Find the HV power supply output voltage increment for each count of the 12-bit DAC.

$$\text{Vstep} = \frac{\text{Vpsinmax}}{4095} 1500$$

0.3663

Find the HV power supply output voltage change after one second of incrementing/decrementing the DAC count at 41 Hz.

```
Vpersec = Vstep 41
15.0183
```