PGA309 Transfer function

Below is the mathematical expression used to compute the output voltage. This equation can be algebraically re-arranged to solve for different terms. For example, during calibration this equation is re-arranged to solve for Vin.

$$V_{out} = \left[\left(mux\_sign \cdot V_{in} + V_{coarse\_offset}\right) \cdot GI + V_{zero\_dac}\right] \cdot GD \cdot GO$$

mux_sign --	This term changes the polarity of the input signal. The value is +/-1. See table 7.28
Vin --	The input signal for the PGA309 (Vin1 = Vinp, and Vin2 = Vinn) See table 7.28.
Vcoarse_offset--	Coarse offset DAC output voltage. See table 6.9.
GI --	Input stage gain. See table 7.29.
Vzero_dac--	Zero DAC output voltage. See table 7.30
GD --	Gain DAC. See table 7.25
GO --	Output Stage Gain. See Table 7.27

$$V_{in} = \frac{V_{out} - GD \cdot GO \cdot \left(V_{zero\_dac} + GI \cdot V_{coarse\_offset}\right)}{GD \cdot GI \cdot GO \cdot mux\_sign}$$

$$V_{zero\_dac} = \frac{V_{out} - GD \cdot GI \cdot GO \cdot \left(V_{coarse\_offset} + V_{in} \cdot mux\_sign\right)}{GD \cdot GO}$$

$$V_{coarse\_offset} = \frac{V_{out} - GD \cdot GO \cdot \left(V_{zero\_dac} + GI \cdot V_{in} \cdot mux\_sign\right)}{GD \cdot GI \cdot GO}$$

$$Total\_Gain = GI \cdot GD \cdot GO$$

$$Total\_Gain = \frac{V_{out\_max} - V_{out\_min}}{V_{in\_max} - V_{in\_min}}$$

Calibration Algorithm

1. For minimum pressure. Apply low gain and offset control to set Vout to 1/2 Vs.

$GI := 4 \qquad GD := \frac{1 + .3333}{2} = 0.667 \qquad GO := 2 \qquad V_{coarse\_offset} := 0$

$$V_{out} = \left[\left(mux\_sign \cdot V_{in} + V_{coarse\_offset}\right) \cdot GI + V_{zero\_dac}\right] \cdot GD \cdot GO$$

$$\frac{5}{2} = \left[(0 + 0) \cdot 4 + V_{zero\_dac}\right] \cdot 0.667 \cdot 2$$

$V_{zero\_dac} = 1.874$ Solve for Zero Dac.

Back calculate Vin, based on Vout measured

$$V_{in\_min} = \frac{V_{out} - GD \cdot GO \cdot \left(V_{zero\_dac} + GI \cdot V_{coarse\_offset}\right)}{GD \cdot GI \cdot GO \cdot mux\_sign}$$

2. Adjust gain according to the if-then relationship below and re-do step 1. This will get a more accurate value for Vin.

```
if (Vin > 0.131)
        Front_Gain = 4;
else if ((Vin > 0.035) &&  (Vin <= 0.131))
        Front_Gain = 8;
else if ((Vin > 0.023) &&  (Vin <= 0.035))
        Front_Gain = 16;
else if ((Vin > 0.015) &&  (Vin <= 0.023))
        Front_Gain = 32;
else Front_Gain = 64;
```

3. Do the same procedure as in step 1 and 2 with maximum pressure.
Now we have Vin_min and Vin_max.

4. Calculate total gain.

$$\mathrm{Total\_Gain} = \frac{V_{out\_max} - V_{out\_min}}{V_{in\_max} - V_{in\_min}}$$

5. Search through all combinations of GI x GO x 0.667 to find the optimal values that is closest to the total gain
i.e. Total_Gain ~ GI x GO x 0.667

6. Solve for the value of GD to get the exact Total_Gain

$$GD = \frac{\mathrm{Total\_Gain}}{GI \cdot GO}$$

7. Solve for V_{coarse_offset} to cancle Vin_min

$$V_{coarse\_offset} = -V_{coarse\_offset}$$

8. Solve for
V_{zero_dac}

$$V_{zero\_dac} = \frac{V_{out} - GD \cdot GI \cdot GO \cdot \left(V_{coarse\_offset} + V_{in} \cdot mux\_sign\right)}{GD \cdot GO}$$

9. Now the gain and offset correction should give aproximatly Vout_max and Vout_min for maximum and minimum stimulus. At this point maximum pressure is applied so the output should be close to the target. However, this will not be the best accuracy. To further improve the accuracy we will do a linear correction to offset (GD, and Vzero_dac).

$$V_{in\_max} = \frac{V_{out} - GD \cdot GO \cdot \left(V_{zero\_dac} + GI \cdot V_{coarse\_offset}\right)}{GD \cdot GI \cdot GO \cdot mux\_sign}$$ improved value

$$V_{zero\_dac} = \frac{V_{out} - GD \cdot GI \cdot GO \cdot \left(V_{coarse\_offset} + V_{in} \cdot mux\_sign\right)}{GD \cdot GO}$$ improved value

10. Adjust pressure to minimum. Measure the output (it should be near the target). Back calculate the input. Use this information to compute the gain and zero dac.

$$V_{in\_min} = \frac{V_{out} - GD \cdot GO \cdot \left(V_{zero\_dac} + GI \cdot V_{coarse\_offset}\right)}{GD \cdot GI \cdot GO \cdot mux\_sign}$$

$$Total\_Gain = \frac{V_{out\_max} - V_{out\_min}}{V_{in\_max} - V_{in\_min}}$$

$$GD = \frac{Total\_Gain}{GI \cdot GO}$$

$$V_{zero\_dac} = \frac{V_{out} - GD \cdot GI \cdot GO \cdot \left(V_{coarse\_offset} + V_{in} \cdot mux\_sign\right)}{GD \cdot GO}$$

11. NAt this point minimum pressure is applied so the output should be close to the target. However, this will not be the best accuracy. To further improve the accuracy we will do a linear correction to offset (GD, and Vzero_dac).

$$V_{in\_min} = \frac{V_{out} - GD \cdot GO \cdot \left(V_{zero\_dac} + GI \cdot V_{coarse\_offset}\right)}{GD \cdot GI \cdot GO \cdot mux\_sign}$$ improved value

$$V_{zero\_dac} = \frac{V_{out} - GD \cdot GI \cdot GO \cdot \left(V_{coarse\_offset} + V_{in} \cdot mux\_sign\right)}{GD \cdot GO}$$ improved value

12. The same procedure is done at all temperatures. At each temperatuer the GD, and Vzero_dac are adjusted to get the ideal Vout_max and Vout min.

13. Use the GD, and Vzero_dac at each temperature to generate the look up table.