



## Gas Blending and Working With Flow Ratios -Part B

### What is the right way to deliver precise ratios of gas flows?

Many applications require a fixed ratio of two or more gas flows. Setting each of the flows independently is certainly one approach. But in cases where you need to change the total flow while keeping the ratio constant, the “set each flow” procedure becomes cumbersome. So for applications like combustion control, gas blending, or vacuum furnace control, setting the flows using a “master/slave ratio” approach is far more dependable and convenient. The Hastings PowerPod 400 performs this function with the capability for up to four gas flows. Once properly configured, the total flow is adjusted with one parameter to provide a settable flow of a constant blend ratio without recalculation—avoiding many sources of operator error. This note outlines specific procedures for setting up the PowerPod 400 for master/slave ratio control and provides examples for some typical applications.

### Objectives

- ✓ Determining ratio settings for specific flow rate combinations.
- ✓ Configuring the PowerPod 400 for master/slave operation.
- ✓ Adjusting the master flow or the ratio values.

### Method for Determining Flow Ratios

Proper set up for master/slave operation begins with defining the desired flow ratio. Then, further calculations depend on how the units of flow measurement have been set, as actual flow units or as percent of full scale (FS). Once this calculated set point is programmed into the PowerPod for each slave MFC, subsequent changes in the master flow will cause proportional changes in the slave flow set point to maintain the ratio.

#### *Full scale ranges are the same*

For example, let’s say you are using a 1000 sccm full scale (FS) oxygen MFC and a 1000 sccm FS hydrogen MFC and the desired flows are 500 sccm oxygen to 400 sccm hydrogen. The actual flow ratio is  $R_a = Q_2/Q_1 = 400\text{sccm}/500\text{sccm} = 0.8$  (See Gas Blending for Stoichiometry-Part A). In this example, the MFCs have the same full scale, so the “percent of full scales” ratio,  $R_{FS}$ , is the same as the actual flow ratio, 0.8.

#### *Full scale ranges are different*

But in cases where the MFCs have different full scales, the ratios  $R_a$  and  $R_{FS}$  will be different. Take the example where you are flowing 8 slm of nitrogen in a 10 slm FS MFC and 200 sccm of helium in a 500 sccm FS MFC. The actual flow ratio is  $R_a = 0.2\text{slm}/8\text{slm} = 0.025$ . However, when each flow is expressed as fraction of FS flow, 0.8 and 0.4, the ratio is  $R_{FS} = 0.5$ . So in that case, the set point voltage delivered to the slave MFC should be exactly half the voltage delivered to the master. To make this a one step calculation, the slave flow set point can be calculated as,

$$Q_{2Set} = \frac{Q_2 Q_{1FS}}{Q_1}$$

when using physical flow units, or as,

$$Q_{2Set\%} = \frac{Q_2 Q_{1FS}}{Q_1 Q_{2FS}} \times 100\%$$

when using %FS units. Here,  $Q_1$  and  $Q_2$  are the actual flows of gas 1 and gas 2 respectively;  $Q_{1FS}$  and  $Q_{2FS}$  are the Full Scale flows of the MFCs. **It is the  $Q_{2Set}$  or  $Q_{2Set\%}$  number (not the actual  $Q_2$ ) that will be programmed as the set point in the PowerPod.** What if  $R_{FS}$  is greater than 1.00? It can cause problems. Consider the situation where  $R_{FS}$  is 1.50. If the master flow is given a set point at 80% of its full scale range, then the slave MFC will be commanded to flow at 140% of its range—that’s a problem. In fact, the

PowerPod does not allow the case where  $R_{FS}$  is greater than 1.00. (In those situations, the roles of the master and slave should be reversed, resulting in a fractional ratio.) This ensures that the master MFC will always be the highest flow relative to its FS and thus the slave MFC will never be commanded to flow more than 100% FS flow.

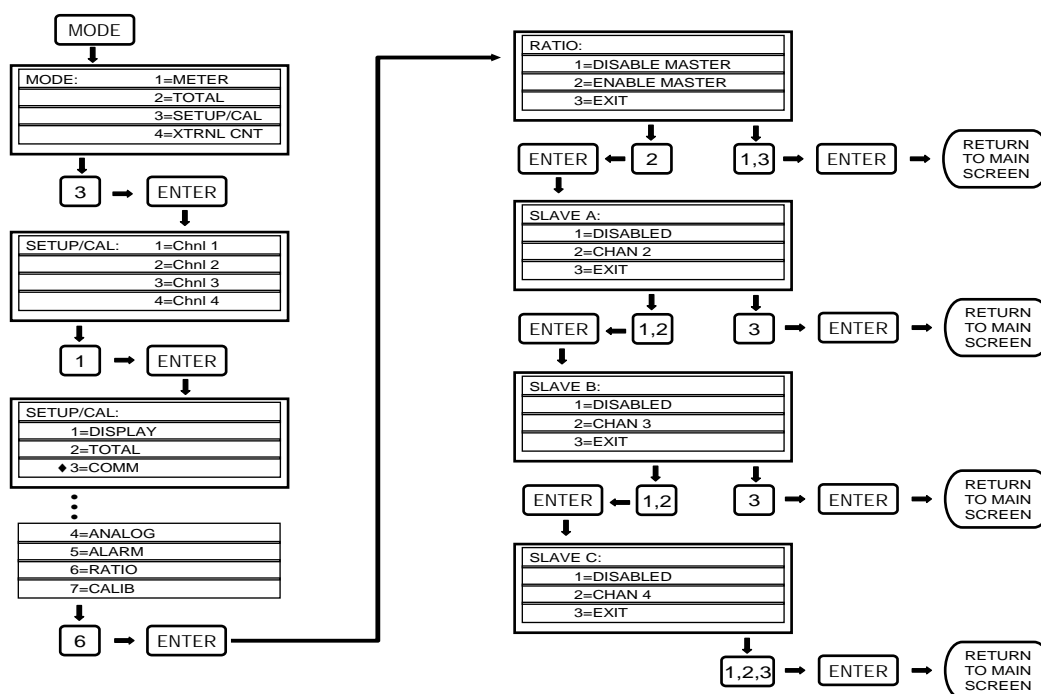
## Configuring the PowerPod 400 for master/slave operation

**NOTE:** Multiplication factor function must be set to 1  
If the PowerPod and MFCs were ordered together, then the factory has set up each channel to reflect the gas type, units and full scale flow. If this is not the case or a flow channel requires reconfiguration, Sections 10.1, 10.2, and 10.8 of the PowerPod manual have detailed instructions for these settings.



There are some basic rules for the master/slave functionality. Only channel 1 can be the master. The master device can be either a controller (MFC) or a meter (MFM). The slave channels must be MFCs. The procedure to enable master/slave operation is as follows:

- To begin from the main screen, press the **MODE** key, then select SETUP/CAL by pressing **3** then **ENTER**.
- To establish channel 1 as the master, press **1**, **ENTER**, **6** for RATIO, **ENTER**, **2** for ENABLE MASTER, and **ENTER**.
- To designate which of the remaining channels are slave MFCs, the screen will next prompt for SLAVE A status setting. If you would like Channel 2 to be a slave, press **2** **ENTER**, if not press **1** **ENTER**. The screen will then prompt in a similar way for SLAVE B to be associated with channel 3 and SLAVE C with channel 4. To exit any of these selection screens, press **3** **ENTER**. The PowerPod will return to the main screen with the current master/slave information updated. If the **ESC** key is pressed at any time during this configuration, the PowerPod will return to the main screen with no updated information.



With the master and slave MFCs selected, the set points can now be entered for each channel. To enter a set point, the [CHANNEL #] key is pressed for the particular channel. The screen will display an asterisk to the left of the current set point. Use the numeric keys to type the new set point (with a decimal as appropriate) and then press [ENTER]. If the PowerPod and flow instruments are actually connected to a system with gas, it is best to start by ensuring there is no flow in the master. If the master is an MFM, this must be done externally to the PowerPod. If the master is an MFC this can be accomplished by commanding the master closed by pressing [CHANNEL 1] [CLOSE] or by commanding its set point to zero. Doing this avoids spurious flow while setting up the slave controllers. The slave channels can each be programmed with their set point values  $Q_{2Set}$  or  $Q_{2Set\%}$  as determined by the formulae given previously. After the slave channels have been programmed, the master channel set point can be entered to command the master and all slave channels at the proper ratios.

The set points to any of the channels can be changed "on the fly" as needed. Changing the master (channel 1) flow will proportionally affect all flows that are participating in the master/slave set up. Adjusting slave set points will modify the ratio, but will also affect the total flow.

Returning to the example where you are flowing 8 slm of nitrogen in a 10 slm FS MFC and 200 sccm of helium in a 500 sccm FS MFC. If the PowerPod is set up with physical units (slm), the slave flow set point is,

$$Q_{2Set} = \frac{Q_2 Q_{1FS}}{Q_1} = \frac{(200sccm) \cdot (10slm)}{8slm} = 250sccm$$

Now, when the master is commanded to flow at 8 slm, the slave will flow at 200 sccm. It's worth mentioning that the slave is not supposed to achieve the entered set point (unless the master happens to be flowing at its full scale).

With the master/slave function enabled and the proper set points entered. The subsequent operation will be far less cumbersome and more dependable compared with setting independent flow devices for the accurate blending of gas mixtures.

#### Notes:

A set point that exceeds the full scale value will be accepted and stored by the PowerPod, but will be treated functionally as if it were a full scale set point.

If changes are made to the units, span, or multiplication factor of the master or any slave channel, the master/slave configuration should be repeated with the new set up.

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