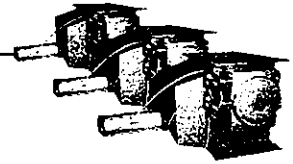




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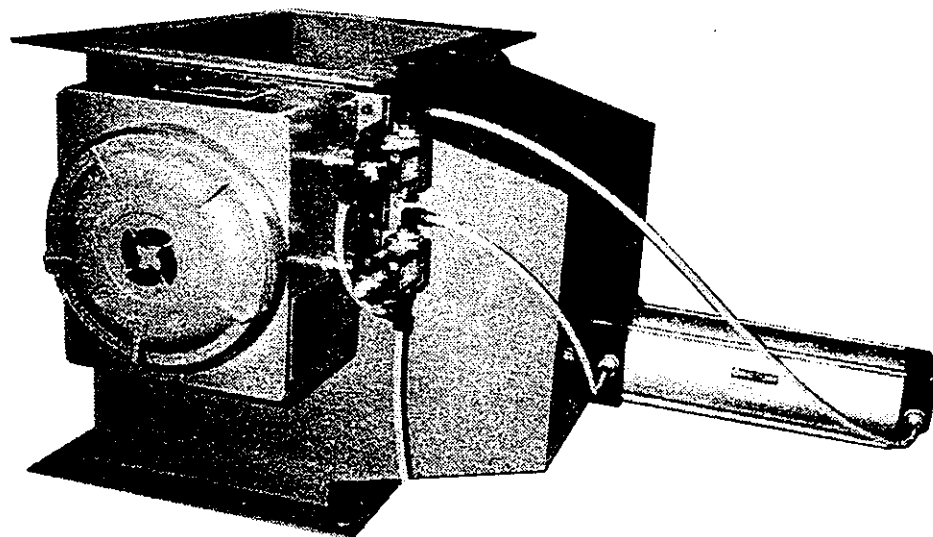
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## **USER'S MANUAL**

### **FOR THE**

# **HPFC SERIES FLOW CONTROLLER**



**June, 1997**  
**Revision 2.1**

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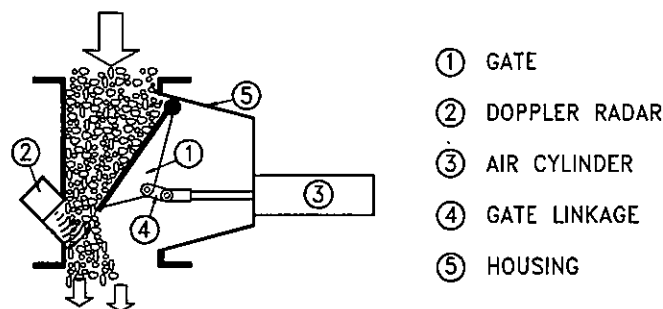
## 1.0 Introduction to the Flow Controller

The HPFC series flow controller is a sophisticated and unique FEEDER intended for controlling and monitoring the discharge of bulk material products. A simple and direct product path optimizes through-put capacity while minimizing the risk of choking. A pneumatic cylinder powers a hinged gate used to control the discharge rate. The gate position angle can be controlled from a full open position, yielding the maximum flow rate, to a full closed position that completely stops the product flow. Position control is achieved by constantly modulating the gate angle; this effectively agitates the product near the point of discharge and improves the flow characteristics. Doppler radar, in combination with advanced Digital Signal Processing (DSP), determines the product flow velocities at the point of discharge. The absence or presence of product discharging is also determined with the Doppler radar.

An RS485 master/slave network provides the control interface. All controls and parameters are exchanged exclusively on this network. A series of flow controllers may be connected by a single twisted-pair cable. Each flow controller connected on the network is assigned a distinct station address with DIP switches. For a single flow controller, the controlling device is typically a HPPMC Panel Mount Controller, an HPCPM Communications Processor Module and/or a computer would be used for multiple flow controllers. The network communication protocol is the same for all levels of interface, allowing any combination of devices to be connected with one another.

The most important function of the flow controller is to discharge a constant amount of product equal to the flow rate set-point and to provide feedback of the actual flow. An integrated totalizer will indicate current product discharge accumulation. This combines with a target function that may be activated to shut off the discharge at a pre-set accumulation. Alarm flags provide an indication of product flow problems and system malfunction.

A small lithium battery on the flow controller's circuit board ensures that all calibration data and learned data is retained during power loss. The lithium battery will maintain the data for approximately ten years.



## 2.0 Flow Controller Installation

The HPFC series flow controller requires only:

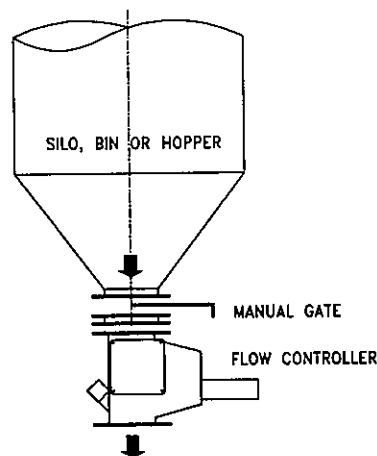
- 1) compressed air
- 2) power
- 3) network connection

## 2.1 Mechanical Installation

A typical installation has the flow controller mounted at the discharge point of a bin, silo or hopper. For bins and silos used to hold or store product, a manual slide-gate should be installed between it and the flow controller. This allows for servicing of the flow controller without having to empty the bin or silo.

The outlet of the flow controller may then feed:

- 1) belt conveyors, screw conveyors, chain conveyors etc.
- 2) air slides.
- 3) rotary valves feeding pneumatic conveying systems.
- 4) bucket elevators.
- 5) processing machinery requiring a controlled feed.
- 6) trucks and rail cars (to control the fill and NOT FOR LEGAL TRADE!)
- 7) containers and hoppers etc.



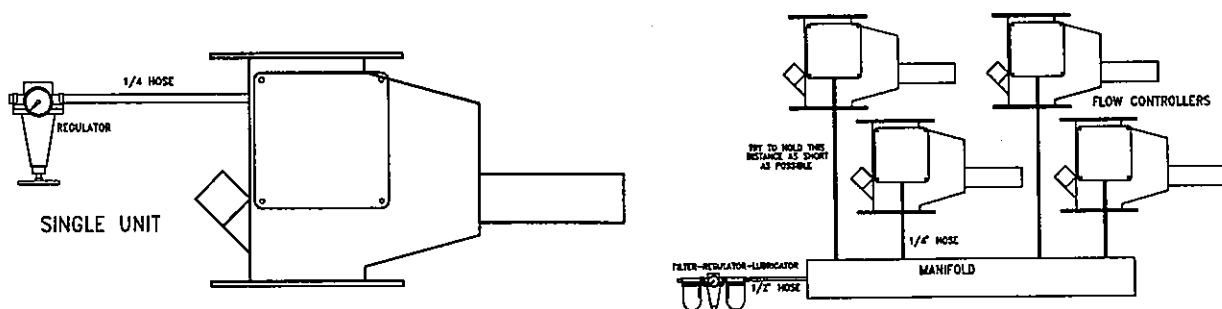
Flow controllers using Doppler radar should have no less than 4-6 inches distance between the outlet flange and a moving object below. This ensures negligible interference of the moving object with the Doppler Radar which may indicate a false reading when no product is present.

In general:

- 1) Make sure the Flow Controller is not exposed to excessive mechanical vibrations.
- 2) Check that the body has not been bent, twisted or distorted due to shipping or installation. This can be checked by moving the gate back and forth by hand. If it moves without binding the housing alignment is OK.
- 3) Ensure that there is no excessive suction or pressure at the outlet of the Flow Controller. This may affect the discharging flow.
- 4) Make sure there is enough clearance around the Flow Controller to be able to remove the electrical enclosure cover, as well as the access panel on the side of the body (if applicable).
- 5) The Flow Controller should not be used for any kind of structural support.
- 6) Check that the plastic air line has not been pinched, cut or chinked.
- 7) Flow Controllers using an impeller wheel remove the access panel on the side of the body (6 #10-32 nuts). Ensure that the impeller is tight on the shaft and spins very freely.
- 8) Ensure that the set screw is properly torqued to the gate position encoder.
- 9) Check that the Electrical Enclosure is securely fastened to the Flow Controller body.

## 2.2 Compressed Air Supply

A small regulator should be installed to control the supplying air pressure. A larger regulator may be used to supply several flow controllers, providing the distance between the regulator and flow controller is not too great. A small shut-off valve is recommended for servicing the flow controller.



Air pressure should be set to approximately 30-40 PSI. This will be adjusted later.

The compressed air supply should be clean and free of moisture.

Lubricator is optional but recommended for severe or continuous service. If a lubricator is used, it must be checked on a regular basis.

## **2.3 Electrical Installation**

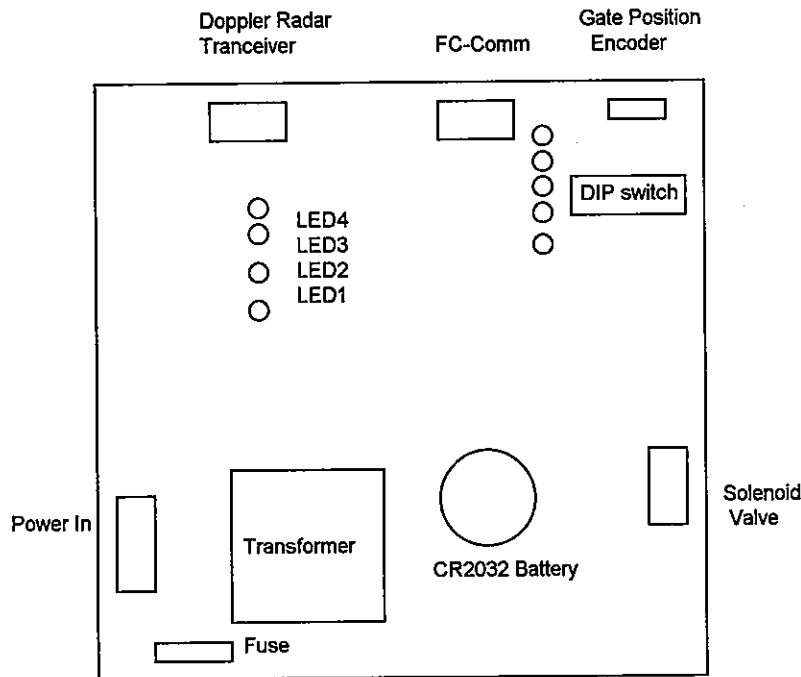
### **2.3.1 Supply Voltage**

The Flow Controller is factory jumpered to operate on 120VAC or 220VAC at 50 or 60 Hz. The maximum current draw is less than 0.25 Amp. As with all electronics, static discharges will damage the circuitry and proper grounding is essential. EMI (electro-magnetic interference) and RFI (radio frequency interference) may cause the electronics to malfunction. Therefore, this feeder should be considered as a computer device and thus requires a clean noise-free power source. A UPS source is recommended.

### **2.3.2 Network Connection**

Regardless of the control device used to interface with the Flow Controller, the physical connection is always the RS485 network. Special installation precautions must be followed to avoid communication problems. This communication problem would result in the loss of control of the Flow Controller. A loss of control means that the Flow Controller will not respond to any command or data changes, but, will continue performing its activities at the time of communication failure. In other words, if the flow controller was running at a specific flow rate, it will continue to do so. If it was stopped, it will continue to be stopped.

The physical connection of the RS485 network requires a single twisted pair, typically, 18 AWG with a shield, to connect the Flow Controller to the interface device. The RS485 network can reliably support eight Flow Controllers daisy-chained on a single run of 18 AWG cable, at a maximum distance of 2000 feet.



**HPFC5C Flow Controller Circuit Board**

In general:

- 1) The communication cable should keep as far away and separated from power cables as possible, at least 1 foot. If they must be near power cables, they should be orthogonal(at right angles) to them.
- 2) The RS485 communication cable may be run with other low voltage communication cables provided it, and they are shielded.
- 3) Observe the polarity of the wires when connecting. Incorrect polarity will result in no communication activities.
- 4) Keep the cable lengths to a minimum. 2000 feet is usually the reliable maximum distance.
- 5) Because of the nature of the RS485 architecture, ground-loops and DC biases on the network will impede the communication and may damage some or all of the RS485 driver circuits attached. Therefore, precautions should be taken to avoid these situations from occurring.

### 3.0 Power-Up Procedure

It is very important to verify all wiring before applying power to the Flow Controller(s) and the interface device. The main items to check are:

- 1) the correct voltage will be applied to the power input terminals.
- 2) the polarity for the communication is correct and that the cable is separate from power cables.

### 3.1 Setting the DIP Switches

The DIP switches on the main printed circuit board are used to configure several operating modes and to set the station address on the RS485 network. Therefore, they must be set correctly for the Flow Controller to function properly and communicate.

There are currently three main board versions:

A) The HPFC02 rev. 1.1 printed circuit board has one eight-switch DIP switch located near the lower left side of the board.

B) The updated HPFC5 rev. 1.0 printed circuit board has one four-switch and one eight-switch DIP switch for a total of 12 ON/OFF switches also located near the lower left side of the board.

C) The HPFC5C rev. 1.0 single printed circuit board has one four-switch and one eight-switch DIP switch for a total of 12 ON/OFF switches also located near the upper right side of the board. This board was put into all machines manufactured from the first week January 1997 to present, identified by the first four digits of the serial number starting with '9701xxxx'.



The version of printed circuit board (PCB) will determine the definition of the DIP switches.

For the HPFC02 rev. 1.1 PCB, the DIP switches are defined as follows:

- 1) Most Significant Bit (MSB) of the station address in binary form
- 2) Bit # 4 of the station address.
- 3) Bit # 3 of the station address.
- 4) Bit # 2 of the station address.
- 5) Least Significant Bit (LSB) of the station address in binary form

DIP switches 1 through 5 are used to establish the RS485 network station address.

6) **4-20mA Active** This switch is **only** activated when a **local** 4-20mA analog interface has been installed in the Flow Controller. Flow Controllers connected to Panel Mount Controllers having the 4-20mA option will have this DIP switch OFF, since it is NOT a local option board.

7) **Velocity Inhibit Mode** This switch may be set ON when the velocity measurements are to be ignored (i.e. in the absence of the DRP board). This will remove the velocity measurements from the control-loop of the Flow Controller. The switch is usually left in the OFF position to include the velocity measurements.

8) **Data Lock Active Mode** The calibration data may NOT be altered if this switch is in the ON position. It may be used as a security device, after the calibration procedure has been performed. This switch must be in the OFF position to edit any of the calibration parameters.

For the HPFC5 rev. 1.0 PCB, the eight-switch DIP switch has the following definitions:

- 1) Least Significant Bit (LSB) of the station address in binary form.
- 2) Bit # 2 of the station address.
- 3) Bit # 3 of the station address.
- 4) Bit # 4 of the station address.
- 5) Most Significant Bit (MSB) of the station address in binary form.

DIP switches 1 through 5 are used to establish the RS485 network station address.

6) **reserved for future use**

7) **Velocity Inhibit Mode** This switch may be set ON when the velocity measurements are to be ignored (i.e. in the absence of the DRP board). This will remove the velocity measurements from the control-loop of the Flow Controller. The switch is usually left in the OFF position to include the velocity measurements.

8) **Data Lock Active Mode** The calibration data may NOT be altered if this switch is in the ON position. It may be used as a security device, after the calibration procedure has been performed. This switch must be in the OFF position to edit any of the calibration parameters.

The HPFC5 rev. 1.0 PCB, the four-switch DIP switch has the following definitions:

1) **Activate the Doppler Radar Diagnostic Communication port** This DIP switch may be switched ON when a computer, running the Doppler Radar Diagnostic Software, is plugged into the DRP Communication port. This will initiate the data exchange between the DRP and the PC. This switch is normally set to the OFF position so the DRP microprocessor will not waste time searching the DRP communications port.

2) **Run Lock-out** When this switch is in the OFF position, the Flow Controller may never be started. It provides a means for the Flow Controller to be locked-out without disconnecting power and still maintain communications. This switch is normally set in the ON position.

3) **Lithium Battery Back-up ON/OFF** This switch provides a means to disconnect the battery from the memory protection circuitry. This may be switched OFF and ON in the event of a catastrophic microprocessor lock-up, to reset the erase the memory. This procedure will only work when the power is switched OFF at the same time. In all other cases this DIP switch is to be left ON!

4) **Power Supply ON/OFF** This will allow the shut-down of the 5-volt power supply, to allow servicing of the digital electronics without removal of the main incoming power. This will NOT shut-down the 24-volt section, therefore, great care must be taken. This switch must be ON to allow the Flow Controller to operate.

For the HPFC5C rev. 1.0 PCB, the eight-switch DIP switch has the following definitions:

- 1) Least Significant Bit (LSB) of the station address in binary form.
- 2) Bit # 2 of the station address.
- 3) Bit # 3 of the station address.
- 4) Bit # 4 of the station address.
- 5) Most Significant Bit (MSB) of the station address in binary form.

DIP switches 1 through 5 are used to establish the RS485 network station address.

6) **Gate Load Inhibit Mode (Function 1)** This switch may be set ON when the discharge gate load measurements are to be ignored. This will remove the gate load sensing from the control-loop of the Flow Controller. This switch is usually left in the OFF position to include the gate load sensing.

7) **Velocity Inhibit Mode (Function 2)** This switch may be set ON when the velocity measurements are to be ignored (i.e. in the absence of the DRP board). This will remove the velocity measurements from the control-loop of the Flow Controller. The switch is usually left in the OFF position to include the velocity measurements.

8) **Alternative Computation Mode (Function 3)** The calibration data may NOT be altered if this switch is in the ON position. It may be used as a security device, after the calibration procedure has been performed. This switch must be in the OFF position to edit any of the calibration parameters.

The HPFC5C rev. 1.0 PCB, the four-switch DIP switch has the following definitions:

- 1) **Activate the Doppler Radar Diagnostic Communication port** This DIP switch may be switched ON when a computer, running the Doppler Radar Diagnostic Software, is plugged into the DRP Communication port. This will initiate the data exchange between the DRP and the PC. This switch is normally set to the OFF position so the DRP microprocessor will not waste time searching the DRP communications port.
- 2) **Run Lock-out** When this switch is in the OFF position, the Flow Controller may never be started. It provides a means for the Flow Controller to be locked-out without disconnecting power and still maintain communications. This switch is normally set in the ON position.
- 3) **Reserved (Function 4)** This switch is reserved for future use and is currently not active.
- 4) **Power Supply ON/OFF** This will allow the shut-down of the 5-volt power supply, to allow servicing of the digital electronics without removal of the main incoming power. This will NOT shut-down the 24-volt section, therefore, great care must be taken. This switch must be ON to allow the Flow Controller to operate.

### 3.2 Definition of the Diagnostic LEDs

Located on the main PCB and on the Doppler Radar Processor PCB are a number of LEDs that can very useful in indicating the operational status of the Flow Controller.

The HPFC5C rev. 1.0 PCB has the Doppler Radar Processor integrated on a single PCB, therefore all the LEDs located on one board. The LEDs associated with the Doppler Radar Processor are located on the left side of the PCB, while the main function LEDs are located on the upper right side.

The HPFC02 rev. 1.1 PCB has four LEDs located to the right of the DIP switches. They are defined from left to right as:

- 1) **ERRor LED (Red):** This LED will be **on** when any of the lower eight bits of the error/status word are set. This LED will also blink eight times to indicate the status of the Flow Controller upon a power reset or system reset.
- 2) **RUN LED (Green):** This LED is **on** when the Flow Controller is to be running. It does not imply that the machine is running correctly, it just indicates that it is trying to run.
- 3) **SOLenoid Active LED (Green):** This LED is **on** when the solenoid valve is to be energized and, therefore, attempting to open the gate. Under normal running conditions, this LED will be blinking **on** and **off** with the solenoid valve.
- 4) **COMMunication Transmit LED (Yellow):** This LED is only **on** when the Flow Controller is sending data with the RS485 transmitter active. This condition only occurs when the Flow Controller has received a valid data packet with the correct station address (master/slave protocol). Thus a blinking LED indicates it is communicating with the interface device.

The HPFC5 rev. 1.0 and the HPFC5C rev. 1.0 PCB have five LEDs located near the right side. They are defined from top to bottom as:

- 1) **COMMunication Transmit LED (Yellow):** This LED is only **on** when the Flow Controller is sending data with the RS485 transmitter active. This condition only occurs when the Flow Controller has received a valid data packet with the correct station address (master/slave protocol). Thus a blinking LED indicates it is communicating with the interface device.
- 2) **SOLenoid Active LED (Green):** This LED is **on** when the solenoid valve is to be energized and, therefore, attempting to open the gate. Under normal running conditions, this LED will be blinking **on** and **off** with the solenoid valve.
- 3) **RUN LED (Green):** This LED is **on** when the Flow Controller is to be running. It is connected with the fluidizing relay.
- 4) **STATus LED (Yellow):** This LED is used in combination with the ERR LED to indicate the class of error, by blinking a code.
- 5) **ERRor LED (Red):** This LED will be **on** when any of the lower eight bits of the error/status word are set. This LED will also blink eight times to indicate the status of the Flow Controller upon a power reset or system reset.

Both the HPFC02 and HPFC5 PCBs have a Doppler Radar Processor (DRP) board piggy-backed on them. On the DRP board are located four LEDs near the middle of the PCB. The HPFC5C PCB has these LEDs located near the left side.

1) **LED # 1 (Red):** This LED will periodically blink to indicate when the analog to digital converter (ADC) has been sampled by the DRP microprocessor. This LED must periodically blink.

2) **LED # 2 and LED # 3 (Green):** These two LEDs will indicate the current sampling rate of the ADC as a code:

LED # 2	LED # 3	
OFF	OFF	Slow sampling rate
ON	OFF	Medium-slow sampling rate
OFF	ON	Medium-fast sampling rate
ON	ON	Fast sampling rate

3) **LED # 4 (Red):** This LED, when **on**, indicates a DRP busy status to the main control PCB. When the LED is **off**, it is ready to exchange data with the main PCB. It is synchronized with LED # 1 and is therefore periodic. Under normal conditions, this LED will only go **off** for a fraction of a second (less than 0.1 sec.). If there is a communication problem between the DRP and the main control PCB, the LED will be **off** for half a second ( 0.5 sec.). Consult the factory if this problem persists.

### 3.3 Applying Power

It is very important that all electrical connections be checked and that the DIP switched are set correctly before power is applied. Only when everything has been verified can the power be switched ON.

When power is applied to the Flow Controller, the red ERRor LED will blink eight times. The combination of long and short blinks reflect the status of the upper eight bits of the status/error word. It is very important that the ERRor LED blink upon a power-on condition or reset condition, since it acts as a diagnostic indicator for most of the electronics and firmware. If this fails to occur, there is something wrong with the microcomputer or power supply section.

#### 4.0 Initial Test Run

After checking installation, electrical connection and applying power, the Flow Controller should be run with no product. This ensures that the feeder will function properly when product is present. The procedure to run the Flow Controller is as follows:

- 1) Ensure that the compressed air is present at the feeder and check that the gate is firmly in the closed position. If the compressed air was turned on after the power was activated, then press the reset button on the main PCB to zero the gate position encoder circuitry. (This is very important!)
- 2) Check that there is communication activity between the Flow Controller and the interface device (e.g. HPPMC or a HPCOM). If not, refer to the previous section on the RS485 network and check the DIP switch setting at both the feeder and the interface.
- 3) Check the calibration values. They do not have to be correct, but they must appear to be reasonable for the product to be used. This check may be done via the interface device. If any of the calibration values are to be changed, then a Reset Parameter command must be invoked. The previous calibration parameters will still be active if this is not done.
- 4) Note and reset any errors via the interface device. The upper eight bit of the error/status word do not have to reset, since they indicate status.
- 5) Check that the accumulation target function is de-activated and the target value is set to zero. Refer to following sections of this manual for an explanation of this function.
- 6) Reset the current accumulation to zero.
- 7) Set an arbitrary but reasonable flow rate value.
- 8) Start the Flow Controller via the interface. The feeder should begin to run by modulating the gate at a constant opening.
- 9) Allow the feeder to run for a few minutes and observe its gate position for stability. Change flow rate setting to ensure the gate position is responding correctly. The gate will open more for larger flow rate and close more for smaller flow rates.
- 10) Stop the Flow Controller when satisfied with its operation. Product may now be allowed to feed through the machine after a Reset Sweep command has been issued.

## 5.0 Gate Oscillation Check

Adjustment of the gate oscillation is optional, but, may be necessary for some products used with the Flow Controller. It is mainly done to minimize air consumption and to optimize machine performance.

There are two methods for adjusting the gate oscillation:

- 1) Adjusting the supply air pressure.
- 2) Adjusting the air exhaust valves on the side of the solenoid valve body.

The simplest method to control the rate of gate oscillation is to adjust the supply air pressure. Increasing the air pressure to the Flow Controller will increase the rate of oscillation by increasing the cylinder's power. A decrease in air pressure will reduce the rate of gate oscillation by decreasing the power of the cylinder.

The second method for adjusting the gate oscillation rate is the two air exhaust set screws on the side of the valve body. One set screw is used to control the speed of the gate opening while the other controls the speed of the gate closing. If the screw is turned clock-wise the speed decreases; if the set screw is turned counter-clock wise the speed will increase.

Final adjustment of the gate oscillation rate should be determined by the product passing through the Flow Controller. In general, sticky powder products require a higher gate oscillation rate than a free-flowing granular product. Only observation of the Flow Controller running will determine the best rate of oscillation for the particular product used. In all cases the gate oscillation rate should be minimized to conserve air, minimizing energy consumption and maximizing pneumatic component life (specifically solenoid valve and air cylinder).



## 6.0 Operational Description

The Operation of the Flow Controller is very simple. The product flow rate set-point is entered as the **Setflow** parameter. The actual flow rate of the discharging product may be monitored via the **Flowrate**. The **Target** parameter allows a product accumulation target to automatically shut off the Flow Controller. This function may be activated or de-activated via the **Control Byte** parameter. A running accumulation of product discharged by the Flow Controller may be monitored via the **Total**.

The **Error and Status Word**, **Average**, **Amplitude**, **Cycle Length** and **Velocity** provide performance data on the operation of the Flow Controller.

It is very important to note that the **Status Byte**, **Error/Status Word** and **Mode Byte** are automatically handled by the user interface. The operator is not required, or expected to manipulate the bit pattern within them. The bits are manipulated in the user interface by menu selections, push buttons, function keys, etc.

### 6.1 The Operating Parameters

Following is a description of the Flow Controller's operational parameters:

**Setflow** : This is the desired flow rate at which the Flow Controller will feed the product. This parameter will register in the units for which the Flow Controller has been calibrated. For example, if kilograms per hour has been used as the units of calibration during the calibration procedure, then a flow rate of **Setflow** = 10000 would mean that the **Setflow** has been entered as 10000 kilograms per hour. The **Setflow** parameter may be changed while the Flow Controller is running.

**Units : pounds per hour (kilos per hour)**

(e.g. 11500 pounds per hour would be entered as 11500)

**Flowrate** : This is the actual running flow rate while the Flow Controller is in operating mode. **Flowrate** will fluctuate near the **Setflow** parameter.

**Units : pounds per hour (kilos per hour)**

(e.g. 11486 pounds would be shown as 11486)

**Target :** This parameter may be set if the operator wishes the Flow Controller to shut off at a certain accumulation. The Target will also register in whichever units that the Flow Controller has been calibrated for. The target must be active for this feature to work. When the target is active the second LSB of the Status Byte will be set to a '1':

**Units : pounds (kilos)**

(e.g. 124000 pounds would be entered as 124000)

**STATUS-> 00000010** <----- second bit from right set indicating that target is set.

When the target function has not been activated the bit will not be set :

**STATUS -> 00000000** <----- bit not set meaning that target function is not active.

**Total :** This parameter will indicate the total accumulation of product that has been discharged through the Flow Controller. The Total is registered in the units that the machine has been calibrated for. If a target has been set the total will stop when it reaches target accumulation. The Total can be set or reset at any point in time to any value.

**Units : pound (kilos)**

(e.g. 12591 pounds would be shown as 12591)

**Average :** The average gate opening of the Flow Controller while in running mode. Average is measured in square inches.

**Units : square inches X 100**

(e.g. 3.56 square inches would be shown as 356)

**Amplitude :** The total area swept by the gate, per gate cycle, while the Flow Controller is running.

**Units : square inches X 100**

(e.g. 0.65 square inches would be shown as 65)

**Cycle Length :** The amount of time required for the gate to move one cycle. The Flow Controller measures cycle length at a rate of 800 counts per second. Therefore a cycle length of 400 would mean that the gate is cycling twice per second.

**Units : counts**

(e.g. 126 counts would be shown as 126)


**Velocity :** The speed of product moving through the opening of the Flow Controller. Velocity is measured in feet per minute.

**Units : feet per minute**

(e.g. 187 feet per minute would be shown as 187)

## 6.2 The Status Byte

The status byte controls the status of various functions of the Flow Controller:

**STATUS ->**   
**Bit #** —> **7 6 5 4 3 2 1 0**

**Bit # 7** - Not used

**Bit # 6** - Indicates if the Flow Controller is displaying Average and Amplitude OR Encoder set-point and Encoder Average. If the bit is set to a "0" the Average and Amplitude are being communicated. If the bit is set to a "1" the Encoder set-point and Encoder Average are being communicated.

**Bit # 5** - Indicated if the Flow Controller is to display Average and Amplitude or DRP Spectral mass or DRP status. If the bit is set to "0" the Average and Amplitude are displayed. If the bit a set to "1" then the DRP Spectral mass and DRP status are displayed regardless of the setting of bit # 6.

**Bit # 4** - Indicates the Flow Controller is forced to operate in an open-loop mode when this bit is set to "1". Open-loop mode disables the velocity compensation and gate load compensation in controlling the gate position of the feeder. When this bit is set to "0" then the Flow Controller will operate in normal closed-loop mode.

**Bit # 3** - Not Used

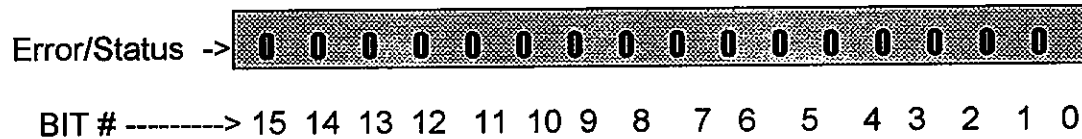
**Bit # 2** - Indicates whether or not the Target set has been achieved or not achieved. When this is bit set to "0" the target has not been reached. When the bit is set to "1" this indicates that the target accumulation has been attained.

**Bit # 1** - Indicates whether or not the Target function is active or not active. When the bit is set to "1" the target function is active. If the bit is set to "0" the target function is deactivated.

**Bit # 0** - Indicates whether or. not the Flow Controller is running or stopped mode. When the bit is set to "0" the Flow Controller is in a stopped mode. If the bit is set to "1" the Flow Controller is in a running mode.

### 6.3 The Error and Status Word

The Flow Controller will notify the user of any errors and status which may occur during the operation of the Flow Controller. The lower eight bits (bit 0 through bit 7) are used for notification of errors. The upper eight bits (bit 8 through bit 15) are used to indicate system status. They represent the status of the various functions of the Flow Controller. If the function is not active, the bit will be "0". If the function is enabled the relevant bit will be set to a "1".



**Bit # 15** - indicates that Remote Operator Panel has control over stop and start functions when bit is set. If a Remoter Operator Panel is in use this bit will set to the " 1 " position if an external input has been configured.

**Bit # 14** - Alternative Method Active. Indicates the status of DIP switch # 8 on the Flow Controller.

**Bit # 13** - Velocity Inhibit. Indicates the status of DIP switch # 7 on the Flow Controller.

**Bit # 12** - Gate Load Inhibit. Indicates the status of DIP switch # 6 on the Flow Controller.

**Bit # 11** - Running Status. Indicates that the Flow Controller is currently running.

**Bit # 10** - DRP Communication Error. Indicates that there is a communication fault between the main processor and the Doppler radar processor within the Flow Controller.

**Bit # 9** - Unlearned Flag. This bit is set when it has not learned the discharge velocity for its current opening.

**Bit # 8** - Velocity Inhibit Mode. Indicates that the measured velocity is not being used to calculate discharge velocity. In effect the measured velocity data is disabled from the control process.

- Bit # 7** - Check Sum Flag. Indicates that Flow Controller learning table has been corrupted when bit is set. This will require resetting the parameters and may require a re-sweep. This error will appear on power-up if the lithium back-up battery is dead on the Flow Controller.
- Bit # 6** - Bad Parameter Flag. Indicates that parameters are set incorrectly.
- Bit # 5** - Power Failure Status. When power to the Flow Controller has been removed and re-applied, this bit will be set.
- Bit # 4** - Not Used.
- Bit # 3** - Dead Gate Error. Indicates the gate cycle has timed-out. Loss of air pressure or a mechanical problem will post this error.
- Bit # 2** - Flow Controller Communication Error. This bit is set by the master device connected to the Flow Controller (the slave) when a communication problem or failure is detected.
- Bit # 1** - Velocity Error. Indicates that there is no discharge velocity occurring.
- Bit # 0** - Gate Position Error. Indicates that the gate position mechanism is malfunctioning when this bit is set. A loss of air pressure or a large object may be caught in the gate may be the cause. This is a serious error and will require immediate attention.

## 7.0 Calibration of the Flow Controller

The Flow Controller can only control the product discharge flow rate by varying the position of the gate. It cannot control the discharge velocity. Discharge velocity is a function of the product characteristics and the gate opening. A larger gate opening will yield a larger discharge velocity and therefore, a larger product flow rate. Conversely, a small opening will yield a smaller discharge velocity and therefore, a smaller product flow rate. The mathematical equation that governs this simple relationship expresses through-put flow rate as a function of cross-sectional area, discharge velocity and product bulk density. It may be shown as:

$$\text{Flow rate} = \text{Cross-sectional area} \times \text{Discharge velocity} \times \text{Bulk density}$$

where:

- Flow rate is expressed in **pounds per hour**.
- Cross-sectional area is expressed in **square feet**.
- Discharge velocity is expressed in **feet per hour**.
- Bulk density is expressed in **pounds per cubic foot**.

The cross-sectional area is derived from a digital position encoder, mechanically connected to the gate (the gate position encoder). The microcomputer computes the cross-sectional area from the gate angle, since it knows the width of the Flow Controller's body.

The dynamics of product flow measurement make it difficult to measure the true discharge velocity. The Doppler radar system will measure particle velocity with excellent accuracy. However, it is difficult to illuminate, with the microwaves, the exact point of discharge. Thus, the product must free-fall a specific distance before passing the radar beam. This implies, there is a specific amount of particle acceleration due to the force of gravity. The net effect of these factors is, that the discharge velocity measured by the Doppler radar system is different than, but, related to the real discharge velocity. To compensate for this, a method of association has been implemented. For every gate positional opening, there is a theoretical velocity and a measured velocity associated with it. The Theoretical velocity is computed from the calibration parameters and the measured velocity is supplied from the Doppler Radar Processor board. These associations are stored in protected memory as an array of tables, referred to as Learning Tables.

The calibration parameters describe the flow characteristics of the product by relating a specific sized opening to a specific product flow rate. Two points have been provided for this:

- 1) **Area 1**(gate opening area) and **Flow 1** (flow rate at that opening)
- 2) **Area 2** and **Flow 2** ( the second area/flow point)

A bulk density compensation parameter is provided so that the Flow Controller can compute approximate discharge density:

- 3) **Kct** (gate load compensation factor)

The two last parameters define the operational limits of the gate opening:

- 4) **Minimum Area** (the lower operational boundary)
- 5) **Maximum Area** (the upper operational boundary)

A command parameter, referred to as the **Mode Byte**, is included to control the calibration procedure. When a parameter is altered, it will have no effect on the Learning Table. A **Parameter Reset** command must be issued via the Mode byte, before the new parameter can have an affect. This command must be issued because the entire Learning Table must be re-computed. Thus, the **Parameter Reset** command forces the re-computation of the Learning Table using the current set of calibration parameters.

Another important function of the Mode byte is to activate and de-activate the **Sweep mode**. The Sweep mode is an automated learning process that is used to learn the measured discharge velocity and gate load for every gate opening position within the operational boundaries. In other words, this mode will automatically acquire the measured velocity and gate load reference for the flow range it is restricted to operate in. The Sweep mode is linked to the stop/start control of the Flow Controller. Therefore, it can be stopped or started at any time without having to activate or de-activate this mode. When the Flow Controller is running, and the Sweep mode is active, the machine will progress from the Minimum Area gate opening to the Maximum Area gate opening, learning the average measured velocity. The time required to perform a sweep is related to:

- 1) The size of the operating boundary as defined by the Minimum Area and Maximum Area parameter.
- 2) How much of the operating boundary the feeder has already learned.
- 3) The quality of the discharge product flow. Erratic flow will require a longer time to collect a good average velocity measurement.

In general:

1) The Sweep mode is an optional step for calibration. The Flow Controller will learn the discharge velocity and gate load while it is running normally. However, it will only learn the discharge velocities and gate load in the regions it is operating in. Which may lead to a fragmented learning table and strange operating characteristics.

2) If a Sweep has been performed and the calibration parameters require modification, the sweep data does not need to be reset. The exception to this is, when the Maximum Area is increased or the Minimum Area is decreased.

3) The Sweep should be reset only if the data is corrupted or discontinuous. A reset of the Sweep should also be performed if a new product is being used with the feeder, or the characteristics of the product has substantially altered.

4) The Sweep mode may be activated or de-activated at any time. While the Sweep mode is active the feeder may be stopped or started at any time.

The Learning Table can be accessed via the communication network using the Diagnostic And Setup Software.

The Learning Table data and calibration parameters will remain in memory for as long as power is maintained. When the power is off the lithium battery will maintain the memory provided the battery is good and it is enabled.

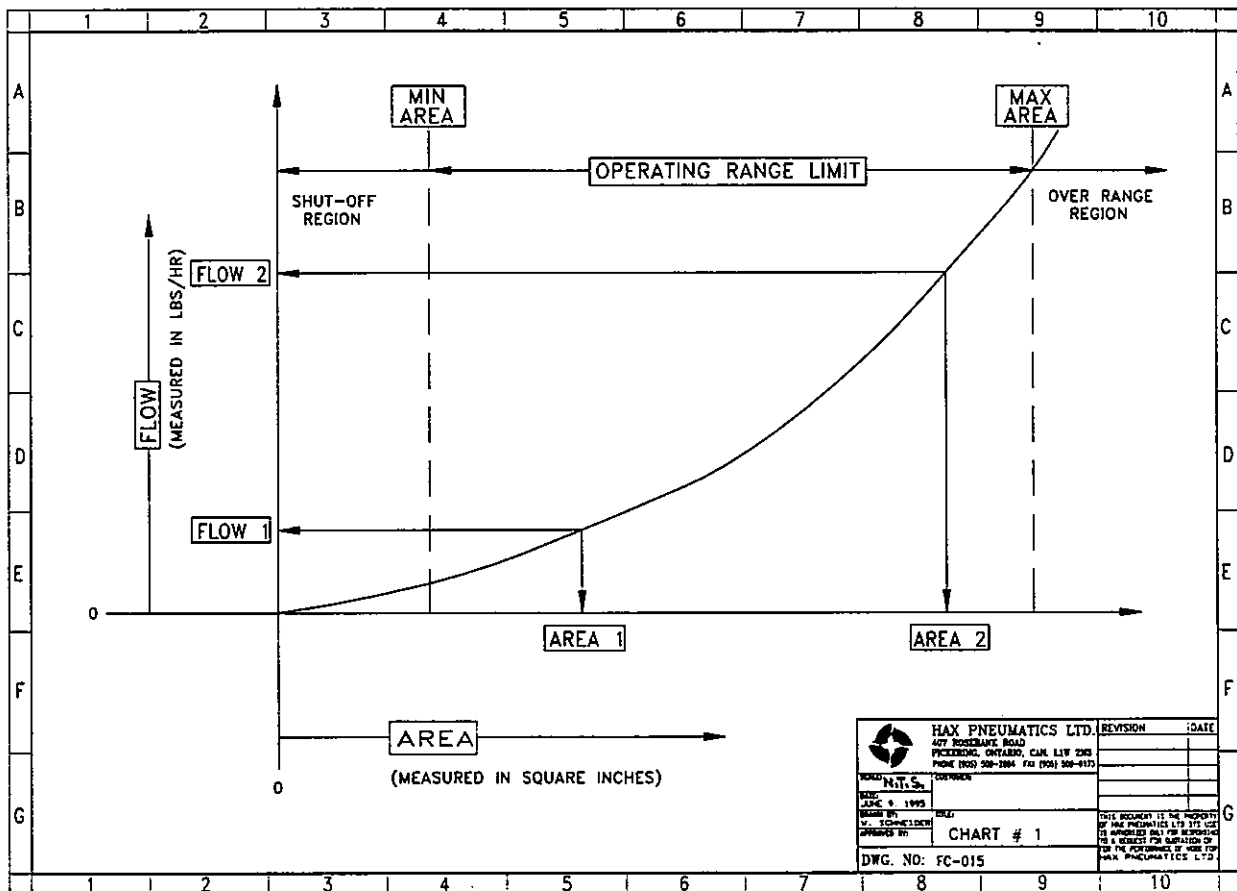
## **8.0 Calibration procedure**

There are two basic methods for determining and setting a calibration values. The first method requires some form of reliable scaling device immediately before or after the Flow Controller that will enable a comparison between the two. This process is by far the easiest since the Flow Controller will allow the calibration to be change while it is running. The first step is to start the flow controller at some conservative flow rate Set-Point and allow it to stabilize. Monitor the reading on the scaling device and compare it to the flow-rate reading on the Flow Controller. If the flow-rate is higher on the scaling device as compared to the Flow Controller then the AREA value must be decreased, thus forcing the Flow Controller to decrease its opening area to attain the same Set-Point. If the flow rate is lower on the scaling device then the AREA value must be increased, thus forcing the flow controller to increase its opening area. This process should be checked and repeated for several different Set-Points throughout the operating range of the process.



The second method can be used when there is no scaling device in the process near the Flow Controller. This method requires that a known quantity of product be run through the Flow Controller at a set opening area and using a stop-watch to determine the time required for the known quantity of product to pass through. A variation of this technique is to allow the product to run through the Flow Controller at a set opening for a specific amount of time and then weigh the product after. This requires that the product flow must be diverted after the Flow Controller to a container that can be weighed by some means. In other words, data must be ascertained that relates a time to a quantity to yield a flow rate.

How successful this method is very much depends on the product sample size, the Area Set-Point used, and also the number of iterations performed. The best results can be obtained with large sample sizes repeated several times at several different gate opening Set-Points.



In general:

1) Start the calibration with the largest usable flow rate by setting it as the **Flow 2** parameter, also enter it as the **Setflow** and estimate the **Area 2** parameter that might yield this flow rate. Set **Flow 1** to zero and **Area 1** to the smallest opening that product begins to flow at (must be greater than zero!). Run the Flow Controller and adjust the **Area 2** parameter.

2) The next step involves the calibration of the **Area 1** and **Flow 1** parameter. Adjust the **Setflow** to the smallest usable flow rate and enter this value as the **Flow 1** parameter. Estimate the **Area 1** parameter and run the Flow Controller and adjust the **Area 1** parameter.

3) Finally, the **Minimum Area** and **Maximum Area** parameters would be adjusted to reflect the result of the previous steps.

## 8.1 The Calibration Parameters

**Minimum Area** : The lower gate opening boundary of the Flow Controllers' operating range. The feeder will not run at any point below the minimum area setting. This parameter should be set such that the gate opening gap will never be less than the diameter of the largest average particle size. As an example, if the largest particle size in the product is 0.25 inches in diameter, then the minimum gate gap should be greater than or equal to 0.25 inches. To compute the Minimum Area, the minimum gate gap must be multiplied by the width of the Flow Controller body. For the example, a 4 X 6 Flow Controller is used, therefore, the Minimum Area would then be greater than or equal to 0.25 inches time 4.00 inches, or 1.00 square inches. Since the Minimum Area parameter units are, square inches time 100, then 100 would be entered in the example.

**Units : square inches X 100**

( e.g. 2.5 square inches would be entered as 250 )

**Maximum Area** : The upper gate opening boundary of the Flow Controllers' operating range. The gate opening will not increase beyond Maximum Area parameter regardless of how large the Flow rate may be set to. This parameter should be set such that the Flow Controller's gate opening cannot exceed the capacity of the machinery it is feeding.

**Units : square inches X 100**

( e.g. 14.5 square inches would be entered as 1450 )

**Kct** : This is a parameter that relates the gate cycle time, operating air pressure and the size of the Flow Controller to the discharging bulk density. The Flow Controller uses this parameter to compute the theoretical discharge density of product. Adjusting this parameter will vary the influence of measured gate load in the computation of the actual flow rate. Therefore, this parameter is used as a tuning variable. This parameter is automatically computed by the Flow Controller upon a successful completion of a sweep function, however, the value must be checked by the user to verify that it fits into the prescribed range define below. If the value is out of range then the user can adjust it and reset the parameters.

**Units : counts**

( normal range is from 10 to 400 )

**Area 1 and Flow 1** : Although these two parameters are separate from one another, they combine to form a point used by the Flow Controller to determine the specific product area / flow curve. Logically, the larger an area is the larger the flow through the opening will be. The Area 1 / Flow 1 point should be set to the minimum usable product flow rate. As an example if 3500 pounds per hour is the minimum flow rate to be used, then, Flow 1 should be set to 3500 and Area 1 must be adjusted until the feeder delivers 3500 pounds per hour with a set-point of 3500 pound per hour. The Area 1 / Flow 1 point must be lower than the Area 2 / Flow 2 point and Area 1 must never be set to zero.

**Units for Area : square inches X 100**

( e.g. 3.2 square inches would be entered as 320 )

**Units for Flow : pound per hour (kilos per hour)**

( e.g. 3500 pound per hour would be entered as 3500 )

**Area 2 and Flow 2** : Like Area 1 and Flow 1, Area 2 and Flow 2 are used to determine a second point on the product area / flow curve. The Area 2 / Flow 2 point should be set to the maximum usable product flow rate. As an example if 18500 pounds per hour is the maximum flow rate to be used, then, Flow 2 should be set to 18500 and Area 2 must be adjusted until the feeder delivers 18500 pounds per hour with a set-point of 18500 pound per hour. The Area 2 / Flow 2 point must be greater than the Area 1 / Flow 1 point and Area 2 must be greater than Area 1 by at least 2.00 square inches.

**Units for Area : square inches X 100**

( e.g. 14.2 square inches would be entered as 1420 )

**Units for Flow : pound per hour (kilos per hour)**

( e.g. 18500 pound per hour would be entered as 18500 )

## 8.2 The Mode Byte

The mode byte is used to control the calibration functions of the Flow Controller. The mode byte is one of the communicated parameters. It may be accessed with the Diagnostic And Set-up Software or controlled with a HPPMC controller or an HPCOM controller.

The following is a bit description of the Mode byte:

**MODE ->**

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

**Bit #---->**    **7 6 5 4 3 2 1 0**

**Bit # 7** - Not used

**Bit # 6** - Is used to reset gate position histogram. When this bit is set to a "1", the histogram will reset. The Flow Controller will set the bit to "0" once the histogram reset process has been completed.

**Bit # 5** - Is used to reset all the learned velocity measurements. This is also referred to as, resetting the sweep. When this bit is set to a "1", the sweep is resetting. The Flow Controller will set the bit to "0" once the sweep has been reset.

**Bit # 4** - Is used to update the calibration parameters and reset the learning tables. This bit is set to a "1" to update. Once the parameters have been reset the bit will set back to "0" by the Flow Controller.

**Bit # 3** - Not used

**Bit # 2** - Not used

**Bit # 1** - Not used

**Bit # 0** - Is used to activate the learning sweep. When the bit is set to "1", the sweep is activated. The sweep function searches the learning tables in ascending order, from the Minimum Area to the Maximum Area, for unlearned discharge velocities. The Flow Controller then learns the discharge velocity for each unlearned gate opening. When it has completed the learning the feeder will set this bit to "0" and stop.

## 9.0 Trouble-shooting Procedure

The following is a list of symptoms and the possible solutions for the HPFC series Flow Controller:

### 1) Product is leaking past the gate when Flow Controller is not running.

- Check that there is sufficient air pressure at the feeder to close the gate, but do not exceed 80 PSI for powders and 50 PSI for granulars.

- High bin or silo pressure or excessive suction at the outlet of the feeder. Aspirate bin properly for pressure conditions or bleed air in at the feeder outlet for suction.

- Check for a bent gate or if applicable a worn gate seal and replace as required.

- Cylinder clevis and link may need to be adjusted out, or maybe loose.

### 2) Feeder appears to have no power.

- Check incoming voltage.

- Check for a blown fuse, replace with BUSS type GMA 250mA or equivalent.

- Check for the existence of 24VDC between the SOLENOID (+) terminal and ground (any one of the screws fastening the PCB will work as a ground). The transformer may be bad.

### 3) Flow Controller does not blink the diagnostic code when reset.

- Check that all connectors are secure and oriented properly.

- Check that all PCBs are securely fastened or inserted correctly.

### 4) Flow controller does not communicate with the interface device and the COMM LED is not blinking.

- Ensure that the Flow controller blinks a code on the ERRor LED when the reset button is pressed on the main PCB.

- Check all communication wiring and terminations.

- Check for correct polarity on the communications.

- Check that the DIP switches are set correctly at the Flow Controller and the interface device. Both must have the same station number in order to communicate.

- Check that the interface device is functioning properly. The interface device is the master, therefore, the Flow Controller cannot answer if it has not receive a data packet from the interface device.

- Check for any ground loops or excessive DC bias on the communication terminals using a good voltmeter. A DC bias higher than +7VDC with respect to (w.r.t.) ground or -5VDC w.r.t. ground will damage the RS485 driver circuits.

**5) Flow Controller starts, but, the gate does not move.**

- Check for compressed air at the feeder.  
- Check that the SOLenoid LED is ON and that the solenoid is energized. If it is not ON then observe the Average Opening value on the interface device. If this value is greater than 200 (2.00 square inches) and the gate is closed, there may be a problem with the encoder and/or the coupling mechanism. This must be tested and resolved before continuing. Refer to problem #7 on this list.

**6) Flow Controller starts, but, the gate goes to a full open position and does not modulate.**

- This is most likely a problem with the gate encoder and/or coupling mechanism. This must be tested and resolved before continuing. Refer to problem #7 on this list.

**7) Gate position is erratic.**

- This is most likely a problem with the gate encoder and/or coupling mechanism. This must be tested and resolved before continuing.  
- To test the encoder, locate and loosen the gate position encoder coupling on the side nearest the Flow Controller body (not the electrical enclosure side). Rotate the coupling (secured to the encoder? ..check!) by hand, it should rotate freely. If it does not rotate freely there is a problem with the encoder bushing and the encoder should be replaced!

The excessive drag of the encoder will cause the coupling to slip and become loose. It is for this reason the gate has an erratic behavior. Excessive drag is caused by high shaft side load. The high side loads are a direct result of the misalignment between the electrical enclosure and the Flow Controller body. Ensure that the Electrical enclosure is properly aligned with the body and that the mounting bolt is secure!

**8) Parameters may randomly change.**

- Check the location and source of the incoming power and communication. Excessive electrical noise or a high static environment is the cause of this symptom. Proper grounding and clean power are essential!

**9) LED # 4 on the Doppler Radar Processor is OFF for 0.5 seconds on every DRP communication update.**

- Reset the Flow controller with the reset button. If this fails to resolve the problem then perform a memory reset by removing power, then disconnect the lithium battery and reconnect the battery, and finally return power. (refer to the DIP switch section for the HPFC5 rev. 1.0 PCB. The HPFC02 rev. 1.1 PCB, the battery can not be disconnected, thus the procedure is more difficult, instead the RAM chip on the CPU board, under the DRP board, must be removed and re-installed!)

If there is an uncertainty about these problems and procedures, or there is still a problem with the Flow Controller, please contact **Hax Pneumatics Limited Technical Support:**

**Phone #      (905) 509 - 2884**  
**Fax #         (905) 509 - 9173**

## **10.0 Advanced Control Features**

The following section outlines the advanced functions of the HPFC series Flow Controllers that may not be available on all interface devices.

This section will also outline the RS485 network communication protocol. This is intended for programmers who wish to create Flow Controller drivers for computers, hardware and software not currently supported by Hax Pneumatics Limited. This protocol may **only** be used for the purpose of interfacing with a HPFC series Flow Controller. Any persons or corporations intending to market software incorporating this protocol must contact Hax Pneumatics Limited to obtain a Licensing Agreement.

## 10.1 The HPFC02 Flow Controller Communication Protocol

All function and controls of the HPFC02 Flow Controller are accessed via a communications port on the controller circuit board, except for the functions set by the DIP switches, i.e. station address (refer to DIP switch configuration chart). Any computer device can be made to interface with a HPFC02 Flow Controller if the correct physical interface requirements are met and the correct protocol is used.

The protocol for the HPFC02 Flow Controller, and its family of devices, involves an exchange of data packets. A master device will issue a data packet and a slave device will respond with a data packet (master/slave protocol). A slave device will **only** send a packet when it has received a packet from a master. The HPFC02 Flow Controller is always a slave device, but, the HPPMC Panel Mounted Controller has both a slave and master communication ports. The physical link description for the HPFC02 Flow Controller communication protocol is:

Type :	2 wire, half duplex , asynchronous, RS485
Code :	Binary
Baud rate:	9600 BPS
Length:	8 bits
Parity:	Even
Stop bits:	1

Typical physical configurations:

COMPUTER <-----> FC

PMC <----->FC

PMC <-----> PMC <-----> FC

COMPUTER <-----> PMC <-----> FC

COMPUTER <-----> CPM <----->FC

COMPUTER <-----> CPM <-----> PMC <-----> FC



where:

**COMPUTER:** A computer, PLC, or other device with an RS485 port

**FC:** Flow Controller (the target slave)

**PMC:** Panel Mounted Controller ( 1 slave channel and 1 master channel that supports 1 slave)

**CPM:** Communications Processor Module (1 slave channel and 4 separate master channels that can support a max. of 16 slaves.)

**<---->** : HPFC02 Flow Controller communication protocol

Master packet:

**STL STH STM STS { DDB data DDB data ... } NUL BCC**

Slave packet:

**STH STL STM STS { DDB data DDB data ...} NUL BCC**

where:

**NUL** is the representation for a **00** byte.

Hexadecimal **55** is abbreviated as **STL**.

Hexadecimal **AA** is abbreviated as **STH**.

These two bytes are combined together to form as part of the packet's header.

The slave station address is abbreviated as **STS**.

The master station address is abbreviated as **STM**.

Valid station address are limited from 1 to 63.

The block check sum is abbreviated as **BCC**.

The block check character (**BCC**) is a means of checking the accuracy of each packet transmission. It is the 2's complement of the 8-bit sum (modulo-256 arithmetic sum) of the **STM**, **STS**, all **DDBs** and all data.