The MFT B-Series Flow Controller.

There are many options available to control a process flow ranging from electronic, mechanical to pneumatic. In the industrial market there are PLCs, PCs, valves and flow meters, all of which are capable of implementing a flow control system. The features on these controllers range from very basic to advanced, with learning curves to match.

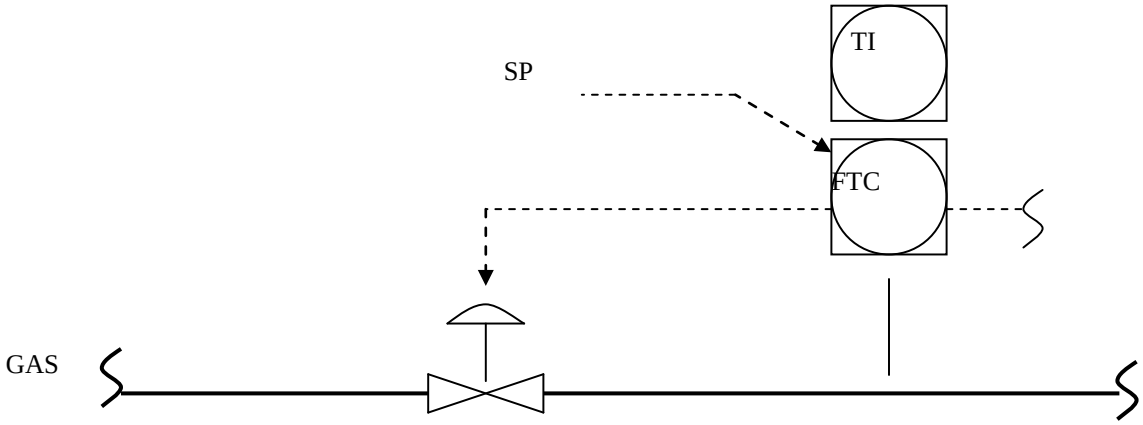
The MFT B-Series has a very basic built-in flow controller which is manually configured. If a simple local flow control PID loop fits into your application, then this may be all you need. This section describes the setup of the flow control functions, nomenclature and also includes a short tutorial on feedback control systems.

Summary of capabilities

Control Output	• 4-20 mA positional signal • Fixed output position control for testing in program mode (% of AO range).
Set Point Register	• Fix flow, menu programmed. • Modbus write register
Analog Input Set point	• 4-20 mA input, engineering units scaled.
Reference Meter	• Meter 1, Flow Rate
PID	• Manual gain setting. • Normalized coefficients **P**: gain **I**: time constant **D**: time constant

Flow Controller Setup

To use the MFT B-Series as an automatic flow controller, you connect one of its 4-20 mA outputs to your control valve, damper or motor controller and it will regulate the flow based on a fixed flow set point value or an analog Input for the set point. The 4-20 mA output can be used as a position command signal for a control valve or motor drive RPM.



The example above has the MFT B-Series flow meter actuating a valve based on an external set point of the flow rate. The second 4-20 mA output channel is sending the flow rate signal elsewhere, although it could be temperature instead of flow rate. PID control of the process is manually configured. The control output may be controlled manually from the LCD display to verify the range operation of the control loop or to manually set the output (control valve) at a fixed position.

PID Setup Steps

1. Mechanically mount all components, test for leaks and check flow control actuator motion or motor controller action.
2. Electrically connect all components. Decide which 4-20 mA output will be the control output and wire this in. The default output of the MFT units is for loop powered 4-20 mA. If you need it to be self powered, see the wiring diagrams.
3. Configure the output 4-20 mA scale for the control device using engineering units of velocity or flow rate. You tell the controller in process flow units what the flow rate is at 4 mA output position and 20 mA output position.
4. Configure the set-point source:
   - External analog input. Configure the 4-20 mA scale with the proper engineering units.
   - Internal Set point: a set point (Flow Rate or Velocity) value is entered to maintain the PID control variable (Flow Rate or Velocity) at a fixed value. This set point can be changed at the meter keypad or via a Modbus command.

5. Tune the control loop for stable operation over the flow range of interest.

The setup of the above parameters are done from *Program Mode* of the Flow meter which are covered next.

Setup PID Data Menu

Enter *Program Mode, by pressing* ***P,*** the ***access code*** (654321), and ***E.*** Press ***2*** *to invoke the Quick Jump* option entry method and select **Option #21***,* for the Setup PID Data menu.

If the screen displays

```
PID FUNCTION IS
NOT INSTALLED!!
```

the meter was not purchased with this option. Section I defines each version of the hardware to check if this feature is available for your meter.

The meter will prompt to set the PID function ON or OFF. Use the **^** or **v** key to change the selection to 'ON' then press **E** to accept the selection.

```
PID STATE
>ON              ^v
```

The next screen will prompt for the PID mode of operation. The selection can be AUTOMATIC or MANUAL. AUTOMATIC is used for constant flow control which adjusts based on an external or internal set point. MANUAL is used for manual flow control using the PID Manual Control Menu to set the PID Control to a fixed position.

```
PID OPERATION
>MANUAL          ^v
```

Use the **^** or **v** key to select the mode of operation and press **E** to accept the selection or **P** to skip to the next display.

The next screen prompts for the control variable. The selection can be FLOW RATE or VELOCITY. Select FLOW RATE for volumetric and mass flow or VELOCITY for flow velocity.

```
PID CONTROL TO
>FLOW RATE       ^v
```

Use the **^** or **v** key to select the variable to be controlled. Press **E** to accept the selection or **P** to skip to the next display.

The next screen prompts for the PID set point reference. The selection can be INTERNAL or EXTERNAL. INTERNAL is selected if the PID variable is controlled with respect to an internal (*internally* stored in the meter's nonvolatile memory) set point value specified by the user. EXTERNAL is selected if the PID variable is controlled with respect to a measured analog input.

```
PID SETPT REF
>INTERNAL      ^v
```

Use the **^** or **v** key to select the PID set point reference. If EXTERNAL is selected, the External Analog Input channel must be assigned to the PID EXT. REF option (Program Mode Option #20). If INTERNAL is selected, the meter will prompt for the set point value. The set point will be in the same units as the CONTROL TO variable selected previously. Use the numeric and decimal keys to enter the PID set point and press **E** to accept the entry or **P** to skip to the next display.

```
PID SETPOINT
>1234.5600   SCFM
```

The set point value can also be specified using Modbus command 0x06, register 44.

The next screens prompt for the PID tuning parameters – Proportional Gain, Integral Time Constant, and Derivative Time Constant. The Integral Gain is the Proportional Gain divided by the Integral Time Constant. This linking of the Integral Time Constant with the Proportional Gain makes it easier to manually tune the system. The Derivative Gain is the Proportional Gain multiplied by the Derivative Time Constant. This linking of the Derivative Time Constant with the Proportional Gain makes it easier to manually tune the system.

```
PP GAIN (KP)
>0.300
```

```
INTEGRAL TC
>1.000        SEC
```

```
DERIVATIVE TC
>0.300        SEC
```

Use the numeric and decimal keys to enter the PID tuning parameters and press **E** to accept the entry or **P** to skip to the next display.

The meter next prompts for the PID low (output) limit. This limit is the lowest flow rate or velocity (depends on the CONTROL TO variable selected) that the meter will control to (see the section on 4-20 mA output range for control output in flow units). Its output will saturate 10% below the entered value. The limit will also prevent the integral term "wind up" or accumulation. Use the numeric and decimal keys to enter a PID Low Limit and press **E** to accept the entry or **P** to skip to the next display.

```
PID LOW LIMIT
>0.000        SCFM
```

The meter next prompts for the PID high (output) limit. This limit is the highest flow rate or velocity (depends on the CONTROL TO variable selected) that the meter will control to (see the section on 4-20 mA output range for control output in flow units). Its output will saturate 10% above the entered value. The limit will also prevent the integral term "wind up" or accumulation. Use the numeric and decimal keys to enter a PID High Limit and press **E** to accept the entry.

```
PID HIGH LIMIT
>5000.00      SCFM
```

Pressing **E** or **P** will exit out of the Setup PID Data Menu and return to the Program Mode Option Entry screen.

Setup for the PID 4-20 mA Control Output

The PID control output is a 4-20 mA positional signal. It uses either one of the 4-20 mA analog outputs. An analog output (AO1 or AO2) must be configured to the PID output. The analog output setup is performed in Program Mode as described below.

Enter *Program Mode* by pressing **P,** the **access code** (654321), and **E.** Press **2** to invoke the *Quick Jump* option entry method and select **Option #5** or **#6**, for the Setup AO1 or Setup AO2 menu, respectively.

The following key/display sequences demonstrate setting up Analog Output #2 as the PID output (if the PID output is needed on Analog Output #1, select Option #5 at the Program Mode Option Entry screen)

The meter will prompt for a function to assign to the analog output. Use the **^** or **v** key to scroll through the selection list until 'PID' is displayed. Press **E** to accept 'PID'.

```
ANALOG OUT 2
>PID              ^v
```

The meter will next prompt for the analog output signal at 4mA. This is the value of the controlled variable (Flow Rate or Velocity) when the valve or damper is fully closed or the fan is OFF; this value is usually zero.

```
AO1 at 4mA
>0.00000000  SCFM
```

Use the numeric and decimal keys to enter a value and press **E** to accept the entry or **P** to skip to the next display.

The meter will next prompt for the analog output signal at 20mA. This is the value of the controlled variable (Flow Rate or Velocity) when the valve or damper is 100% open or the fan is at full speed (controlled device).

```
AO1 at 20mA
>12345.678   SCFM
```

Use the numeric and decimal keys to enter a value and press **E** to accept the entry.

Pressing **E** or **P** will exit out of the Setup AO Menu and return to the Program Mode Option Entry screen.

Setup for the External Input for PID Remote Reference

The PID is controlled from a set point reference. The PID set point reference can be defined as either INTERNAL or EXTERNAL. When the set point reference is INTERNAL, the set point value is specified by the user and stored in the MFT-B. This value can be changed at the meter keypad or can be specified via Modbus. Alternatively, the reference set point can be read from an ANALOG INPUT (4-20mA) signal. When the PID is controlled from an ANALOG INPUT signal, the PID set point reference is configured as EXTERNAL.

The Analog Input for the EXTERNAL PID set point is setup in Program Mode as described below.

Enter *Program Mode* by pressing **P,** the **access code** (654321), and **E.** Press **2** to invoke the *Quick Jump* option entry method and select **Option #20**, for the Setup External Input menu.

If the screen displays

```
EXTERNAL INPUT
IS NOT INSTALLED
```

the meter was not purchased with this option. Section I defines each version of the hardware to check if this feature is available for your meter.

If the meter is factory configured with the external analog input feature, the meter will prompt to assign a function to the External (Analog) Input.

```
EXT. INPUT USAGE
>PID EXT. REF  ^v
```

Use the **^** or **v** key to scroll to 'PID EXT. REF' and press **E** to accept the selection or **P** to skip to the next display.

The next menu items setup the 4-20mA range of the external analog input. The meter first prompts for the External Input value at 4.00 mA. This is the minimum value of the PID set point that can be used. The value is in the same units as the controlled variable configured when the PID was set up (Flow Rate or Velocity). The example below shows a flow meter with the PID controlled variable as the Flow Rate.

```
INP VAL AT 4mA
>0.000000    SCFM
```

Use the numeric and decimal key to enter the minimum PID set point and press **E** to accept the new entry or **P** to skip to the next display.

The meter will next prompt for the External Input value at 20.00 mA. This is the maximum value of the PID set point that can be used. The value is in the same units as the controlled variable configured when the PID was set up (Flow Rate or Velocity).

```
INP VAL AT 20mA
>0.000000    SCFM
```

Use the numeric and decimal key to enter the maximum PID set point and press **E** to accept the new entry or **P** to skip to the next display.

The meter will next prompt for the External Input digital filter time constant, the default is 0.5 seconds.

```
FILTER TC
>0.500        SEC
```

Use the numeric and decimal key to enter the FILTER TIME CONSTANT and press E to accept the new entry. Pressing **E** or **P** will exit out of the Setup External Input Menu and return to the Program Mode Option Entry screen.

PID CONTROLLER OPERATION

The PID controller can be setup to operate in Automatic or Manual mode. The PID operation is configured in Program Mode using the Setup PID Data menu **(Option #21)**.

PID Control in Automatic Mode

PID control action will start as soon as the Automatic mode is set in the PID setup menu (in Program mode). The flow rate or velocity is maintained to the PID set point value. The PID control is in the Automatic mode if the PID operation selected is AUTOMATIC. Refer to the section 'Setup PID Data Menu'.

PID Control in Manual Mode

The PID control is in the Manual mode if the PID operation selected is MANUAL and the PID State is ON. Refer to the section 'Setup PID Data Menu'. The manual control is performed by manually adjusting the PID output or 4-20 mA position signals in Program Mode as described below.

Enter *Program Mode* by pressing **P,** the **access code** (654321), and **E.** Press **2** to invoke the *Quick Jump* option entry method and select **Option #22**, for the Manual PID Control menu.

If the screen displays

```
PID FUNCTION IS
NOT INSTALLED!!
```

the meter was not purchased with this option. Section I defines each version of the hardware to check if this feature is available for your meter.

If the screen displays

```
PID STATE IS OFF
NOT ACTIVE
```

the PID state needs to be turned ON in the Setup PID Data menu (**Option #21**).

If the screen displays

```
PID IS AUTOMATIC
SET MANUAL MODE
```

the PID operation needs to be set to MANUAL in the Setup PID Data menu.

If the meter is factory configured with the PID function, the PID state is ON, and the PID Operation is set to MANUAL, the meter will display the following prompt for the PID manual control.

```
OUT=  0 PERCENT
^=OPEN    v=CLOSE
```

Use the **^** key to increase the output and the **v** key to decrease the output. When 100 percent is displayed, the maximum PID limit equivalent to the maximum output current is reached. When 0 percent is displayed, the minimum PID limit equivalent to the minimum output current is reached.

Displaying the PID Remote Reference Reading

The External Input reading can be viewed in Display Mode. Enter Display Mode by pressing **D** and **2** to invoke the *Quick Jump* option entry method and select **Option #41** for the External Input display. The screen will display the following

```
IN= XX.XXX      mA
AT YYYY.YY    SCFM
```

The XX.XXX value is the 4-20mA signal (current) read from the Analog Input and the YYYY.YY value is the equivalent PID reference (Flow Rate or Velocity) at the XX.XXX current level. The mapping of input current to Flow Rate or Velocity is configured in the Set External Input Data menu.

Press **H** to exit from the External Input display and return to the Option Entry screen of Display Mode. Press **H** again to return to *Run Mode*.

PID Tuning.

Manual tuning of a PID loop can be done by following the steps listed below.

1. Place the unit in manual control mode or open loop control. Increase or decrease the 4-20 mA output by 5 to 10%. Note the flow response change.

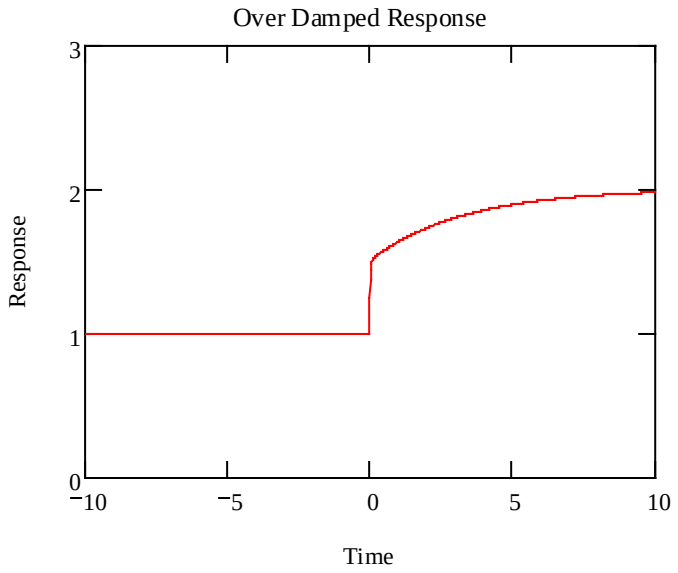
   Then the Proportion Gain starting point is: 2 x Output change (engineering units)/(Flow Response change) *(this is a unit less number)*

   Note the system response time (0 to 63% change) to the change. Set the Integral response time to this number.

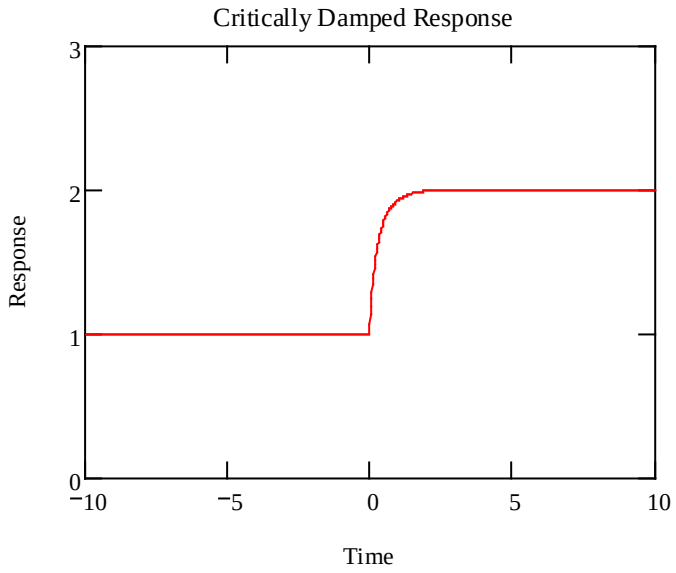
   Set the derivative time constant to 1/6 of the integral time.

2. Now place the system in closed loop or automatic operation. Do a small change of the set point and observe how it reacts.

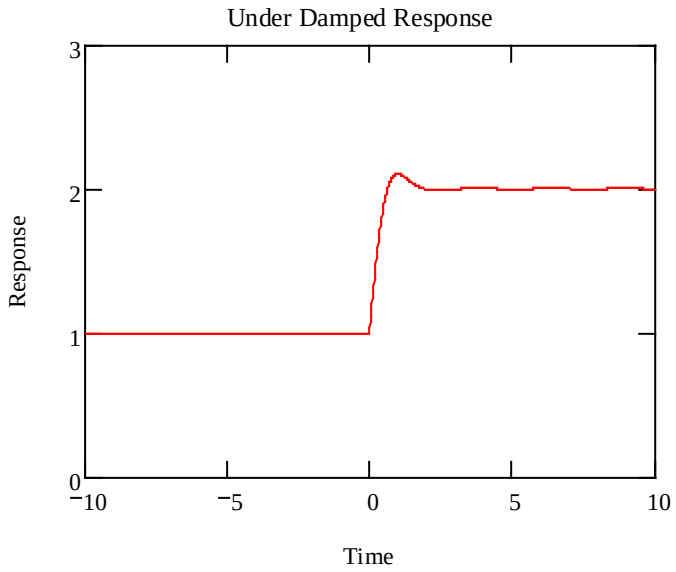
Example system responses



Increase the proportional Gain and reduce the integral time constant.



System tuned just right. Note the parameters and you are done.



Reduce the proportional gain and increase the integral time constant by the same percentage, say 25%.

3. Some systems require different parameters at different operating points. The best way to handle this is to optimally tune it at the normal flow rate and live with the non-ideal response at the other flow rates. If the variation in loop stability is too large over the normal operating flow ranges, then an advanced PID controller with variable gain settings will be required instead of the built-in flow controller.