PULSAFEEDER®
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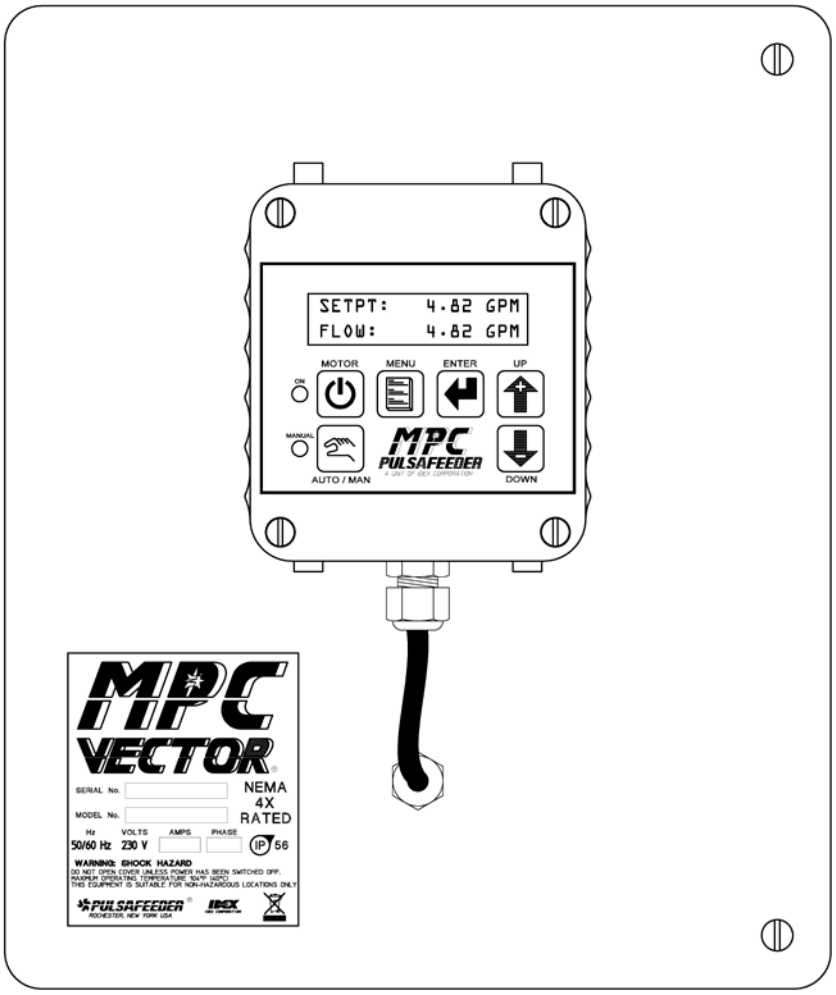
Installation, Operation & Maintenance Manual



Universal Control for Pulsa and Eclipse. Suitable for any Gear, Reciprocating or Positive Displacement Pumps.

BULLETIN No. IOM-MPCVector UMPC-11/201010 Rv. A

MPC VECTOR

Microprocessor Based Positive Displacement Pump Speed Controller

MPC VECTOR™ FACTORY SERVICE POLICY

Your MPC VECTOR is a state of the art microprocessor based motor speed controller for use with positive displacement type pumps. The controller includes extensive on-board diagnostics. If you are experiencing a problem with your MPC VECTOR, first review the on-screen information, then consult the troubleshooting guide. If the problem is not covered or cannot be solved, please contact your local authorized Sales Representative or our Technical Service Department at (585) 292-8000 for further assistance.

Trained individuals are available to diagnose your problem and arrange a solution. Solutions may include purchasing a replacement unit or returning the unit to the factory for inspection and repair. All returns require a Return Material Authorization (R.M.A.) number to be issued by Pulsafeeder. Replacements purchased under a possible warranty situation may be credited after an examination of the original parts by Pulsafeeder personnel.

Certain components may be purchased for replacement. Refer to **20 Spare Parts** for more information and part numbers. Parts purchased to correct a warranty issue may be credited after examination of the original parts by Pulsafeeder personnel. Parts returned for warranty consideration that test satisfactorily, will be sent back to the originator via freight collect.

Any field modifications will void the Pulsafeeder warranty. Out-of-warranty repairs will be subject to Pulsafeeder's standard bench fees and testing costs associated with replacement components.

FCC Warning

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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Conventions

For the remainder of this bulletin, the following Conventions are in effect.

A WARNING DEFINES A CONDITION THAT COULD CAUSE DAMAGE TO BOTH THE EQUIPMENT AND THE PERSONNEL OPERATING IT. PAY CLOSE ATTENTION TO ANY WARNING.

Notes are general information meant to make operating the equipment easier.

Safety Considerations:

1. Read and understand all related instructions and documentation before attempting to install or maintain this equipment
2. Observe all special instructions, notes, and cautions.
3. Act with care and exercise good common sense and judgment during all installation, adjustment, and maintenance procedures.
4. Ensure that all safety and work procedures and standards that are applicable to your company and facility are followed during the installation, maintenance, and operation of this equipment.

1. MPC Vector Operation

The MPC VECTOR is a microprocessor based motor speed control device, for use with positive displacement pumps. It has been designed for simplicity, yet still has many advanced features that allow the MPC VECTOR to operate in a wide variety of positive displacement pump environments and applications.

NOTE **Pumps utilizing stroke length control must keep the stroke length constant**. For maximum flow rate adjustment 100% stroke length is recommended.

This product is not just a variable speed drive. It is a state of the art multifunctional controller, which provides functionally that no one stand-alone variable speed drive does. What makes this product unique is that it combines functionality of several devices in one:

- Vector type variable speed drive.
- Input output processor (4-20 mA in and out, digital input/output), including PID loop for closed loop flow control.
- A user configurable pump calibration engine allowing process flow units as the main controllable parameter.
- A remotely located hand-held local pump control user interface.
- Power monitor for detection of run-dry conditions

This instruction manual covers the MPC VECTOR controller only. For information and safety precautions specific to the pump or any other accessories, please refer to the appropriate IOM.

1.1 MPC VECTOR Standard Features

- Local (Manual) and Remote operational modes
- User keypad and display for ease of operation (Remote location up to 1000 feet from pump)
- Display pump operation in GPH, LPH, GPM, LPM, or RPM
- One 4-20 mA analog input signal for flow or speed control
- One 4-20 mA analog input for flow feedback control (with an external, user supplied flow meter)
- Sensorless vector motor speed control
- Two configurable digital dry contact inputs
- Three configurable open collector/drain digital outputs (transistor type, 40 VDC maximum)
- Analog 4-20 mA output for flow or speed
- Available in NEMA 4X (IP56) ratings or an OPEN CHASSIS panel mount
- 208-230 Volts, 50/60 Hz, single or three phase AC input power for 1-3 HP motors
- 208-230 Volts, 50/60 Hz, three phase (only) AC input power for 5 HP motors
- 380,415,440,460,480 Volts, 50/60Hz, 3 phase for 1-5HP motors
- Security code lockout of configuration menus
- Standard configurable pump protection utilizing proprietary PulsaGuard technology

1.2 Description

The MPC VECTOR is designed for a wide variety of control applications. If delivered with a pump and motor, the device is factory configured. Field configuration may be required in certain installations. Local setup and control is achieved through the keypad and a backlit two-line liquid crystal display. Basic operation is simple with dedicated

function keys eliminating the need for a sophisticated menu system. Pump output is displayed as Gallons or Liters per Hour (GPH/LPH), Gallons or Liters per Minute (GPM/LPM), or Revolutions per Minute (RPM).

Digital and analog inputs will support a variety of industry standard signals to offer flexible remote control. Digital and analog outputs provide for system monitoring.

The MPC VECTOR is designed to simplify and automate the calibration of pump flow and analog signals. Flow calibration uses on-screen prompting and automated pump operation to ease flow setup. Once calibration is provided, all subsequent flow monitoring may be done using flow units. Analog signal calibration is also accomplished by simple keypad entry. It includes a real-time display of signal level. This eliminates the need for external meters.

The MPC VECTOR is an advanced pump flow rate controller whose purpose is to precisely adjust output flow of a process media by means of pump motor speed control. The MPC Vector can be controlled and monitored via remote SCADA control or a local hand-held user interface. The controller can operate in two system level modes, two operational modes, and two control modes. See below for detail on mode descriptions.

1.2.1 System Input/Output Power Ratings

The MPC VECTOR will accept, and automatically adjust to, either 50 Hz or 60 Hz input power. No special modifications, settings, or adjustments are required.

The MPC VECTOR controller can be supplied with a 60 Hz, 50 Hz, or dual rated 50/60 Hz motor. The controller/motor combination allows for 60 Hz rated pump flow (1800 rpm motor speed) even when operating from a 50 Hz input.

Note: Users in locations with 50 Hz AC supply do not have to de-rate pump flow with this controller.

Minimum motor speed will be pump and motor type dependent and can be user configurable via a turndown ratio to work with various applications. (See SYSTEM SETUP: turndown/motor setup)

Input Frequency	MPC VECTOR **Motor**	**Max** MPC VECTOR – **Output**
60 Hz (USA and similar)	60 Hz (or dual rated)	60 Hz / 1800 rpm
50 Hz (Europe, Asia, etc)	50 Hz or 60 Hz or dual rated	60 Hz / 1800 rpm

The motor, used in conjunction with MPC VECTOR controller, whether supplied from Pulsafeeder or by the user **must be a three-phase inverter duty/ready) motor**. The three-phase power delivered to the pump motor is generated internally by the MPC VECTOR controller. Input power ratings provided to the MPC VECTOR can be single-phase 208-230, three-phase 208- 230, or 3 phase 480VAC (see ***Section 13 Specifications*** for acceptable voltage ranges and tolerances). The nameplate on the front of your MPC VECTOR controller will list the appropriate supply requirements for your controller.

Motor Hp Rating	**MPC VECTOR Input Voltage***	**Motor Voltage Rating****
1	208/230/240 VAC 1 or 3 phase 380/415/440/460/480 VAC (3 phase only)	208-230 VAC 400VAC/460 VAC
2	208/230 VAC 1 or 3 phase 380/415/440/460/480 VAC (3 phase only)	208-230 VAC 400VAC/460 VAC
3	208/230 VAC 1 or 3 phase 380/415/440/460/480 VAC (3 phase only)	208-230 VAC 400VAC/460 VAC

5	208/230 VAC 3 phase only 380/415/440/460/480 VAC (3 phase only)	230 VAC 400VAC/460 VAC

Table 1-1 Available MPC Vector Input/Motor Output Ratings

*** all input ratings are 50 or 60 Hz**
**** output to pump motor is always 60 Hz maximum frequency**

The AC drive used in the MPC VECTOR maintains tight control over voltage and current supplied to the pump motor, resulting in lower motor operating temperatures and less stress on motor windings. Control of these key motor parameters results in longer motor life and more reliable overall operation. Further motor selection information can be found in **Section 14 Pump Motor Selection.**

1.2.2 Handheld User Interface Operation

Figure 1-1 Local Handheld User Interface Elements

Key	Function	Description
	Motor On/Off	Press to start pump, press again to stop pump
	Auto/Manual	Press to toggle between automatic (remote) and manual (local) control of the pump
	Menu	Press to adjust controller settings, to exit the menu system, to move cursor back when entering values, or to step back to higher level menus
	Enter	Press to accept changes in menus, to move cursor forward when entering values, and to access lower level menus.
	Arrow Up	Press to increase value, and to scroll up through menu options
	Arrow Down	Press to decrease value, and to scroll down through menu options
Lamp	**Color**	**Description**
ON 	Off, Green, Red	Off = Motor off Green = Motor on Red (blinking) = System Error
MANUAL 	Green, Off	Green = Manual (Local) Control Off = Automatic (Remote) Control

Table 1-2 – Keypad and Lamp Operation

1.2.3 System Modes

The MPC VECTOR operates at two system level modes, normal system control mode and system configuration mode. Normal system control mode allows the user to change flow rates or motor RPM in order to adjust process flow conditions to suit their needs. System Configuration mode allows the user to setup the controller for various user applications, thus customizing the pump rate controller for a particular process.

1.2.3.1 System Configuration Mode

System configuration mode allows the user to set up the pump controller for the particular customer application. The configuration mode has 4 major categories for the user to setup their pump application. Most configurations must be done in the pump off state.

Shown below are the major configuration categories and the sub categories within each configuration area.

Configuration Menu	Sub Menu	Description
Calibration		
	Pump Flow	Pump flow calibration for open and closed loop flow setups. 2 point calibration
	Analog Input	Allows 4-20 mA signal calibration for speed control in sensorless vector speed control and flow in closed loop control.
	Analog Output	Provides 4-20 mA output calibration of current output vs. speed in sensorless vector mode and flow in closed loop mode
	Motor Parameters	Provides motor nameplate data entry and calibration of the chosen pump motor.
	PulsaGuard	Provides setup of run dry feature and calibration
Digital I/O		
	Digital Input 1&2	Allows enabling the input, defining whether active high or low, and defining its use
	Digital Output 1,2 &3	Allows enabling the output, defining whether active high or low, and defining its use
Analog I/O		
	Analog Input 1	Allows activation of the 4-20 mA analog input for open loop speed or closed loop flow control.
System Setup		
	Status	Provides history of pump status and errors (up to last 4)
	Language	Allows user to select language
	Factory Init	Restores pump to factory settings
	Flow Units	Allows user to set pump flow units GPM, GPH, LPH, LPM
	Information	Displays system software levels, performing digital/analog diagnostics, set system turndown, setting pump max flow rate and speed

	Flow Detect	Allows setting of flow detection delay time for flow detect digital input
	Flow Meter	Allows activation/deactivation of flow meter for closed loop flow control
	Security	Enables/Disables and sets password protection number
	PulsaGuard	Activate/ Deactivate Run Dry sensing
	PID Parameters	Allows setting of proportional, integral, and derivative parameters for closed loop flow meter based systems
	TCF Parameters	Allows the user to change AC drive parameters to suit motor/pump application.

Table 1-3 MPC Vector System Configuration Menu Items

1.2.4 Normal System Operational Modes

1.2.4.1 Manual (Local) Operational Mode

Manual (also referred to as Local) operational mode requires that the user be present at the pump user interface (hand-held unit) in order to operate the pump (Note: this location may be up to 1000 ft from the pump). This mode is indicated by the manual LED being illuminated. A user may, at any time the pump is running, place the pump into the off condition by pressing the Motor ON/OFF key  or place the controller into the Manual mode of operation, using the Auto/Manual key  .

Operations and monitoring that can occur from local operational mode include the following:

- Observation and entry of flow rate and RPM set points
- Starting/stopping the pump via Motor On/Off 

Motor ON/OFF turns the pump on or off at anytime

- Placing the controller between the 2 operational modes, Auto or Manual 
- Increasing or decreasing flow or motor speed with up/down arrows 
- Providing system setup, digital I/O setup, Analog I/O Setup, and Calibration via Menu entry 
- System calibrations – including pump flow, motor, analog I/O, PulsaGuard
- Observation of pump status (running/stopped/error) and mode (manual/auto)

1.2.4.2 Auto (Remote) Operational Mode

Auto (also referred to as Remote) operational mode utilizes control signals from a SCADA or PLC system to control the pump flow (when in closed loop flow mode) or speed (when in sensorless vector mode) and does not require the user to be present. This allows the MPC VECTOR to be operated automatically and at remote sites.

Simple remote control can consist of start/stop control (digital dry-contact input). The pump flow rate for simple control is set in local mode at a fixed user entered flow rate, once set, all remote start/stop commands via a digital input will command the pump to run at that fixed user flow rate.

More complex flow rate control can be performed by using a 4-20mA current loop and a remote start/stop digital input signal. The digital input signal will start and stop the pump. The analog input signal will command the pump motor speed in sensorless vector control and pump flow rate in closed loop control (flow meter in system configuration).

Operation, control, and monitoring that can be performed while in auto (remote) mode include:

- Automatic Start/Stop via Digital Input (set up as Start/Stop).
- Process Flow or Speed Set Point Changes with 4-20mA input.
- Flow or Speed Monitoring via 4-20 mA output.

1.2.5 Control Modes

The MPC Vector provides two types of flow process control. The flow control methods are dependent upon whether the user's system provides an analog flow meter or not.

- **Sensorless Vector control** provides no process flow feedback information and is based upon a flow rate versus motor RPM calibration. The internal calibration engine calculates the appropriate speed based upon the user desired flow rate of the pump system.

- **Closed loop control** uses a flow meter placed in the flow path as feedback to the controller board. The controller, knowing the process fluid flow rate is now able to adjust motor speed based upon a PID algorithm. See **Section 7.1.2 Analog Input 2 – Flow meter Feedback** for set up of an analog flow meter.

1.2.5.1 Sensorless Vector Flow Control

Sensorless Vector control mode does not use a feedback signal that monitors the flow rate of the process fluid to the controller. Sensorless Vector control uses a flow rate versus speed algorithm. Flow rates and speed are entered via a user assisted drawdown calibration procedure in order to derive flow accuracy (**See Section 8.1.1 Open Loop Pump Flow Calibration).** The user provides 2 points of calibration, one point at high speed/flow (maximum motor RPM recommended) and a second point recommended at low motor speed /minimum flow. These 2 points, once characterized, provide a linear flow relationship for the positive displacement pump application. The flow curve below shows a user's two point calibration. Once flows are measured, a speed versus flow conversion is utilized to adjust all new flow set points. ***Note: Stroke length must remain constant for sensorless vector control. Changing stroke length requires recalibration.***

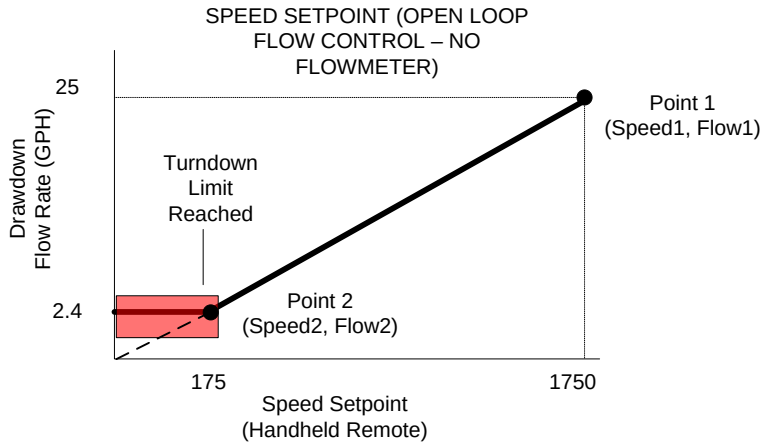


Figure 1-2 Open Loop Flow Calibration Curve

1.2.5.2 Closed Loop Flow Control

Closed loop flow control utilizes an analog flow meter in conjunction with an internal PID control algorithm, providing excellent flow control by maintaining process flow set point. Flow meter feedback must be in the form of a 4-20 mA signal representing process flow rates. The flow meter should be located as close as possible to the pump in order to provide a measurement of the current process flow rate without flow rate time lag introduced into the feedback loop (delayed flow readings will cause flow stability issues). The analog flow signal (see flow meter setup **Section 7.1.2 Analog Input 2 – Flow meter Feedback** for details) is fed into MPC Vector Analog Input 2, and is activated in the System Setup menu under the sub-category of Flow Meter.

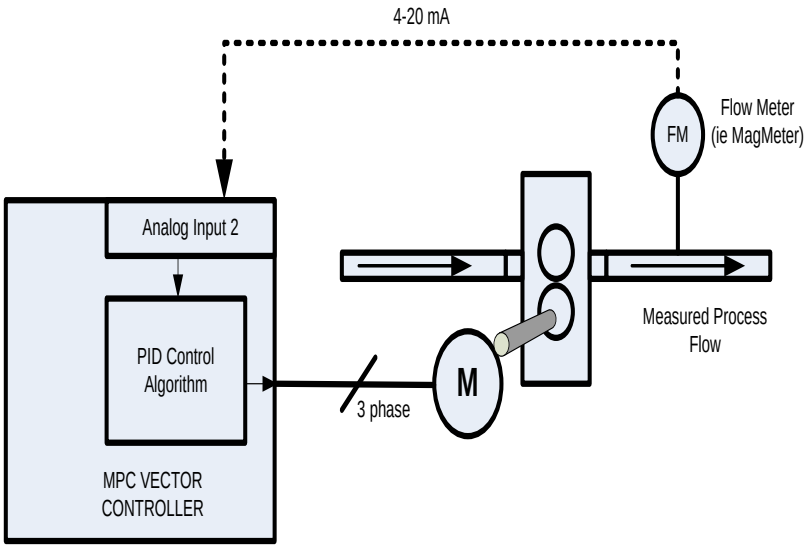


Figure 1-3 Closed Loop Control Feedback Block Diagram

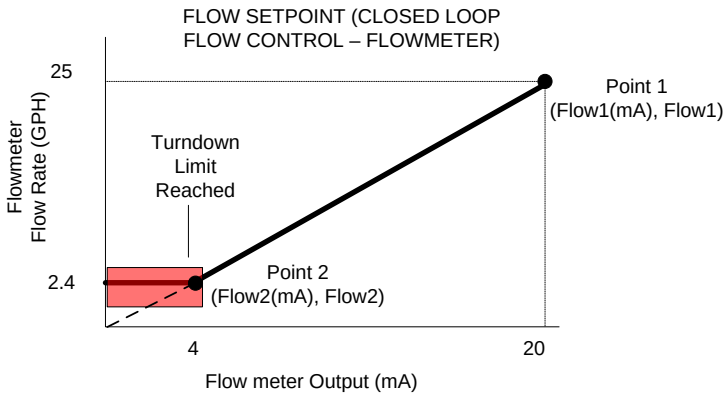


Figure 1-4 Closed Loop Flow Calibration Curve

2. Safety Considerations

- Read and understand all related instructions and documentation before attempting to install or maintain this equipment.
- Observe all special instructions, notes, and cautions.
- Act with care and exercise good common sense and judgment during all installation, adjustment, and maintenance procedures.
- Ensure that all safety rules, work procedures, and standards that are applicable to your company and facility are followed during the installation, maintenance, and operation of this equipment.

2.1 General Safety

The MPC VECTOR was designed as a pump rate controller for operation with positive displacement type pumps. Use for any other application is considered unsafe and voids all certification markings and warranties.

2.2 Electrical Safety

The MPC VECTOR is an industrial process controller. Improper application and use can be hazardous. You are solely responsible for its use.

The MPC VECTOR electrical installation must conform to all relevant electrical codes. Installation and electrical maintenance must be performed by a qualified electrician. Before installing or servicing this device, all power must be disconnected from the source at the main distribution panel.

The MPC VECTOR emits electro-magnetic energy and may generate radio frequency interference. Its use is restricted to industrial applications. You are responsible for shielding this energy/interference.

Certain wiring procedures may require that the user wear a wrist strap to dissipate static charges.

Wait a minimum of 5 minutes after disconnecting power before servicing the MPC VECTOR or pump motor. Capacitors retain a charge even after power is removed from the controller.

2.3 Mechanical Safety

Users should note that the pump motor is always under the control of the MPC VECTOR, and as such may actuate without warning. Care should be taken to keep loose clothing and other objects away from the pump motor.

The MPC VECTOR was designed to be service free. It contains no user-maintainable components. Disassemble the MPC VECTOR enclosure only for initial field wiring, or as instructed to do so within this manual. Evidence of unauthorized disassembly shall void the warranty.

2.4 Hydraulic Safety

Thoroughly review and adhere to the contents of your particular pump Installation, Operation, Maintenance and Instruction manual for any pump used with the MPC Vector control. As a microprocessor controlled device, the MPC VECTOR may activate the pump motor without warning – generating hydraulic pressure and fluid flow. Care should be taken to protect both users and systems should the pump activate.

3. Equipment Inspection

When you receive your order, check all equipment for:

- Completeness against the shipping document / purchase order
- For any evidence of shipping damage

Shortages or damage should be reported immediately to the carrier and your Pulsafeeder Representative.

4. Storage Instructions

The MPC VECTOR can be successfully stored for extended periods. The key to successful storage is dependent on temperature and humidity control.

4.1 Short Term (0 - 12 months)

The MPC VECTOR should be stored in a temperature and humidity controlled environment. It is preferable to keep the temperature constant in the range of -18° to 60° Celsius (0° to 140° Fahrenheit). The relative humidity should be 0 to 90% non-condensing.

4.2 Long Term (12 months or more)

Storage of the MPC VECTOR for periods of longer than twelve months is not recommended. If extended storage is unavoidable the MPC VECTOR should be stored in accordance with those conditions stipulated for Short Term Storage. In addition, a porous bag of 85g (3 oz) silica gel or similar desiccant should be placed inside the enclosure. The cover should be re-installed to seal the desiccant within the enclosure. The conduit connections must be tightly capped.

Special note for long-term storage:

If AC input power has not been applied to the MPC VECTOR for a period greater than 12 months, the controller must be prepared for operation. The MPC VECTOR should have AC power applied at the input for a period of 8 hours before placing pump into normal operation. Refer to Installation and Wiring section for AC power connection instructions.

5. Installation and Wiring

5.1 Installation Notes

The MPC VECTOR is a microprocessor-based controller that uses electro-static sensitive CMOS components. Do not make any (high or low voltage) electrical connections without adequately grounding the MPC VECTOR and the worker to eliminate an electro-static charge between the two.

A CONDUCTIVE WRIST STRAP WORN BY THE WORKER AND ATTACHED TO THE MPC VECTOR'S INTERNAL GROUND PLATE IS ADEQUATE TO SATISFY THIS REQUIREMENT.

Calibration is an important element of successful MPC VECTOR operation. If a flow meter is being used for process feedback the flow meter must be calibrated by the supplying manufacturer prior to MPC VECTOR calibration according to manufacturer recommendations.

Conduit connections can carry fluids and vapors into the MPC VECTOR causing damage and void the warranty. Care should be taken when installing conduit to protect against fluid/vapor entry. If necessary, provide sealed entries or conduit drains near the point of entry. The user must supply the correct connection for the power entry, as per the local codes and requirements. Any cable entrances that are not used should be appropriately sealed against moisture and vapors.

5.2 Controller Location

The following section describes the installation steps necessary for a successful installation.

Review the Safety section (*Section 2*) prior to installing the MPC VECTOR. It contains information required to properly install and operate the MPC VECTOR in an industrial environment.

The site selected for the installation of your MPC VECTOR is largely dependent on your particular pump(s) physical location. Review the Installation, Operation, and Maintenance manual provided with your particular pump type. The Installation, Operation, and Maintenance manual details system related issues that are important to proper operation of the pump.

Consider the following MPC VECTOR installation related issues when selecting an installation site.

- Location of the controller enclosure **must be within 100 feet (30.5 meters) of the pump motor**, otherwise consult factory on longer distances if necessary.
- Avoid locations where the MPC VECTOR would be subjected to extreme cold or heat **(<0 or >40 Degrees Celsius, <32 or >104 Degrees Fahrenheit)**. Note the warning statement on the next page. The installation of this device must comply with national, state and local electrical codes.
- Location for the handheld device used to display flow and control manual operation of the pump, a maximum of 1000 feet (305 meters) is allowed.

The MPC VECTOR controller must be secured to an appropriate support before use. Use appropriate hardware to secure the MPC VECTOR controller to a smooth vertical surface.

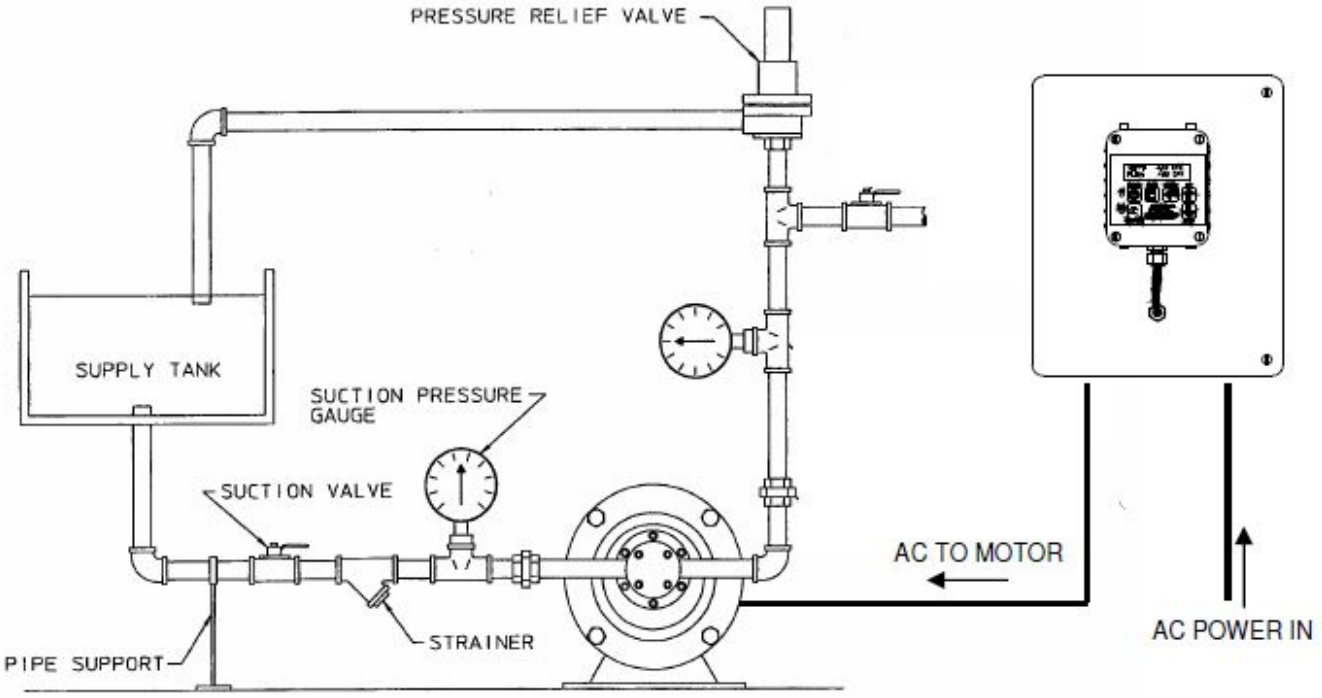


Figure 5-1 – Typical Installation (Gear Pump Shown)

WARNING

AVOID LOCATIONS WHERE THE MPC VECTOR WOULD BE SUBJECTED TO EXTREME COLD OR HEAT [LESS THAN 0° CELSIUS (32° FAHRENHEIT) OR GREATER THAN 40 ° CELSIUS (104 ° FAHRENHEIT)] OR DIRECT SUNLIGHT. FAILURE TO OBSERVE THIS WARNING COULD DAMAGE THE MPC VECTOR AND VOID ITS WARRANTY.

The MPC VECTOR is provided in two form factors, a NEMA 4X enclosure, and an OPEN CHASSIS custom mountable panel.

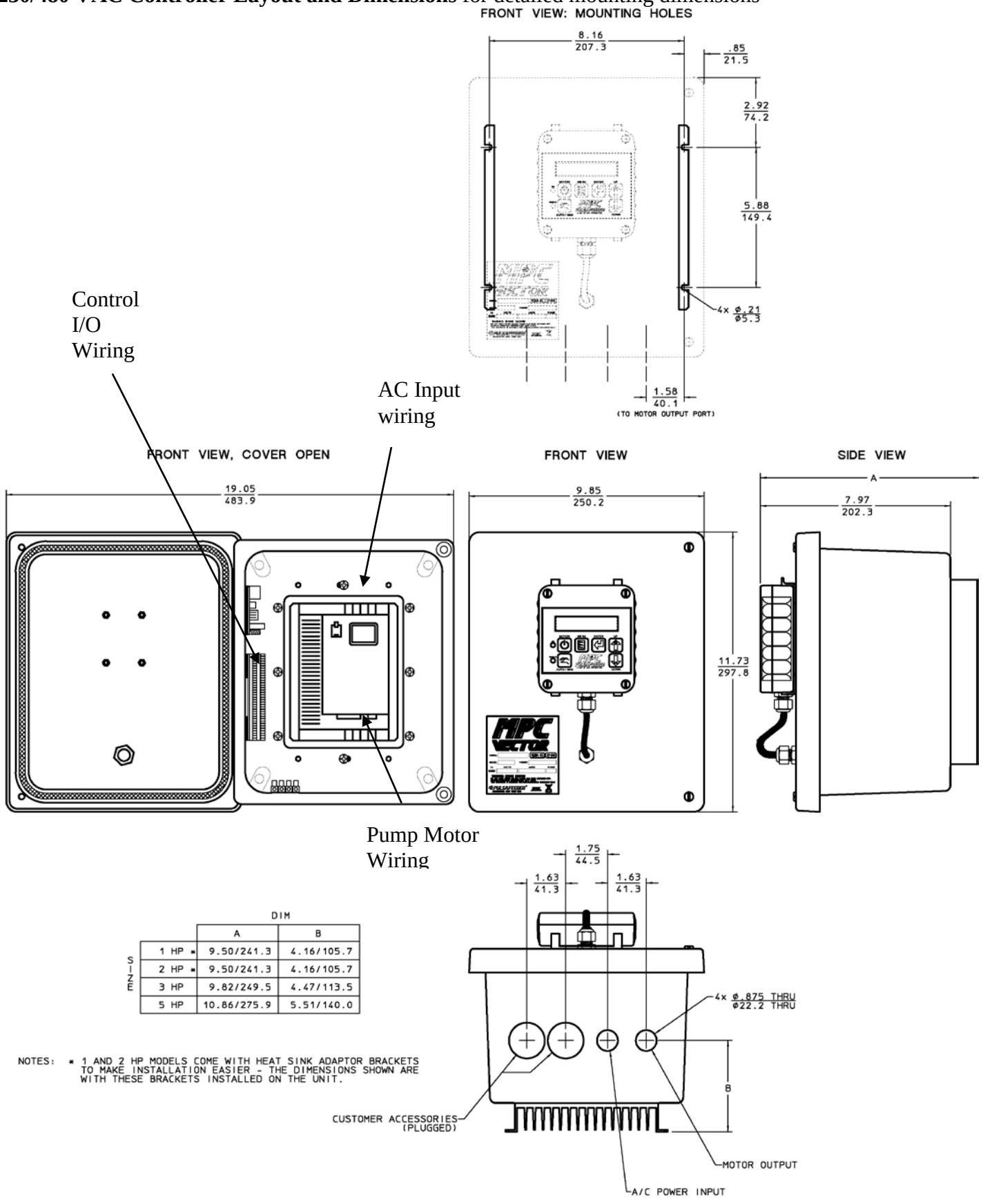
5.2.1 Controller Mounting and Layout

The MPC VECTOR is provided in two form factors, a NEMA 4X enclosure, and an OPEN CHASSIS custom mountable panel.

5.2.2 NEMA 4X Version

The NEMA 4X design, both 230VAC and 480 VAC, of the MPC VECTOR incorporates all control circuitry onto one easily accessed control panel. This controller circuitry is located on the inside of the main controller enclosure. Gain access to this circuitry by removing the 2 cover screws to the hinged enclosure. **See Figure 5-2 – NEMA 4x**

230/480 VAC Controller Layout and Dimensions for detailed mounting dimensions



SIZE	DIM A	DIM B
1 HP *	9.50/241.3	4.16/105.7
2 HP *	9.50/241.3	4.16/105.7
3 HP	9.82/249.5	4.47/113.5
5 HP	10.86/275.9	5.51/140.0

NOTES: * 1 AND 2 HP MODELS COME WITH HEAT SINK ADAPTOR BRACKETS TO MAKE INSTALLATION EASIER - THE DIMENSIONS SHOWN ARE WITH THESE BRACKETS INSTALLED ON THE UNIT.

Figure 5-2 – NEMA 4x 230/480 VAC Controller Layout and Dimensions

5.2.3 OPEN CHASSIS Panel Mount Version

The OPEN CHASSIS design of the MPC VECTOR incorporates all control circuitry onto one easily accessed open-frame chassis for 230 VAC designs. Note: 480 (3 phase) VAC designs require a control transformer to step down one phase of 480VAC to 230 VAC for control electronic power supply. The main MPC Vector control board is located on the left hand side of the panel. See **Figure 5-3 OPEN CHASSIS Panel Mount Controller Layout and Dimensions** for detailed mounting dimensions.

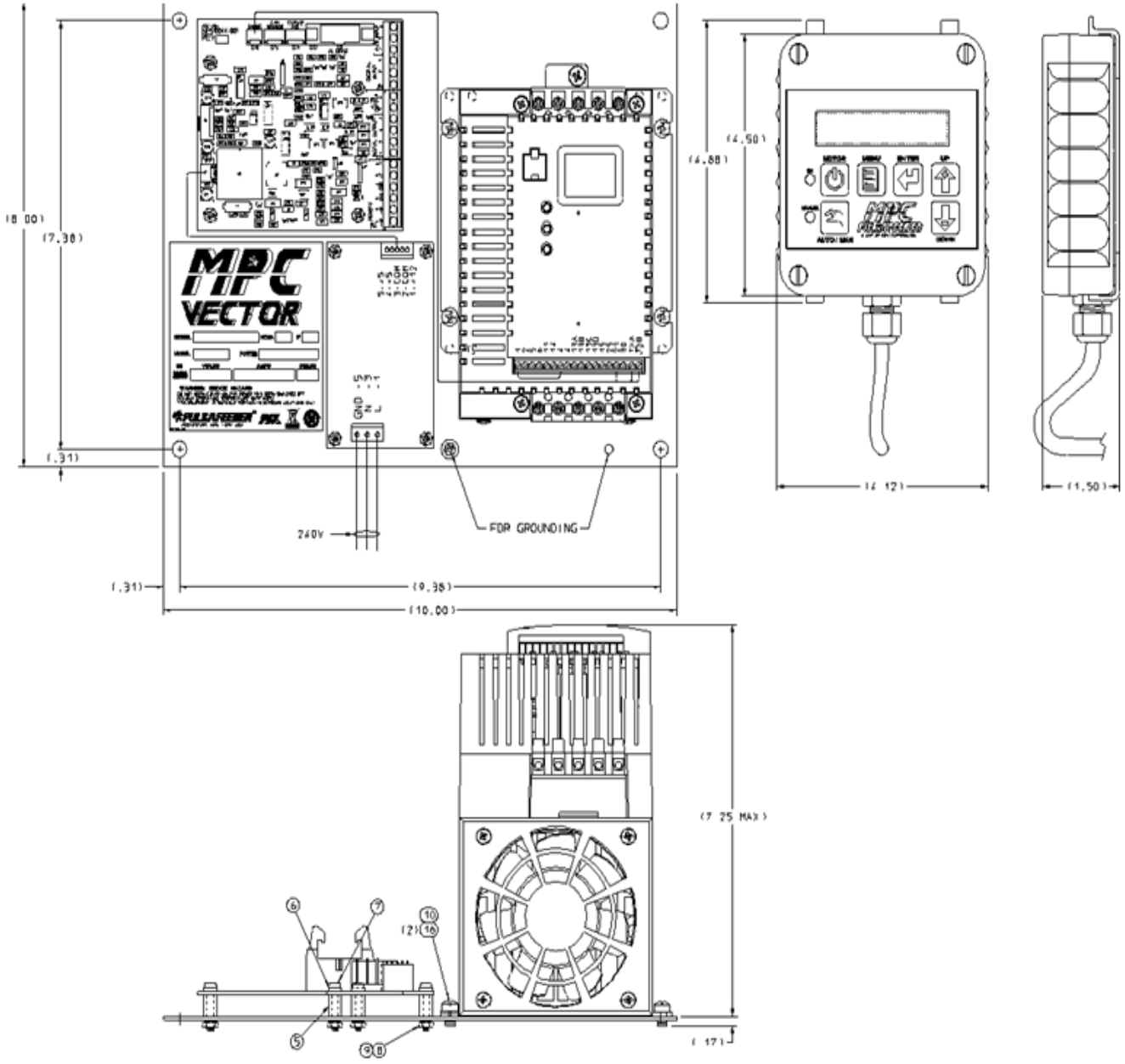


Figure 5-3 OPEN CHASSIS Panel Mount Controller Layout and Dimensions

5.3 Electrical Wiring

WARNING

IF THE CONTROLLER WAS PREVIOUSLY POWERED, WAIT A MINIMUM OF 5 MINUTES AFTER DISCONNECTING POWER BEFORE SERVICING THE MPC VECTOR OR PUMP MOTOR. CAPACITORS RETAIN A CHARGE EVEN AFTER POWER IS REMOVED FROM THE CONTROLLER.

Shown below is a summary of the electrical wiring steps necessary to install an MPC VECTOR (see appropriate sections to follow for details)

1. Connect the 3 phase pump motor.
2. Connect the Supply Voltage, single or three phase.
3. **(Optional)** Connect your pump's application control wiring
    a. Analog input signal(s), so the MPC VECTOR can accept a process input signal or flow meter input
    b. Analog output signal, for user monitoring of speed or flow
    c. Digital input signals, for example start/stop and/or tank level inputs
    d. Digital output signals, for example auto/manual status and/or alarm outputs
4. Conduct a final power-up and test the MPC VECTOR
5. Go to Section 6 System Configuration for details on how to configure I/O and perform power-up tests

5.3.1 Pump Motor Wiring

Using a VFD rated cable route the 3 phase motor connections between the MPC Vector AC drive connections marked U, V, and W as shown in **Figure 5-4 MPC VECTOR Pump Motor Wiring Termination** below. Next terminate the VFD cable at the pump motor location, being careful to wire the proper motor voltage connections (generally L1, L2, L3, refer to your motor voltage wiring diagram for dual voltage rated motors).

The motor wires are secured to the terminal strip at the bottom end of the AC drive. Remove approximately 0.20 – 0.25" of insulation from the end of each conductor. Loosen the terminal strip screw, and insert the stripped wire end fully into the terminal. Tighten the screw to secure the conductor **(Torque Requirement 2.0 lb-in/0.2 Nm)** making certain that the terminal grips the wire, not the insulation. Ensure that all wiring meets applicable local and national codes and requirements.

Ensure that the motor voltage wiring connections (230/480 VAC) match your MPC Vector voltage rating by referring to the motor wiring diagram on motor conduit cover. Use the nameplate voltage rating of the MPC Vector.

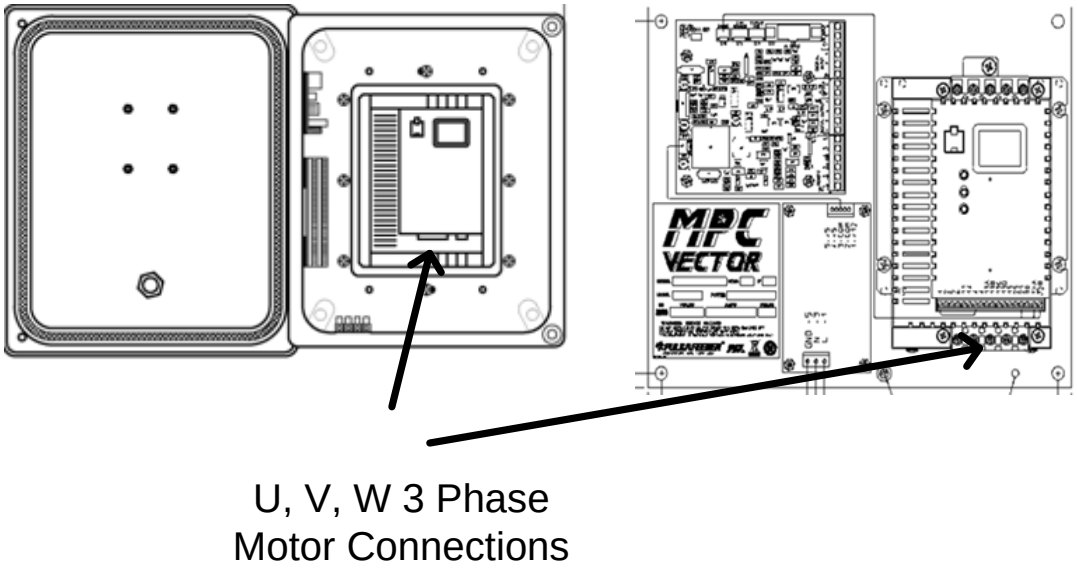


Figure 5-4 MPC VECTOR Pump Motor Wiring Termination

5.3.2 AC Line Input Wiring

NOTE

- **Verify the correct supply voltage (230VAC single/three phase or 480VAC three phase) with the nameplate affixed to your MPC VECTOR. Ensure that your AC line input voltage matches the MPC VECTOR configuration.**

- **The 1 hp, 2 hp, and 3 hp rated MPC VECTOR use single phase or three phase 208-230VAC input.**
- **The 5 hp 230 VAC MPC VECTOR must be powered by three phase input only.**
- **All 480VAC MPC VECTOR use 3 phase power only.**

- **Wires should be routed within the enclosure in a manner that maintains separation between high voltage (power) and low voltage (control) conductors. High voltage conductors should be routed to the side opposite the control circuitry.**
- **Incoming power wiring should adhere to all applicable local and national electrical codes and regulations. A circuit breaker or fuse(s) must be provided as noted below.**
- **Upon initial application of AC power, a current inrush will occur to charge the DC bus capacitors. This is normal operation, and breakers and other circuit protection devices should be sized accordingly.**
- **Motor Rated circuit breakers are recommended for use (allows input surge).**
- **Wiring Torque Requirement 2.0 lb-in/0.2 Nm.**
- **Wire and Ground in accordance with NEC or CEC, and all applicable codes.**
- **Motor wire must run in separate conduit away from control wires and AC line input.**
- **Do not install contactors bewteen the MPC Vector and the motor.**
- **Use only UL and CSA approved wire.**
- **Use 300V rated wire for 208/240 VAC systems and 600V for 400/480VAC systems.**
- **Wire gauge must be based on a minumum of 125% of the rated input/output current of the drive, and a minimum 75 Degrees C insulation rating. Copper wire only.**

5.3.2.1 AC Input Wire and Circuit Breaker Sizing

General Input Wiring Guidance

The MPC VECTOR requires one connection to an external AC power source. The controller uses this AC connection to power its own internal supply and the AC pump motor. You must take all of these loads into consideration when sizing the branch circuit. A circuit breaker or disconnect switch with fuses must be wired in series with terminals L1 and L2/N (single phase) and L1, L2, and L3 (three phase) in accordance with all applicable local and national electrical codes and regulations. The circuit breaker or disconnect switch shall be located in close proximity to the MPC VECTOR controller installation, and must be marked or labeled to identify it as the power disconnect for the MPC VECTOR.

Conduit Entrance

The MPC VECTOR controller is provided with a 7/8" thru hole for incoming AC power wiring and a 7/8" thru hole for motor wiring at the bottom of the enclosure. Utilize the appropriate conduit fittings to route and seal the supply wires into the MPC VECTOR enclosure.

Depending on the model you are installing see the appropriate sections below for 230 or 480 VAC to determine proper AC installation guidelines. See nameplate for HP rating, refer to **Figure 5-5 MPC VECTOR Product Label**.

Figure 5-5 MPC VECTOR Product Label

230 VAC Models - Single and Three Phase

See Table 5-1 Sizing Branch Circuits (208/230VAC) below for recommended wire and circuit breaker sizing information.

Power Requirements	***Recommended Minimum Wiring and Circuit Breaker***							
	Single Phase 208/230 VAC				***Three Phase 208/230 VAC***			
	Actual Draw	***Circuit Breaker***	***Wire Size***	***Wire Size***	***Actual Draw***	***Circuit Breaker***	***Wire Size***	***Wire Size***
MPC VECTOR and 1.0 Hp motor	10.6 A	15 A	14 AWG	2.0 mm^2	5.8 A	10 A	14 AWG	2.0 mm^2
MPC VECTOR and 2.0 Hp motor	14.8 A	20 A	12 AWG	3.5 mm^2	9.1 A	15 A	14 AWG	2.0 mm^2
MPC VECTOR and 3.0 Hp motor	19.7 A	25 A	12 AWG	3.5 mm^2	12.4 A	20 A	12 AWG	3.5 mm^2
MPC VECTOR and 5.0 Hp motor	---	---	---	---	19.6 A	25 A	12 AWG	3.5 mm^2

Table 5-1 Sizing Branch Circuits (208/230VAC)

480 VAC Models – Three Phase

See Table 5-2 – Sizing Branch Circuits (400/480VAC) below for recommended wire and circuit breaker sizing information.

Power Requirements	*Recommended Minimum Wiring and Circuit Breaker*			
	Three Phase 400/480 VAC			
	Actual Draw	*Circuit Breaker*	*Wire Size*	*Wire Size*
MPC VECTOR and 1.0 Hp motor	2.9 A	7 A	14 AWG	2.0 mm^2
MPC VECTOR and 2.0 Hp motor	4.5 A	7 A	14 AWG	2.0 mm^2
MPC VECTOR and 3.0 Hp motor	6.2A	10 A	14 AWG	2.0 mm^2
MPC VECTOR and 5.0 Hp motor	10.6	15A	14 AWG	2.0 mm^2

Table 5-2 – Sizing Branch Circuits (400/480VAC)

5.3.2.2 230 VAC Model NEMA 4x and 480VAC Panel Mount Line Wiring

Make the incoming 230VAC power connections, paying particular attention to whether the installation is single or three phase. See **Figure 5-6 230 VAC Single and Three Phase Line Input Wiring** and **Table 5-3 230VAC Single and Three Phase Terminal Connection Guide** to assist with wiring details. Note that wiring for 230 VAC models is routed directly to the top of drive terminals.

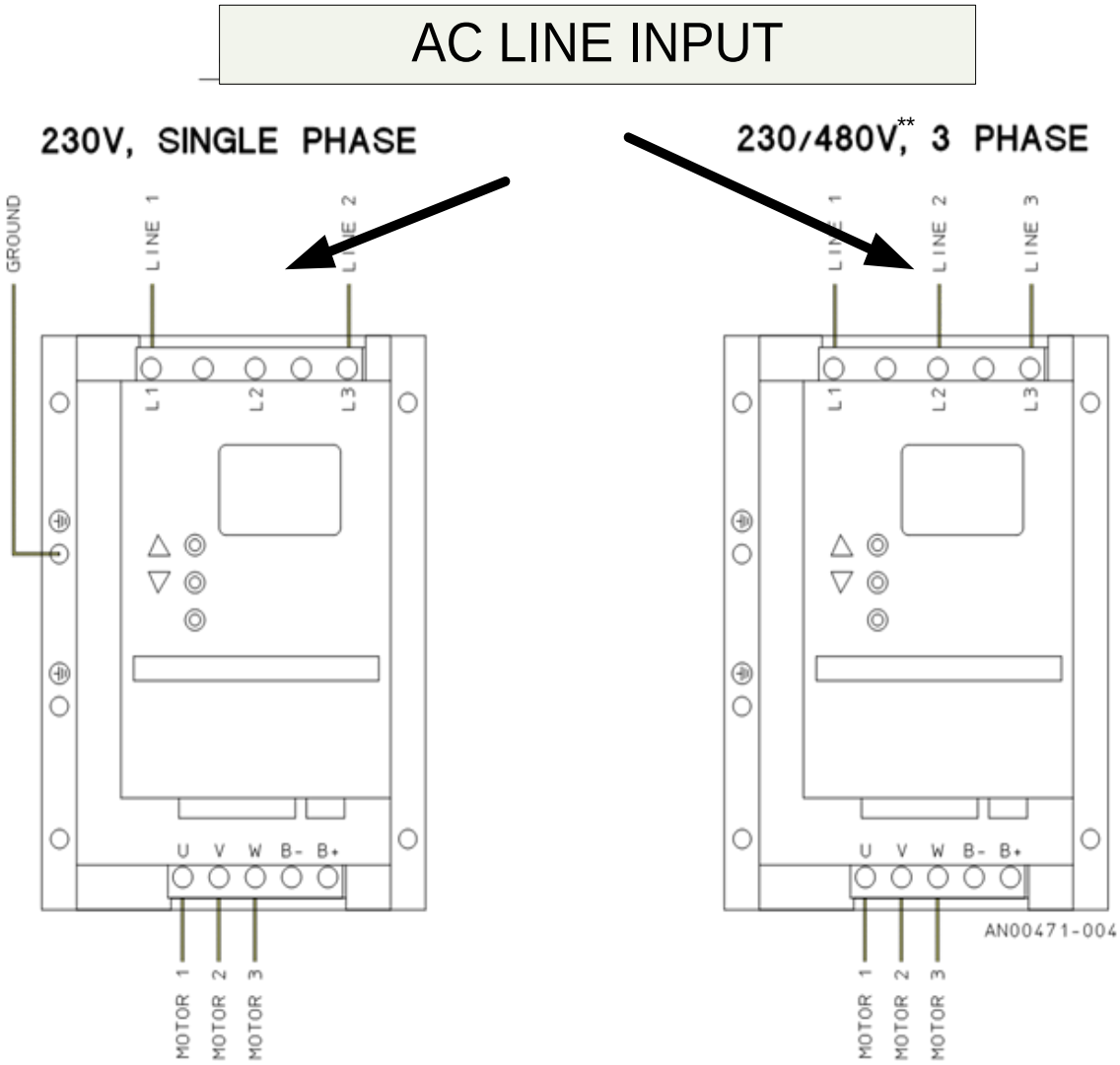


Figure 5-6 230 VAC Single and Three Phase Line Input Wiring

**Note: 480 VAC Panel Version wired directly into drive

MPC VECTOR Drive Terminal	Single Phase 208/230 VAC	Three Phase 208/230/480** VAC
L1	Line 1	Line 1
L2	N/C(No Connect)	Line 2
L3	Line 2/Neutral	Line 3
Ground Plate	Chassis/Earth Ground	Chassis/Earth Ground

Table 5-3 230VAC Single and Three Phase Terminal Connection Guide
**480 VAC Panel Mount has AC connected directly to the drive

5.3.2.3 480 VAC NEMA 4x Enclosure Input Wiring

Make the incoming 480 VAC three phase power connections. See **Figure 5-7 480VAC NEMA 4x AC Input Wiring Termination Details** to assist with wiring details. Note that input wiring for 480 VAC NEMA 4x models is routed to a supplied terminal strip block.

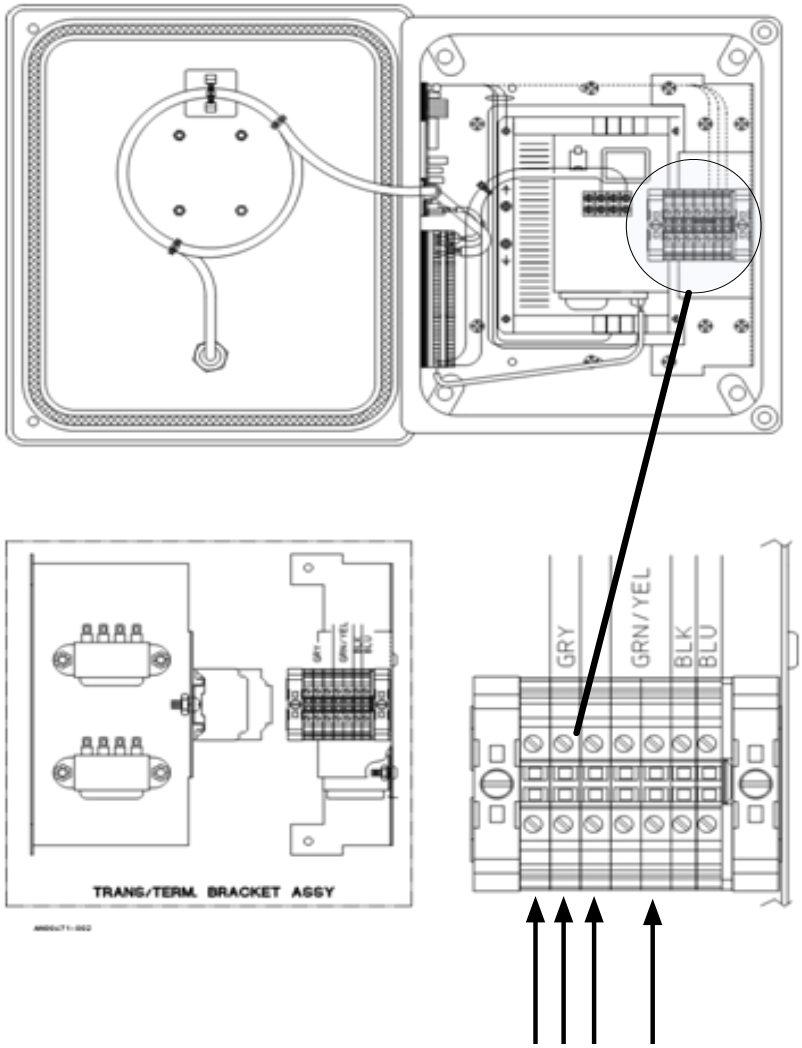


Figure 5-7 480VAC NEMA 4x AC Input Wiring Termination Details

At this point power wiring is complete. At this point you should apply power to the MPC VECTOR and your attached pump to ensure proper power wiring connection. See **Section 6** for start-up screen information. Do not attempt to start the pump until MPC Vector configuration has been completed in **Section 6** .

WARNING

WAIT A MINIMUM OF 5 MINUTES AFTER DISCONNECTING POWER BEFORE SERVICING THE MPC VECTOR OR PUMP MOTOR. CAPACITORS RETAIN A CHARGE EVEN AFTER POWER IS REMOVED FROM THE CONTROLLER.

5.3.3

Control Input/Output Signal Wiring

5.3.3.1 Determination of Input and Outputs

Based upon system configuration and control required, decide which control signal Inputs and Outputs (i.e., remote start/stop, 4-20mA in/out, etc.) will be used for your pump application and make the appropriate digital and analog connections. See details of control connections below.

5.3.3.2 Routing

Signal wiring is routed through the two leftmost unused conduit openings **Figure 5-2 – *NEMA 4x 230/480 VAC Controller Layout and Dimensions*** at the base of the MPC VECTOR (NEM4x enclosures, panel version based upon on conduit entry). All input/output signals are connected to the terminal strip at the edge of the MPC VECTOR circuit board. Use caution to observe proper wire location and signal polarity. Wires should be routed within the enclosure in a manner that maintains separation between high voltage and low voltage conductors. Ensure all low voltage wiring is installed per any applicable local and national electrical codes and regulations

Unused conduit openings should be plugged as required to avoid ingress of moisture and contaminants into the MPC VECTOR enclosure. Do not remove the factory provided plug from openings that are not required for field wiring.

.

5.3.3.3 Suggested Cable

Utilize 16 to 22 AWG stranded, 250 V shielded cable with a 75° C insulation rating (or better) for all signal input and output wiring. Recommended strip length is 0.39” or 10 mm.

5.3.3.4 Control Terminal Strip Termination Description

IT IS RECOMMENDED THAT A GROUNDING (ESD) WRIST STRAP BE WORN WHEN MAKING CONNECTIONS TO ANY PRINTED CIRCUIT BOARD.

The MPC VECTOR terminal strip mapping is shown in **Figure 5-8 *–I/O Terminal Strip Details (Panel & NEMA4x Shown)***. The terminal strip is composed of 5 major connection areas:

- Remote Handheld Interface
- Digital Output Interface
- Analog Output Interface
- Digital Input Interface
- Analog Input Interface

See the appropriate control wiring sections for example I/O wiring and terminal strip locations. Customize the I/O wiring for your pump configuration.

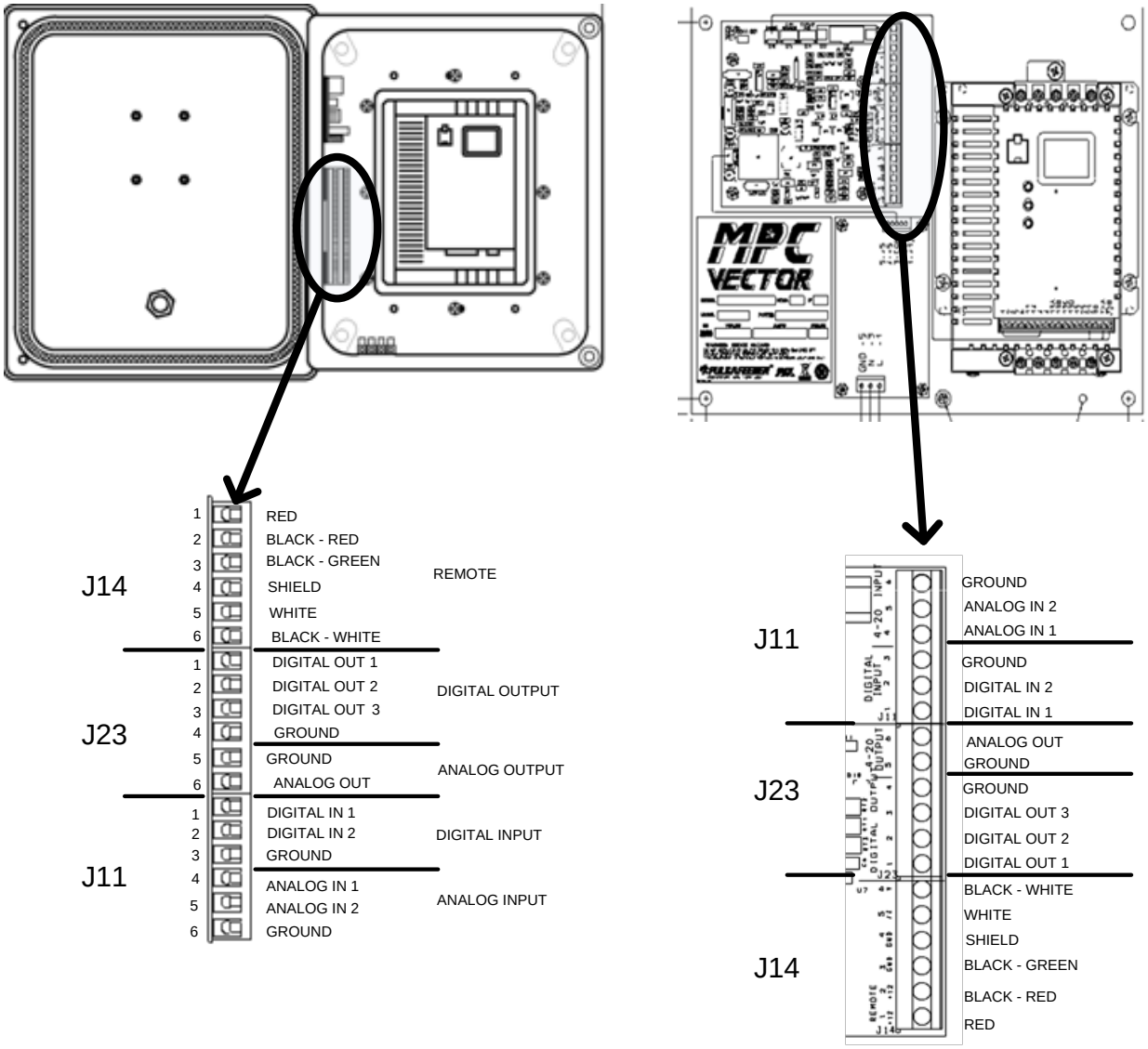


Figure 5-8 –I/O Terminal Strip Details (Panel & NEMA4x Shown)

5.3.3.5 Digital Output Wiring Example (Open Collector/Drain)

MPC VECTOR Digital non-isolated output signals can drive DC (direct current) devices such as LED's, relays, indicator lamps, or any device that does not require more than 500mA of current. Activation of a digital output from the MPC VECTOR provides a low impedance connection to the external power supply's ground, allowing current flow through the user device.
(Warning: MPC VECTOR Outputs are not relay contacts)

An external 24 VDC power supply must be supplied. Digital Outputs 1-3 consist of an open collector/drain current sinking low side switch capable of sinking 500 mA. The maximum external voltage that may be applied to these digital outputs is 40 VDC (see **Section 13 Specifications,** for more information).

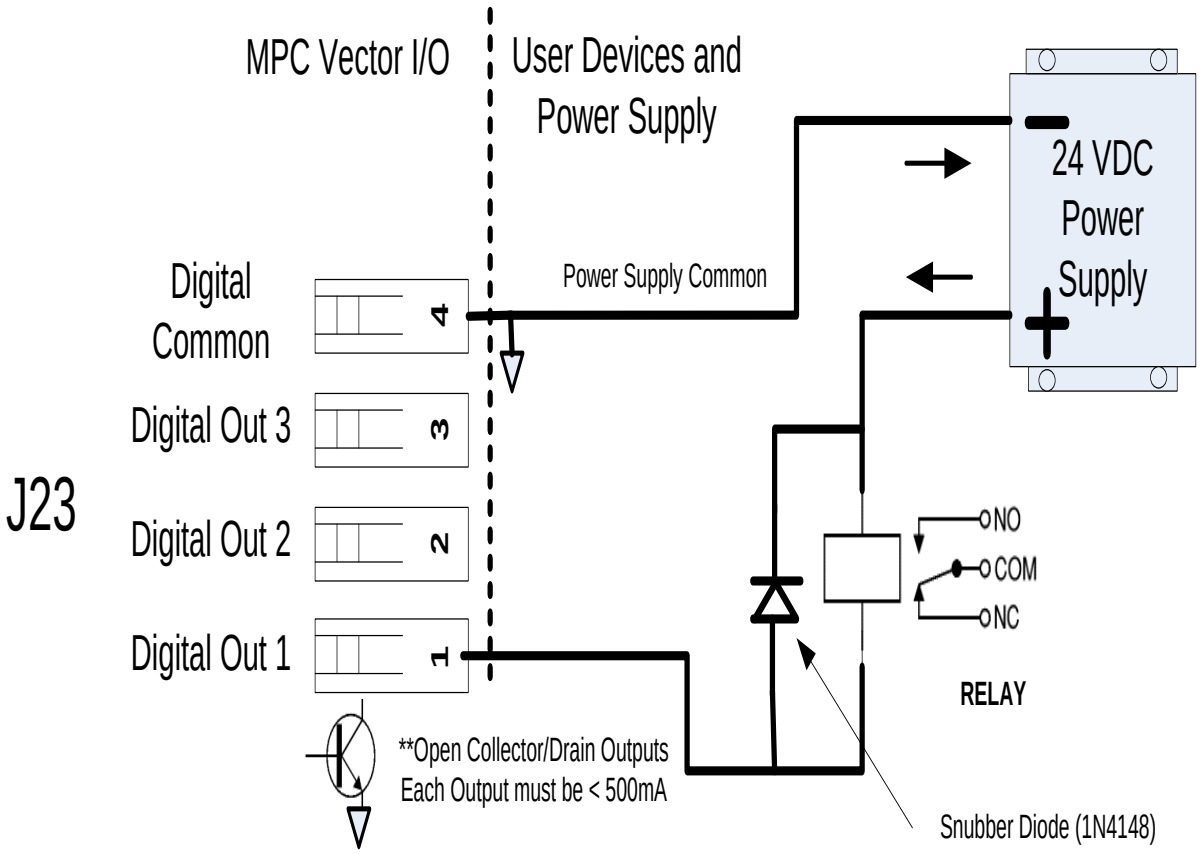


Figure 5-9 – Sample Digital Output Connections, (power can be in the range of 5 – 40 VDC)

5.3.3.6 Digital Input Example Wiring

Digital Inputs 1 and 2 provide monitoring of **dry contact (voltage free)** type inputs. Contact resistance when closed must not exceed 500 ohms in order to be recognized as an active closure. Inputs can be wired normal open or normally closed. See example below.

Warning: do not apply any voltage type outputs to these inputs, damage will occur.

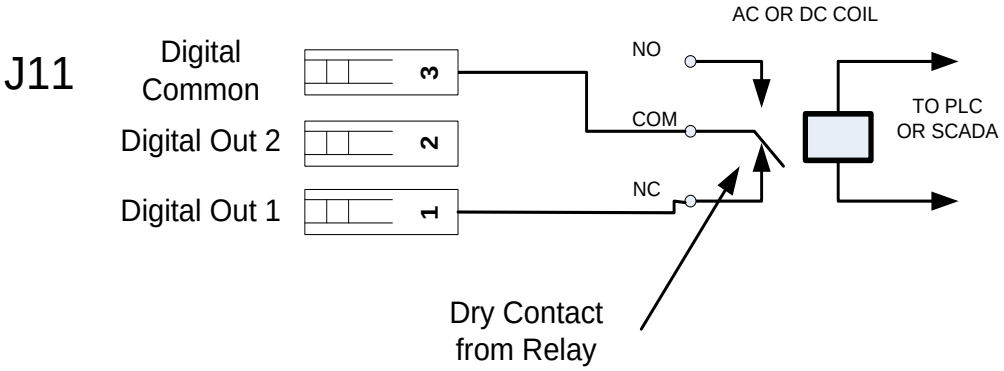


Figure 5-10– Sample Digital Input Connections

5.3.3.7 Analog Input Wiring Example

Analog inputs require a loop powered (current sourcing) transmitter capable of driving a minimum 250 ohm resistive load. The transmitter maybe a two wire or three wire type. The analog inputs are not isolated. Some installations may require an analog input isolator. See **Figure 5-11– *Sample Analog Input Connections*** below for wiring details.

5.3.3.7.1 Flow Meter (Analog Input 2)

Analog input 2 is dedicated for flow meter based systems. The analog input is use to provide a 4-20 mA flow feedback signal in order to provide closed loop flow control.

5.3.3.7.2 Set point (Analog Input 1)

Analog input 1 is dedicated as a user set point input. The analog input is used to command speed (which is proportional to flow) in open loop systems and flow rated for closed loop systems.

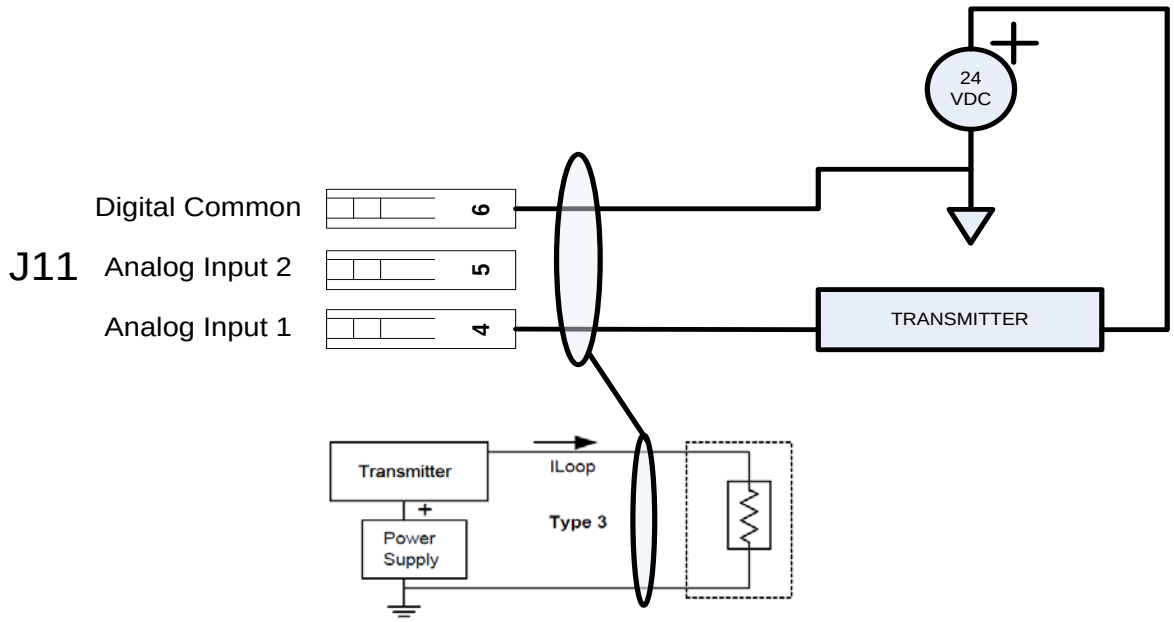


Figure 5-11– Sample Analog Input Connections

5.3.3.8 Analog Output Example Wiring

The MPC Vector provides internally powered two wire 4-20 mA transmitter which outputs speed. The output is capable of driving a 300 ohm load maximum. See **Section 7.3 Analog Output Setup** for configuration details.

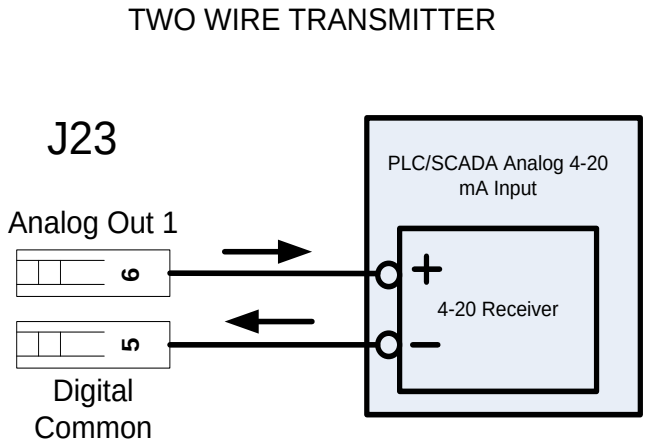


Figure 5-12– Sample Analog Output Connections

5.4 Check Wiring and Close Access Cover

Double-check all of your electrical connections. Pay attention to polarity of all inputs and outputs. Additionally, insure that all terminals are clamping onto the bare conductor and not on its insulation. Ensure that wires will not be trapped or pinched when front cover is replaced and secured. Ensure that excess insulation is not removed from the wires, as this can lead to poor connections or faulty operation.

Close the main access cover and secure the 2 screws.

6. System Configuration

6.1 Overview

Once all electrical connections have been made, your MPC VECTOR is ready for initial setup, calibration, and operation. All setup occurs using the handheld remote user interface. The following sections detail the procedures required to complete the MPC VECTOR configuration.

WARNING

WHEN POWER IS SUPPLIED TO THE UNIT, LINE VOLTAGE IS PRESENT WITHIN THE MPC VECTOR ENCLOSURE EVEN WHEN THE PUMP MOTOR IS OFF.

During Start-up, it is necessary to run the pump motor. This will cause fluid to discharge from the pump. You are responsible for safely diverting flow from the pump during start-up and calibration.

6.2 Critical System Configuration Steps

For proper operation of the MPC VECTOR the following parameters and calibrations must be entered and/or verified (recommended order of setup shown):

Step Number	Parameter(s)	Reference IOM Section

Step 1	Confirm Handheld Remote Operation	Section 6.3 Confirm Display
Step 2	Set flow units	Section 6.5 Flow Display and Units
Step 3 (Optional)	Set AC Line Voltage Only for 200-208 and 380-400 VAC installations	Section 10 AC Input Voltage Setting
Step 4	Set the Pump maximum flow and maximum Speed	Section 6.6 Setting Max Flow and Max Speed
Step 5	Motor parameter setup and calibration (Note: pump rotation may not occur if motor not calibrated)	Section 11 Motor Parameter Setup and Tuning
Step 6 (Optional)	***ONLY IF USING FLOW METER:*** If using closed loop flow control, Flow Meter Activation. Test flow meter 4-20 input	Section 9 Flow Meter Input
Step 7 (Optional)	Activate and Configure Digital Inputs and Outputs	Section 7.2 and 7.4 Digital Input and Digital Output
Step 8(Optional)	Testing Digital I/O	Section 7.2.2 Test Digital Inputs Section 7.4.2 Test Digital Outputs
Step 9	Flow calibration	Section 8.1.1 Open Loop Pump Flow Calibration Section 8.1.2 Closed Loop Pump Flow Scaling and Calibration
Step 10 (Optional)	Analog Output signal setup, test, and calibration	Section 8.1.4 Analog Output Calibration

Step 11 (Optional)	Analog Input #1 signal setup, test, and calibration	Section 7.1 Analog Input Setup Section 8.1.3 Analog Input Calibration

6.3 Confirm Display and Keypad Functionality

NOTE **The example display messages are shown in English for demonstration purposes. If an alternate language has been set, the text is displayed as a translation of the English version.**

Now that you have confirmed that the MPC VECTOR is receiving power, it is necessary to confirm that the display and keypad are functioning properly. On normal power-up, the following display sequence appears.

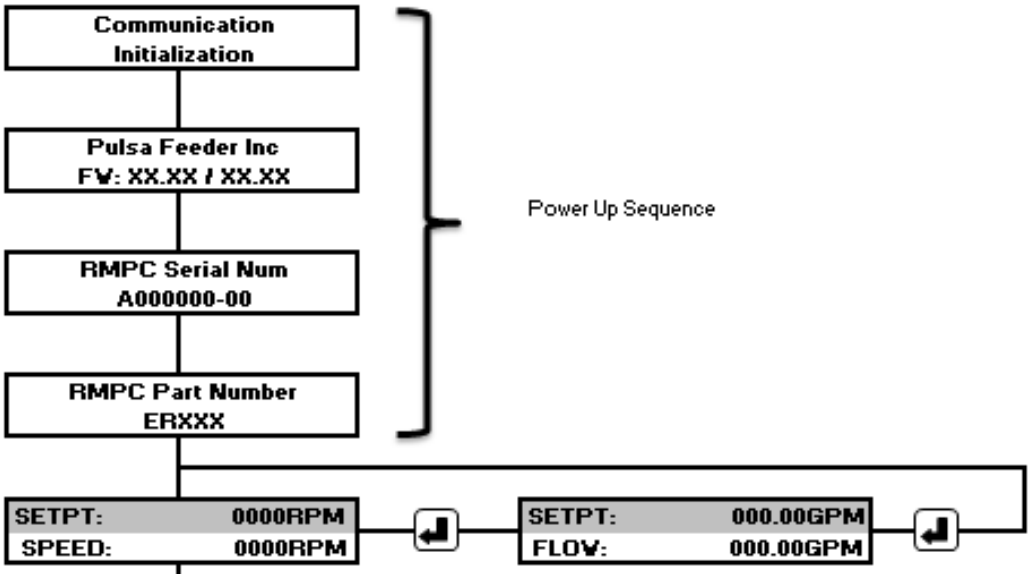


Figure 6-1 ***MPC VECTOR Display Power Up Sequence***

Upon power application the display will show all black squares (approx. 2 seconds). The next four screens show communication initialization, firmware version, serial number, and part number. These parameters are generally set at the factory. The firmware screen has the first four digits displayed as the software revision for the MPC VECTOR control board, and the second four indicate the software revision for the remote board.

NOTE **The revision numbers should be identical for both units. Unpredictable or unstable operation may result with mismatched software revisions.**

Please note that it may be necessary to adjust the display contrast. Please refer to **Section 8.5 Display Contrast Adjustment** if adjustment is required.

6.4 Motor Parameter Setup

The MPC VECTOR controller interfaces closely with the positive displacement pump motor. The MPC VECTOR needs to know certain details about the motor (generally found on the motor nameplate) in order to function properly and optimize performance. End users may have to input or adjust motor parameters before operation. Use the following as a guide:

If you: Have received your MPC VECTOR and positive displacement pump and motor as a unit from the factory,

and Your MPC VECTOR to motor wiring distance is ***less than*** 25 feet

Then you should not have to perform any motor parameter setup or motor calibration. All parameters and setup have been completed for you at the factory.

If you: Are using the MPC VECTOR with a motor that did not come from the factory, ***or***

Your MPC VECTOR to motor wiring distance is ***greater than*** 25 feet,

or

You are replacing the motor on an existing setup

Then you will have to enter the motor parameters, and you will have to perform a motor calibration procedure. Please reference **Section 11 Motor Parameter Setup and Tuning**, before proceeding with operation of your MPC VECTOR controller.

6.5 Flow Display and Units

The MPC VECTOR will display calibrated pump flow in GPH, LPH, GPM, or LPM on the digital display when configured for flow control. The motor speed (in RPM) may also be viewed while in flow control. Changes to the flow units are made in the ***Menu ->System Setup-> Flow Units*** Menu. See **Section 16 Menu Maps** for assistance.

6.6 Setting Max Flow and Max Speed

What is Max Flow?

The value entered into the Max Flow is largely used for display purposes. It limits the flow rates that can be entered via the handheld unit during normal operations, as well as during analog calibration routines and PulsaGuard calibration. Internally it is also used in PID calculations.

What should my Max Flow be set to?

Max Flow can vary for a displacement pumps based on the viscosity of the fluid being pumped and the system pressure. **It is recommended that the Max Flow be set 10% higher than pump rated flow at 0PSI**. This will allow for a full range of flow entry values .

What if I try to set my pump to a flow higher than it can actually achieve for my current pressure and viscosity?

The pump has internal software protections and validations which prevent the motor from exceeding 1800 RPM (approximate). Example: If the pump can only achieve 2.5GPM at 1800 RPM for your system configuration and the flow rate is set to 10GPM, the motor will spin at 1800 RPM and produce 2.5GPM.

What is Max Speed?

Max Speed is the maximum speed that the motor can spin, according to the manufacturer. This is largely unused by the MPC Vector at the moment and will not affect operations. It is recommended that this value is kept at 1800 RPM.

Setting Max Flow (example shown with GPM units)

1) Begin at the main screen displaying the current flow/speed set point

```
SETPT      0.00GPM
FLOW       0.00GPM
```

2) Press the MENU key to access the menus.

```
-MENU-
CALIBRATION
```

3) Press the UP or DOWN arrow keys until you get to System Setup.

```
-MENU-
SYSTEM SETUP
```

4) Press the ENTER key to access System Setup Menus.

```
SYSTEM SETUP

STATUS
```

5) Press the UP key until you see the Information setup option.

```
SYSTEM SETUP

INFORMATION
```

6) Press the ENTER key to access the Information screens.

```
PULSAFEEDER, INC

FW : 1.04/1.04
```

7) Press the UP or DOWN arrow keys until you see Max flow and Speed displayed.

```
MAX:       6.00GPM
MAX:       1800RPM
```

8) Press the Enter key to allow Max Flow to be edited. A blinking cursor will appear

```
MAX:       6.00GPM
MAX:       1800RPM
```

9) Press the UP or DOWN arrow keys to manipulate the flow rate until you reach your max flow.

```
MAX:       8.50GPM
MAX:       1800RPM
```

10) Press the ENTER key to accept the new Max Flow rate. Note that the blinking cursor has moved to the Max Speed location.

```
MAX:      8.50GPM
MAX:      1800RPM
```

11) Press the ENTER key again to save the Max Flow and Max Speed. Note that the blinking cursor should disappear at this point.

```
MAX:      8.50GPM
MAX:      1800RPM
```

6.7 Wrapping up

Your MPC VECTOR is now commissioned for use. Note that you cannot configure the software in a way that would damage the MPC VECTOR. Typically, whenever you are about to set a critical value (e.g., Calibrate Flow), you are always prompted to confirm your change before it takes effect. If you are ever dissatisfied with the configuration of your MPC VECTOR, you can always return to the Factory Defaults by referring to ***Section 6.8*** **Factory Re-Initialization**.

6.8 Factory Re-Initialization

NOTE

Factory Re-initialization is typically not required. When re-initializing your MPC VECTOR, all of the current system settings and calibration information will be overwritten by the original factory default settings. The controller must be re-configured and re-calibrated to your specifications.

A Factory Re-initialization should be performed only if there is reason to believe that the MPC VECTOR is operating abnormally. The condition usually manifests itself with inconsistent or erratic operation – often associated with meaningless characters on the display, or exaggerated numerical values. Commonly, a user has entered incorrect parameters, or made changes to the setup of the control.

Once a re-initialization has been performed, all operating parameters should be checked and adjusted or re-entered as necessary, including maximum flow and rpm, motor parameters, flow and analog signal calibrations, etc.

Factory Re-Initialization:

1. Press the MENU key to access the System Setup Menu

```
-MENU-
CALIBRATION
```

2. Press the UP arrow key to display

```
-MENU-
SYSTEM SETUP
```

3. Press the ENTER key

```
SYSTEM SETUP
STATUS
```

4. Press the UP arrow key twice

```
SYSTEM SETUP
FACTORY INIT
```

5. Press the ENTER key

```
PRESS ENTER
TO FACTORY INIT
```

6. Press the ENTER key

```
ARE YOU SURE?
YES=ENTER  NO=MENU
```

7. Pres the ENTER key

```
RESETTING PUMP
TO FACTORY INIT
```

7. Input/Output Setup

Use the "DIGITAL I/O" and "ANALOG I/O" menus to activate and configure the input and output for the functions required for the application.

Users may also reference **Section 16 Menu Maps** for additional configuration assistance.

7.1 Analog Input Setup

Two Analog Inputs are provided for the User. Analog Input 1 is used for pump set point (flow or speed pacing) input. Analog Input 2 is used for systems configured for analog 4-20 mA flow feedback from a user supplied flow meter.

7.1.1 Analog Input 1 – Set point

Ensure that you have your Analog Input signal connected to the proper location before activating, **See Figure 5-8 *–I/O Terminal Strip Details (Panel & NEMA4x Shown)*– Use Menu->Analog I/O-> Analog Input #1** to activate the analog input signal function. The menu can be used to set the analog input to either ACTIVE or INACTIVE. Proceed to **Section 8.1.3 Set point Calibration and Range Setup** to calibrate your input based upon open or closed loop operation.

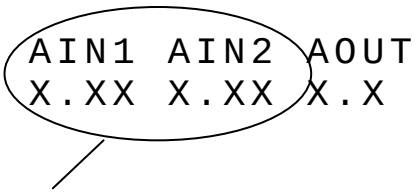
7.1.2 Analog Input 2 – Flow meter Feedback

See **Section 9 Flow Meter Input** for installation instructions. The flow meter input signal must be configured properly prior to use. Use ***Menu* ->*System Setup-> Flow Meter ->Meter Type->Analog*** to enable the process feedback analog input. The flow meter type must be set to "ANALOG" to enable this input. Users may also reference **Section 16 Menu Maps** for additional configuration assistance.

7.1.3 Analog Input Testing

The MPC VECTOR allows for testing of the analog inputs with approximate accuracy. Analog input does not have to be active to use this feature. The user must provide an analog signal from a PLC/SCADA or 4-20mA transmitter/calibrator to the input under test. See **Section 5.3.3.7 Analog Input Wiring Example** for connection. To view the analog input value, proceed to ***System Setup -> Information -> Analog I/O Diagnostics*** screen. See **Section 16 Menu Maps** for navigation if necessary.

Once in the Analog Diagnostics Screen the user will see the following:



AIN1 and AIN2 show the values, in mA's, currently applied to analog input 1 and 2, respectively. Changing the value input from the PLC/SCADA, transmitter/calibrator, or instrumentation (i.e. flow meter) should be reflected in these two input values. If values do not change be sure to check input control wiring (signal is polarity sensitive), PLC wiring, and flow meter connections.

7.2 Digital Input Setup

7.2.1 Multi-purpose Digital Inputs

Each of the 2 Digital INPUTS can be selected as:

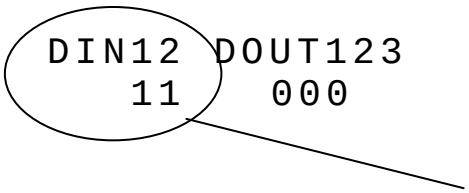
Inactive
Tank Level Input
Leak Detection (using external device)
Remote ON/OFF Input
Flow verification Input

Each can be set as normally OPEN or normally CLOSED. For example, if an input is set to ON/OFF and NORMALLY CLOSED, this means a CLOSED dry contact will activate the pump. A NORMALLY OPEN setup will give the opposite response. These inputs are to be attached to a dry contact circuit only, apply no voltage to these inputs.

7.2.2 Testing Digital Inputs

The MPC VECTOR allows for testing of the two digital inputs. The user must provide a dry contact closure from a PLC/SCADA or a switch to the digital input under test. See **Section 5.3.3.6 Digital Input Example Wiring** for connection details. To view the digital input value, proceed to Menu->System Setup->Information -> Digital I/O Diagnostics. See Section 16 Menu Maps for navigation if necessary.

Once in the Digital Diagnostics Screen the user will see the following



DIN1 and DIN2 show the current values of the digital input on digital input 1 and 2 respectively. A ZERO represents a closed contact in this screen, an open contact will show a ONE. If values do not change be sure to check input control wiring.

7.3 Analog Output Setup

No activation is required for the analog output. The 4-20 mA Analog output is always available at the corresponding terminals (**see Section 5.3.3.8 Analog Output Example Wiring**). The analog output follows and is proportional to percent motor speed. This output must be calibrated for current output (4-20mA) versus percent speed. See **Section 8.1.4** Analog Output Calibration

7.4 Digital Output Setup

7.4.1 Multi-purpose Digital Outputs

Each of the 3 Digital OUTPUTS can be configured to represent:

- ON/OFF Status
- AUTO/MAN Status
- Leak Detected
- Alarm Indicator
- Tank Level Status

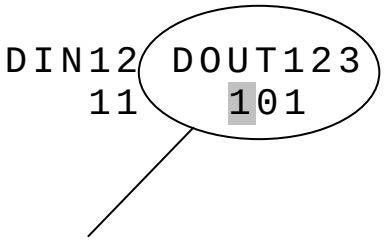
Each output can be set as NORMALLY OPEN (N.O.) or NORMALLY CLOSED (N.C.). For example, if an output is set to ON/OFF status and NORMALLY CLOSED, this means that when the motor is running (indicator lamp is ON) the output will be CLOSED. A NORMALLY OPEN setup will give the opposite response.

Digital output circuits are transistor based and limited to 24 VDC maximum (500 mA current limit per output), see ***Section 5.3.3.5*** **Digital Output Wiring Example (Open Collector/Drain)**, and ***Section 13*** **Specifications** for more information.

7.4.2 Testing Digital Outputs

The MPC VECTOR allows the user to test the three (3) digital outputs. To manually control the digital output values, proceed to ***Menu->System Setup – Information – Digital I/O Diagnostics***. See the **Section 16 Menu Map** for navigation if necessary. The user can select the desired output by pressing the ENTER key. Once an output is selected, the user can change the output by pressing UP/DOWN. Doing so will activate and deactivate the selected output.

Once in the Digital Diagnostics Screen the user will see the following



DOUT123 shows whether the digital output is activated (1) or deactivated (0) on digital outputs 1, 2, and 3, respectively. The example above shows Digital Outputs 1 and 3 activated and 2 deactivated. The user has selected digital output 1 for activation/deactivation.

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8. Calibrations

WARNING **YOUR MPC VECTOR IS NOT FACTORY CALIBRATED AS THE CALIBRATIONS ARE SYSTEM DEPENDENT AND FLOW METER DEPENDENT. YOU MUST ALWAYS PERFORM A CALIBRATION WITH THE MPC VECTOR INSTALLED IN YOUR SYSTEM PRIOR TO USE. FAILURE TO PROPERLY CALIBRATE THE UNIT MAY RESULT IN DAMAGE TO SYSTEM COMPONENTS.**

As a convention in this manual:

"WET" calibration procedures will refer to those that require normal operating conditions, for example:

- the pump running with fluid
- an electrical signal input (i.e. 4-20mA calibrator) provided at the appropriate terminals.

"DRY" calibration procedures are run under non-operational conditions, and often do not require the pump to run or that a specific input signal be present.

Some of the calibration routines may be performed either way. Note any system requirements listed for each routine.

8.1 Pump Flow Calibration

The MPC Vector uses a **two point** pump flow calibration method. This calibration method is used for both open (speed based) and closed loop flow control (flow meter based) systems. For details on theory of operation, refer to **Section 1.2.5 Control Modes.** Refer to **Section 16 Menu Maps** for key press sequences.

8.1.1 Open Loop Pump Flow Calibration

Open loop speed based flow calibration will need two flow rate points and require two drawdown intervals (wet cal only), one at a high speed (max speed recommended) and another at low speed (full turndown recommended). These pump RPM points can be adjusted for flow within your pumps flow rate. In order to use the full speed range (default 10:1 turndown) use the maximum allowable speed range based upon motor turndown.

Note: The following calibration example shows an example pump with measured flow rates of 25 GPH at 1800 RPM and 2.5 GPH at 180 RPM (maximum turndown utilized). These will be the two calibration points used by the system, once calibration is complete.

Below is a flow Calibration Table to aid as an example in recording your two point pump flow information.

	Speed (RPM)	Volume Delivered (GAL)	Time Elapsed (seconds)	Calculated Flow Rate
Point 1	1800	0.416	60 sec	25 GPH
Point 2	180	0.0416	60 sec	2.5 GPH
Your Point 1				
Your Point 2				

For GPH (Gallons Per Hour):

$$Flow\ Rate\ (GPH) = (Volume\ Delivered(GAL) \div Time\ Elasped\ (sec)) \times 3600 sec/hr$$

For GPM (Gallons Per Minute):

$$Flow\ Rate\ (GPM) = (Volume\ Delivered(GAL) \div Time\ Elasped\ (sec)) \times 60 sec/min$$

Shown below is the two point calibration curve for the example data presented in the above table. These values represent the speed-to-flow characterization of your pump. The two speed values, 180 RPM (10%) and 1800 RPM (100%), will correspond to 2.5 and 25 GPH, respectively for this pump. The speed values can be used for set point input calibration, see **Section 8.1.3 Set point Calibration and Range Setup** .

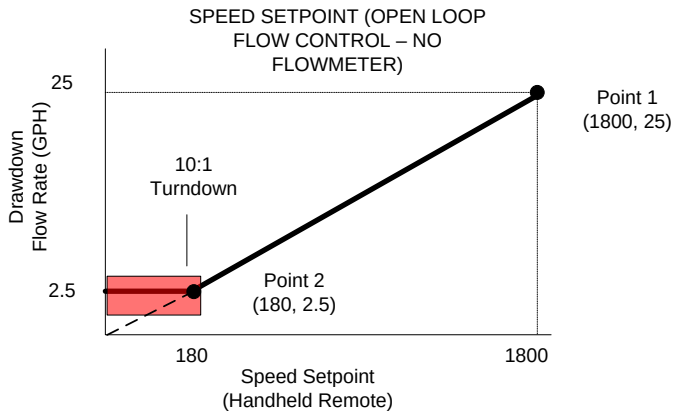


Figure 8-1 Open Loop Speed-to-Flow Calibration Flow Curve

The default drawdown interval is 60 seconds although the user may terminate for shorter intervals. You will be requested to enter your calculated flow rate at the end of each drawdown period.

8.1.1.1 Open Loop Dry Flow Calibration

The open loop ***Dry*** Flow Calibration routine does not require the pump to run. Instead, the user must input 2 known flow rate versus speed points. These points may come from previous calibrations or from a pump data sheet. The user will be prompted for these values. This process can be used for fine adjustment of flow rate display, or in situations where it is not possible or not safe to run the pump during calibration.

Note: A good default entry for pump dry flow is pump maximum rated flow at 1800 RPM and one-tenth of pump maximum flow at maximum speed turn down of 180 RPM.

Proceed with the following steps from the handheld remote:

1. Press the MENU key to access the Calibration Menu.

```
-MENU-
CALIBRATION
```

2. Press the ENTER key to access Pump Flow Calibration screen.

```
CALIBRATION
 PUMP FLOW
```

3. Press the ENTER key to access Dry Pump Flow Calibration screen.

```
PUMP FLOW
 DRY CAL
```

4. Press ENTER to edit the high speed (“HI SPEED” where the default = 1800 RPM) and flow rate calibration point.

```
HI SPEED: 1800RPM
FLOW:     25.00GPH
```

5. Using the UP/DOWN/ENTER keys enter the calibration speed and flow points.
6. Press the ENTER key to accept the calibration flow rate and proceed to the low speed calibration point.

```
LOWSPEED: 180 RPM
FLOW:     2.50 GPH
```

7. Press ENTER to edit the low speed (default=180 RPM) and flow rate calibration point.
8. Using the UP/DOWN/ENTER keys enter the calibration speed and flow points.
9. Press the ENTER key to accept the calibration flow rate and save the two point calibration.
10. At this point, the system will check the dry calibration values, and if the values are acceptable will complete the calibration.

```
PUMP FLOW
CALIBRATED
```

8.1.1.2 Open Loop Wet Flow Calibration

The Open Loop ***Wet*** Flow Calibration routine requires the user to run the pump and record the corresponding flow at two known pump speeds.

Before proceeding, ensure the following:

- That it is safe to run the pump and dispense liquid into the system.
- That the pump is fully primed with the product.
- That the calibration column has enough fluid for the dispensing time to prevent a run dry scenario.
- That you are prepared to record the volume and time interval for 2 draw downs.

Then proceed with the following steps from the handheld remote:

1. Press the MENU key to access the Calibration Menu.

```
-MENU-
CALIBRATION
```

2. Press the ENTER key to access Pump Flow Calibration screen.

```
CALIBRATION
 PUMP FLOW
```

3. Press the ENTER key to access Wet Pump Flow Calibration screen.

```
PUMP FLOW
 WET CAL
```

4. Press the ENTER key to begin Flow Calibration

```
SET MOTOR SPEED
HIGH:  1800 RPM
```

5. Using the UP and/or DOWN arrow keys adjust the motor speed to a high flow speed setpoint. The speed set is the high speed calibration point for the MPC VECTOR that you will measure flow at.
6. Press the ENTER key to accept the calibration speed.

```
PRESS ENTER TO
 START MOTOR
```

THE MOTOR WILL START WHEN THE ENTER KEY IS PRESSED. MAKE SURE THAT YOUR SYSTEM IS PREPARED FOR OPERATIONS BEFORE STARTING THE MOTOR.

7. Press the ENTER key to start the motor. The system advances to the draw down interval count down screen. The default interval will be 60 seconds. At any time, pressing the ENTER key will take the user immediately to the next screen. This allows for shorter drawdowns using the ENTER key. All other keys abort the calibration.

```
RUNNING 60 SECS** (WILL COUNT DOWN)
MOTOR:  1800 RPM
```

**60 SECONDS WILL ELAPSE BY DEFAULT

8. Based upon your drawdown interval and volume dispensed, calculate the high speed calibration flow rate value. Using the UP and/or DOWN arrow keys adjust the flow to your calculated value.

```
FLOW AT 1800RPM
FLOW: 25.00GPH
```

9. Press the ENTER key to accept the calibration flow rate and proceed to the low speed calibration point.
10. Using the UP and/or DOWN arrow keys adjust the motor speed to an approximate low speed setpoint. This speed is the low speed calibration point for the MPC VECTOR that you will measure flow at.

```
SET MOTOR SPEED
LOW:  180  RPM
```

11. Press the ENTER key to accept the calibration speed.

```
PRESS ENTER TO
 START MOTOR
```

THE MOTOR WILL START WHEN THE ENTER KEY IS PRESSED. MAKE SURE THAT YOUR SYSTEM IS PREPARED FOR OPERATIONS BEFORE STARTING THE MOTOR.

12. Press the ENTER key to start the motor and advance to the draw down interval count down screen. The default interval will be 60 seconds. Pressing the ENTER key will take the user immediately to the next screen. Shorter drawdowns are available using the ENTER key. All other keys abort the calibration.

```
RUNNING 60 SECS**
MOTOR:  180 RPM
**60 SECONDS WILL ELAPSE BY DEFAULT
```

THE MOTOR WILL START WHEN THE ENTER KEY IS PRESSED. MAKE SURE THAT YOUR SYSTEM IS PREPARED FOR OPERATIONS BEFORE STARTING THE MOTOR.

13. Based upon your drawdown interval and volume dispensed, calculate the low speed calibration flow rate value. Using the UP and/or DOWN arrow keys adjust the flow to your calculated value.

```
FLOW AT 180 RPM
FLOW: 2.50  GPH
```

14. Press the ENTER key to accept the low speed calibration flow rate.
15. At this point,the system will check the calibration values, and if the values are acceptable will complete the calibration.

```
PUMP FLOW
CALIBRATED
```

8.1.2 Closed Loop Pump Flow Scaling and Calibration

NOTE: Be sure to set flow meter to active. See Section 7.1.2 Analog Input 2 – Flow meter Feedback

Closed loop flow control calibration and scaling requires the following:

- Two calibration speeds of user preference, nominally full range (1800 RPM to high speed turndown)
- A calibrated flow meter with a flow output signal providing flow feedback, a 4-20mA current signal.
- Two flows associated with two these current feedback values (i.e. two calibration points).
    - WET flows come from normal running conditions at two speeds.
    - DRY flows come from the flow meter ZERO AND SPAN settings

The DRY calibration is the default method - if you know your flow meter ZERO AND SPAN flow rate

Example: If you have a pump with a rated capacity of 20 GPH, configure your flow meter span for 25.0 GPH at 20.0 mA and 0.00 GPH at 4.00 mA, then proceed to the closed loop dry flow calibration and enter these two flow versus current calibration values. See Figure 8-2 Example Flow Meter Current Output vs. Flow Rate Curve below as an example of setting your calibration points.

Note: Be sure to set your flow meters span and size your flow meter slightly higher than the rated capacity identified on the pumps nameplate.

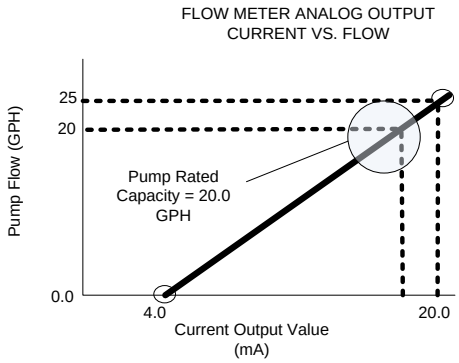


Figure 8-2 Example Flow Meter Current Output vs. Flow Rate Curve

8.1.2.1 Closed Loop Dry Flow Calibration

The closed loop ***Dry*** Flow Calibration routine does not require the pump to run. Instead, the user must input 2 known flow meter flow rates versus current output points. The user will be prompted for these values. This process can be used when it is not possible or not safe to run the pump during calibration.

Proceed with the following steps from the handheld remote:

1. Press the MENU key to access the Calibration Menu.

```
-MENU-
CALIBRATION
```

2. Press the ENTER key to access Pump Flow Calibration screen.

```
CALIBRATION
 PUMP FLOW
```

3. Press the ENTER key to access Dry Pump Flow Calibration screen.

```
PUMP FLOW
 DRY CAL
```

4. Press ENTER to edit the high speed/flow mA reading and corresponding flow rate calibration point.

```
MAX METER: 20.0MA
FLOW:     30.00GPH
```

5. Using the UP/DOWN/ENTER keys enter the calibration mA and flow rate point.
6. After setting the high flow calibration point, press the ENTER key to accept the calibration point and proceed to the low flow calibration point.

```
MIN METER: 4.0 MA
FLOW:      0.0 GPH
```

7. Press ENTER to edit the low speed/flow mA reading and corresponding flow rate calibration point.

8. Using the UP/DOWN/ENTER keys enter the calibration mA and flow points.

9. After setting the low speed calibration point, press the ENTER key to accept the calibration flow rate and save the two point calibration.

10. At this point, the system will check the dry calibration values, and if the values are acceptable will complete the calibration.

```
PUMP FLOW
CALIBRATED
```

8.1.2.2 Closed Loop WET Flow Calibration

The closed loop ***WET*** flow calibration routine will require the user to run the pump and provide system flow at a user selected low and high speed. The controller will monitor the current from the flow meter and store it for both high and low flow readings. The user **must provide the corresponding meter flow rate readout**, providing a two point calibration. Note: The flow meter output current must be configured to be within the 4-20 mA range over the full speed/flow range of the pump. See your flow meter's IOM to set analog 4-20 mA output range versus the flow rate measured.

NOTE **To optimize feedback, it is best to set your flow meter 4mA to 0 flow and 20mA to a value slightly higher (10-20% or so) than your pumps rated capacity. This allows the user a full range of flow set points as well as giving the MPC VECTOR the best possible 4-20mA analog resolution.**

Shown below is the speed, flow, and current graph for the two point closed loop calibration.

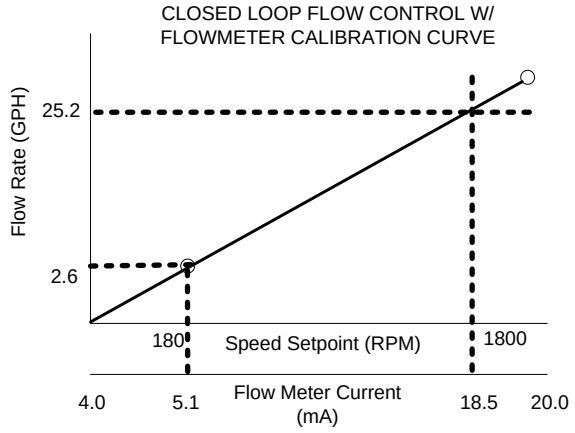


Figure 8-3 Closed Loop Flow Control WET Calibration Curve

Ensure the following:

- That your flow meter is providing output to Analog Input 2.
- That your system is set up for flow meter/closed loop operation. (**See section 5.3.3.7.1 Flow Meter (Analog Input 2)** i.e. flow meter set to analog)
- That it is safe to run the pump and dispense liquid into the system.
- That the pump is fully primed with the product.
- That you are prepared to read the flow rate from your meter. Then proceed with the following steps from the handheld remote:

1. Press the MENU key to access the Calibration Menu.

```
-MENU-
CALIBRATION
```

2. Press the ENTER key to access Pump Flow Calibration screen.

```
CALIBRATION
PUMP FLOW
```

3. Press the ENTER key to access Wet Pump Flow Calibration screen.

```
PUMP FLOW
WET CAL
```

4. Press the ENTER key to begin Flow Calibration

```
SET MOTOR SPEED
HIGH:  1800 RPM
```

5. Using the UP and/or DOWN arrow keys adjust the motor speed to an approximate high speed setpoint. This speed is the high speed calibration point for the MPC MPC VECTOR that you will measure flow at.
6. Press the ENTER key to accept the calibration speed.

```
PRESS ENTER TO
START MOTOR
```

THE MOTOR WILL START WHEN THE ENTER KEY IS PRESSED. MAKE SURE THAT YOUR SYSTEM IS PREPARED FOR OPERATIONS BEFORE STARTING THE MOTOR.

7. Press the ENTER key to start the motor and advance to the calibration interval count down screen. The default interval will be 60 seconds. Pressing the ENTER key will take the user immediately to the next screen. Shorter drawdowns are available by using the ENTER key to terminate at the desired interval. All other keys abort the calibration. Observe the final flow rate on your flow meter at the end of the interval as it must be entered in the next step.

```
RUNNING 60 SECS**
METER:  18.5 MA
```

```
**60 SECONDS WILL ELAPSE BY DEFAULT
```

8. Using the UP and/or DOWN arrow keys adjust the flow to your flow meter's displayed flow rate value at the end of the calibration interval.

```
FLOW AT 18.5 MA
FLOW: 25.2 GPH
```

9. Press the ENTER key to accept the calibration flow rate and proceed to the low flow calibration point.

10. Using the UP and/or DOWN arrow keys adjust the motor speed to an approximate low speed setpoint. This speed is the low speed calibration point for the MPC VECTOR. This speed will produce a low flow and provide a flow feedback signal to the controller. At this speed you will monitor flow rate from the flow meter and enter it via the handheld unit.

```
SET MOTOR SPEED
LOW:  180   RPM
```

11. Press the ENTER key to accept the calibration speed.

```
PRESS ENTER TO
  START MOTOR
```

THE MOTOR WILL START WHEN THE ENTER KEY IS PRESSED. MAKE SURE THAT YOUR SYSTEM IS PREPARED FOR OPERATIONS BEFORE STARTING THE MOTOR.

12. Press the ENTER key to start the motor and advance to the calibration interval count down screen. The default interval will be 60 seconds. Pressing the ENTER key will terminate the calibration interval and take the user immediately to the next screen. All other keys abort the calibration.

```
RUNNING 60 SECS**
METER:  5.1 MA

**60 SECONDS WILL ELAPSE BY DEFAULT
```

13. Based upon your drawdown interval and volume dispensed, observe the final flow rate on your flow meter at the end of the interval as it must be entered in the next step.
14. Using the UP and/or DOWN arrow keys adjust the flow to your observed value.

```
FLOW AT 5.1 MA
FLOW: 2.6  GPH
```

15. Press the ENTER key to accept the low speed calibration flow rate.
16. At this point,the system will check the calibration values, and if the values are acceptable will complete the calibration.

```
PUMP FLOW
CALIBRATED
```

8.1.3 Set point Calibration and Range Setup

Set point calibration and range setup will allow the user to scale and calibrate the 4-20 mA current input for speed or flow, depending upon whether the system is open or closed loop. This calibration and setting of range can be done wet or dry. To perform a ***Wet*** calibration the signal-generating device must be active and capable of generating the full range (4-20 mA) of current input signals. ***Dry*** calibration requires no input signal.

To perform a ***Wet*** set point calibration, you must first correctly wire an external current signal source, to Analog Input #1. Refer to ***Section 5.3.3.7.2*** **Set point** (Analog Input 1).

Set point Range/Calibration for Open Loop Systems (Speed Control)

Set points, applied remotely to Analog Input #1 are used to **adjust motor speed in RPM** when the system is configured for open loop speed control. In the example shown below the user has scaled/calibrated the 4ma signal to correspond to 180 RPM and 20 mA to correspond to 1800 RPM. This scaling configuration uses the full range of pump motor speed available and maximizes the available pump flow rates.

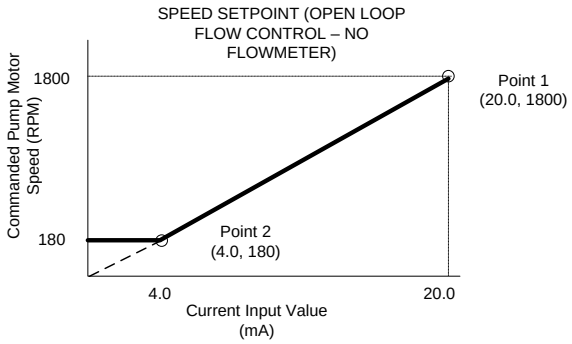


Figure 8-4 Set point Input 4-20 mA Scaling/Calibration (Speed)

Set point Range/Calibration for Closed Loop Systems (Flow Control)

If your system is configured for closed loop flow control (e.g., flow meter feedback), the applied set point input is used to control **the flow rate of the pump**. In the example shown below, the user has scaled/calibrated the 4mA signal to correspond to 2.5 GPH and 20 mA to correspond to 25 GPH. This scaling configuration uses the full range of flow rates available and maximizes the available pump flow rates.

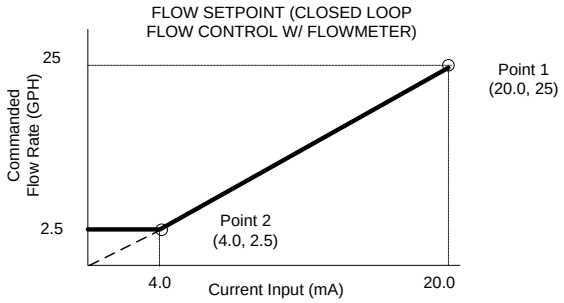


Figure 8-5 Set point Input4-20 Scaling/Calibration (Flow)

If the MPC VECTOR is configured for Closed Loop Flow Control the displays below will show “flow” and scale the 4-20 mA to flow rate. The displays below are currently showing pump flow.

If the MPC VECTOR is configured for Open Loop Flow Control the displays below will show “speed” and scale the 4-20 mA to motor RPM.

Note: The set point input calibration shown below is for closed loop flow control.

8.1.3.1 “WET” Set point Input Calibration (with a field signal)

1. The starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key

-MENU-
CALIBRATION

3. Press the ENTER key

CALIBRATION
PUMP FLOW

4. Press the DOWN arrow key once, to access the analog input calibration

CALIBRATION
ANALOG INPUT

5. Press the ENTER key

ANALOG INPUT

WET CAL

6. Press the ENTER key

APPLY MAX MA

ENTER TO START

7. Apply your desired maximum mA control signal to the MPC VECTOR (usually 20 mA)
8. Press the ENTER key

MAX SETPT 20.0MA
FLOW 25.00GPH

(The mA value will be equal to your signal source/calibrator level)
(The lower line shows the flow or speed set point the MPC VECTOR will use for this signal value)

9. Press the UP and DOWN arrow keys to change the Speed/Flow corresponding to the Analog Input Value.
10. Press the ENTER key once more to accept the calibration value

APPLY MIN MA
ENTER TO START

11. Apply your desired minimum mA control signal to the MPC VECTOR (usually 4 mA)
12. Press the ENTER key

MIN SETPT 4.0MA
FLOW 2.50GPH

(The mA value will be equal to your input signal level)
(The lower line shows the setting the MPC VECTOR will use for this signal value)

13. Press the UP and DOWN arrows to adjust the Speed/Flow corresponding to the Analog Input value.
14. Press the ENTER key once more to accept the calibration value

ANALOG INPUT
CALIBRATED

15. Analog input signal calibration is complete
16. Press the MENU key three times to exit back to the main operating screen.

If you receive the following message:

CURRENT DELTA
OUT OF RANGE

This indicates that there is not a wide enough range between your maximum and minimum analog signals. The minimum signal range is 3 mA. The most likely source of this error is the user did not change the value of the incoming analog signal when moving from the MIN calibration to the MAX calibration.

The analog input signal calibration procedure should be performed again, ensuring that a minimum of 3 mA difference exsists between the MIN and MAX signal levels.

8.1.3.2 "DRY" Set point Input Calibration (keypad only, no signal present)

1. The starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key

```
-MENU-
CALIBRATION
```

3. Press the ENTER key

```
CALIBRATION
 PUMP FLOW
```

4. Press the UP arrow key twice, to access the analog input calibration

```
CALIBRATION
ANALOG INPUT
```

5. Press the ENTER key

```
ANALOG INPUT
WET CAL
```

6. Press the UP or DOWN key

```
ANALOG INPUT
DRY CAL
```

7. Press the ENTER key to access the DRY Pump Flow Calibration routine for ANALOG Flow Meters. A blinking cursor will show you that you are adjusting the Current (mA).

```
MAX SETPT   0.0MA
FLOW:     0.00GPM
```

8. Press the UP and/or DOWN keys to adjust the Current set point.

```
MAX SETPT   20.0MA
FLOW:     0.00GPM
```

9. Press the ENTER key to accept this setpoint. The Cursor will now blink on the second line, indicating that the flow rate at 20.0 mA is the active field. Press the UP and/or DOWN keys to adjust the Flow setpoint.

```
MIN SETPT   4.0MA
FLOW:     0.00GPM
```

10. Press the ENTER key to access the MIN setpoint values. The cursor will blink on the top line indicating that the Current setpoint may be adjusted.

```
MAX SETPT 16.0MA
FLOW:     4.00GPM
```

11. Press the UP and/or DOWN arrow keys to adjust the Max Current setpoint.

```
MAX SETPT 20.0MA
FLOW:     4.00GPM
```

Press ENTER to accept the Current Setpoint. The cursor will blink on the bottom line indicating that the Flow setpoint may be adjusted.

12. Press the UP and/or DOWN arrow keys to adjust the Max Flow setpoint.

```
MAX SETPT 20.0MA
FLOW:     5.92GPM
```

NOTE

You may back out of the DRY calibration routine at any point up to now without saving any calibration settings by pressing the MENU key several times.

Press the ENTER key to save the new Analog Calibration values. Upon completion of Calibration you should see the following screen.

```
ANALOG INPUT
CALIBRATED
```

13. Press the MENU key several times to return to Operation Mode.

8.1.4 Analog Output Calibration

The analog output calibration routine maps the motor speed as % of maximum motor speed configured in **Section 6.5 Flow Display and Units**
The MPC VECTOR will display calibrated pump flow in GPH, LPH, GPM, or LPM on the digital display when configured for flow control. The motor speed (in RPM) may also be viewed while in flow control. Changes to the flow units are made in the Menu ->***System Setup***-> ***Flow Units*** Menu. See **Section 16 Menu Maps** for assistance.

Setting Max Flow and Max Speed of the MPC VECTOR to a 4-20mA output signal. The output signal is NOT proportional to pump flow. If a 4-20mA signal representing flow is required it must be obtained by splitting the flow meter output signal.

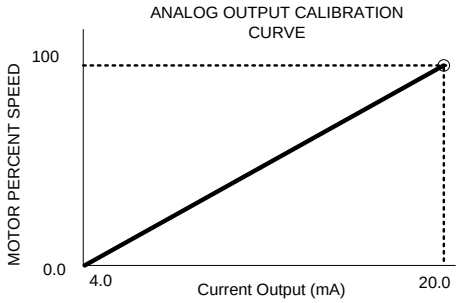


Figure 8-6 Analog Output Scaling/Calibration Curve

1. The starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key

```
-MENU-
```

CALIBRATION

3. Press the ENTER key

CALIBRATION
PUMP FLOW

4. Press the UP ARROW key to access the analog output calibration

CALIBRATED
ANALOG OUTPUT

5. Press the ENTER key

SET 0% SPEED TO
4.0 MA

NOTE **You may measure the output of the analog output during the calibration procedure. Likewise during the calibration the analog output is active and should be seen by your PLC/SCADA system.**

6. Use the UP and DOWN arrow keys to adjust the output signal as required. The value displayed on the screen may not match the actual output signal and is for visual reference only.
7. Press the ENTER key once more to accept the calibration

SET 100% SPEED TO
20.0 MA

8. Use the UP and DOWN arrow keys to adjust as in step 6 above
9. Press the ENTER key once more to accept the calibration value

ANALOG OUTPUT
CALIBRATED

10. Analog output signal calibration is complete
11. Press the MENU key three times to exit back to the main operating screen

<u>If you receive the following message:</u>

CURRENT DELTA
OUT OF RANGE

This indicates that the output current for 0% speed has been set greater than or equal to the output current setting for 100% speed. Repeat the process and ensure that the 0% calibrated signal is set to a value lower than the 100% calibrated signal.

8.2 PulsaGuard Pump Protection

PulsaGuard is designed to turn your pump off when running in dangerous conditions. These conditions are user configurable and can be easily modified to meet each application.

8.3 Closed Loop Flow PulsaGuard Protection

When a flow meter is installed in the system, PulsaGuard will turn off your motor if the present system flow rate is below a user desired low flow threshold for more than 10 seconds. This will protect the pump in under-loaded or overloaded conditions, which would cause the flow to be reduced below the user's acceptable threshold limit.

The MPC VECTOR will also trigger an alarm condition if the flow set point cannot be reached for some reason. This alarm will be displayed on the MPC VECTOR display but will not shut the motor off.

8.4 Open Loop Speed PulsaGuard Protection

If the MPC VECTOR is operating without flow meter feedback PulsaGuard can read the motor current and shut off the pump if the current drops below the shut off level and stays under that level for 10 seconds, effectively protecting equipment from under-loaded conditions.

The PulsaGuard pump protection may be enabled and disabled as desired from the System Setup menus. Note that once a PulsaGuard calibration is performed the pump protection is automatically enabled, you will not have to manually enable it.

8.4.1 PulsaGuard Calibration - Closed Loop Flow Control

1. The starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key

```
-MENU-
CALIBRATION
```

3. Press the ENTER key

```
CALIBRATION
PUMP FLOW
```

4. Press the UP key

```
CALIBRATION
PULSAGUARD
```

5. Press the ENTER key

```
MIN SETPOINT
SETPT:   0.00GPM
```

6. Using the UP and DOWN arrow keys set the low flow setpoint

```
MIN SETPOINT
SETPT:   0.50GPM
```

7. Press the ENTER key to complete the PulsaGuard Calibration.

```
PULSAGUARD
CALIBRATED
```

8.4.2 PulsaGuard Calibrations- Open Loop Speed Control

PulsaGuard may be calibrated WET or DRY. A WET calibration requires that the user simulate underloaded conditions.

Follow Steps 1-4 above. You should see the following screen

```
CALIBRATION
PULSAGUARD
```

5. Press the ENTER key.

```
PULSAGUARD
  WET CAL
```

WET CALIBRATION:

6. Press the ENTER key again to access the WET calibration routine.

```
START MOTOR
YES=ENTR NO=MENU
```

7. Run the pump to meet desired low setpoint conditions. You may adjust the speed of the motor using the UP and DOWN arrow keys. The output current of the motor will be displayed on the screen. In the example shown below, a RPM of 600 RPM creates a motor current draw of 2.0 amps. If the motor becomes underloaded the current will drop below this value, creating a PulsaGuard alarm.

```
MIN SETPT  2.0A
SPEED:   600RPM
```

8. Once the MPC MPC VECTOR has reached the desired low current setpoint, press the ENTER key.

```
PULSAGUARD
CALIBRATED
```

9. PulsaGuard Pump Protection is now calibrated and enabled.

DRY CALIBRATION:

10. Press the UP key.

```
PULSAGUARD
  DRY CAL
```

11. Press the ENTER key.

```
MIN SETPOINT
SETPT:      0.0A
```

12. Use the UP and DOWN keys to adjust the current setpoint.

```
MIN SETPOINT
SETPT:      2.0A
```

13. Press the ENTER key to accept the calibration value.

```
PULSAGUARD
CALIBRATED
```

14. PulsaGuard Pump Protection is now calibrated and enabled.

8.5 Display Contrast Adjustment

Should adjustment of the contrast level of the remote handheld display become necessary, use the following procedure while in the normal operating mode.

To increase contrast, press and hold   at the same time.

To decrease contrast, press and hold   at the same time.

8.6 Tuning the Control Algorithm

<u>This option should only be used by control systems engineers who are familiar with tuning PID loops.</u> This is not intended for the casual user. Changing these values may result in the system oscillating without settling on the set point or never reaching the set point at all. See *Section 21, Appendix 2* for more information and theory on PID control.

The MPC VECTOR allows users to tune the motor control algorithm to speed up or slow down the MPC VECTOR set point response time. This is done by adjusting the PID Controller parameter coefficients.

The user may adjust the Proportional coefficient, k_p, the Integration coefficient, k_i, and the Derivative coefficient, k_d, independently. The user may also view and modify the sampling period of the control loop, t_s.

Modifying the PID coefficients

1. The starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key.

```
     -MENU-
  CALIBRATION
```

3. Press the UP arrow key.

```
     -MENU-
  SYSTEM SETUP
```

4. Press the ENTER key.

```
  SYSTEM SETUP
     STATUS
```

5. Press the DOWN.

```
  SYSTEM SETUP
 PID PARAMETERS
```

6. Press the ENTER key.

```
 PID PARAMETERS
  COEFFICIENTS
```

7. Press the ENTER key.

```
  PROPORTIONAL
     X.XXX
```

8. Press the UP and/or DOWN keys to adjust, k_p.

PROPORTIONAL

0.100

9. Press the ENTER key.

INTEGRAL

X.XXX

10. Press the UP and/or DOWN keys to adjust, k_i.

INTEGRAL

0.050

11. Press the ENTER key.

DERIVATIVE

X.XXX

12. Press the UP and/or DOWN keys to adjust, k_d.

DERIVATIVE

0.050

13. You may back out without saving the new PID coefficients at this point by hitting the MENU key several times to return to the first screen. If you want to save the changes press the ENTER key.

PID PARAMETERS

COEFFICIENTS

14. The new PID coefficients have been set.

Modifying the Sampling Interval, when Flow Meter feedback is used

1. The starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key.

```
-MENU-
CALIBRATION
```

3. Press the UP arrow key.

```
-MENU-
SYSTEM SETUP
```

4. Press the ENTER key.

```
SYSTEM SETUP
STATUS
```

5. Press the DOWN key until you get to the PID screen.

```
SYSTEM SETUP
PID PARAMETERS
```

6. Press the ENTER key.

```
PID PARAMETERS
COEFFICIENTS
```

7. Press the UP arrow key.

```
PID PARAMETERS
SAMPLING PERIOD
```

8. Press the ENTER key.

```
SAMPLING PERIOD
PERIOD:    XXXMS
```

9. Press the UP and/or DOWN arrows to adjust the sampling period, t_s. (Note: value is entered in milli-seconds e.g., 1000 milliseconds = 1 second)

```
SAMPLING PERIOD
PERIOD:    XXXMS
```

10. Press the ENTER key to accept the new sampling period

```
PID PARAMETERS
SAMPLING PERIOD
```

11. The new PID sampling period has been set.

9. Flow Meter Input

The MPC VECTOR accepts flow meter process feedback from an analog (4-20mA) flow metering device. The manufacturer of the flow meter is not important but the process signal must conform to a set of minimum specifications in order to work with the MPC VECTOR. See section 13 Specifications

9.1 Flow Meter Installation and Activation

Prior to installation make sure your flow meter conforms to the MPC VECTOR's flow meter specifications (refer to ***Section* 13 Specifications.** Your flow meter must also be calibrated independently prior to installation.

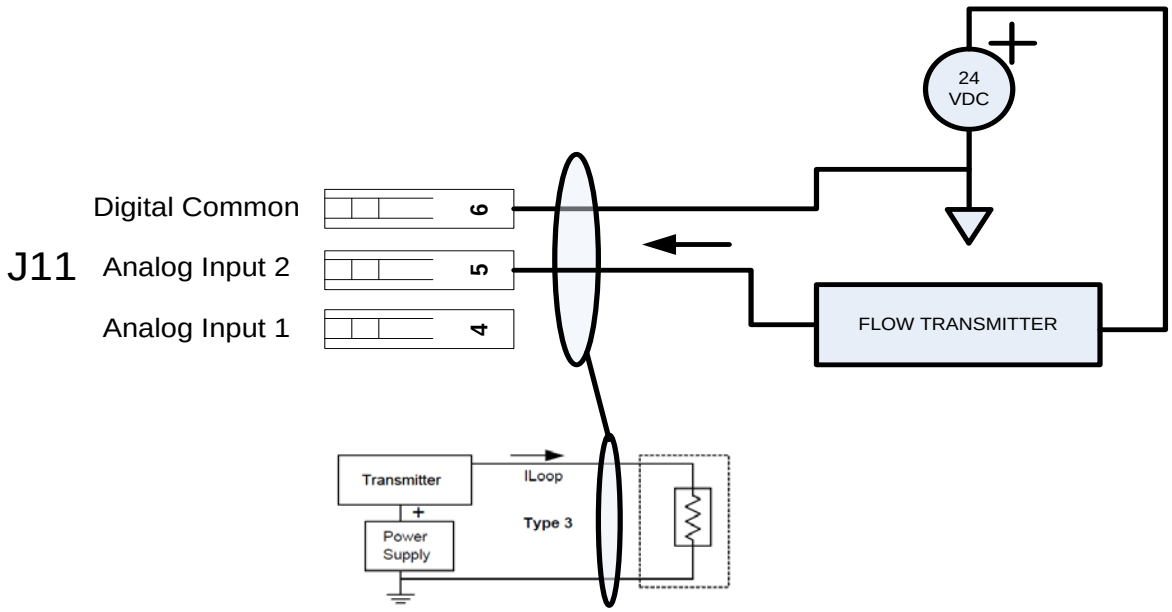


Figure 9-1– Flow Meter Connection

1. The system information is displayed, the starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key

```
-MENU-
CALIBRATION
```

3. Press the UP arrow key

```
-MENU-
SYSTEM SETUP
```

4. Press the ENTER key

```
SYSTEM SETUP
  STATUS
```

5. Press the DOWN key five (5) times

```
SYSTEM SETUP
 FLOW METER
```

6. Press the ENTER key to enter the Flow Sensor setup menus.

```
FLOW METER
METER TYPE
```

7. Press the ENTER key to see the current sensor configuration.

```
SENSOR TYPE
  INACTIVE
```

8. Press the ENTER key to change the sensor type.

```
SENSOR TYPE
<INACTIVE>
```

9. Press the UP arrow key until the analog flow meter option is displayed.

```
SENSOR TYPE
  <ANALOG>
```

10. Press the ENTER key to accept the new configuration.

```
SENSOR TYPE
  ANALOG
```

11. Press the MENU key several times to return to the Main screen.
12. Perform either a WET or DRY Pump Flow Calibration on your MPC VECTOR (see ***Section 8.1.2*** **Closed Loop Pump Flow Scaling and Calibration**).
13. Your MPC VECTOR is now ready for use with your flow meter.

10. AC Input Voltage Setting

Warning: Do not set this parameter if your installation line voltage is 230 or 480 VAC.

If your AC line input voltage is 200-208 VAC or 318-400 VAC then you must set parameter number 01 to a value of 2, indicating low line voltage to the AC drive. The AC drive needs this voltage calibration in order to monitor bus voltages and motor current, ensuring protection of your pump motor.

1. Starting from the main operational screen

```
SETPT       XX.XXX
FLOW        XX.XXX
```

2. Press the MENU key

```
  -MENU-
CALIBRATION
```

3. Press the UP arrow key

```
-MENU-
SYSTEM SETUP
```

4. Press the ENTER key

```
SYSTEM SETUP
STATUS
```

5. Press the DOWN key

```
SYSTEM SETUP
TCF PARAMETERS
```

6. Press the ENTER key

```
PARAM     01
VALUE      1
```

7. Press the ENTER key

```
PARAM     01
VALUE    <1>
```

8. Press the UP arrow key

```
PARAM     01
VALUE    <2>
```

9. Press the ENTER key

```
PARAM     01
VALUE      2
```

10. Press the MENU key

```
TCF PARAMETERS
ACTIVE
```

11. Approximately 2 seconds

```
SYSTEM SETUP
TCF PARAMETERS
```

12. Press the MENU key several times to return to main operational screen
13. Your MPC VECTOR is now ready for use with lower voltage ratings of 200-208 or 318-400 VAC.

11. Motor Parameter Setup and Tuning

The MPC VECTOR controller must know several motor characteristics before the motor can be calibrated. This calibration allows the controller to maintain precise control over the operation of the motor.

Note that the ranges listed in the table below reflect absolute min/max accepted by the drive and may not match a specific application. These do not have to be set in any particular order but will be presented sequentially by the User Interface. The parameters will need to be entered in each field if the MPC VECTOR controller was shipped without a motor, or if the motor is changed to a different model than was originally supplied.

SETTING THESE PARAMETERS IMPROPERLY AND RUNNING THE AUTO-CALIBRATION ROUTINE CAN RESULT IN DRIVE ERRORS.

Reference motor parameter table, next page

Param.	Name	Description	Range	Typical	Note
85	Motor Rated Speed	Nameplate RPM Rating	300 – 65,000 RPM	1800 RPM	
86	Motor Rated Amps	Nameplate FLA Rating	0.0 – 480 Amps	Various	1
87	Motor Rated Volts	Nameplate Voltage Rating	0 – 600 Volts	230/480 VAC	
88	Motor Base Frequency	Nameplate Frequency	25 – 500 Hz	50 or 60 Hz	
91	Motor Power Factor(PF)	Nameplate Power Factor	0.4 – 0.99	Approx 0.8	2
81	Invoking this parameter begins the auto-calibration routine				

Figure 11-1 Motor Parameters

NOTES:

1. FLA = Full Load Amps
2. The ***Power Factor,*** also known as Cosine Phi will sometimes be on the nameplate as ***"PF"***. If the Power Factor is given as a percentage (%), always use the decimal equivalent (for example a power factor of 84% would be entered as 0.84) If the Power Factor is not provided by the motor manufacturer, one of the following formulas may be used.

$$(1)\ PowerFactor = \cos\left[\sin^{-1}\left(\frac{Magnetizing\ Current}{Motor\ Current}\right)\right]$$

$$(2)\ PowerFactor = \frac{Motor\ HP \times 746}{Motor\ Efficiency \times Motor\ Voltage \times Motor\ Current \times 1.732}$$

After all of the Parameters have been entered, the drive needs to perform an auto-calibration routine. This calibration routine will take several seconds to complete. The user may use the Menu Key to back up and/or out of the calibration any time prior to the auto calibration. The motor, and therefore the pump, will ***not*** run during this auto-calibration procedure.

11.1 Motor Parameter Setup and Calibration

1. Navigate to the CALIBRATION menu and press ENTER, and scroll (UP/DOWN) to the MOTOR PARAM option. The starting display will be:

```
CALIBRATION
MOTOR PARAM
```

2. Press the ENTER key

```
MOTOR RATED RPM
<1750>
```

3. Use UP and DOWN arrows to adjust value as required, then press the ENTER key

```
MOTOR CURRENT
<1.2>
```

4. Use UP and DOWN arrows to adjust value as required, then press the ENTER key

```
MOTOR VOLTAGE
<230>
```

5. Use UP and DOWN arrows to adjust value as required, then press the ENTER key

```
MOTOR FREQUENCY
<60>
```

6. Use UP and DOWN arrows to adjust value as required, then press the ENTER key

```
MOTOR PWR FACTOR
<0.80>
```

7. Use UP and DOWN arrows to adjust value as required, then press the ENTER key

```
ENTER TO START
```

8. Press the ENTER key (**Note: calibration may take up to a minute)**

```
CALIBRATING
```

9. The last screen will show

```
MOTOR PARAM
CALIBRATED
```

10. Upon completion of the routine, remove power from the MPC VECTOR controller for one minute, and then re-apply power to complete the process.

12. Alarm and Error Messages

If a fatal error has occurred while in Operational Mode, the error will flash on the screen and the Red LED will also flash. The menus can still be accessed by pressing the menu key. This allows the user to try and fix the source of the error if possible.

12.1 Error Log

As each error occurs an entry is saved in an Error Log. You may view the four most recent errors as well as the current status through the System Setup Menus.

12.1.1 Viewing the Error Log

1. The starting display will be:

```
SETPT      XX.XXX
FLOW       XX.XXX
```

2. Press the MENU key

```
-MENU-
CALIBRATION
```

3. Press the UP arrow key

```
-MENU-
SYSTEM SETUP
```

4. Press the ENTER key

```
SYSTEM SETUP
STATUS
```

5. Press the ENTER key again to view the current status

```
--NO—
--ERROR—
```

6. Press the DOWN key to view the most recent system error

```
ALARM
LEAK DETECT
```

7. Continue pressing the DOWN key to scroll through the 4 most recent errors.
8. Press the MENU key at any time, while viewing either current status or Log entries, to exit the Error Log.

Once you see 'NO ERROR' in the Error Log (the screens AFTER current status) there will be no errors in any of the subsequent positions. If the pump turns off for any reason check the Error Log to see any messages that were reported. Some errors may clear themselves from the screen, but the entry will still be in the Error Log.

12.1.2 Clearing Error Log Entries

Any of the entries in the Error Log may be cleared while viewing by pressing the ENTER key. If the problem is recurring or still present it may not be clearable.

12.2 Alarm and Error Message System Behavior

The following table gives an example of these messages and when you can expect them to be displayed.

Message	Displayed When:	Error Clearing/Pump Response
FATAL ERRORS: The pump and controller will not run while one of these error conditions exists. The Red LED will blink and the error message will flash on the screen. Users can access the menu system by pressing the MENU key. The red LED and the message will cease when the error condition has been corrected.		
Analog Input #1 Out of Range	The analog input is less than 2.4 mA or greater than 24 mA	Self-Clearing- Pump motor will stop and remain stopped until the signal is between 2.4 and 24mA. The pump will resume speed or flow when the signal is returned.
FLOW METER SIG.LOW/MISSING	The flow meter feedback signal (Closed Loop Operation) has fallen below 2.5 ma or is missing.	Self-Clearing – Pump motor will stop, closed loop operation will cease. Once signal is returned closed loop flow operation will continue.
--ALARM-- LOW LEVEL	The tank level monitoring digital input has triggered	Self-Clearing – Pump motor will stop when a tank level input is activated. When the tank level input is deactivated, the pump motor will start automatically in remote mode. Manual mode requires a pump restart (on/off pressed)
--ALARM-- LEAK DETECTED	The leak detection monitoring digital input has triggered.	Self Clearing/Self-Latching – Pump motor will stop when the leak detection input is activated. When the leak input is deactivated, the pump motor will not start and will require a manual restart.
PUMP FLOW NOT DETECTED	The flow detection monitoring digital input has triggered. (Only available in open loop mode)	Not Self-Clearing (Latched) – Pump motor will stop. Pump may not be restarted until cleared. Pump must return to manual mode in order to be restarted. (Remote restarts on flow not detected not allowed)
--ALARM-- AC DRIVE FAULT	Internal fault	Not Self-Clearing (Latched) - Pump Motor will stop. Record AC drive error code on AC drive LED screen and Consult Factory. Cycle power to attempt to clear fault.
AC DRIVE FAULT COMMUNICATION	Communication error exists between the MPC VECTOR controller and the AC DRIVE	Self-Clearing – Pump motor will stop after 10 seconds of loss of communications between the controller and AC drive. When communications are restored the pump will restart.
COMMUNICATION --ERROR--	Communication error exists between the MPC VECTOR controller and the keypad/display module	Not Self-Clearing (Latched) – In Manual Mode the pump will stop after a 20 second interval if communication is not restored. In Remote Mode the pump will continue to run when communications is lost between the keypad and controller.
--ALARM-- PULSAGUARD	Flow has fallen below or not gone above user defined low flow threshold for 20 seconds.	Not-Self Clearing – Pump motor will stop, closed loop operation will cease. In manual (local) mode the pump must be restarted with the on/off key. In remote mode the pump will keep attempting to restart after each PulsaGuard alarm is recognized.

Continues next page…

NON-FATAL ERRORS: The pump and controller can still be run while these conditions exist. The Red LED will flash and the error will flash on the screen. The Red LED and error message will cease once the error condition has been corrected.	
PUMP FLOW OUT OF RANGE	The flow set point has not been attained for duration of 60 seconds. (Closed Loop Operation Only) Self Clearing - Pump Motor will continue to run, showing a pump flow out of range error message. Once actual flow meets the flow set point the warning will clear.
CONSULT factory Error = ####	Unidentified error, record error number and consult factory
USER NOTIFICATIONS: These are errors in setup or calibration. They will display on the screen for several seconds. They can be corrected by properly completing the procedure involved.	
Cannot access With motor on	User is trying to change a setting that cannot be changed while the pump is running. Press motor on/off key to turn motor off.
Current delta Out of range	Not enough difference between high and low signals during an analog input signal calibration (min 3 mA)
No remote Control	User is trying to activate the AUTO mode, but the analog input is not active or remote on/off is not configured for the controller.

For unlisted or numbered error codes, consult the factory for assistance.

13. Specifications

Control Inputs	*Wiring*	*Specification / Description*
Analog In #1	J11 pins 4(+) and 6(-)	4-20mA control signal Max current 30mA; Input resistance 200 Ohm Internally protected with self resetting fuse Minimum signal accepted = 2.4 mA Maximum signal accepted = 24 mA
Analog Flow Meter Input	J11 pins 5(+) and 6(-)	4-20mA flow meter feedback signal Max current 30mA; Input resistance 200 Ohm Internally protected with self resetting fuse Minimum signal accepted = 2.4 mA Maximum signal accepted = 24 mA
Digital In #1	J11 pins 1-3	User to provide dry-contact input *
Digital In #2	J11 pins 2-3	User to provide dry-contact input *

***Do not apply power, maximum 2K Ohm resistance to register as "active"**

Digital input functions:

1. Remote on/off control of pump
2. Level input from supply tank
3. Leak Detection with external device
4. Flow detection with external device

Control Outputs	*Wiring*	*Specification / Description*
Analog Out #1	J23 pins 5-6	4-20mA output for pump flow indication Max voltage out 12 Volts; Max current out 30mA; Max load resistance 300 Ohm Internally protected with resettable fuse
Digital Out #1	J23 pins 1-4	Transistor-based output, various functions *
Digital Out #2	J23 pins 2-4	Transistor-based output, various functions *
Digital Out #3	J23 pins 3-4	Transistor-based output, various functions *

* **All digital outputs maximum 24 VDC, maximum 500 mA**
NOTE: requires external power source

Digital output functions:

1. Triggering an external relay due to a fault condition
2. Auto/Manual status
3. On/Off status
4. Leak Detected
5. Tank level status indication

Input Voltage: Nominal: 230 (208/240 acceptable range) VAC
Nominal: 480 (400/480 acceptable range) VAC

	Note: factory configured only for correct input voltage range (specified at time of purchase) Single Phase or Three-Phase (Single-Phase not available for 5 hp) 50 or 60 Hz.
Tolerance:	Input voltage +10%/-15% maximum
	Input frequency range 48 Hz to 62 Hz
Motor Req:	Commercially available motor supplied by the manufacturer of the pump controller
	See Section 14 for motor selection requirements
Motor Distance:	Maximum motor to controller distance is 100 feet (30.5 meters) For distances greater than 25 feet (7.6 meters) see motor information, next page Consult factory for distances greater than 100 feet (30.5 meters)
Keypad:	Mounted to MPC VECTOR main enclosure, can be made remote from the enclosure, maximum of 1000 feet
Display:	Backlit 2 line extended temperature 16 character LCD
Enclosure:	NEMA 4X and IP56 ratings and open chassis panel mount option available
Altitude:	3300 Ft (1000 M) above sea level (derate 5% HP for each additional 3300 feet)
Humidity:	0-90% (non-condensing)
Temperature:	0^{o} C (32^{o} F) Minimum operating temperature
	40^{o} C (104^{o} F) Maximum operating temperature
Earth Leakage Current:	Size Earth Leakage Circuit Breakers (ELCB) to a detection level of 30 mA or greater

14. Pump Motor Selection

Your MPC VECTOR pump controller can accept **input power** in the at frequency ranges of both 50 and 60 Hz power. This allows your controller to be run from 50 and 60 Hz line frequency locales. Your motor supply frequency may be 50 or 60 Hz and is independent of your supply input frequency as the motor's input supply frequency is generated by the AC drive. Maximum synchronous motor speed (derived from the frequency of operation); however, will directly affect your pump flow capacity (maximum flow rate). In general, 60 Hz motors will have a theoretical synchronous speed of 1800 RPM while 50 Hz motors will be 1500 RPM. The speed difference theoretically results in a pump capacity reduction of approximately 17%.

14.1 General Specifications

All motors used with the MPC VECTOR controller must meet these minimum specifications:

- 50 or 60 Hz 3-phase input power AC induction motor
  - 208/230 VAC for 208/240 VAC Input Voltages
  - 400/460 VAC for 400/480 VAC Input Voltages
- 1800 rpm (60 Hz) or 1500 rpm (50 Hz) synchronous speed
- Service Factor 1.05 or greater
- Class F Insulation (minimum)
- Refer to your equipment specifications and documentation for the correct frame size
- Motors may or may not need feet and/or a C-face mount depending on equipment

14.2 Motor Type and Turndown Requirements

Motor turndown is defined by the ratio of motor base speed to the slowest speed used in the pump application. Pump application specifics will determine the motor type and turndown required to drive your pump.

Motor turndown ratings are dependent on the application and intended use of the pump. Users should understand and take into account the following factors when considering motor selection:

- Application required turndown ratio
- Motor Cooling
- Length of wiring between the MPC VECTOR controller and the pump (motor)

Application Turndown

Shown below are the typical motor types and recommended maximum turndowns. The user must ensure that the positive displacement pump application can operate over the turndown range (that is max flow to turndown flow) effectively in order to fully utilize the turndown range of the motor. Shown below are the typical motor types and recommended maximum turndowns.

Motor Type	Typical Turndown
Commercial Duty Motor	2:1
Premium Efficiency Motor (Inverter Ready) *	4:1 – 10:1
Inverter Duty Motor*	Up to 15:1
Vector Duty Motor	Up to 20:1

*All motors must be inverter ready per NEMA Standard MG1 Part 31, failure to comply may result in premature motor winding breakdown and motor failure.

Motor Cooling

Motor cooling will be dependent upon motor selection. Premium efficiency motors will generally provide cooling from a shaft mounted fan. Typical motor type would be Totally Enclosed Fan Cooled (TEFC). Motors of this type should use a maximum turndown of 10:1 as low speed operation leads to inefficient fan cooling, resulting in premature bearing and winding failure. Inverter Duty and Vector Duty motors are designed to be used for lower speed (higher turndown) applications and generally are Totally Enclosed Non Ventilated (TENV). Cooling is provided via convection and a large heat sinking motor enclosure.

Motor to Controller Cable Distance

Motor to controller distance in all cases should be minimized. AC drive motor control waveforms are formed from a DC bus and are "chopped" to create an AC control waveform. These waveforms create motor wiring high voltage spikes. These spikes are made worse with longer cabling (due to impedance mismatch and the corresponding reflected waveform, dv/dt). These reflected waveforms can easily double the voltage seen by the motor windings.

Cable Length	**Minimum Required Motor Turndown Rating**	
MPC VECTOR to motor **less** than 25 feet (7.6 meters)	Use ratings guidelines in chart above	
MPC VECTOR to motor **greater** than 25 feet (7.6 meters)	**4:1 or 10:1 turndown**	**20:1 turndown**
	Must use 10:1 inverter duty rated motor	Consult factory

NOTE: the maximum pump to controller distance is 100 feet (30.5 meters). If longer distances are required, please contact the factory. Line and load reactors can be utilized to allow operation over longer distances.

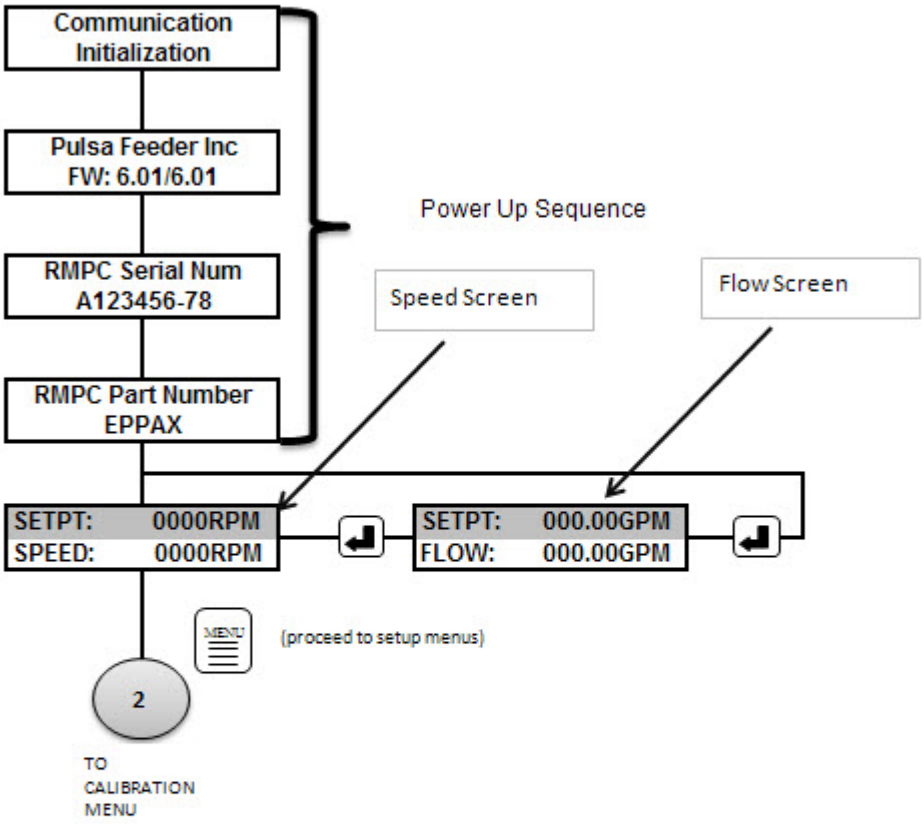
15. Model Identification

Position	Sample	Specifies	Options
1 and 2	**EP**		**EP** – MPC VECTOR
3	**C**	Enclosure Type	**C** – Enclosure meets NEMA 4X specifications
	P		**P –** Panel Open Chassis, Remote NEMA 4X
4	**B**	Motor HP/Input Voltage Rating *	**A** - Fractional to 1.0 Hp (0.75kW); Drive Input: 208-230 VAC **B** - 2 Hp (1.5 kW); Drive Input: 208-230 VAC **C** - 3 Hp (2.2 kW); Drive Input: 208-230 VAC **D** - 5 Hp (3.7 kW); Drive Input: 208-230 VAC (3-phase only) **E** – Fractional to 1HP (0.75kW) – 480 VAC (3 phase only) **F** – 2 Hp (1.5 kW); Drive Input: 480 VAC (3 phase only) **G** – 3 Hp (2.2 kW); Drive Input: 480 VAC (3 phase only) • **H** – 5 Hp (3.7 kW); Drive Input: 480 VAC (3-phase only)
5	**X**	Language	**X** – English (default) **A** - German **B** - French **C** - Spanish

*** Reference specific motor selection requirements in Section 14.1 General Specifications**

16. Menu Maps

START UP / OPERATING SCREEN



Denotes adjustable parameter

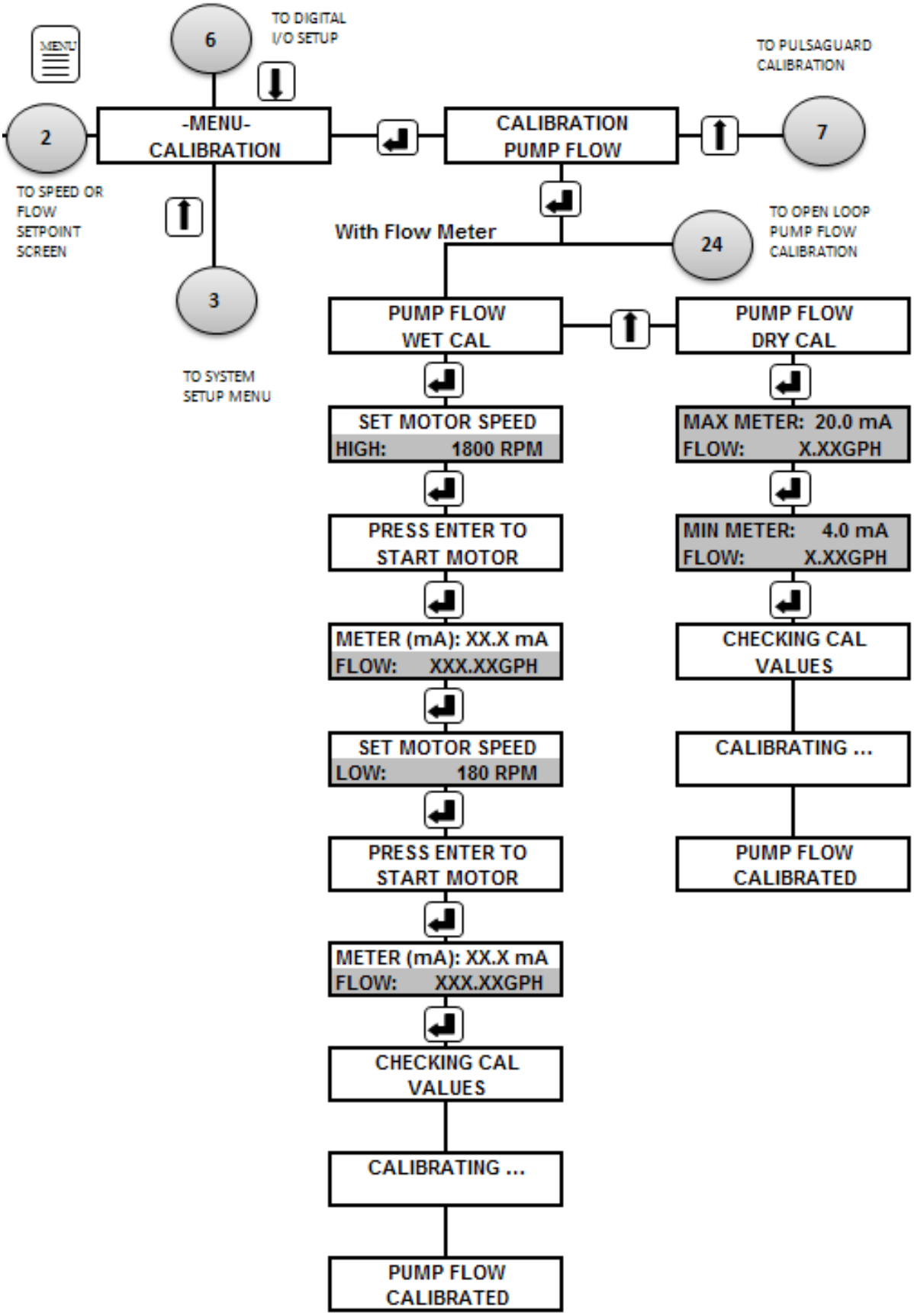
Note: For closed loop systems using a flowmeter, only the flow setpoint may be adjusted.

Menu Key allows user to enter menu mode and brings the user back to previous menu

Enter Key takes the user to the next screen and enter values

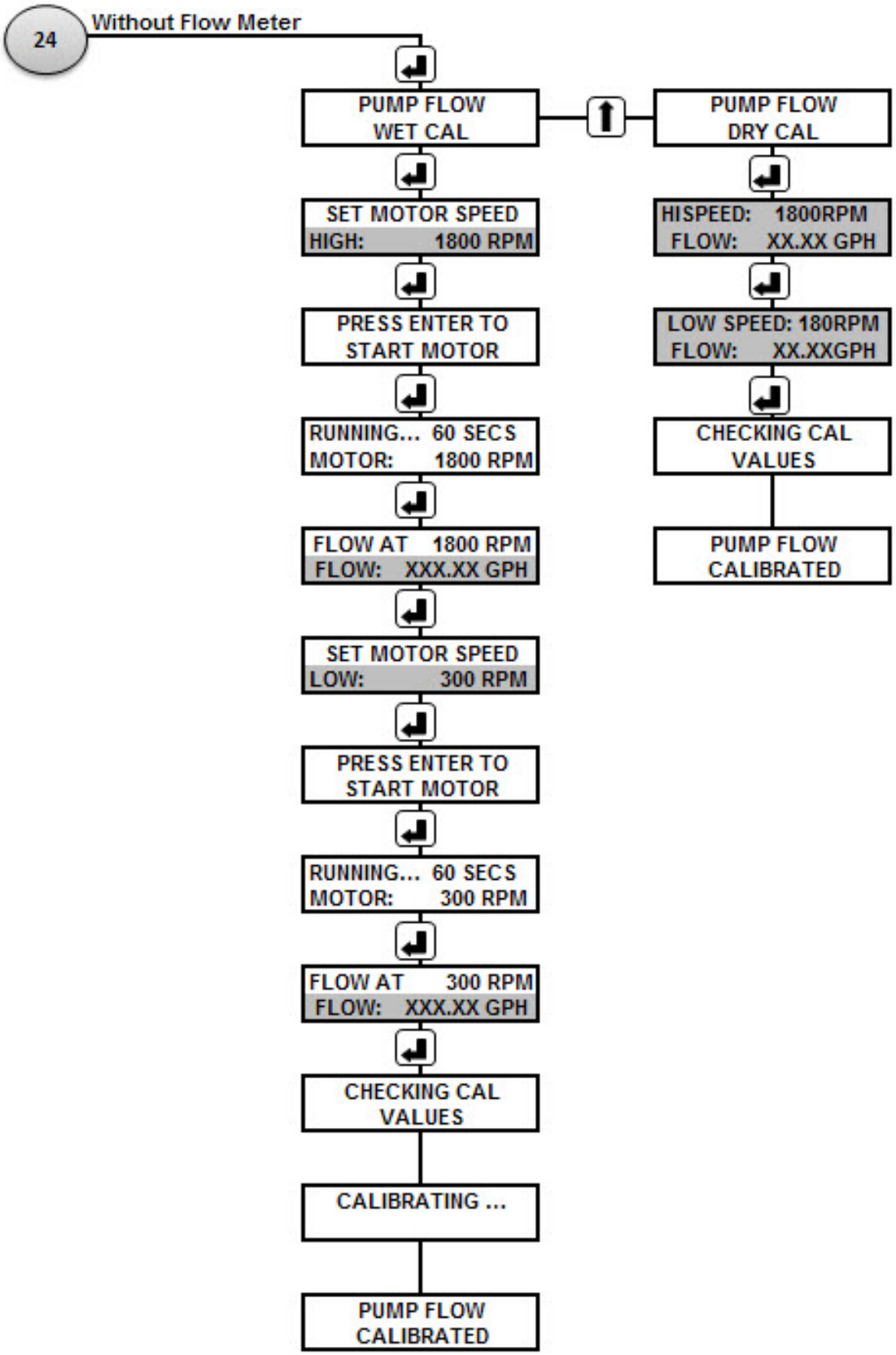
Up/Down Keys allow adjustement of parameters and menu selection

CLOSED LOOP PUMP FLOW CALIBRATION

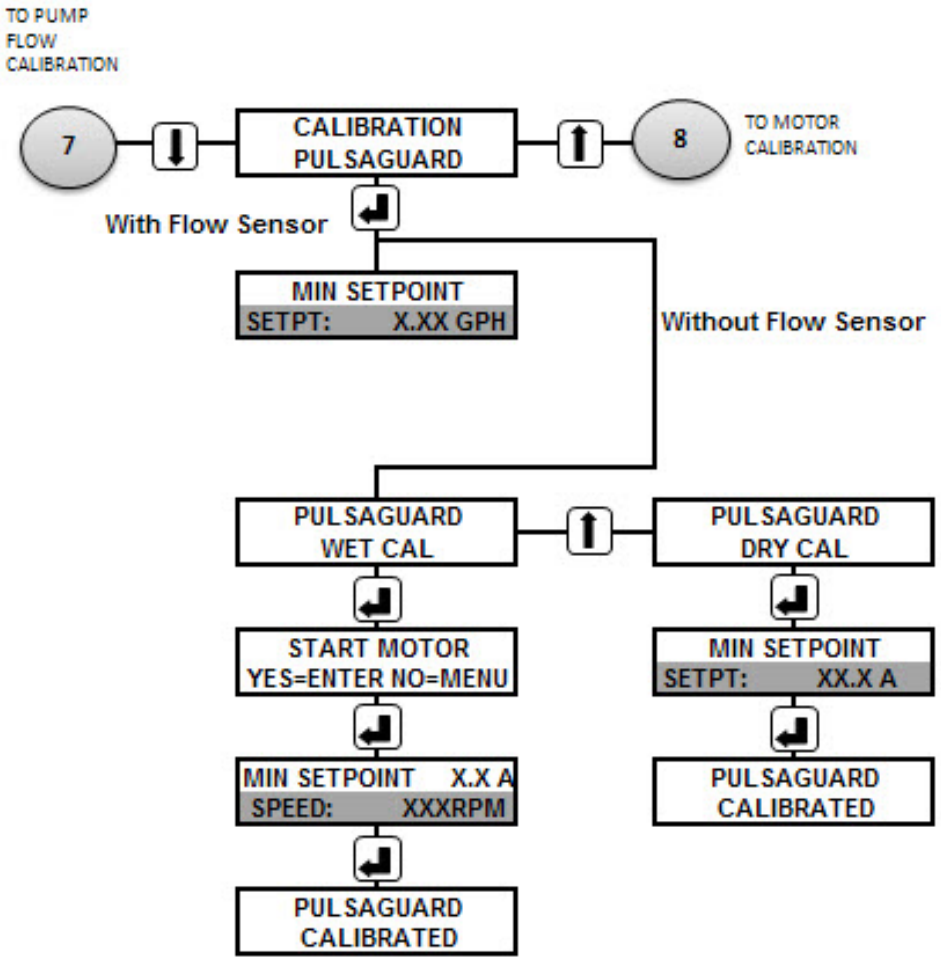


OPEN LOOP PUMP FLOW CALIBRATION

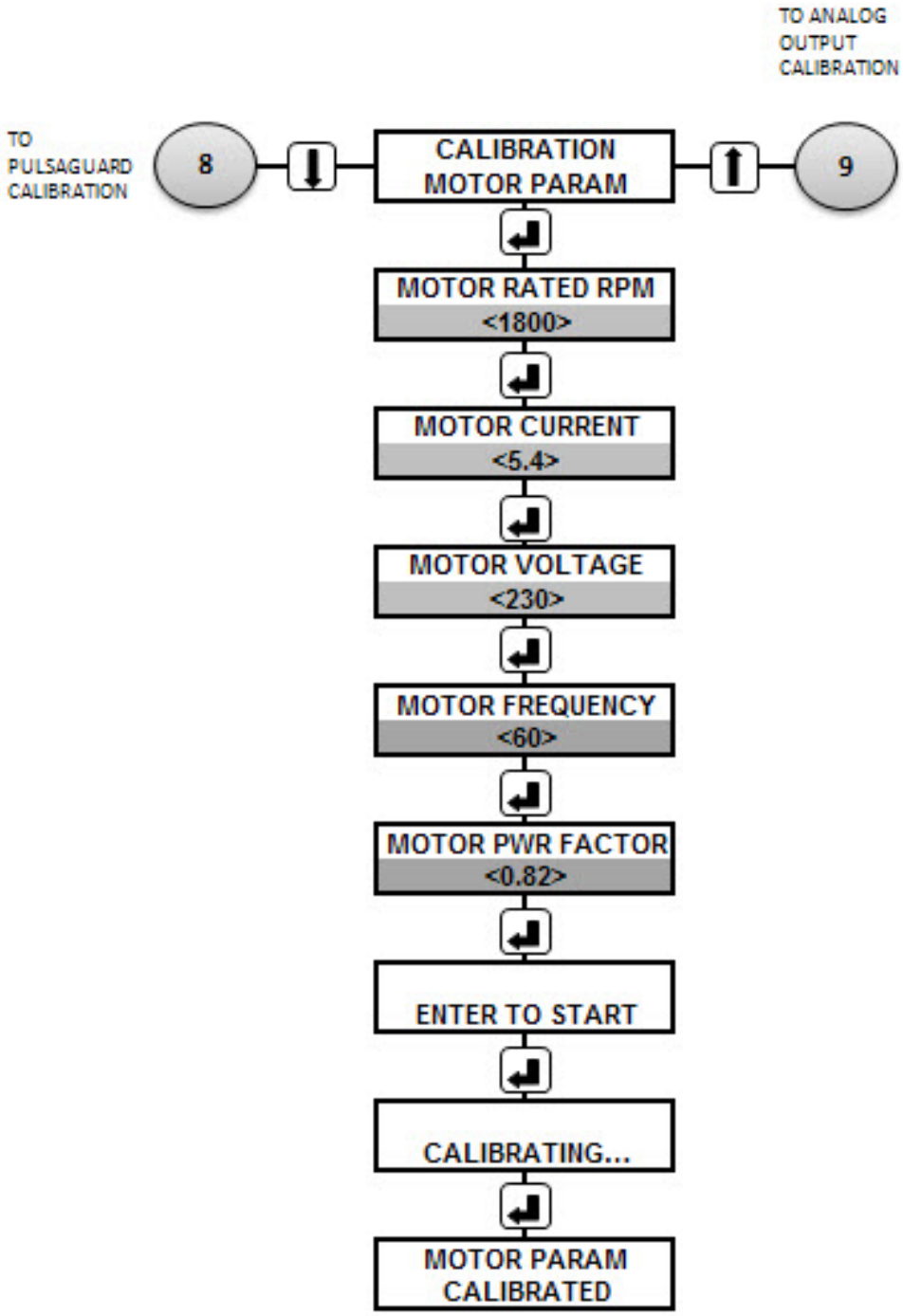
Note: see closed loop pump flow calibration for systems with a flow meter



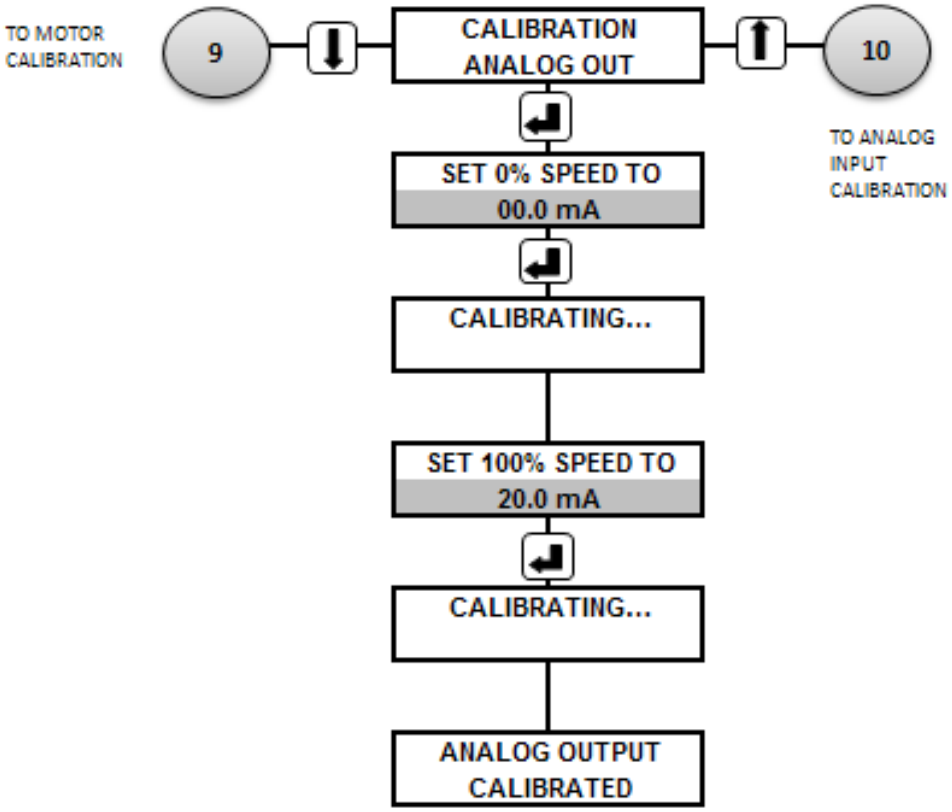
PULSA GUARD CALIBRATION



MOTOR CALIBRATION

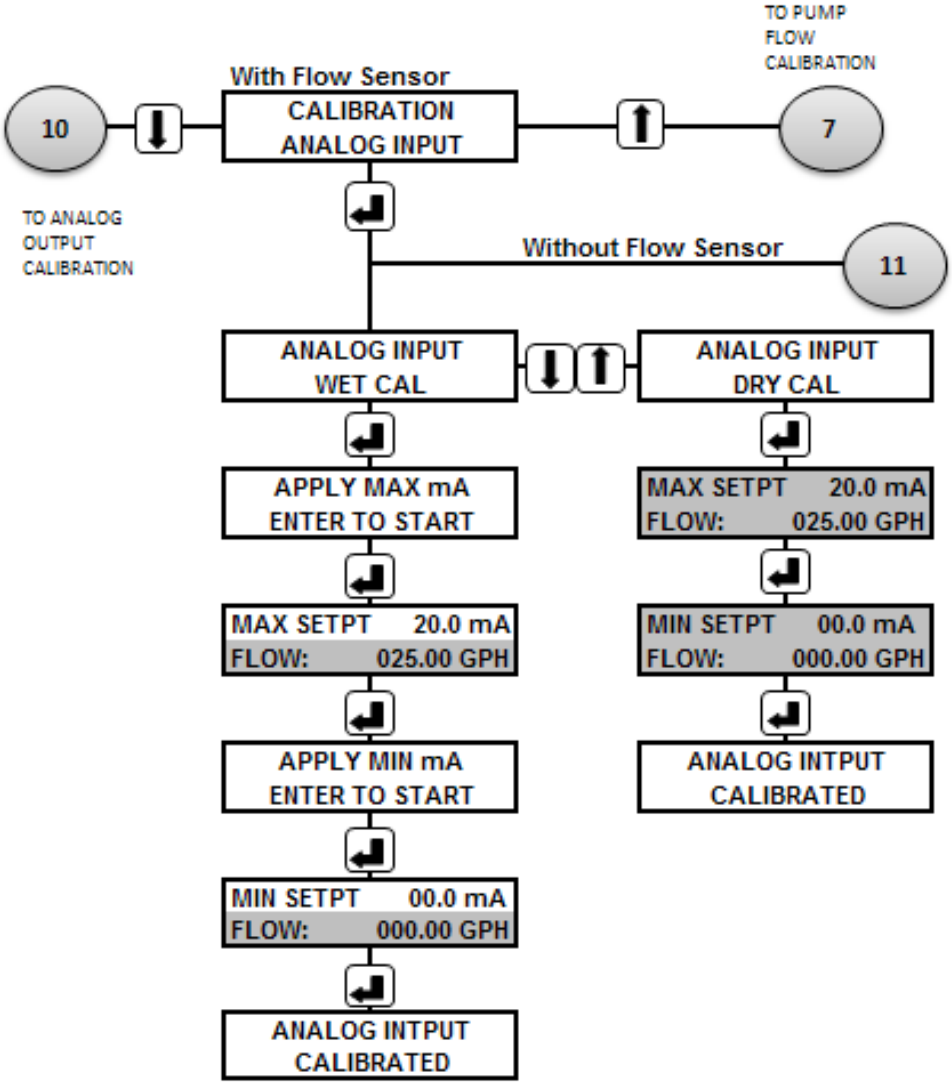


ANALOG OUTPUT CALIBRATION



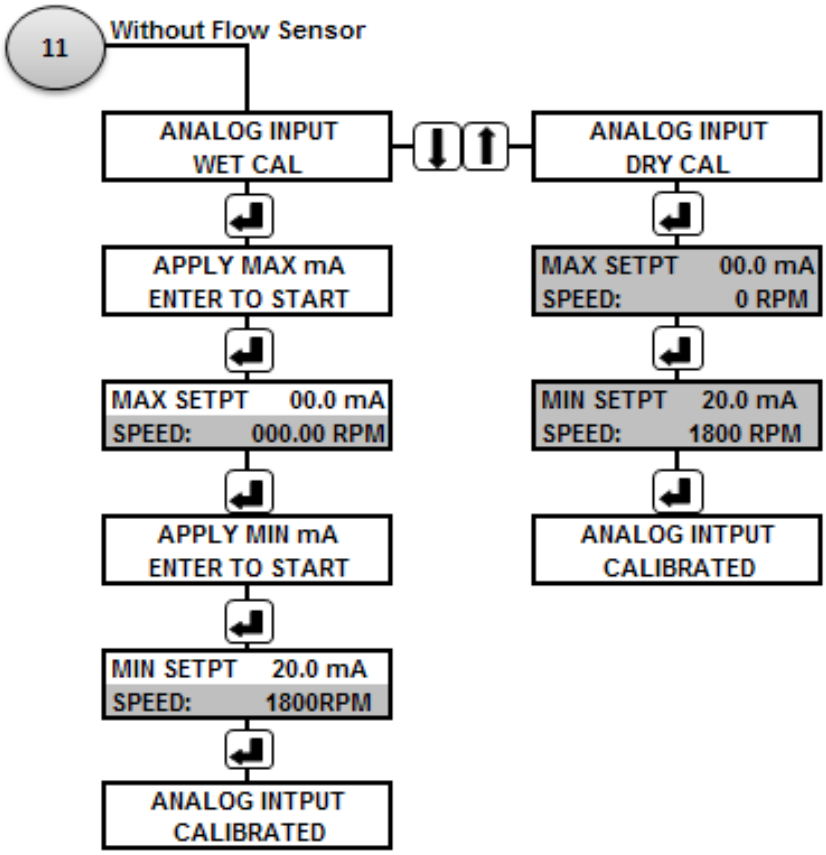
ANALOG INPUT CALIBRATION (CLOSED LOOP) - FLOW**

**Note: System must have a flow meter for closed loop operation

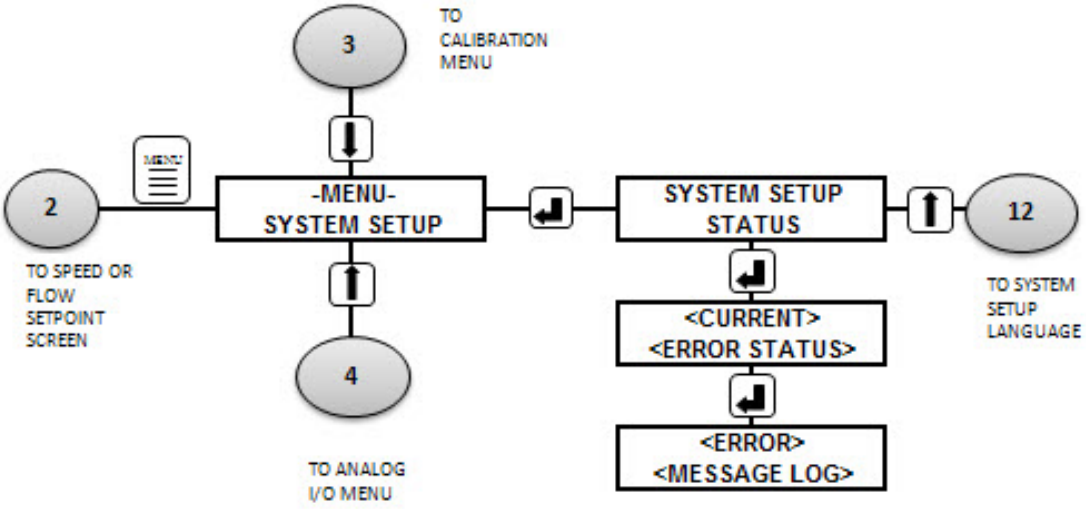


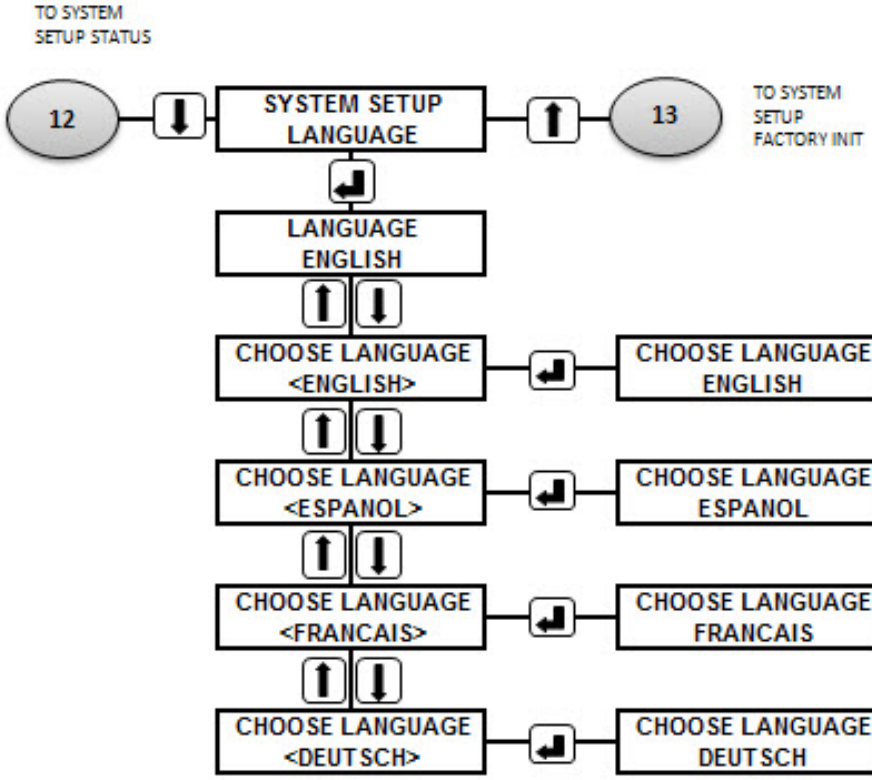
ANALOG INPUT CALIBRATION (OPEN LOOP) - SPEED

**Note: System does not have flow meter (speed control only)

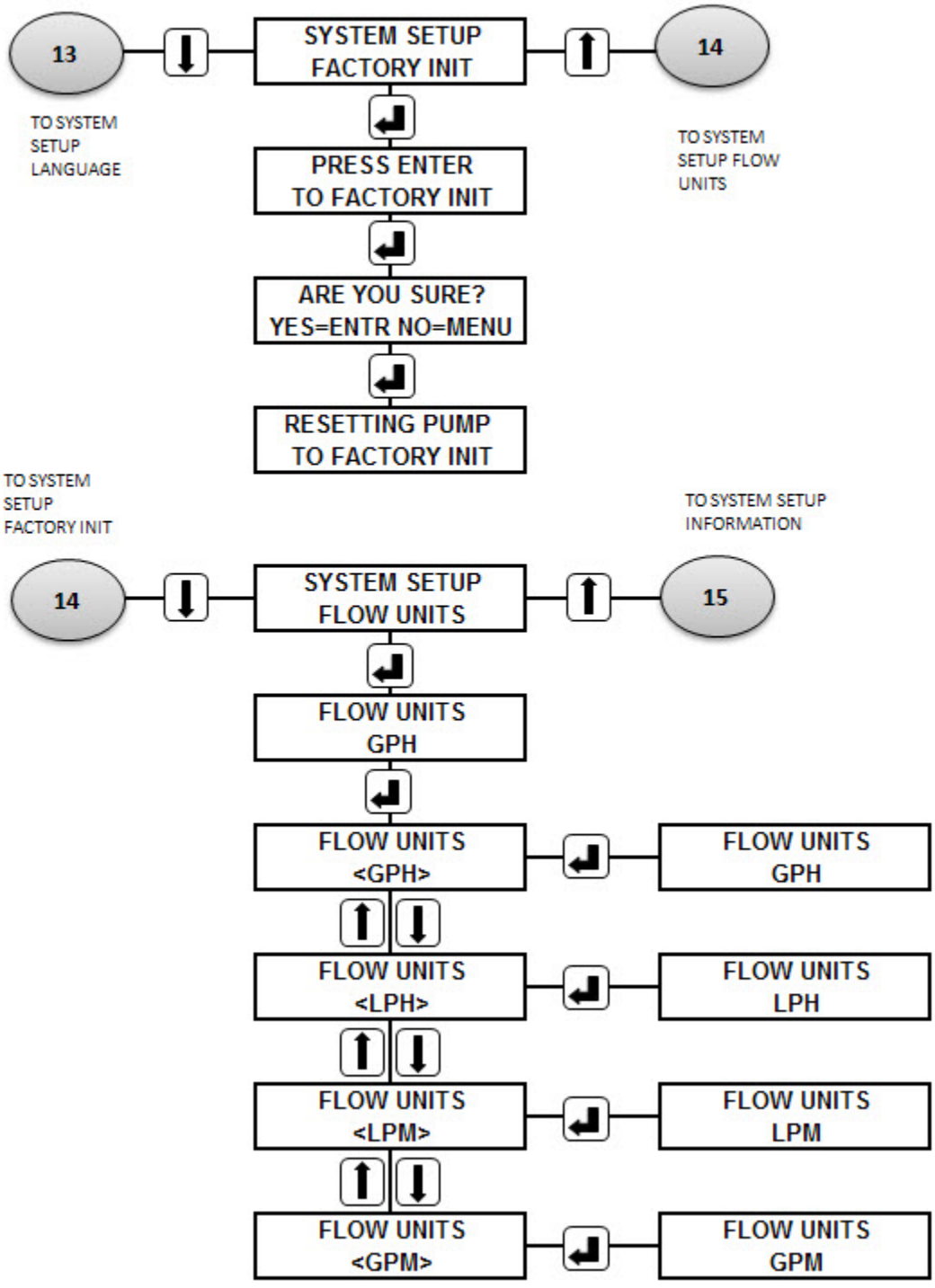


SYSTEM SETUP - STATUS & LANGUAGE

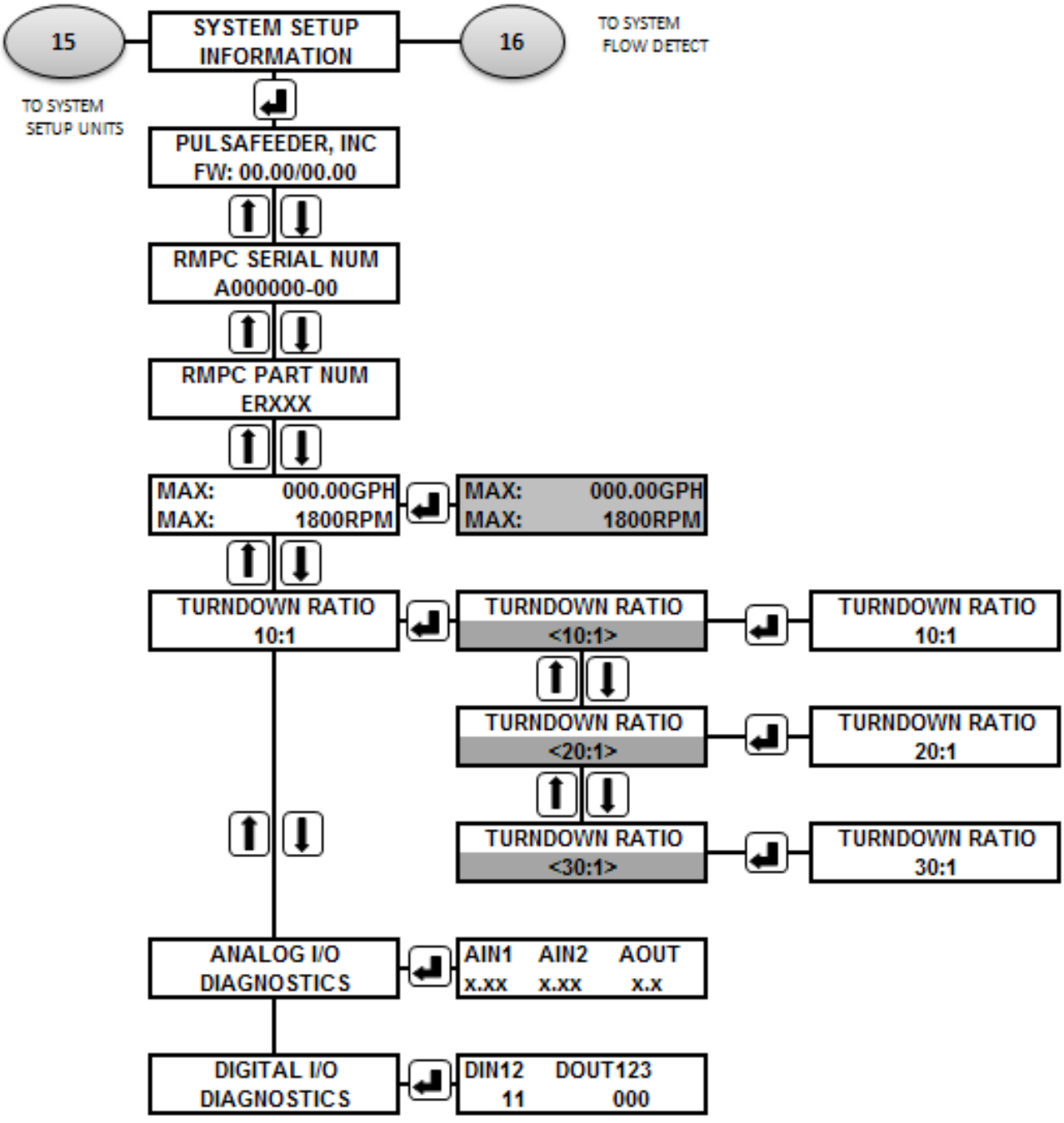




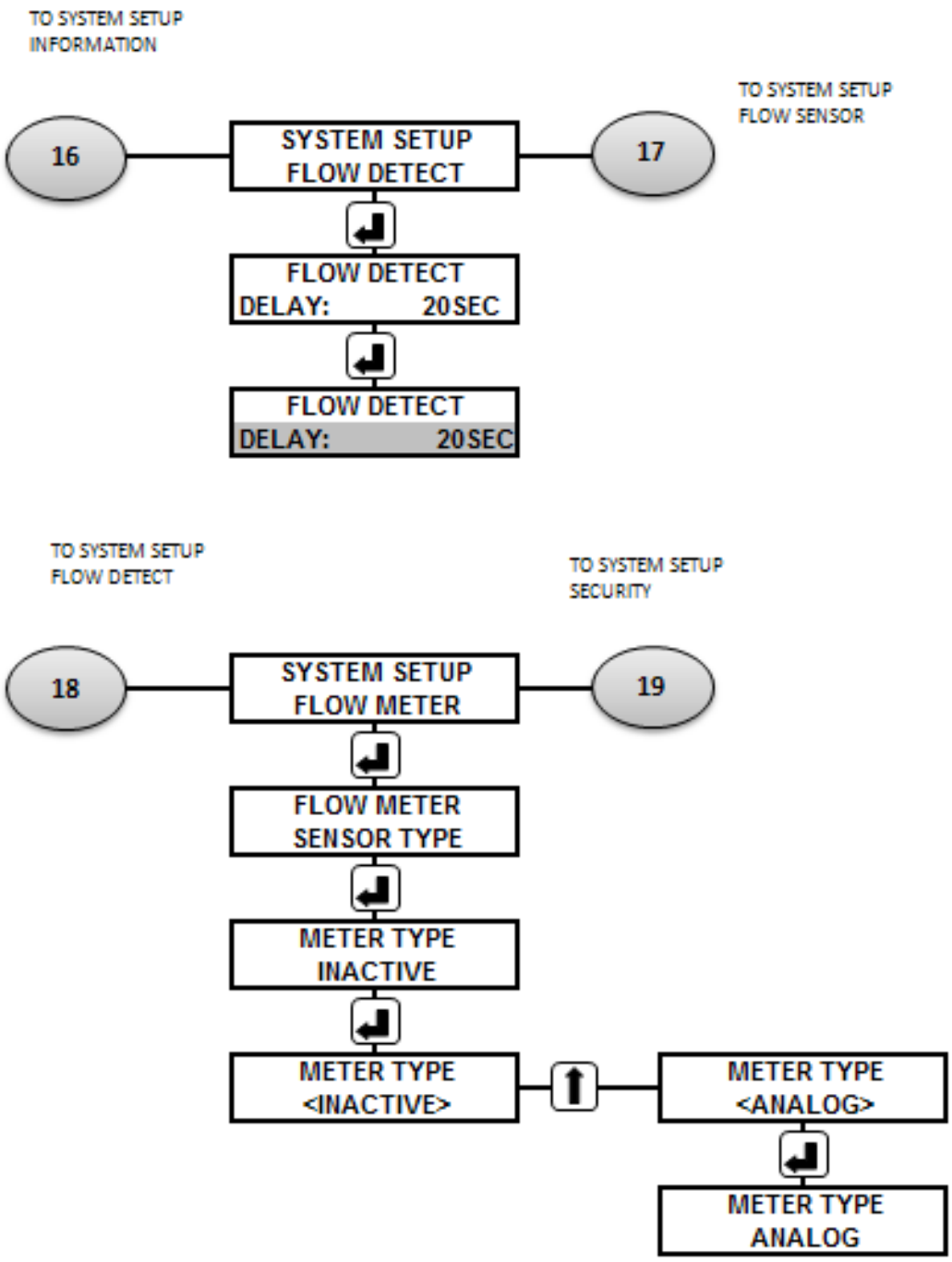
SYSTEM SETUP - FACTORY INIT & FLOW UNITS



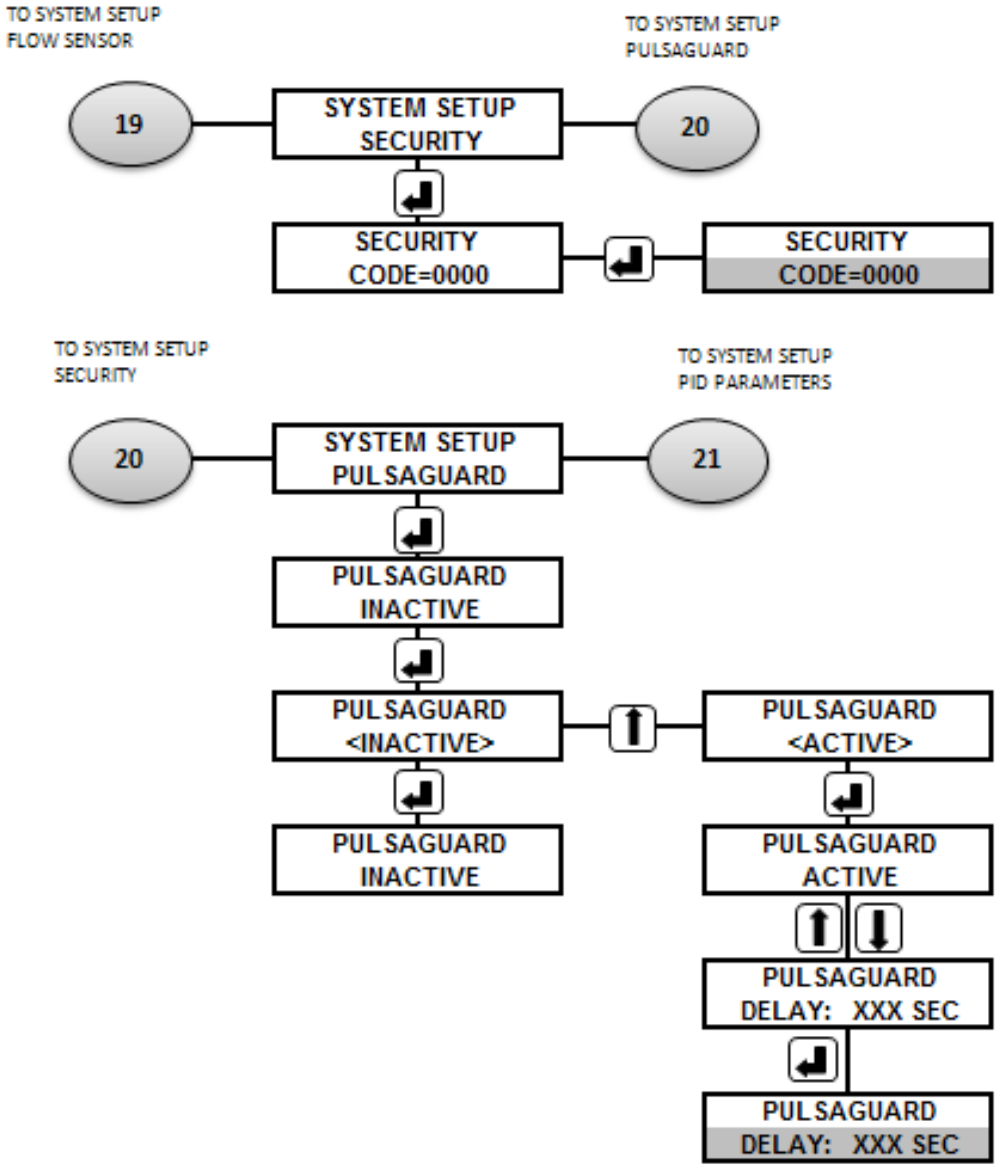
SYSTEM SETUP - INFORMATION



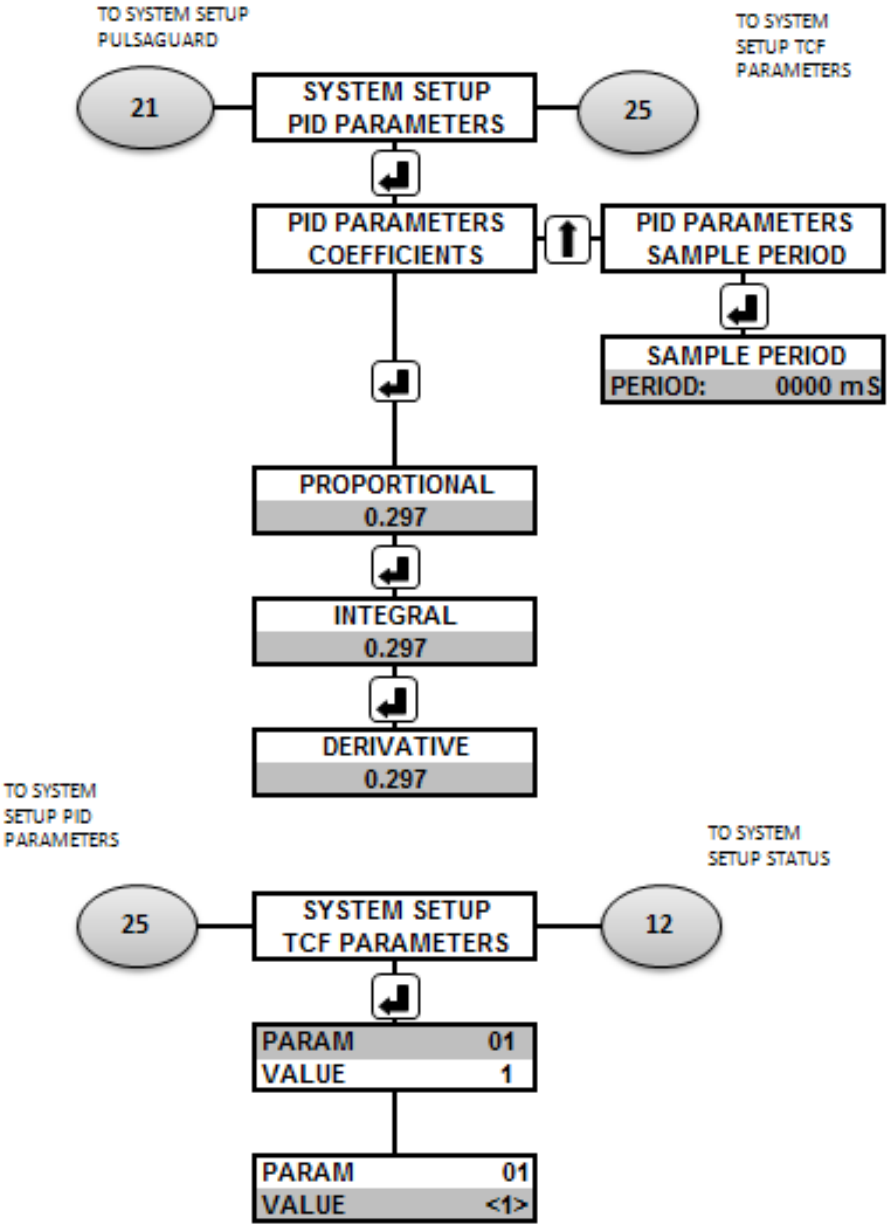
SYSTEM SETUP - FLOW DETECT & FLOW SENSOR



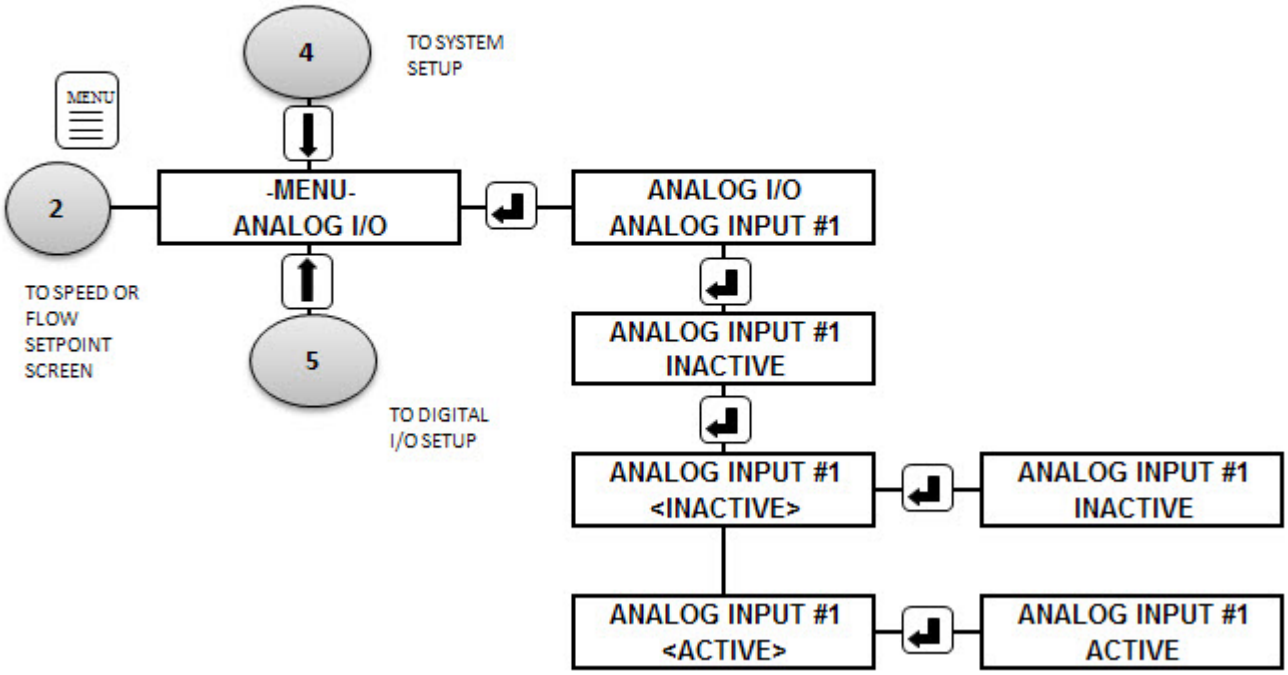
SYSTEM SETUP - SECURITY & PULSAGUARD



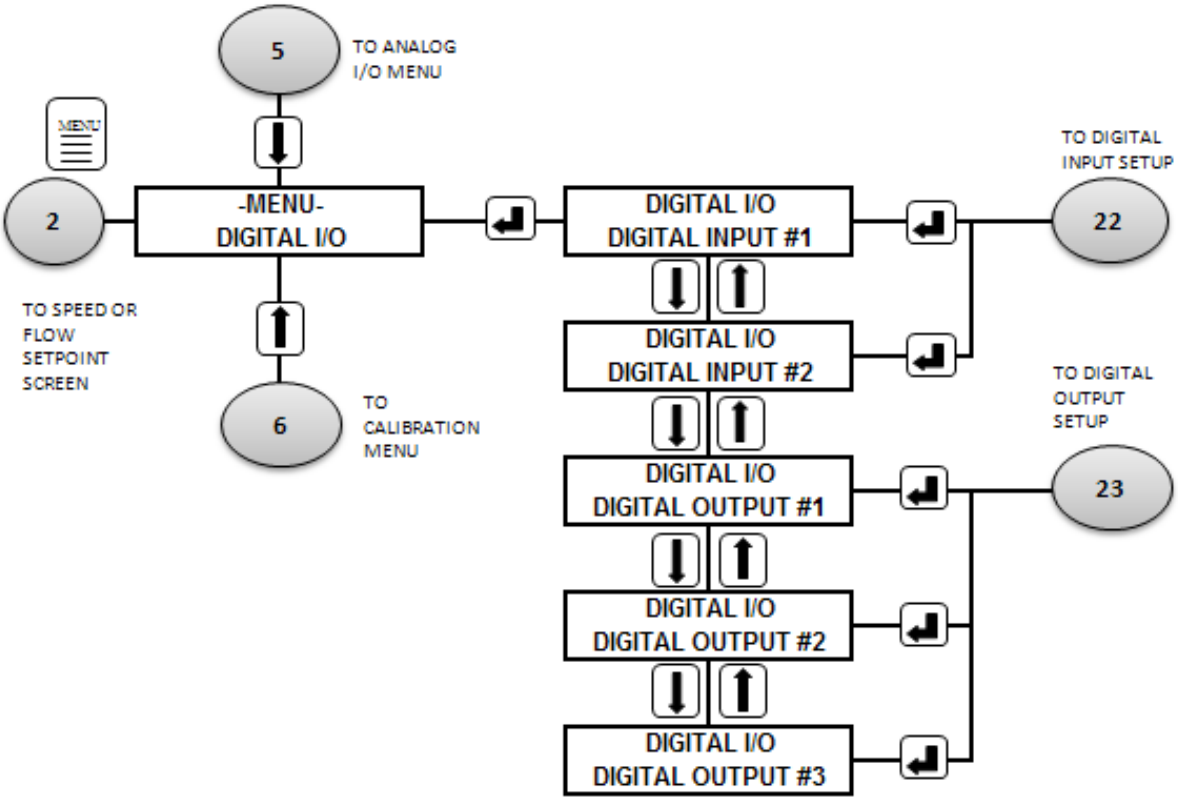
SYSTEM SETUP - PID AND TCF PARAMETERS



ANALOG I/O MENU

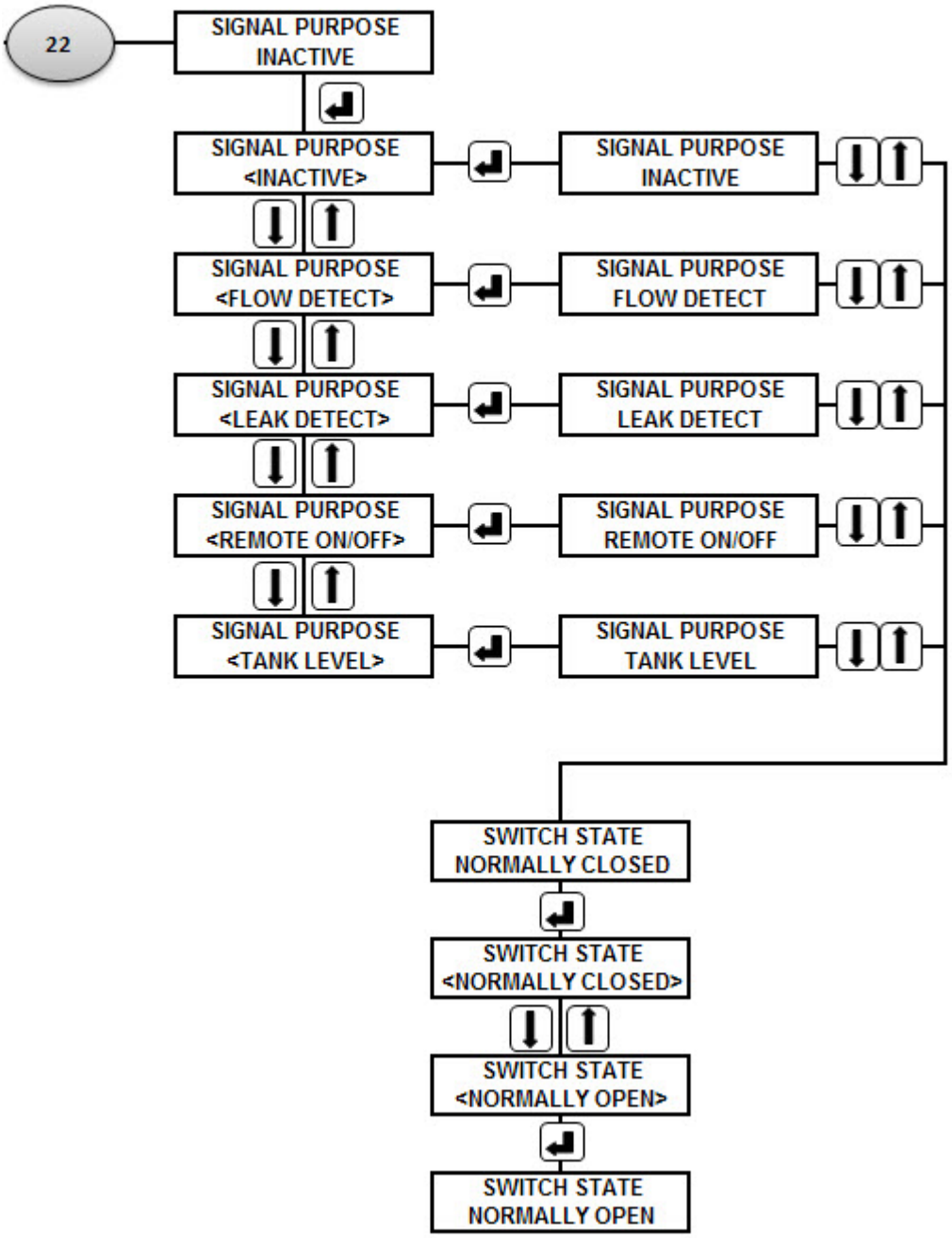


DIGITAL I/O MENU

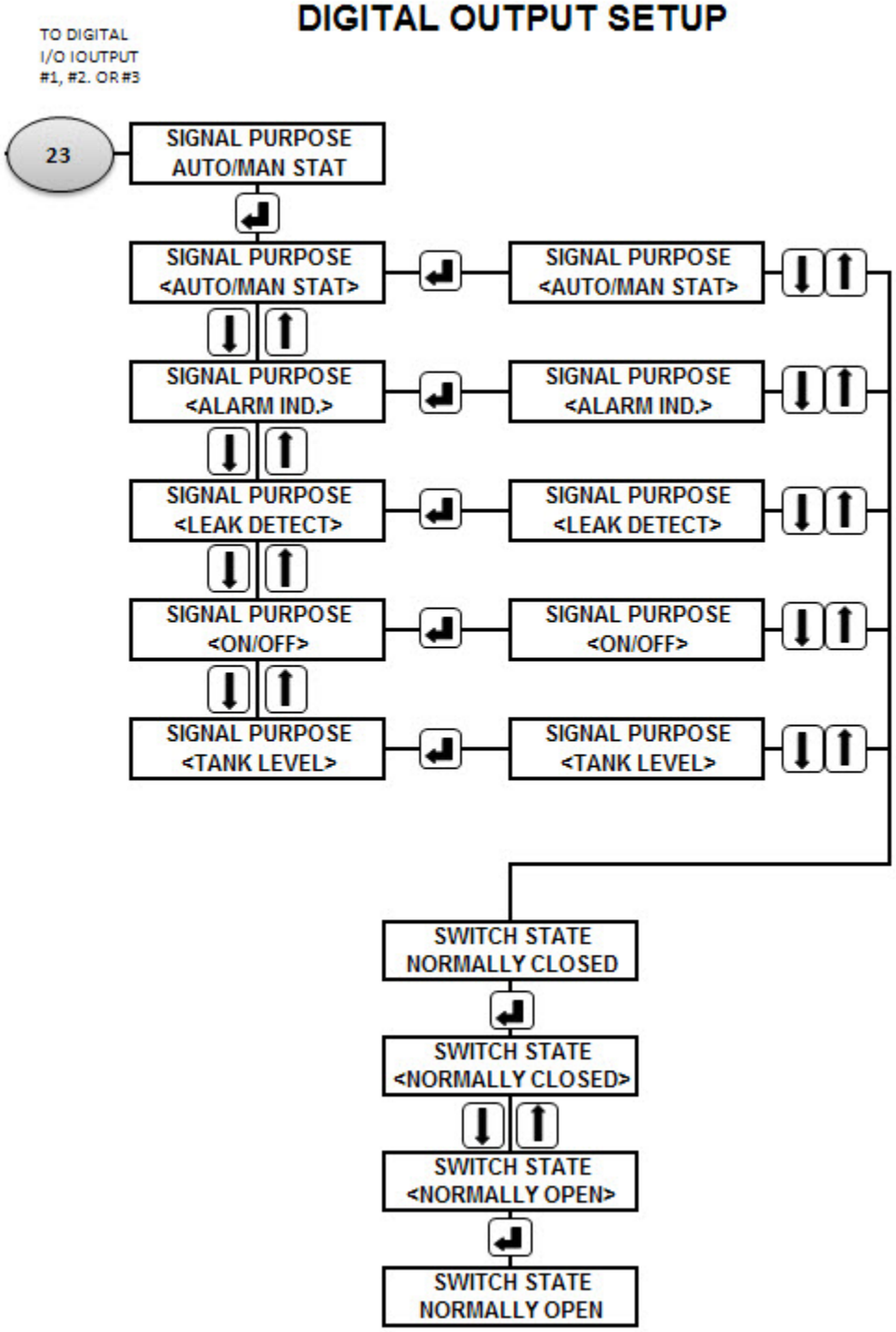


DIGITAL INPUT SETUP

TO DIGITAL I/O INPUT #1 OR #2



DIGITAL OUTPUT SETUP



17. Factory Default Values

Parameter	Factory Set Value
Digital Input #1	INACTIVE, normally closed
Digital Input #2	INACTIVE, normally closed
Analog Input #1	INACTIVE
Analog Input #2	INACTIVE
Digital Output #1	ON/OFF indication, normally closed
Digital Output #2	AUTO/MANUAL Indication, normally closed
Digital Output #3	ALARM Indication, normally closed
Security Code	Default = 0000
Language	ENGLISH
MODE	Local (Manual)
UNITS	GPM (gallons per minute)

18. Retrieval of Setup Information

Users can access the `system SETUP: INFORMATION` menu, which will list the following data, this may be helpful in troubleshooting:

- Controller software revisions
- Pump serial number
- MPC VECTOR model number
- Pump maximum flow
- Pump maximum speed
- Pump Turndown

19. Troubleshooting Guide

Problem	Potential Cause	Solution
POWER		
No AC drive red LEDs lit Should see "---"after power up sequence.	Improper AC line input wiring or low line input voltage.	Check L1, L2, L3 for proper voltage (230/480 VAC) and wiring. Check circuit breakers.
No Green LED blinking on controller board.	DC power supply not powered.	Check Blue and Brown wire for voltage at power supply 230 VAC systems = ~1.4 * AC line = 1.4 * 230 = 325 VDC 480 VAC systems = 230 VAC
Green LED not blinking on controller (local) board.	DC power supply not providing output power to local control board.	Check voltage with meter on output of power supply Black(-)-to-Red(+) = 5vdc Black(-)-to-Green(+) = 12 vdc
HANDHELD DISPLAY		
LED backlighting not lit on remote handheld, but green LED blinking at 1 second interval on local board.)	Remote handheld not receiving power.	Open Handheld Front Cover and measure voltage J5-1/2 to J5-3/4. Voltage should be ~ 12.0 volts dc. See Figure 21-1 Handheld Remote Wiring
LED's not lit, keypad not responding	Remote keypad connector not seated properly.	Open Handheld Front Cover and measure voltage and check J4 for proper connection. See Figure 21-1 Handheld Remote Wiring
LCD display not readable, no text on display (too light/too dark)	Contrast not adjusted properly.	Use ENTER key with UP ARROW and DOWN ARROW keys to adjust darker and lighter, respectively.
No Text on LCD display	Improper software initialization	Remove power for 5 seconds then reapply.
SYSTEM ERRORS		
Handheld displays "AC Drive Fault Communications" on LCD handheld screen.	Communications link between the AC drive and local board has timed out	Ensure 3 wire connection from local control board to AC drive. J28 on local board to drive control terminal strip pins 2-ground (green), TXA (red), and TXB (black).
Handheld displays "Communication --ERROR—"	Communications link between the local control board and the handheld remote has timed out.	Ensure connections between local board and remote handheld are made. See Figure 21-1 Handheld Remote Wiring for connection details. Be sure to check black/white and white wires.
Handheld displays "AC Drive Fault OVERCURRENT"	Motor is drawing excessive current and the AC drive is limiting its output.	Ensure proper motor sizing and drive sizing for application.

DRIVE ERRORS AND FAULTS		
Drive module display reads “CL”	Drive has gone into a current limit mode to protect the pump motor.	Check for pump binding or drive/ motor combination being undersized.
Drive module display reads “nld”	An attempt was made to start the controller prior to calibrating the pump motor.	Perform a motor calibration as outlined in Section 6.4 Motor Parameter Setup
Drive module display reads “HF” or “LF”	The AC drive DC bus is to high (HF) or the DC bus is too low (LF)	Check incoming line voltages for proper input tolerances. See Section 13 Specifications for input tolerances.
Drive module display reads “PF”	Current Overload has occurred and drive shuts down.	Check pump for binding or mechanical failure.
Drive module display reads “F1-F9”	Drive has internal fault.	Consult factory

Problem	Potential Cause	Solution
DISPLAY		
No Display Back-lighting	No power supplied.	Check power source. plug & circuit breaker
	Supply power wired incorrectly.	Check wiring.
	Supply power outside of specification.	Check voltage/frequency against specification.
No Text on Display	Contrast out of adjustment.	Adjust as per section 8.4
	Software did not initiate properly.	Remove and re-apply AC power
POWER		
No power Indicators	No power supplied.	Check power source. Plug & Circuit Breaker
	Supply power wired incorrectly.	Check wiring.
	Supply power outside of specification.	Check voltage/frequency against specification.

20. Spare Parts

User replaceable parts for the MPC VECTOR.

Pulsafeeder P/N	Description
NP530091-000	½” wiring liquid-tight connector
NP530137-000	¼” wiring liquid-tight connector
W213946-NTR	Hand-held enclosure gasket
NP250079-RYT	Replacement Handheld front cover
NP550113-000	Front Cover Membrane Switches/LED
NP250078-RYT	Replacement Handheld back cover
W772568-STL	½” conduit opening plug
W772585-018	¼” conduit opening plug
NP140066-PVC	Plastic Handheld Bracket
RS240005-000	DIN Rail Terminal Blocks

21. *Appendix 1*, Handheld Wiring

The hand-held controller for your MPC can be placed as far as 1000 feet from the main control unit. It is recommended that all calibrations be completed before the cable is lengthened, as these tasks are easier when the pump and hand-held controller are close to each other.

POWER TO THE UNIT MUST BE OFF! A GROUNDING WRIST STRAP SHOULD BE WORN WHEN MAKING CONNECTIONS TO ANY PCB

The following standard length cables are available from Pulsafeeder for use with the MPC:

Cable Length	Part Number	Notes
6 feet	NP530130-000	Standard, supplied with all MPC controllers
Others per foot	NP530147-000 (1 ft)	NOTE: do not exceed 1,000 feet total length

21.1 Removal and Connection of the Cable from the Handheld:

1. Open the handheld unit by removing the 4 screws on the face of the unit.
2. Open the unit by separating the cover from the base.
3. Use care with the keypad tail that is connected to the board, it can be left in place during this process.
4. Make a note of what color lead is in each position of the terminal block “J5”. Cut the tie-wrap that secures the cable. Unscrew each screw on the terminal block “J5” and remove each lead.
5. Loosen the outer domed nut on the liquid tight, releasing the tension on the cable. Pull the cable through the liquid tight. Thread the new cable through the liquid tight with enough length to reconnect to the terminal block.
6. Cut the shield wire as close as possible to the outer insulation at the remote end **only**.
7. Wrap the end of the cable with electrical tape to insulate any remaining shield so that it will not contact the circuit board, equipment case, or any other parts.
8. Referring to the notes taken earlier, connect each lead of the new cable to the proper position of the terminal block, lock the lever back in place to hold lead. NOTE: It is recommended that you insert and secure one lead at a time.
9. Tighten the dome nut of the liquid tight to secure/seal cable.
10. Check that the keypad tail is still firmly connected, re-insert if necessary.
11. Replace cover and tighten screws. Be sure the o-ring is in its groove, paying special attention to the corners. NOTE: Do not over tighten.

21.2 Removal and Connection of the Cable from the Base Unit:

Wait a minimum of 5 minutes after disconnecting power before servicing the MPC or pump motor. Capacitors retain a charge even after power is removed from the controller.

1. Remove the screws that are securing the cover of the main unit.
2. CAUTION: The cover is wired and should be opened gently being sure not to pull any of the wires that are connected to it.
3. Make a note of what color lead is in each position of the terminal block “J14”. Unscrew each screw on the terminal block “J14” and remove each lead.
4. Loosen the outer domed nut on the liquid tight, releasing the tension on the cable. Pull the cable through the liquid tight. Thread the new cable through the liquid tight with enough length to reconnect to the terminal block.
5. Prepare the end of the cable as per *Figure 7* on the following page. Ensure that the shield is fully insulated until the point where it enters the terminal. No part of the shield should be allowed to come in contact with the circuit board, equipment case, or any other surface.
6. Note that the black-green lead should be paired with the green wire.
7. Referring to the notes taken earlier, connect each lead of the new cable to the proper position of the terminal block, and then lock the lever back in place to hold lead. NOTE: It is recommended that you insert and secure one lead at a time.
8. Tighten the dome nut of the liquid tight to secure/seal cable.
9. Replace cover carefully being sure not to crimp any of the cables/leads between cover and enclosure and tighten screws.
10. Power the unit on, if all connections were properly made the unit will power as normal and the display will show the start up screen.

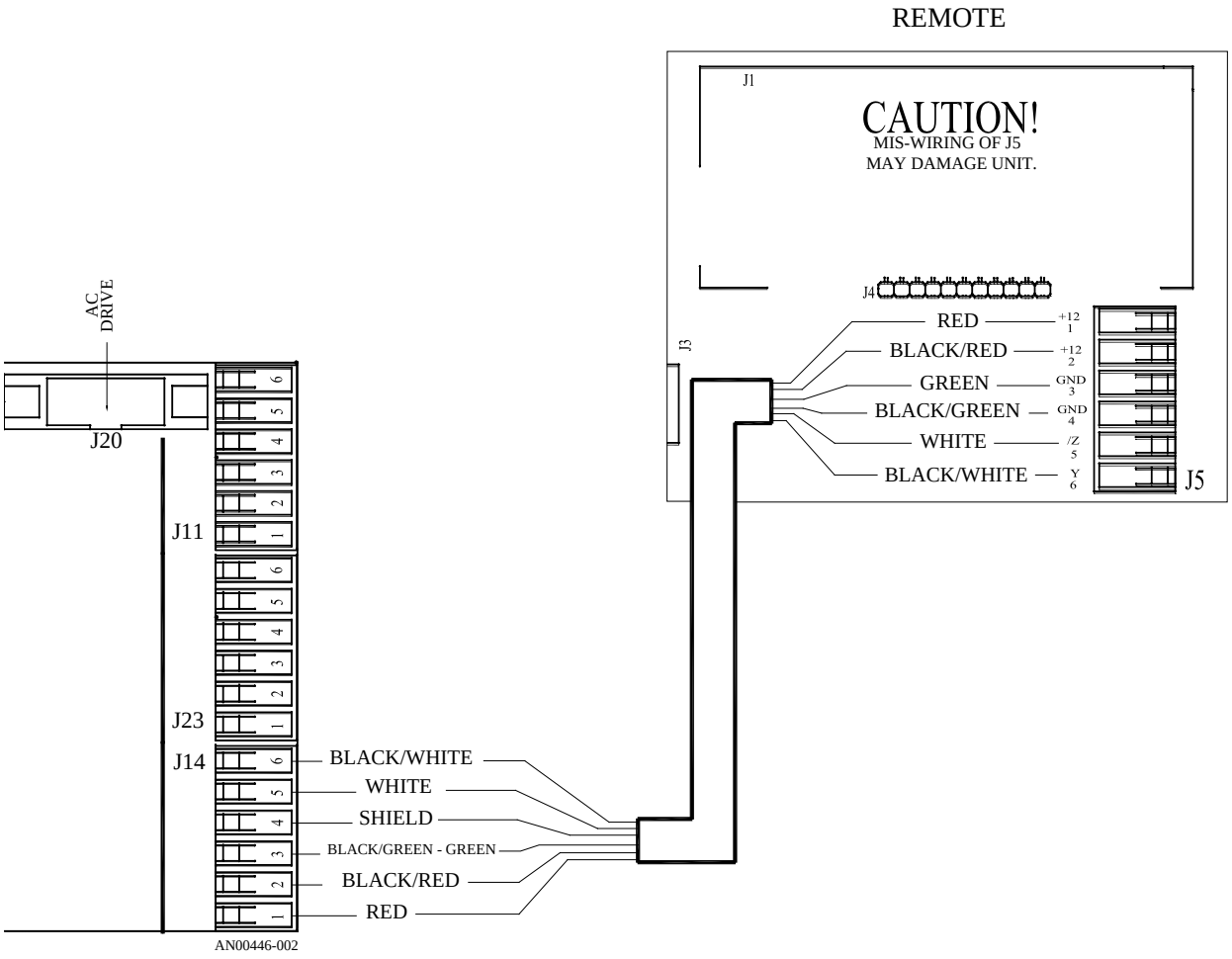


Figure 21-1 Handheld Remote Wiring

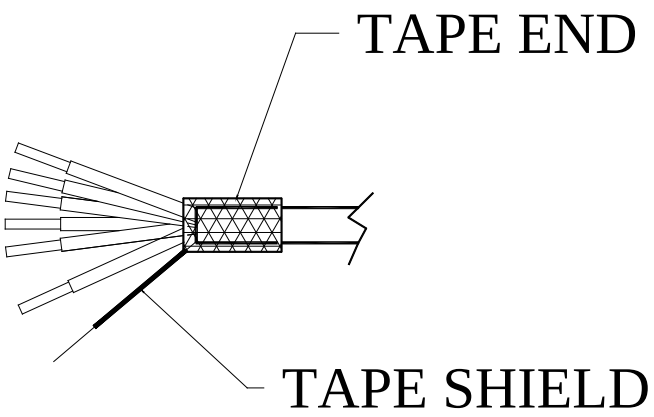


Figure 7 – Wire Preparation Detail, Base Unit End

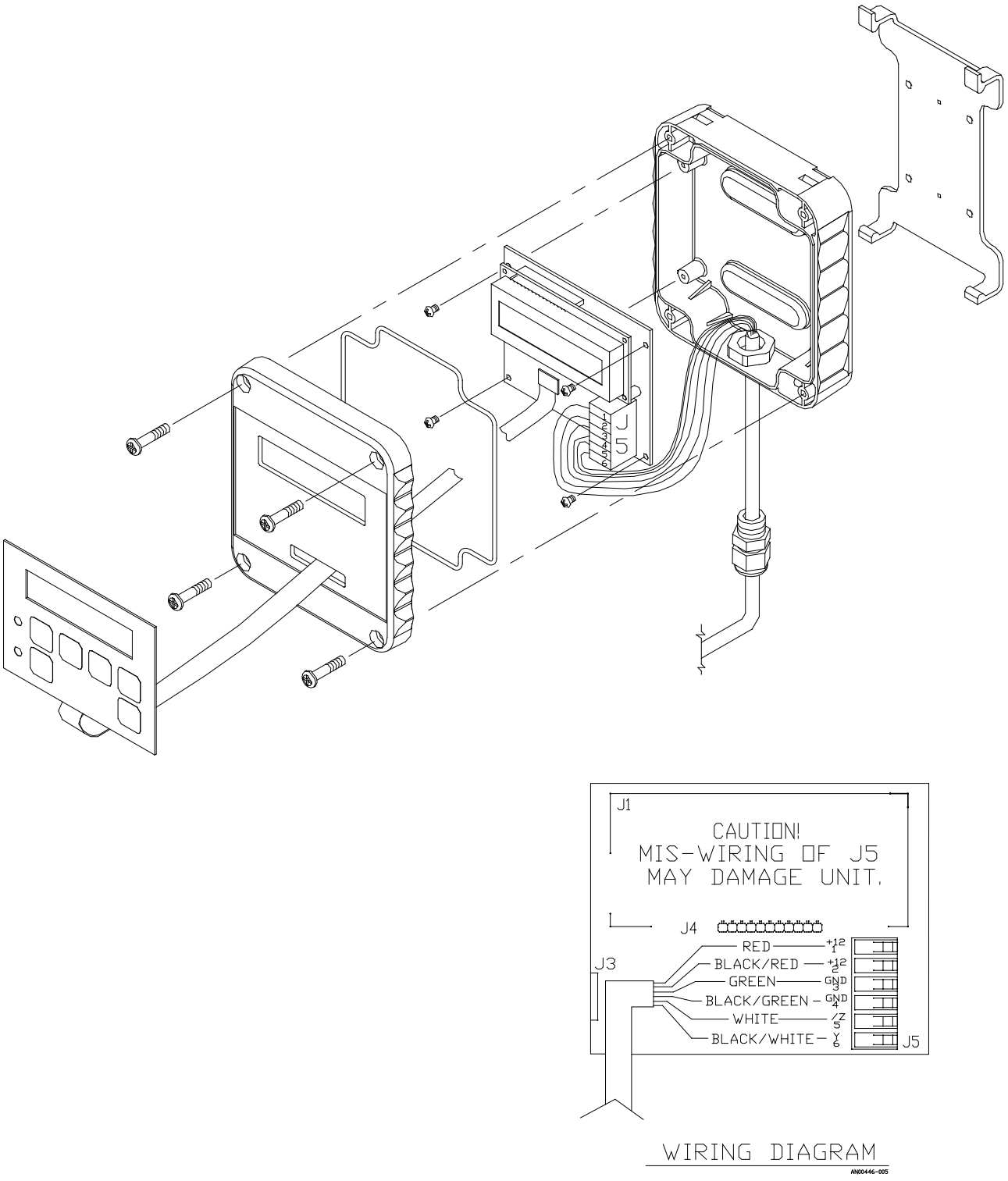


Figure 8 – Handheld Remote

22. *Appendix 2*, PID Theory and Adjustment

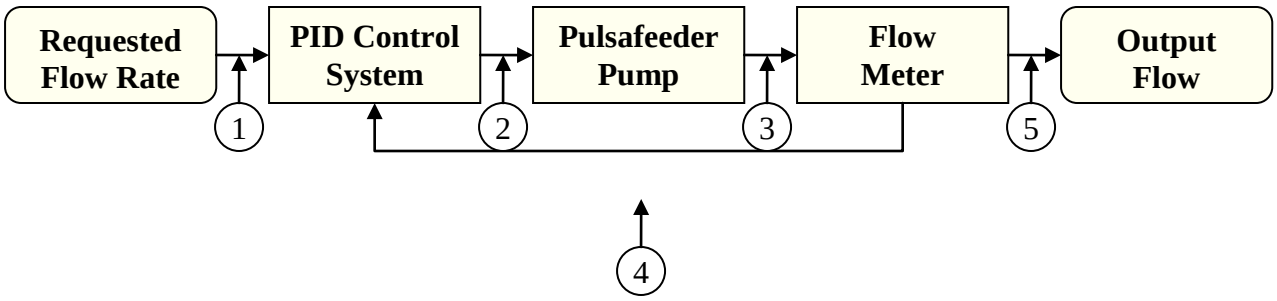
The PID control method allows the ***MPC Vector*** to accurately maintain a specific desired set point for flow rate from the pump it is connected to.

The PID Control Loop is a widely accepted general purpose control algorithm which is built into the ***MPC Vector***. A PID control loop consists of three components which each have their own specific responsibilities in the control loop; the Proportional, Integral, and Derivative components. Although these mathematical terms are derived from calculus, and are internally implemented as such, the PID can be tuned without using a calculator by simply understanding the roles each of the three components play. Note that if you aren't interested in a semi-technical discussion of PID Control Loops you can skip ahead to *Section 21.3*.

22.1 PID Controller Theory:

The basic PID Control Loop consists of an input command, the control system, and feedback (*see diagram, following page*). The user enters an input flow rate. This command is sent through the control system which decides what the new motor speed should be. That motor speed command is sent to the pump which then changes the output rate. A flow meter at the output of the pump measures the output flow and feeds the data back to the controller. Based on the feedback the control system adjusts the motor speed and subsequently the flow in an attempt to meet the required set point. This process is repeated continuously bringing the flow rate closer and closer to the target until it eventually settles on the target. In the drawing, both the Requested Flow Rate and Control System are integrated into the MPC Vector controller.

Basic MPC Vector Control Loop



1. Requested flow rate from the user
2. Motor speed command from the control system
3. Flow output from the pump
4. Flow measurement from the flow meter
5. Flow output from flow meter

The function we are controlling is liquid flow from the pump, and the variable being controlled by the MPC Vector is motor speed. This control must be based on some type of feedback, in this case a flow meter measuring liquid flow rate.

Feedback and Error

Feedback is critical in control systems. The feedback lets the controller know the actual flow rate being output by the pump at all times. Utilizing the feedback, the control system is able to determine the error which can be defined as the difference between the expected flow rate and the actual flow rate. The PID controller acts on the error, manipulating the process variable being controlled (in the case of the MPC Vector, motor speed) in order to bring the process closer to the set point, thereby eliminating the error.

The PID controller does not act on the actual flow rate being reported by the flow meter, it acts on the error between the actual flow rate, and the desired set point, it's goal being to eliminate the error between the two as much as possible.

Sampling Rate

In the digital world the control loop is run at some base period which is called the sampling rate, Ts. After the initial command is given the control system waits for this period of time and then samples the output, compares it to the set point, and makes motor speed adjustments. After the same period of time expires again, it samples the flow rate again and compares it to the expected flow rate and adjusts. This continues as long as the pump is running. Like many other options for the MPC Vector, this is a configurable setting. The sampling rate of the MPC Vector should be at least twice as fast as the sampling rate of the flow sensor.

22.2 Three Control Components:

The PID controller has three adjustable internal components, all of which contribute to the final output value; they are proportional, integral, and derivative.

Proportional Component

The proportional component of the control system (also known as “gain”) is concerned with the current error (“current” as in time, not electricity). The component is calculated by multiplying the current error by a proportional coefficient, commonly known as Kp or proportional gain. Since the proportional component is only concerned with current error it is able to contribute to initial startup speeds. Think of the proportional gain as the component which gives a jump start to the pump. Typical values of Kp for this application are in the 0.25 -> 0.7 range.

Proportional Part = Kp * error

Integral Component

The integral component of the control system (also known as “reset”) provides a historical memory to the system. This is accomplished by adding the errors into an error summation. The sum of the errors is then multiplied by an integral coefficient, Ki which is also called the integral gain. Because the integral component is a historical component, it can take some time to build “history”. The Integral component is used mainly to force the control to track closer to the desired set point, to eliminate any “offset”. Typical values of Ki are in the same range as Kp, 0.25 -> 0.7.

Integral Part = Ki * error sum

Derivative Component

The derivative component (also known as “rate”) provides a predictive element to the system. The derivative component compares the current error and previous error to calculate the approximate change over the last sample period. This is then multiplied by the differential coefficient, Kd which is also called the differential gain. When the flow rate of the pump is rising, the differential component is used to keep it from rising too fast. This is because as you get closer to the flow set point, the current error will be smaller than the last error. The differential term can be used to stabilize systems with excessive overshoot, it slows down the response as the set point is reached.

Derivative Part = Kd * (error – last error)

22.3 PID Basic Summary, what happens when I…

When the **proportional control** is *increased*:

Initial rise time to set point gets faster

Overshoot once set point is reached tends to increase (gets worse)

Steady-state error can be reduced but will never be eliminated

Settling time (ability to hold set point) is not strongly affected

Proportional is used mainly to affect the initial startup of the system, how quickly it reaches the desired set point. Too much proportional control will result in overshoot and oscillation, and inability to hold a set point over time.

When the **integral control** is *increased*:

Initial rise time to set point gets faster

Overshoot once set point is reached tends to increase (gets worse)

Steady state error is eliminated with the proper setting

Settling time (ability to hold set point) is increased (gets worse)

Transient response (for example, to an upset condition) may get worse

Integral is used mainly to tune the system to reach a certain set point, to eliminate any offset the might be present, for example the desired flow rate is 5.0 GPH, but the system settles and runs at a consistent 5.2 GPH. If too much integral control is used, the system can overshoot, not settle, and not react smoothly to transient (temporary) upset events.

When the **derivative control** is *increased*:

Stability of the system is increased

Rise time to set point is not significantly affected

Overshoot is controlled and decreased with the proper setting

Settling time is decreased and controlled with the proper setting

Steady state operation is not affected significantly

Derivative is used to tune out oscillation of the system around the desired set point. Too much derivative control will result in a system that never reaches set point, reacts too slowly, or is unstable and will not hold set point.

A properly tuned PID loop will:

Reach the desired set point in a reasonable amount of time

Maintain operation at or very close to the set point with minimal oscillation

React quickly to transient changes or upset conditions

22.4 Putting it all together to run the *MPC Vector*

The proportional, integral, and differential components are all added together into a command sum which is used to set the motor speed. The motor speed command does have software protection which prevents the motor speed from ever exceeding the max motor speed or from being negative and therefore if the command loop is unstable, no damage can be caused to the drive, motor, or pump. ***Please be aware though that the motor could reach maximum speed during tuning and all necessary system precautions should be taken.***

Also note that the differential part alone cannot be used to start the motor since it depends on previous values. If the previous saved error matches the current error then the differential part will be 0 and therefore the differential part alone will not start the motor reliably. It is possible to eliminate one of the parts by setting the appropriate coefficient to 0 (i.e. if you want a PI only controller set Kd to 0 to eliminate the differential part). However the tuning steps below assume that all 3 parts will be used.

Step 1 – Configure the *MPC Vector (reference earlier sections of this IOM for more detail*)

1. Make sure that the chosen flow meter is hooked up to the proper location in the MPC Vector.
2. Flow units should be set appropriately in the menu
3. Max flow should be set to at least the max flow achievable by the pump at max speed.
4. Flow sensor type should be set appropriately (digital or analog)
5. Flow calibration should be performed to make sure the MPC Vector flow reading matches flow meter feedback.

Step 2 – Choosing the test set point

In order to tune the PID loop it is necessary to choose a test speed. For most purposes the test flow should be set to approximately 80 – 85% of the max flow. If the test point is too close to the maximum flow, you may not notice the overshoot. If the test point is too low you may have an unstable system at higher flow rates.

Step 3 – Tune the Proportional gain

1. Start with an integral gain of 0 and a derivative gain of 0. The proportional gain should be set to allow the motor to start reliably.
2. Set the motor to the test set point
3. Start with a proportional gain of 0.1
4. Make sure that the integral and differential gains are 0
5. At the main operations mode screen, attempt to start the pump. If the motor starts and settles at a low speed with minimal flow then the proportional gain is set. If not, increase the gain by 0.05 and try again. Continue until motor start condition is met reliably.

Step 4 – Tune the Integral gain

1. The Integral gain is what will ultimately pull the speed up to the desired set point. Note that because the Integral gain is based on a sum it takes some time for the Integral part to stabilize.
2. Make sure that the proportional gain is set as found above. differential gain is still 0
3. Start with an integral gain of 0.05
4. At the main operations mode screen, start the pump. You should see that the flow is now slowly building towards the set point. Increasing the integral gain will cause the buildup to occur faster. Keep adding 0.05 to the integral gain until you overshoot your set point. As an example, if your set point is 5 GPM, your gain might go to 5.1 GPM before falling down to 4.9 GPM or so and oscillate for a few seconds.

Once you see the oscillation, back the integral gain down by 0.05 – 0.1. Start the pump again and make sure that the flow rate does not overshoot the set point significantly.

Note: you may want to use a stopwatch to time how long it takes to get to 80% of the set point, especially if you are using the PulsaGuard pump protection. PulsaGuard will stop the pump if the minimum flow is not reached within the timeout limit. In any case the pump should be able to get to at least 90% of the given flow set point within 25 seconds.

Step 5 – Tune the derivative gain

The derivative gain is not required under all circumstances. In many cases, a PI controller alone is sufficient to control the pump flow. If derivative gain is added, start with a low setting (0.05 or so) and keep adjusting in 0.05 increments until desired settling time is met.

22.5 Troubleshooting

My flow rate is never reached. How can I fix it?

If the flow rate is never reached you have what is called an over-damped system. Try increasing the Integral gain to help pull the set point up higher. Also, make sure your flow rates and units match. If you are trying to set a flow higher than the pump can provide, you'll never reach it!

My flow goes past the set point and back below again and oscillates a long time. How can I fix it?

Some oscillation is natural in many PID controlled systems. To minimize it you need to decrease the Proportional and/or Integral gains to slow the system down a bit.

PULSAFEEDER

A Unit of IDEX Corporation

EC Declaration of Conformity

Manufacturer:
Pulsafeeder, Inc.
2883 Brighton Henrietta Townline Rd.
Rochester, NY 14623 USA

Pulsafeeder Inc. declares the following product(s) comply with the applicable standard(s) as listed below:

Device(s):
Metering Pump Controller (MPC)

Description:
Servo Controllers for Metering Pumps

Applicable EU Directive(s) for all MPC(s):
73/23/EEC - Low Voltage (LVD)

Applicable EU Directive(s) for only 230VAC Input MPC(s):
89/336/EEC - Electromagnetic Compatibility (EMC)

Applicable Harmonized Standard(s) for all MPC(s):
EN61010-1:2001

Applicable Harmonized Standard(s) for only 230VAC Input MPC(s):
EN61000-4-3, EN61000-4-4, EN61000-4-5,
EN61000-4-6, EN 61000-6-2, EN61000-6-4

DATE/APPROVAL/TITLE:
12 May 2004

Nick Valente, Vice President of Business Development

IDEX CORPORATION

P/N: NP550127-DEC Rev. A

PULSAFEEDER®
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++1 (585) 424-5619

An ISO 9001 and ISO 14001 Certified Company

IDEX CORPORATION

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