Installation, Operation and Maintenance Manual
MAN-02-04-55-0735-EN Rev. 0
July 2019

Bettis 2000 Series M2CP User Manual



BETTIS™

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Appendix A: Definitions

This document covers the current Digital Futronic firmware version (Ver 4.6 released July 2019) and also references previous versions where applicable.

Section 1: Introduction

The Digital Futronic module uses the latest integrated microcontroller technology to enable one electronics module to perform valve actuator modulating and positioning control from analog control signals. The control module uses Bettis's M2CP TBM01 termination panel for interface of all analog control types.
The Digital Futronic module converts 4-20mA analog input to digital for processing and from digital to 4-20mA analog output for position feedback. The Digital Futronic module controls four Bettis motor control starter types.

1. Futronic II — Electro-mechanical AC motor starter
2. Futronic III — SCR H-Bridge Solid-state DC motor starter (Powered by 115VAC, 1-Ph)
3. Futronic IV — Triac Solid-state (SSR) AC motor starter
4. Futronic VII — MOSFET Solid-state pure DC motor starter (Powered by 24VDC or 48VDC)

⚠ CAUTION

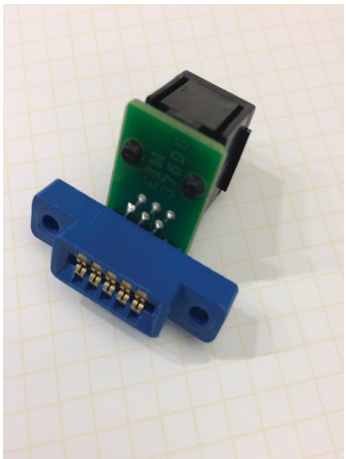
When downloading firmware to the Digital Futronic circuit board using the Programming Header device, part number VA37696 (See Figure 1 below) or reading EEPROM, the following conditions are required to validate firmware download.

1. Actuator is NOT fully closed (LSC is not active)
2. Actuator is NOT fully open (LSO is not active)
3. Selector Switch must be in OFF Position
4. DIP 1 is OFF
5. DIP 2 is OFF
6. DIP 3 is OFF
7. DIP 4 is OFF

When calibrating and/or configuring the Digital Futronic circuit board, the following conditions are required to validate the configuration calibration process.

1. Programming Header device must NOT be connected to the board
2. Selector switch must NOT be in REMOTE position.

Figure 1



Section 2: Features and Specifications

Digital microcontroller adapts to any actuator and valve size, speed/stroke-time, process pressure, etc. by automatically tuning controls to obtain maximum accuracy without any user adjustments for deadband, delay time, etc.

Automatic calibration of position input to valve travel limits when selector switch is position at LOCAL MODE.

Built-in protection for motor and motor controls.

DC motor speed control for Futronic III and Futronic VII.

Easy setup and calibration to user's external analog control signal input and analog feedback output. All setup and calibration adjustments by on-board DIP switches and two miniature push buttons. When selector switch is at OFF position only.

LED indicators for normal/fault operating conditions, setup mode, loss of analog signal, and solid-state motor control output.

Isolated Analog Input: 4-20mA with 12-bit (.025%) resolution (calibration range of 0-24mA). 210 Ohms input resistance. Operates from 10V to 32V loop supply. Allows up to 750 Ohms loop resistance at 24V.

Isolated Analog Output: 4-20mA with 16-bit (.0015%) resolution (calibration range of 0-24mA). Drive loop resistance up to 750 Ohms. True current source with internal 24VDC power supply. No external power source required to power loop. Internal automatic resetting fuse for 24VDC power supply.

Isolation dielectric strength: 2500V AC for 1 Minute (Input to output and I/O to ground).

Inverted Analog I/O Option: where 20mA = close valve position and 4mA = open valve position.

Go To Default Position Option: On loss of control signal, user selected default valve position anywhere between 0 and 100%.

Table 1.

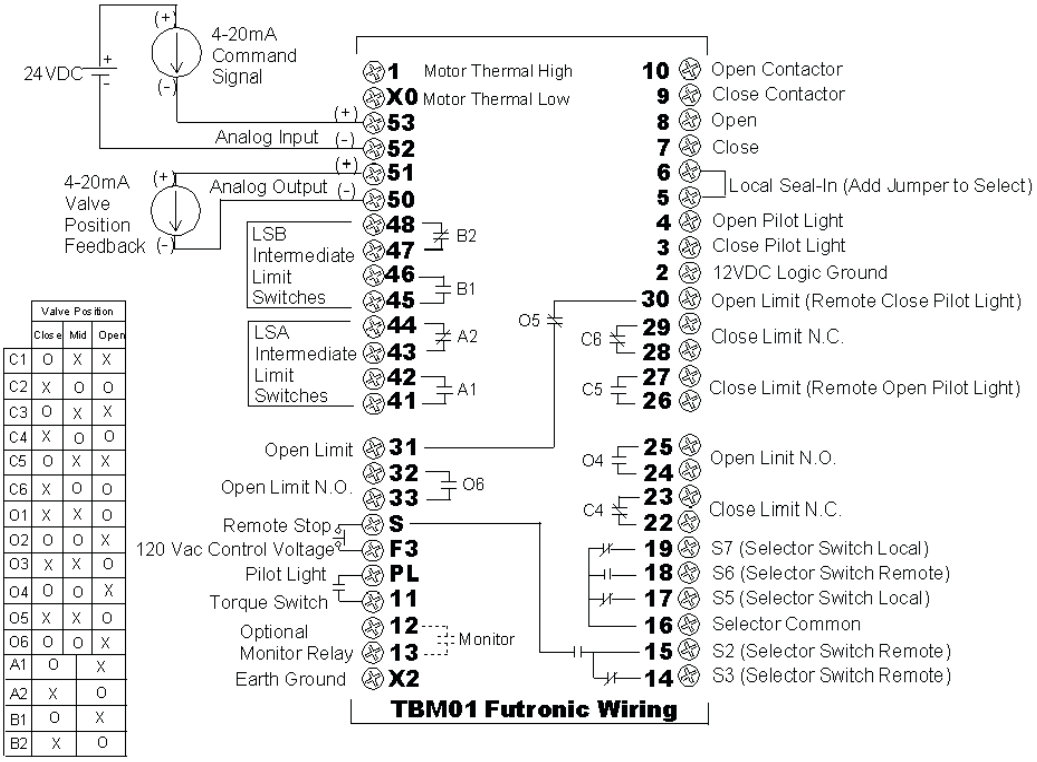
Control Accuracy	Futronic II mode	+/- 1.0% @ 15 second stroke time or greater
	Futronic III mode	+/- 0.25% @ 15 second stroke time or greater
	Futronic IV mode	+/- 0.5% @ 15 second stroke time or greater
	Futronic VII mode	+/- 0.25% @ 15 second stroke time or greater
Nonlinearity	<0.05% of calibrated analog input and output over full range of 0-100%.	
Operating Temperature Range	-40 °C to +85 °C (-40F to +185F)	
Humidity	10% - 95% (Non-condensate)	

Section 3: Installation and Wiring

Refer to the wiring diagram supplied with the actuator for wiring details and options supplied with the system. Figure 2 below is generic and provided primarily for wiring 4-20mA analog input and output signals. Refer to Figure 2 for proper wiring of analog I/O and associated polarities relative to external equipment and power supplies.
Use the following rules when wiring analog I/O signals.

1. Route analog I/O cables into actuator enclosure through separate conduit entries from power wiring.
2. Always use twisted-pair instrumentation cable for wiring 4-20mA analog input and output signals.
3. Use shielded cable when analog signals are being installed in or routed through high noise areas.
4. If shielded cable is used, earth ground the shield by connecting only one end of the shield to earth.
5. Instruments or control equipment must source current to the analog input of the Digital Futronic.
6. Remote current source to analog input must have own power source, or an external supply is required.
7. Do not connect an external power source to the 4-20mA analog output of the Digital Futronic module.
8. The Digital Futronic module contains its own internal 24VDC power supply for the 4-20mA output and sources current to external instruments or control equipment.

Figure 2 TBM01 Futronic Wiring



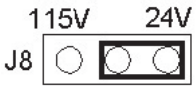
	Valve Position		
	Close	Mid	Open
C1	O	X	X
C2	X	O	O
C3	O	X	X
C4	X	O	O
C5	O	X	X
C6	X	O	O
O1	X	X	O
O2	O	O	X
O3	X	X	O
O4	O	O	X
O5	X	X	O
O6	O	O	X
A1	O		X
A2	X		O
B1	O		X
B2	X		O

NOTE:

Refer to wiring diagram supplied with actuator for wiring details and options.

Important

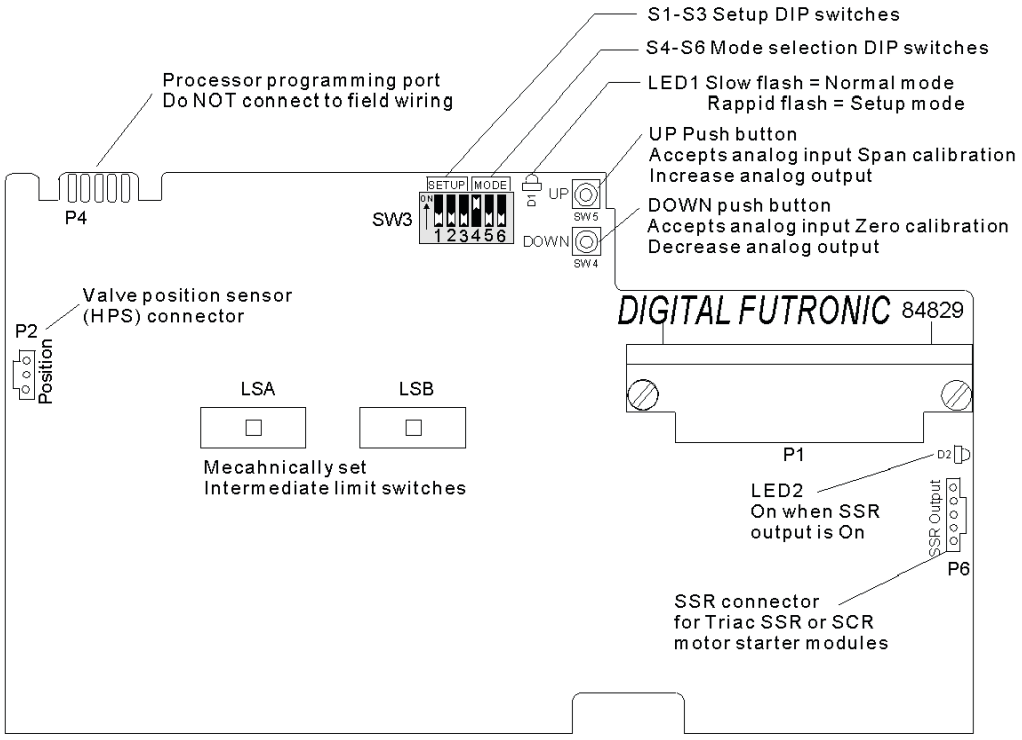
Jumper J8 located on the bottom of TBM01 must be in the 24V position before the Digital Futronic card will operate.



Section 4: Module Setup and Calibration

DIP Switch SW3 has 6 switches designated as S1-S6 for calibration and mode selection as summarized below. There are two miniature push buttons labeled **UP** and **DOWN**. Refer to Figure 3 for location of DIP switches and push buttons. Switches S1-S4 are used for setup and calibration and switches S5-S6 are used for mode selection. If any one or more of switches S1, S2, S3, S4 are on, the actuator is in setup mode. The actuator returns to normal operating mode when all three switches S1-S3 are turned off. When changing from setup mode to normal operating mode, do not turn off power to the actuator for at least 120 seconds to allow the controller to store the new setup values to EEPROM nonvolatile memory. Setup and normal operating modes are designated by LED 1 as defined below.

Figure 3 Locations of DIP switches and Push-buttons



4.1 Indicator Lights

4.1.1 LED 1

- Slow Flash = Normal Operating Mode.
- Rapid Flash = Setup mode (any one of switches S1 through S3 are on).
- Alternating Between Slow and Rapid Flash = Lost Analog Input (Command) Signal.
- Steady On or Steady Off = Module failure.

4.1.2 LED 2

- On when Solid State Relay (SSR or SCR) is On (control power applied to output).

4.2 Number Display (Firmware Version and Digital Futronic Type)

4.2.1 Firmware Version Number Display

Each time the actuator is powered up, the firmware version number is displayed by LED1 with the following sequence of flashes.

At power up, LED1 stays on for 4 seconds and then begins to flash. Count the number of times the LED flashes on before it turns on solid again for 2 seconds. The number of flashes is the high order firmware version number.

After a 2-second solid on delay, the LED will begin to flash again. Count the number of flashes until the LED turns on solid again for 4 seconds. The number of flashes is the low order firmware version number. After the 4-second delay, LED1 will then flash at the normal rate defined under Indicator Lights above.

If unable to correctly count the number of flashes to properly determine the firmware version number, then cycle power to the actuator and the display process will repeat.

4.2.2 Digital Futronic Number Type Display (New for Ver 4.6)

Digital Futronic firmware Ver 4.6 will display additional information on LED1 following flash sequence shown in 4.2.1. On power up, LED1 will display Actuator Type which is currently configured after it displays firmware version.

The LED flashes the actuator type as shown below before it turns on solid again for 2 seconds.

- DF II, 2 Flashes
- DF III, 3 Flashes
- DF IV, 4 Flashes
- DF VIII, 7 Flashes

NOTE

LED1 flash sequence for Firmware Version and Digital Futronic type will display every startup (or power cycle).

4.3 Setup

4.3.1 Normal Run Mode (S1, S2, S3, S4 OFF)

Turn off S1, S2, S3 & S4 for Normal Run Mode - Figure 4.

Figure 4



4.3.2 Cal Analog Input (S1 ON)

Press **UP** to set **Span** (20mA) Input - Figure 5.

Press **DOWN** button to set **Zero** (4mA) Input - Figure 5.

Figure 5

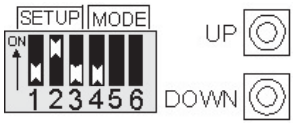


4.3.3 Cal Analog Output Zero (S2 ON)

Press **UP** to increase (4mA) Output - Figure 6.

Press **DOWN** to decrease (4mA) Output - Figure 6.

Figure 6



4.3.4 Cal Analog Output Span (S3 ON)

Press **UP** to increase (20mA) Output - Figure 7.

Press **DOWN** to decrease (20mA) Output - FIgure 7.

Figure 7



4.3.5 Set Modulation Delay (S1, S2 ON)

Press **UP** to select 3-Ph motor (delay = 2 sec) - Figure 8.

Press **DOWN** to select 1-Ph motor (delay = 12 sec) - Figure 8.

Figure 8



4.3.6 Set Default Position (S2 & S3 ON)

Press **UP** or **DOWN** to accept applied analog input (setpoint) as default position - Figure 9.

Figure 9



4.3.7 Invert Analog I/O (S1, S2 & S3 ON)

Press **UP** to Select Inverted Mode - Figure 10.

Press **DOWN** to Disable Inverted Mode - Figure 10.

Figure 10

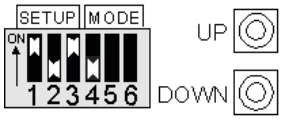


4.3.8 Double Deadband (S1 & S3 ON)

Press **UP** to Double control deadband defined. See Note (1) - Figure 11.

Press **DOWN** to Return deadband to default values - Figure 11.

Figure 11



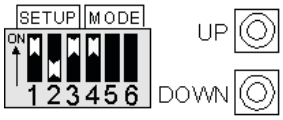
NOTE
New for firmware Ver 4.6, default Double Deadband setting is 1%.

4.3.9 2% Deadband (S1, S3, S4 ON)

Press **UP** to Select 2% control deadband. See Note (2) - Figure 12.

Press **DOWN** to Select 1.5% control deadband - Figure 12.

Figure 12



NOTE:

(1) Doubling the control deadband (bandwidth) reduces control accuracy by twice the values stated on Page 1. Use this function only for difficult to control applications. Doubling the deadband affects accuracy of all four versions of actuator operating controls, as follows:

	Default	Double
Futronic II mode	+/- 1.0%	+/- 2.0%
Futronic III mode	+/- 0.25%	+/- 0.5%
Futronic IV mode	+/- 0.5%	+/- 1.0%
Futronic VII mode	+/- 0.25%	+/- 0.5%

(2) 2% Deadband (bandwidth) affects accuracy of Futronic III, IV & VII only, as below.

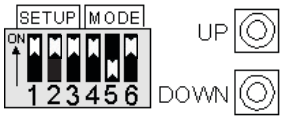
	UP button	DOWN button
Futronic II mode	NA	NA
Futronic III mode	+/- 2%	+/- 1.5%
Futronic IV mode	+/- 2%	+/- 1.5%
Futronic VII mode	+/- 2%	+/- 1.5%

4.3.10 Pulsing Control (S1, S2, S3, S4, S6 ON & S5 OFF)

Press **UP** to Select Pulsing Control - Figure 13.

Press **DOWN** to Disable Pulsing Control to default values - Figure 13.

Figure 13



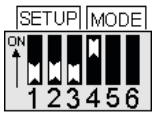
NOTE

New for firmware Ver 4.6, default setting for Pulsing Control is OFF/Disabled. ON/Enabled Pulsing Control not recommended for Digital Futronic II, III and VII for any operating condition, or Futronic IV when either the input command signal is constantly changing, or stroke time is greater than one (1) minute. ON/Enabled Pulsing Control directs actuator to continue operation (motor power cycles on and off) within the control bandwidth of setpoint.

4.4 Mode Selection

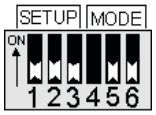
S4 ON = Go to Default Position on loss of analog input control signal - Figure 14.
S4 OFF = Stay put on loss of analog input control signal - Figure 14.

Figure 14



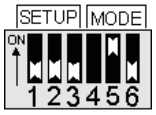
S5 OFF and S6 OFF > Select Futronic II mode - Figure 15.
(Electromechanical motor starter) - Figure 15.

Figure 15



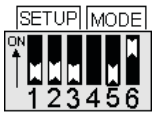
S5 ON and S6 OFF > Select Futronic III mode - Figure 16.
(SCR solid-state DC motor starter) - Figure 16.

Figure 16



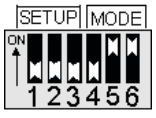
S5 OFF and S6 ON > Select Futronic IV mode - Figure 17.
(Triac solid-state (SSR) motorstarter) - Figure 17.

Figure 17



S5 ON and S6 ON > Select Futronic VII mode - Figure 18.
(MOSFET solid-state (SSR) motor starter) - Figure 18.

Figure 18



4.5 Calibration Procedures

⚠ CAUTION

Place selector switch in “OFF” position before calibrating actuator.

4.5.1 Calibrate Analog Input (Position Command Signal)

1. Connect 4-20mA calibration source to TBM Terminals **52 (-)** and **53 (+)**.
2. Set **S1** to **ON** (up) position. Apply 4mA **zero** calibration signal and then press **DOWN** push button.
3. Apply 20mA **full-scale** (span) calibration signal and then press **UP** push button.
4. Return **S1** to **OFF** (down) position.

NOTE:

When **S1** is **ON**, the analog input signal is fed to the analog output. A current meter may be connected to TBM terminals **50(-)** and **51(+)** to monitor the analog input at the output.

4.5.2 Calibrate Analog Output (Position Feedback)

1. Connect calibrated 4-20mA meter to TBM Terminals **50 (-)** and **51 (+)**.
2. Set **S2** to **ON** (up) position.
3. Press **UP** or **DOWN** push button to increase or decrease **zero** (4mA) analog output signal.
4. Return **S2** to **OFF** (down) position.
5. Set **S3** to **ON** (up) position.
6. Press **UP** or **DOWN** push button to increase or decrease **full-scale** (20mA) analog signal.
7. Return **S3** to **OFF** (down) position.

4.5.3 Select Modulation Delay Time

1. Set **S1** and **S2** to **ON** (up) position.
2. Press **UP** push button to select 3-Phase motor (Modulation delay = 2 seconds).
3. Press **DOWN** push button to select 1-Phase motor (Modulation delay = 12 seconds).
4. Return **S1** and **S2** to **OFF** (down) position.

4.5.4 Enable/Disable Go-To-Position on Loss of Signal

1. Set **S4 ON** (up) to Enable Go-To-Position on loss of signal.
2. Set **S4 OFF** (down) to Disable Go-To-Position on loss of signal, i.e. Stay in last position on loss of signal.

4.5.5 Set Default Position (Position of valve on loss of analog input signal when S4 enabled)

NOTE:
If it is desirable for the valve to move to position while setting the default position then place the selector switch in the "REMOTE" position, else leave the selector in the "OFF" position to prevent the valve from moving.

1. Connect 4-20mA calibration source to TBM Terminals **52 (-)** and **53 (+)**.
2. Set **S2** and **S3** to ON (up) position.
3. Apply calibration signal for the desired position (4-20mA or 0-100%).
4. Press either **UP** or **DOWN** push button to accept the analog input as the default position.
5. Return **S2** and **S3** to OFF (down) position.

Calibrate To Limits: (firmware Ver 4.2 and below only, see 4.5.7 for firmware Ver 4.6:
When setup is complete, place selector switch in "Local" mode and stroke valve from limit to limit for two full strokes. This allows the controller to calibrate the analog position feedback to the position limits before operation in remote control mode.

4.5.6 Assign Digital Futronic Type (New for Ver 4.6)

Firmware Ver 4.6 requires the Digital Futronic type to be actively configured. Previous firmware Ver 4.2 and below only require setting the DIP Switches S5 and S6.

1. Set DIP Switches S5 and S6 (See Table 1) to assign Digital Futronic type.
2. Set S1 and S4 to ON (up) position.
3. Set S2 and S3 to OFF (down) position.
4. Selector Switch in OFF
5. Press UP push button to accept the actuator type configuration.

Digital Futronic Type	DIP Switch Position	Reference Section 4.4 (Figure)
DF III	5 ON, 6 OFF	Fig 16
DF IV	5 OFF, 6 ON	Fig 17
DF VII	5 ON, 6 ON	Fig 18

4.5.7 Calibrate To Limits (New for Ver 4.6)

Firmware Ver 4.6 requires the Digital Futronic actuator position limits to be configured and verified by using a push button.

6. Set S1, S2, S3, and S4 to OFF (down) position.
7. Place selector switch in Local.
8. Stroke Valve to fully open and fully close at least once.

Analog Position Feedback Fully Open (LSO Active)

1. Stroke Valve a second time to Fully Open
2. Press UP Push Button until LED1 display pattern flash rate changes

Analog Position Feedback Fully Close (LSC Active)

1. Stroke Valve to Fully Close a second time
2. Press DOWN Push Button until LED1 display pattern flash rate changes

Appendix A: Definitions

- **Command** = 4-20mA analog input position command signal generated by remote control equipment. Same as position command setpoint. Zero and Full-scale calibrated by user.
- **Position** = 0-5V valve position analog input signal generated by Hall-effect Position Sensor (HPS). Zero and Full-scale automatically calibrated by controller based on LSC and LSO valve travel limit switches.
- **Feedback** = 4-20mA analog output signal for feedback of valve position to remote control equipment. Zero and Full-scale calibrated by user.
- **Invert** = Inverted calibration of 4-20mA command where close position = 20mA, and open position = 4mA. Feedback is also inverted.
- **Deadband** = Allowable error tolerance to keep valve stopped, i.e. do not turn on motor control outputs. Deadband can be configured by the user as the defined default values or double the default values or 2% or 1.5%. Deadband has a beginning default value based on selected operating mode (motor starter type) and then controller automatically adjusts the deadband to obtain the best accuracy.

  Default deadband based on motor starter type:

  a. Futronic II = +/-1.0% deadband

  b. Futronic III = +/-0.25% deadband

  c. Futronic IV = +/-0.50% deadband

- **Error** = Difference between Command and Position.
  Error = Command-Position
  If not Invert and Error = Positive then open valve
  If not Invert and Error = Negative then close valve
  If Invert and Error = Positive then close valve
  If Invert and Error = Negative then open valve
- **Nonlinearity** = Difference between analog input and analog output at current valve position over the full valve operating range.
- **Close Coast** = Difference between Position when the motor is turned off and Position when the valve stops moving in the close direction. Coast is caused by both inertia of the motor and latency of Position update due to analog input filtering. The controller measures close coast to automatically tune control for maximum accuracy.

- **Open Coast** = Difference between Position when the motor is turned off and Position when the valve stops moving in the open direction. The controller measures open coast to automatically tune control for maximum accuracy.
- **Modulation Delay** = Time between when the motor is turned off until the motor can be started again. This delay prevents excessive number of starts of the motor, preventing overheating the motor and premature burnout of the reversing contactor. Modulation delay also prevents valve plugging when the actuator reverses direction. If a three phase motor is used, the delay time is 2 seconds or 1800 starts per hour. If a single phase, capacitor start, AC motor is used, then the delay is 12 seconds or 300 starts per hour. The delay between motor control pulses while the valve is being jogged to position is automatically reduced to one second.
- **Turn-off Delay = 10 Seconds** = Delay after motor stops before turning off Open or Close reversing contactor outputs unless a reversal in direction is required. If reversal in direction, then Modulation Delay time is used. Valid only when Futronic III or Futronic IV modes are selected. This delay prevents excessive operation of the contactor while modulating or the 4-20mA command signal is being ramped by a PID control loop.
- **Accel** = Time required to accelerate motor speed from zero to full speed when motor is started due to Error greater than Deadband. The purpose of Accel is to soft-start the motor and to help prevent control overshoot when making small position changes. Accel is inversely proportional to Error and is automatically adjusted by the controller.
- **Decel** = Time required to decelerate motor speed from full speed to zero while Position is approaching Command position setpoint. Valid only when Futronic III or Futronic IV modes are selected. Decel is proportional to Error. If motor is at full speed (Accel time expired) and Error is less than tuned parameter then the controller begins decelerating motor speed over a period of time where Decel = (Error-Deadband)*T Sec. Decel is activated only when Accel time has expired. This prevents motor stall when making small position changes.
  If Error is less than Deadband then Decel = 0.
- **DC Motor Speed Control** = Full speed of the motor is set at the factory using a potentiometer on the SCR motor control module. The Digital Futronic module regulates full speed of the motor, maintaining accurate speed/valve travel time regardless of high or low power line conditions and varying load conditions. Valid only for Futronic III.

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