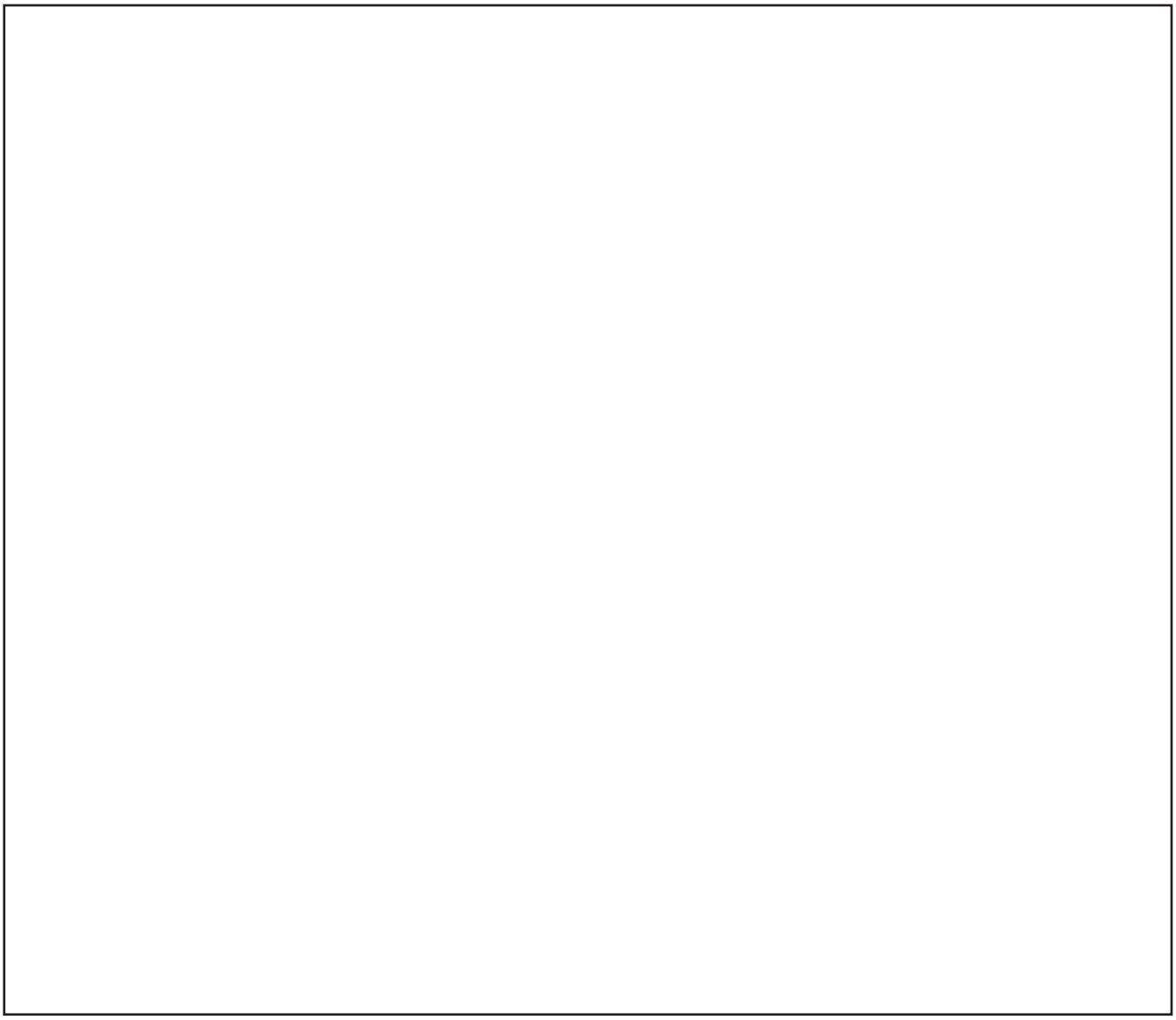
User Manual
84829 Rev. D
March 2013

Bettis 2000 Series M2CP Digital Futronic



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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 three Bettis motor control starter types.

1. Futronic II Electro-mechanical AC motor starter
2. Futronic III SCR Solid-state DC motor starter
3. Futronic IV Triac Solid-state (SSR) AC motor starter

Section 2: Features and Specifications

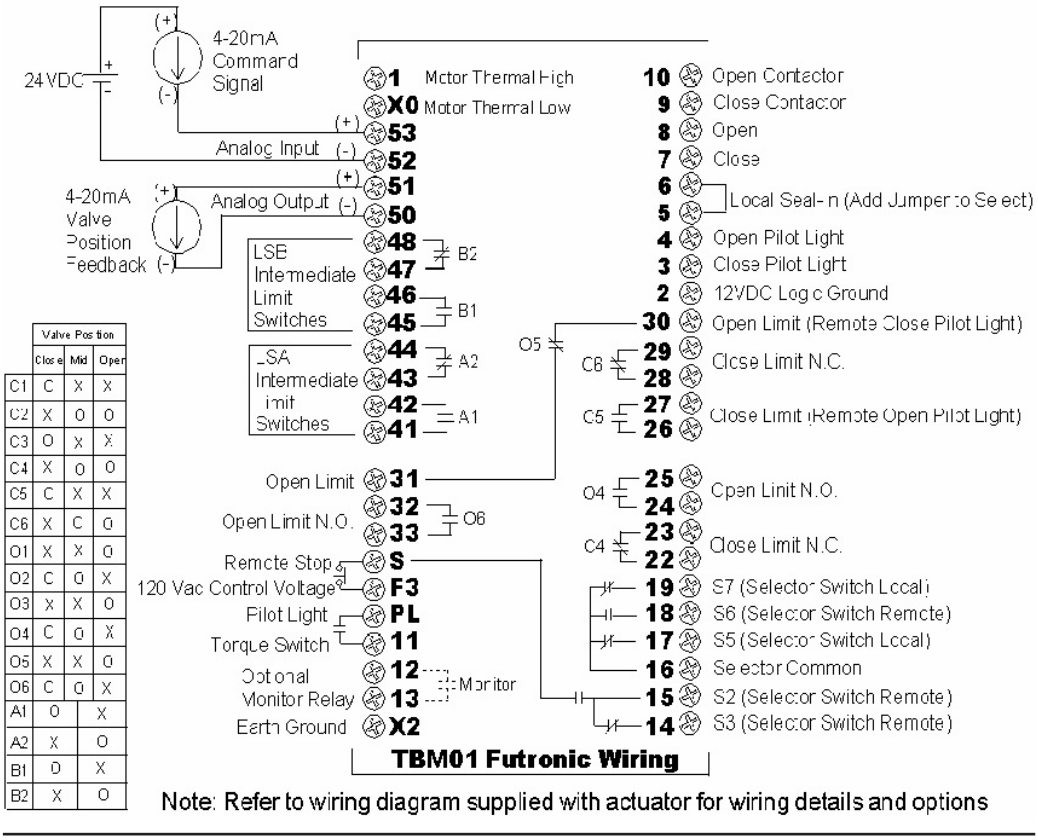
- Integral auto-tuning PID control maximizes accuracy without any user adjustments.
- Digital microcontroller adapts to any actuator and valve size, speed/stroke-time, process pressure, etc. by automatically tuning controls to obtain maximum accuracy without any user adjustments for bandwidth, delay time, etc.
- Automatic calibration of position input to valve travel limits.
- Built-in protection for motor and motor controls.
- DC motor speed control for Futronic III.
- 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.
- 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%.
- 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
- Nonlinearity: <0.05% of calibrated analog input and output over full range of 0-100%.
- Operating Temperature Range: -40C to +85C (-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 1 below is generic and provided primarily for wiring 4-20mA analog input and output signals. Refer to Figure 1 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 1 TBM01 Futronic Wiring

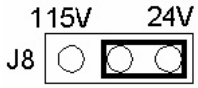


	Valve Position		
	Close	Mid	Oper
C1	C	X	X
C2	X	O	O
C3	O	X	X
C4	X	O	O
C5	C	X	X
C6	X	C	O
O1	X	X	O
O2	C	O	X
O3	X	X	O
O4	C	O	X
O5	X	X	O
O6	C	O	X
A1	O	X	
A2	X	O	
B1	O	X	
B2	X	O	

Note: Refer to wiring diagram supplied with actuator for wiring details and options

Important Notice:

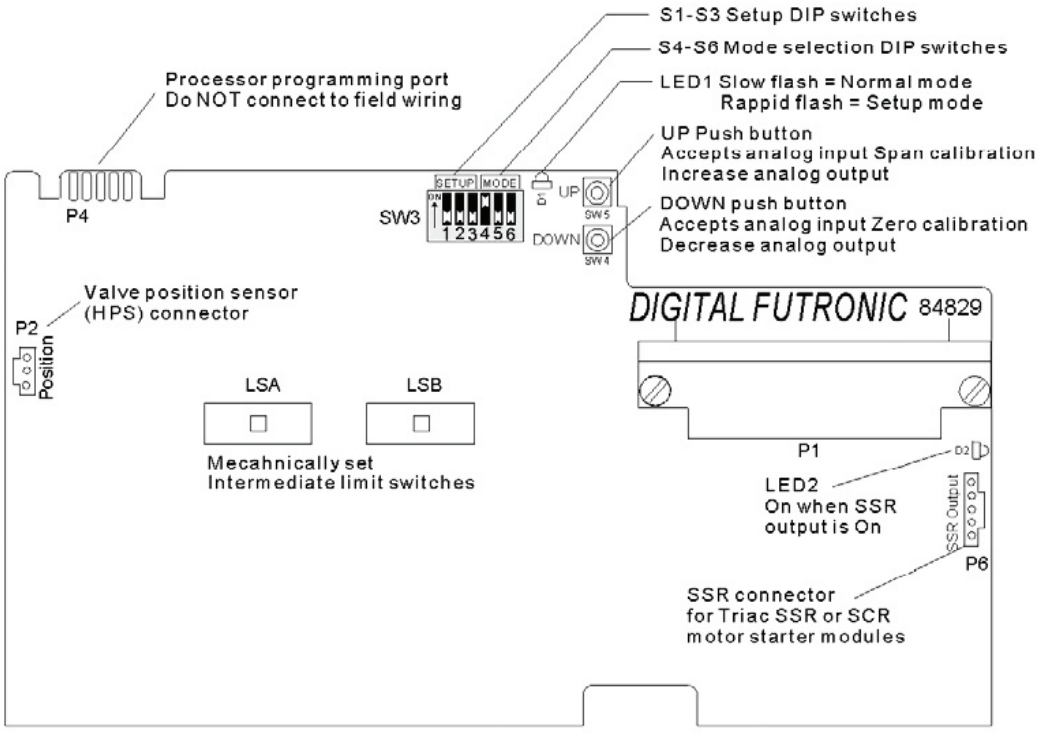
Jumper J8 located on the bottom of TBM01 must be in the 24V positionbefore the Digital Futronic card will operate.



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 push buttons labeled UP and DOWN.
Refer to Figure 2 for location of DIP switches and push buttons.

Figure 2



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

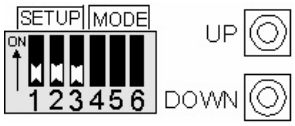
- On when Solid State Relay (SSR or SCR) is On (control power applied to output).

4.2 Setup

4.2.1 Normal Run Mode (S1, S2, S3 OFF)

Turn off S1, S2 & S3 for Normal Run Mode - Figure 3.

Figure 3



4.2.2 Cal Analog Input (S1 ON)

Press **UP** to set Span (20mA) Input - Figure 4.

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

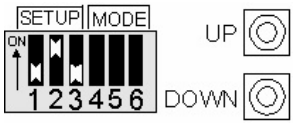
Figure 4

4.2.3 Cal Analog Output Zero (S2 ON)

Press **UP** to increase (4mA) Output - Figure 5.

Press **DOWN** to decrease (4mA) Output - Figure 5.

Figure 5

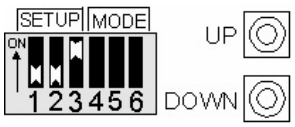


4.2.4 Cal Analog Output Span (S3 ON)

Press **UP** to increase (20mA) Output - Figure 6.

Press **DOWN** to decrease (20mA) Output - FIgure 6.

Figure 6

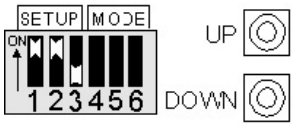


4.2.5 Set Modulation Delay (S1, S2 ON)

Press **UP** to select 3-Ph motor (delay = 2 sec) - Figure 7.

Press **DOWN** to select 1-Ph motor (delay = 12 sec) - Figure 7.

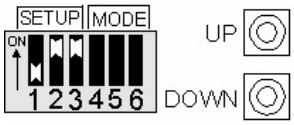
Figure 7



4.2.6 Set Default Position (S2 & S3 ON)

Press **UP** or **DOWN** to accept current valve position as default position - Figure 8.

Figure 8

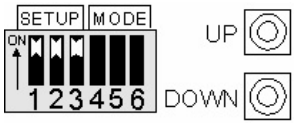


4.2.7 Invert Analog I/O (S1, S2 & S3 ON)

Press **UP** to Select Inverted Mode - Figure 9.

Press **DOWN** to Disable Inverted Mode - Figure 9.

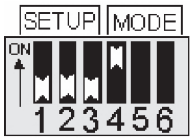
Figure 9



4.3 Mode

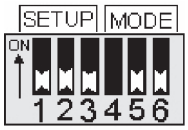
1. S4 ON = Go to Default Position on loss of analog input control signal - Figure 10.
   S4 OFF = Stay put on loss of analog input control signal - Figure 10.

Figure 10



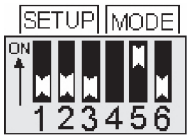
2. S5 OFF and S6 OFF > Select Futronic II mode
   (Electromechanical motor starter) - Figure 11.

Figure 11



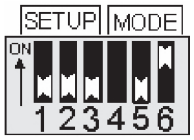
3. S5 ON and S6 OFF > Select Futronic III mode
   (SCR solid-state DC motor starter) - Figure 12.

Figure 12



4. S5 OFF and S6 ON > Select Futronic IV mode
   (Triac solid-state (SSR) motorstarter) - Figure 13.

Figure 13



4.4 Calibration Procedures

⚠ CAUTION

Place selector switch in "OFF" position before calibrating actuator.

4.4.1 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 connect to TBM terminals 50(-) and 51(+) to monitor the analog input at the output.

4.4.2 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.

4.4.3 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.

Appendix A: Definitions

1. 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.
2. 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.
3. Feedback = 4-20mA analog output signal for feedback of valve position to remote control equipment. Zero and Full-scale calibrated by user.
4. Invert = Inverted calibration of 4-20mA command where close position = 20mA, and open position = 4mA. Feedback is also inverted.
5. Deadband = Allowable error tolerance to keep valve stopped, i.e. do not turn on motor control outputs. Deadband cannot be adjusted by the user. 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
6. 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
7. Nonlinearity = Difference between analog input and analog output at current valve position over the full valve operating range.
8. 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.
9. 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.
10. 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.

11. Turn-off Delay = 10 Seconds = Delay after motor stops before turning off Openor 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.
12. 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.
13. 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.
14. 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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