MODEL DLC - DUAL LOOP CONTROLLER

GENERAL DESCRIPTION

The Model DLC, Dual Loop Controller, is a full featured, DIN rail mounted, dual input PID controller. The DLC is designed as a modular building block for multi-zone process control applications. The controller has two independent “A” & “B” input channels. Each channel’s input can be configured to accept a wide range of thermocouple, RTD, 0-10 V, 0/4-20 mA, or resistive signals. The two time-proportioning or DC Analog outputs can be programmed to control two independent processes. The two alarms per channel can be configured for various alarm modes, or provide a secondary control output for heat/cool applications.

The control and alarm outputs are N channel open drain MOSFETs capable of switching up to 1 Amp DC. For applications requiring larger loads, several DIN rail mount relays are available.

The controller operates in the PID Control Mode for both heating and cooling, with on-demand auto-tune, that establishes the tuning constants. The PID tuning constants may be fine-tuned through the serial interface. The controller employs a unique overshoot suppression feature, which allows the quickest response without excessive overshoot. The controller can be transferred to operate in the Manual Mode, providing the operator with direct control of the output, or the On/Off Control Mode with adjustable hysteresis.

The controller’s high density packaging and DIN rail mounting saves time and panel space. The controller snaps easily onto standard top hat (T) profile DIN rails.

ALARMS

The DLC’s two solid-state alarms can be configured independently for absolute high or low acting with balanced or unbalanced hysteresis. They can also be configured for deviation and band alarm. In these modes, the alarm trigger values track the setpoint value. Adjustable alarm trip delays can be used for delaying output response. The alarms can be programmed for Automatic or Latching operation. Latched alarms must be reset with a serial command. A standby feature suppresses the alarm during power-up until the temperature stabilizes outside the alarm region. The outputs can also be manually controlled with register commands.

COMMUNICATIONS

The RS485 serial communications allows the DLC to be multi-dropped, with baud rates up to 38400. The CBPRO0007 programming cable converts the RS232 port of a PC to RS485 and is terminated with an RJ11 connector. The bi-directional capability of the CBPRO0007 allows it to be used as a permanent interface cable as well as a programming cable.

SOFTWARE

The DLC is programmed with Windows™ based SFDLC software. The software allows configuration and storage of DLC program files, as well as calibration. Additionally, all setup and control parameters can be interrogated and modified through MODBUS™ register and coil commands.

ANALOG OUTPUT OPTION

The optional dual DC Analog Output (10 V or 20 mA) can be independently configured and scaled for control or re-transmission purposes. These outputs can be assigned to separate channels, or both outputs can be assigned to the same channel. Programmable output update time reduces valve or actuator activity.

SAFETY SUMMARY

All safety related regulations, local codes and instructions that appear in the manual or on equipment must be observed to ensure personal safety and to prevent damage to either the instrument or equipment connected to it. If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Do not use the controller to directly command motors, valves, or other actuators not equipped with safeguards. To do so can be potentially harmful to persons or equipment in the event of a fault to the controller. An independent and redundant temperature limit indicator with alarm outputs is strongly recommended.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>MODEL NO.</th>
<th>DESCRIPTION</th>
<th>PART NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLC</td>
<td>Dual Loop Controller</td>
<td>DLC00000</td>
</tr>
<tr>
<td>SFC</td>
<td>Dual Loop Controller w/ 2 Analog Outputs</td>
<td>DLC10000</td>
</tr>
<tr>
<td>SF</td>
<td>PC Configuration Software for Windows™</td>
<td>SFDLC</td>
</tr>
<tr>
<td>CBPRO</td>
<td>Programming Interface Cable</td>
<td>CBPRO0007</td>
</tr>
<tr>
<td>CBJ</td>
<td>Cable RJ11 to RJ11 (6 inch jumper)</td>
<td>CBJ11BD5</td>
</tr>
<tr>
<td>DRR</td>
<td>RJ11 to Terminal Adapter</td>
<td>DRRJ11T6</td>
</tr>
<tr>
<td>P89</td>
<td>Paradigm to RJ11 Cable</td>
<td>P893805Z</td>
</tr>
</tbody>
</table>

See our RSRLY8, RLY6, and RLY7 literature for details on DIN rail mountable relays.
1. **POWER:** 
18 to 36 VDC, 13 W
(4 W if +24 VDC Output excitation is unused)
24 VAC, ±10% 50/60 Hz, 15 VA
(7 VA if +24 VDC Output excitation is unused)

2. **+24 VDC OUTPUT POWER:** 24 VDC, +15%, -5%, 200 mA max

3. **MEMORY:** Nonvolatile E²PROM retains all programmable parameters.

4. **INPUT:**
   - Sample Time: 100 msec (9.5 Hz)
   - Failed Sensor Response: Open or shorted (RTD only) sensor coils indicated, error code returned in Process Value
   - Common Mode Rejection: >110 dB, 50/60 Hz
   - Normal Mode Rejection: >±40 dB, 50/60 Hz
   - Temperature Coefficient: 0.013%/°C
   - Overvoltage: 50 VDC max
   - Step Response Time: 300 msec typ., 400 msec max

5. **THERMOCOUPLE INPUTS:**
   - Types: T, E, J, K, R, S, B, N, C, linear mV
   - Input Impedance: 20 MΩ
   - Lead Resistance Effect: 0.25 μV/°Ω
   - Cold Junction Compensation: Less than ±1°C typical (±1.5°C max) over 0 to 50°C ambient temperature range or less than ±1.5°C typical (2°C max) over -20 to 65°C maximum ambient temperature range.

   **Resolution:** 1° or 0.1° for all types

   **WIRE COLOR**
   - ANSI: T (+) Black, E (+) Brown, J (+) Orange, K (+) Brown, R (+) Green, S (+) Blue, B (+) Red, N (+) Violet, C (+) White
   - BS 1843: T (+) Orange, E (+) Brown, J (+) Black, K (+) Black, R (+) Blue, S (+) Blue, B (+) Red, N (+) Violet, C (+) White

   **MEASUREMENT RANGE**
   - T: -200 to +400°C
   - E: -200 to +750°C
   - J: -200 to +760°C
   - K: -200 to +1250°C
   - R: 0 to +780°C
   - S: 0 to +840°C
   - B: +149 to +1785°C
   - N: -200 to +1300°C
   - C: 0 to +2315°C
   - W5/W6: -10 mV to 65 mV

6. **RTD INPUTS:**
   - Type: 2 or 3 wire
   - Excitation: 150 μA
   - Lead Resistance: 15 Ω max
   - Resolution: 1 or 0.1° for all types

   **WIRE COLOR**
   - ANSI: W (+) Purple, R (+) Red, N (+) Yellow, C (+) Blue, W5 (+) White, W6 (+) Black
   - BS 1843: W (+) Purple, R (+) Red, N (+) Yellow, C (+) Blue, W5 (+) White, W6 (+) Black

   **MEASUREMENT RANGE**
   - 385: 100 Ω platinum, Alpha = .00385
   - 392: 100 Ω platinum, Alpha = .00391
   - 672: 120 Ω nickel, Alpha = .00672
   - ohms: Linear Resistance

7. **TEMPERATURE INDICATION ACCURACY:** ± (0.3% of span, +1°C). Includes NIST conformity, cold junction effect, A/D conversion errors, temperature coefficient and linearization conformity at 23 °C after 20 minute warm up.

8. **PROCESS INPUT:**

9. **ISOLATION LEVEL:** 500 V @ 50/60 Hz, for one minute (50 V working) between:
   - Ch A Input and all Control & Alarm Outputs
   - Ch B Input
   - RS485/Analog Output

   **Power Supply**

   **Notes:**
   - Ch A Input and all Control/Alarm Outputs share the same common
   - RS485 and Analog Outputs are not internally isolated and must not share the same common (i.e., earth ground).

10. **SERIAL COMMUNICATIONS:**
   - Type: RS485, RTU and ASCII MODBUS modes
   - baud: 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400
   - Format: 7/8 bits, odd, even, and no parity
   - Transmit Delay: Programmable: See Transmit Delay explanation.
   - Transmit Enable (TXEN): (primarily for 20 mA loop converter) open collector VOH = 10 VDC max, VOL = 0.5 VDC @ 5 mA max current limit

11. **A/D CONVERTER:** 16 bit resolution

12. **CONTROL AND ALARM OUTPUTS:**
   - Type: Non-isolated switched DC, N Channel open drain MOSFET
   - Current Rating: 1 A max
   - VPS on: 0.3 V @ 1 A
   - VPS max: 30 VDC
   - Offstate Leakage Current: 0.5 mA max

13. **MAIN CONTROL:**
   - Control: PID or On/Off
   - Output: Time proportioning or DC Analog
   - Cycle Time: Programmable
   - Auto-Tune: When selected, sets proportional band, integral time, derivative time values, and output dampening time
   - Probe Break Action: Programmable

14. **ALARM:** 1 or 2 alarms
   - Modes:
     - Manual (through register/coil)
     - Absolute High Acting (Balanced or Unbalanced Hysteresis)
     - Absolute Low Acting (Balanced or Unbalanced Hysteresis)
     - Deviation High Acting
     - Deviation Low Acting
     - Inside Band Acting
     - Outside Band Acting
   - Reset Action: Programmable; automatic or latched
   - Standby Mode: Programmable; enable or disable
   - Hysteresis: Programmable
   - Sensor Fail Response: Upscale

15. **COOLING:** Software selectable (overrides Alarm 2).
   - Control: PID or On/Off
   - Output: Time proportioning or DC Analog
   - Cycle Time: Programmable
   - Proportional Gain Adjust: Programmable
   - Heat/Cool Deadband Overlap: Programmable

16. **ANALOG DC OUTPUTS:** (optional)
   - Control or retransmission, programmable update rate from 0.1 to 250 sec
   - Step Response Time: 100 msec

   **OUTPUT RANGE**
   | ACURRACY |
   | COMPLIANCE |
   | RESOLUTION |
   | COMPLIANCE |
   | RESOLUTION |
   | COMPLIANCE |

* Accuracies are expressed as ± percentages after 20 minute warm-up.
** Outputs are independently jumper selectable for either 10 V or 20 mA.
   The output range may be field calibrated to yield approximate 10% overrange and a small underrange (negative) signal.

17. **ENVIRONMENTAL CONDITIONS:**
   - Operating Temperature Range: -20 to +65°C
   - Storage Temperature Range: -40 to +85°C
   - Operating and Storage Humidity: 85% max relative humidity, noncondensing, from -20 to +65°C
   - Altitude: Up to 2000 meters
18. CERTIFICATIONS AND COMPLIANCE:

SAFETY
EN 61010-1, IEC 1010-1
Safety requirements for electrical equipment for measurement, control, and laboratory use, Part I

ELECTROMAGNETIC COMPATIBILITY

Immunity to EN 50082-2
- Electrostatic discharge EN 61000-4-2 Level 3; 8 kV air\(^1\)
- Electromagnetic RF fields EN 61000-4-3 Level 3; 10 V/m
- Fast transients (burst) EN 61000-4-4 Level 4; 2 kV I/O
- RF conducted interference EN 61000-4-6 Level 3; 10 V/\(\text{rms}\)
- Power frequency magnetic fields EN 61000-4-8 Level 4; 30 A/m
- Simulation of cordless telephone ENV 50204 Level 3; 10 V/m

Emissions to EN 50081-2
- RF interference EN 55011 Enclosure class A
  Power mains class A

\(^1\) This controller was designed for installation in an enclosure. To avoid electrostatic discharge to the unit in environments with static levels above 6 kV, precautions should be taken when the device is mounted outside an enclosure. When working in an enclosure (ex. making adjustments, setting switches etc.), typical anti-static precautions should be observed before touching the controller.

19. CONSTRUCTION: Case body is black high impact plastic. Installation Category I, Pollution Degree 2.


21. MOUNTING: Snaps on to standard DIN style top hat (T) profile mounting rails according to EN50022 -35 x 7.5 and -35 x 15.

22. WEIGHT: 10.5 oz. (298 g.)

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**BLOCK DIAGRAM**

[Diagram of block diagram showing connections and components such as input power, power supply, process circuitry, memory, isolators, and other electrical components.]

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(DO NOT CONNECT pins 8 and 18)
EMC INSTALLATION GUIDELINES

Although this controller is designed with a high degree of immunity to Electromagnetic Interference (EMI), proper installation and wiring methods must be followed to ensure compatibility in each application. The type of the electrical noise, source or coupling method into the controller may be different for various installations. The controller becomes more immune to EMI with fewer I/O connections. Cable length, routing, and shield termination are very important and can mean the difference between a successful or troublesome installation. Listed are some EMC guidelines for successful installation in an industrial environment.

1. Use shielded (screened) cables for all Signal and Control inputs. The shield (screen) pigtail connection should be made as short as possible. The connection point for the shield depends somewhat upon the application. Listed below are the recommended methods of connecting the shield, in order of their effectiveness.
   a. Connect the shield only at the DIN rail where the controller is mounted to earth ground (protective earth).
   b. Connect the shield to earth ground at both ends of the cable, usually when the noise source frequency is over 1 MHz.
   c. Connect the shield to common of the controller and leave the other end of the shield unconnected and insulated from earth ground.

2. Never run Signal or Control cables in the same conduit or raceway with AC power lines, conductors feeding motors, solenoids, SCR controls, and heaters, etc. The cables should be run through metal conduit that is properly grounded. This is especially useful in applications where cable runs are long and portable two-way radios are used in close proximity or if the installation is near a commercial radio transmitter.

3. Signal or Control cables within an enclosure should be routed as far away as possible from contactors, control relays, transformers, and other noisy components.

4. In extremely high EMI environments, the use of external EMI suppression devices, such as ferrite suppression cores, is effective. Install them on Signal and Control cables as close to the controller as possible. Loop the cable through the core several times or use multiple cores on each cable for additional protection. Install line filters on the power input cable to the controller to suppress power line interference. The following EMI suppression devices (or equivalent) are recommended:
   - Ferrite Suppression Cores for signal and control cables:
     - Fair-Rite # 0443167251 (Red Lion Controls # FCOR0000)
     - TDK # ZCAT3035-1330A
     - Steward # 28B209-0A0
   - Line Filters for input power cables:
     - Schaffner # FN610-1/07 (Red Lion Controls # LFIL0000)
     - Schaffner # FN670-1.8/07
     - Corcom # 1 VR3

   Note: Reference manufacturer’s instructions when installing a line filter.

5. Long cable runs are more susceptible to EMI pickup than short cable runs. Therefore, keep cable runs as short as possible.

6. Switching of inductive loads produces high EMI. Use of snubbers across inductive loads suppresses EMI.
   - Snubber: Red Lion Controls # SNUB0000.

STEP 1  SETTING THE JUMPERS

The jumpers are accessible from the bottom of the controller. Needle-nose pliers are needed to remove the jumpers. They should be set prior to installation. To insure proper operation, the jumpers must match the controller software configuration.

ANALOG DC OUTPUTS (OPTIONAL)

Analog Output 1 and Analog Output 2 can be configured for voltage (V) or current (I), independent of each other. Both V/I + and V/I - jumpers of the same channel must be set for the same type of output signal.

INPUTS

Channel A and Channel B can be configured independent of each other. Jumper position can be ignored for thermocouple and millivolt inputs.
STEP 2 INSTALLING THE CONTROLLER

INSTALLATION
The controller is designed for attachment to standard DIN style top hat (T) profile mounting rails according to EN50022 -35 x 7.5 and -35 x 15. The controller should be installed in a location that does not exceed the maximum operating temperature and provides good air circulation. Placing the controller near devices that generate excessive heat should be avoided.

T Rail Installation
To install the DLC on a “T” style rail, angle the controller so that the top groove of the mounting recess is located over the lip of the top rail. Push the controller toward the rail until it snaps into place. To remove a controller from the rail, insert a screwdriver into the slot on the bottom of the controller, and pry upwards until it releases from the rail.

STEP 3 WIRING THE CONTROLLER

WIRING CONNECTIONS
All conductors should meet voltage and current ratings for each terminal. Also, cabling should conform to appropriate standards of good installation, local codes and regulations. When wiring the controller, use the numbers on the label to identify the position number with the proper function. Strip the wire, leaving approximately 1/4” (6 mm) of bare wire exposed. Insert the wire into the terminal, and tighten the screw until the wire is clamped tightly. (Pull wire to verify tightness.) Each terminal can accept up to one #14 AWG (2.55 mm), two #18 AWG (1.02 mm), or four #20 AWG (0.61 mm) wires.

INPUT CONNECTIONS

RTD and Resistance *

<table>
<thead>
<tr>
<th>Exc./ Jumper</th>
<th>0–10V, 0–20mA RTD EXC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense</td>
<td>TC+ OR RTD</td>
</tr>
<tr>
<td>Sense</td>
<td>INPUT COMMON</td>
</tr>
<tr>
<td>TBB</td>
<td>CH A = Terminals 4, 5 &amp; 6 CH B = Terminals 1, 2 &amp; 3</td>
</tr>
</tbody>
</table>

Thermocouple and Millivolt

<table>
<thead>
<tr>
<th>DC+</th>
<th>0–10V, 0–20mA RTD EXC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC+</td>
<td>INPUT COMMON</td>
</tr>
<tr>
<td>TC–</td>
<td>CH A = Terminals 4, 5 &amp; 6 CH B = Terminals 1, 2 &amp; 3</td>
</tr>
</tbody>
</table>

Voltage or Current

<table>
<thead>
<tr>
<th>DC+</th>
<th>0–10V, 0–20mA RTD EXC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT COMMON</td>
<td></td>
</tr>
</tbody>
</table>

2 Wire Current Signal Requiring DLC Excitation **

<table>
<thead>
<tr>
<th>LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>+24VDC OUT (200 mA max)</td>
</tr>
<tr>
<td>CH A = Terminals 4, 5 &amp; 6 CH B = Terminals 1, 2 &amp; 3</td>
</tr>
</tbody>
</table>

3 Wire Current or Voltage Signal Requiring DLC Excitation **

<table>
<thead>
<tr>
<th>LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>+24VDC OUT (200 mA max)</td>
</tr>
<tr>
<td>CH A = Terminals 4, 5 &amp; 6 CH B = Terminals 1, 2 &amp; 3</td>
</tr>
</tbody>
</table>

* For two wire RTDs, install a copper sense lead of the same gauge and length as the RTD leads. Attach one end of the wire at the probe and the other end to input common terminal. Complete lead wire compensation is obtained. This is the preferred method. If a sense wire is not used, then use a jumper. A temperature offset error will exist. The error may be compensated by programming a temperature offset.

** +24 VDC OUT (Terminal 3) shares common with Ch A Inputs & All Control/Alarm Outputs.
CONTROL AND ALARM OUTPUT CONNECTIONS

**LOAD POWER FROM DLC EXTERNAL CONTROLLER POWER**

- AL2/OP2
- AL1
- OP1
- OUTPUT COMMON
- DC+/ (AC)
- DC− / (AC)
- TBA

**SEPARATE EXTERNAL POWER FOR LOAD AND CONTROLLER**

- AL2/OP2
- AL1
- OP1
- OUTPUT COMMON
- DC+/ (AC)
- DC− / (AC)
- TBA

**COMBINED EXTERNAL POWER FOR LOAD AND CONTROLLER**

- AL2/OP2
- AL1
- OP1
- OUTPUT COMMON
- DC+/ (AC)
- DC− / (AC)
- TBA

CH A = Terminals 5, 6, & 7
CH B = Terminals 8, 9, & 10

ANALOG DC OUTPUT CONNECTIONS

- Controller, Recorder
- OUT
- TBB
- ANALOG OUTPUT 0−10V, 0(4)—20mA

**DEFAULT SERIAL SETTING CONNECTIONS**

- RJ11
- 1 DLC Not used
- 2 B−
- 3 A+
- 4 COMM
- 5 TXEN
- 6 Not used

- DLC CONNECTOR
- Protocol: RTU
- Address: 247
- Data Bits: 8
- Parity: none

RS485 SERIAL CONNECTIONS

There are two modular connectors located on the front for paralleling communications. For single device communications, either connector can be used. Reverse A+ and B− wiring for Red Lion Control Paradigm products. An RS485 to RS232 converter is available from Red Lion Controls.

The CBPRO007 programming cable converts the RS232 port of a PC to RS485 and is terminated with an RJ11 connector. The bi-directional capability of the CBRO007 allows it to be used as a permanent interface cable as well as a programming cable.

**STEP 4 IDENTIFYING THE LEDS - LED FUNCTIONALITY**

On power-up, all LEDs are turned on briefly in an alternating pattern to allow visual check of LED functionality.

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PRIORITY</th>
<th>PWR/COMM</th>
<th>CH A OP</th>
<th>CH A ALM</th>
<th>AUTOTUNE</th>
<th>CH B OP</th>
<th>CH B ALM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Applied</td>
<td>1</td>
<td>On</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
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<tr>
<td>Communicating</td>
<td>1</td>
<td>Flashing</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
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<tr>
<td>OP1 On (Channel A) **</td>
<td>4</td>
<td>--------</td>
<td>On</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>OP1 On (Channel B) **</td>
<td>4</td>
<td>--------</td>
<td>--------</td>
<td>On</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>AL1 On (Channel A) *</td>
<td>4</td>
<td>--------</td>
<td>On</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>AL1 On (Channel B) *</td>
<td>4</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>On</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>AL2 On (Channel A) *</td>
<td>4</td>
<td>--------</td>
<td>Fast Flashing</td>
<td>--------</td>
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<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>AL2 On (Channel B) *</td>
<td>4</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>Fast Flashing</td>
<td>Appendix</td>
</tr>
<tr>
<td>OP2 On [Cool](Channel A)</td>
<td>5</td>
<td>--------</td>
<td>Fast Flashing</td>
<td>--------</td>
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<td>--------</td>
<td>Appendix</td>
</tr>
<tr>
<td>OP2 On [Cool](Channel B)</td>
<td>5</td>
<td>--------</td>
<td>--------</td>
<td>Fast Flashing</td>
<td>--------</td>
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<td>Appendix</td>
</tr>
<tr>
<td>Auto-Tune On (Channel A)</td>
<td>3</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>On</td>
<td>--------</td>
<td>Appendix</td>
</tr>
<tr>
<td>Auto-Tune On (Channel B)</td>
<td>3</td>
<td>--------</td>
<td>--------</td>
<td>Fast Flashing</td>
<td>--------</td>
<td>--------</td>
<td>Appendix</td>
</tr>
<tr>
<td>Input Error (Channel A)</td>
<td>3</td>
<td>--------</td>
<td>Slow Flashing</td>
<td>Slow Flashing</td>
<td>--------</td>
<td>--------</td>
<td>Appendix</td>
</tr>
<tr>
<td>Input Error (Channel B)</td>
<td>3</td>
<td>--------</td>
<td>Slow Flashing</td>
<td>Slow Flashing</td>
<td>--------</td>
<td>Slow Flashing</td>
<td>Appendix</td>
</tr>
<tr>
<td>Calibration Mode</td>
<td>2</td>
<td>--------</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>Appendix</td>
</tr>
<tr>
<td>Checksum Error</td>
<td>1</td>
<td>Slow Flashing</td>
<td>Slow Flashing</td>
<td>Slow Flashing</td>
<td>Slow Flashing</td>
<td>Slow Flashing</td>
<td>Appendix</td>
</tr>
</tbody>
</table>

* If AL1 & AL2 outputs are on at the same time, the ALM annunciator will alternate between On and Fast Flashing every ½ second.

** If OP1 and AL2/OP2 (configured for cool) outputs are on at the same time, the annunciator will only show the OP1 state. The OP2 state is only shown when OP1 is off.

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Additionally, if the serial settings are unknown or forgotten, they can be reset to the factory defaults by connecting the Serial Default terminal 7 to Input Common terminal 4 with a jumper and then cycling power. Remove jumper after cycling power.
Insert the SFDLC diskette into the A: or B: drive. Then Run A:\SETUP (or B:\SETUP) to install RLCPro onto the hard drive. An icon labeled RLCPro will be created under the group RLCPro.

STEP 6 PROGRAMMING - Getting Started

Run RLCPro by double-clicking the icon, or use the start menu.

Use the FILE pull-down menu to select a NEW file, and then the model.

STEP 7 PROGRAMMING THE PID SETTINGS

Note: The register numbers correspond to (Channel A/Channel B).

The Auto-Tune procedure of the controller sets the Proportional Band, Integral Time, Derivative Time, Digital Filter, Control Output Dampering Time, and Relative Gain (Heat/Cool) values appropriate to the characteristics of the process.

Proportional Band (40007/40023): Proportional band, entered as percent of full input range, is the band from the setpoint where the controller adjusts the percent output power based on how close the process value is to the setpoint. For temperature inputs, the input range is fixed per the entered thermocouple or RTD type. For process inputs, the input range is the difference between the entered Process Low Scaling Value and the Process High Scaling Value. The proportional band should be set to obtain the best response to a process disturbance while minimizing overshoot. A proportional band of 0.0% forces the controller into On/Off Control with its characteristic cycling at setpoint.

Integral Time (40008/40024): Integral time is defined as the time, in seconds, it takes the output power due to integral action alone to equal the output power due to proportional action alone during a constant process error. As long as the error exists, integral action repeats the proportional action each integral time. Integral action shifts the center point position of the proportional band to eliminate error in the steady state. The higher the integral time, the slower the response. The optimal integral time is best determined during PID Tuning. If time is set to zero, the previous Integral output power value is maintained. Offset Power can be used to provide Manual Reset. Integral Action can be disabled by writing a ‘1’ to the Disable Integral Action register (40044/40052).

Derivative Time (40009/40025): Derivative time, entered as seconds per repeat, is the time that the controller looks ahead at the ramping error to see what the proportional contribution will be and it matches that value every Derivative time. As long as the ramping error exists, the Derivative action is repeated by Proportional action every derivative time. Increasing the derivative time helps to stabilize the response, but too high of a derivative time, coupled with noisy signal processes, may cause the output to fluctuate too greatly, yielding poor control. Setting the time to zero disables Derivative Action.

Control Mode (40041/40049): In Automatic Mode, the percentage of Output Power is automatically determined by PID or On/Off Control. In Manual Mode, the percentage of Output Power is entered manually. For more information, see Control Mode Explanations Section.

Output Power (40005/40021): This parameter can only be changed by direct entry in Manual Mode. For more details on this parameter, see the Control Mode Explanations Section.

Offset Power (Manual Reset) (40010/40026): If the Integral Time is set to zero (Automatic Reset is off), it may be necessary to modify the output power to eliminate errors in the steady state. The offset power is used to shift the proportional band to compensate for errors in the steady state. If Integral Action is later invoked, the controller will re-calculate the internal integral value to provide “bumpless” transfer.

Auto-Tune Code (40013/40029): Prior to starting Auto-Tune, this code should be set to achieve the necessary dampening level under PID Control. When set to zero, it yields the fastest process response with possible overshoot. A setting of 2 yields the slowest response with the least amount of overshoot. If the Auto-Tune Code is changed, Auto-Tune needs to be reinitiated for the changes to affect the PID settings. Auto-tune is initiated by writing a ‘1’ to the Auto-Tune start register (40011/40027). The Auto-Tune phase will be shown in register (40012/40028). For more information, see PID Tuning Explanations Section.
STEP 8  PROGRAMMING THE INPUT SETUP

Input Type (40101/40201): Select the proper input type from the pull down menu. Make sure the input jumpers are set to match the input signal selection.

Scale (40102/40202): Select either degrees Fahrenheit or Celsius. For mV, resistance, voltage or current types, this has no effect. If changed, check all temperature related values, as the DLC does not automatically convert these values.

Resolution (40103/40203): For all Input Types except mV, low (x1) resolution selects whole units of measure. In these same modes, high (x10) resolution selects tenth of units of measure. For mV mode, low selects tenths of mV and high selects hundredths of mV. If changed, be sure to check all parameters because the controller does not automatically convert related parameter values. For voltage or current types, this has no effect.

Rounding (40104/40204): Rounding selections other than 1 cause the process value to round to the nearest rounding increment selected. (For example, rounding of 5 causes 122 to round to 120 and 123 to round to 125.) Rounding starts at the least significant digit of the process value. If the signal is inherently jittery, the process value may be rounded to a value higher than 1. If the range of the signal exceeds the required resolution (for example, 0-1000 psi, but only 10 psi resolution is required), a rounding increment of 10 will effectively make the reading more stable.

Digital Filtering (40105/40205): The filter is an adaptive digital filter that discriminates between measurement noise and actual process changes. If the signal is varying too greatly due to measurement noise, increase the filter value. If the fastest controller response is needed, decrease the filter value.

Span Correction (40106/40206): This value is the correction slope. A span of 1.0000 applies no correction. Span only applies to temperature sensor inputs.

Offset Correction (40107/40207): This value offsets the temperature value by the entered amount. Offset only applies to temperature sensor inputs.

Scaling Points (40111-40114/40211-40214): Low and high scaling points are necessary to scale the controller for process voltage and current inputs. Each scaling point has a coordinate pair of input and process value entries. The process value will be linear between and continue past the entries up to the

High (40112/40212) values would be 0 and 10000. The scaling point has a coordinate pair of input and process value entries. The process value will be linear between and continue past the entries up to the

Process Decimal Point (Dec Pt) (40115/40215): The decimal point position is used to enable SFDLC display in desired engineering units for voltage and current Process values. It is not used internally by the DLC.

STEP 9  PROGRAMMING THE SETPOINTS

Setpoint (40002/40018): Enter the setpoint value. Deviation of Process Value (40001/40017) from setpoint value can be viewed in the Setpoint Deviation register (40006/40022).

Low Limit (40108/40208): High Limit (40109/40209): The controller has programmable high and low setpoint limit values to restrict the setting range of the setpoint. Set the limits so that the setpoint value cannot be set outside the safe operating area of the process.

Ramp Rate (40110/40210): The setpoint ramp rate can reduce sudden shock to the process and reduce overshoot on startup or after setpoint changes, by ramping the setpoint at a controlled rate. The ramp rate is in process units per minute, where a unit is the least significant digit of the process value. Writing a ‘0’ disables setpoint ramping. The Disable Setpoint Ramping register (40042/40050) can also be used to disable ramping. The Setpoint Ramping In-Process register (40043/40051) will be a ‘1’ during setpoint ramping. While ramping is enabled, the Ramp Register can be viewed in register (40045/40053).

Once the ramping setpoint reaches the target setpoint, the setpoint ramp rate disengages until the setpoint is changed again. If the ramp value is changed during ramping, the new ramp rate takes effect. If the setpoint is ramping prior to starting Auto-Tune, the ramping is suspended during Auto-Tune and then resumed afterward using the present Process value as a starting value. Deviation and band alarms are relative to the target setpoint, not the ramping setpoint. A slow process may not track the programmed setpoint rate. At power-up, the ramping setpoint is initialized to the starting process value.

STEP 10  PROGRAMMING THE OUTPUTS

Cycle Time (40116/40216): The cycle time, entered in seconds, is the combined time of an on and off cycle of a time proportioning control output OP1/OP2. With time proportional output, the percentage of control power is converted into output on time of the cycle time value. (If the controller calculates that 65% power is required and has a cycle time of 10 seconds, the output will be on for 6.5 seconds and off for 3.5 seconds.) For best control, a cycle time equal to one-tenth of the process time constant, or less, is recommended. When using the DC Analog output signal for control, a setting of zero will keep output OP1 off. The status of OP1 can be read through registers 40014/40030.

Control Action (40117/40217): This determines the control action for the PID loop. Programmed for direct action (cooling), the DLC output power will increase if the Process value is above the Setpoint value. Programmed for reverse action (heating), the output power decreases when the Process Value is above the Setpoint Value. For heat and cool applications, this is typically set to reverse. This allows OP1 to be used for heating, and AL2/OP2 to be used for cooling.
Power Low Limit (40118/40218); High Limit (40119/40219): These parameters may be used to limit controller power due to process disturbances or setpoint changes. Enter the safe output power limits for the process. If Alarm 2 is selected for cooling, the range is from -100 to +100%. At 0%, both OP1 and OP2 are off; at 100%, OP1 is on; and at -100%, OP2 is on. When the controller is in Manual Control Mode, these limits do not apply.

Sensor Fail Power Preset (40120/40220): This parameter sets the power level for the control outputs in the event of a sensor failure. If Alarm 2 is not selected for cooling, the range is from 0% (OP1 output full off) to 100% (OP1 output full on). If AL2 is selected for cooling, the range is from -100 to +100%. At 0%, both OP1 and OP2 are off; at 100%, OP1 is on; and at -100%, OP2 is on. The alarm outputs are upscale drive with an open sensor, and downscale drive with a shorted sensor (RTD only), independent of this setting. Manual Control overrides the sensor fail preset.

Dampening Time (40121/40221): The dampening time, entered as a time constant in seconds, dampens (filters) the calculated output power. Increasing the value increases the dampening effect. Generally, dampening times in the range of one-twentieth to one-fiftieth of the controller’s integral time (or process time constant) is effective. Dampening times longer than these may cause controller instability due to the added lag effect.

On/Off Control Hysteresis (40122/40222): The controller can be placed in the On/Off Control Mode by setting the Proportional Band to 0.0%. The On/Off Control Hysteresis (balanced around the setpoint) eliminates output chatter. In heat/cool applications, the control hysteresis value affects both Output OP1 and Output OP2 control. It is suggested to set the hysteresis band to 100 (Factory Setting) prior to starting Auto-Tune. After Auto-Tune, the hysteresis band has no effect on PID Control. On/Off Control Hysteresis is illustrated in the the On/Off Control Mode section.

STEP 11 PROGRAMMING THE ALARMS

Alarm 1 and 2: The controller is equipped with two alarms for each channel. The status of these alarms can be read through AL1 registers 40015/40031 and AL2 registers 40016/40032.

Action (40131/40231), (40136/40236): Select the action for the alarms. See Alarm Action Figures for a visual explanation.

- Manual: In Manual mode, the alarms are forced on and off by writing '0' or '1' to the appropriate alarm output register. In this mode, the alarms will not respond to Alarm and Hysteresis Values.
- Absolute HI (balanced or unbalanced hysteresis): The alarm energizes when the Process Value exceeds the alarm.
- Absolute LO (balanced or unbalanced hysteresis): The alarm energizes when the Process Value falls below the alarm.
- Deviation HI, Deviation LO, Band Acting: In these actions, Alarm 1 and 2 value tracks the Setpoint value.
- Cooling (OP2): For heat/cool applications, select Cool for Alarm 2. The controller then utilizes the Alarm 2 output as the Cooling Output (OP2). If cooling is selected, the remaining Alarm 2 parameters are not available.

Note: Hys in the above figures refers to the Alarm Hysteresis.
STEP 12 PROGRAMMING THE COOLING

To enable Cooling in Heat/Cool applications, the Alarm 2 Action must first be set for Cooling. When set to cooling, the output no longer operates as an alarm but operates as an independent cooling output. The OP2 terminals are the same as AL2. Cooling output power ranges from -100% (full cooling) to 0% (no cooling, unless a heat/cool deadband overlap is used). The Power Limits in the Output category also limits the cooling power.

Cycle Time (40141/40241): This cycle time functions like the OP1 Output Cycle Time but allows independent cycle time for cooling. A setting of zero will keep output OP2 off. The status of OP2 can be read through registers (40016/40032).

Relative Gain (40142/40242): This defines the gain of the cooling relative to the heating. It is generally set to balance the effects of cooling to that of heating. This is illustrated in the Heat/Cool Relative Gain Figures. A value of 0.0 places the cooling output into On/Off Control. This may be done independent of the OP1 Output PID or On/Off Control Modes.

Deadband (40143/40243): This defines the area in which both heating and cooling are active (negative value) or the deadband area between the bands (positive value). If a heat/cool overlap is specified, the percent output power is the sum of the heat power (OP1) and the cool power (OP2). If Relative Gain is zero, the cooling output operates in the On/Off Control Mode, with the Deadband value becoming the cooling output hysteresis (positive value only). This is illustrated in the On/Off Control Mode section. For most applications, set this parameter to 0.0 prior to starting Auto-Tune. After the completion of Auto-Tune, this parameter may be changed.
**STEP 13  PROGRAMMING THE ANALOG OUTPUT (Optional)**

Note: The register numbers correspond to (Analog Output 1/Output 2).

Assignment (40301/40309): This setting selects the value that the Analog Output will retransmit, or track. The Analog output can be assigned for the following:

<table>
<thead>
<tr>
<th>SELECTION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Power A</td>
<td>Transmits the Output Power demand of Channel A. Used if linear control is desired.</td>
</tr>
<tr>
<td>Process Value A</td>
<td>Retransmits Process Value Channel A</td>
</tr>
<tr>
<td>Setpoint A</td>
<td>Retransmits Setpoint Value Channel A</td>
</tr>
<tr>
<td>Ramping Setpoint A</td>
<td>Retransmits Ramping Setpoint Channel A</td>
</tr>
<tr>
<td>Deviation A</td>
<td>Retransmits Deviation (difference of Setpoint Value - Process Value) Channel A</td>
</tr>
<tr>
<td>Direct Entry Value 1</td>
<td>Retransmits Direct Entry Value 1 (Manual Analog Control)</td>
</tr>
<tr>
<td>Output Power B</td>
<td>Transmits the Output Power demand of Channel B. Used if linear control is desired.</td>
</tr>
<tr>
<td>Process Value B</td>
<td>Retransmits Process Value Channel B</td>
</tr>
<tr>
<td>Setpoint B</td>
<td>Retransmits Setpoint Value Channel B</td>
</tr>
<tr>
<td>Ramping Setpoint B</td>
<td>Retransmits Ramping Setpoint Channel B</td>
</tr>
<tr>
<td>Deviation B</td>
<td>Retransmits Deviation (difference of Setpoint Value - Process Value) Channel B</td>
</tr>
<tr>
<td>Direct Entry Value 2</td>
<td>Retransmits Direct Entry Value 2 (Manual Analog Control)</td>
</tr>
</tbody>
</table>

Mode (40302/40310): Select the type of output and range. The Analog output jumpers must be set to match the output type and range selected. The Analog output can be calibrated to provide up to 5% of over range operation.

Output Scaling Values: The Scaling Low value (40303/40311) corresponds to 0 V, 0 mA or 4 mA, depending on the range selected. The Scaling High value (40304/40312) corresponds to 10 V or 20 mA depending on the range selected. An inverse acting output can be achieved by reversing the Scaling Low and Scaling High points.

Deadband (40305/40313): The output power change must be greater than the deadband value in order for the Analog output to update. This only applies when the Analog Output is assigned to Output Power. This setting can be used to reduce actuator activity.

Update Time (40306/40314): To reduce excess valve actuator or pen recorder activity, the update time of the analog output can be set in seconds. A value of zero seconds results in an update time of 0.1 second.

Direct Entry Value (40307/40315): If the analog output is programmed for Direct Entry, it retransmits this value. This value may be controlled by the host.

**STEP 14  PROGRAMMING THE DLC COMMS PORT**

Note: If the communication settings are changed and then a download is performed, the controller will immediately respond to the new settings. Any further attempts to communicate to the controller must target the new address, with the new settings.

**SERIAL SETTINGS**

<table>
<thead>
<tr>
<th>MODBUS Protocol (40405)</th>
<th>RTU or ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Address (40401)</td>
<td>1-247</td>
</tr>
<tr>
<td>Baud Rate (40402)</td>
<td>300 to 38400</td>
</tr>
<tr>
<td>Data Bits (40404)</td>
<td>7 or 8</td>
</tr>
<tr>
<td>Parity (40403)</td>
<td>odd, even, or none</td>
</tr>
</tbody>
</table>

Transmit Delay (40406): Programmable from 1-250 milliseconds.

The Transmit Delay is the time the DLC waits to respond to a serial command, UNLESS the values in the table are larger.

Note: Changing the above parameters by writing to their registers directly will not update the DLC until Load Serial Settings register 40407 is a ‘1’. After a write, this register will return to ‘0’.

Default Serial Settings: If you do not know or cannot recall the DLC settings, they can be reset to factory defaults. Connect the Serial Default terminal to Input Common, and cycle power. Remove the connection after cycling power. The Defaults button in the SDLC software will update the category display to these settings.

Communications Diagnostics: The Communications Diagnostics function (MODBUS Function Code 08) can be used to troubleshoot systems that are experiencing communication errors. Press the Read button to retrieve the diagnostics information. The Commands Received and the Commands Processed values are automatically reset when the values are read, at each controller power-up, and when the Commands Received reaches 65536.

Commands Received: The total number of messages received that started with the controller’s own address since the last reset or power up.

Commands Processed: The number of “good” messages received. A “good” message is considered one that contained the correct unit address, parity, and checksum (CRC or LRC).
**STEP 15  PC PORT CONFIGURATION**

Go to the SETTINGS pull-down menu, and select PC PORT SETTINGS.

The Communications Settings window allows you to set up the software properly to perform a download.

**Connection:** Select the computer port (COMM 1-4) that the DLC is connected to.

**Note:** The following settings must match the DLC. If you do not know or cannot recall the DLC settings, they can be reset back to factory defaults. Simply jumper the Default Serial Setting terminal to Common, and cycle power. The serial settings will default to RTU mode, 9600 baud, 8 data bits, No parity, with an address of 247.

**Protocol:** RTU or ASCII

**Unit Address:** 1-247

**Baud Rate:** 300, 600, 1200, 2400, 4800, 9600, 19200, 38400

**Data Bits:** 7 or 8

**Parity:** odd, even, or none

Connect the DLC to the computer with the CBPRO007 interface cable (or any suitable RS232/RS485 converter).

Apply power to the supply terminals of the DLC.

**Note:** The CBPRO007 download cable DOES NOT typically require power. In most cases it will derive its power from the PC. If communications can not be established, follow the troubleshooting guide. If it is determined that the converter requires power, attach a 12 VDC power supply to the VDC and common terminals of the cable.

**STEP 16  DOWNLOADING**

Go to the FILE pull-down menu, and select DOWNLOAD.

The following screen prompts you to ensure that the proper file is downloaded to the correct controller. Click “OK” to continue.

**STEP 17  SCRATCH PAD MEMORY**

The Scratch Pad category can be used to read or write to the Scratch Pad memory locations (41101-41116). The Scratch Pad locations can be used to store user information.

**Data Format:** Allows registers to be viewed in decimal or hexadecimal format.

**Upload:** The Upload button causes SFDLC software to read the Scratch Pad registers from the controller.

**Download:** The Download button causes SFDLC software to write to the Scratch Pad registers in the controller.

**Note:** Downloading new values to the controller Scratch Pad locations overwrites the information that is currently stored in those registers.

**Defaults:** For this category, there are no controller factory defaults. The defaults for this category are only SFDLC software basic default values.
**STEP 18  VIEW REGISTERS**

The View Registers category can be used as a method of diagnostics. Use the DLC Register Table as a reference of register assignments and data.

**First Register:** This specifies the first register to be read in a block.

**# of Registers:** This is the length of the block to be read. The controller supports block read and write commands up to 32 registers in length. The SFDLC software only allows 16 to be read in a block.

**Data Format:** Allows registers to be viewed in decimal or hexadecimal format.

**Read:** Clicking the Read button causes SFDLC software to read the selected registers from the controller.

**Write:** Clicking the Write button causes SFDLC software to write the selected registers to the controller.  
*Note: The Write button overwrites the existing register values, and may change the module setup and operation.*

**Defaults:** For this category, there are no controller factory defaults. By clicking Defaults, the present entries from the other SFDLC software category screens will be displayed.

**STEP 19  CALIBRATION**

The DLC is fully calibrated from the factory. Recalibration is recommended every two years. Each channel is calibrated separately. All calibration settings are stored in the E²PROM. Calibration may be performed by using SFDLC software or MODBUS commands. When using SFDLC for calibration, connect the signal or measuring source to the proper DLC terminals, verify the input or output jumper positions, select the type of calibration to be performed, and click the Calibrate button. Follow the calibration procedures in the software.

*Note: Allow the DLC to warm up for 30 minutes minimum and follow the manufacturer’s warm-up recommendations for the calibration source.*

**INPUT CALIBRATION**

When calibrating the input, the millivolt calibration must be performed first. All other input types use the millivolt points. Each input range (non-thermocouple) also has its own internal references that are recalled when the range is selected. Non-used types need not be calibrated.

**Calibration Type:** This specifies the type of calibration to be performed.

- **Millivolt:** Millivolt calibration requires a precision voltage source with an accuracy of 0.03% or better. It is used for thermocouple inputs and as a basis for all other input calibration types.
- **RTD:** RTD calibration requires a 0.1% (or better) precision 277.0 ohm resistor.
- **Process Voltage:** Process calibration requires a precision signal source with an accuracy of 0.03% (or better) that is capable of generating 10.00 V.
- **Process Current:** Process current calibration requires a precision signal source with an accuracy of 0.03% (or better) that is capable of generating 20.00 mA.
- **Cold Junction:** Cold Junction calibration requires a thermocouple of known accuracy of types T, E, J, K, C or N only and a calibrated external reference thermocouple probe.
  - **TC Type:** This selects the type of TC that is being used to calibrate the cold junction.
  - **Scale:** This selects the scale in which the Thermometer temperature is entered and the controller temperature is displayed.
  - **Thermometer:** Enter the reference thermometer temperature here.
  - **DLC:** This displays the DLC process temperature value after a cold junction calibration is completed to verify the accuracy.

**Calibrate:** The Calibrate button initiates the calibration process after the appropriate settings are selected.

**ANALOG OUTPUT CALIBRATION**

**Calibration Type:** This specifies the Analog Output point to be calibrated.

- **Volts:** Analog Output Voltage calibration requires a precision meter with an accuracy of 0.05% (or better) that is capable of measuring 10.00 V.
- **mA:** Analog Output Current calibration requires a precision meter with an accuracy of 0.05% (or better) that is capable of measuring 20.00 mA.

**Meter Value:** After pressing the Calibrate button, this shows the value the DLC is outputting. Measure the actual output with an external meter and enter that value here. Press the Calibrate button again and follow the prompts.

**Calibrate:** The Calibrate button initiates the calibration process after the appropriate settings are selected.
### TROUBLESHOOTING

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>CAUSE</th>
<th>REMEDIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power LED will not light</td>
<td>Controller power</td>
<td>Check controller power connections and voltage level</td>
</tr>
<tr>
<td>Process Value not changing or incorrect</td>
<td>Input signal Incorrect channel Incorrect programming</td>
<td>Check input signal connections and signal level Check proper channel setup, reading and connections Check input setup, scaling values, and re-download</td>
</tr>
<tr>
<td>Alarms not functioning properly</td>
<td>Calculated trigger points are over +32000 or below -32000</td>
<td>Adjust alarm value, alarm hysteresis, and setpoint value to ensure value trigger points</td>
</tr>
<tr>
<td>Alarms disabled</td>
<td>Checksum error</td>
<td>See checksum error remedies</td>
</tr>
<tr>
<td>Process Value stays at -32001 or +32001</td>
<td>Input Signal (sensor) under-range or over-range</td>
<td>Check input type, level, channel, jumpers and re-download. Replace sensor. Perform calibration.</td>
</tr>
<tr>
<td>Process Value stays at -32002</td>
<td>Shorted RTD sensor</td>
<td>Check input sensor, level, channel, jumpers and re-download. Replace probe.</td>
</tr>
<tr>
<td>Process Value stays at +32002</td>
<td>Open TC or RTD sensor</td>
<td>Check input sensor, level, channel, jumpers and re-download. Replace probe.</td>
</tr>
<tr>
<td>Process Value stays at +32003 or +32003</td>
<td>Process Value underrange (&lt;-32000) or overrange (&gt;+32000)</td>
<td>Check input level, scaling, jumpers and re-download</td>
</tr>
<tr>
<td>Process Value stays at +32100, Flashing LEDs, Alarms disabled</td>
<td>Parameter checksum error † Calibration checksum error † Integral and Offset/Manual Power checksum error †</td>
<td>Re-download SFDLC file Perform calibration procedure Consult Factory</td>
</tr>
<tr>
<td>Will not communicate (Comm. LED not flashing)</td>
<td>Incorrect serial settings (DLC port) Incorrect serial settings (computer port) Incorrect wiring</td>
<td>Verify DLC communications setup Go to pull down menu SETTINGS, PC PORT SETTING Switching A+ and B- lines</td>
</tr>
</tbody>
</table>

* Can also be monitored by accessing coils 5-8 and 17-20, or register 40504.
† Can also be monitored by accessing coils 1-3, or register 40505.

For further technical assistance, contact technical support.

### APPLICATION

A plastic extrusion company was building a four-zone extruder, and wanted a centrally located, multi-zone interface. The interface needed to display the temperature and setpoint values, as well as the screw RPM and barrel pressure. The customer provided a speed proportional 0-10 Volt signal from a motor drive, and installed a 4-20 mA output pressure sensor in the extruder barrel. Each of the four heat/cool zones were equipped with a thermocouple.

Three DLC-Dual Loop Controllers, with a Paradigm HMI, allowed the customer to build his own control system. Only three DLCs were required; two were needed to control the four temperature zones, and one was needed to monitor the two process signals.

All three units were connected to the RS485 port of the Paradigm display. The customer created his own displays on the HMI, which allowed him to monitor and control the setpoints and alarms within the DLCs. The Paradigm’s multi-protocol capability allowed it to tie the DLCs to his PLC, creating a true centralized interface.

### CONTROL MODE EXPLANATIONS

#### MANUAL CONTROL MODE

In Manual Control Mode, the controller operates as an open loop system (does not use the setpoint and process feedback). The user enters a percentage of power through the Output Power register (40005/40021) to control the heat (reverse) or cool (direct) for Output OP1. When Alarm 2 is configured for Cooling (OP2), Manual operation provides 0 to 100% power to OP1 (heating) and -100 to 0% power to OP2 (Cooling). The Low and High Power limits are determined by PID or On/Off calculations based on the setpoint and process feedback. For this reason, PID Control and On/Off Control always imply Automatic Control Mode.

#### MODE TRANSFER

When transferring the controller mode from or to Automatic, the controlling outputs remain constant, exercising true bumpless transfer. When transferring from Manual to Automatic, the power initially remains steady, but Integral Action corrects (if necessary) the closed loop power demand at a rate proportional to the Integral Time. The Control Mode can be changed through the Control Mode register (40041/40049).

#### AUTOMATIC CONTROL MODE

In Automatic Control Mode, the percentage of output power is automatically determined by PID or On/Off calculations based on the setpoint and process feedback.
**ON/OFF CONTROL**

The controller operates in On/Off Control when the Proportional Band is set to 0.0%. In this control, the process will constantly oscillate around the setpoint value. The On/Off Control Hysteresis (balanced around the setpoint) can be used to eliminate output chatter. Output OP1 Control Action can be set to reverse for heating (output on when below the setpoint) or direct for cooling (output on when above the setpoint) applications.

**ON/OFF CONTROL - REVERSE OR DIRECT ACTING FIGURES**

Note: HYS in the On/Off Control Figures refers to the On/Off Control Hysteresis.

For heat and cool systems, OP1 Control Action is set to reverse (heat) and the Alarm 2 Action is set to cooling (OP2). The Proportional Band is set to 0.0 and the Relative Gain in Cooling to 0.0. The Deadband in Cooling sets the amount of operational deadband or overlap between the outputs. The setpoint and the On/Off Control Hysteresis applies to both OP1 and OP2 outputs. The hysteresis is balanced in relationship to the setpoint and deadband value.

**PID CONTROL**

In PID Control, the controller processes the input and then calculates a control output power value by use of a modified Proportional Band, Integral Time, and Derivative Time control algorithm. The system is controlled with the new output power value to keep the process at the setpoint. The Control Action for PID Control can be set to reverse for heating (output on when below the setpoint) or direct for cooling (output on when above the setpoint) applications. For heat and cool systems, the heat (OP1) and cool (OP2) outputs can be used together in the PID Control. The PID parameters can be Auto-Tune or Manual Tune to the process.

**PID TUNING EXPLANATIONS**

**AUTO-TUNE**

Auto-Tune is a user-initiated function where the controller automatically determines the Proportional Band, Integral Time, Derivative Time, Digital Filter, Control Output Dampening Time, and Relative Gain (Heat/Cool) values based upon the process characteristics. The Auto-Tune operation cycles the controlling output(s) at a control point three-quarters of the distance between the present process value and the setpoint. The nature of these oscillations determines the settings for the controller’s parameters.

Prior to initiating Auto-Tune, it is important that the controller and system be first tested. (This can be accomplished in On/Off Control or Manual Control Mode.) If there is a wiring, system or controller problem, Auto-Tune may give incorrect tuning or may never finish. Auto-Tune may be initiated at start-up, from setpoint or at any other process point. However, insure normal process conditions (example: minimize unusual external load disturbances) as they will have an effect on the PID calculations.
Start Auto-Tune

1. Enter the On/Off Control Hysteresis value.
   (For most applications, 10 is a suggested value.)
2. Enter the Deadband value, if using OP2.
   (For most applications, 0 is a suggested value.)
3. Enter the Setpoint value.
   (If Auto-Tune overshoot is unacceptable, then lower the value and restart.)
4. Enter the Auto-Tune Code.
   (See Figure for details)
5. Enter ‘1’ in the Auto-Tune Start register
   (Channel A 40011/Channel B 40027).
6. The Auto-Tune LED will come on.

Auto-Tune Progress

The controller will oscillate the controlling output(s) for four cycles. The cycling phase can be monitored from the Auto-Tune Phase Register (Channel A 40012/Channel B 40028). The time to complete the Auto-Tune cycles is process dependent. The controller should automatically stop Auto-Tune and store the calculated values when the four cycles are complete. If the controller remains in Auto-Tune unusually long, there may be a process problem. Auto-Tune may be stopped by entering ‘0’ in Auto-Tune Start Register (Channel A 40011/Channel B 40027).

PID Adjustments

In some applications, it may be necessary to fine tune the Auto-Tune calculated PID parameters. To do this, a chart recorder or data logging device is needed to provide a visual means of analyzing the process. Compare the actual process response to the PID response figures with a step change to the process. Make changes to the PID parameters in no more than 20% increments from the starting value and allow the process sufficient time to stabilize before evaluating the effects of the new parameter settings.

In some unusual cases, the Auto-Tune function may not yield acceptable control results or induced oscillations may cause system problems. In these applications, Manual Tuning is an alternative.

PROCESS RESPONSE EXTREMEs

MANUAL TUNING

A chart recorder or data logging device is necessary to measure the time between process cycles. This procedure is an alternative to the controller’s Auto-Tune function. It will not provide acceptable results if system problems exist. This procedure should be performed by directly accessing the controller’s registers. The register numbers correspond to (Channel A/Channel B).

1. Set the Proportional Band (40007/40023) to 10.0% for temperature inputs and 100.0% for process inputs.
2. Set both the Integral Time (40008/40024) and Derivative Time (40009/40025) to 0 seconds.
3. Set the Output Dampening Time (40121/40221) to 0 seconds.
4. Set the Output Cycle Time (40116/40216) to no higher than one-tenth of the process time constant (when applicable).
5. Place the controller in Manual Control Mode (40041/40049) and adjust the Output Power (40005/40021) to drive the process value to the Setpoint value. Allow the process to stabilize after setting the Output Power.
6. Place the controller in Automatic Control Mode (40041/40049). If the process will not stabilize and starts to oscillate, set the Proportional Band two times higher and go back to Step 5.
7. If the process is stable, decrease Proportional Band setting by two times and change the setpoint value a small amount to excite the process. Continue with this step until the process oscillates in a continuous nature.
8. Fix the Proportional Band to three times the setting that caused the oscillation in Step 7.
9. Set the Integral Time to two times the period of the oscillation.
10. Set the Derivative Time to one-eighth (0.125) of the Integral Time.
11. Set the Output Dampening Time to one-fortieth (0.025) the period of the oscillation.
MODBUS INFORMATION

The remaining sections of this bulletin list information for MODBUS conformity with DLC registers and coils data.

MODBUS SUPPORTED FUNCTION CODES

**FC01: Read Coils**
1. Valid coil addresses are 1-28.
2. All coils can be requested.
3. Block starting point can not exceed coil 28.

**FC05: Force Single Coil**
1. Valid write (force) coil addresses are 1-4, 10-13, 15-16, 22-25, 27-28.
2. HEX <8001> is echoed back for a request to write to a read only coil, to indicate that the coil did not change.

**FC15: Force Multiple Coils**
1. Valid write (force) coil addresses are 1-4, 10-13, 15-16, 22-25, 27-28.
2. Block starting point can not exceed coil 28.
3. If a multiple write includes read only coils, then only the write coils will change.

**FC03: Read Holding Registers**
2. Up to 32 registers can be requested at one time.
3. Block starting point can not exceed the register boundaries.
4. HEX <8000> is returned in registers beyond the boundaries.
5. Holding registers are a mirror of Input registers.

**FC06: Preset Single Register**
2. HEX <8000> is echoed back that the register did not change during the request to write to a read only register.
3. If the write value exceeds the register limit (see Register Table), then that register value changes to its high or low limit. It is also returned in the response.

**FC16: Preset Multiple Registers**
2. No response is given with an attempt to write to more than 32 registers at a time.
3. Block starting point can not exceed the read and write boundaries.
4. If a multiple write includes read only registers, then only the write registers will change.
5. If the write value exceeds the register limit (see Register Table), then that register value changes to its high or low limit.

**FC04: Read Input Registers**
2. Up to 32 registers can be requested at one time.
3. Block starting point can not exceed register boundaries.
4. HEX <8000> is returned in registers beyond the boundaries.
5. Input registers are a mirror of Holding registers.

**FC08: Diagnostics**
The following is sent upon FC08 request:
Module Address, 08 (FC code), 04 (byte count), “Total Comms” count, “Total Good Comms” count, checksum of the string
“Total Comms” is the total number of messages received that were addressed to the DLC. “Total Good Comms” is the total messages received by the DLC with good address, parity and checksum. Both counters are reset to 0 upon response to FC08, on power-up, and when Total Comms register rolls over.

**FC17: Report Slave ID**
The following is sent upon FC17 request:
Unit Address, 17 (FC code), RLC-DLC00000 (model number), 0100 (for code version 1.00), 32 (number of read supported registers), 32 (number of writes supported registers), 16 (number of registers available for GUID/Scratch pad memory), checksum of the string.

SUPPORTED EXCEPTION CODES

**01: Illegal Function**
Issued whenever the requested function is not implemented in the controller.

**02: Illegal Data Address**
Issued whenever an attempt is made to access a single register or coil that does not exist (outside the implemented space) or to access a block of registers or coils that falls completely outside the implemented space.

**03: Illegal Data Value**
Issued when an attempt is made to read or write more registers or coils than the controller can handle in one request.

**07: Negative Acknowledge**
Issued when a write to coil or register is attempted with an invalid string length.

CHECKSUM ERRORS

1. Calibration checksum covers the E2PROM area that contains calibration values for all ranges. When a calibration checksum error occurs, coil 1 becomes a “1”.
2. Parameter checksum covers the E2PROM area that contains the stored Holding register settings. When this checksum error occurs, coil 2 becomes a “1”.
3. Integral and Offset/Manual Power checksum covers the E2PROM area that contains the stored Integral register settings. When this checksum error occurs, coil 3 becomes a “1”.
4. All LEDs except PWR/COMMS will flash as long as one of the errors exist.
5. The control and alarm outputs are disabled as long as one of the errors exist.
6. These errors can be cleared or activated manually by writing to the appropriate coil. (This does not correct the reason for the error. It may be necessary to reconfigure or calibrate.)
7. The checksums are verified at power up.

CALIBRATION USING MODBUS COMMANDS

The DLC is fully calibrated from the factory. Recalibration is recommended every two years. Each channel is calibrated separately. All calibration settings are stored in the E2PROM. The DLC may be calibrated using MODBUS. However, the preferred method of calibrating the controller is through the SFDLC software.

When calibrating the input, a successful millivolt calibration must be performed first. All other input types use the millivolt points. Each input range (non-thermocouple) also has its own internal references that are recalled when the range is selected. Non-used types need not be calibrated.

Each of the procedures below show the calibration steps/register numbers for both channels A & B, however, only one channel can be calibrated at a time.

**Note:** Allow the DLC to warm up for 30 minutes minimum and follow the manufacturer's warm-up recommendations for the calibration or measuring source.

**mV Calibration**

Millivolt calibration requires a precision signal source with an accuracy of 0.03% (or better) that is capable of generating the range to be calibrated. It is used for thermocouple inputs and as a basis for all other input calibration types.

1. Connect the signal source to the proper DLC terminals.
2. To start mV calibration, enter 1 (Ch A) or 101 (Ch B) into register 40501.
3. To open calibration mode, enter 48 into register 40501.
4. Enter 13 (for mV input) into register 40101 (Ch A) or 40201 (Ch B).
5. When calibrating the input, a successful millivolt calibration must be performed first. All other input types use the millivolt points. Each input range (non-thermocouple) also has its own internal references that are recalled when the range is selected. Non-used types need not be calibrated.
6. To store the calibration results and end calibration, enter 0 into register 40501.

**RANGE** | **Ch A** | **Ch B**
--- | --- | ---
0 mV | 2 | 102
14 mV | 3 | 103
28 mV | 4 | 104
42 mV | 5 | 105
56 mV | 6 | 106

7. Repeat steps 5 and 6 for each range to be calibrated for that channel.
8. To save the calibration results and end calibration, enter 0 into register 40501.
Cold Junction Calibration *
Cold Junction calibration requires a thermocouple of known accuracy of types T, E, J, K, C or N only and a calibrated external reference thermocouple probe.
1. Connect the thermocouple probe source to the proper DLC terminals.
2. Enter the connected thermocouple type into register 40101 (Ch A) or 40201 (Ch B).
3. Enter 1 for °C into register 40102 (Ch A) or 40202 (Ch B).
4. Enter 1 for resolution into register 40103 (Ch A) or 40203 (Ch B).
5. Place an external reference thermometer probe at the end of the DLC probe. The two probes should be shielded from air movement and allowed sufficient time to equalize in temperature. (As an alternative, the DLC probe may be placed in a calibration bath of known temperature.)
6. To open calibration mode, enter 48 into register 40501.
7. To start CJ calibration, enter 10 (Ch A) or 110 (Ch B) into register 40501.
8. Read the Process Value register 40001 (Ch A) or 40017 (Ch B).
9. Subtract the external reference reading from the Process Value register. If the difference is -2 degrees, then adjust to -2.0 and remove decimal point yielding a value of -20.
10. Add the value from step 9 (maintain the sign) to the value existing in register 40502.
11. If necessary, continue to adjust the register 40502 value until the Process Value register 40001 (Ch A) or 40017 (Ch B) matches the external reference reading.
12. To exit CJ calibration, enter 11 (Ch A) or 111 (Ch B) into register 40501.
13. To save the calibration results and close calibration mode, enter 0 into register 40501.

RTD Calibration *
RTD calibration requires a 0.1% (or better) precision 277.0 ohm resistor.
1. Connect a precision 277.0 ohm resistor, and a short, to terminals 1 & 2 (Ch A) or 4 & 5 (Ch B). During the complete procedure, short terminals 2 & 3 (Ch A) or 5 & 6 (Ch B).
2. Verify the input jumper is in the RTD position.
3. Enter 12 (ohms mode) into register 40101 (Ch A) or 40201 (Ch B).
4. To open calibration mode, enter 48 into register 40501.
5. To start RTD calibration, enter 20 (Ch A) or 120 (Ch B) into register 40501.
6. Leave 0 ohms (short) on terminals 1 & 2 (Ch A) or 4 & 5 (Ch B) for 10 seconds.
7. To store 0 ohm results, enter 21 (Ch A) or 121 (Ch B) into register 40501.
8. Apply 277 ohms by removing the short from terminal 1 & 2 (Ch A) or 4 & 5 (Ch B) for 10 seconds.
9. To store 277 ohm results, enter 22 (Ch A) or 122 (Ch B) into register 40501.
10. To save the calibration results and close calibration mode, enter 0 into register 40501.

Process Voltage Calibration *
Process calibration requires a precision signal source with an accuracy of 0.03% (or better) that is capable of generating 10.00 V.
1. Connect the signal source to proper DLC terminals.
2. Verify the input jumper is in the 10 V position.
3. Enter 14 (for voltage input) into register 40101 (Ch A) or 40201 (Ch B).
4. To open calibration mode, enter 48 into register 40501.
5. To start voltage calibration, enter 12 (Ch A) or 112 (Ch B) into register 40501.
6. Apply 0.00 V for a minimum of 10 seconds.
7. To store 0.00 V reading, enter 13 (Ch A) or 113 (Ch B) into register 40501.
8. Apply 10.00 V for a minimum of 10 seconds.
9. To store 10.00 V reading, enter 14 (Ch A) or 114 (Ch B) into register 40501.
10. To save the calibration results and close calibration mode, enter 0 into register 40501.

Process Current Calibration *
Process current calibration requires a precision signal source with an accuracy of 0.05% (or better) that is capable of generating 20.00 mA.
1. Connect the signal source to proper DLC terminals.
2. Verify the input jumper is in the 20 mA position.
3. Enter 15 (for current input) into register 40101 (Ch A) or 40201 (Ch B).
4. To open calibration mode, enter 48 into register 40501.
5. To start current calibration, enter 15 (Ch A) or 115 (Ch B) into register 40501.
6. Apply 0.00 mA for a minimum of 10 seconds.
7. To store 0.00 mA reading, enter 16 (Ch A) or 116 (Ch B) into register 40501.
8. Apply 20.00 mA for a minimum of 10 seconds.
9. To store 20.00 mA reading, enter 17 (Ch A) or 117 (Ch B) into register 40501.
10. To save the calibration results and close calibration mode, enter 0 into register 40501.

Analog Output Voltage Calibration
Analog Output Voltage calibration requires a precision meter with an accuracy of 0.05% (or better) that is capable of measuring 10.00 V.
1. Connect the meter to proper DLC terminals.
2. Verify the output jumpers are in the V positions.
3. To open calibration mode, enter 48 into register 40501.
4. To start 0 volt calibration, enter 30 (Out 1) or 130 (Out 2) into register 40501.
5. Adjust register 40502 value until the external meter displays 0.00 V.
6. To start 10 volt calibration, enter 31 (Out 1) or 131 (Out 2) into register 40501.
7. Adjust register 40502 value until the external meter displays 10.00 V.
8. To save the calibration results and close calibration mode, enter 0 into register 40501.

Analog Output Current Calibration
Analog Output Current calibration requires a precision meter with an accuracy of 0.05% (or better) that is capable of measuring 20.00 mA.
1. Connect the meter to proper DLC terminals.
2. Verify the output jumpers are in the I position.
3. To open calibration mode, enter 48 into register 40501.
4. To start 0 mA calibration, enter 32 (Out 1) or 132 (Out 2) into register 40501.
5. Adjust register 40502 value until the external meter displays 0.00 mA.
6. To start 20 mA calibration, enter 33 (Out 1) or 133 (Out 2) into register 40501.
7. Adjust register 40502 value until the external meter displays 20.00 mA.
8. To save the calibration results and close calibration mode, enter 0 into register 40501.

Restore Factory Settings
The Factory Settings are listed in the DLC Register Table. This restore does not affect the calibration or communication settings of the DLC but may change all other settings for the channel.
1. To open calibration mode, enter 48 into register 40501.
2. To restore Factory Settings, enter 66 (Input Ch A and Analog Out 1) or 166 (Input Ch B and Analog Out 2) into register 40501.
3. To save the restore results and close calibration mode, enter 0 into register 40501.

Nominal Calibration Settings
Nominal Calibration Settings does not require any calibration signals nor meters. This calibration should not be performed under normal circumstances.
Caution: This procedure results in up to ±10% reading error and the DLC will no longer be within factory specifications.
1. To open calibration mode, enter 48 into register 40501.
2. To enter Nominal Calibration Settings, enter 77 (Input Ch A and Analog Out 1) or 177 (Input Ch B and Analog Out 2) into register 40501.
3. To save the Nominal Calibration Settings and close calibration mode, enter 0 into register 40501.

* - Dependent on successful mV calibration.
**DLC REGISTER TABLE**

The below limits are shown as Integers or HEX values. Read and write functions can be performed in either Integers or Hex as long as the conversion was done correctly. Negative numbers are represented by two’s complement. The controller’s parameters can be viewed or changed by these registers through the SP DLC software View Registers Category.

Note: If stored parameters (Setpoints, Alarm values, PID Settings, etc) are expected to be changed hundreds of times per day or more, the Disable E²PROM Writes Register (40503) should be used to prevent wear-out of the internal non-volatile E²PROM. E²PROM writes may be re-enabled periodically, if desired, to store latest values.

<table>
<thead>
<tr>
<th>REGISTER ADDRESS</th>
<th>REGISTER NAME</th>
<th>LOW LIMIT</th>
<th>HIGH LIMIT</th>
<th>FACTORY SETTING</th>
<th>ACCESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH A</td>
<td>CH B</td>
<td>CONTROLLING VALUES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40001</td>
<td>40017</td>
<td>Process Value</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>Process value of present input level. This value is affected by Input Type, Resolution, &amp; Scaling.</td>
</tr>
<tr>
<td>40002</td>
<td>40018</td>
<td>Setpoint Value</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td>Limited by Setpoint Limit Low and Setpoint Limit High.</td>
</tr>
<tr>
<td>40003</td>
<td>40019</td>
<td>Alarm 1 Value</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td></td>
</tr>
<tr>
<td>40004</td>
<td>40020</td>
<td>Alarm 2 Value</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PID PARAMETERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40005</td>
<td>40021</td>
<td>Output Power</td>
<td>0.0 or -100.0</td>
<td>100.0</td>
<td>Read/Write</td>
<td>1 = 0.1%, 0.0 = Off; Limited by Power Low Limit and Power High Limit. Negative percent is only available to OP2 when AL2 is set for Cooling. Write only possible during Manual Mode.</td>
</tr>
<tr>
<td>40006</td>
<td>40022</td>
<td>Setpoint Deviation</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>Deviation = Process Value - Setpoint Value; During Auto-Tune: Process Value - Auto-Tune Setpoint Value</td>
</tr>
<tr>
<td>40007</td>
<td>40023</td>
<td>Proportional Band</td>
<td>0</td>
<td>9999</td>
<td>Read/Write</td>
<td>0 = On/Off Control, 1 = 0.1%</td>
</tr>
<tr>
<td>40008</td>
<td>40024</td>
<td>Integral Time</td>
<td>0</td>
<td>9999</td>
<td>Read/Write</td>
<td>0 = Off, 1 = 1 second</td>
</tr>
<tr>
<td>40009</td>
<td>40025</td>
<td>Derivative Time</td>
<td>0</td>
<td>9999</td>
<td>Read/Write</td>
<td>0 = Off, 1 = 1 second</td>
</tr>
<tr>
<td>40010</td>
<td>40026</td>
<td>Offset Power</td>
<td>-1000</td>
<td>1000</td>
<td>Read/Write</td>
<td>1 = 0.1%; Applied when Integral Time is 0.</td>
</tr>
<tr>
<td>40011</td>
<td>40027</td>
<td>Auto-Tune Start</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = Stop, 1 = Start; Mirror of Coil 16/28.</td>
</tr>
<tr>
<td>40012</td>
<td>40028</td>
<td>Auto-Tune Phase</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>0 = Off, 4 = Last phase during Auto-Tune</td>
</tr>
<tr>
<td>40013</td>
<td>40029</td>
<td>Auto-Tune Code</td>
<td>0</td>
<td>2</td>
<td>Read/Write</td>
<td>0 = Fastest response, 2 = Slowest response</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OUTPUT STATUS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40014</td>
<td>40030</td>
<td>Control Output OP1</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>0 = Off, 1 = On; Mirror of Coil 9/21.</td>
</tr>
<tr>
<td>40015</td>
<td>40031</td>
<td>Alarm Output AL1</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = Off, 1 = On; A write of 1 is only possible when alarm is set for Manual. Mirror of Coil 10/22.</td>
</tr>
<tr>
<td>40016</td>
<td>40032</td>
<td>Alarm Output AL2 / OP2</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = Off, 1 = On; A write of 1 is only possible when alarm is set for Manual. Mirror of Coil 11/23.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CONTROL STATUS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40041</td>
<td>40049</td>
<td>Control Mode</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = Automatic, 1 = Manual; Mirror of Coil 12/24.</td>
</tr>
<tr>
<td>40042</td>
<td>40050</td>
<td>Disable Setpoint Ramping</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = Enabled, 1 = Disabled; Mirror of Coil 13/25.</td>
</tr>
<tr>
<td>40043</td>
<td>40051</td>
<td>Setpoint Ramping In Process</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>0 = No, 1 = Yes; Mirror of Coil 14/26.</td>
</tr>
<tr>
<td>40044</td>
<td>40052</td>
<td>Disable Integral Action</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = Enabled, 1 = Disabled; Mirror of Coil 15/27.</td>
</tr>
<tr>
<td>40045</td>
<td>40053</td>
<td>Ramping Setpoint Value</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>N/A = Setpoint Value during ramping.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INPUT PARAMETERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40010</td>
<td>40201</td>
<td>Input Type</td>
<td>0</td>
<td>15</td>
<td>Read/Write</td>
<td>See Input Type Register Table.</td>
</tr>
<tr>
<td>40012</td>
<td>40202</td>
<td>Temperature Scale</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = °F, 1 = °C; For Input Types 0-11.</td>
</tr>
<tr>
<td>40013</td>
<td>40203</td>
<td>Resolution</td>
<td>0</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = Low (x1) whole input units, 1 = High (x10) tenth of input units; For Input Types 0-13.</td>
</tr>
<tr>
<td>40014</td>
<td>40204</td>
<td>Rounding</td>
<td>1</td>
<td>100</td>
<td>Read/Write</td>
<td>Greater than 1 causes rounding starting at least significant digit.</td>
</tr>
<tr>
<td>40015</td>
<td>40205</td>
<td>Digital Input Filter</td>
<td>0</td>
<td>4</td>
<td>Read/Write</td>
<td>0 = least, 4 = highest</td>
</tr>
<tr>
<td>40016</td>
<td>40206</td>
<td>Span Correction</td>
<td>0</td>
<td>32000</td>
<td>Read/Write</td>
<td>100.0 = 1.0000 (applies no correction), 1 = 0.0001; For Input Types 0-11.</td>
</tr>
<tr>
<td>40017</td>
<td>40207</td>
<td>Offset Correction</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td>For Input Types 0-11.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SETPOINT PARAMETERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40018</td>
<td>40208</td>
<td>Low Limit</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td></td>
</tr>
<tr>
<td>40019</td>
<td>40209</td>
<td>High Limit</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td></td>
</tr>
<tr>
<td>40010</td>
<td>40210</td>
<td>Ramp Rate</td>
<td>0</td>
<td>32000</td>
<td>Read/Write</td>
<td>1 = 0.1 LSD of process value per minute, 0 = Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCALING POINTS PARAMETERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40011</td>
<td>40211</td>
<td>Process Low</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td>For Input Types 13-14.</td>
</tr>
<tr>
<td>40012</td>
<td>40212</td>
<td>Process High</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td>For Input Types 13-14.</td>
</tr>
<tr>
<td>40013</td>
<td>40213</td>
<td>Input Low</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td>1 = 0.001 V or 0.001 mA; For Input Types 13-14.</td>
</tr>
<tr>
<td>40014</td>
<td>40214</td>
<td>Input High</td>
<td>-32000</td>
<td>32000</td>
<td>Read/Write</td>
<td>1 = 0.001 V or 0.001 mA; For Input Types 13-14.</td>
</tr>
<tr>
<td>40015</td>
<td>40215</td>
<td>Process Decimal Point</td>
<td>0</td>
<td>5</td>
<td>Read/Write</td>
<td>Can be used by host to determine resolution of input. For Input Types 13-14.</td>
</tr>
</tbody>
</table>

1. For Input Registers, replace the 4xxxx with a 3xxxx in the above register address. The 3xxxx are a mirror of the 4xxxx Holding Registers.
2. An attempt to exceed a limit will set the register to its high or low limit value.
3. See MODBUS Calibration for procedure on restoring Factory Settings.
### DLC REGISTER TABLE Continued

<table>
<thead>
<tr>
<th>REGISTER ADDRESS</th>
<th>REGISTER NAME</th>
<th>LOW LIMIT</th>
<th>HIGH LIMIT</th>
<th>FACTORY SETTING</th>
<th>ACCESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>40116</td>
<td>40216</td>
<td>Cycle Time</td>
<td>0</td>
<td>250</td>
<td>2</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40117</td>
<td>40217</td>
<td>Control Action</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40118</td>
<td>40218</td>
<td>Power Low Limit</td>
<td>0 or -100</td>
<td>100</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40119</td>
<td>40219</td>
<td>Power High Limit</td>
<td>0 or -100</td>
<td>100</td>
<td>100</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40120</td>
<td>40220</td>
<td>Sensor Failure Power Preset</td>
<td>0 or -100</td>
<td>100</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40121</td>
<td>40221</td>
<td>Dampening Time</td>
<td>0</td>
<td>250</td>
<td>3</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40122</td>
<td>40222</td>
<td>On/Off Control Hysteresis</td>
<td>1</td>
<td>250</td>
<td>10</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40131</td>
<td>40231</td>
<td>Action</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40132</td>
<td>40232</td>
<td>Reset</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40133</td>
<td>40233</td>
<td>Enable Standby Delay</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40134</td>
<td>40234</td>
<td>Hysteresis</td>
<td>1</td>
<td>250</td>
<td>1</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40135</td>
<td>40235</td>
<td>On Delay</td>
<td>0</td>
<td>32000</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40136</td>
<td>40236</td>
<td>Action</td>
<td>0</td>
<td>9</td>
<td>1</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40137</td>
<td>40237</td>
<td>Reset</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40138</td>
<td>40238</td>
<td>Enable Standby</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40139</td>
<td>40239</td>
<td>Hysteresis</td>
<td>1</td>
<td>250</td>
<td>1</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40140</td>
<td>40240</td>
<td>On Delay</td>
<td>0</td>
<td>32000</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40141</td>
<td>40241</td>
<td>Cycle Time</td>
<td>0</td>
<td>250</td>
<td>2</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40142</td>
<td>40242</td>
<td>Relative Gain</td>
<td>0</td>
<td>100</td>
<td>10</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40143</td>
<td>40243</td>
<td>Deadband</td>
<td>-32000</td>
<td>32000</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40301</td>
<td>40309</td>
<td>Assignment</td>
<td>0</td>
<td>11</td>
<td>0(Out 1) 6(Out 2)</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40302</td>
<td>40310</td>
<td>Mode</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40303</td>
<td>40311</td>
<td>Scaling Value Low</td>
<td>-32000</td>
<td>32000</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40304</td>
<td>40312</td>
<td>Scaling Value High</td>
<td>-32000</td>
<td>32000</td>
<td>1000</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40305</td>
<td>40313</td>
<td>Deadband</td>
<td>0</td>
<td>250</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40306</td>
<td>40314</td>
<td>Update Time</td>
<td>0</td>
<td>250</td>
<td>0</td>
<td>Read/Write</td>
</tr>
<tr>
<td>40307</td>
<td>40315</td>
<td>Direct Entry Value</td>
<td>-32000</td>
<td>32000</td>
<td>0</td>
<td>Read/Write</td>
</tr>
</tbody>
</table>

### SERIAL COMMUNICATIONS

<table>
<thead>
<tr>
<th>REGISTER ADDRESS</th>
<th>REGISTER NAME</th>
<th>LOW LIMIT</th>
<th>HIGH LIMIT</th>
<th>FACTORY SETTING</th>
<th>ACCESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>40401</td>
<td>Unit (Node) Address</td>
<td>1</td>
<td>247</td>
<td>247</td>
<td>Read/Write</td>
<td>Node serial DLC address.</td>
</tr>
<tr>
<td>40402</td>
<td>Baud Rate</td>
<td>0</td>
<td>7</td>
<td>5</td>
<td>Read/Write</td>
<td>See Serial Baud Rate Register Table.</td>
</tr>
<tr>
<td>40403</td>
<td>Parity</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>Read/Write</td>
<td>1 = None; 2 = Even; 3 = Odd</td>
</tr>
<tr>
<td>40404</td>
<td>Data Bits</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = 7 bits, 1 = 8 bits</td>
</tr>
<tr>
<td>40405</td>
<td>MODBUS Protocol</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Read/Write</td>
<td>0 = ASCII Mode; 1 = RTU Mode</td>
</tr>
<tr>
<td>40406</td>
<td>Transmit Delay</td>
<td>2</td>
<td>250</td>
<td>2</td>
<td>Read/Write</td>
<td>2 = 2 msec; See Transmit Delay explanation.</td>
</tr>
<tr>
<td>40407</td>
<td>Load Serial Settings</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Read/Write</td>
<td>Changing 40401-40405 will not update the DLC until 40407 is 1. After a write, the communicating device must be changed to the new DLC settings and 40407 returns to 0.</td>
</tr>
</tbody>
</table>

### CALIBRATION

<table>
<thead>
<tr>
<th>REGISTER ADDRESS</th>
<th>REGISTER NAME</th>
<th>LOW LIMIT</th>
<th>HIGH LIMIT</th>
<th>FACTORY SETTING</th>
<th>ACCESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>40501</td>
<td>Unit Calibration</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Read/Write</td>
<td>See MODBUS Calibration explanation.</td>
</tr>
<tr>
<td>40502</td>
<td>Calibration Data Register</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Read/Write</td>
<td>See MODBUS Calibration explanation.</td>
</tr>
<tr>
<td>40503</td>
<td>EEPROM Write Disable</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Read/Write</td>
<td>0 = Enable writes, 1 = Disable writes; Returns to 0 at power cycle. Mirror of Coil 4.</td>
</tr>
<tr>
<td>40504</td>
<td>Input Error Status Register</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>Bits 0-7 are mirror of Coils 5-8/17-20, See Coils Table.</td>
</tr>
<tr>
<td>40505</td>
<td>Checksum Error Status Register</td>
<td>0</td>
<td>N/A</td>
<td>0</td>
<td>Read/Write</td>
<td>Bits 0-3 are mirror of Coils 1-3, See Coils Table.</td>
</tr>
<tr>
<td>40101-41010</td>
<td>Slave ID</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Read Only</td>
<td>RLC-DL100000 (model) 1.00 version (maybe higher) 32 reads, 32 writes 16 scratch. See FC17 explanation.</td>
</tr>
<tr>
<td>41101-41116</td>
<td>GUID/Scratch Pad</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Read/Write</td>
<td>This area is for the user to store any related information. This register area does not affect DLC operations.</td>
</tr>
</tbody>
</table>

1 For Input Registers, replace the 4xxxx with a 3xxxx in the above register address. The 3xxxx are a mirror of the 4xxxx Holding Registers.
2 An attempt to exceed a limit will set the register to its high or low limit value.
3 See MODBUS Calibration for procedure on restoring Factory Settings.
## COILS TABLE

<table>
<thead>
<tr>
<th>COIL ADDRESS</th>
<th>COIL NAME</th>
<th>MIRROR REGISTER</th>
<th>ACCESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CalibrationChecksum Error</td>
<td>40505 (bit 0)</td>
<td>Read/Write</td>
<td>1 = Error; Disables control and alarm outputs, causes flashing LEDs. Writing a zero clears the error.</td>
</tr>
<tr>
<td>2</td>
<td>ParameterChecksum Error</td>
<td>40505 (bit 1)</td>
<td>Read/Write</td>
<td>1 = Error; Disables control and alarm outputs, causes flashing LEDs. Writing a zero clears the error.</td>
</tr>
<tr>
<td>3</td>
<td>Integral and Offset/Manual PowerChecksum Error</td>
<td>40505 (bit 2)</td>
<td>Read/Write</td>
<td>1 = Error; Disables control and alarm outputs, causes flashing LEDs. Writing a zero clears the error.</td>
</tr>
<tr>
<td>4</td>
<td>E²PROM Write Disable</td>
<td>40503</td>
<td>Read/Write</td>
<td>1 = Enables writes to the E²PROM; Returns to 0 (writes are enabled) at power cycle.</td>
</tr>
</tbody>
</table>

### CH A CH B

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>Read Only</td>
<td>0 = Off, 1 = On</td>
<td>0 = Off, 1 = On</td>
<td>0 = Under Range Error</td>
<td>0 = Over Range Error</td>
<td>0 = Off, 1 = On</td>
<td>0 = Off, 1 = On</td>
<td>0 = Automatic Mode, 1 = Manual Mode</td>
<td>0 = Enabled, 1 = Disabled</td>
<td>0 = No, 1 = Yes</td>
<td>0 = Enabled, 1 = Disabled</td>
<td>0 = Stop, 1 = Start</td>
<td></td>
</tr>
</tbody>
</table>

### INPUT TYPE REGISTER (40101/40201) TABLE

<table>
<thead>
<tr>
<th>MODE</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Thermocouple - T</td>
</tr>
<tr>
<td>1</td>
<td>Thermocouple - E</td>
</tr>
<tr>
<td>2</td>
<td>Thermocouple - J</td>
</tr>
<tr>
<td>3</td>
<td>Thermocouple - K</td>
</tr>
<tr>
<td>4</td>
<td>Thermocouple - R</td>
</tr>
<tr>
<td>5</td>
<td>Thermocouple - S</td>
</tr>
<tr>
<td>6</td>
<td>Thermocouple - B</td>
</tr>
<tr>
<td>7</td>
<td>Thermocouple - N</td>
</tr>
<tr>
<td>8</td>
<td>Thermocouple - C</td>
</tr>
<tr>
<td>9</td>
<td>RTD platinum 385</td>
</tr>
<tr>
<td>10</td>
<td>RTD platinum 392</td>
</tr>
<tr>
<td>11</td>
<td>RTD nickel 672</td>
</tr>
<tr>
<td>12</td>
<td>Linear Ohms</td>
</tr>
<tr>
<td>13</td>
<td>Linear mV</td>
</tr>
<tr>
<td>14</td>
<td>Process Voltage</td>
</tr>
<tr>
<td>15</td>
<td>Process Current</td>
</tr>
</tbody>
</table>

### ALARM 1 (40131/40231) AND ALARM 2 (40136/40236) ACTION REGISTER TABLE

<table>
<thead>
<tr>
<th>MODE</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Manual</td>
</tr>
<tr>
<td>1</td>
<td>Absolute HI (Balanced)</td>
</tr>
<tr>
<td>2</td>
<td>Absolute LO (Balanced)</td>
</tr>
<tr>
<td>3</td>
<td>Absolute HI (Unbalanced)</td>
</tr>
<tr>
<td>4</td>
<td>Absolute LO (Unbalanced)</td>
</tr>
<tr>
<td>5</td>
<td>Deviation HI</td>
</tr>
<tr>
<td>6</td>
<td>Deviation LO</td>
</tr>
<tr>
<td>7</td>
<td>Band Inside Acting</td>
</tr>
<tr>
<td>8</td>
<td>Band Outside Acting</td>
</tr>
<tr>
<td>9</td>
<td>Cooling (Alarm 2 only)</td>
</tr>
</tbody>
</table>

### ANALOG OUTPUT ASSIGNMENT REGISTER (400301/40311) TABLE

<table>
<thead>
<tr>
<th>MODE</th>
<th>ASSIGNMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Output Power A</td>
</tr>
<tr>
<td>1</td>
<td>Process Value A</td>
</tr>
<tr>
<td>2</td>
<td>Setpoint A</td>
</tr>
<tr>
<td>3</td>
<td>Ramping Setpoint A</td>
</tr>
<tr>
<td>4</td>
<td>Deviation A</td>
</tr>
<tr>
<td>5</td>
<td>Direct Entry Value 1</td>
</tr>
<tr>
<td>6</td>
<td>Output Power B</td>
</tr>
<tr>
<td>7</td>
<td>Process Value B</td>
</tr>
<tr>
<td>8</td>
<td>Setpoint B</td>
</tr>
<tr>
<td>9</td>
<td>Ramping Setpoint B</td>
</tr>
<tr>
<td>10</td>
<td>Deviation B</td>
</tr>
<tr>
<td>11</td>
<td>Direct Entry Value 2</td>
</tr>
</tbody>
</table>

### SERIAL BAUD RATE REGISTER (40402) TABLE

<table>
<thead>
<tr>
<th>MODE</th>
<th>BAUD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>1</td>
<td>600</td>
</tr>
<tr>
<td>2</td>
<td>1200</td>
</tr>
<tr>
<td>3</td>
<td>2400</td>
</tr>
<tr>
<td>4</td>
<td>4800</td>
</tr>
<tr>
<td>5</td>
<td>9600</td>
</tr>
<tr>
<td>6</td>
<td>19200</td>
</tr>
<tr>
<td>7</td>
<td>38400</td>
</tr>
</tbody>
</table>

1 = Error; Disables control and alarm outputs, causes flashing LEDs. Writing a zero clears the error.

Writing a zero clears the error.