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RED LION CONTROLS

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MODEL DLC - DUAL LOOP CONTROLLER

- *MODULAR BUILDING BLOCK FOR MULTI-ZONE PROCESS CONTROL*
- *TWO INDEPENDENT PID CONTROL LOOPS*
- *PID CONTROL WITH REDUCED OVERSHOOT*
- *UNIVERSAL INPUTS ACCEPT TC, RTD, 0-10 V and 0/4-20 mA SIGNALS*
- *ON DEMAND AUTO-TUNING OF PID SETTINGS*
- *TWO DC ANALOG OUTPUTS (OPTIONAL)*
- *WINDOWS™ CONFIGURATION SOFTWARE*
- *RS485 MODBUS™ PROTOCOL*

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 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 CBPRO007 allows it to be used as a permanent interface cable as well as a programming cable.

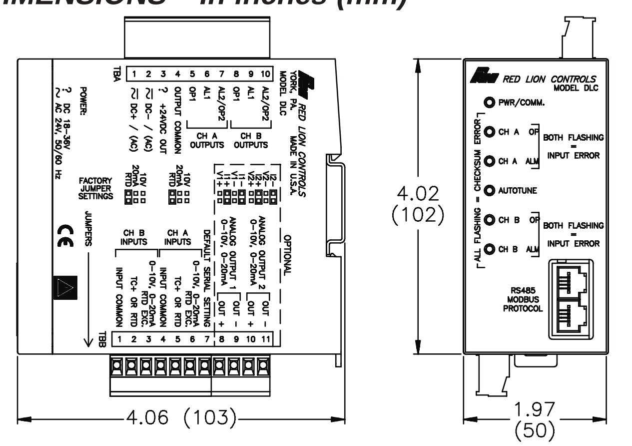
SOFTWARE

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.

DIMENSIONS "In inches (mm)"



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.

CAUTION: Read complete instructions prior to installation and operation of the unit.

CAUTION: Risk of electric shock.

ORDERING INFORMATION

MODEL NO.	DESCRIPTION	PART NUMBER
DLC	Dual Loop Controller	DLC00000
	Dual Loop Controller w/ 2 Analog Outputs	DLC01000
SF	PC Configuration Software for Windows™	SFDLC
CBPRO	Programming Interface Cable	CBPRO007
CBJ	Cable RJ11 to RJ11 (6 inch jumper)	CBJ11BD5
DRR	RJ11 to Terminal Adapter	DRRJ11T6
P89	Paradigm to RJ11 Cable	P893805Z
See our RSRLYB, RLY6, and RLY7 literature for details on DIN rail mountable relays.		

SPECIFICATIONS

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 indication, 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

TYPE	MEASUREMENT RANGE	WIRE COLOR	
		ANSI	BS 1843
T	-200 to +400°C -328 to +752°F	(+) Blue (-) Red	(+) White (-) Blue
E	-200 to +750°C -328 to +1382°F	(+) Violet (-) Red	(+) Brown (-) Blue
J	-200 to +760°C -328 to +1400°F	(+) White (-) Red	(+) Yellow (-) Blue
K	-200 to +1250°C -328 to +2282°F	(+) Yellow (-) Red	(+) Brown (-) Blue
R	0 to +1768°C +32 to +3214°F	No Standard	(+) White (-) Blue
S	0 to +1768°C +32 to +3214°F	No Standard	(+) White (-) Blue
B	+149 to +1820°C +300 to +3308°F	No Standard	No Standard
N	-200 to +1300°C -328 to +2372°F	(+) Orange (-) Red	(+) Orange (-) Blue
C W5/W6	0 to +2315°C +32 to +4199°F	No Standard	No Standard
mV	-10 mV to 65 mV	N/A	N/A

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

TYPE	INPUT TYPE	RANGE
385	100 Ω platinum, Alpha = .00385	-200 to +600°C -328 to +1100°F
392	100 Ω platinum, Alpha = .003919	-200 to +600°C -328 to +1100°F
672	120 Ω nickel, Alpha = .00672	-80 to +215°C -112 to +419°F
ohms	Linear Resistance	0 to 320 Ω

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**:

INPUT RANGE	ACCURACY * (18 to 28°C) (10 to 75% RH)	IMPEDANCE	MAX CONTINUOUS OVERLOAD	RESOLUTION
10 VDC (-1 to 11)	0.10% of reading +0.02 V	1 MΩ	50 V	1 mV
20 mA DC (-2 to 22)	0.10% of reading +0.03 mA	10 Ω	100 mA	1 µA

* Accuracies are expressed as ± percentages after 20 minute warm-up.

9. **ISOLATION LEVEL**: 500 V @ 50/60 Hz, for one minute (50 V working) between:
   Ch A Input and all Control & Alarm Outputs [1]
   Ch B Input
   RS485/Analog Output [2]
   Power Supply
   Notes:
   [1] Ch A Input and All Control/Alarm Outputs share the same common
   [2] 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 V_{OH} = 10 VDC max, V_{OL} = 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
   $V_{DS\ ON}$: 0.3 V @ 1 A
   $V_{DS\ MAX}$: 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**	ACCURACY * (18 to 28°C) (10 to 75% RH)	COMPLIANCE	RESOLUTION (TYPICAL)
0 to 10 V	0.10% of FS + 1/2 LSD	10 KΩ min	1/18000
0 to 20 mA	0.10% of FS + 1/2 LSD	500 Ω max	1/18000
4 to 20 mA	0.10% of FS + 1/2 LSD	500 Ω max	1/14400

* 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

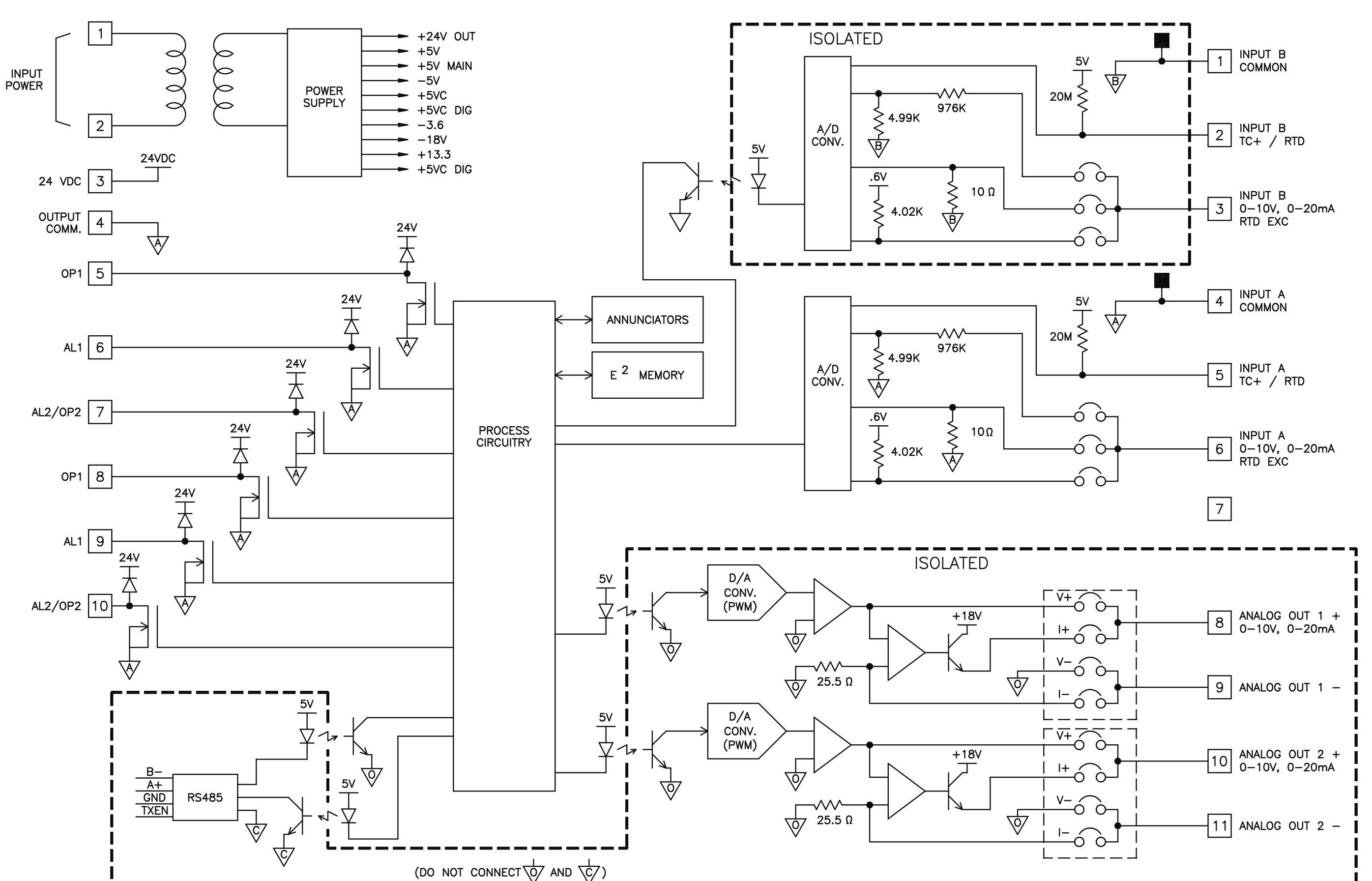
ELECTROMAGNETIC COMPATIBILITY

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
		80 MHz - 1 GHz
Fast transients (burst)	EN 61000-4-4	level 4; 2 kV I/O
		Level 3; 2 kV power
RF conducted interference	EN 61000-4-6	Level 3; 10 V/rms
		150 KHz - 80 MHz
Power frequency magnetic fields	EN 61000-4-8	Level 4; 30 A/m
Simulation of cordless telephone	ENV 50204	Level 3; 10 V/m
		900 MHz ± 5 MHz
		200 Hz, 50% duty cycle
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.
20. **CONNECTIONS**: Wire clamp screw terminals. Removable terminal blocks.
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.)

BLOCK DIAGRAM



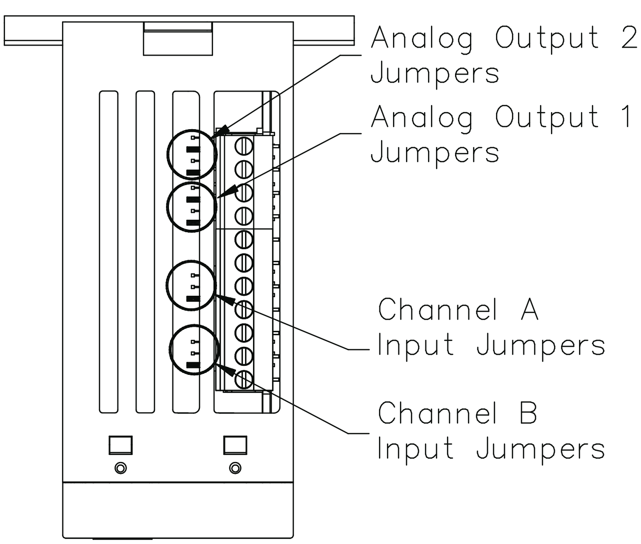
EMC INSTALLATION GUIDELINES

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.

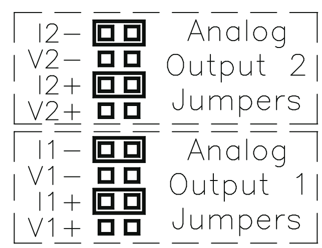
STEP 1 SETTING THE JUMPERS

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.



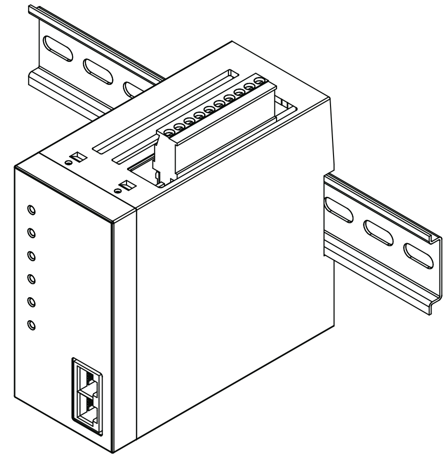
INPUTS

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

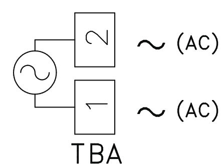
WIRING CONNECTIONS

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.

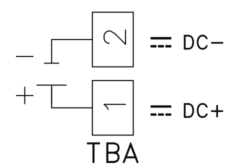
CONTROLLER POWER CONNECTIONS

For best results, the power should be relatively "clean" and within the specified limits. Drawing power from heavily loaded circuits or from circuits that also power loads that cycle on and off should be avoided. It is recommended that power supplied to the controller be protected by a fuse or circuit breaker.

24 VAC POWER

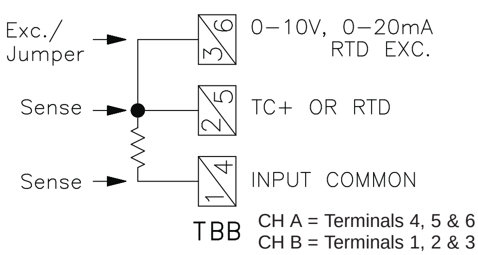


18 to 36 VDC POWER

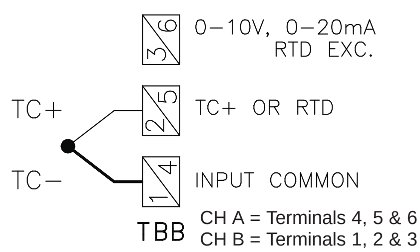


INPUT CONNECTIONS

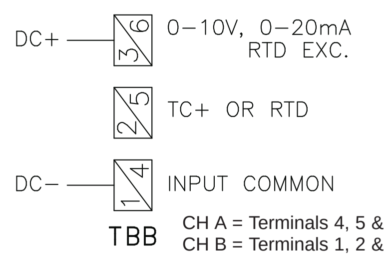
RTD and Resistance *



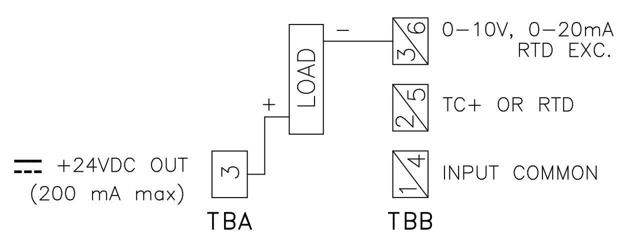
Thermocouple and Millivolt



Voltage or Current

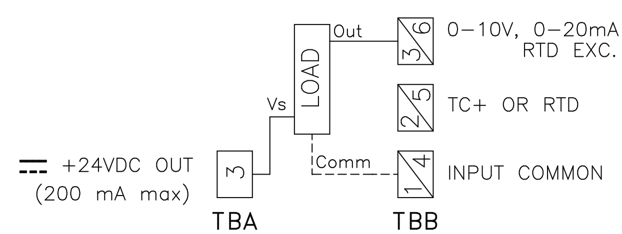


2 Wire Current Signal Requiring DLC Excitation **



CH A = Terminals 4, 5 & 6
CH B = Terminals 1, 2 & 3

3 Wire Current or Voltage Signal Requiring DLC Excitation **



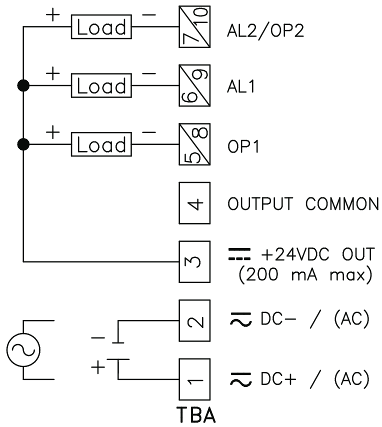
CH A = Terminals 4, 5 & 6
CH B = Terminals 1, 2 & 3

* 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.

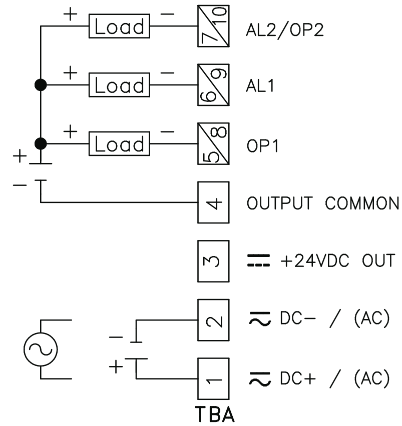
CONTROL AND ALARM OUTPUT CONNECTIONS

Load Power from DLC External Controller Power



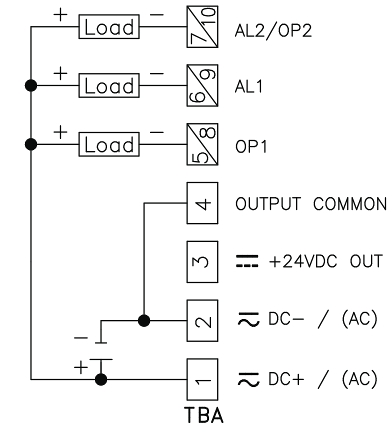
CH A = Terminals 5, 6, & 7
CH B = Terminals 8, 9, & 10

Separate External Power For Load and Controller



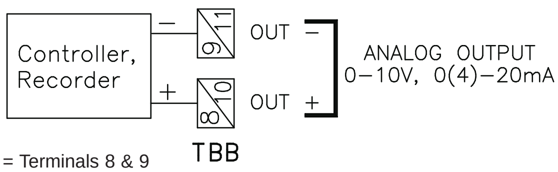
CH A = Terminals 5, 6, & 7
CH B = Terminals 8, 9, & 10

Combined External Power For Load and Controller



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

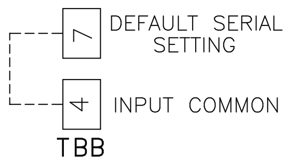
ANALOG DC OUTPUT CONNECTIONS



Output 1 = Terminals 8 & 9
Output 2 = Terminals 10 & 11

***Note**: Analog Outputs & RS485 are not internally isolated and must not share the same common (i.e., earth ground).*

DEFAULT SERIAL SETTING CONNECTIONS



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.

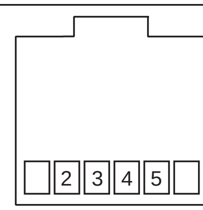
Defaults: **Protocol:** RTU **Data Bits:** 8
Address: 247 **Parity:** none
Baud Rate: 9600

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.

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



DLC CONNECTOR

STEP 4 IDENTIFYING THE LEDs - LED FUNCTIONALITY

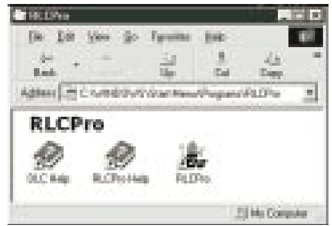
On power-up, all LEDs are turned on briefly in an alternating pattern to allow visual check of LED functionality.

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

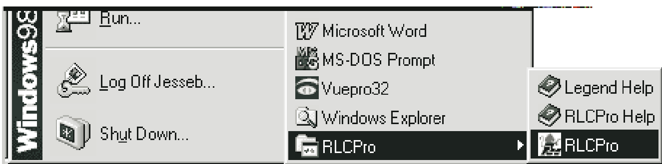
* If AL1 & AL2 outputs are on at the same time, the ALM annunciator will alternate between On and Fast Flashing every ½ second.
** If OP1 and AL2/OP2 (configured for cool) outputs are on at the same time, the annunciator will only show the OP1 state. The OP2 state is only shown when OP1 is off.

STEP 5 INSTALLING SFDLC (Software for DLC)

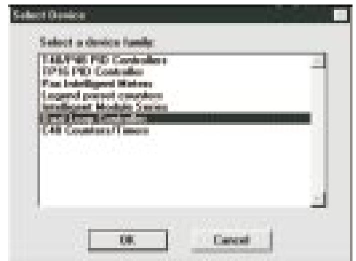
Insert the SFDLC diskette into the A: or B: drive. Then Run A:\SETUP (or B:\SETUP) to install RLCPro onto the hard drive. An icon labeled RLCPro will be created under the group RLCPro.



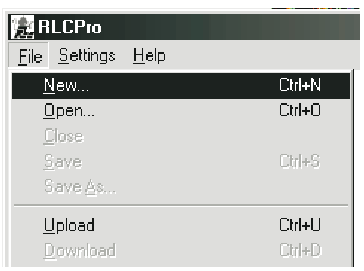
STEP 6 PROGRAMMING - Getting Started



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

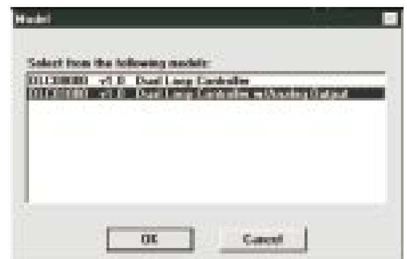


You will be prompted to select the proper device,

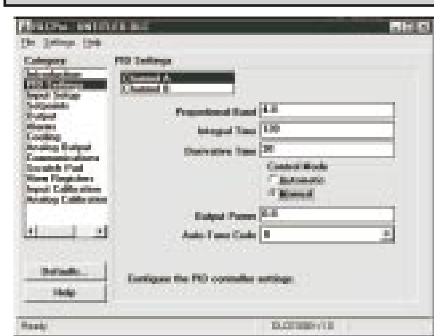


Use the FILE pull-down menu to select a NEW file.

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 Ouput Dampening 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 Intergral 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.

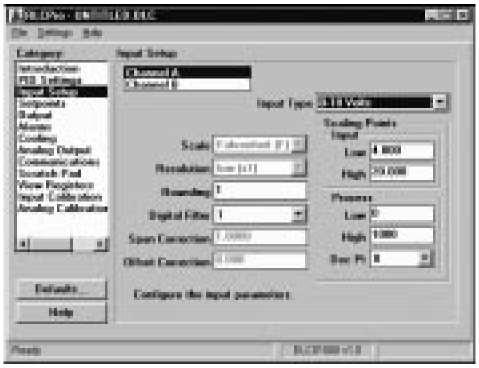
Control Mode (40041/40049): In Automatic Mode, the percentage of Output Power is automatically determined by PID or On/Off Control. In Manual Mode, the percentage of Output Power is entered manually. For more information, see Control Mode Explanations Section.

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.

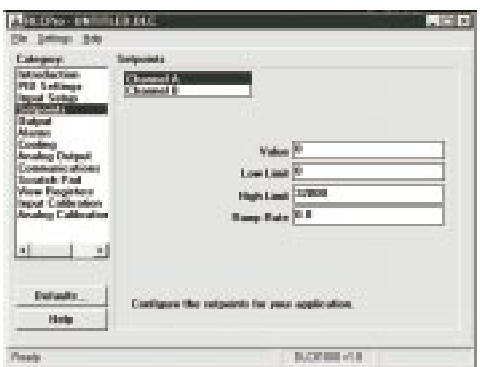
Span Correction (40106/40206): This value is the correction slope. A span of 1.0000 applies no correction. Span only applies to temperature sensor inputs.

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 limit of the input range. Reverse acting measurement can be accomplished by reversing the Input or Process entries, but not both. (Do not reverse the input wires to change the action.) To scale a 4-20 mA Input signal to provide process values of 0 to 100.00 (% in hundredths), the Input Low (40113/40213) and Input High (40114/40214) values would be 4000 and 20000 (0.001 mA resolution), and the Process Low (40111/40211) and Process High (40112/40212) values would be 0 and 10000.

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



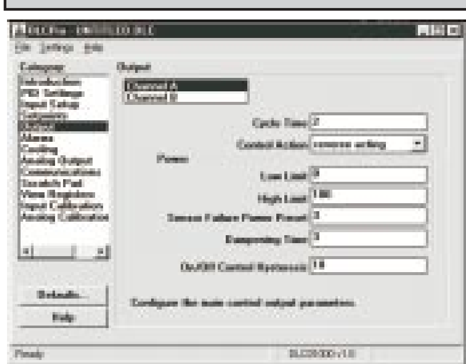
Setpoint (40002/40018): Enter the setpoint value. Deviation of Process Value (40001/40017) from setpoint value can be viewed in the Setpoint Deviation register (40006/40022).

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 Ramping Setpoint 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.

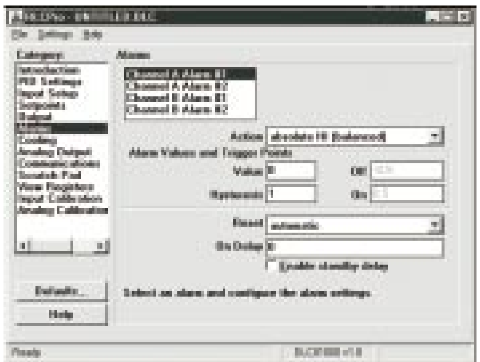
Power Low Limit (40118/40218); **High Limit (40119/40219)**: These parameters may be used to limit controller power due to process disturbances or setpoint changes. Enter the safe output power limits for the process. If Alarm 2 is selected for cooling, the range is from -100 to +100%. At 0%, both OP1 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 10 (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.

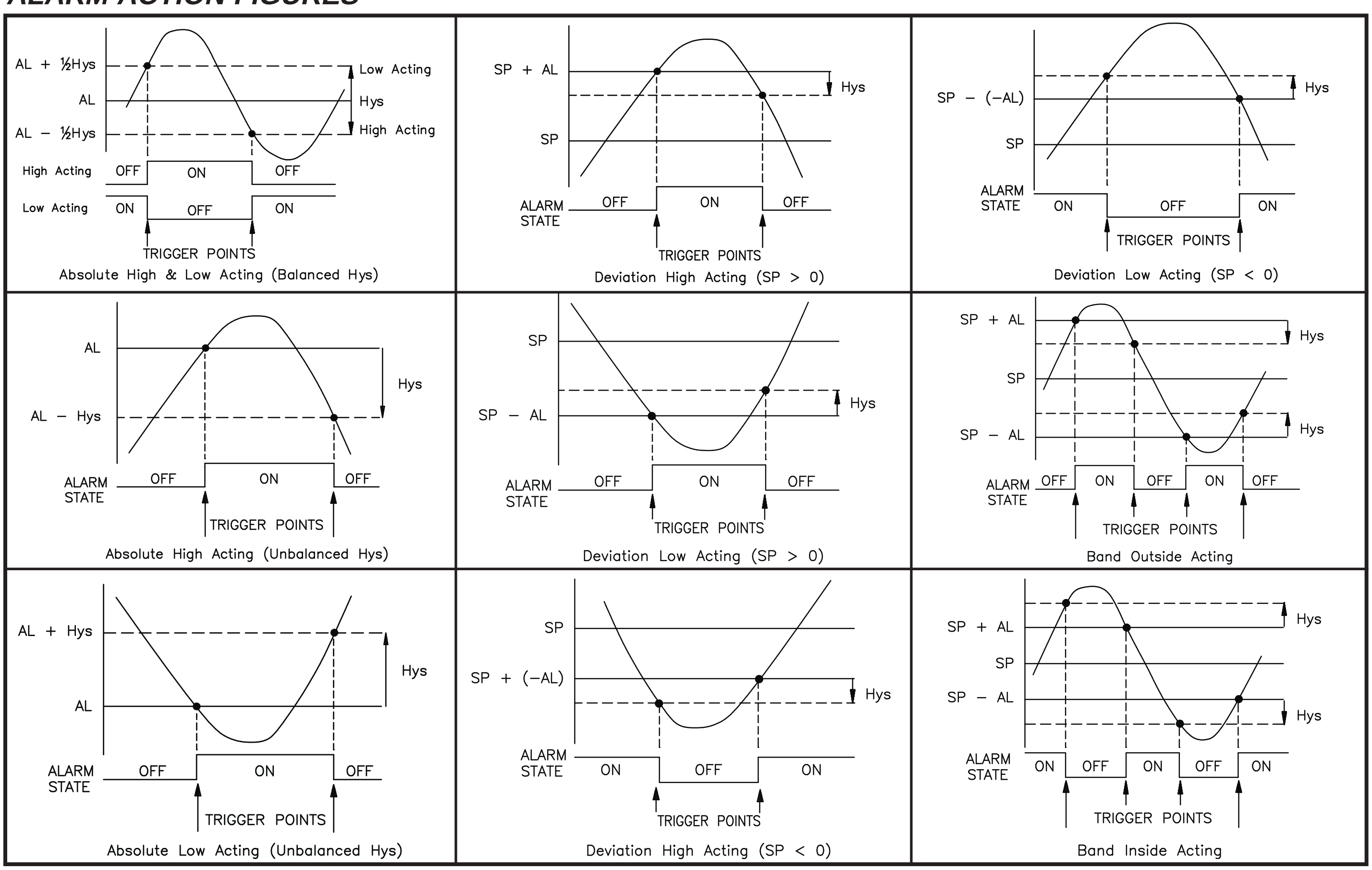
Absolute HI (balanced or unbalanced hysteresis): The alarm energizes when the Process Value exceeds the alarm.

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.

ALARM ACTION FIGURES



***Note**: Hys in the above figures refers to the Alarm Hysteresis.*

Value (40003/40019), (40004/40020): The alarm values are entered as process units or degrees.

Hysteresis (40134/40234), (40139/40239): The Hysteresis Value is either added to or subtracted from the alarm value, depending on the alarm action selected. See the Alarm Action Figures for a visual explanation of how alarm actions are affected by the hysteresis.

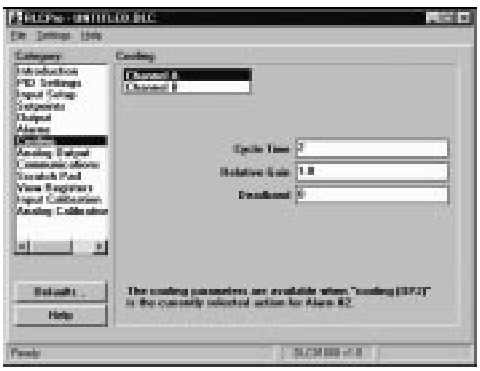
Trigger Points: Trigger points are the Process Values where the alarm state changes. Their values cannot be entered directly, but are shown as a reference in the SFDLC software. The alarm value, hysteresis value, and setpoint alarm type determine the trigger points. With Deviation or Band actions, the alarm value and setpoint value are combined to determine the trigger points. Trigger points must not be greater than +32000 or less than -32000. If these limits are exceeded, the alarm may not function properly.

Reset (40132/40232), (40137/40237): The alarms can be programmed for Automatic or Latched. In Automatic mode, an energized alarm turns off automatically once the Process Value leaves the alarm region. In Latched mode, an energized alarm requires a manual reset. This is done by writing ‘0’ to the appropriate output status register. After writing ‘0’, the Automatic or Latched alarm will not turn on again until after the Process Value first returns to the alarm off region. Only alarms configured for Manual action can be energized by writing a ‘1’ to its’ alarm output status register.

On Delay (40135/40235), (40140/40240): The time, in seconds, required for the Process Value to be in the alarm region before the alarm will activate. It is used to allow temporary or short excursions into the alarm region without tripping the alarm.

Enable Standby Delay (40133/40233), (40138/40238): Standby prevents nuisance (typically low level) alarms after a power up or setpoint change. After powering up the controller or changing the setpoint, the process must leave the alarm region. Once this has occurred, the standby is disabled and the alarm responds normally until the next controller power up or setpoint change.

STEP 12 PROGRAMMING THE COOLING



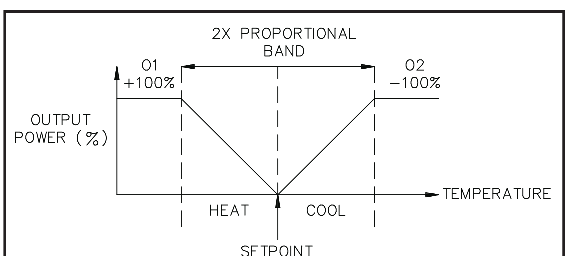
To enable Cooling in Heat/Cool applications, the Alarm 2 Action must first be set for Cooling. When set to cooling, the output no longer operates as an alarm but operates as an independent cooling output. The OP2 terminals are the same as AL2. Cooling output power ranges from -100% (full cooling) to 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).

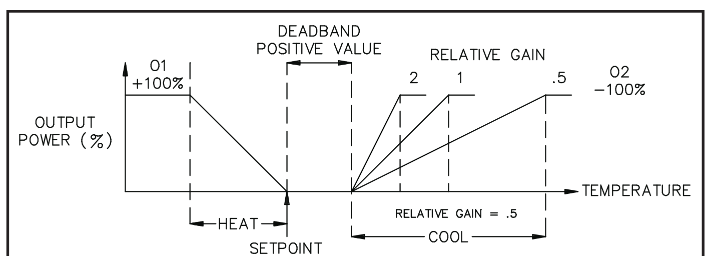
Relative Gain (40142/40242): This defines the gain of the cooling relative to the heating. It is generally set to balance the effects of cooling to that of heating. This is illustrated in the Heat/Cool Relative Gain Figures. A value of 0.0 places the cooling output into On/Off Control. This may be done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

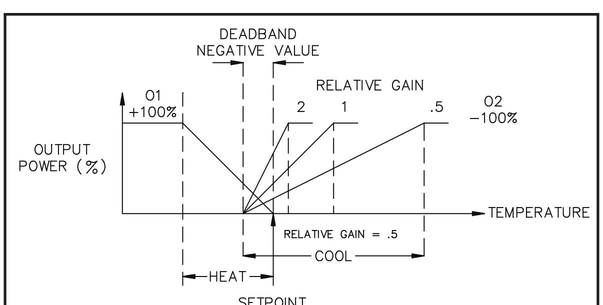
HEAT/COOL RELATIVE GAIN FIGURES



Heat/Cool Deadband = 0

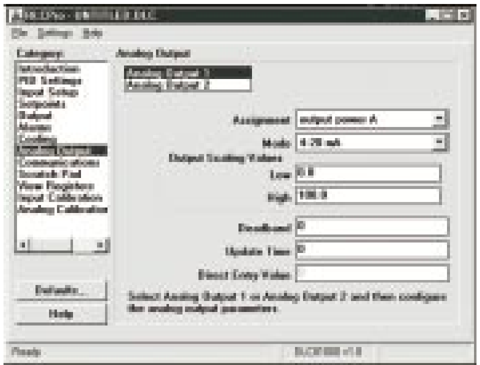


Heat/Cool Deadband > 0



Heat/Cool Deadband < 0

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:

SELECTION	DESCRIPTION
Output Power A	Transmits the Output Power demand of Channel A. Used if linear control is desired.
Process Value A	Retransmits Process Value Channel A
Setpoint A	Retransmits Setpoint Value Channel A
Ramping Setpoint A	Retransmits Ramping Setpoint Channel A
Deviation A	Retransmits Deviation (difference of Setpoint Value - Process Value) Channel A
Direct Entry Value 1	Retransmits Direct Entry Value 1 (Manual Analog Control)
Output Power B	Transmits the Output Power demand of Channel B. Used if linear control is desired.
Process Value B	Retransmits Process Value Channel B
Setpoint B	Retransmits Setpoint Value Channel B
Ramping Setpoint B	Retransmits Ramping Setpoint Channel B
Deviation B	Retransmits Deviation (difference of Setpoint Value - Process Value) Channel B
Direct Entry Value 2	Retransmits Direct Entry Value 2 (Manual Analog Control)

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.

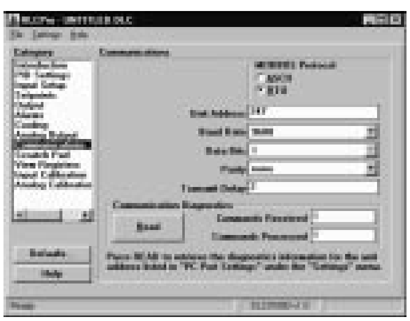
Output Scaling Values: The Scaling Low value (40303/40311) corresponds to 0 V, 0 mA or 4 mA, depending on the range selected. The Scaling High value (40304/40312) corresponds to 10 V or 20 mA depending on the range selected. An inverse acting output can be achieved by reversing the Scaling Low and Scaling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

MODBUS Protocol (40405): RTU or ASCII
Unit Address (40401): 1-247
Baud Rate (40402): 300 to 38400
Data Bits (40404): 7 or 8
Parity (40403): odd, even, or none
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.

MINIMUM TRANSMIT DELAY

BAUD	RTU	ASCII
38400	2 msec	2 msec
19200	3 msec	2 msec
9600	5 msec	2.3 msec
4800	9 msec	4.6 msec
2400	17 msec	9.2 msec
1200	33 msec	18.4 msec
600	65 msec	36.7 msec
300	129 msec	73.4 msec

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 SFDLC software will update the category display to these settings.

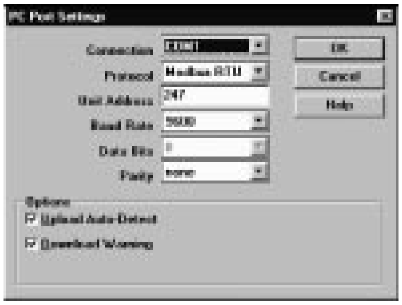
Communications Diagnostics: The Communications Diagnostics function (MODBUS Function Code 08) can be used to troubleshoot systems that are experiencing communication errors. Press the Read button to retrieve the diagnostics information. The Commands Received and the Commands Processed values are automatically 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.

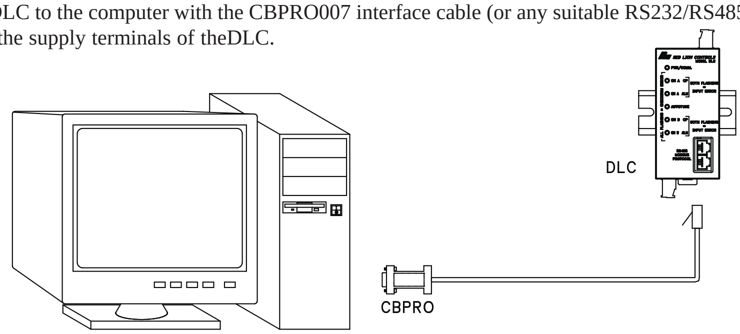
Connection: Select the computer port (COMM 1-4) that the DLC is connected to.

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 theDLC.

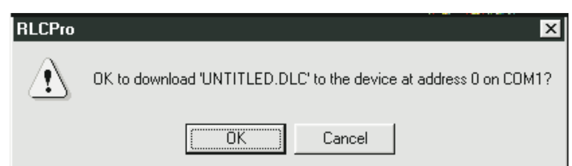
Note: *The CBPRO007 download cable DOES NOT typically require power. In most cases it will derive its power from the PC. If communications can not be established, follow the troubleshooting guide. If it is determined that the converter requires power, attach a 12 VDC power supply to the VDC and common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



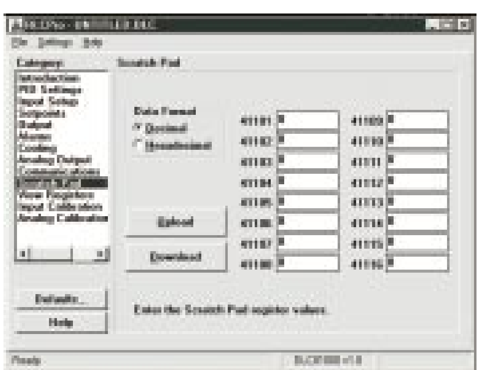
STEP 16 DOWNLOADING

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.

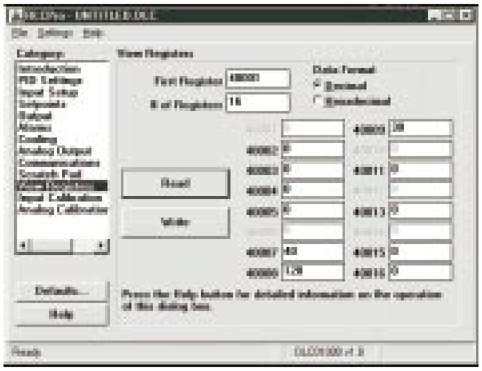
Upload: The Upload button causes SFDLC software to read the Scratch Pad registers from the controller.

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.

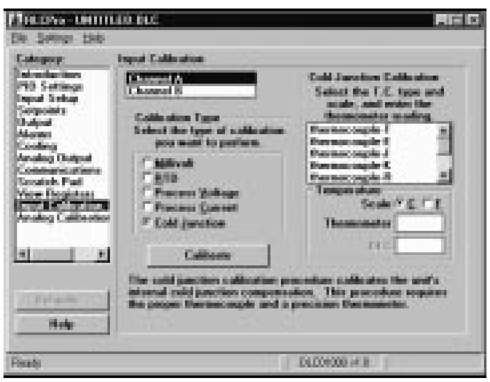
Write: Clicking the Write button causes SFDLC software to write the selected registers to the controller.
Note: The Write button overwrites the existing register values, and may change the module setup and operation.

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 E^2PROM. 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.

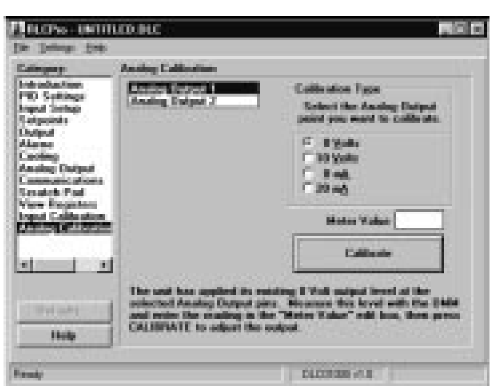
Process Voltage: Process calibration requires a precision signal source with an accuracy of 0.03% (or better) that is capable of generating 10.00 V.

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

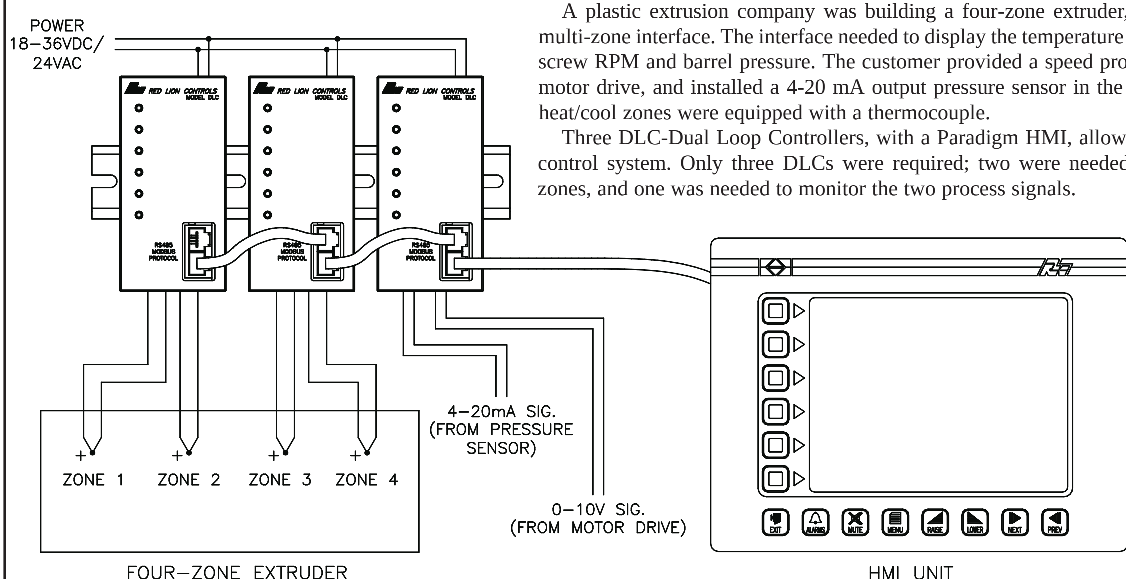
PROBLEM	CAUSE	REMEDIES
Power LED will not light	Controller power	Check controller power connections and voltage level
Process Value not changing or incorrect	Input signal Incorrect channel Incorrect programming	Check input signal connections and signal level Check proper channel setup, reading and connections Check input setup, scaling values, and re-download
Alarms not functioning properly	Calculated trigger points are over +32000 or below -32000	Adjust alarm value, alarm hysteresis, and setpoint value to ensure value trigger points
Alarms disabled	Checksum error	See checksum error remedies
Process Value stays at -32001 or +32001	Input Signal (sensor) under-range or over-range *	Check input type, level, channel, jumpers and re-download. Replace sensor. Perform calibration.
Process Value stays at -32002	Shorted RTD sensor *	Check input sensor, level, channel, jumpers and re-download. Replace probe.
Process Value stays at +32002	Open TC or RTD sensor *	Check input sensor, level, channel, jumpers and re-download. Replace probe.
Process Value stays at -32003 or +32003	Process Value underrange (<-32000) or overrange (>+32000)	Check input level, scaling, jumpers and re-download
Process Value stays at +32100, Flashing LEDs, Alarms disabled	Parameter checksum error † Calibration checksum error † Integral and Offset/Manual Power checksum error †	Re-download SFDLC file Perform calibration procedure Consult Factory
Will not communicate (Comm. LED not flashing)	Incorrect serial settings (DLC port) Incorrect serial settings (computer port) Incorrect wiring	Verify DLC communications setup Go to pull down menu SETTINGS,PC PORT SETTING Try switching A+ and B- lines
	Note*: The DLC serial settings must match the device that it is communicating with. If you do not know or cannot recall the DLC settings, they can be reset back to factory defaults. Simply jumper the Default Serial terminal to Input Common, and cycle power.*	

* 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 ignored when the controller is in Manual.

For time proportional outputs, the output power is converted into output On time using the Cycle Time. For example, with a four second cycle time and 75% power, the output will be on (4×0.75) for three seconds and off for one second. For Analog Outputs (0-10 VDC or 0/4-20 mA), the percent output power is converted into a linear value according to the Percent Low and High scaling set for the analog output. For example, with 0 VDC (scaled 0.0%) to 10 VDC (scaled 100%) and 75% power, the analog output will be 7.5 VDC.

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).

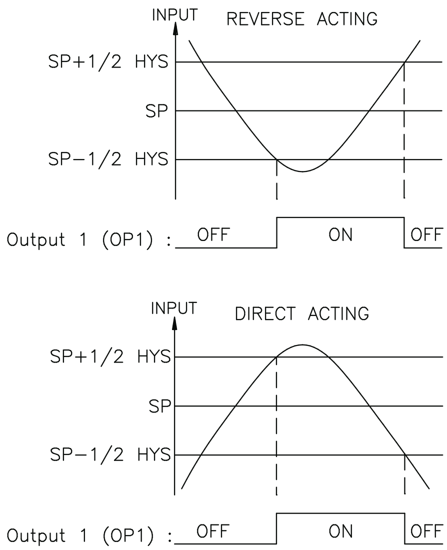
AUTOMATIC CONTROL MODE

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. For this reason, PID Control and On/Off Control always imply Automatic Control Mode.

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.

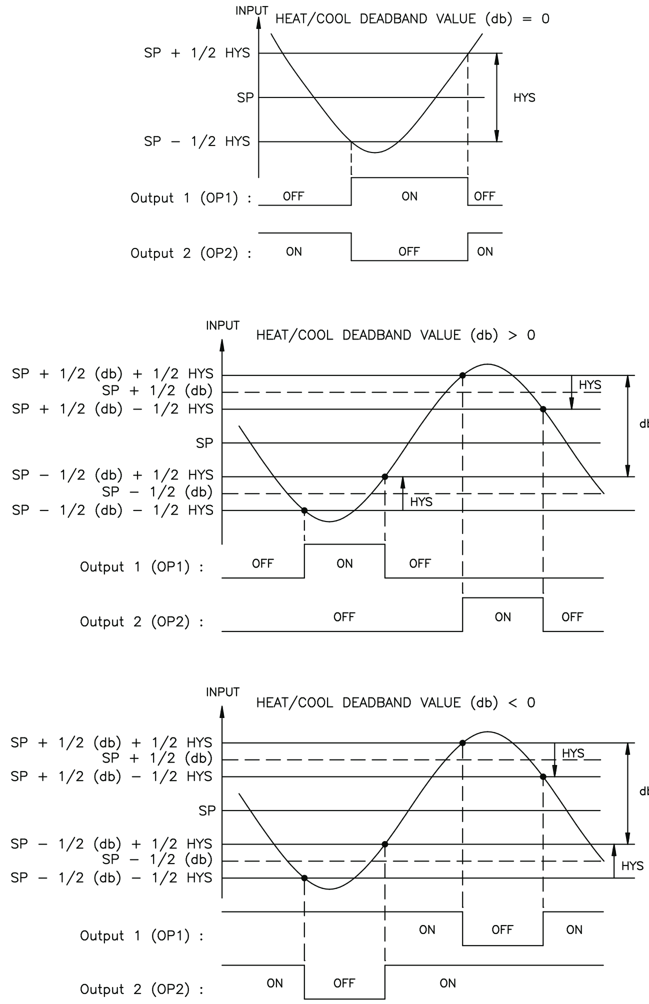
ON/OFF CONTROL - REVERSE OR DIRECT ACTING FIGURES



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.

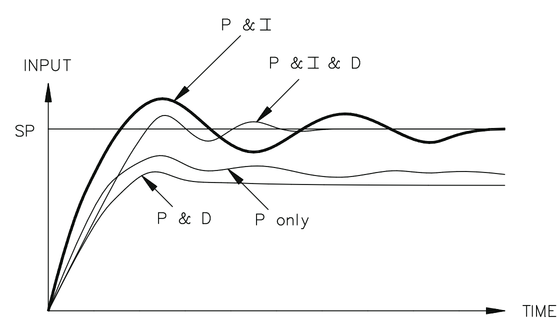
ON/OFF CONTROL - HEAT/COOL OUTPUT FIGURES



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.

TYPICAL PID RESPONSE CURVE



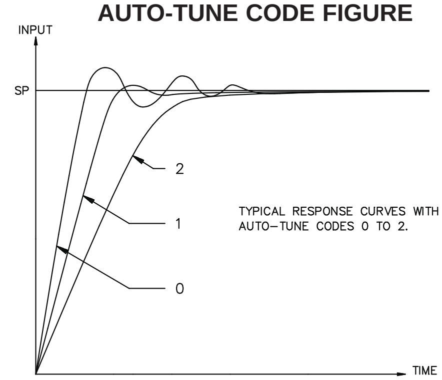
PID TUNING EXPLANATIONS

AUTO-TUNE

Auto-Tune is a user-initiated function where the controller automatically determines the Proportional Band, Integral Time, Derivative Time, Digital Filter, Control Ouput 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.

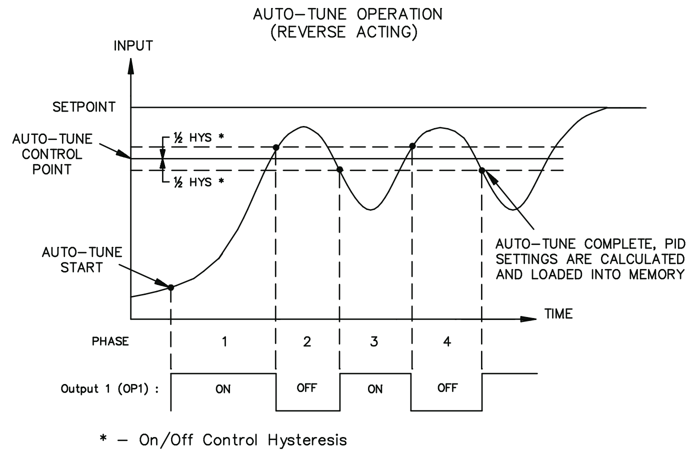
Prior to initiating Auto-Tune, it is important that the controller and system be first tested. (This can be accomplished in On/Off Control or Manual Control Mode.) If there is a wiring, system or controller problem, Auto-Tune may give incorrect tuning or may never finish. Auto-Tune may be initiated at 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.

AUTO-TUNE CODE FIGURE



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

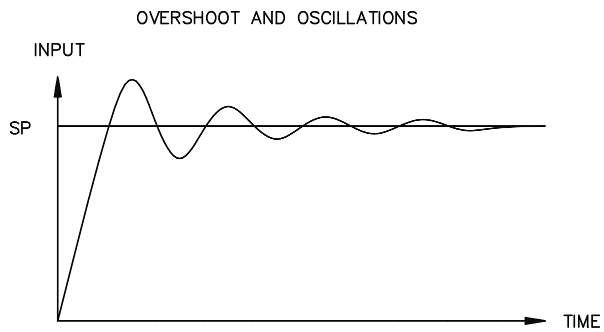
The controller will oscillate the controlling output(s) for four cycles. The cycling phase can be monitored from the Auto-Tune Phase Register (Channel A 40012/Channel B 40028). The time to complete the Auto-Tune cycles is process dependent. The controller should automatically stop Auto-Tune and store 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

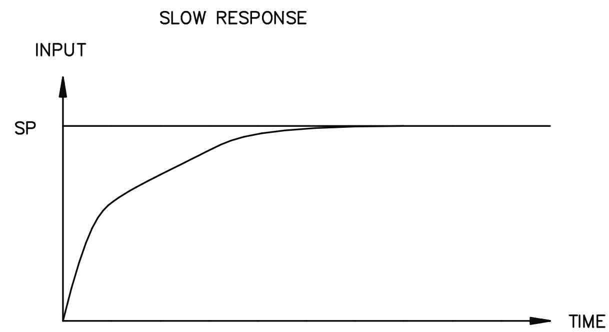
In some applications, it may be necessary to fine tune the Auto-Tune calculated PID parameters. To do this, a chart recorder or data logging device is needed to provide a visual means of analyzing the process. Compare the actual process response to the PID response figures with a step change to the process. 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



TO DAMPEN RESPONSE:
- INCREASE PROPORTIONAL BAND.
- INCREASE INTEGRAL TIME.
- USE SETPOINT RAMPING.
- USE OUTPUT POWER LIMITS.
- RE–INVOKE AUTO–TUNE WITH A HIGHER DAMPENING CODE.
- INCREASE DERIVATIVE TIME.
- CHECK CYCLE TIME.



TO QUICKEN RESPONSE:
- DECREASE PROPORTIONAL BAND.
- DECREASE INTEGRAL TIME.
- INCREASE OR DEFEAT SETPOINT RAMPING.
- EXTEND OUTPUT POWER LIMITS.
- RE–INVOKE AUTO–TUNE WITH A LOWER DAMPENING CODE.
- DECREASE DERIVATIVE TIME.

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

1. Valid register addresses are 40001-40032, 40041-40045, 40049-40053, 40101-40122, 40131-40143, 40201-40222, 40231-40243, 40301-40307, 40309-40315, 40401-40407, 40501-40505, 41001-41010, 41101-41116.
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

1. Valid write (preset) register addresses are 40002-40005, 40007-40011, 40013-40016, 40018-40021, 40023-40027,40029-40032, 40041-40042, 40044, 40049-40050, 40052, 40101-40122, 40131-40143, 40201-40222, 40231-40243, 40301-40307, 40309-40315, 40401-40407, 40501-40505, 41101-41116.
2. HEX <8001> 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

1. Valid write (preset) register addresses are 40002-40005, 40007-40011, 40013-40016, 40018-40021, 40023-40027,40029-40032, 40041-40042, 40044, 40049-40050, 40052, 40101-40122, 40131-40143, 40201-40222, 40231-40243, 40301-40307, 40309-40315, 40401-40407, 40501-40505, 41101-41116.
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

1. Valid register addresses are 30001-30032, 30041-30045, 30049-30053, 30101-30122, 30131-30143, 30201-30222, 30231-30243, 30301-30307, 30309-30315, 30401-30407, 30501-30505, 31001-31010, 31100-31116.
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 E^2PROM area that contains calibration values for all ranges. When a calibration checksum error occurs, coil 1 becomes a “1”.
2. Parameter checksum covers the E^2PROM 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 E^2PROM 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 E^2PROM. 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. Enter 13 (for mV input) into register 40101 (Ch A) or 40201 (Ch B).
3. To open calibration mode, enter 48 into register 40501.
4. To start mV calibration, enter 1 (Ch A) or 101 (Ch B) into register 40501.
5. Apply the appropriate calibration voltage for a minimum of 10 seconds.
6. To store the mV calibration reading, enter the corresponding range number 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 high 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 reading. Adjust the results to tenths position, drop decimal point, and maintain the results sign. (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 0.03% (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 SFDLC 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 E^2PROM Writes Register (40503) should be used to prevent wear-out of the internal non-volatile E^2PROM. E^2PROM writes may be re-enabled periodically, if desired, to store latest values.

REGISTER ADDRESS [1]		REGISTER NAME	LOW LIMIT [2]	HIGH LIMIT [2]	FACTORY SETTING [3]	ACCESS	COMMENTS
CH A	CH B	**CONTROLLING VALUES**					
40001	40017	Process Value	N/A	N/A	N/A	Read Only	Process value of present input level. This value is affected by Input Type, Resolution, & Scaling.
40002	40018	Setpoint Value	-32000	32000	0	Read/Write	Limited by Setpoint Limit Low and Setpoint Limit High.
40003	40019	Alarm 1 Value	-32000	32000	0	Read/Write	
40004	40020	Alarm 2 Value	-32000	32000	0	Read/Write	
		PID PARAMETERS					
40005	40021	Output Power	0.0 or -100.0	100.0	0.0	Read/Write	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.
40006	40022	Setpoint Deviation	N/A	N/A	N/A	Read Only	Deviation = Process Value - Setpoint Value; During Auto-Tune: Process Value - Auto-Tune Setpoint Value
40007	40023	Proportional Band	0	9999	40	Read/Write	0 = On/Off Control, 1 = 0.1%
40008	40024	Integral Time	0	9999	120	Read/Write	0 = Off, 1= 1 second
40009	40025	Derivative Time	0	9999	30	Read/Write	0 = Off, 1= 1 second
40010	40026	Offset Power	-1000	1000	0	Read/Write	1 = 0.1%; Applied when Integral Time is 0.
40011	40027	Auto-Tune Start	0	1	0	Read/Write	0 = Stop, 1 = Start; Mirror of Coil 16/28.
40012	40028	Auto-Tune Phase	N/A	N/A	N/A	Read Only	0 = Off, 4 = Last phase during Auto-Tune
40013	40029	Auto-Tune Code	0	2	0	Read/Write	0 = Fastest response, 2 = Slowest response
		OUTPUT STATUS					
40014	40030	Control Output OP1	N/A	N/A	N/A	Read Only	0 = Off, 1 = On; Mirror of Coil 9/21.
40015	40031	Alarm Output AL1	0	1	0	Read/Write	0 = Off, 1 = On; A write of 1 is only possible when alarm is set for Manual. Mirror of Coil 10/22.
40016	40032	Alarm Output AL2 / OP2	0	1	0	Read/Write	0 = Off, 1 = On; A write of 1 is only possible when alarm is set for Manual. Mirror of Coil 11/23.
		CONTROL STATUS					
40041	40049	Control Mode	0	1	0	Read/Write	0 = Automatic, 1 = Manual; Mirror of Coil 12/24.
40042	40050	Disable Setpoint Ramping	0	1	1	Read/Write	0 = Enabled, 1 = Disabled; Mirror of Coil 13/25.
40043	40051	Setpoint Ramping In Process	N/A	N/A	N/A	Read Only	0 = No, 1 = Yes; Mirror of Coil 14/26.
40044	40052	Disable Integral Action	0	1	0	Read/Write	0 = Enabled, 1 = Disabled; Mirror of Coil 15/27
40045	40053	Ramping Setpoint Value	N/A	N/A	N/A	Read Only	Setpoint Value during ramping.
		INPUT PARAMETERS					
40101	40201	Input Type	0	15	2	Read/Write	See Input Type Register Table.
40102	40202	Temperature Scale	0	1	0	Read/Write	0 = °F, 1 = °C; For Input Types 0-11.
40103	40203	Resolution	0	1	0	Read/Write	0 = Low (x1) whole input units, 1 = High (x10) tenth of input units; For Input Types 0-13.
40104	40204	Rounding	1	100	1	Read/Write	Greater than 1 causes rounding starting at least significant digit.
40105	40205	Digital Input Filter	0	4	1	Read/Write	0 = least, 4 = highest
40106	40206	Span Correction	0	32000	10000	Read/Write	10000 = 1.0000 (applies no correction), 1 = 0.0001; For Input Types 0-11.
40107	40207	Offset Correction	-32000	32000	0	Read/Write	For Input Types 0-11.
		SETPOINT PARAMETERS					
40108	40208	Low Limit	-32000	32000	0	Read/Write	
40109	40209	High Limit	-32000	32000	32000	Read/Write	
40110	40210	Ramp Rate	0	32000	0	Read/Write	1 = 0.1 LSD of process value per minute, 0 = Off
		SCALING POINTS PARAMETERS					
40111	40211	Process Low	-32000	32000	0	Read/Write	For Input Types 13-14.
40112	40212	Process High	-32000	32000	1000	Read/Write	For Input Types 13-14.
40113	40213	Input Low	-32000	32000	4000	Read/Write	1 = 0.001 V or 0.001 mA; For Input Types 13-14.
40114	40214	Input High	-32000	32000	20000	Read/Write	1 = 0.001 V or 0.001 mA; For Input Types 13-14.
40115	40215	Process Decimal Point	0	5	3	Read/Write	Can be used by host to determine resolution of input. For Input Types 13-14.

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

REGISTER ADDRESS [1]		REGISTER NAME	LOW LIMIT [2]	HIGH LIMIT [2]	FACTORY SETTING [3]	ACCESS	COMMENTS
CH A	**CH B**	**CONTROL (OP1) PARAMETERS**					
40116	40216	Cycle Time	0	250	2	Read/Write	1 = 1 second; 0 = OP1 Off
40117	40217	Control Action	0	1	0	Read/Write	0 = Reverse Acting, 1 = Direct Acting
40118	40218	Power Low Limit	0 or -100	100	0	Read/Write	1 = 1%; Negative percent is only available to OP2 when AL2 is set for Cooling.
40119	40219	Power High Limit	0 or -100	100	100	Read/Write	1 = 1%; Negative percent is only available to OP2 when AL2 is set for Cooling.
40120	40220	Sensor Failure Power Preset	0 or -100	100	0	Read/Write	1 = 1%; Negative percent is only available to OP2 when AL2 is set for Cooling.
40121	40221	Dampening Time	0	250	3	Read/Write	1 = 1 second
40122	40222	On/Off Control Hysteresis	1	250	10	Read/Write	
		ALARM 1 (AL1) OUTPUT PARAMETERS					
40131	40231	Action	0	8	1	Read/Write	See Alarm Action Register Table.
40132	40232	Reset	0	1	0	Read/Write	0 = Automatic, 1 = Latched
40133	40233	Enable Standby Delay	0	1	0	Read/Write	0 = Disable, 1 = Enable
40134	40234	Hysteresis	1	250	1	Read/Write	
40135	40235	On Delay	0	32000	0	Read/Write	1 = 1 second
		ALARM 2 (AL2) OUTPUT PARAMETERS					
40136	40236	Action	0	9	1	Read/Write	See Alarm Action Register Table.
40137	40237	Reset	0	1	0	Read/Write	0 = Automatic, 1 = Latched; Not for Cooling Action.
40138	40238	Enable Standby	0	1	0	Read/Write	0 = Disable, 1 = Enable; Not for Cooling Action.
40139	40239	Hysteresis	1	250	1	Read/Write	Not for Cooling Action.
40140	40240	On Delay	0	32000	0	Read/Write	1 = 1 second; Not for Cooling Action.
		COOLING (OP2) PARAMETERS					**APPLIES WHEN ALARM 2 IS SET FOR COOLING**
40141	40241	Cycle Time	0	250	2	Read/Write	1 = 1 second; 0 = OP2 Off
40142	40242	Relative Gain	0	100	10	Read/Write	1 = 0.1; 0 = On/Off Control
40143	40243	Deadband	-32000	32000	0	Read/Write	
OUT 1	**OUT 2**	**ANALOG OUTPUT PARAMETERS**					**ANALOG MODEL ONLY**
40301	40309	Assignment	0	11	0(Out 1) 6(Out 2)	Read/Write	See Analog Output Assignment Register Table.
40302	40310	Mode	1	3	3	Read/Write	1 = 0-10 V, 2 = 0-20 mA, 3 = 4-20 mA
40303	40311	Scaling Value Low	-32000	32000	0	Read/Write	Corresponds with 0 V, 0 mA or 4 mA output.
40304	40312	Scaling Value High	-32000	32000	1000	Read/Write	Corresponds with 10 V or 20 mA output.
40305	40313	Deadband	0	250	0	Read/Write	1 = 0.1%; Applies when Assignment is Output Power.
40306	40314	Update Time	0	250	0	Read/Write	0 = scan rate (10 updates/ sec) 1 = 1 second
40307	40315	Direct Entry Value	-32000	32000	0	Read/Write	Applies when Assignment is Direct Entry Value.
		SERIAL COMMUNICATIONS					
40401		Unit (Node) Address	1	247	247	Read/Write	Node serial DLC address.
40402		Baud Rate	0	7	5	Read/Write	See Serial Baud Rate Register Table.
40403		Parity	1	3	1	Read/Write	1 = None, 2 = Even, 3 = Odd
40404		Data Bits	0	1	1	Read/Write	0 = 7 bits, 1 = 8 bits
40405		MODBUS Protocol	0	1	1	Read/Write	0 = ASCII Mode, 1 = RTU Mode
40406		Transmit Delay	2	250	2	Read/Write	2 = 2 msec; See Transmit Delay explanation.
40407		Load Serial Settings	0	1	0	Read/Write	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.
		CALIBRATION					
40501		Unit Calibration	N/A	N/A	N/A	Read/Write	See MODBUS Calibration explanation.
40502		Calibration Data Register	N/A	N/A	N/A	Read/Write	See MODBUS Calibration explanation.
40503		E^2PROM Write Disable	0	1	0	Read/Write	0 = Enable writes, 1 = Disable writes; Returns to 0 at power cycle. Mirror of Coil 4.
40504		Input Error Status Register	N/A	N/A	N/A	Read Only	Bits 0-7 are mirror of Coils 5-8/17-20, See Coils Table.
40505		Checksum Error Status Register	0	N/A	0	Read/Write	Bits 0-3 are mirror of Coils 1-3, See Coils Table.
41001-41010		Slave ID	N/A	N/A	N/A	Read Only	RLC-DLC10000 (model) 1.00 version (maybe higher) 32 reads, 32 writes 16 scratch. See FC17 explanation.
41101-41116		GUID/Scratch Pad	N/A	N/A	N/A	Read/Write	This area is for the user to store any related information. This register area does not affect DLC operations.

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

COIL ADDRESS		COIL NAME	MIRROR REGISTER	ACCESS	COMMENTS
1		Calibration Checksum Error	40505 (bit 0)	Read/Write	1 = Error; Disables control and alarm outputs, causes flashing LEDs. Writing a zero clears the error.
2		Parameter Checksum Error	40505 (bit 1)	Read/Write	1 = Error; Disables control and alarm outputs, causes flashing LEDs. Writing a zero clears the error.
3		Integral and Offset/Manual Power Checksum Error	40505 (bit 2)	Read/Write	1 = Error; Disables control and alarm outputs, causes flashing LEDs. Writing a zero clears the error.
4		E^2PROM Write Disable	40503	Read/Write	1 = Disables writes to the E^2PROM; Returns to 0(writes are enabled) at power cycle.
CH A	CH B				
5	17	Shorted RTD Input Error	40504	Read Only	1 = Shorted RTD; Causes process value to be -32002, disables alarms, maintains control output at present level, causes flashing LEDs.
6	18	Open thermocouple or RTD Input Error	40504	Read Only	1 = Open thermocouple or RTD; Causes process value to be 32002, disables alarms, maintains control output at present level, causes flashing LEDs.
7	19	Input and Process Value Under Range Input Error	40504	Read Only	1 = Under Range Error; Causes process value to be -32001, disables alarms, maintains control output at present level, causes flashing LEDs.
8	20	Input and Process Value Over Range Input Error	40504	Read Only	1 = Over Range Error; Causes process value to be 32001, disables alarms, maintains control output at present level, causes flashing LEDs.
9	21	Control Output OP1 State	40014/40030	Read Only	0 = Off, 1 = On
10	22	Alarm 1 Output AL1 State	40015/40031	Read/Write	0 = Off, 1 = On; A write of 1 is only possible when alarm is set for Manual.
11	23	Alarm 2 Output AL2/OP2 State	40016/40032	Read/Write	0 = Off, 1 = On; A write of 1 is only possible when alarm is set for Manual.
12	24	Control Mode	40041/40049	Read/Write	0 = Automatic Mode, 1 = Manual Mode
13	25	Disable Setpoint Ramping	40042/40050	Read/Write	0 = Enabled, 1 = Disabled
14	26	Setpoint Ramping In Process	40043/40051	Read Only	0 = No, 1 = Yes
15	27	Disable Integral Action	40044/40052	Read/Write	0 = Enabled, 1 = Disabled
16	28	Auto-Tune Start	40011/40027	Read/Write	0 = Stop, 1 = Start

INPUT TYPE REGISTER (40101/40201) TABLE

MODE	TYPE
0	Thermocouple - T
1	Thermocouple - E
2	Thermocouple - J
3	Thermocouple - K
4	Thermocouple - R
5	Thermocouple - S
6	Thermocouple - B
7	Thermocouple - N

MODE	TYPE
8	Thermocouple - C
9	RTD platinum 385
10	RTD platinum 392
11	RTD nickel 672
12	Linear Ohms
13	Linear mV
14	Process Voltage
15	Process Current

ANALOG OUTPUT ASSIGNMENT REGISTER (400301/40311) TABLE

MODE	ASSIGNMENT
0	Output Power A
1	Process Value A
2	Setpoint A
3	Ramping Setpoint A
4	Deviation A
5	Direct Entry Value 1
6	Output Power B
7	Process Value B
8	Setpoint B
9	Ramping Setpoint B
10	Deviation B
11	Direct Entry Value 2

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

MODE	ACTION
0	Manual
1	Absolute HI (Balanced)
2	Absolute LO (Balanced)
3	Absolute HI (Unbalanced)
4	Absolute LO (Unbalanced)
5	Deviation HI
6	Deviation LO
7	Band Inside Acting
8	Band Outside Acting
9	Cooling (Alarm 2 only)

SERIAL BAUD RATE REGISTER (40402) TABLE

MODE	BAUD
0	300
1	600
2	1200
3	2400
4	4800
5	9600
6	19200
7	38400