LC USER MANUAL

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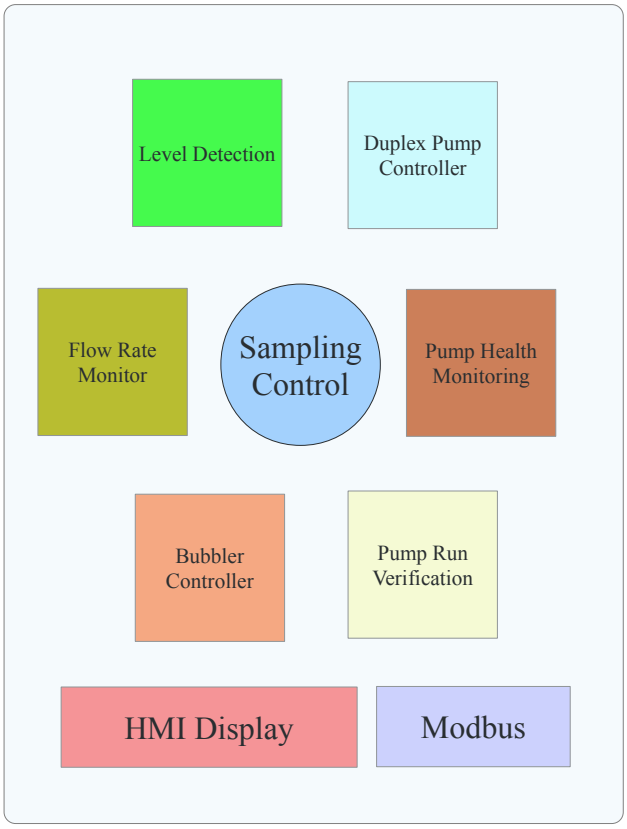
Chapter 1 Product Overview

Introduction

The Ingram Products Level Controller Product Family provides Level Detection, with an integrated Bubbler controller, a Duplex Pump Controller with pump Health monitoring and Run Verification and integrated Flow Rate Monitoring.



The LC-1 provides a fully functional Level Control solution in a small, DIN rail mounted controller. The integrated HMI provides access to an extensive set of run time statistics covering pump health, pump performance and system operating costs.

Features

Multi-pump (Tankless) Bubbler system
- Alternator – Variable duty factor
- Variable Sample rate, auto-tuning
- Auto-purging

Integrated Duplex Controller
- 2 pump control (alternate, 1 – 2, 2 – 1, user defined)
- automatic switch if lead fail (Error)

Pump Health Monitoring
- Leak Seal monitor
- Pump Temperature monitor

Run Verification
- Aux Contact Monitor
- Current Monitor (verifies current to pump)
- Flow Rate monitoring
- Phase unbalance monitoring

Integrated Flow Rate Monitor
- Measure rate of flow
- Low Outflow Error thresholds

Extensive Diagnostics
- Indicators for Air Pump & Pump status
- Indicators for Off, Low, Mid & High Levels

HMI statistics
- System & individual pump run times
- Pump Flow rate
- Pump Seal Leak Resistance

Communications
- Modbus RTU
- Ethernet (Modbus TCP/IP)

Highly Configurable
- All parameters configured thru HMI
- Password protected
- All values shown in engineering units
- support for U.S., Imperial and Metric units

Level Detection

The level detection subsystem accepts an analog signal representing the current liquid level and is scaled to standard engineering units (feet, meters etc.) before being compared to user defined thresholds, setting one of 5 different output 'states' indicating the current level.

Bubbler Controller

The Bubbler controller provides a fully integrated bubbler control subsystem to monitor liquid levels. The bubbler may be operated with or without air storage tanks and supports both continuous and pulsed pump operation, greatly extending the air pump life times.

The bubbler supports dual air sources and provides timed alternation between the two sources. In a tank-less system air pumps provide the air directly to the bubbler tube, eliminating the air tank. To maximize pump lifetimes the pumps may be activated on a timed basis and the alternate pump will be switched on in the case of a failure.

Flow Rate Monitoring

Flow rate monitoring measures the change in level between successive samples to determine the overall In Flow, Out Flow and individual pump flow rates.

The tank geometry is used to calculate the flow in standard engineering units. The user may select between US, Imperial or metric measurement units.

Alarm and/or warning outputs will be activated if the measured flow rate exceeds specific rates.

Duplex Pump Controller

An integrated Duplex Pump controller is provided that provides a wide range of user defined pump alternating sequences that may be modified based on an internal Time-of-Day timer. The Timer supports 32 set points which may be activated on a daily, weekly or monthly basis. Pump activity is triggered by the Level Detection subsystem and flow rate monitoring is provided for each pump.

If the current LEAD pump fails the LAG pump is automatically switch in.

Pump Health Monitoring

Pumps exist in four states: ONLINE (LEAD or LAG pump), DEMOTED (LAG pump only), DISABLED (will not be activated) or OFFLINE (user disabled).

Pump Health Monitoring uses seal leak detection, pump over-temperature detection and conditions from the Flow Rate and Run Verification subsystems to determine the state of each pump.

Run Verification

Run verification ensures that when activated a pump operates within it's specified operating range. The system monitors the auxiliary contact from the motor starter and the pump current.

The operating current upper and lower ranges may be set as both warnings (demoted) or error (offline) levels.

Operating warnings and errors are made available as discrete outputs to activate external alarm systems as well as being accessible from both the HMI and communication interfaces.

HMI Display

An HMI display allows setting all parameters and may be password protected. All operating statistics and run time information may be called up and error and warning conditions will be immediately displayed, taking the guess work out system maintenance.

Communications

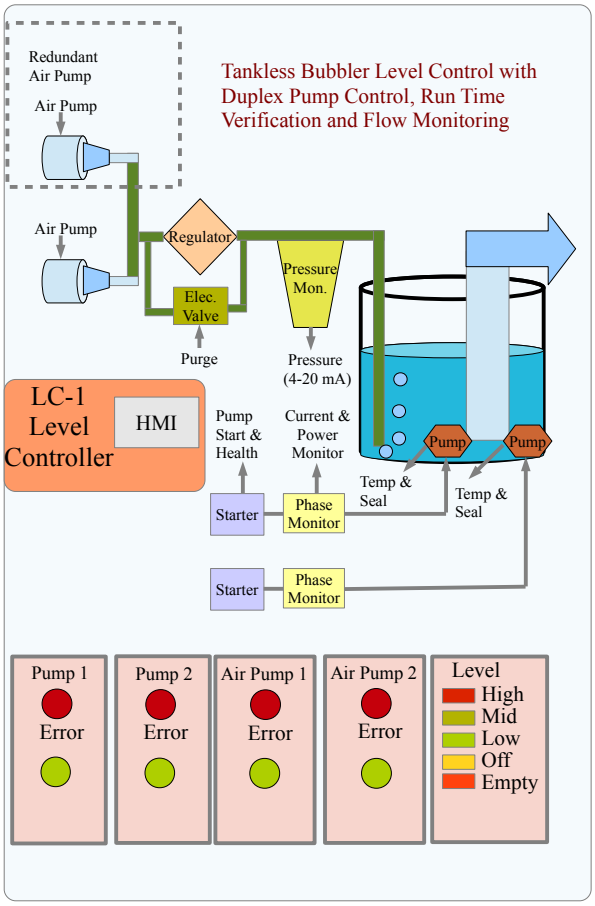
Communications adapters allow parameters to be set using Modbus RS485 (RTU) or Modbus TCP/IP (Ethernet) connections, allowing all run time statistics to be easily collected. An SMS adapter allows errors to be reported on remote phone systems.

Small Size

The DIN-rail mounted LC-1, measuring 3.5" X 5", requires a minimum space. Some models support an I/O expansion unit that provides additional status outputs.

Typical Application

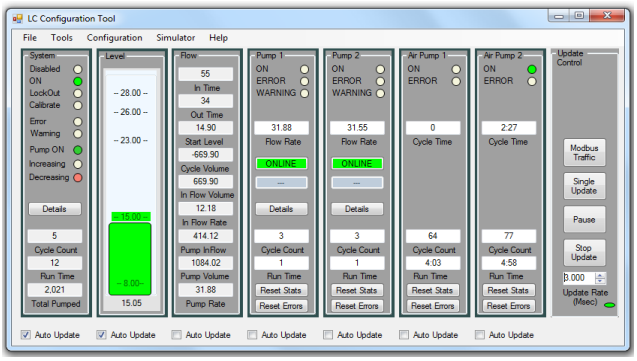
The following application illustrates an LC-1 controller providing level control on a waste water lift station. A dual air pump tank-less bubbler system is used for level monitoring with the duplex pump control system that provides run verification, power monitoring and flow rate statistics.



Configuration Support

Installations may be fully configured in the field using the integrated HMI display. A Windows based application program (LC_Config) is available that provides a GUI screen view of all operating parameters, allows setting the configuration options and includes an integrated tank/pump simulator.

Application profiles may be loaded from a computer file, allowing fast configuration within the field and. current operating statistics may be collected and saved.



All products are provided with an integrated HMI display and a Modbus compatible communications port.

Other custom user configurations are available.

Modular Capabilities

Product Configurations

	Analog Level Detection	Bubbler Controller	Flow Rate Monitoring	Duplex Pump Control	Pump Health Monitoring	Pump Run Verification	HMI Display	Communications
LC-1	X	X	X	X	X	X	X	X
LC-2	X		X				X	X
LC-3	X	X					X	X
LC-4			*	X	X	X	X	X
LC-5			*				X	X
LC-6	X		X	X	X	X	X	X

The Standard LC-1 controller provides an advanced, fully functional level control solution. The LC-2 and LC-3 provides 5 discrete digital outputs which may be used with alternate Duplex Controllers.

The LC-4 and LC-5 accepts discrete inputs to provide a Duplex Controller with optional flow rate information, providing a convenient 'add-on' for any existing level control product.

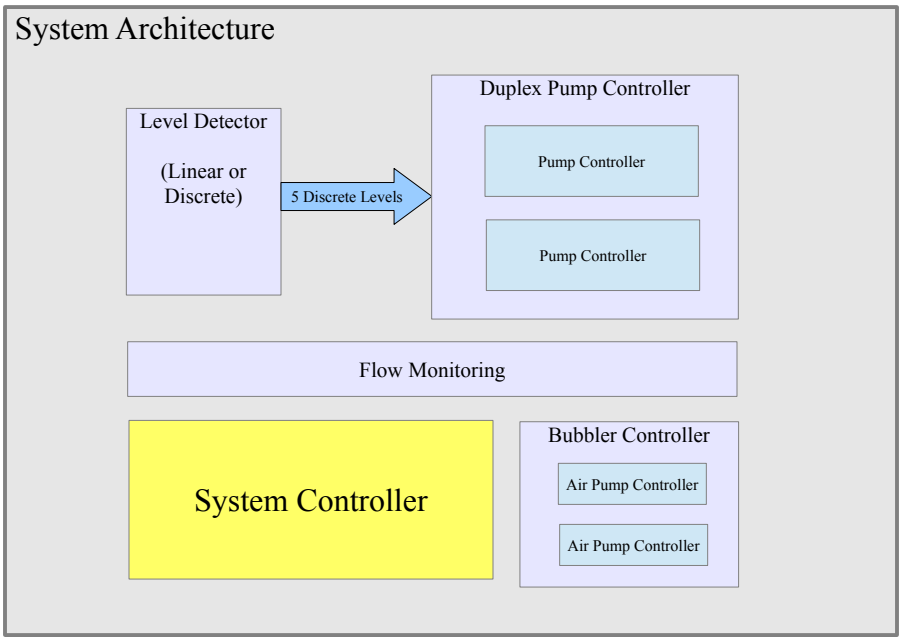
The LC-6 supports all the LC-1 functions with the exception of the Bubbler subsystem.

Specifications

Power:	24 Vdc, @ 100 mA
Size:	126 mm X 90 mm X 58.5 mm
Environment:	IEC68-2
EMC:	IEC801-3
Inputs:	24 Vdc (digital) 200 kohms (seal detect) 0-10 Vdc/4-20 mA (external level detect)
Outputs:	NO Relay (0-240 Vac, 10 Amp resistive) NPN (sink) (24 Vdc, 2 Amp) PNP (Source) (24 Vdc, 2 Amp)
Levels:	5 Level (Zero, Off, Low, Mid, High) Set in Inches, Feet or Meters
Bubbler:	1 or 2 air pumps with or without air tank +/- 1 cm (0.3") Min sample rate 0.5 sec
Pump Sequencer:	1-2, 2-1, Alternating or user defined sequence 4 user defined sequences 2 user defined Time of Day sequence groups
Pump Health:	Seal Resistance Pump Temperature contact
Run Verification:	Auxiliary Contact Closure Pump Current (Min/Max)
Flow:	Gallons, Imp. Gallons or Liters Reported per second, minute or hour

Chapter 2 SYSTEM

The LC family of level controllers consist of 5 major components: a System controller, a Level Detector, a Duplex Pump controller, Flow Monitoring, and an optional Bubbler controller. All implementations include a System controller that controls the overall operation of the device.



System Configuration

The system configuration information includes the firmware version and a configuration word that defines the hardware configuration and a control word the defines the operating mode of the device.

Block	Parameter	Description
000 (THRD)	Gain	Version, ie: 1.05
	Offset	Configuration Word
	Voff	Simulator Mode
001 (THRD)	Offset	Operating Mode
	Gain	Password

Version

The Firmware version number is represented as a Major.Minor version number, for example Version 1.05. The version information is not monitored by the LC device and should not be changed by the user.

Configuration Word

The configuration word consists of 4 fields.

Number of Bubbler Pumps (0..9)	Detector Type (0..9)	Number of Pumps (0..9)	Model Type (0..99)
0..2 indicating number of bubbler pumps used by Bubbler Controller	0 = Discrete 1 = Linear 2 = Bubbler	0..2 indicating number of pumps used by Duplex Controller	LC Model Number

The configuration word is made available for configuration and monitoring tools such as the LC_Config application program to determine the hardware configuration. The configuration word is not monitored by the LC device and should not be changed by the user.

Simulator Enable

The Simulator Enable word configures the device to operate in the 'simulation' mode. While in the simulation mode the analog inputs (Level, Seal, Current) are remapped to internal registers that may be written to by configuration tools such as the LC_Config tool.

The digital inputs are not remapped. Simulation tools may write to internal registers that are internally 'OR'd' with the physical inputs. If operating in simulation mode the external digital inputs must be held in the OFF state.

The simulator mode is entered if the Simulator Enable word is set to a value > 0. Refer to the Simulator Chapter for additional information.

Operating Mode

The operating mode controls the overall operation of the device.

Mode	Description
0 (Disabled)	All control outputs (Pumps, Air Pumps) are held in the OFF state. No level sampling or flow calculations are performed.
1 (Enabled)	Normal operating mode
2 (Lockout disabled)	Normal operating mode. The Zero Level Lockout that prevents pumps from operating below the 'Zero' Level is disabled, allowing manual control of the pumps to levels below the 'zero level'.
3 (Calibrate)	Duplex controller disabled, zero level lockout disabled. Allows calibration of sensor input.

The Lock Out function attempts to protect the pumps from manual operation below a configurable 'Zero Level'. When disabled, damage may occur to the pumps if activated below the Zero Level.

The Calibrate mode disables the Lock Out feature and the duplex controller and is typically used when establishing the Sensor parameter.

Real Time Clock

The device Real Time Clock is used to control alternate sequences within the Duplex Controller. Setting the Real Time Clock may be performed through the HMI display or through the LC_Config application.

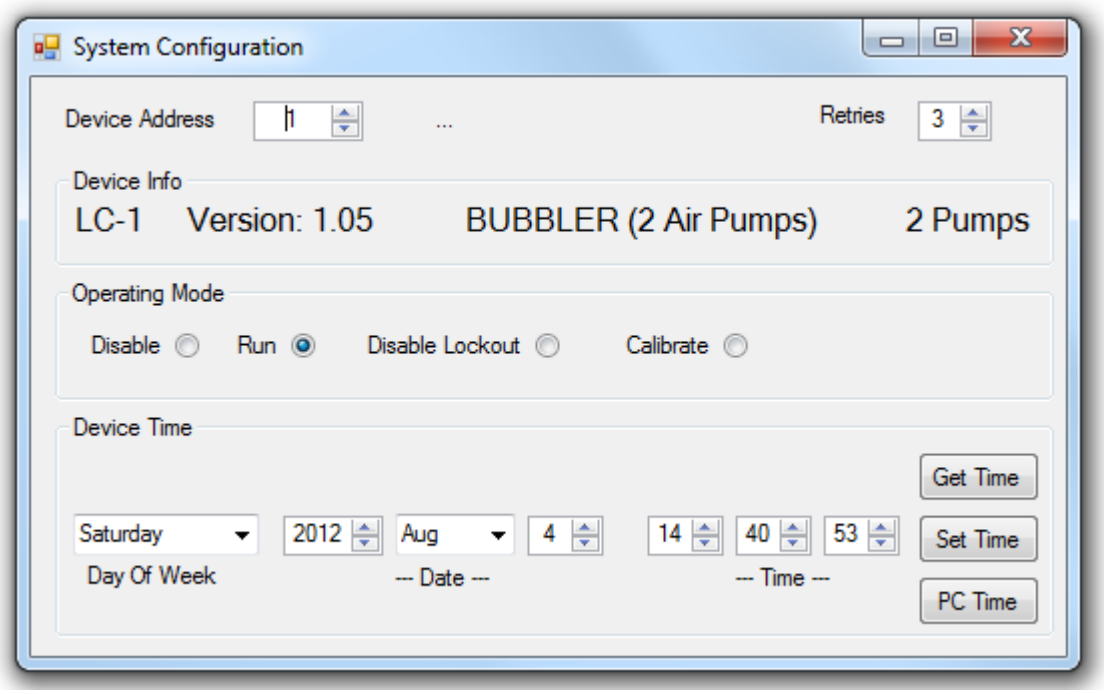
LC_Config System Configuration

The following LC_Config screen (Configuration/System) shows the System parameters that may be configured. The LC_Config screen allows setting the Modbus address used to address the device, the number of retries in case of communication failures, the device Real Time Clock and the device operating mode.

To simplify setting the real time clock a 'PC Time' button is available that reads the current PC time and date and loads it to the configuration screen device time of day display. To modify the actual device time the 'Set Time' button must be pressed.

The 'Device Address' option allows changing the Modbus address used by the LC_Config application to access the device. It does NOT change the address of the device. If the device is not found an error message will be displayed.

To change the Device Address use the HMI interface screen or the LC_Config 'Modbus Interface' tool.



Status Indicators

Two System Status indicators are available: the WARNING indicator that indicates some non-fatal abnormal condition exists and the ERROR indicator that indicates a machine fault exists. A separate output is provided to indicate when the level exceeds the 'High Level' point. The following table summarizes the conditions that will activate the Warning and Error states.

Warning	Condition	Related To
M6	Zero Lock Out disabled	System
M13	Machine Disabled	System
M30	Pump 1 Demoted	Duplex Controller
M42 /	Pump 1 Flow Not OK	Duplex Controller
M62	Pump 2 Demoted	Duplex Controller
M74 /	Pump 2 Flow Not OK	Duplex Controller
M88 /	Level below Zero Level	Level Detection
M113	Level Above Blocked Level	Bubbler System

/ indicates complemented logic, active when 'off'

Error	Condition	Related To
M29	Pump 1 Disabled	Duplex Controller
M61	Pump 2 Disabled	Duplex Controller
M92	Level above High Level	Level Detection
M114	Blocked Error	Bubbler System

Run Time Data

The following SYSTEM run time data is collected and is available through the indicated Data Registers. All system run time data is retained if power is lost. These values may not be reset.

Data Register	Name	Description
DW13	Cycle Count	The number of cycles that the system has experienced. A cycle is initiated when the level rises above the 'OFF' level and ends when the level drops below the 'OFF' level.
DW14	Run Time	The number of days – hours:mins that the system has been operating. The maximum value is 999,999,999 minutes, representing ~ 1902 years.
DW15 *	Total Pumped	Total volume pumped. The maximum value is 999,999,999 and is provided in the units selected when configuring the system Flow information. The value provided is the sum of the Pump 1 and Pump 2 Flow Volume information.

* Cleared by pump Reset Statistics, retained on loss of power.

Run Time Status

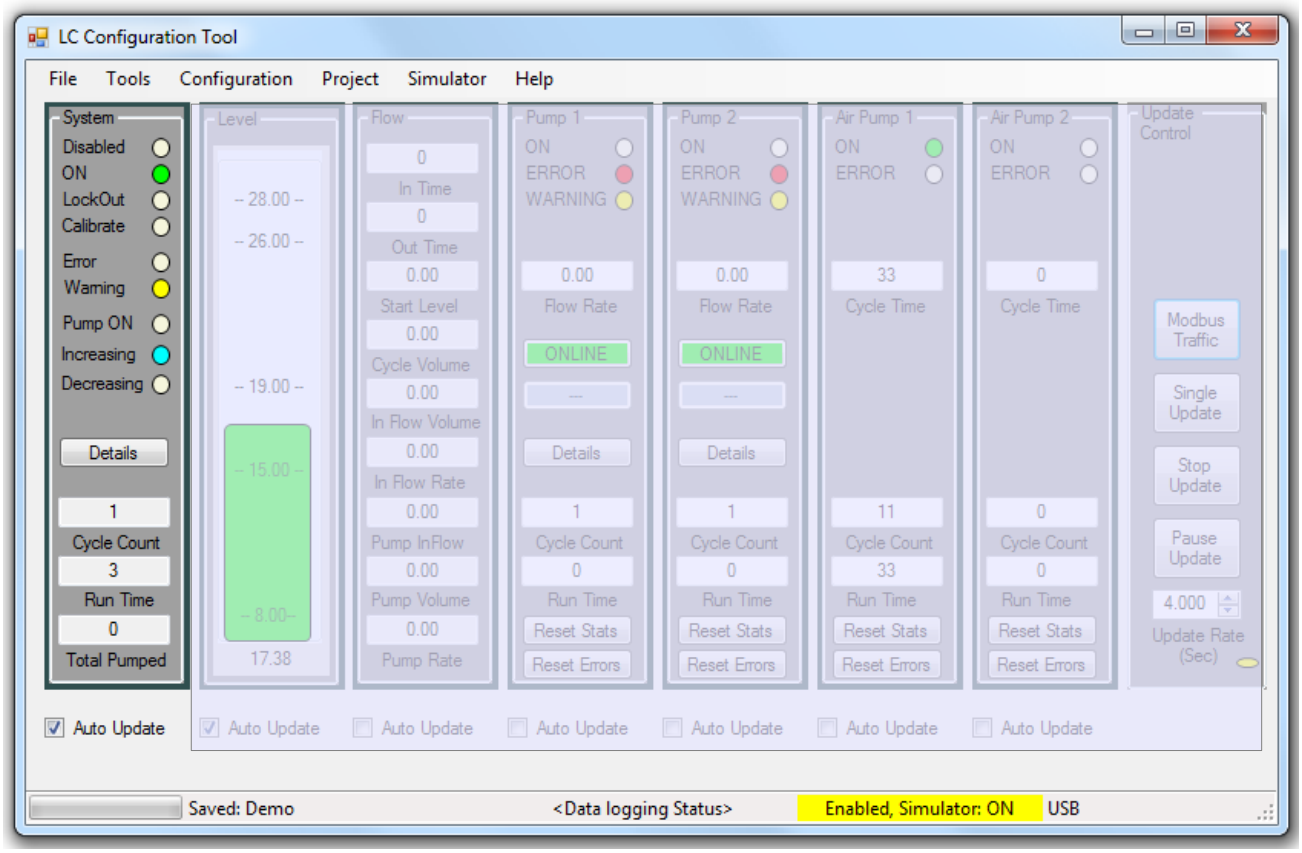
The following SYSTEM run time status information is available through the indicated Bit Registers. All status information is volatile (not retained if power is lost).

Bit Register	Name	Description
M0..5	Reserved	Reserved
M6	LockOut Disabled	Zero detect lockout has been disabled

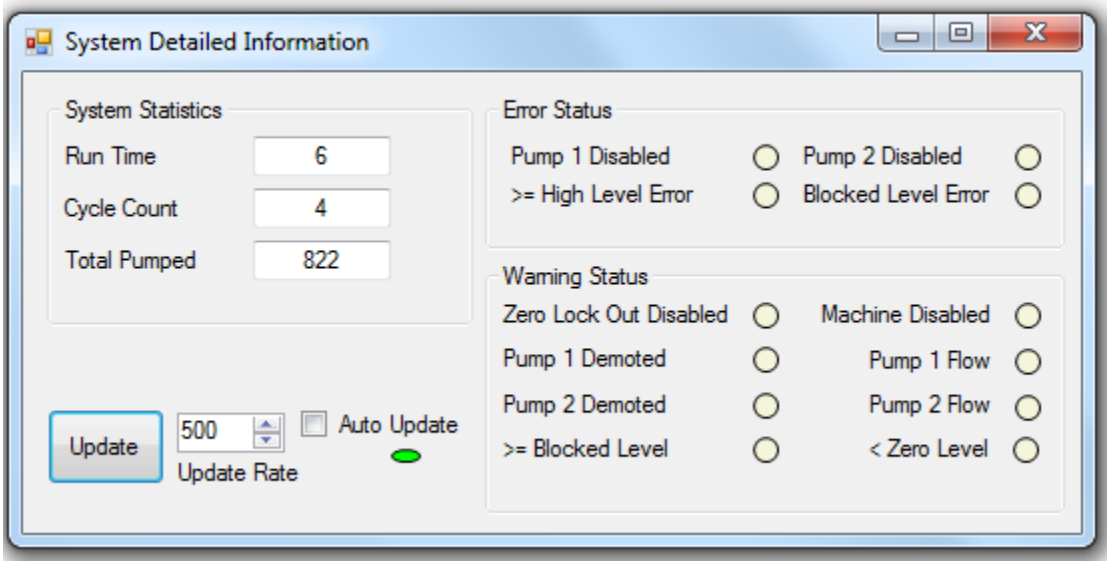
M7	Calibrate Mode	System is in the calibrate mode.
M8	System Warning	A warning condition exists
M9	System Error	An error condition exists. Cleared by clearing the corresponding error condition.
M10	Any Pump ON	One of the pumps is active
M11	Increasing	Level increased during the last sample period
M12	Decreasing	Level decreased during the last sample period
M13	Machine Disabled	System is in the Disabled mode
M14	Second Tick	Internal 'second' clock tick
M15	Minute Tick	Internal 'minute' clock tick

LC_Config System Display

The LC_Config tool displays the SYSTEM information as shown below. The 'Details' button will display the cause of any System Warnings or System Errors.

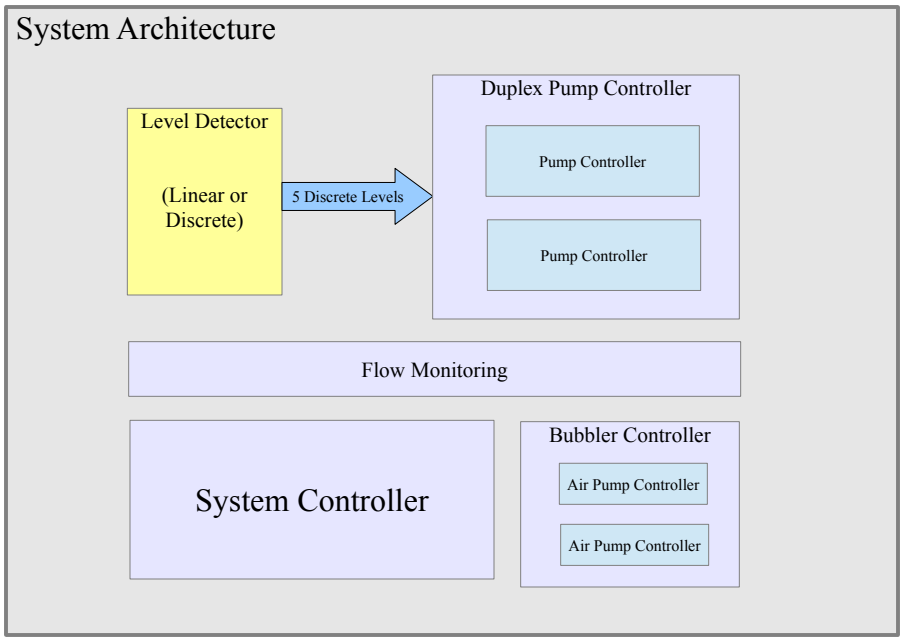


The 'Details' button will display additional System status information.

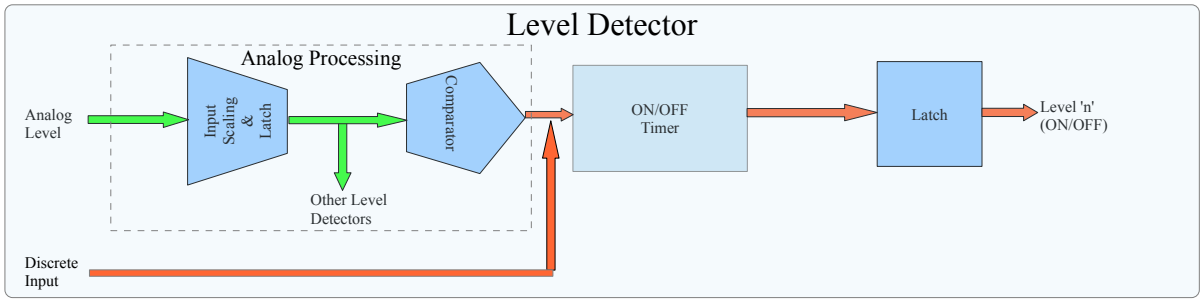


Chapter 3 LEVEL DETECTION

The Level Detector subsystem accepts either linear (analog) or discrete (digital) inputs and is responsible for determining the current level within the tank. A linear detector samples an Analog signal representing the current tank level which is compared against user defined setpoints. A discrete (float) detector accepts one of 5 digital inputs, typically connected to float switches, to determine the current level.

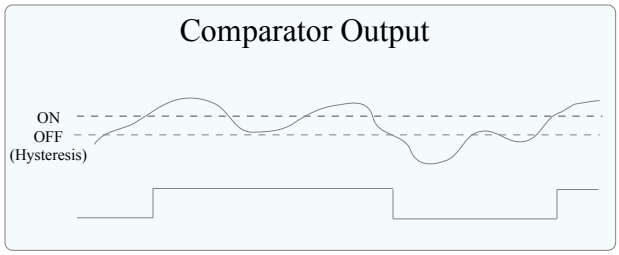


The level detection system supports 5 distinct levels. The linear level comparators include hysteresis to avoid false readings due to signal jitter. Following the threshold comparison the signal is further conditioned with a dual timer to ensure that the signal is stable prior to being latched at the end of each sampling period. Discrete level detectors apply the float signals directly to the dual timers.



The Input Scaling and Latch function converts the input signal into standard engineering units (Feet/Inches or Meters/Centimeters), allowing user defined levels to be specified in the corresponding units, and then is applied to each level detector. In addition, the input signal is 'latched' as the current level during at the end of each sample period, allowing it to be used in the flow rate calculations.

Each linear level detector consists of a comparator that includes a hysteresis calculation. If the input level is at or above the user defined threshold ON level the comparator output will be active. If the input level is below the user defined threshold OFF level the comparator output will be inactive. The hysteresis levels are typically set ~ 0.25 below the threshold level.

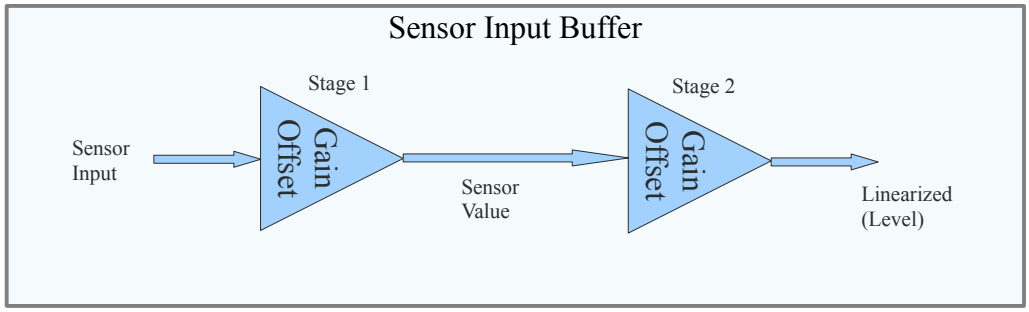


To avoid sporadic or false triggering a dual timer is used for each level threshold that verifies the comparator output or discrete (float) input remains constant for a user defined time, referred to as the THRESHOLD ON and THRESHOLD OFF time. When the comparator is turned on it must remain on for the specified ON time. When it turns off it must remain off for the specified OFF time. At the end of the Sample Time the Detection Level states are latched and will remain constant until the end of the next sample period.

The Sampling subsystem ensures the inputs are sampled at a periodic rate and is used to establish flow information. Note that discrete inputs will not provide information of the level between each discrete (float) input.

Sensor Input

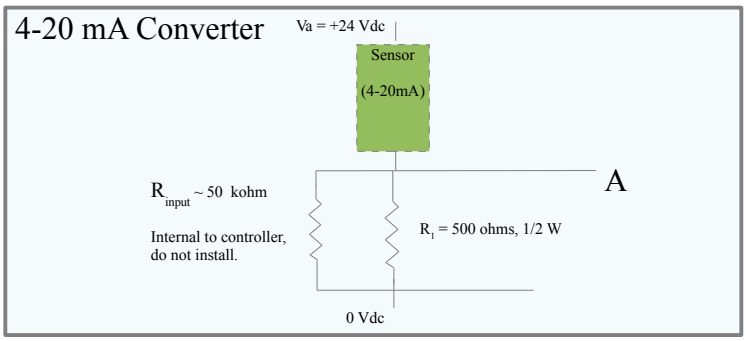
The Sensor Input provided in the linear level detector provides a two stage buffer to linearize the sensor signal and convert it into a signal representing the tank level. Each stage offers a Gain and Offset value.



The LC controller accepts a 0-10 Vdc input, with an input impedance > 50 Kohms. If a 4-20 mA sensor is used the signal may be converted to 2-10 Vdc using the following circuit. Stage 1 is typically used to remove the 2 volt offset by setting the Offset to -2.00 and the gain to 1.25, resulting in a Sensor Value signal of 0 – 10 Vdc.

For sensors that supply a voltage 0-10 Vdc output the Stage 1 gain may be set to 1 and the Offset to 0. If the sensor supplies a 0-5 Vdc signal the gain is set to 2 and the offset set to 0. Other sensor input types may be used, provided the maximum input voltage is limited to 10 Vdc.

Positive displacement sensors will have an increasing output signal as the level increases. Negative displacement sensors will have a decreasing output signal as the level increases. Setting the gain of the stage 1 buffer to a negative number (ie, -1.00) and providing an offset of +10.00 will convert a negative displacement 10 – 0 Vdc signal to one that increases (0 – 10 Vdc) as the level increases.



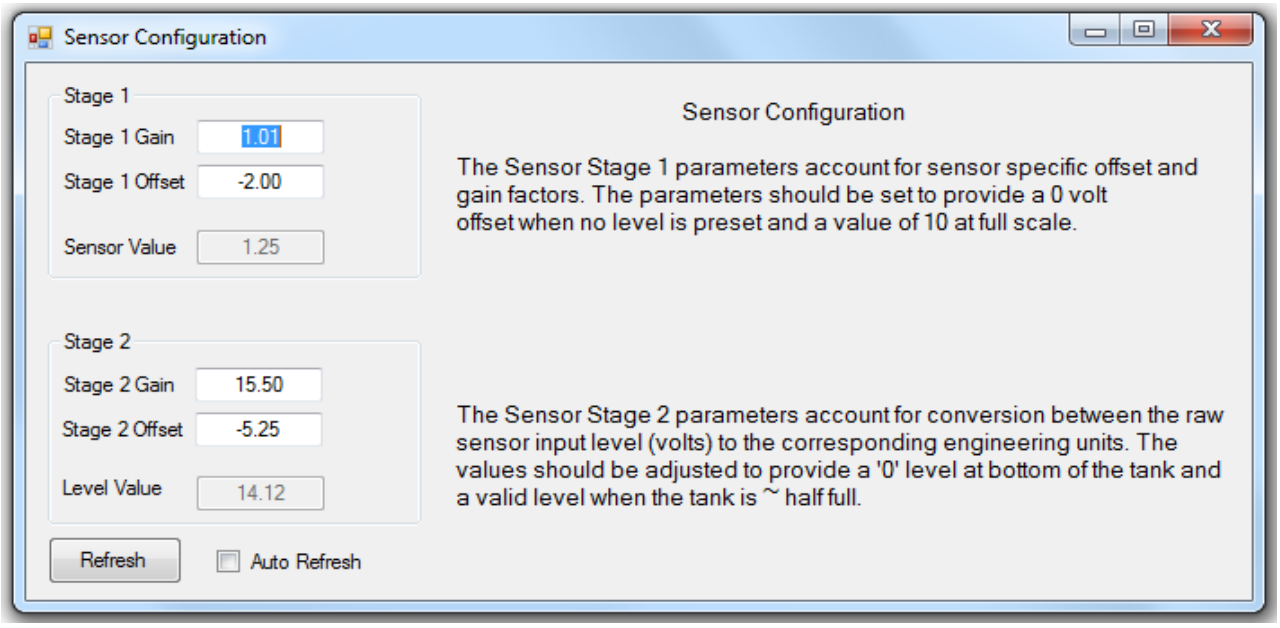
The second stage buffer is used to convert the 0-10 Vdc signal to a signal representing the level within the tank represented in engineering units (inches/feet/meters) and the Gain and Offset values are particular to the specific sensor.

Sensor Configuration

The sensor is configured by setting the Gain and Offset for the two buffer stages.

Block	Parameter	Description
024 (AMP)	Gain	Multiplier to convert signal to 0-10.00 span
	Offset	Offset to provide 0 level when physical level is 0
025 (AMP)	Offset	Multiplier to provide true level (ie 10 feet) as output
	Gain	Offset to provide 0 level when physical level is 0

The following LC_Config screen (Configuration/Sensor) shows the Sensor Parameters that may be set. The configuration screen also shows the Stage 1 and Stage 2 outputs from the dual stage buffer.

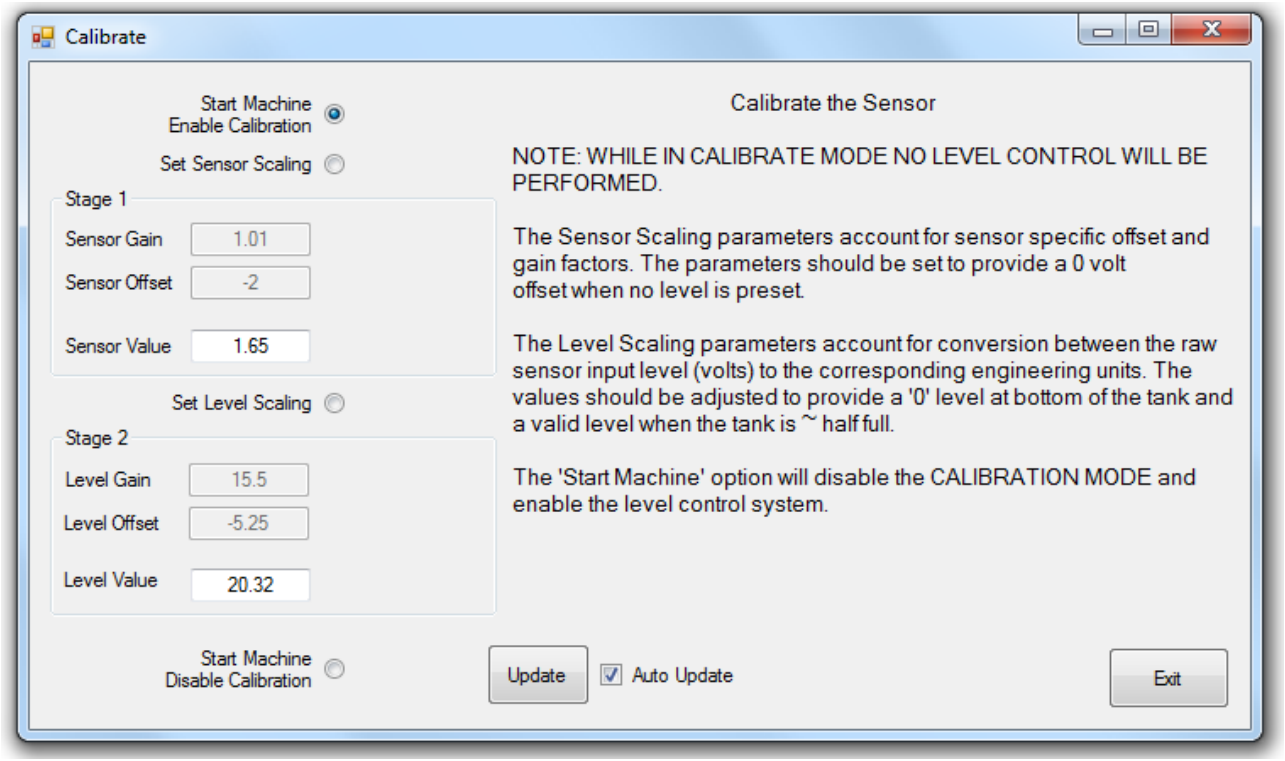


Sensor Calibration

To calibrate the LC controller to use a specific sensor the following steps should be performed:

1 – Set machine into Calibration Mode
2 – With a 'zero' level presented to the sensor set the Stage 1 Offset to provide a 0.00 stage 1 output.
3 – With a 'full scale' level presented to the sensor set the Stage 1 Gain to provide a 10.00 stage 1 output.
4 – With a 'zero' level presented to the sensor set the Stage 2 Offset to provide a 0.00 stage 2 output.
5 – With a known level presented to the sensor set the Stage 2 Gain to provide the known level as the stage 2 output.
6 – Return the machine to the Run Mode.

To assist in the calibration process the LC_Config tool includes a 'Calibration Tool' (Tools/Calibrate) that sequences through the preceding steps.



Sensor Run Time Data

The following run time data is available for the Sensor.

Data Register	Name	Description
DW16	Sensor Level	The output from the Stage 2 buffer.
DW21	Sensor Value	The output from the Stage 1 buffer.

Sensor Run Time Status

There is no Run Time Status available for the sensor.

Discrete Inputs

Systems that use discrete inputs require no specific sensor configuration. The five digital inputs are configured as 'Active High', implying that the signal should be activated when the corresponding level switch is closed.

Level Sampling

The level detection system sampling sequence is broken into 5 distinct time periods as shown below.

Time Period	Units	Description
Sample Settling Time	Secs.msec	Time required for level detection device to stabilize.
Threshold ON Time	Secs.msec	Minimum time for a level to be at or above the threshold before being set 'ON'.
Threshold OFF Time	Secs.msec	Minimum time for a level to be under the threshold before being set 'OFF'.
Threshold Timer Delay	0.5 secs	Fixed 0.5 second threshold timer delay
Sample Delay	Secs.msec	Time delay before the next sample period

Sample Settling Time

The Sample Settling Time allows the input signal to stabilize. For purely analog inputs (Pressure transducer, ultrasonics etc, continuous Bubbler systems etc.) this time may be set to a minimum of 0.01 seconds. For pulsed Bubbler systems, this time represents the time required for the air flow to stabilize.

The Threshold ON and Threshold OFF times, set as part of the Level Thresholds, ensure that the level remains above (or below) the user defined level for a specified time, typically 1-2 seconds.

At the end of the Sample ON time the outputs of the Input Scaling amplifier and each of the 5 level detectors are latched and will remain constant until the end of the next Sample Settle Time.

The Sample ON time is calculated by the system as:

Sample ON = (Sample Settling Time + Threshold ON + Threshold OFF) + 0.5 seconds

Sample Segments

The distance between the previous 'setpoint (level)' and the next 'setpoint (level)' is divided by a user provided Segment value to determine the Segment size. The sampling system may adjust the sampling algorithm based on the calculated segment.

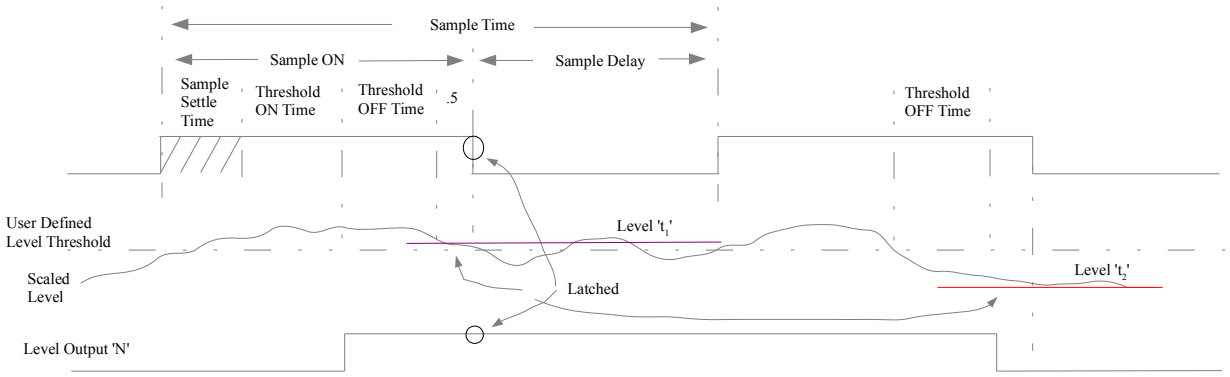
Sample Mode

The Sample rate is determined by the user or can be automatically calculated by the system and will determine the overall sampling rate of the system. The mode of sampling depends on the Sample Delay time and the Sample Adjust Time parameters allows three different options.

Mode	Delay Time	Adjust Time	Description
Continuous	0.010 sec	0	Sampling is done continuously
Timed	0.010 - ??? sec	0	The sample delay is set by the Sample Delay Time parameter
Auto	0.010 - ??? sec	> 0.010 sec	The sample delay is calculated by the system to achieve 1 sample per segment. The sample Delay Time determines the maximum delay between samples.

In the Continuous Mode, the sampling is done continuously, with a minimal delay time between each sample.

In the Timed Mode the user defines the sample delay time. A large sample delay time will reduce the cycling on air pumps but level detection will only be enabled during the Sample On time. Large changes may occur if the Sample time is set to a large value.



In Auto Tune Mode, the sample delay time is tuned by the system based on the user provided 'segment' value. Following a sample cycle, the change in level is compared to the current segment size and if the level has changed more than the segment size the Sample Delay is reduced. If the level has changed less than 1/2 of the segment size the Sample Delay is increased.

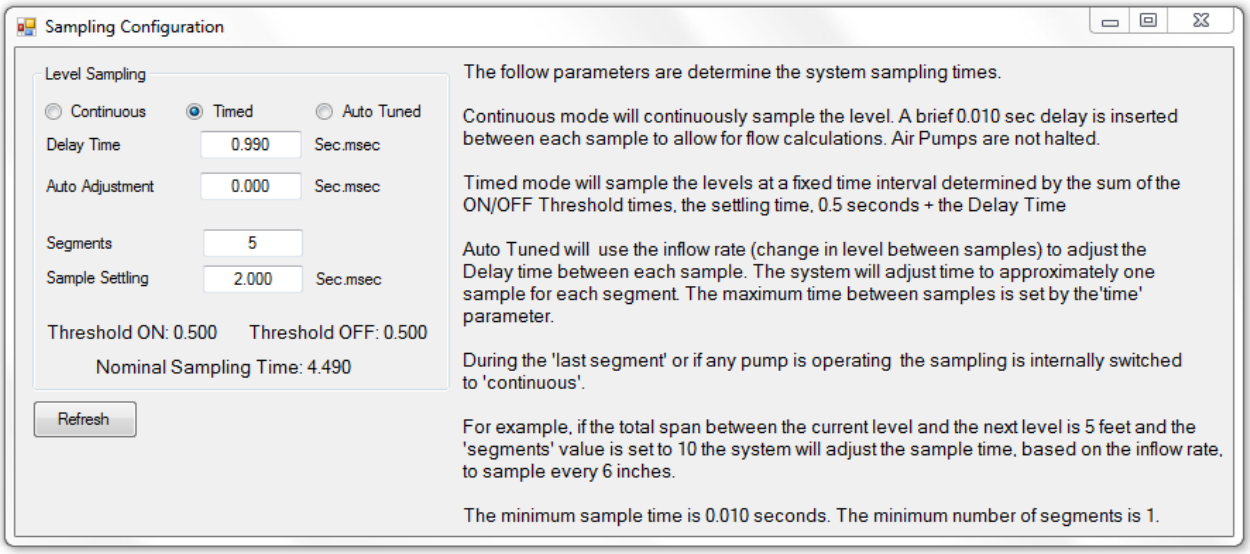
For all modes, when the level is within 1 segment size of the next threshold level or if any pump is active the system automatically switches to continuous sampling.

Sampling Configuration

The Sampling subsystem is configured by setting the sampling mode, the Delay Time, the Auto-adjust Time, the number of segments and the Sample Settling time.

Block	Parameter	Description
020 (CMPR)	Offset	Sample Settling Time
021 (CMPR)	Offset	Sample Delay Time
022 (CMPR)	Offset	Sample Delay Adjustment – 0 for no auto adjust
023 (CMPR)	Offset	Sample Segments

The following LC_Config screen shows the Sampling parameters that may be configured. The LC_Config interface uses the values of the Sample Delay and Sample Adjust times to determine which of the 3 modes are currently in effect.



Sampling Run Time Data

The following SAMPLING run time information is available through the indicated DW Registers. All SAMPLING run time data except the Actual Sample ON and OFF times are non-volatile (retained if power is lost).

Data Register	Name	Description
DW16	Sensor Level	Input provided by Sensor (See Sensor Run Time Data)
DW120	Threshold ON time	Value provided by Level Configuration
DW121	Threshold OFF time	Value provided by Level Configuration
DW122	Sample Delay Time	Value provided by Sampling Configuration
DW123	Sample Segments	Value provided by Sampling Configuration
DW124	Sample Adjust Time	Value provided by Sampling Configuration
DW125	Sample Settle Time	Value provided by Sampling Configuration
DW126	Off – Low Segment Size	Calculated as (Low Level – Off Level) / Sample Segments

DW127	Low – Mid Segment Size	Calculated as (Mid Level – Low Level) / Sample Segments
DW128	Actual Sample OFF time	Calculated Sample OFF time based on mode
DW129	Actual Sample ON time	Calculated Sample ON time based on mode

Sampling Run Time Status

The following SAMPLING run time status information is available through the indicated Bit Registers. All status information is volatile (not retained if power is lost).

Bit Register	Name	Description
M96	Force Continuous	System is forcing continuous mode
M97	Continuous Mode	Continuous mode (Sample Delay <= 0.010 sec)
M98	Auto Tune Mode	Auto Tuning mode (Sample Adjust Time > 0)
M99	Segments	Number of segments > 1
M100	Sample ON	Sample ON state is active
M101	Sample ACTIVE	Sample Settle Time has expired
M102	Sample OFF Strobe	Pulse generated at the end of the Sample ON time
M103	Reserved	

Level Thresholds

Five user defined Level Thresholds are supported.

Threshold	Definition
Zero Threshold	Determines absolute lowest level. Pumps will be disabled below the Zero Threshold
Off Threshold	When the level drops below the OFF threshold the duplex pump controller will turn off the pumps.
Low Threshold	When the level goes above the LOW threshold the LEAD pump will be turned on.
Mid Threshold	When the level goes above the MID threshold the LAG pump will be turned on.
High Threshold	When the level goes above the HIGH threshold the HIGH ALARM will be activated.

Variable Low Threshold

In normal operation the Lead pump will be activated whenever the Low Threshold is reached. To introduce a degree of variation in the low level to avoid build up on the tank wall a Variable Low Range value is used to allow the system to vary the 'LOW' threshold from the user defined Low Threshold value.

The Variable Low Range parameter defines the maximum level above the user defined Low Threshold. The controller will adjust the Low level by adding $1/5^{th}$ of the Variable Low Range value after each cycle. After 6 cycles the Low level is reset to the User Defined Low Threshold.

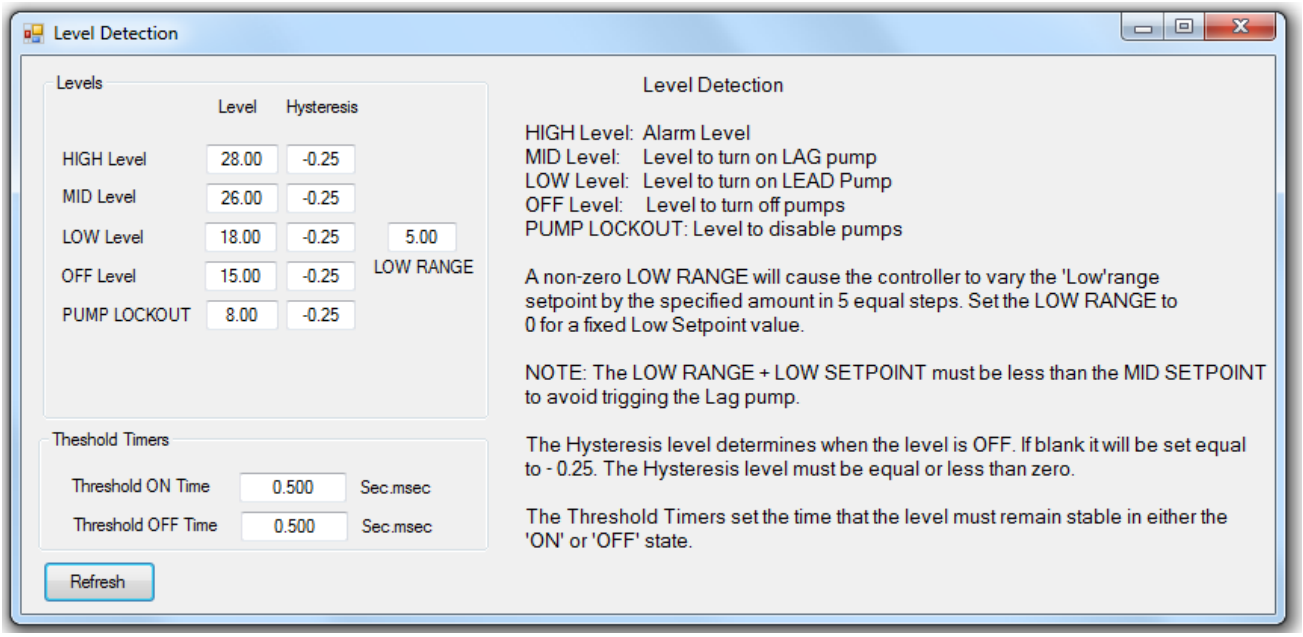
Setting the Variable Low Range value to 0 will disable the adjustable Low Threshold feature. The Variable Low Range value must be selected such that the Low Threshold + Variable Low Range is less than the Mid Threshold to avoid having the LAG pump triggered.

Level Configuration

The Level Detector is configured by setting each of the level setpoints, the hysteresis value and the ON and OFF threshold times.

Block	Parameter	Description
002 (WARP)	Offset	Zero Level – inhibits pumps from operating below this level
003 (WARP)	Voff	Zero Level Hysteresis
004 (WARP)	Offset	Off Level – Pumps will shut off when level drops below the OFF level
005 (WARP)	Voff	Off Level Hysteresis
006 (WARP)	Offset	Low Level – Lead pump will turn on when level rises above the LOW level
007 (WARP)	Voff	Low Level Hysteresis
008 (WARP)	Offset	Mid Level – Lag pump will turn on when level rises above the MID level
009 (WARP)	Voff	Mid Level Hysteresis
010 (WARP)	Offset	High Level – High Alarm will be activated if level rises above the HIGH level
011 (WARP)	Voff	High Level Hysteresis
012 (WARP)	Offset	Threshold ON time – time level must be at or above the setpoint to be turned ON
013 (WARP)	Offset	Threshold OFF time – time level must be below the setpoint to be turned ON
014 (CMPR)	Offset	Range for auto-adjustment of Low level

The following LC_Config screen shows the Level Threshold parameters that may be configured.



Level Run Time Data

The following LEVEL run time status information is available through the indicated DW Registers. All SAMPLING run time data is non-volatile (retained if power is lost).

Data Register	Name	Description
DW91	Zero Level	Value provided by Level Configuration
DW92	Off Level	Value provided by Level Configuration
DW93	Low Level	Value calculated based on Low Level Base + Variable Low Level data
DW94	Mid Level	Value provided by Level Configuration
DW95	High Level	Value provided by Level Configuration
DW96	Current Level	Level determined by the current Sampling cycle
DW97	Variable Count Cycle	Value ranging from 0 .. 5 indicating what adjustment to be made to Variable Low Level
DW98	Low Level Base	Value provided by Level Configuration
DW99	Variable Range	Value provided by Level Configuration

Level Run Time Status

The following LEVEL run time status information is available through the indicated Bit Registers. All status information is volatile (not retained if power is lost).

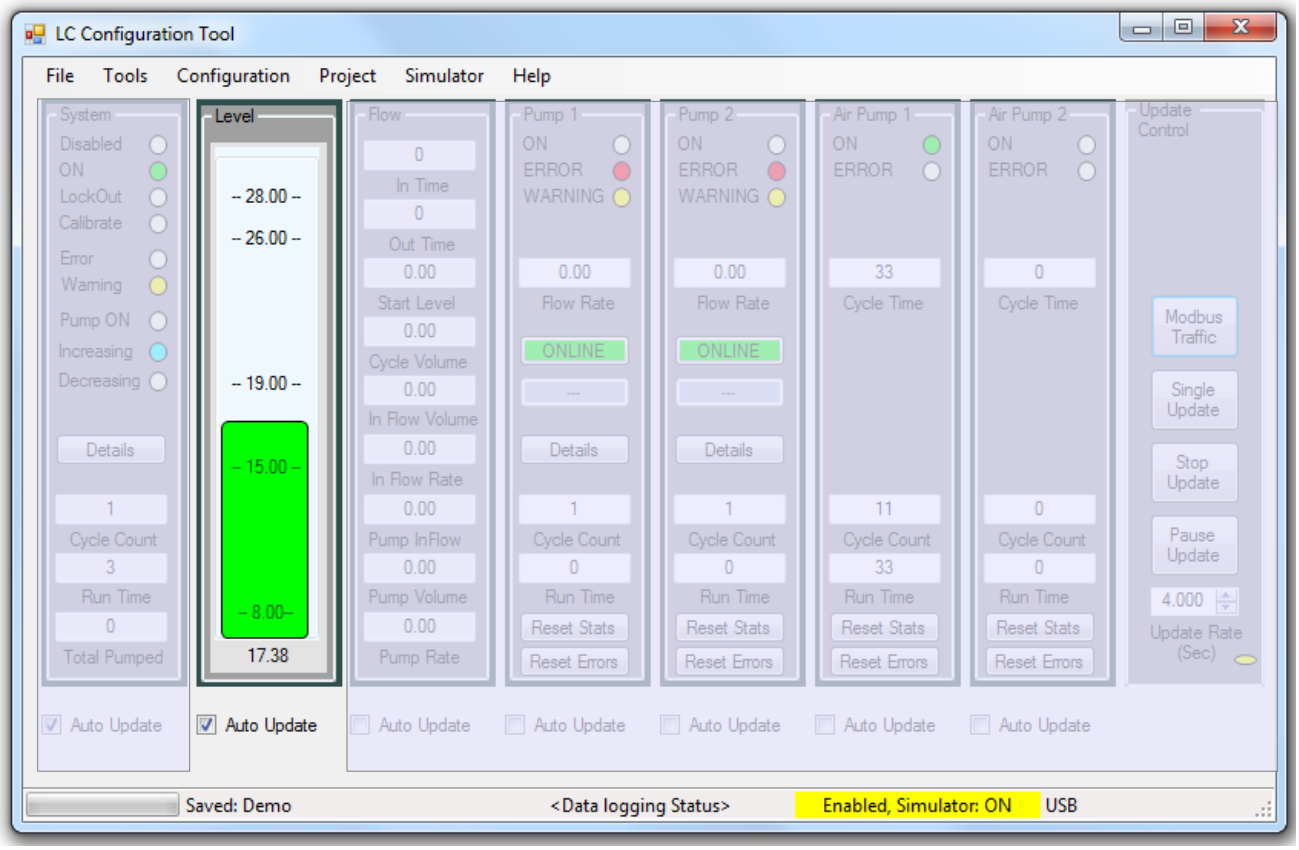
Bit Register	Name	Description
M88	Zero Level	Level is >= Zero Level Threshold
M89	Off Level	Level is >= Off Level Threshold
M90	Low Level	Level is >= Low Level Threshold
M91	Mid Level	Level is >= Mid Level Threshold
M92	High Level	Level is >= High Level Threshold
M93	Near Low Level	Level is >= (Low Level Threshold – Segment Size)
M94	Near Mid Level	Level is >= (Mid Level Threshold – Segment Size)
M95	Variable Low Level	Variable Range > 1
M120	Zero Level *	Level is >= Zero Level Threshold, prior to Ton and Toff delay processing
M121	Off Level *	Level is >= Off Level Threshold, prior to Ton and Toff delay processing
M122	Low Level *	Level is >= Low Level Threshold, prior to Ton and Toff delay processing
M123	Mid Level *	Level is >= Mid Level Threshold, prior to Ton and Toff delay processing
M124	High Level *	Level is >= High Level Threshold, prior to Ton and Toff delay processing

Level Information with Discrete Inputs

The flow calculations are dependent on accurate level information. If discrete (float) inputs are used the corresponding Level configurations must accurately reflect the float levels. The hysteresis values and 'variable low level' information are ignored. In addition, there is no ability to detect when the level is approaching the Low or Mid levels.

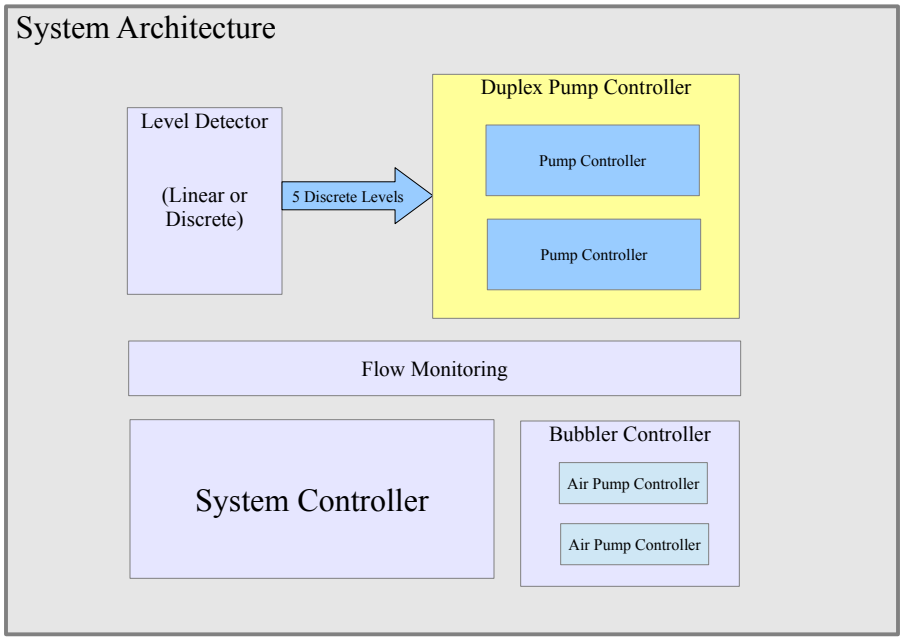
LC_Config Level Display

The LC_Config tool displays the LEVEL information as shown below. Each of the level Thresholds are displayed and as the current level approaches the Low or Mid level the text color changes. The current level is shown both graphically and as the actual value.


LC Configuration Tool
File
Tools
Configuration
Project
Simulator
Help
System
Disabled
ON
LockOut
Calibrate
Error
Warning
Pump ON
Increasing
Decreasing
Details
1
Cycle Count
3
Run Time
0
Total Pumped
Level
-- 28.00 --
-- 26.00 --
-- 19.00 --
-- 15.00 --
-- 8.00--
17.38
Flow
0
In Time
0
Out Time
0.00
Start Level
0.00
Cycle Volume
0.00
In Flow Volume
0.00
In Flow Rate
0.00
Pump InFlow
0.00
Pump Volume
0.00
Pump Rate
Pump 1
ON
ERROR
WARNING
0.00
Flow Rate
ONLINE
Details
1
Cycle Count
0
Run Time
Reset Stats
Reset Errors
Pump 2
ON
ERROR
WARNING
0.00
Flow Rate
ONLINE
Details
1
Cycle Count
0
Run Time
Reset Stats
Reset Errors
Air Pump 1
ON
ERROR
33
Cycle Time
11
Cycle Count
33
Run Time
Reset Stats
Reset Errors
Air Pump 2
ON
ERROR
0
Cycle Time
0
Cycle Count
0
Run Time
Reset Stats
Reset Errors
Update Control
Modbus Traffic
Single Update
Stop Update
Pause Update
4.000
Update Rate (Sec)
Auto Update
Auto Update
Auto Update
Auto Update
Auto Update
Auto Update
Auto Update
Saved: Demo
<Data logging Status>
Enabled, Simulator: ON
USB

Chapter 4 DUPLEX CONTROLLER

The Duplex Controller supports a Lead and Lag pump system with flexible sequencing options and extensive pump health and run time verification.



The Duplex Controller is implemented as 3 major components: a Pump Sequencer that selects which pump should operate and two Pump Controllers. Each Pump controller includes a Pump Health monitor that ensures the pump is capable of operating and a Run Verification monitor that ensures that the pump operates within specifications. In addition, several manual control functions are provided to allow enabling and controlling each pump as well as clearing error conditions and run time statistics.

The Duplex Controller supports 2 pumps. When the level rises above the specified *Low Level* one of the pumps, designated as the *lead* pump will be turned on. When the level drops below the *Off Level* the pump will turn off. The selection of which pump should act as the Lead pump is determined by the Sequencer.

If the level continues to rise after the lead pump is activated and reaches the *Mid Level* the second pump, referred to as the *lag* pump will turn on and both pumps will remain on until the level drops below the Off Level. A lag pump turn on delay ensures that a specific time elapses after turning on the lead pump before the lag pump will turn on. The turn off sequence of the pumps is determined by the Lead and Log turn off delays specified within the Sequencer.

If the level reaches the *High Level* an alarm will be activated, indicating that the Inflow rate exceeded the pumping capacity of the two pumps and immediate interaction is required.

Pump Sequencer

The two pumps may be operated in Alternating, Fixed 1-2 or Fixed 2-1 sequences. Two additional sequences are defined, referred to as 'Both' or 'None' (described below). A 'time of day' clock is provided, allowing two different sequencing controls to be implemented based on the time/date. A sequence cycle is defined as starting when the level rises above the OFF level and continuing until the level drops below the OFF level.

Pump cycles are broken into 'Even' and 'Odd' cycles. The *Even Seq 1* parameter determines which pump (None, 1, 2 or Both) should act as the Lead pump during even cycles and the *Odd Seq 1* parameter determines which pump (None, 1, 2 or Both) should act as the Lead pump during odd cycles.

The Time-Of-Day clock may be set to trigger ON or OFF at 32 specific times, based on a yearly, monthly, weekly, daily or on specific days of the week. When the Time-Of-Day clock is 'OFF' the *Even Seq 1* and *Odd Seq 1* pair are used to determine the Lead Pump. If the Time-Of-Day clock is 'ON' the *Even Seq 2* and *Odd Seq 2* pair are used. If a pump is *Disabled* or *Demoted* the alternate pump will be used as the Lead pump.

Sequence Selection

The Sequence selection is made by specifying a value (0..3) for each of the Even/Odd cycles for Group 1 (Time-Of-Day OFF) and Group 2 (Time-Of-Day ON).

Sequence Type	Description
0 = NONE	The Lead Pump (and Lag Pump) are activated at the MID level.
1 = LEAD 1	Pump 1 acts as Lead Pump, activated at the LOW level
2 = LEAD 2	Pump 2 acts as Lead Pump, activated at the LOW level
3 = BOTH	Both pumps will be activated as Lead Pumps at the LOW level

Either pump may be taken 'off-line' by deactivating the corresponding *Pump Enable* control. If a pump is off-line the alternate pump will assume the Lead role. If both pumps are off-line an error alarm is generated.

Sequence Type 'None'

If type NONE is selected neither pump will turn on at the LOW level. When the level reaches the MID level the least recently used pump will activate as the Lead pump. If the level has not dropped below the MID level prior to the LAG On Delay the second pump will turn On. The pumps will alternate.

Sequence Type 'Lead 1'

Pump 1 will be used as the Lead pump and turn on at the LOW level. If the level continues to rise to the MID level Pump 2 will be used as the Lag pump.

Sequence Type 'Lead 2'

Pump 2 will be used as the Lead pump and turn on at the LOW level. If the level continues to rise to the MID level Pump 1 will be used as the Lag pump.

Sequence Type 'Both'

Both pumps will be activated when the level reaches the LOW level. The least recently used pump will be activated as the Lead pump (turn on immediately) and the second pump will turn on after the Lag On Delay.

Time-Of-Day

The Time-Of-Day scheduler selects between Group 1 sequences and Group 2 sequences. Each entry consists of a year, month, day, and time of day as well as which group should be active. (OFF = Group 1, ON = GROUP 2). Sixteen different date entries are supported.

As shown below, if for example the scheduler is operating on a Monthly basis the Year and Month information is not required. The ON/OFF activity will occur on the specified day of each month. Multiple days within a month could be supported by utilizing the 32 different time entries available.

The time entries are consecutive and must be in ascending order.

Type	Year	Month	Day of Month	Day of Week	Time	State
1=Yearly	Year	Month (1-12)	Day (1-31)	0-6 (Mon-Fri)	00:00:00 - 23:59:59	ON or OFF
2=Monthly	-	-	Day (1-31)	-	00:00:00 - 23:59:59	ON or OFF
3=Day of Month	-	-	Day (1-31)	-	00:00:00 - 23:59:59	ON or OFF
4=Fixed Date	Year	Month (1-12)	Day (1-31)	0-6 (Mon-Fri)	00:00:00 - 23:59:59	ON or OFF
5=Mon	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
6=Tues	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
7=Wed	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
8=Thurs	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
9=Fri	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
10=Sat	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
11=Sun	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
12=Mon-Thurs	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
13=Mon-Fri	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
14=Mon-Sat	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
15=Fri-Sun	-	-	-	-	00:00:00 - 23:59:59	ON or OFF
16=Sat-Sun	-	-	-	-	00:00:00 - 23:59:59	ON or OFF

Lag ON Delay

The *Lag ON Delay* specifies the minimum delay time between turning on the Lead and Lag pumps, preventing large current inrushes if both pumps are required to operate at the same time.

Turn Off Sequence

If both the Lead and Lag pump have been activated the turn off sequence is controlled by the *Lead OFF Delay* and *Lag Off Delay* times. If the Lead OFF Delay is less than the Lag OFF Delay the lead pump will turn off first (First ON, First OFF). If the Lead OFF Delay is greater than the Lag OFF Delay the lead pump will turn off last (First ON, Last OFF).

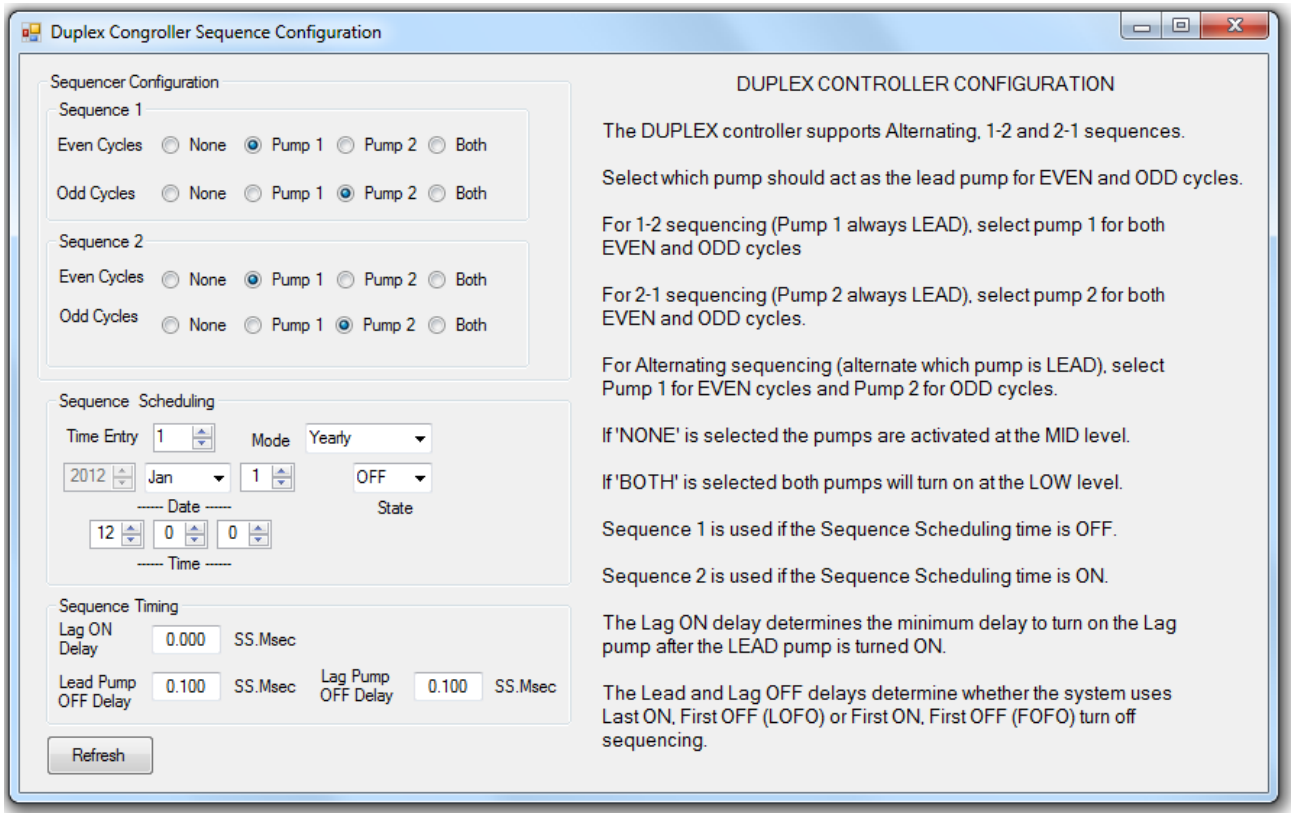
Condition	Turn Off Type	Description
Lead OFF Delay > Lag OFF Delay	FOLO	The Lead pump is always turned on first. Since the Lead OFF delay is > than the Lag Off delay the turn off sequence is 'First ON, Last OFF'
Lead OFF Delay < Lag OFF Delay	FOFO	The Lead pump is always turned on first. Since the Lead OFF delay is < than the Lag Off delay the turn off sequence is 'First ON, First OFF'
Lead OFF Delay = Lag OFF Delay	-	Both pumps turn off at the same time

Sequencer Configuration

The sequencer is configured by setting the Even and Odd sequence information, the Time-Of-Day information, the LAG ON delay and the Lead and Lag OFF delays.

Block	Parameter	Description
060 (SCHD)	<times>	32 defined ON / OFF times to select sequence group 1 or sequence group 2
061(WARP)	Offset	Even Sequence, Group 1 (Time-Of-Day OFF)
062 (WARP)	Offset	Odd Sequence, Group 1 (Time-Of-Day OFF)
063 (WARP)	Offset	Even Sequence, Group 2 (Time-Of-Day ON)
064 (WARP)	Offset	Odd Sequence, Group 2 (Time-Of-Day ON)
065 (WARP)	Offset	Lead Off Delay – time delay from when Low level goes inactive to turning off Lead Pump
066 (WARP)	Offset	Lead Off Delay – time delay from when Low level goes inactive to turning off Lag Pump
067(CMPR)	Offset	LAG On delay – time required between turning on Lead pump before turning on Lag pump

The following LC_Config screen shows the Duplex Sequencing parameters that may be configured.



Sequencer Run Time Data

The following Sequencer run time information is available through the indicated DW Registers. All SEQUENCING run time data except the Actual Sample ON and OFF times is volatile (not retained if power is lost).

Data Register	Name	Description
DW82	Group 1, Even Seq	Value provided by Sequencer Configuration
DW83	Group 1, Odd Seq	Value provided by Sequencer Configuration
DW84	Group 2, Even Seq	Value provided by Sequencer Configuration
DW85	Group 2, Odd Seq	Value provided by Sequencer Configuration
DW86	Pump 1 Off Delay	Determined based on Lead/Lag position during current cycle
DW87	Pump 2 Off Delay	Determined based on Lead/Lag position during current cycle
DW88	Lead Pump Off Delay	Value provided by Sequencer Configuration
DW89	Lead Pump Off Delay	Value provided by Sequencer Configuration

Sequencer Run Time Status

The following SEQUENCER run time status information is available through the indicated Bit Registers. All status information is volatile (not retained if power is lost).

Bit Register	Name	Description
M117	Lead Pump Active	The Lead Pump level (Low/Mid) has been reached
M118	Group 2 Active	The Time of Day clock output is ON
M119	Lag Pump Enable	The LAG ON Delay timer has expired

Pump Controller

The Duplex Controller supports 2 pumps, each controlled by an internal Pump Controller. Each pump may be set to run under the control of the Duplex Controller (Online Mode), may be manually forced ON or OFF or may be taken Offline (disabled). The pump controller is responsible for monitoring the Health and Run Time Verification of the pump.

Pump Mode

Each pump operates in one of four modes: *Online*, Force *OFF* and Force *ON and Offline*. In the Online mode the pump is controlled by the Duplex Sequencer. In the Force OFF mode the pump is not available to the Duplex Sequencer and is off. In the Force ON mode the pump is not available to the Duplex Sequencer and is forced ON, subject to the zero level detection level. In the Offline mode the pump is prevented from operating.

Mode	Description
0 (Online)	Operates under the control of the Duplex Controller
1 (Force OFF)	Pump is unavailable to the Duplex controller and is held in the OFF state
2 (Force ON)	Pump is unavailable to the Duplex controller and is held in the ON state. Note that the Zero Level Detect will over-ride the ON state to ensure that the pump is turned OFF if the level drops below the Zero Level.
3 (Offline)	Pump is not available to the Duplex Controller or Force Modes and is held in the OFF state.

Online

In the Pump Online mode the pump is switched on or off under the control of the Duplex Sequencer. If the pump is currently operating as the Lead Pump and is switched to another mode the alternate pump will be immediately switched On.

Force OFF

If the pump mode is set to Force OFF mode it will force the pump to the OFF state. The turn off will be immediate – the Lead/Lag off delay times will be ignored.

Force ON

If the pump mode is set to Force ON mode it will force the pump to the ON state. The turn on of the pump will be delayed by the LAG ON delay time if the alternate pump has been started within the LAG ON delay time.

Offline

When a pump is in the Offline mode it is not available to the Duplex controller. The pump is held in the OFF state.

Hardware FORCE ON

Each pump has a dedicate input signal which will force the pump ON. When activated, the Hardware FORCE ON input will force the pump ON if the pump is in the ONLINE, Force On or Force OFF modes. It will have no affect if the pump is in the OFFLINE mode. The Zero Level LockOut will be observed.

Pump Mode Configuration

The Pump Mode is configured by setting the Mode value within the Pump Configuration blocks (See Pump Configuration below).

The LC_Config provides access to the Pump Mode information as part of the LC_Config Pump Status display (See Below).

The Pump Mode information is made available as part of the Pump Run Time Data and Pump Run Time Status (see Below).

Pump Health

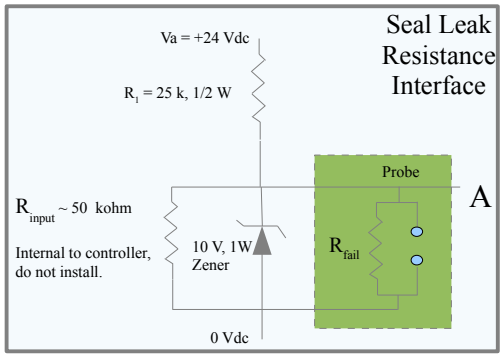
The Pump Health function monitors the seal leak detector and pump temperature inputs to determine the health of the pump. The seal detection input for each pump may be connected directly to the seal leak signals from the pump or connected to an external seal leak relay contact. The pump temperature input may be configured as normally open (NO) or a normally closed (NC) contact. Timers are provided to ensure that the signals are valid for a specific time before acted upon.

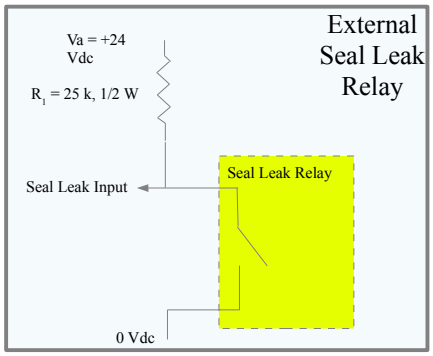
Seal Leak Input

The seal leak detector of a submersible pump consists of a set of contacts that measures the resistance of the internal bearings area of the pump and if the resistance drops below ~ 100k ohms it indicates that water has leaked past the internal seals of the pump. If the controller is connected directly to the seal leak contacts of the pump it allows both a 'Warning Level' (typically ~ 80 K ohms) and an 'Error Level' (typically ~ 50 K ohms) to be set.

The analog inputs of the controller has an input impedance of a nominal 50 Kohms. The following circuit may be used to connect to the seal leak sensor of the pump directly to the controller input and the Table shows expected input voltages. The zener diode (1N5240 or equivalent) clamps the open circuit voltage at 10.0 volts.

Condition	R_{fail}	Voltage (A)
Oil only	> 1 mohm	10 Vdc
Slight leak	100 kohm	7.5 Vdc
Fault leak	50 kohm	5.0 Vdc
Short	0 ohm	0 volts





If an external Pump Seal relay is used it may be connected as a normally open (close if fail) contact between the SEALOK input and +24 Vdc supply. Note that if an external seal leak relay is used the Error and Warning values should be set > 100 K Ohms. Only the Seal Error condition will be detected. Alternatively, the resistor and relay may be swapped, allowing the circuit to operate as a normally closed (open if fail) configuration. By setting the gain to -1 and the offset to 10.00 normally closed (open if fail) contacts may be used.

If the seal leak input drops below the 'Warning Level' the warning output is activated and the pump will be 'demoted' - removed from the 'lead' position option but will still operate in the lag position. If the seal leak input drops below the 'Error Level' the error output is activated and the pump will be 'disabled'. A timer is provided to filter momentary level transitions.

The Seal Inputs to the controller are applied to analog threshold detector offering a 'gain', 'offset' and threshold value. Setting the 'gain' to 10 and the 'offset' to 0 when connected to the circuit shown above will provide a approximate 'resistance' reading (K Ohms) corresponding to the probe resistance. Typical values for the Warning threshold is 80.00 Kohms and 50.00 Kohms for the Error Threshold.

The Seal Detection Filter Time ensures that the signal is stable. The signal must be above the specified threshold for at least the Seal On Time, typically ~ 1.000 seconds, before it is considered ON and must drop below the threshold for the Seal OFF time, typically ~ 0.100 seconds before it is considered OFF.

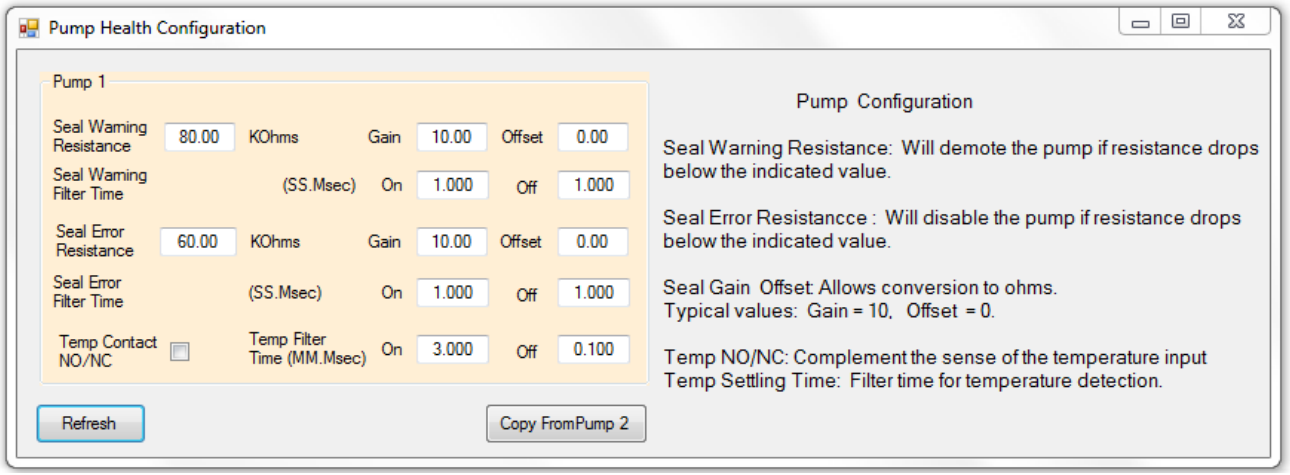
Over Temperature

The Over Temperature contact is provided by the pump and if activated it indicates that the pump internal operating temperature has been exceeded. The pump will be disabled and will not operate until it has cooled. The Temperature Inputs may be configured as Normally Open (closes on error condition) or Normally Closed (opens on error condition). The Temperature Filter ensures that the signal is stable. The signal must be active for at least the Temperature On Time, typically ~ 1.000 seconds, before it is considered ON and go inactive for the Temperature OFF time, typically ~ 0.100 seconds before it is considered OFF.

Pump Health Configuration

The Pump Health parameters are configured by setting the Seal Warning/Level Thresholds and filter times and the Temperature NO/NC state and filter time within the Pump Configuration blocks (See Pump Configuration below).

The following LC_Config screen (Configuration/Pump/Health) shows the Pump Health parameters that may be configured. The LC_Config configuration screen allows copying the parameters between Pump 1 and Pump 2.



The Pump Health Run Time information is made available as part of the Pump Run Time Data and Pump Run Time Status (see Below).

Run Verification

The Run Verification function monitors each pump while it is running to ensure that the pump is operating within specifications. The controller monitors the Auxiliary contact from the motor contactor block, the operating current and a contact from an external Phase monitoring (or other fault detection) relay. Auxiliary contact and Phase errors are internally latched.

Pump Start Delay

The Pump Start delay provides an 'on delay' from the activation of the pump to when monitoring of the pump current is started to allow the pump to stabilize. The time delay is a function of the start up characteristics of the pump and is typically 1 -3 seconds.

Auxiliary Contact

The Auxiliary contact input is connected to the pump starter auxiliary contact and ensures that the contact closes within the specified time from the activation of the pump. The sense of the contact may be configured as Normally Open (NO) or Normally Closed (NC). Failure to close within the specified Aux Contact ON Time will be treated as an 'Aux Contact' Error.

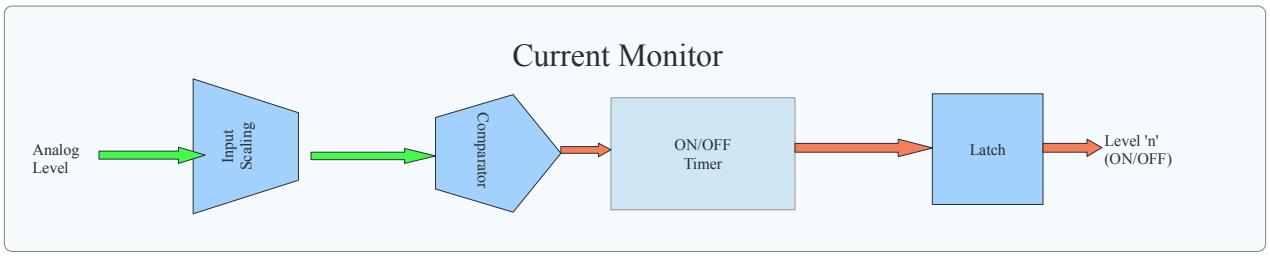
If the Auxiliary contact closes and then re-opens while the pump is running it is treated as a 'Thermal Overload' Error, indicating that the contactor has prematurely opened.

The Auxiliary Contact Time ON determines the maximum time for the pump starter auxiliary contact to close after the pump activation signal and is typically < 1.0 second. The Time OFF is reserved and should be set to 0.010 seconds.

The Aux Contact Error and the Thermal Overload Error are latched and can only be cleared by setting the 'Reset Error' state to non-zero.

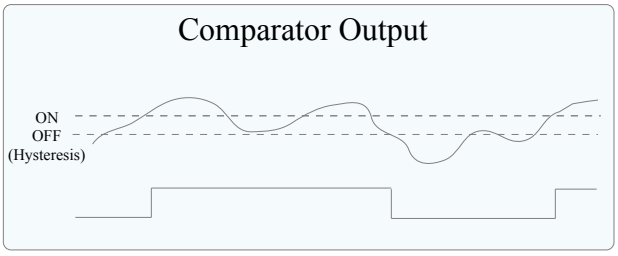
Pump Current

After the Pump On delay time the pump current is monitored and compared to a 'high' and 'low' threshold detector. Each detector includes hysteresis to avoid false readings due to signal jitter as well as a dual timer to ensure that the signal is stable. If the current is above the high threshold an 'Over Current' Error is reported. If the current is below the low threshold an 'Under Current' Error is reported.



The Input Scaling converts the input signal into standard engineering units (Amps) allowing user defined levels to be specified in the corresponding threshold comparator. The Current Gain and Current Offset parameters allow converting the current sensor signal to 'Amps'.

Each detector consists of a comparator that includes a hysteresis calculation. If the input level is at or above the user defined threshold ON level the comparator output will be active. If the input level is below the user defined threshold OFF level the comparator output will be inactive. The hysteresis levels are typically set ~ 0.25 below the threshold level.



To avoid sporadic or false triggering a dual timer is used for each threshold that verifies the comparator output remains constant for a user defined time, referred to as the THRESHOLD ON and THRESHOLD OFF time. When the comparator is turned on it must remain on for the specified ON time. When it turns off it must remain off for the specified OFF time.

The Over Current Error and the Under Current Error are latched and can only be cleared by setting the 'Reset Error' state to non-zero.

Phase Error Contact

The Phase Error contact input is connected to an external Phase Error relay contact to ensure that no phase errors occur. The sense of the contact may be configured as Normally Open (NO) or Normally Closed (NC). Failure to close will be treated as an 'Phase Error' Error. Phase monitoring occurs after the specified Pump Start Delay time.

The Phase Error Time ON determines the maximum time for external Phase Error relay contact to close after the Pump Start Delay time and is typically < 1.0 second. The Time OFF determines the time that the contact may be momentarily open (contact bounce) before reporting a 'Phase Error' Error.

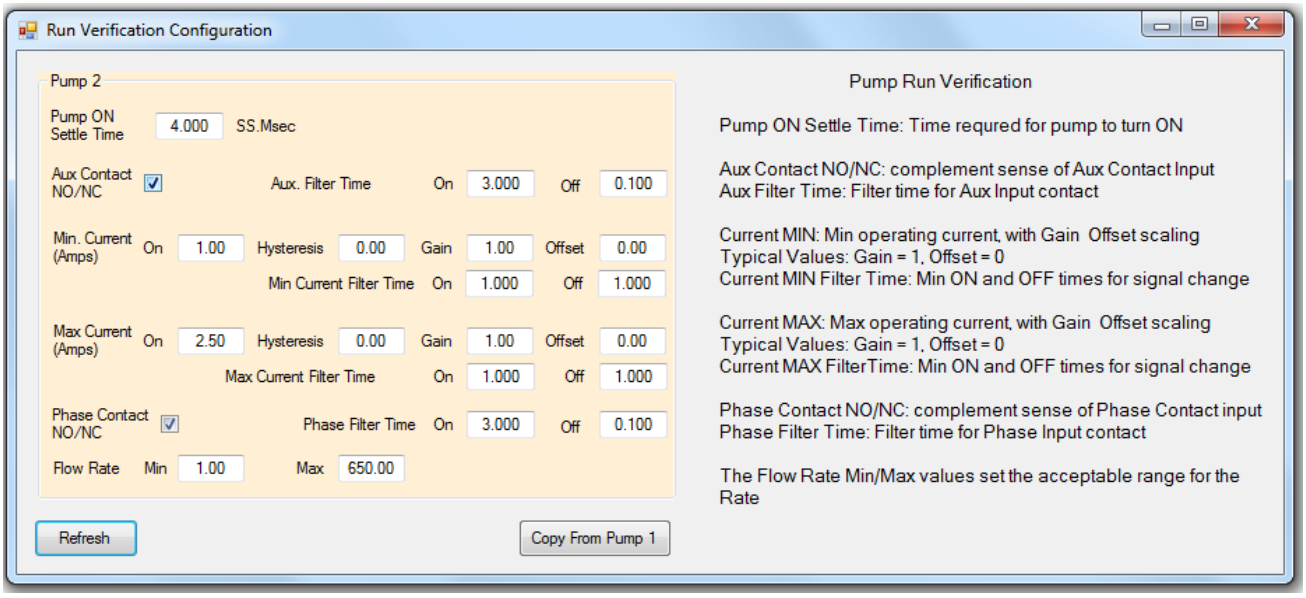
Although designated as the 'Phase Error' condition the Phase input may be connected to any fault detecting device

The Phase Error are latched and can only be cleared by setting the 'Reset Error' state to non-zero.

Pump Run Verification Configuration

The Pump Run Verification parameters are configured by setting the Auxiliary Contact NO/NC state and filter time, the Maximum and Minimum current thresholds and linearization parameters and the Phase Error NO/NC state and filter time within the Pump Configuration blocks (See Pump Configuration below).

The following LC_Config screen (Configuration/Pump/Run Verification) shows the Pump Run Verification parameters that may be configured. The LC_Config configuration screen allows copying the parameters between Pump 1 and Pump 2.



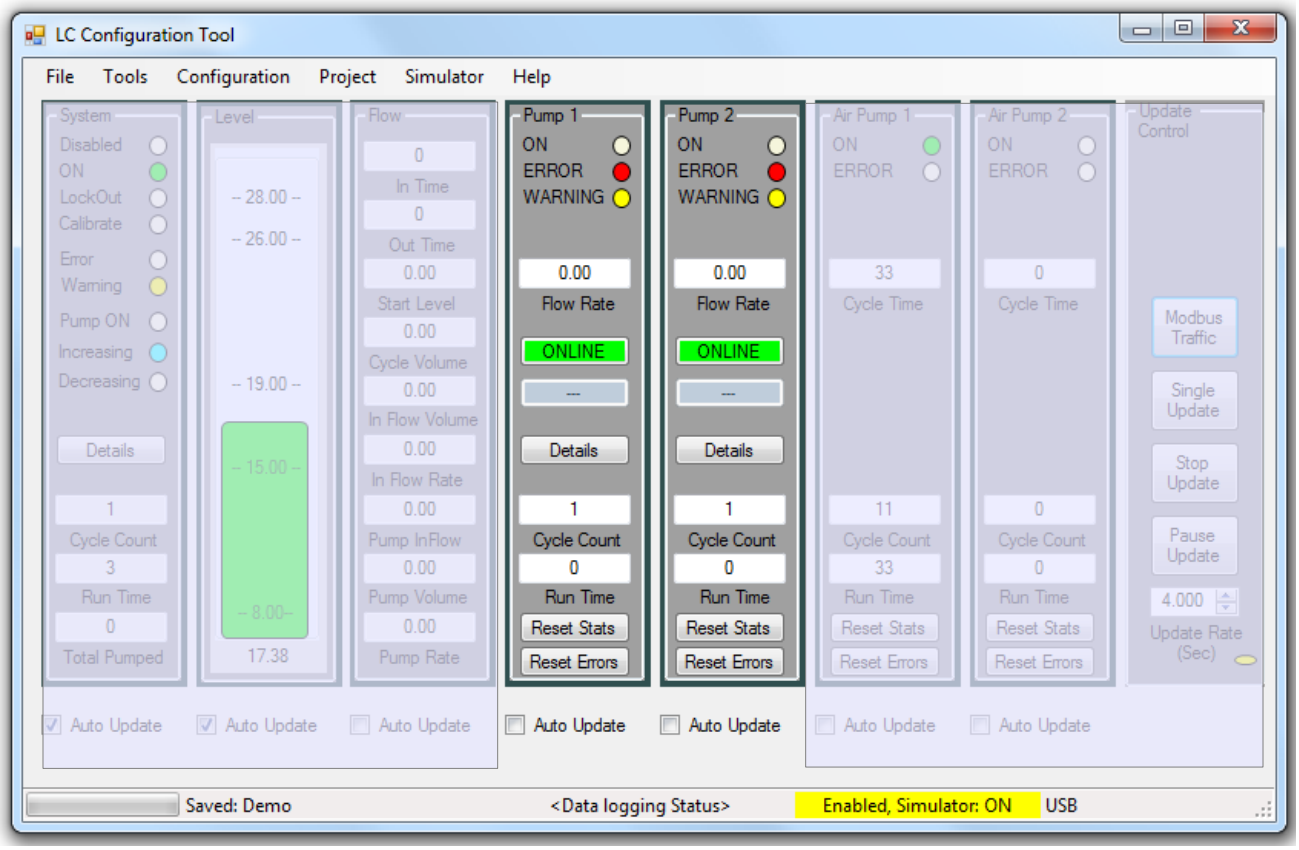
Pump Reset

Two reset functions are available for each pump. The Reset Error allows resetting the latched error status of the pump. The Reset Statistics will reset the accumulated statistics for each pump. The Reset operation is performed by writing a non-zero value to the appropriate Data (DW) register. Following the reset operation the register will be returned to zero.

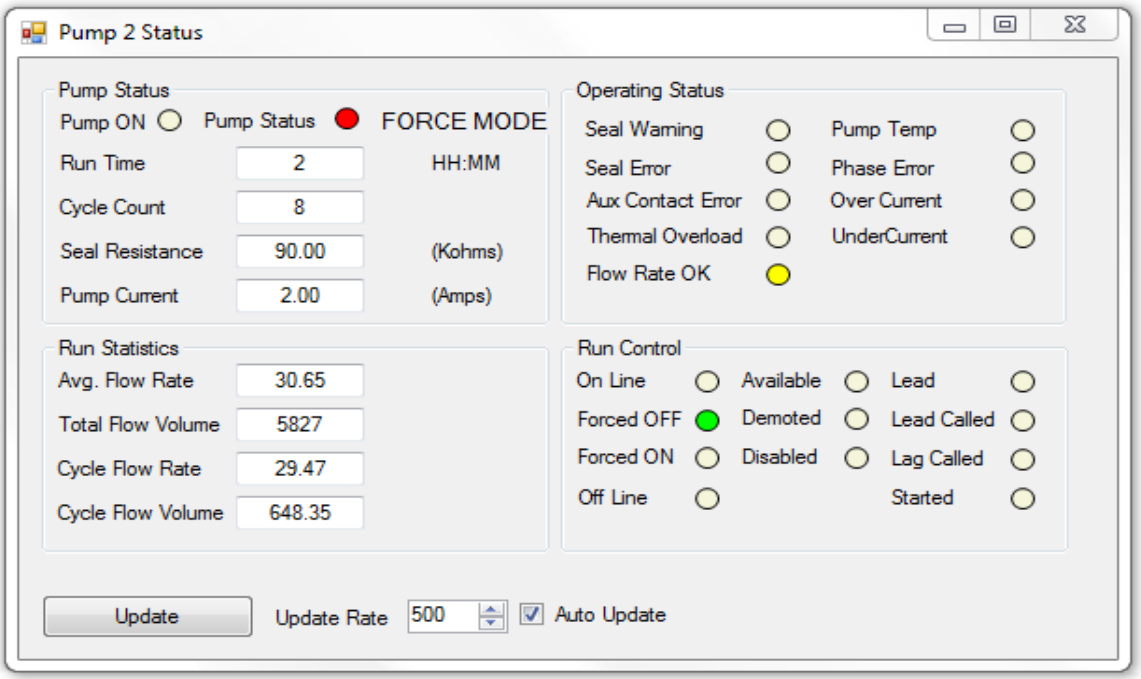
When activated the Hardware Reset Signal will reset the latched error conditions on BOTH PUMPS.

LC_Config Pump Controller Display

The LC_Config tool displays the PUMP CONTROLLER information as shown below.



Additional Pump Details are available by selecting the 'Details' button on the appropriate Pump Control panel.



Pump Configuration Blocks

The following table itemizes the configuration blocks used when configuring the Pump Controllers.

Pump 1 Block	Pump 2 Block	Parameter	Description	User Values	
026 (CMPR)	042 (CMPR)	Offset	Mode (0=Automatic, 1 = Force OFF, 2 = Force ON, 3 = Disabled)		
027 (CMPR)	043 (CMPR)	Von	Seal Warning Level		
		Gain	Parameters to convert input reading to K Ohms		
		Offset	Parameters to convert input reading to K Ohms		
028 (TONF)	044 (TONF)	Ton	Seal Warning Filter ON Time		
		Toff	Seal Warning Filter OFF Time		
029 (CMPR)	045 (CMPR)	Von	Seal Error Level		
		Gain	Parameters to convert input reading to K Ohms		
		Offset	Parameters to convert input reading to K Ohms		
030 (TONF)	046 (TONF)	Ton	Seal Error Filter ON Time		
		Toff	Seal Error Filter OFF Time		
031 (UDCT)	047 (UDCT)	Threshold	Temperature Input: 0 = NO, 1 = NC		
032 (TONF)	048 (TONF)	Ton	Temperature Error Filter ON Time		
		Toff	Temperature Error Filter OFF Time		
033 (UDCT)	048 (UDCT)	Threshold	Auxiliary Contact Input: 0 = NO, 1 = NC		

034 (TONF)	050 (TONF)	Ton	Auxiliary Contact Filter ON Time		
		Toff	Auxiliary Contact Filter OFF Time		
035 (TOND)	051 (TOND)	Ton	Pump Settling Time		
036 (WARP)	052 (WARP)	Von	Maximum Current ON level		
		Voff	Maximum Current Hysteresis		
		Gain	Parameters to convert input reading to Amps		
		Offset	Parameters to convert input reading to Amps		
037 (TONF)	053 (TONF)	Ton	Maximum Current Filter ON Time		
		Toff	Maximum Current Filter OFF Time		
038 (WARP)	054 (WARP)	Von	Minimum Current ON level		
		Voff	Minimum Current Hysteresis		
		Gain	Parameters to convert input reading to Amps		
		Offset	Parameters to convert input reading to Amps		
039 (TONF)	054 (TONF)	Ton	Minimum Current Filter ON Time		
		Toff	Minimum Current Filter OFF Time		
040(UDCT)	055 (UDCT)	Threshold	Phase Error Contact Input: 0 = NO, 1 = NC		
041 (TONF)	056 (TONF)	Ton	Phase Error Contact Filter ON Time		
		Toff	Phase Error Contact Filter OFF Time		
042 (WARP)	059 (WARP)	Von	Minimum acceptable flow rate		
		Voff	Maximum acceptable flow rate		

Pump Controller Run Time Data

The following run time data is collected for each pump and is accessible through the indicated DW Registers.

DW Register		Name	Description
Pump 1	Pump 2		
DW32	DW48	Pump Mode	Mode provided in Pump Configuration Block
DW33	DW49	Cycle Count *	The number of ON-OFF cycles that the pump has experienced since the last reset (see Pump Reset)
DW34	DW50	Run Time *	The number of days – hours:mins that the pump has been operating since the last reset (see Pump Reset)
DW35	DW51	Flow Rate	The flow rate from the time the pump was activated (Low Level threshold) to the time that the pump was deactivated (Off Level threshold).
DW36	DW52	Current	The current being drawn by the pump.
DW37	DW53	Seal Resistance	The resistance of the seal input circuit. Typically shown in K Ohms, but specific units may be programmed by setting the corresponding Offset & Gain of the seal input scaling function.
DW38	DW54	Flow Volume	The volume pumped from the time the pump was activated (Low Level threshold) to

			the time that the pump was deactivated (Off Level threshold).
DW46	DW62	Reset Errors	Writing a non-zero value will cause the Latched errors to be cleared.
DW47	DW63	Reset Stats	Writing a non-zero value will reset the Count, Run Time, Flow Average and Flow Volume values.
DW8	DW11	Average Flow Rate *	The Average Flow Rate.
DW9	DW12	Total Volume *	The total volume pumped since the last reset.

* Cleared by pump Reset Statistics, retained on loss of power.

Pump Controller Status Information

The following status information is collected for each pump and is available through the indicated Bit Registers.

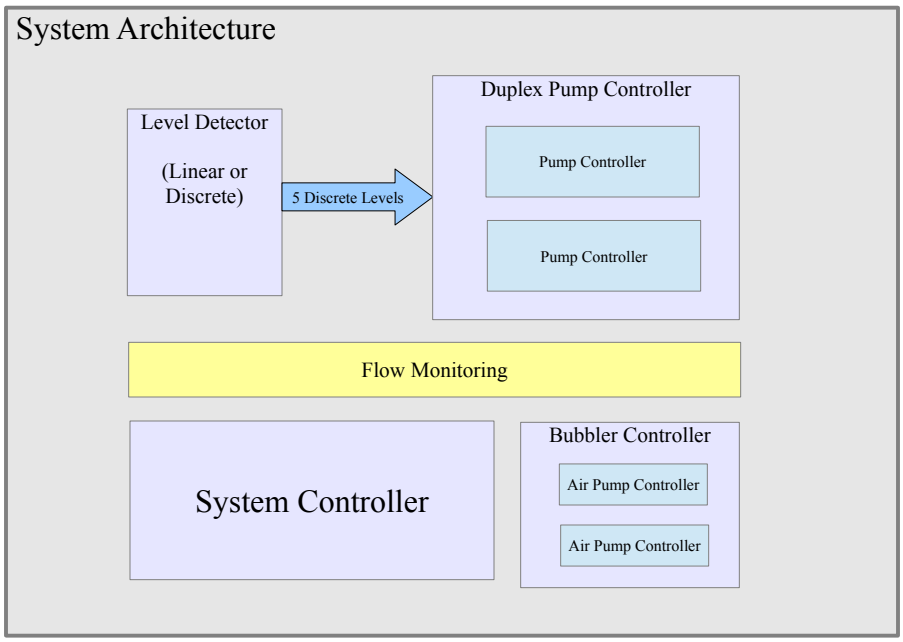
Bit Register		Name	Description
Pump 1	Pump 2		
M16	M48	Pump State	0 == Pump is OFF, 1 == Pump is ON
M17	M49	Pump Status	0 == Online and No Errors or Warnings
M18	M50	Temperature Input	1 == pump temperature error condition
M19	M51	Aux Contact Input	1 == Aux contact is active
M20	M52	Phase Error Input	1 == Phase Error contact is active
M21	M53	Seal Warning	Seal input is < specified warning threshold
M22	M54	Seal Error	Seal input is < specified error threshold, self clearing
M23	M55	Aux Contact Error *	Aux contact input not active within the specified Aux Contact ON delay time
M24	M56	Thermal Overload *	Aux contact input became inactive before pump turn off
M25	M57	Phase Error *	Phase error contact inactive after Pump Start UP delay time
M26	M58	Over Current *	Current exceeded specified maximum current level
M27	M59	Under Current *	Current less than specified minimum current level
M28	M60	Offline	Pump has been disabled by user (See Pump Controls)
M29	M61	Disabled	Pump removed from service due to an error condition (ERROR)
M30	M62	Demoted	Pump removed from Lead position due to warning condition (WARNING)
M31	M63	Available	Pump is available to participate in Lead/Lag control
M32	M64	Forced OFF	Pump has been forced OFF by user (See Pump Controls)
M33	M65	Forced ON	Pump has been forced ON by user (See Pump Controls)
M34	M66	Lead Select	Pump will act as LEAD pump on next pump cycle
M35	M67	Lead Call /	Pump has been called to act as the LEAD pump by the duplex controller (active low)
M36	M68	Lag Call /	Pump will act as the LAG pump on the next pump cycle (active Low)
M37	M69	Pump Called	Pump has been called as Lead or Lag pump
M38	M70	Pump Started	Pump has been started.

M39	M71	Flow Rate OK	Flow rate is within user defined limits
M130	M140	Temp NONC	State of Temperature NO/NC control bit
M131	M141	Temp %	Temperature State prior to time ON/OFF filtering
M132	M142	Aux NONC	State of Auxiliary Contact NO/NC control bit
M133	M143	Aux %	Auxiliary Contact State prior to time ON/OFF filtering
M134	M144	Phase NONC	State of Phase Error Contact NO/NC control bit
M135	M145	Phase %	Auxiliary Phase Error State prior to time ON/OFF filtering
M136	M146	Reset Stats	Pulse generated when Statistic information is reset
M137	M147	Pump Started /	Pump is not started (active low)

* Latched Error condition, cleared by pump Reset Error function

Chapter 5 Flow Monitoring

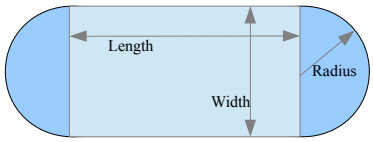
The flow monitoring subsystem is responsible for monitoring the inflow and outflow of the fluid.



Flow rates are calculated by measuring the change in level over a unit of time and using the geometry of the holding tank to calculate the flow volume and flow rate. The system tracks the instantaneous level changes, the INFLOW rate and the estimated OUTFLOW rate.

Holding Tank Geometry

To perform flow calculations the length, width and radius of the tank must be known.



Top View

For a square tank, the radius is set to 0. For a circular tank the length and width are set to 0. For oblong tanks the length, width and radius can be used. If the tank surface area is non-geometric the measured area may be entered as the Length and set the Width to 1 and the Radius to 0.

The surface area is calculated as:

$$\text{Area} = (\text{Length} \times \text{Width}) + (\text{Radius}^2 \times \text{PI})$$

Units

The dimensions may be entered as inches, feet, liters or other user defined scaler units. The volume information is displayed as Gallons, Imperial Gallons or Liters or other user defined units.

The 'Units' parameter value is used to convert the volume to conventional flow units, such as Gal/Min. The following table provides common conversion factors, although other units of measurement may be used.

Units	Conversion Factor			
	Inches	Feet	Meters	Other
US Gallons	0.00433 Gal/In^3	7.48052 Gal/ft^3	264.17200 Gal/m^3	
Imp. Gallons	0.00360 Imp. Gal/In^3	6.22883 Imp. Gal/ft^3	219.96900 Imp. Gal/m^3	
Liters	0.01638 Liters/In^3	28.31680 Liters/ft^3	1000.00000 Liters/m^3	

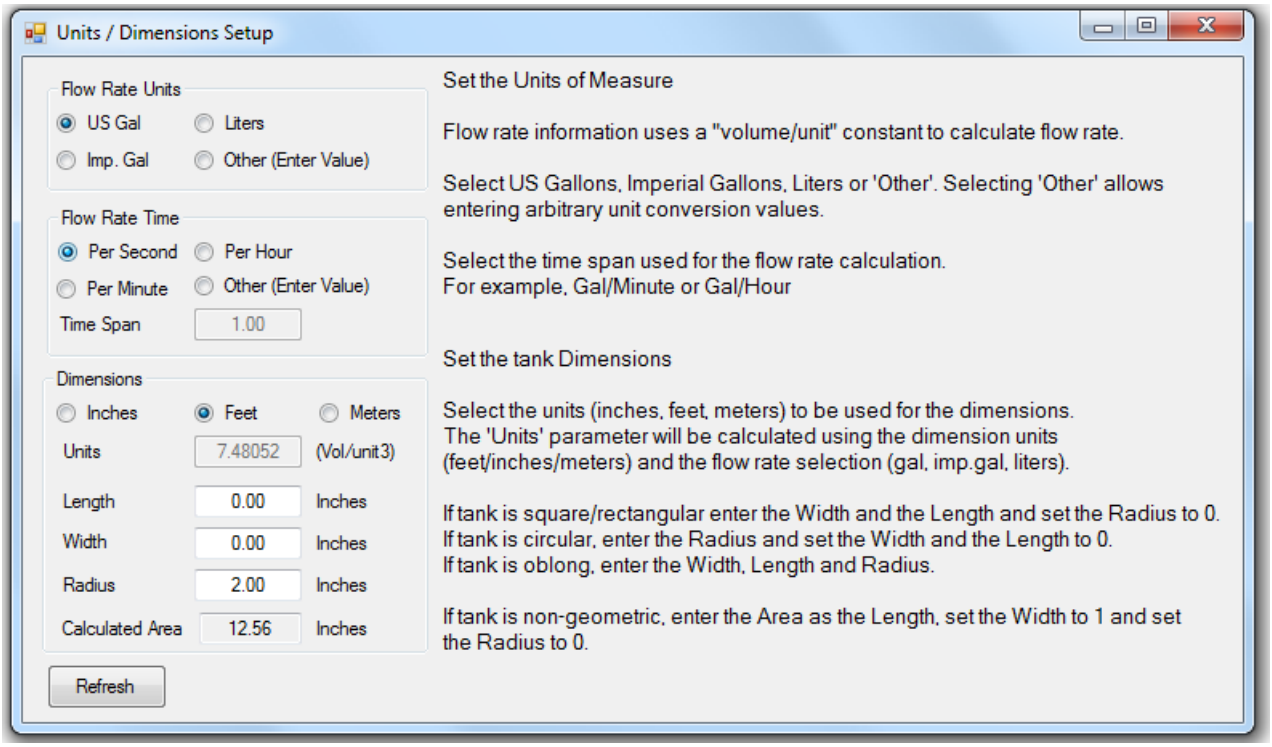
All flow calculations are done based on a 10 msec based clock which is resolved to 1 sec time span. The Time Span value is used to convert the measured volume changes to specific intervals, for example 'Gal/Min'.

Dimensions/Units Configuration

The Dimensions and Unit information is configured by setting the Length, Width, Radius, Unit and Time Span parameters.

Block	Parameter	Description
015 (WARP)	Offset	Length
016 (WARP)	Offset	Width
017 (WARP)	Offset	Radius
018 (WARP)	Offset	Unit Conversion Factor
018 (WARP)	Offset	Time Span value

The following LC_Config screen (Configuration/Dimensions) shows the Dimension and Unit parameters that may be configured. The LC_Config interface allows selecting common scaler dimensions (inches, feet, meters) and common volume units (Gallons, Imperial Gallons, Liters) and will insert the appropriate Unit value. User defined conversion factors may be entered. Common time intervals (seconds, minutes, hours) may be selected or a user defined Time Span value may be entered.



Dimension Run Time Data

The following Dimension and Unit run time information is available through the indicated DW Registers. All Dimension run time data is non-volatile (retained if power is lost).

Data Register	Name	Description
DW100	Length	Value provided by Dimension Configuration
DW101	Width	Value provided by Dimension Configuration
DW102	Radius	Value provided by Dimension Configuration
DW103	Units	Value provided by Dimension Configuration
DW104	Time Span	Value provided by Dimension Configuration
DW105	UnitArea	Calculated as (Length X Width + (Radius^2 X 3.142))) X Units
DW106	Circular Area	Calculated as (Radius^2 X 3.142))

Dimension Run Time Status

There is no Dimension Run Time status information.

Flow Information

To estimate the flow rates for each pump the following assumptions are mode when each pump is first activated during a pump-down cycle:

1) The Inflow rate remains relatively constant
2) The flow rates of any currently operating pumps remains relatively constant

If these two conditions are met, any change in the Net Outflow Rate will be due to the incremental flow rate contributed by the pump that is being activated.

Sample Flow

At the end of the Sample ON Time the current level is latched and used to calculate the level change between each sample.

$$\text{Sample Level Change} = \text{Level } t_2 - \text{Level } t_1$$

The Sample Flow Volume information is calculated by the controller as:

$$\text{Sample Flow Volume} = (\text{Level Change} \times \text{Area} \times \text{Units})$$

The Sample Flow Rate information is calculated by the controller as:

$$\text{Sample Flow Rate} = \text{Sample Flow Volume} / \text{Sample Time}$$

Cycle Flow

A cycle begins when the level rises above the Off Level. The current level is latched as the 'Start Level' and the 'Flow' timer is started, beginning the 'Inflow' portion of the cycle. When the level rises above the Low Level a pump will start. The Inflow Volume and Rate are calculated as:

$$\text{Inflow Volume} = ((\text{Start Level} - \text{Current Level}) \times \text{Area} \times \text{Units})$$

$$\text{Inflow Rate} = \text{Inflow Volume} / \text{Flow Time}$$

The Start Level is reset to the current level and the Flow Timer is reset, starting the 'Outflow' portion of the cycle. When the pump is turned off the Outflow Volume and Rate are calculated as:

$$\text{Outflow Volume} = ((\text{Start Level} - \text{Current Level}) \times \text{Area} \times \text{Units})$$

$$\text{Outflow Rate} = \text{Outflow Volume} / \text{Flow Time}$$

The calculated Outflow Rate and Volume are assigned to the currently operating pump. These values are then added to the Total Flow Volume and Average Flow Rate values for the pump.

Increasing/Decreasing Flags

Internal Increasing/Decreasing flags are set based on the change in levels between each successive Sample. If the current level is greater than the previous level the Increasing Flag is set. If the current level is less than the previous level the Decreasing Flag is set.

Flow Information Run Time Data

The following Flow Information run time information is available through the indicated DW Registers. All Flow Information run time data is volatile (not retained if power is lost).

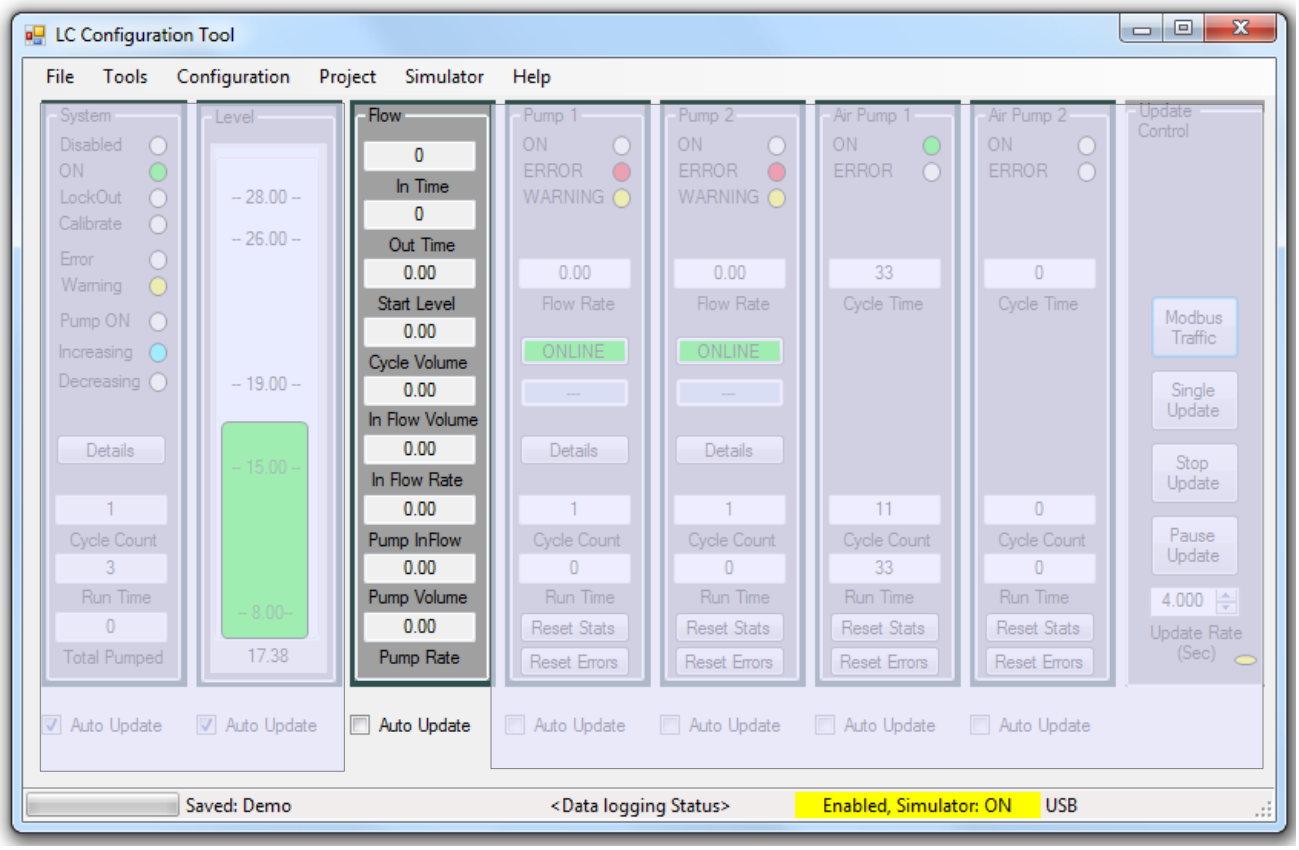
Data Register	Name	Description
DW16	Sensor Value	Sensor Value (see Sensor)
DW17	Sample Flow Rate	Value provided by Dimension Configuration
DW18	Last Level	Last Sample Level
DW19	Sample Level Change	Change in level
DW20	Sample Flow Volume	Calculated Change in Volume
DW21	Unscaled Sensor Value	Unscaled Sensor (see Sensor)
DW22	Flow Time Counter	Inflow (Outflow) timer
DW23	Inflow Time	Latched Inflow time
DW24	Outflow Time	Latched Outflow time
DW25	Flow Start Level	Level when Inflow or Outflow stage begins
DW26	Flow Volume	Inflow or Outflow Volume
DW27	Inflow Volume	Latched Inflow volume
DW28	Inflow Rate	Latched Outflow volume
DW29	Inflow While Pumping	Calculated inflow volume while pump is active
DW30	Pump Flow Volume	Calculated pumped value
DW31	Pump Flow Rate	Calculated pump flow rate
DW96	Current Level	Used by Flow Calculations, contained as part of the Levels Run Time Data

Flow Information Run Time Status

There is no Flow Information Run Time status information.

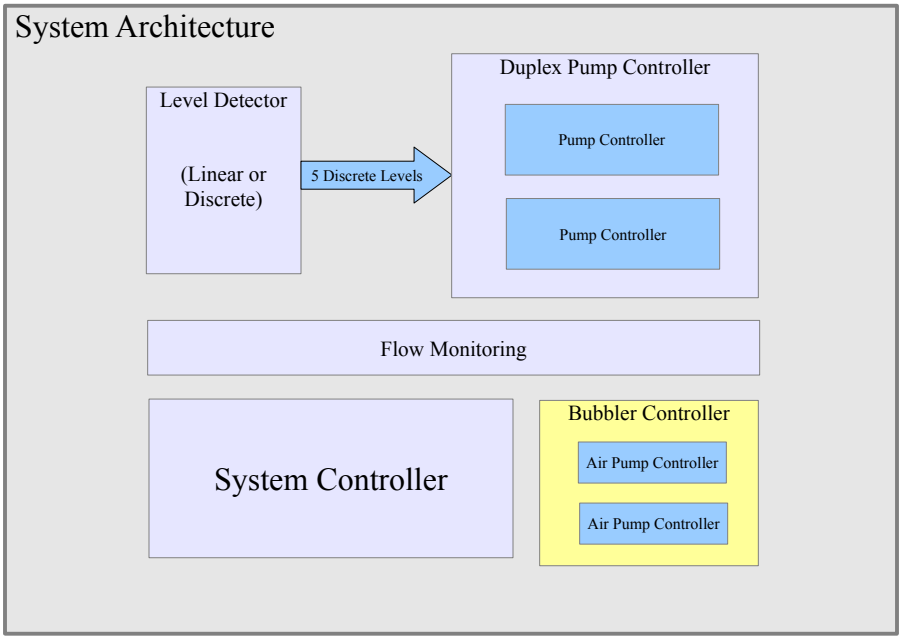
LC_Config Flow Display

The LC_Config tool displays the FLOW information as shown below.

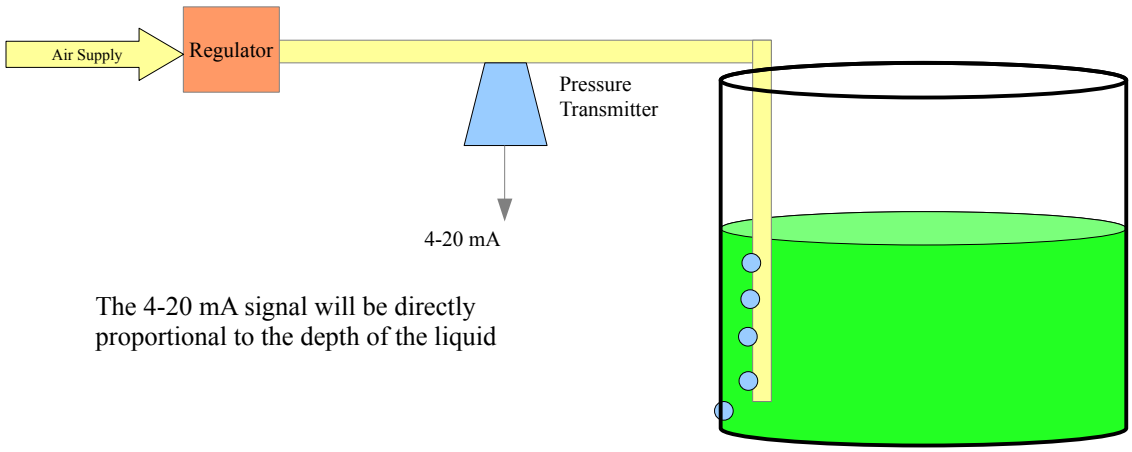


Chapter 6 BUBBLER SYSTEM

The Bubbler controller provides full control over two air pumps to provide pressure to the bubbler system in with or without an air tank (Tank-less or Tanked system). A pressure transducer (4-20 mA or 0-10 Volt) may be used to measure the bubbler air pressure and is used as the sensor input to the Level Detection system.



A Bubbler system measures the depth of a liquid by forcing bubbles up from the bottom. The air pressure required to force the bubbles is directly proportional to the depth of the liquid. A pressure transmitter connected in the air supply path may be connected to the Analog input of the Level Detector system to determine the depth of the liquid. A regulator is used to provide a constant air flow.



The 4-20 mA signal will be directly proportional to the depth of the liquid

Bubbler Controller

The Bubbler controller manages 1 or 2 air pumps, with an option to use an Air Tank. In a dual pump system the pumps are alternated based on the accumulated running time to extend the life of the pumps. If a pump fails the alternate pump will be switched on.

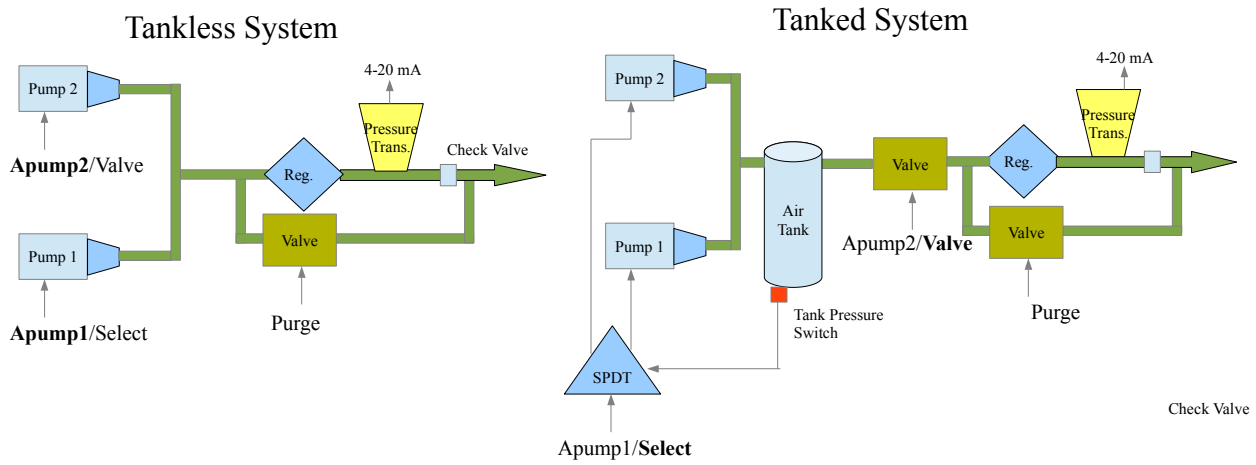
If the measured air pressure rises above the expected maximum, indicating a blocked bubbler line the system will attempt to purge the line. If the air pressure drops below the expected minimum, indicating a faulty pump the alternate pump will be switched on.

Bubbler Mode

The bubbler system may be run as either a tank-less system, where the air pumps are directly connected to the air regulator or a tanked system, where the air is pumped into a tank and released to the regulator through a pneumatic valve.

Three outputs are provided by the controller to control the air pump system. The functioning of the outputs are determined by the Bubbler Mode configuration. Setting the Bubble Mode to 2 disables the Bubbler controller functionality.

Output	Bubbler Mode = 0 (Tankless)	Bubbler Mode = 1 (Tanked)
Apump1/Select	Activates to turn on Pump 1	OFF if Pump 1 should operate ON if Pump 2 should operate
Apump2/Valve	Activates to turn on Pump 2	Activate pneumatic value to allow air flow
Purge	Active to bypass regulator to purge air line	Active to bypass regulator to purge air line



Air Pump Run Times

The Air Pump 1 and Air Pump 2 Run Time parameters determine how long each air pump operates before switching to the alternate air pump.

In Mode 0 (tank-less) the current air pump is turned on at the beginning of each Sample time and remains on until the start of the Sample Delay time. At the beginning of the Sample Delay time the total accumulated running time for the current pump is compared to the Pump Run time value and if the time has been exceeded the alternate pump will be selected for subsequent samples. The Air Pumps will not be switched during a Sample period.

On a tank less system, the Pump Run times may be set to 0.010 seconds to cause the pumps to alternate on each cycle.

In Mode 1 (tanked) the air pumps are started based on the air pressure of the tank using an external pressure switch. An external SPDT relay may be controlled by the Apump1/Select output to alternate which pump will be activated when the tank pressure drops below the pressure switch level. At the beginning of the Sample Delay time the total accumulated air flow time for the current pump is compared to the Pump Run time value and if the time has been exceeded the alternate pump will be selected by switching the state of the Apump1/Select output for subsequent samples. The activation of air tanks is dependent on the air tank pressure switch, although which pump will be activated is determined by the Apump1/Select output.

In Mode 1 the second output (Apump2/Valve) is used to activate a pneumatic value,allowing the air to flow during the sampling period.

Purging

If at any time the measured level exceeds the Block Level Threshold it is assumed that a blockage has occurred and the system will enter a purge cycle. The controller will activate the Purge valve, bypassing the regulator and applying the full pressure to the bubbler tube for the time specified by the Purge ON Time parameter. In mode 0 (Tank-less) both Air Pump 1 and Air Pump 2 outputs will be activated.

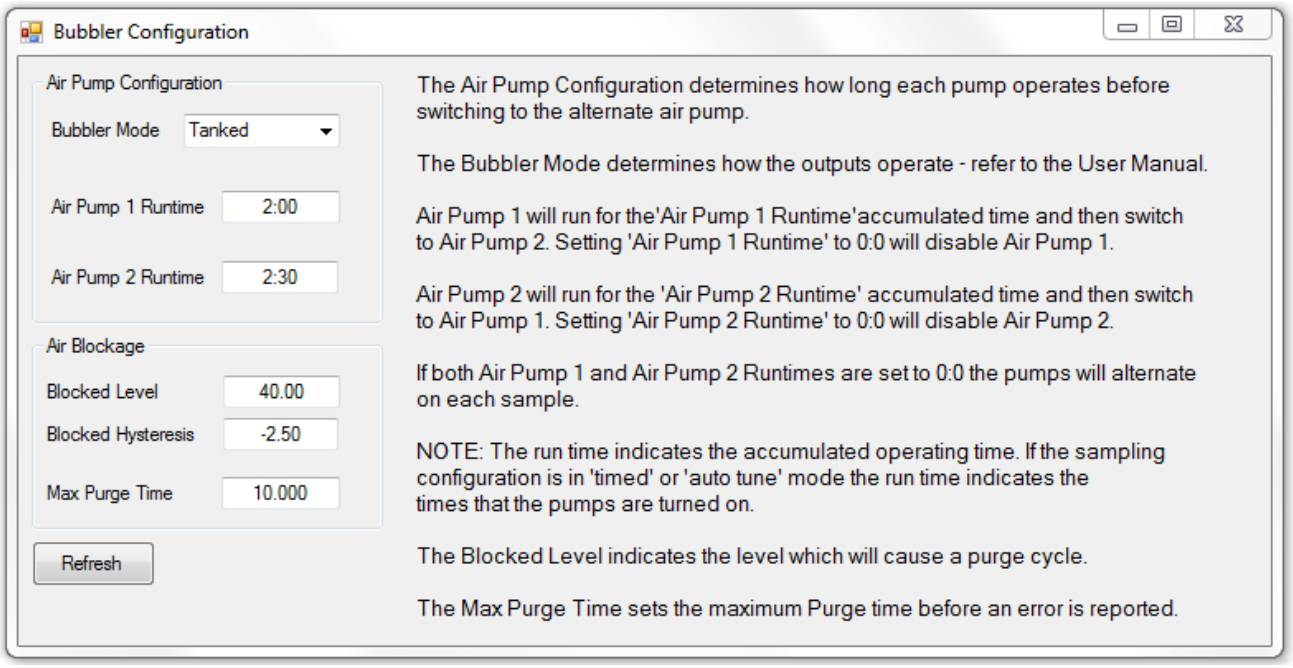
If at the end of the Purge ON Time the level still exceeds the Tank Level Threshold the ALARM output will be activated.

LC_Config Bubbler Configuration

The Bubbler subsystem is configured by setting the Bubbler Mode, the Air Pump 1 and Air Pump 2 Run times, the 'Blocked Level' preset and the Maximum Purge time parameters.

Block	Parameter	Description
068 (CMPR)	Offset	Mode: 0 = Tanked, 1= Tankless
069 (CMPR)	Offset	Air Pump 1 Run Time
070 (CMPR)	Offset	Air Pump 2 Run Time
071 (WARP)	Von	Blocked Level Preset, activates Purge cycle if level reaches the value
	Voff	Blocked Level Hysteresis
072 (TOND)	Ton	Maximum Purge time before and Error is reported

The following LC_Config screen shows the Bubbler parameters that may be configured.



Bubbler Run Time Data

The following run time data is collected for each pump and is accessible through the indicated DW Registers.

DW Register		Name	Description
Pump 1	Pump 2		
DW64	DW72	Cycle Count *	The number of ON-OFF cycles that the pump has experienced since the last reset (see Pump Reset)
DW65	DW73	Run Time *	The number of days – hours:mins that the pump has been operating since the last reset (see Pump Reset)
DW66	DW74	Cycle Time	The current time that the pump has been operating since the last pump switch over.
DW70	DW78	Reset Errors	Writing a non-zero value will cause the Latched errors to be cleared.
DW71	DW79	Reset Stats	Writing a non-zero value will reset the Count and Run Time values.
DW107		Bubbler Mode	As set in Bubbler Configuration
DW108	DW109	Pump ON Time	Pump ON time as set in Bubbler Configuration

* Cleared by pump Reset Statistics, retained on loss of power.

Bubbler Run Time Status

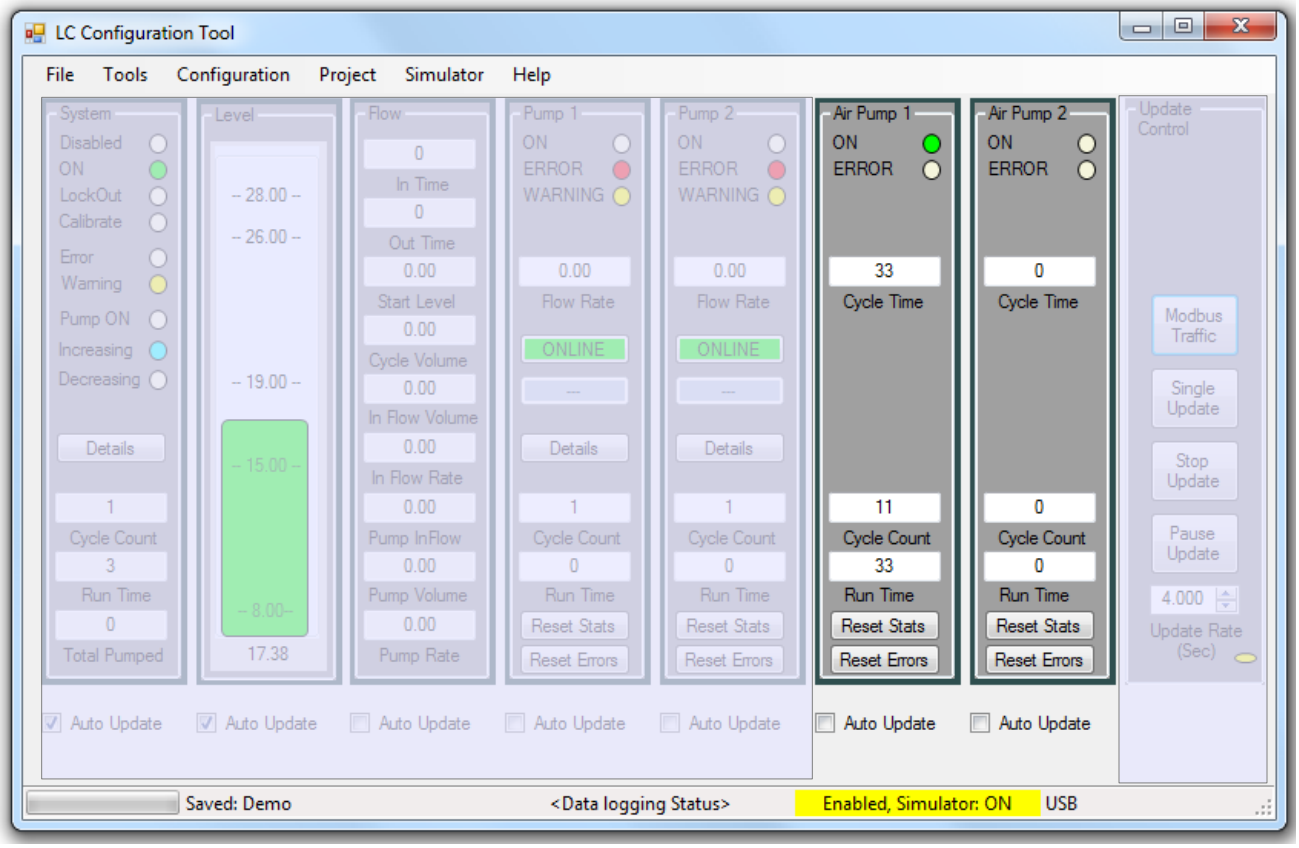
The following status information is collected for each pump and is available through the indicated Bit Registers.

Bit Register		Name	Description
Pump 1	Pump 2		
M80	M84	Pump State	0 == Pump is OFF 1 == Pump is ON
M81	M85	Pump Status	0 == No Errors or Warnings 1 == Pump Error
M104	M105	Pump Trigger	Pump is being trigger to Run
M106		Bubbler Mode	0 == Tanked System 1 == Tankless System
M107	M108	Pump Time Out	Pump has reached it's ON time as defined in the Bubbler Configuration
M108	M110	Pump Zero Time	Bubbler Configuration has set the ON time for the pump to 0
M113		Block/Purge	Blocked Level has been reached, Purge cycle in progress
M114		Block Error	A Blocked Error condition has occurred
M115		Block %	Block State prior to Ton / Toff filtering

* Latched Error condition, cleared by pump Reset Error function

LC_Config Bubbler Display

The LC_Config tool displays the operating state of the two air pumps as shown below.



Chapter 7 LC-1 HARDWARE INTERFACE

The LC-1 configuration allows for a linear (analog) input and provides DUPLEX pump controller outputs and a Bubbler sub-system.

Power:	24 Vdc, @ 100 mA
Size:	126 mm X 90 mm X 58.5 mm
Environment:	IEC68-2
EMC:	IEC801-3
Inputs:	24 Vdc (digital) 200 kohms (seal detect) 0-10 Vdc/4-20 mA (external level detect)
Outputs:	NO Relay (0-240 Vac, 10 Amp resistive) NPN (sink) (24 Vdc, 2 Amp) PNP (Source) (24 Vdc, 2 Amp)
Levels:	5 Level (Zero, Off, Low, Mid, High) Set in Inches, Feet or Meters
Bubbler:	1 or 2 air pumps with or without air tank +/- 1 cm (0.3”) Min sample rate 0.5 sec
Pump Sequencer:	1-2, 2-1, Alternating or user defined sequence 4 user defined sequences 2 user defined Time of Day sequence groups
Pump Health:	Seal Resistance Pump Temperature contact
Run Verification:	Auxiliary Contact Closure Pump Current (Min/Max)
Flow:	Gallons, Imp. Gallons or Liters Reported per second, minute or hour

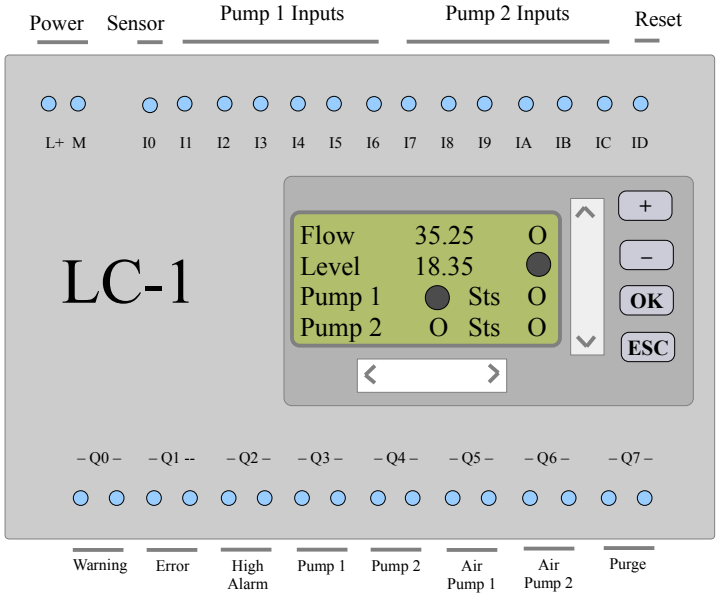
Hardware Connections

The LC-1 controller Hardware Interface is shown below.

INPUT		Description
AI0 (I0)		Sensor Input (Analog)
Pump 1	Pump 2	
AI1 (I1)	AI7 (I7)	Pump Seal Input (Analog)
AI2 (I2)	AI8 (I8)	Pump current level (Analog)
I3	I9	Pump Temperature contact
I4	IA	Pump Auxiliary contact
I5	IB	Pump Phase Error relay contact
I6	IC	Manual ON – Pump will be turned on when the input is active.
ID		Reset Pump Errors

Note: The 14 inputs are labeled I0, I1…I9, IA, IB, IC, ID

OUTPUT		Description
Q0		Active if any WARNING conditions exist
Q1		Active if any ERROR conditions exist
Q2		Active if HIGH Level is reached
Pump 1	Pump 2	
Q3	Q4	Pump ON, turn on pump when output is activated
Q5		Air Pump 1 (Bubbler System)
Q6		Air Pump 2 (Bubbler System)
Q7		Purge (Bubbler System)



Chapter 8 LC-6 HARDWARE INTERFACE

The LC-6 configuration allows for a linear (analog) input and provides DUPLEX pump controller outputs. There is no Bubbler sub-system. An optional I/O expander unit provides additional status outputs.

Power:	24 Vdc, @ 100 mA
Size:	126 mm X 90 mm X 58.5 mm
Environment:	IEC68-2
EMC:	IEC801-3
Inputs:	24 Vdc (digital) 200 kohms (seal detect) 0-10 Vdc/4-20 mA (external level detect)
Outputs:	NO Relay (0-240 Vac, 10 Amp resistive) NPN (sink) (24 Vdc, 2 Amp) PNP (Source) (24 Vdc, 2 Amp)
Levels:	5 Level (Zero, Off, Low, Mid, High) Set in Inches, Feet or Meters
Pump Sequencer:	1-2, 2-1, Alternating or user defined sequence 4 user defined sequences 2 user defined Time of Day sequence groups
Pump Health:	Seal Resistance Pump Temperature contact
Run Verification:	Auxiliary Contact Closure Pump Current (Min/Max)
Flow:	Gallons, Imp. Gallons or Liters Reported per second, minute or hour
Optional:	APB-22ERD expansion unit to provide additional status information and optional discrete inputs.

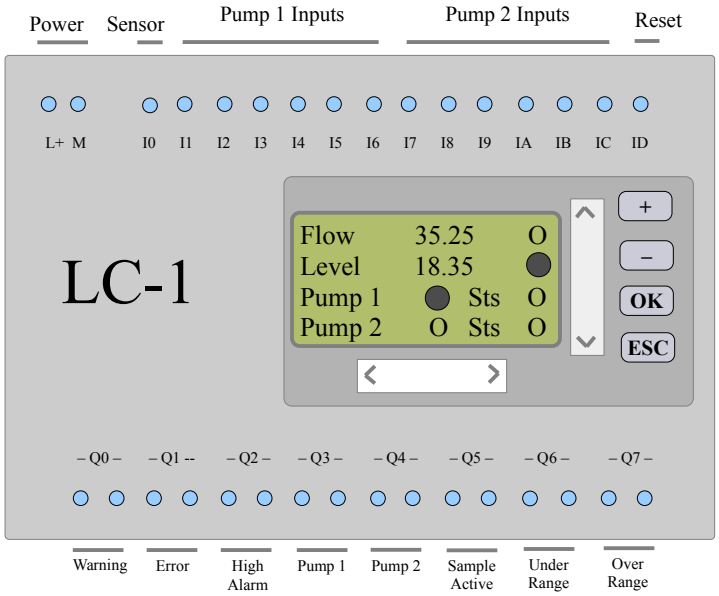
Hardware Connections

The LC-6 controller Hardware Interface is shown below.

INPUT		Description
AI0 (I0)		Sensor Input (Analog)
Pump 1	Pump 2	
AI1 (I1)	AI7 (I7)	Pump Seal Input (Analog)
AI2 (I2)	AI8 (I8)	Pump current level (Analog)
I3	I9	Pump Temperature contact
I4	IA	Pump Auxiliary contact
I5	IB	Pump Phase Error relay contact
I6	IC	Manual ON – Pump will be turned on when the input is active.
ID		Reset Pump Errors

Note: The 14 inputs are labeled I0, I1…I9, IA, IB, IC, ID

OUTPUT		Description
Q0		Active if any WARNING conditions exist
Q1		Active if any ERROR conditions exist
Q2		Active if HIGH Level is reached
Pump 1	Pump 2	
Q3	Q4	Pump ON, turn on pump when output is activated
Q5		Sample Active
Q6		Under-range (ERROR)
Q7		Over-range (ERROR)



(LC-6 CONTROLLER)

The LC-6 Controller supports the addition of an I/O expander (APB-22ERD) that provides additional status information outputs and optional discrete level inputs. Note that power must be connected to both the controller and the expander unit.

INPUT	Description
I10	Discrete Zero (Lockout) Level
I11	Discrete Off Level
I12	Discrete Low Level
I13	Discrete Mid Level
I14	Discrete High Level
I15	Discrete Purge (Over-range) Level
I16- I1D	Unused

The discrete inputs may be used as 'backup' inputs connected to float switches to protect against failures within the linear (analog) level detectors. The discrete inputs are OR'd with the comparator outputs (see Level Detection) and will force pump operation if the analog input fails. If the discrete inputs are not used the corresponding input signals should be connected to 0 Vdc.

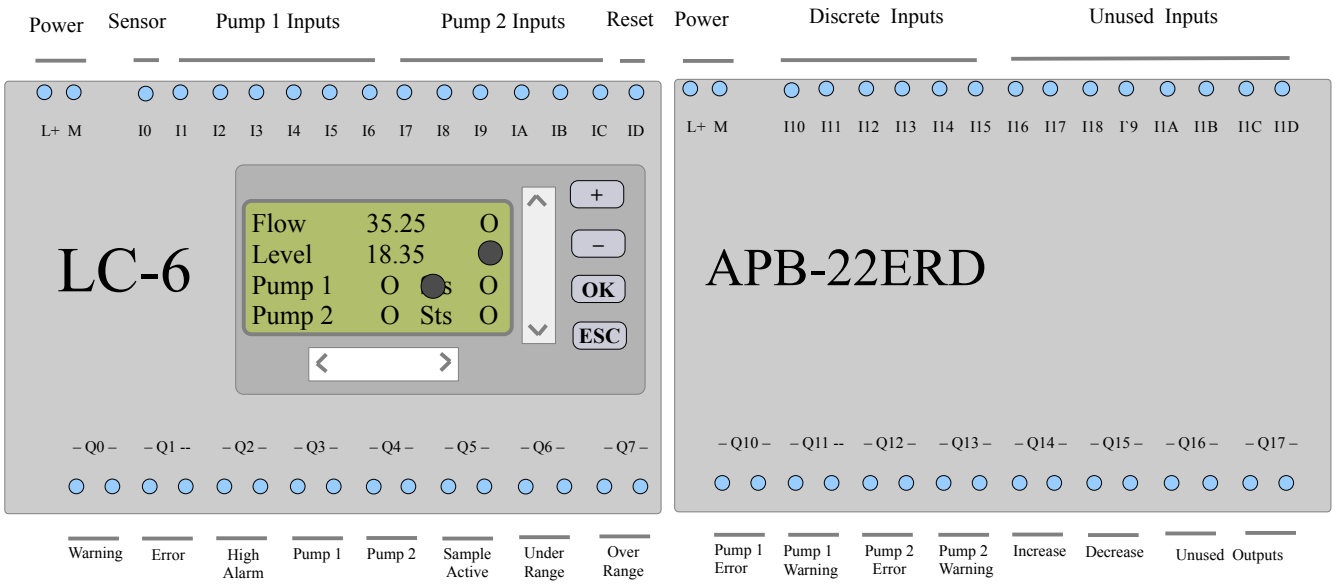
All discrete inputs are configured as normally open contacts. When the level reaches a specific level the float switch should close, applying a +24 Vdc input to the discrete input.

OUTPUT	Description
Q10	Pump 1 ERROR (Disabled) state
Q11	Pump 1 WARNING (Demoted) state
Q12	Pump 2 ERROR (Disabled) state
Q13	Pump 2 WARNING (Demoted) state
Q14	Level INCREASING
Q15	Level DECREASING
Q16 - Q17	Unused

The status outputs may be used to drive indicators to provide additional panel based information.

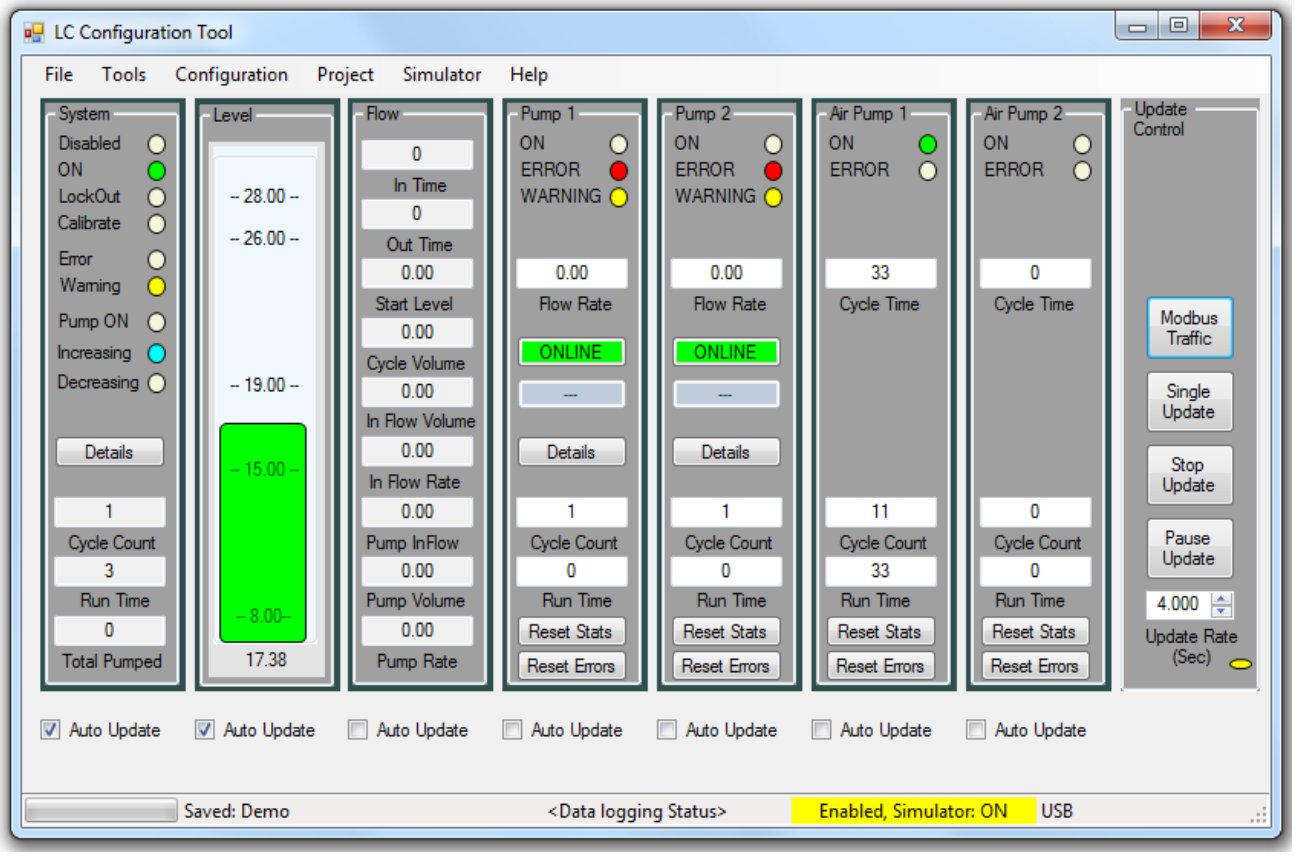
The I/O Expander is optional. If the unit is connected the LC-6 will be automatically configured to provide the additional outputs and process the discrete level inputs.

NOTE: The LC-1 controller does NOT support the I/O expander.


Power
Sensor
Pump 1 Inputs
Pump 2 Inputs
Reset
Power
Discrete Inputs
Unused Inputs
L+ M
I0 I1 I2 I3 I4 I5 I6 I7 I8 I9 IA IB IC ID
L+ M
I10 I11 I12 I13 I14 I15 I16 I17 I18 I'9 I1A I1B I1C I1D
LC-6
Flow 35.25 O
Level 18.35
Pump 1 O Sts O
Pump 2 O Sts O
+
–
OK
ESC
APB-22ERD
– Q0 – – Q1 -- – Q2 – – Q3 – – Q4 – – Q5 – – Q6 – – Q7 –
– Q10 – – Q11 -- – Q12 – – Q13 – – Q14 – – Q15 – – Q16 – – Q17 –
Warning
Error
High Alarm
Pump 1
Pump 2
Sample Active
Under Range
Over Range
Pump 1 Error
Pump 1 Warning
Pump 2 Error
Pump 2 Warning
Increase
Decrease
Unused Outputs

Chapter 9 LC_Config Utility

The LC_Config application program operates on a Windows compatible PC, providing a graphic configuration, simulation and monitoring tool for the LC product family.



Each of the 5 major components of the LC controller (System, Level Detector, Duplex Controller, Flow Monitoring and Bubbler system) are represented by a number of 'control panels'. The Duplex Controller and Bubbler system each provide two panels, one for each of the pumps used within the subsystem.

The operation of the LC_Config application is controlled by the Update Control panel.

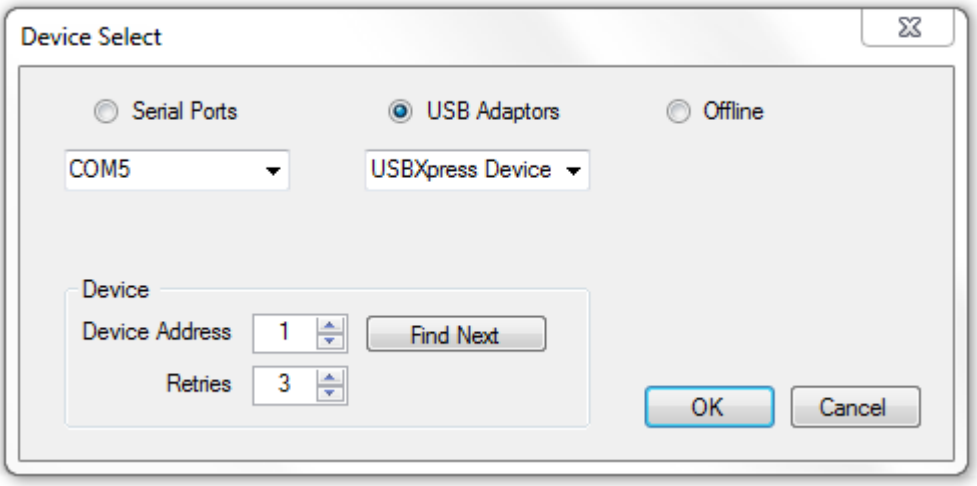
Start Up

When started the LC_Config tool displays a initial start up screen that allows selecting the interface type, the device to be addressed and the number of retries in cases of communication failures.

The USBExpress device provides a USB to RS485 adapter that offloads the Modbus specific protocol from the PC and provides a higher performance and more reliable interface. It requires a APB-EXPMC Modbus adapter connected to the LC controller.

The alternative interface is through a PC serial port. The serial port adapter (RS485 or RS232) must connect through an APB-EXPMC interface. Note that on many PC's the serial channels may connect through the PC USB interface but are internally treated as a conventional serial channel. The APB-DUSB adapter appears to the PC as a serial adapter and provides an alternative interface that connects directly to the LC Controller.

The Offline option allows using the LC_Config tool to prepare configuration files. No interaction with external devices will occur and the Control Panels and Simulator are disabled.



The Device Address must correspond to an LC device connected to the interface adapter. The default address is 1, although this may be changed using the LC HMI interface if several LC devices are connected to the same network.

The Number of Retries allows the communications to make several attempts if a communication failure occurs.

Find Next

The Find Next option will cause LC_Config to search for each of the 254 possible devices addresses (1..254) to determine if any device is present. When clicked, the button will change to 'Cancel', allowing the searching to be terminated.

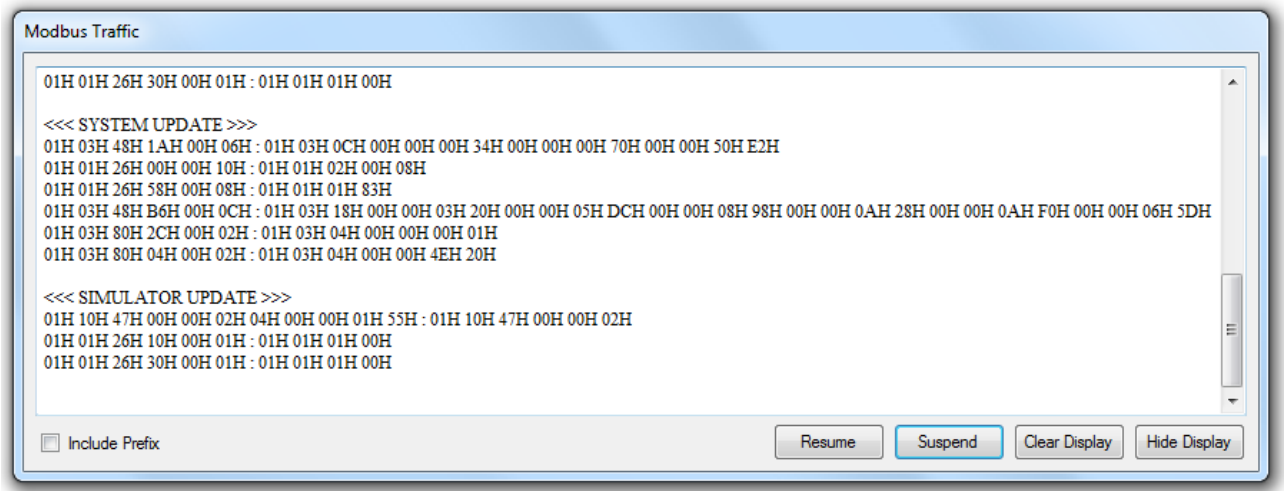
Update Control Panel

The Update Control panel allows viewing the individual Modbus transaction packets, a button that will cause all control panels to be updated, a button that allows continuous updating of selected control panels at a specific update rate and a final button that allows pausing the automatic update.

Modbus Traffic

The Modbus Traffic button will open a separate display window that shows the Modbus transaction data. In normal operation this is not required. If used, it should be noted that the updating of the display may impact the overall LC_Config update times.

The Suspend and Resume buttons only affect the display, not the Modbus transactions. The Hide display button collapses the display.



Single Update

The Single Update button will update all the LC_Config Control panels.

Auto Update

The Auto Update button will update the LC_Config Control panels at a periodic rate determined by the Update Rate value. The following table provides a estimate of the time required to update each panel which depends on the amount of data displayed by the panel.

Control Panel	Time
System Panel	80 msec
Level Panel	80 msec
Flow Panel	150 msec
Pump Panels (each)	80 msec
Air Pump Panels (each)	80 msec

If all panels are activated for update it requires ~ 650 msec for the entire update process.

Individual panels may be selected for updating by checking the 'Auto Update' box immediately below the panel. If a panel is selected for Auto Update the master Auto Update control will be enabled.

Pause Update

The Pause Update button temporarily suspends the Auto Update function.

Update Rate

The update rate is specified in seconds and should be selected to allow sufficient time for all control panels, sub panels and the simulator to update the required data. Setting an update rate too low (fast) will cause sluggish reactions to the mouse and keyboard since the system is loaded updating the controls.

Main Menu Options

Menu Item	Sub Menu	Sub Menu	Description
File			
	Open		Opens and loads a system configuration file
	Save		Saves the current configuration file
	Save As		Saves the current configuration file under a new name
	Printer Setup		Establishes parameters to be used when printing reports
	Print Preview		Preview print pages on screen
	Print		Prints the current configuration for documentation purposes
	Exit		Exits the LC_Config application
Tools	Configuration Files		Defines an application configuration (same as Project)
	Definition Files		Defines the underlying device attributes (Advanced Users)
	Modbus Interface		Allows Reading/Writing all parameters using specific Modbus commands
	Manual Mode		Allows placing pump into FORCE Mode to manually control the pumps
	Calibrate		Configuration assistant
	Simulator		Opens Simulator display
	Data Logging		Data Logging (Future Application Support)
	Options		User define preferences/options (Future Application Support)
Configure	System		Configure the SYSTEM parameters
	Sensor		Configure the SENSOR parameters
	Level		Configure the Level (Thresholds)
	Dimensions/Units		Configure dimensions of tank and units of measure
	Duplex Controller		Configure DUPLEX CONTROLLER sequencer
	Pump 1	Health	Configured Pump 1 Health parameters

	Pump 1	Run Verification	Configure Pump 1 Run Time Verification Parameters
	Pump 2	Health	Configured Pump 2 Health parameters
	Pump 2	Run Verification	Configure Pump 2 Run Time Verification Parameters
	Bubbler		Configure the BUBBLER system
Project			Project Management options
Simulator			Opens Simulator display
Help			Provides help

File

The file menu provides access to configuration files that define the parameters of the LC controller.

Open

Opens a configuration file and loads it to the device.

Save

Saves the current device configuration file.

Save As

Saves the current device configuration file.

Print Setup

Allows setting the printer information to be used when printing the configuration report.

Print Preview

Displays the configuration report on the screen prior to printing.

Print

Prints a configuration report summarizing the current device configuration.

Exit

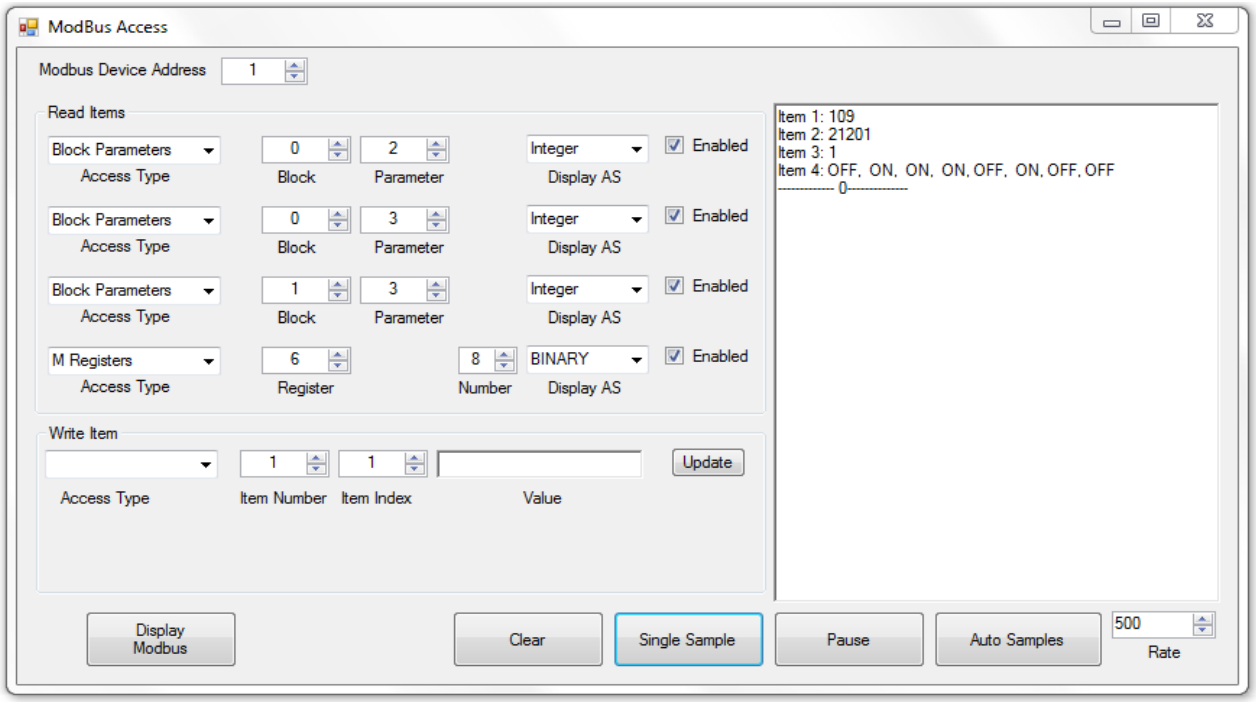
Exit the program. If the current configuration has not been saved the program will prompt asking whether the file should be saved.

Tools

The Tools menu options provide access to several accessories.

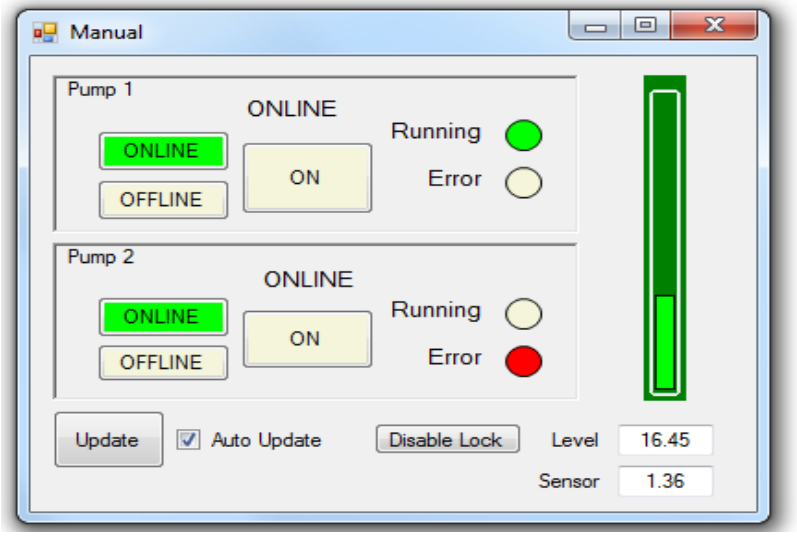
Modbus Interface

The Modbus interface allows direct access to all of the internal LC controller DW data registers, M Bit Registers, control blocks (parameters) and the system Time of Day clock and Device Address. Extreme care should be exercised in writing to any of the control blocks as the LC controller may be permanently damaged.



Manual Mode

The Manual Mode allows the direct control of the pump. The Pump Mode control (DUPLEX CONTROLLER) may be set to any of the 'ONLINE', 'FORCE ON', 'FORCE OFF' or 'OFFLINE' modes and the SYSTEM 'Zero Lockout' control may be over-ridden, allowing the pump to operate below the 'Zero Level' threshold.

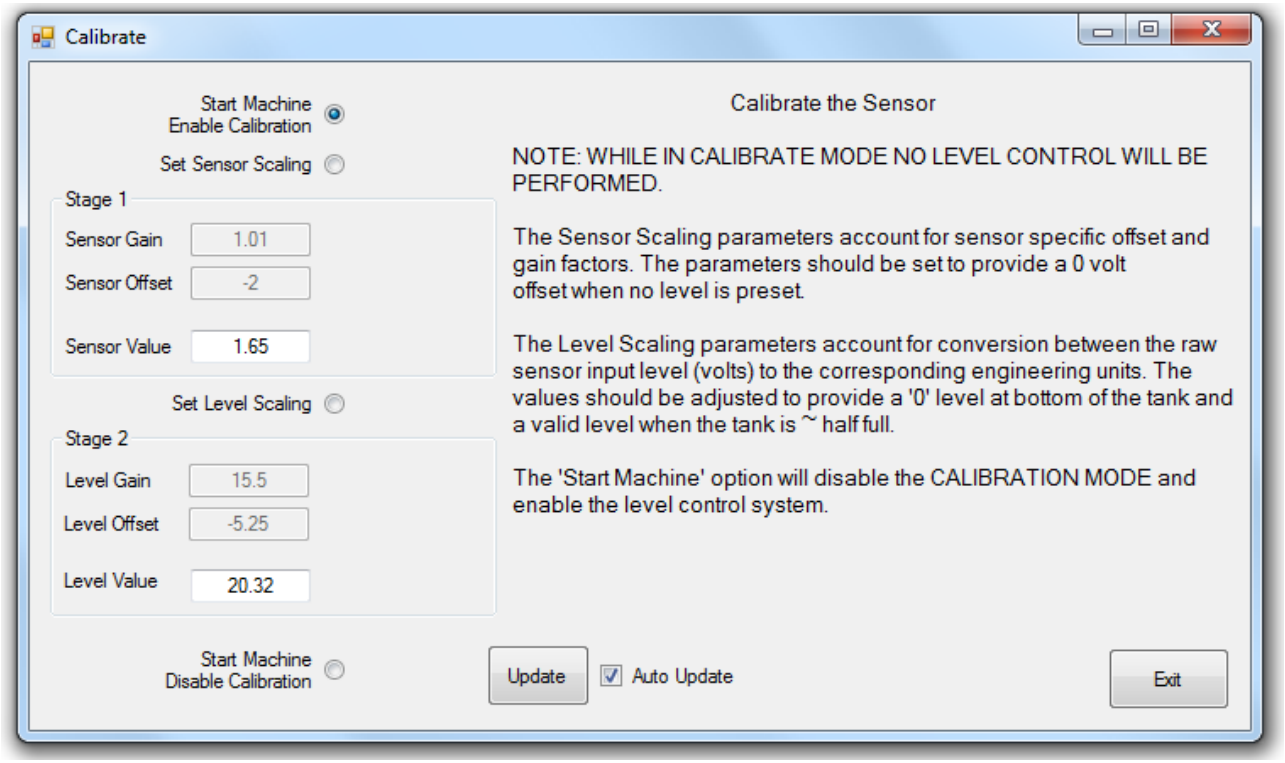


Calibrate

To calibrate the LC controller to use a specific sensor the following steps should be performed:

1 – Set machine into Calibration Mode
2 – With a 'zero' level presented to the sensor set the Stage 1 Offset to provide a 0.00 stage 1 output.
3 – With a 'full scale' level presented to the sensor set the Stage 1 Gain to provide a 10.00 stage 1 output.
4 – With a 'zero' level presented to the sensor set the Stage 2 Offset to provide a 0.00 stage 2 output.
5 – With a known level presented to the sensor set the Stage 2 Gain to provide the known level as the stage 2 output.
6 – Return the machine to the Run Mode.

To assist in the calibration process the LC_Config tool includes a 'Calibration Tool' (Tools/Calibrate) that sequences through the preceding steps.

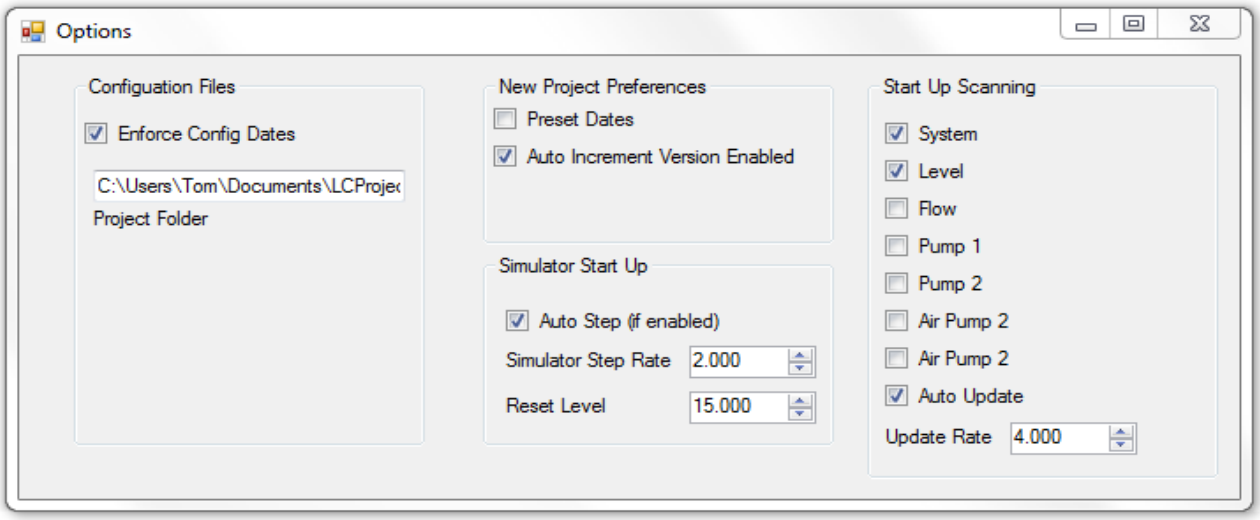


Simulator

The Simulator option within the Tools menu links to the Main Menu Simulate option.

Options

The Options screen allows setting the options to be configured when the LC_Config program first starts up. These values are NOT updated during the operation of the LC_Config program but must be manually set by the user. Options are automatically stored when LC_Config exits, allowing the same operating environment to be used the next time the LC_Config program starts.

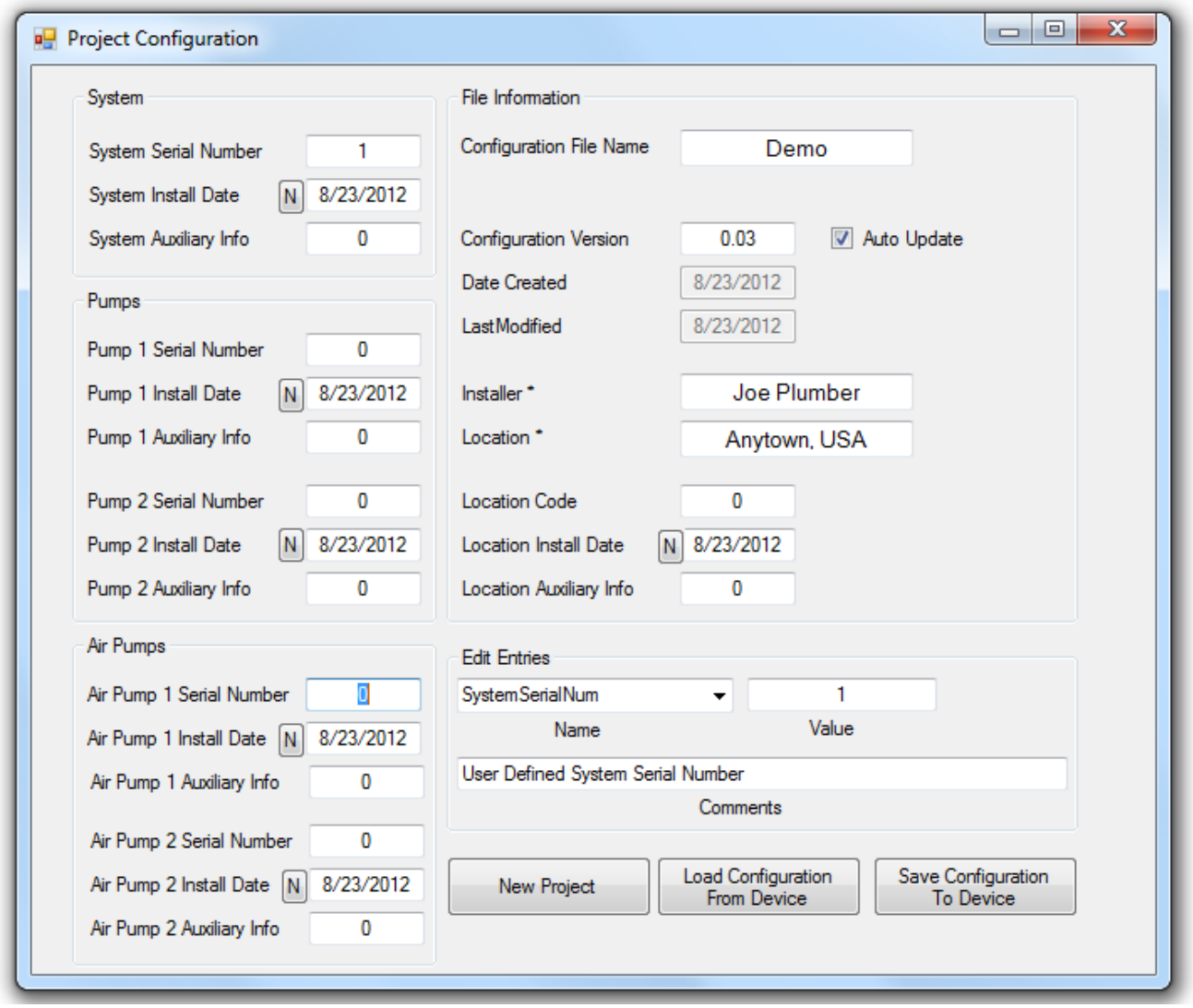


Configuration

Each of the configuration screens allow setting the machine configuration as discussed in the associated chapters.

Project

The project screen allows defining project specific parameters.



All of the fields entered are used as 'information only' fields and do not affect the operation of the LC controller. The information is stored as part of the configuration file as well as on the device.

The project information is grouped into 4 major sections. The System, Pump and Air Pump section each include 3 fields: a user assigned serial number (up to 9 digits), a user assigned date of installation and an optional 'Auxiliary Info' field that will accept a value from 0-65535.

The 'N' button beside each date field will insert the current date.

The File Information section defines the overall installation information.

Configuration File Name

The configuration file name (up to 16 characters) is saved on the device. When a device is first attached the system will attempt to read the specified file to reload the configuration information for editing. If the file is not available the information from the device is used.

Configuration Version

The configuration version information includes a version number, date of creation and date last modified. An 'Auto Update' option is included that will cause the version number to increment whenever the Configuration file is save to disk.

Installation Information

The installation information includes the name of the person installing the configuration and the where the device was installed. Each field will accept up to 16 characters. In addition, a user defined numeric 'location code' and date of installation is provided.

Edit Entries

The Edit Entry area allows reviewing all configuration information contained on the device. Each field is displayed and may be modified. A comment field is provided allowing each parameter to have a comment added. Note that comments are retained in the configuration file but not on the device.

Configuration File Format

Configuration files are saved in standard 'TAB Delimited' files. Each entry consists of the Parameter Name, the Parameter Value and the optional comment field with a 'TAB' character between each field. These files may be read and modified using standard spread sheet programs (Excel, Open Office etc.).

	A	B	C
1	Parameter	Value	Comments
2			
3	%SystemSerialNum%	12345	Any Number (0-999999999)
4	%SystemInstallDate%	8/17/2012	
5	%SystemAuxInfo%	554	Any Number (0-65535)

The Parameter Name has a leading and trailing '%' symbol which is used by LC_Config when reading the configuration file to differentiate Parameter Names. Files may be modified with additional records added provided the first character of the line does not begin with a % character.

When generating the file the LC_Config program outputs a 'header' line consisting of:

Parameter [tab] Value [tab] Comments

followed by a blank line.

Simulator

The LC controller includes a simulation option, allowing the controller inputs to be internally mapped to simulated signals. The simulator is invaluable in testing LC applications without the need of running physical pumps.

NOTE: The simulator does NOT emulate the actions of the LC controller but simply remaps the analog and digital inputs to internal registers within the LC controller, allowing the LC_Config application to drive the level input and emulate the actions of the external pumps. All control logic is performed by the LC controller.

There are three major components to the Simulator: A Tank Simulator, a Sensor Simulator and 2 Pump Simulators. The simulator uses the parameters defined in the Level Detection subsystem (Sensor Data) and the Dimensions defined in the Flow Monitor subsystem (Dimensions, Time Span and Units).

When the Simulator window opens it immediately reads the Dimension/Units and Sensor Gain/Offset parameters from the current device and the state of the Simulation control logic on the LC controller.

Simulator Controls

The simulator is controlled by three control functions (upper left corner).

Enable (Disable) Simulator

The Enable Simulator button activates the simulator function within the LC controller. The standard input connections are remapped to internal registers which may be modified by the simulator, allowing the simulator to apply a 'virtual level' input based on the virtual sensor and modify the pump inputs based on the state of the virtual pumps.

NOTE: The simulator mode within the LC controller handles the analog and digital signals differently. The Analog signals (Level, Seal Resistance, Current) are remapped and the corresponding hardware inputs have no affect. The digital signals (Pump Temperature, Auxiliary Contact, Phase Error Contact) are OR'd with the hardware inputs. The hardware inputs should remain disconnected for the simulator to operate correctly.

Once the Simulator mode has been entered it will remain enabled until specifically disabled using the DISABLE Simulator. When the Simulator is entered it reads the state of the LC controller and will display the activation button as either 'Enable Simulator' or 'Disable Simulator'. Power cycling the unit **does not** affect the simulation mode setting.

Inflow Rate

The Inflow rate determines the flow rate (units/timer period) of the liquid flowing INTO the tank. The flow rate value is provided to the Tank Simulator.

Auto Step

The Auto Step check box and corresponding time (Seconds) indicates how often the Inflow rate is updated.

Tank Simulator

The Tank simulator acts as a 'virtual tank' with a user settable Inflow Rate. The Auto Step parameter defines how often the tank information is updated. After the step interval expires the Tank Simulator Calculates a new tank Level by calculating:

New Volume = (Inflow rate – (Pump 1 Flow Rate + Pump 2 Flow Rate)) * Elapsed Time

New Level = New Volume / ((Length * Width) + (Radius^2 X Pi))

The Conversion Units is compared to the know constants (see Level Detection) and if known the units of measure are updated, ie: Gallons/Feet or Gallons/Inches etc. Similarly, the Time Span parameter is used to determine if the controller is monitoring Units/Hr, Units/Min or Units/Sec. The Dimension/Units cannot be modified within the Simulator. Changes to the Dimensions/Units must be made through the device configuration screens. The 'Refresh' buttons will re-read the current device settings.

At any time the current level may be reset to a user specified level.

The New Level is then passed to the Sensor Simulator.

Sensor Simulator

The Sensor Simulator accepts a level from the Tank Simulator and translates it into a sensor 'voltage' using the value provided by the 'Sensor Parameters', read from the LC controller. If the Sensor is reconfigured the 'Refresh' button will re-read the current parameters.

Pump Simulator

There are two Pump Simulators provided. The Pump simulator panels allow the user to set the characteristics of the 'virtual pumps' (seal resistance, on delays, pump rates etc.). These values are written to the LC controller Simulation inputs which are applied in place of the physical I/O.

The Pump Simulator reads the state of the LC Pump Controller to determine if the LC controller has activated the pump. When the pump is activated the simulator ramps the virtual flow rate using the Start Up Ramp time. When the pump output is deactivated the simulator ramps the virtual flow rate down using the Shut Down Ramp time.

The Turn On and Turn Off of the pump simulator will cause the Auxiliary Contact, Current and Phase Contact to activate as the pump state is switched. The Seal Resistance and Pump Temperature inputs remain constant, but may be varied by the user.