Installation Manual

I. APPLICATION

A. Introduction

All Curtis controls are of the conduction or resistance sensing amplifier type. A low voltage, taken from the built-in isolation transformer, appears at the input terminals of the control. An external resistance, equal to or less than the control's sensitivity, connected to the input will allow a small current to flow. This current is amplified by the circuitry and operates the output relay.

Curtis controls can be used for liquid level control of conductive fluids (water or most water-based solutions) or numerous other applications where a compact, inexpensive and reliable resistance sensing amplifier is required.

B. Liquid Level Control

1. Level Sensing

The simplest application of a control is to detect the presence or absence of liquid at a specific level. A simple probe, at the desired level, is connected to the "H" input. The "C" input connects to the tank, or to a return electrode. When the liquid is touching the probe a current path exists through the liquid and probes, causing the control relay to operate. As liquid recedes from probe, the current path is broken and the relay is deenergized.

Output may be to an alarm, indicator, programmable controller, etc. For indications of multiple levels, a probe and control are required for each level.

2. Maintaining A Level

When it is desired to fill or empty a tank, two (2) probes are normally used to set high and low levels. In the forward or pump-down mode the control relay is deenergized until the liquid rises to contact the high probe. Upon probe contact the relay energizes to activate the controlled pump, valve, or other load. In addition, a set of holding contacts connect the low probe into the circuit. The relay now remains energized until the liquid falls below the low probe. At this point, the relay deenergizes, the low probe is disconnected and the cycle is ready to repeat.

The latch feature provided by the holding contacts can also be used for other purposes. For example, by connecting a normally closed reset switch from "L" to "C", the control relay will operate upon high probe contact and remain energized until manually reset.

Both forward mode and reverse mode controls can provide either pump-up or pump-down operation by choice of the normally open or normally closed contacts on the control relay. However a specific mode may be desireable to provide a fail-safe output state in the event of probe/control malfunction or loss of power.

3. Reverse Mode

A reverse mode control differs in that the control relay is energized in the absence of continuity at the input, and deenergizes when the probe circuit is completed. In the reverse or pump-up mode, the relay is energized until the liquid rises to contact the high probe. Upon probe contact the relay deenergizes, remaining off until the liquid falls below the low probe. At this point the relay again energizes and the cycle is ready to repeat.

Both forward mode and reverse mode controls can provide either pump-up or pump-down operation by choice of the normally open or normally closed contacts on the control relay. However a specific mode may be desireable to provide a fail-safe output state in the event of probe/control malfunction or loss of power.

3. Other Uses

1. Contact sensing

Since the ERSA detects the presence of an external circuit, any circuit making scheme may be used. For example, a spring contact probe can sense the presence of a metal part. Because of the isolated low voltage on the probe, shock hazard is minimal. The control circuitry limits probe current to less than .01 ampere and a continuous short at the probe causes no harm.

2. Pilot Relay

A device having limited contact ratings, such as a reed switch or thermostat, can control larger loads through an ERSA used as a sensitive relay. This scheme also permits a long run of low voltage cable between the switch and load.

3. Transducers

Any sensing element giving contact closure or variable resistance output can serve as an imput to the control.

Typical sensors include:
Thermistor, Photoconductive Cell, Float Switch, Humidity Grid

When precise repeatablility is required, the model PCT should be used.

II. INSTALLATION

A. Fluid Compatibility

All electrically conductive liquids can be sensed by a conductivity type control. This includes water, most water based solutions and slurries, and materials such as moist sand. Purified or distilled water has a high resistivity and will require a sensitive control (Model LHS) and, in some cases, special probes.

Oils and non-polar solvents will not work with this type control. Oil/water mixtures may cause trouble if the oil forms a film over the probe insulating it from the water.

A rough measurement of fluid conductivity can be made using an ordinary ohmmeter. A reading which gradually increases in value indicates that electrolysis is occuring; in such a case the initial, or lowest value should be used.

B. Liquid Level Probes

Functionally a probe is an electrode which makes connection to the fluid being sensed. Probe material may be anything compatible with the fluid: typically stainless steel, or when necessary, titanium or graphite. Probe configuration is usually a rod which is suspended from the top of a tank, or inserted through the side, to make contact with the fluid at the level to be sensed. With ordinary water a small contact area will provide sufficient current flow to operate the control; with pure water several inches of contact surface may be required to produce a usable signal. A metal "flag" may be mounted on a probe rod to provide additional contact area.

To form a complete circuit a return connection is also required. The tank itself, if metal, or fixed objects such as pipes or pumps may serve this purpose. When nothing else is available, another probe rod may be used for the return connection.

Probes must be insulated at their mounting so that the only current path is through the fluid. If splashing or condensation is present, this must be kept from bridging the insulation to prevent false signals. Fully insulated probe headers are useful in such cases.

When turbulence is present it may be necessary to mount the probe behind a baffle or in a stillwell to prevent relay chatter. Alternately, high and low probes may be used to provide hysteresis greater that the ripple height.

Standard Curtis probe rods are 316 stainless steel rod, 1/4 inch in diameter. Rods are threaded on one end and screw into header. These are easily cut with a hacksaw and may be trimmed to final length at the time of installation. When coated rods are shortened the coating should be removed from the rod end for a distance of 1/8 to 1 inch, depending on the fluid conductivity, to provide adequate contact area.

C. Wiring

Typical connections for level control applications are shown in the catalog for each model. Single point sensing is done by omitting the low probe and leaving the "L" terminal open.

Since the sensor current is minute, #22 AWG wire is adequate for probe wiring. Thermostat or control cable may be used for class 2 wiring. Note that most electrical codes require all wires in a bundle to be insulated for the highest voltage present.

Input wires should be isolated as much as possible from power or load wiring to minimize pick up of electrical noise which can cause erratic operation. Shielded cable or seperate conduit may be required, especially if power and signal lines run parallel to each other.

Sensor leads can be any length without concern for voltage drop. The limiting factor on cable length is inter-conductor capacitance. Parallel conductors exhibit a capacitance between each other which increases with length. A reactive, or phantom, current flows through this cable capacitance, which the control will see as probe current. This may cause false operation, especially at high sensitivities. Runs of 20 feet of control cable or 100 feet of individual wires in conduit are normally acceptable.

If greater distance is required, the LC series of controls has provision for cancelling out the cable capacitance by adding an equal value fixed capacitor to the bridge circuit. On other models, a bridge rectifier circuit may be added to transform the probe current to DC. With DC cable lengths of thousands of feet are possible, at the expense of probe electrolysis.

D. Mounting

Control boards may be mounted in an equipment cabinet or control panel in any position. Isolation from shock and vibration is desirable to prevent relay loosening or solder joint fatigue. Ambient temperature limits are listed for each model in the catalog. Boards must be protected from condensation or dripping.

Shielding or mounting away from heavy power switching components is sometimes required to reduce false operation from electrical noise pickup. A MOV suppressor mounted at the line terminals may help in severe cases.

Standard NEMA boxes are available to make a self-contained system. Accessories such as contactors, pilot lights, or control switches may mount in the same enclosure.

E. Ratings

Basic electrical and mechanical data for each model are given in the catalog.

Sensitivity is defined as the maximum value of sensor resistance which will cause the control to operate. Any lower value, down to zero, will operate the control.

Ambient temperature limits are based upon full load operation. At reduced load currents somewhat higher ambients can be tolerated before the output relay attains its maximum internal temperature. The lower limit is based upon capacitor and relay performance; operation down to -40 degrees is possible if some shift in operating point is accepted.

Operating point differential is the difference in sensitivity between the pick-up and drop-out points. Often external factors, such as supply voltage drop with load switching, will affect the differential.

Response speed is dependent mainly on the relay operate time (0.2 second typical) and the release time of the relay / capacitor combination (0.5 second typical). Release times of up to 3 seconds can be supplied.

Output ratings are based upon relay contact life of 100,000 operations. Operating at less than maximum current will prolong contact life. For inductive loads some form of arc suppression is desirable.

F. Safety

Open circuit probe voltage is less than 30 volts RMS, which poses no shock hazard under normal circumstances. Lower voltages can be supplied for special applications. Short circuit probe current is limited to a value which will cause little sparking or heating. If intrinsic safety is required, the control can be located remotely and isolated by appropriate "Zener Safety Barriers".

III. MAINTENANCE

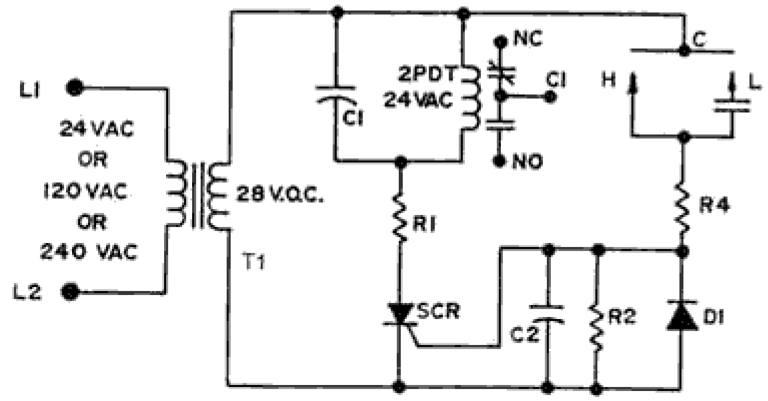
A. Theory of Operation

All Curtis' standard controls are of the conductivity type; that is the control reacts to the flow of a small current through the sensing circuit. Major components are a power supply, an amplifier, and a relay.

1. ELS

Figure 1 shows a basic control, the ELS. Transformer T1 reduces the supply voltage to a safe value and isolates the sensing circuit from the power line. SCR is the amplifier. When energized, SCR will conduct on alternate halves of the AC cycle, giving pulsating DC to the relay coil. Capacitor S1 smooths this output to prevent relay chatter.

FIGURE 1 ELS



SENSITIVITY RANGE

A 0 TO 100KΩ
B 0 TO 50KΩ
C 0 TO 25KΩ

NOTE: Transformer secondary winding may have tap, not shown

Completing a circuit between sensor terminals "H" and "C" allows current to flow into SCR gate to activate the unit. Resistor R4 limits maximum probe current to .01 ampere, while R2 bypasses leakage current from SCR gate to cathode and sets the maximum sensitivity of the circuit. Diode D1 limits reverse bias on the SCR input and eliminates any DC component in the sensor current. Capacitor C2, when used, improves noise immunity by shunting any high frequency input.

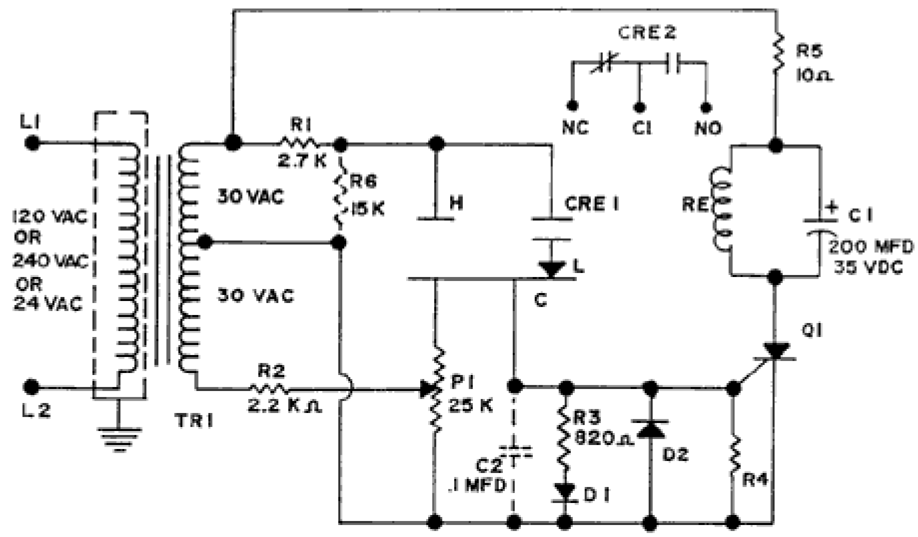
Alternating current is normally used for sensing to reduce probe electrolysis in level control applications. Since the SCR is an on/off device, there is a threshold value of sensor resistance, usually specified as the control's "sensitivity", above which the SCR will be off (relay deenergized), and below which the SCR will be on (relay energized). Any resistance below the sensitivity value, down to zero, will operate the control. Because current flow is limited, a short circuit at the input will cause no harm.

The latching feature is provided by a set of normally open relay contacts in series with the "L" input. This input is effective only while the relay is energized, and can be used for a low probe or holding circuit.

2. LCS

The exact sensitivity will vary slightly with supply voltage, temperature, etc. This is normally not a problem with go/no-go applications such as level control. A more stable threshold results from a bridge circuit, such as that of the LCS, shown in Figure 2.

FIGURE 2 LCS-10/20/30

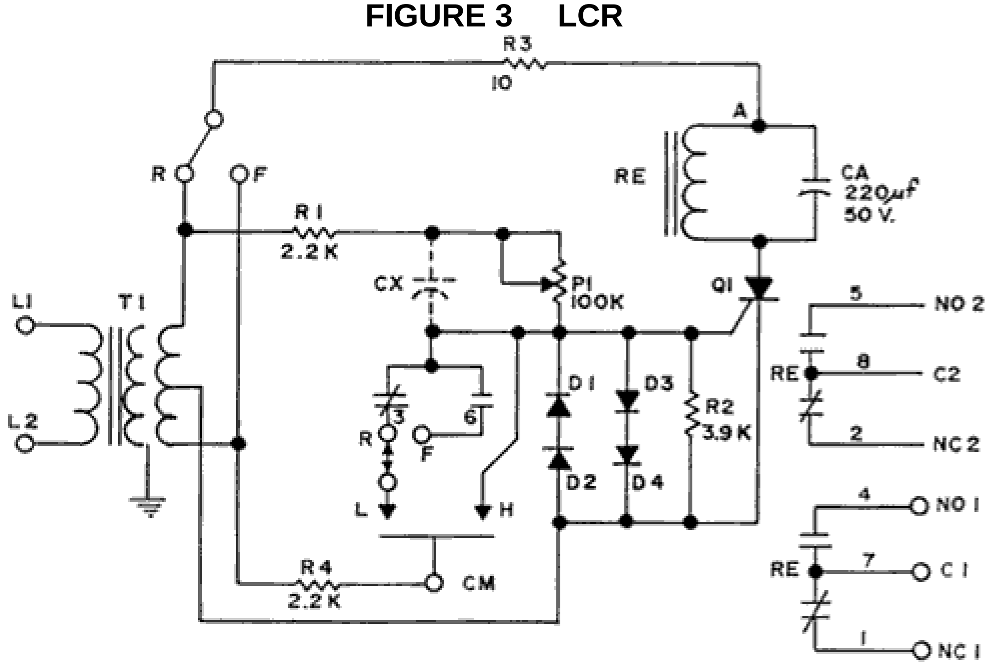


This circuit uses a center-tapped transformer winding to supply an out-of-phase bias to the SCR. When the in-phase signal through the sensor exceeds the bias, Q1 will turn on. Diode D1 and resistor R3 provide temperature compensation of Q1's turn-on current; however, stability results mainly from the use of a resistive bridge circuit. Resistor R6 may be added to limit open circuit probe voltage.

3. LCF / LCR

The circuits described above are "forward - mode", i.e., the relay is energized when sensor current flows. Figure 3 shows a "reverse - mode" circuit, wherein the relay is on without current and deenergizes with an input signal. This is accomplished by supplying a forward bias and using the input to cancel it. Operation otherwise is similar to the LCS control. Note that the LC Board can be configued for either forward mode (LCF) or reverse mode (LCR) operation by moving two jumper wires. In reverse mode the latching circuit uses normally closed holding contacts on the relay.

FIGURE 3 LCR

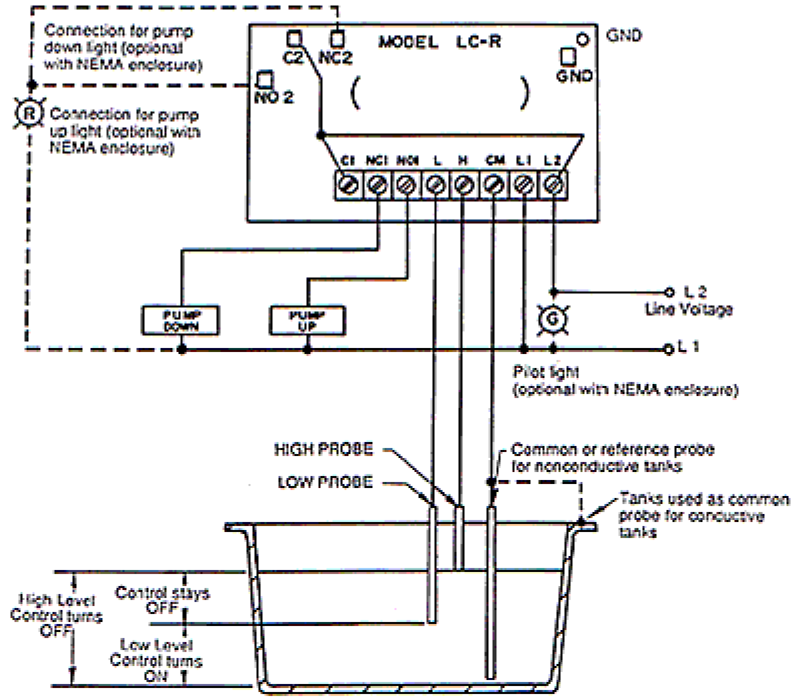


NOTE: CX capacitor to be installed by customer

Figure 4 shows typical wiring for the model LCR.

Optional capacitor CX can be added to the bridge circuit to cancel out reactive current from probe cable capacitance.

FIGURE 4
Wiring Diagram for Model LC-R
(Reverse Mode)
Liquid Level Control

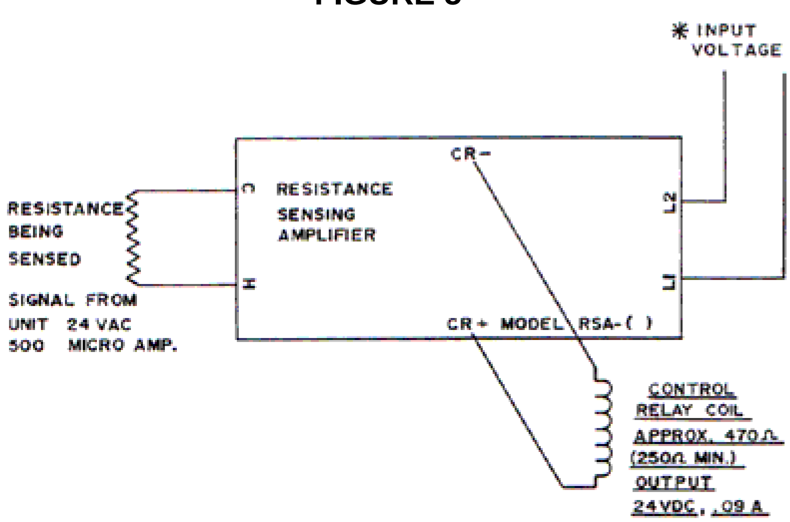


NOTE: If low probe is omitted then any level below hi probe is low level and control turns on.

4. RSA

Figure 5 shows RSA connections. Model RSA is similar to the LCS, but has no on-board relay.

FIGURE 5



*INPUT	VOLTAGE			RELAY DE-ENERGIZED	RELAY DE-ENERGIZED
MODEL	RSA-1	120V	50/60	HZ 1 WATT	5 WATT
MODEL	RSA-2	240V	50/60	HZ 1 WATT	5 WATT
MODEL	RSA-3	24V	50/60	HZ 1 WATT	5 WATT

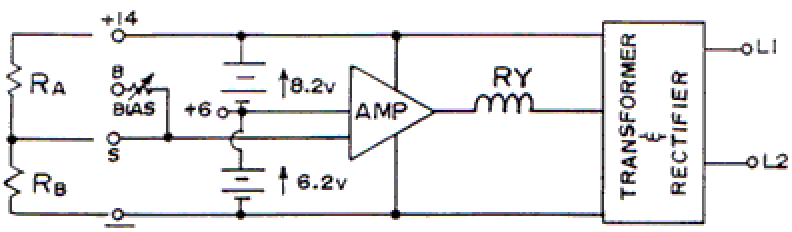
5. LHS

Model LHS is also similar to the LCS, but has additional amplfier circuitry and a higher resistance bridge circuit.

6. PCT

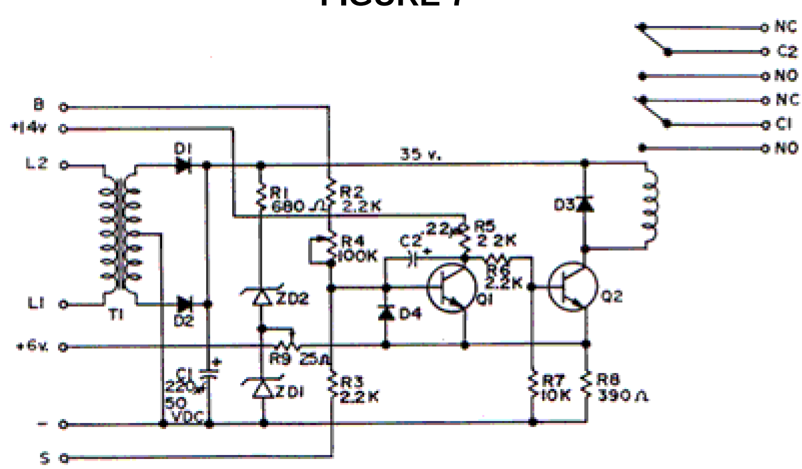
Figures 6 and 7 show the PCT control. This model uses regulated DC for the sensing circuit to provide maximum stability with thermistors or other gradually varying input signals.

FIGURE 6



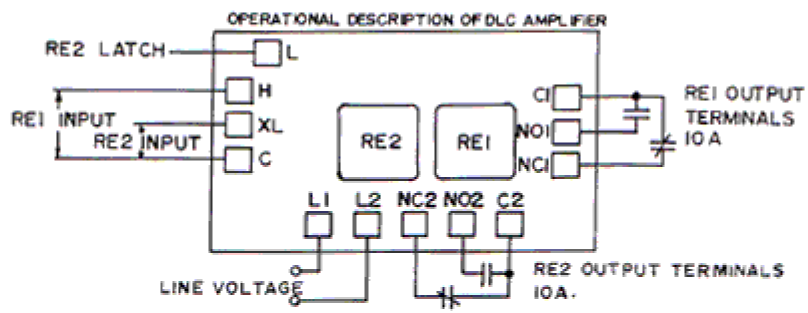
A.) Unit compares ratio of external resistors RA & RB to ratio of two Zener-regulated voltages (6.2V & 8.2V Nominal).
B.) Switches state when RA ≈ 1.32 RB (Negative going input energizes relay)
C.) Sensor may be connected as either RA or RB depending on desired operation; reference leg should be adjustable to compensate for component tolerances.
D.) On-Board bias potentiometer (range 0-100k) may be used as part or all of RA or RB. Note that RA and RB should never both be zero.

FIGURE 7



R9: Differential Control is optional. It may be replaced with a fixed resistor or a jumper.
C2 Controls the response time of the circuit.

FIGURE 8



1) The H & C input energizes relay RE 1 and contact terminals marked C 1, NC 1, & NO 1.

   When the H & C input is open or high (resistance greater than 15KΩ) then RE 1 is "pulled in" and contacts C 1, NC 1, & N) are switched.

   When the H & C input is low (less than 15KΩ) RE 1 drops out.

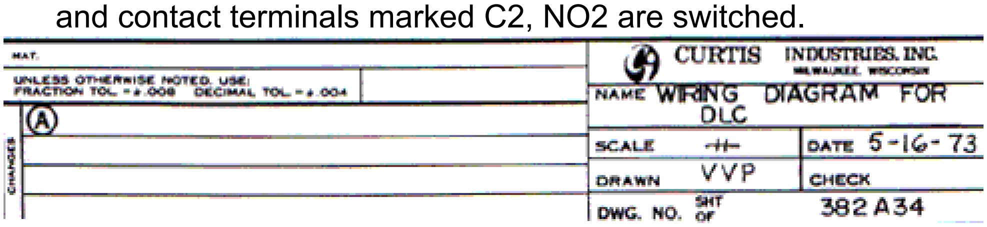
   If the High probe resistance is considered as the "normal state" then RE 1 works in reverse mode.

   The L terminal in conjunction with the H & C terminals can provide a low probe latching function.

2) The XL & C input energizes relay RE2 (lockout relay).

   When the XL & C terminals are high (resistance greater than 15KΩ then RE 2 is dropped out.

   When the XL & C input is low (less than 15KΩ), RE 1 "pulls in" and contact terminals marked C2, NO2 are switched.



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3)To illustrate the operation of the DLC let us examine a boiler tank application.

In this situation we have three probes controlling the water level:

1) The XL probe indicates minimum water level.
2) The H probe indicates minimum water level.
3) The L probe prevents the control from turning on and off at minor water level fluctuations.

As soon as we activate the main switch, relay RE 1 "pulls in" and starts filling the boiler tank through the "fill water" valve.

At this time the water level is below minimum and the XL probe senses and open circuit (greater than 15KΩ); RE 2 relay is deenergized and the heater is disconnected.

When the XL probe senses an XL or minimum water level (less than 15KΩ) the RE 2 relay "pulls in" and the heater contactor energizes the heater.

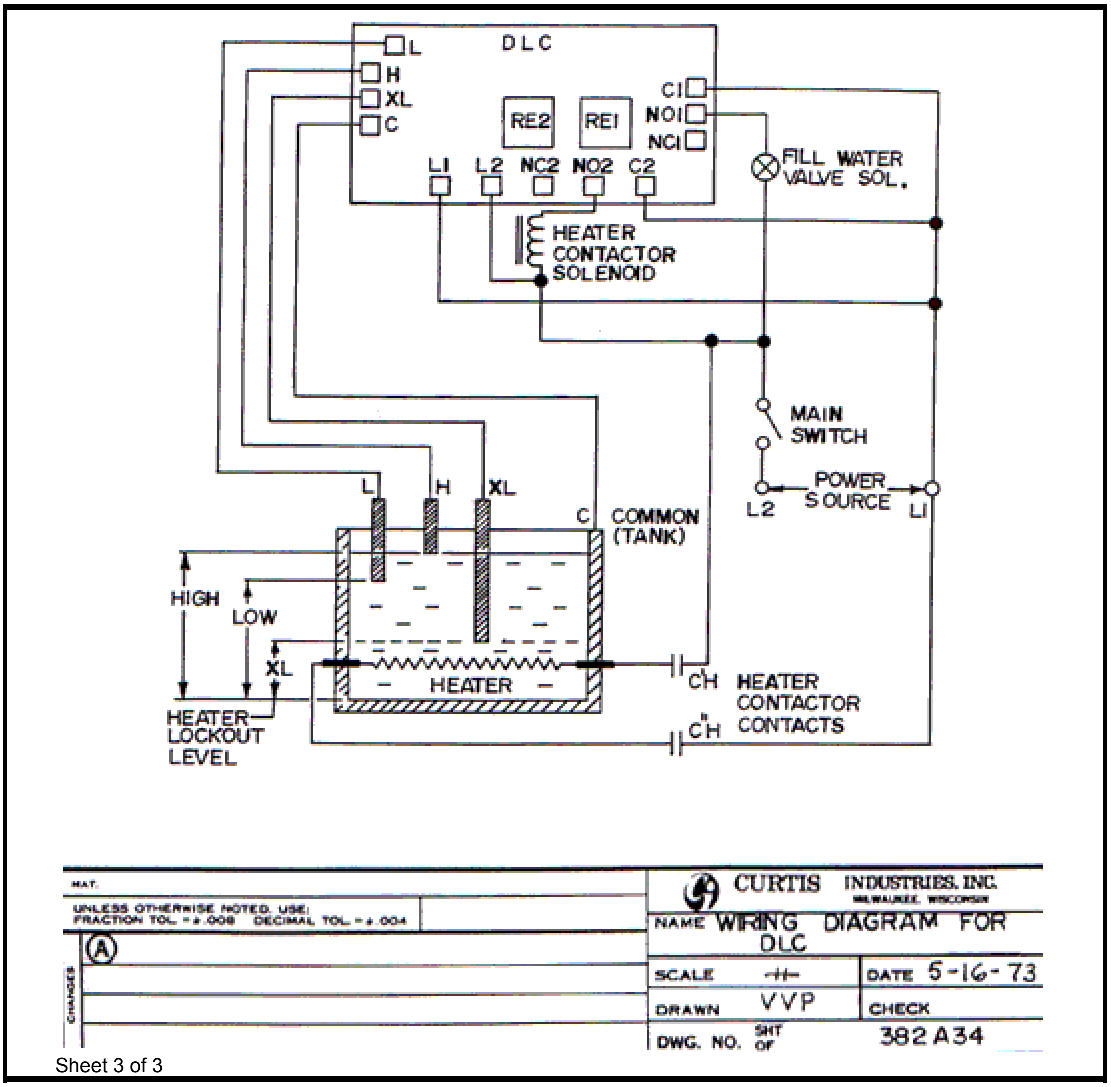
Water still continues to flow into the tank until the H or high level is reached. At the H level (H & C less than 15KΩ) RE 1 drops out and the water valve solenoid shuts off.

To prevent minor water level variations from turning the controls on and off (creating a chatter), we have connected an L probe (as shown in the wiring diagram).
The L probe "latches in" through a NC contact as the relay (RE 1) drops out at the H water level. It keeps the H & C input low until low until the water level drops below the L level.

If the L probe is not used, the RE 1 relay and the water valve solenoid would be energized as soon as the liquid level would drop below the H level.

MAT.	CURTIS INDUSTRIES, INC. MILWAUKEE, WISCONSIN
UNLESS OTHERWISE NOTED, USE: FRACTION TOL. = ±.008 DECIMAL TOL. = ±.004	NAME WIRING DIAGRAM FOR DLC
CHANGES (A)	SCALE —‖— DATE 5-16-73
	DRAWN VVP CHECK
	DWG. NO. SHT OF 382 A34

DLC Boiler Application Wiring Diagram



B. Normal Maintenance

Because the ERSA circuitry is fully solid state, the only normal maintenance required is replacement of the output relay when its contacts are worn. The relays used are rated for 100,000 operations at full load, and normally last much longer at reduced loads.

Probes and probe insulators should be kept clean, and dust or dirt should not be allowed to build up on the control board.

C. Checkout & Calibration

(A) Models LCS-1, LCS-10, LCF-1

1. Bench Check
   a. Turn sensitivity control fully counterclockwise to stop, then 1/4 turn clockwise.
   b. Apply 120 volts AC to line terminals "L1" and "L2". Relay should not energize.
   c. Jumper probe terminals "C" and "H" relay should energize (armature is visible through clear cover; also producers audible click).
   d. Remove jumper; relay should deenergize. Jumper terminals "C" and "L"; relay should remain deenergized.
   e. Momentarily jump "C" and "H"; relay should energize and remain

energized.

f. Remove jumper from "C" and "L"; relay should deenergize.
g. Turn sensitivity control fully clockwise. Relay should remain deenergized.
h. Connect the resistance of 90,000 to 100,000 ohms from "C" to "H". Relay should energize.
i. Control is functional.

2. Calibration
   a. With control installed and probes connected, fill tank with liquid until liquid just touches high probe. Turn sensitivity control counterclockwise until relay deenergizes, then back clockwise 1/4 turn.
   b. If foam or agitation causes false operation, sensitivity can be reduced slightly, but setting must be at or above operating point for full fluid contact.

(B) Model ELS-1

1. Apply 120 volts AC to line terminals "L1" and "L2". Relay should not energize.
2. Connect a fixed resistance (47,000 ohms for "A" range, 22,000 ohms for "B" range, or 10,000 ohms for "C" range) between probe terminals "H" and "C". Relay should energize.
3. Disconnect resistor; relay should deenergize. Jumper terminals "L" and "C"; relay should remain deenergized.
4. With above jumper in place, again connect resistor. Relay should energize.
5. Remove resistor. Relay should remain energized.
6. Remove jumper. Relay should deenergize.
7. Control is functional.

(C) Troubleshooting & Repair

1. Fault Isolation

   Most difficulities occur either in the sensor or control board and can be isolated to either area by a simple test: Disconnect the input leads (H, L, & C) and apply power to the control board. Bridging terminals "C" and "H" with a wire jumper, or a resistance less than the control's sensivitiy, should cause the output relay to operate. If the relay fails to operate, the problem is on the control board; if the relay does operate, the problem is external.

2. Sensor Problems

   Assuming the system had once been working, failure is most likely due to deterioration of the sensor. Level probes can become covered with mineral deposits, leading to a high resistance, or the insulator can fail or be contaminated, causing a low resistance to ground. Ohmmeter measurements will give some indication of these conditions. Regular probes cleaning may be required in some installations. In boiler applications, high pressure can cause conduction through vapor, and built up sludge will foul electrodes. A switch to purified water may require greater control sensitivity. Other sensor types can also be checked with an Ohmmeter.

Wiring can be checked by standard methods. Installation of new equipment or changes in wiring, can introduce electrical interference if isolation is not maintained in the sensor wiring

3. Control Problems

   The plug-in control relay is the only component which will wear out in normal operation. Relay life may be six months to many years depending on load current and frequency of operation. If relays fail prematurely in heavy service, some form of contact protection, such as a MOV suppressor, may be required.

   With normal supply voltage and sensitivity set greater than zero, bridging the "C" and"H" inputs should cause operation of the relay, visible through its plastic cover.

   Total loss of operation is most often caused by a defective relay, an open or shorted SCR, an open transformer or a broken solder connection.

   The relays used are standard plug-in types having 12 volt or 24 volt DC coils, depending on control model. Suitable replacements are available from many manufacturers.

   SCR's are sensitive gate, 1 ampere, 100 volt types and may be replaced by C103, 2N5060, or similar. A shorted SCR may also cause damage to the transformer and electrolytic capacitor. Note that replacement SCR's may have different terminal configurations.

   Transformers are custom made for each model and have no standard replacement. Some transformers, however, have a fuse located just below the final insulating tape which can, in an emergency, be replaced or bypassed.

   Solder connections to the printed circuit board can be broken, especially at relay socket pins, by force on the relay, shock, or vibration. If any fractured joint is found, the whole board should be examined and resoldered as necessary. Addition of a relay hold down spring may be advisable in some environments.

   Relay coil "buzz" will result if the electrolytic capacitor becomes open. The relay should also be examined for contact damage.

   Other components may occasionally fail or be damaged. Refer to the appropriate circuit diagram for information. All resistors are 1/2 watt and unspecified diodes may be type 1N4002 or equivalent.