YSI MODEL 3000 T-L-C METER INSTRUCTION MANUAL

YSI

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PRICE $10.00

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GENERAL DESCRIPTION

The YSI Model 3000 System

The YSI Model 3000 T-L-C Meter is a self-contained field instrument and probe system that measures temperature, water level, conductivity and temperature compensated conductivity for water quality applications.

The digital meter uses a 3½ digit LCD with ½ inch high characters for easy reading. This watertight instrument is housed in the center of the easy-to-use cable reel and can be removed when necessary for replacement of batteries. A low battery indicator signals when the batteries need to be changed. The case is made of tough molded nylon and ABS. It is bright yellow for easy visibility. Abbreviated instructions are printed on the back of the instrument. An integral clipboard offers convenience in carrying papers and notes.

The probe is designed to fit easily into well boreholes, but is equally functional in general surface water applications. The probe and cable are of materials generally accepted for borehole use.

Temperature is measured by means of a precision thermistor assembly built into the probe housing, and is expressed in degrees Celsius (°C).

Conductivity is displayed in millimhos/centimeter (m℧/cm). The YSI Model 3000 is direct reading for conductivity with a sensor which has a cell constant of K = 5.0/cm. Overrange is indicated by a 1 followed by blank spaces on the display.

By convention, the conductivity of a solution is referenced to 25°C. Two temperature compensated conductivity ranges are provided on the Model 3000 which permit the reading to be corrected to 25°C. This automatic correction uses a temperature coefficient of 2%/°C*, calculated by the following formula:

$$\text{Compensated Conductivity} = \frac{\text{Uncompensated Conductivity}}{[(P/4\%)(.04T - 1)] + 1}$$

T = temperature in °C
P = temperature coefficient (2%/°C)

The probe cable is marked at one foot intervals. When the probe is lowered into a well casing, level can be easily determined by watching the instrument display for a significant rise in the reading as the sensor comes into contact with the water. Level may then be read directly from the cable.

Probe Description

The YSI Model 3050 is an integral conductivity/temperature probe of rigid and durable chlorinated polyvinyl chloride. Its stainless steel weight facilitates lowering it into a borehole or well casing. The CPVC body is 1 inch in diameter by 4¾ inches in length.

Two platinized electrodes measure conductivity, and a precision thermilinear thermistor measures temperature.

A 150 foot polyurethane jacketed cable is attached to the probe body to permit deep immersion. This four conductor cable is marked every foot with numbers and a pointer in the form of the letter **V** to indicate the depth of the probe. A watertight MS type connector terminates the cable.

The probe is accurate for temperature changes in 40 to 60 seconds, and to conductivity changes in 10 seconds.

*Recommended in *Official Methods of Analysis of the Association of Official Analytical Chemists*, Ed. Sidney Williams, 14th edition, 1984, Arlington.

Back view of the Model 3000, showing the Instruction Label.

SYSTEM SPECIFICATIONS

Conductivity

Ranges: 0.0 through 1.999 m℧/cm conductivity
0.0 through 19.99 m℧/cm conductivity
0.0 through 1.999 m℧/cm conductivity temperature compensated to 25°C.
0.0 through 19.99 m℧/cm conductivity temperature compensated to 25°C.

Accuracy of Conductivity Measurements: ±3% of full scale at 25°C.

Accuracy of Temperature Compensated Conductivity Measurements: ±4% of full scale over normal ambient temperature range.

Temperature Compensated Conductivity: automatically corrected to 25.0°C (77.0°F) with a temperature coefficient of 2%/°C.

Resolution: 1 part in 2000 in conductivity or temperature compensated conductivity.

Temperature

Measurement Range: −5.0 to 50.0°C (23.0 to 122.0°F). Measurements beyond this range will not be within specification accuracy.

Accuracy of Temperature Measurements: ±0.3°C.

Resolution: 0.1°C.

Probe

Cable Length: 150 feet ±.3 feet: ±.1 foot per 50 feet

Cell Constant: K=5.0/cm ±2%, at 25.0°C (77.0°F), at 0.0 to 20.00 m℧/cm, referenced to a 0.01 normal KCl solution.

Instrument

Size: 31.2 h by 25.4 w by 15.2 d centimeters (12.3 h by 10.0 w by 6.0 d inches)

Weight: 3.4 kilograms (7.5 pounds) maximum.

Ambient Operating Temperature Range: 0.0 to 50.0°C (32.0 to 122.0°F)

Humidity: Will operate under any humidity condition as long as seals are intact and dessicant is in place.

Watertight: Impervious to rain or well water (tested according to procedures in MIL-T-28800 C)

Shock and Vibration: Shock tested to 30 G and vibration tested to 3 G (per MIL-T-28800 C)

EMI: Complies with FCC emanation rules (47CFT part 15 subpart J) as applicable for Class A and Class B environments

Battery

Voltage: 9 VDC (six 1.5 VDC heavy-duty "C" cells)

Indicator: display will indicate "BAT" when combined batteries fall below 7.2 ±0.2 VDC; approx. 8 hours of use left.

Life: 1200 hours minimum, at 4 hours per day use. Alkaline batteries will provide approximately 1700 hours of use.

ACCESSORIES

3040 Test Probe
3045 Platinizing Instrument
3050 Probe and Reel Assembly
3140 Platinizing Solution
3167 Conductivity Calibrator Solution, 1 m℧/cm, 8 one pint bottles
3168 Conductivity Calibrator Solution, 10 m℧/cm, 8 one pint bottles

Accessories may be purchased from your YSI dealer.

REPLACEMENT PARTS

060885	Probe Weight	060857	Knob
060854	Switch PC Board	060845	Amplifier PC Board Assembly
060852	1⅜" O-ring	060851	6¼" O-ring
001495	Switch Nut	060829	⅞" O-ring
060836	Dessicant	060850	¼-turn Stud
060923	Maintenance Kit		

Replacement parts may be purchased from your YSI dealer or directly from the YSI Product Service Department.

Required Notice

The Federal Communications Commission defines this product as a computing device and requires the following notice:

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- reorient the receiving antenna
- relocate the computer with respect to the receiver
- move the computer away from the receiver
- plug the computer into a different outlet so that the computer and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: "How to Identify and Resolve Radio-TV Interference Problems." This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 0004-000-00345-4.

OPERATION

Temperature

(a) To measure temperature, set the function switch to **°C**.
(b) Completely submerge the probe in the water to be measured.
(c) Once submerged, allow time for the probe to come to temperature equilibrium with the water. This usually takes about three minutes.
(d) Read the displayed value after the reading is stable.

Conductivity

(a) To measure conductivity, set function switch to **2 m℧/cm**.
(b) Completely submerge the probe and observe the displayed value after reading is stable. This usually takes from 10 to 20 seconds.
(c) If the overrange signal is displayed (1.---), then the conductivity of the water is in excess of 1.999 m℧/cm. Reset the switch to **20 m℧/cm**. If the overrange signal is still displayed, the conductivity is greater than 19.99 m℧/cm.
Measurements are not temperature compensated in this mode.

Temperature Compensated Conductivity

(a) To measure temperature compensated conductivity, set the function switch to **2 m℧/cm TC to 25°C**.
(b) Completely submerge the probe and allow sufficient time for it to reach equilibrium with the water. This usually takes from 10 to 20 seconds.
(c) Observe the displayed value after the reading is stable.
(d) If the overrange signal is displayed (1.---), then the temperature compensated conductivity of the water is in excess of 1.999 m℧/cm. Reset the switch to **20 m℧/cmTC to 25°C**. If the overrange signal is still displayed, the conductivity is greater than 19.99 m℧/cm.

Table 1 shows corrections for 2%/°C change from 25°C at 1 m℧/cm.
Table 2 shows correction values applied to two typical solutions.

Level

(a) To measure water level, set the function switch to any of the conductivity modes.
(b) Lower the probe into the well or borehole just until the displayed value rises suddenly from about zero to some higher value. The probe begins to measure conductivity when the conductivity cell electrodes just touch the water. The reading at this point will be about ½ of the actual conductivity. When the probe is completely submerged, the reading will be about double the value displayed at the original contact point, where the probe just touches the water.
(c) Raise the probe slowly out of the water until the displayed value goes back to approximately zero.
(d) Lower the probe very slowly until the reading rises suddenly to about ½ the full conductivity value read above.
(e) Compare cable marking to the well reference point to determine the water level. Read the number of feet from the probe cable and measure tenths and hundredths of a foot with the .5 foot scale printed on the instruction label. Note that the rule is calibrated in tenths and hundredths of a foot and is designed to make it easy either to add or to subtract hundredths of a foot from a cable foot marker.

CABLE REEL OPERATION The cable used in the YSI Model 3000 has been selected for a number of special properties. One property that has been compromised, however, in order to obtain an accurate and durable product, is the coefficient of friction between adjacent surfaces of the cable.

The cable winds into its housing like fishing line onto a reel. It is important to provide drag manually when winding the cable in order to insure a compressed cable wind. Since there is no level-wind mechanism to distribute the probe cable evenly, the user must control its winding and unwinding. Regulate both drag and cable motion by feeding it through your fingers to insure even distribution. While rewinding, the cable entry aperture of the instrument should be pointed toward the mouth of the well.

A wet cable aids in achieving a flat wind because the water decreases the friction between the cable surfaces. Rewinding will require more effort when winding dry cable; the winding effort necessary will diminish markedly when wet cable reaches the reel.

The cable may be pulled or unwound out of the housing for about the first six feet. Thereafter, the reel should rotate freely until the entire 150 feet has been dispensed. The user should provide some drag or friction along the edge of the reel flange in order to have control of its spinning motion when the probe reaches the water surface.

Errors

The maximum error of a meter reading will be a worst case combination of temperature and conductivity specification tolerances. Errors can be minimized by calibrating the Model 3000 with YSI conductivity standards. (See Calibration.)

(a) Temperature – The maximum error in this instrument when used to measure temperature between the measuring limits of –5.0° and 50.0°C is ±0.3°C. Example:
Meter Reading: 16.5°C
Error: ±0.3°C
Accuracy: 16.5 ±.3°C
(b) Conductivity – The maximum instrument error (not including temperature error) when used to measure conductivity in either range is ±3% of the full scale range limit. This represents the combined instrument and probe errors. Example:
Meter Reading: 9.00 m℧/cm
% Error: .03 × 20.00 m℧/cm
Accuracy: 9.00 m℧/cm ±.60 m℧/cm
(c) Temperature Compensated Conductivity: The maximum error when measuring temperature compensated conductivity in either range is ±4% of the full scale range limit. This represents the combined instrument, probe and temperature errors. Example:
Meter Reading: 11.00 m℧/cm
% Error: .04 × 20.00 m℧/cm
Accuracy: 11.00 m℧/cm ±.80 m℧/cm
(d) Level: The maximum error for water level measurement is ±1 inch/50 feet. This represents the combined errors due to the cable foot indicators, the 6 inch rule on the label and the cable stretch when fully suspended in a well casing. Example:
Cable Reading: 87.4 feet
Error: ±.2 feet
Accuracy: 87.4 ±.2 feet

MAINTENANCE

Instrument

The Model 3000 requires only battery replacement, dessicant replacement, seal replacement and occasional cleaning. A kit for annual maintenance is available from your dealer or from YSI. See Replacement Parts.

Battery Replacement: The six heavy-duty "C" cell batteries supplied with the instrument will last approximately 1200 hours when used about 4 hours a day. Alkaline batteries will provide about 1700 hours of use. When BAT appears in the upper left corner of the display, about 8 hours of use remain. However, it is wise to replace the batteries as soon as possible after this signal appears. Follow these procedures:

(a) Rotate the reel handle to uncoil about one foot of the cable.

(b) Next, with coin or screwdriver, turn in a counterclockwise direction the ¼-turn screw located in the face of the instrument.

(c) Remove the electronics and probe reel assemblies from the housing and disconnect the probe connector (located on the back of the electronics assembly) by turning its sleeve counterclockwise. Carefully note, or mark, the side of the reel into which the electronics assembly is inserted; the probe connector will not reach the jack, or the reel will not properly engage into the handle if the reel is reversed.

(d) Remove the nine screws on the back of the electronics assembly.

(e) Remove the probe reel from the electronics assembly.

(f) Separate the front and back halves, being careful not to damage the three o-rings that provide watertight integrity.

(g) Remove the old batteries and replace with new batteries in the battery holders. Be careful to observe the correct polarity; red indicators mark the positive terminals. Turn on the unit after the batteries are installed to make sure that the instrument is in working order before it is reassembled.

(h) Remove, dry and replace, or install a new dessicant container.

(i) Reassemble the instrument by reversing the dissassembly steps. Be very careful not to damage or misalign the o-rings.

Electronics Housing, showing battery placement

Dessicant Replacement: When the case is opened for any reason, the interior will have the same relative humidity as the surrounding air. If resealed and later operated at a lower temperature, internal condensation might occur. The dessicant prevents this. The dessicant container should be removed for replacement annually. Do not remove the new dessicant container from its protective bag until ready for instrument reassembly.

Seal Replacement: To insure watertight integrity, the three o-rings and nine screw seals should be replaced annually. See Battery Replacement for disassembly and reassembly procedures. The third o-ring is located on the socket side of the MS type connector.

Cleaning: When it is necessary to clean off dirt and collected films, simply wipe the case with a solution of liquid detergent and water. Rinse the instrument with clean water. Do not disassemble. If a stubborn stain cannot be removed with soap and water, alcohol may be used. Do *not* use ketones or chlorinated solvents to clean the case as they will damage it.

Storage: When the Model 3000 is to be stored for more than a few months, the batteries should be removed to reduce the risk of corrosion damage.

Probe

Cleaning: The probe cable may be cleaned by wiping with a wet sponge. Isopropyl alcohol may be used for stubborn residues.

The probe must be kept clean at all times to assure proper operation and accuracy. A dirty probe will contaminate the sample and cause the conductivity to change. Any of the foaming acid tile cleaners such as Dow Chemical "Bathroom Cleaner" will clean the probe adequately. When a stronger cleaning preparation is required, use a solution of equal parts of isopropyl alcohol and 10 normal HCl. Do not clean the probe in aqua regia or in any solution known to etch platinum or gold.

Dip the probe into the cleaning solution and agitate for two or three minutes. Rinse the probe in several changes of distilled or deionized water. Inspect the platinum black electrode coating to determine whether replatinizing is required. CAUTION: Do not use anything to touch the electrodes inside the probe body. Platinum black is soft and can be easily scraped off.

Storage: It is best to store conductivity probes in deionized water. Probes stored in water require less frequent platinizing. When probes are stored dry, it is necessary to soak them in deionized water for 24 hours before use.

Replatinizing: If cleaning does not restore probe performance, or if flaking or other defects in the platinum black coating are apparent, replatinizing is necessary. A YSI 3045 Platinizing Instrument and YSI 3140 Platinizing Solution are available for this procedure. Clean the probe thoroughly and replatinize as follows:

(a) Uncoil about two feet of cable and remove the electronics and probe reel assemblies from the instrument housing. Remove the probe cable connector from its jack.

(b) Immerse the probe's electrodes in the platinizing solution, either in the bottle provided, or in another suitable, non-reactive vessel. Do not submerge the entire probe body; the thermistor housing located beside the bend relief spring should not come in contact with the platinizing solution.

(c) Connect the probe's MS connector to the Platinizing Instrument and hand tighten the connector sleeve. Once this connection is made, the LED on the Model 3045 will light to indicate that there is good continuity to the electrodes and enough life in the battery to complete the replatinizing. If the LED does not light, replace the battery.

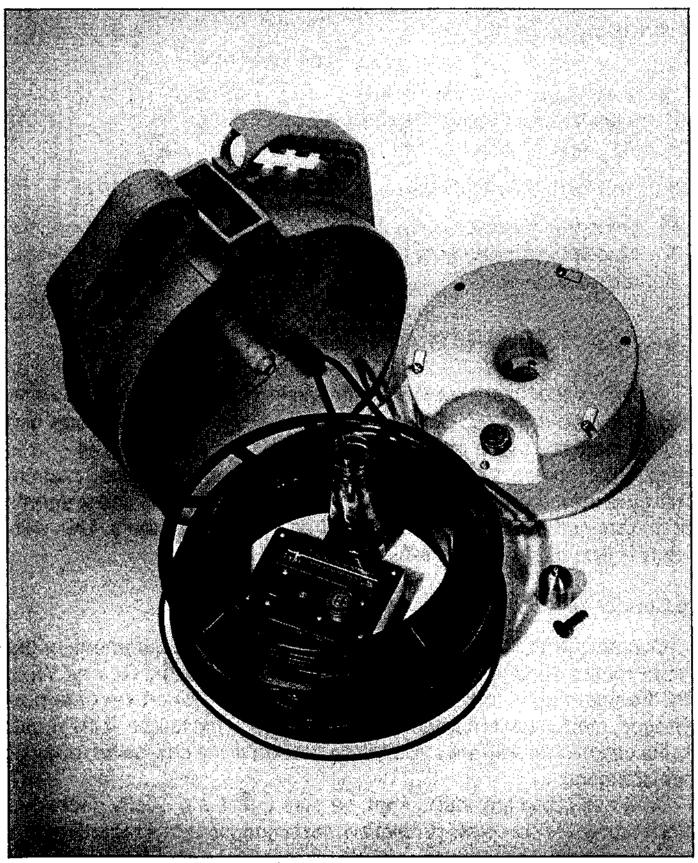
(d) Using the slide switch, reverse the polarity every 30 seconds until both electrodes are covered with a thin layer of platinum black (about 4 to 5 minutes). Do not over-platinize.

(e) Remove the probe from the solution; disconnect it from the Platinizing Instrument.

(f) Reassemble and reconnect the probe and reassemble the YSI 3000. Rinse the probe electrodes with flowing tap water for about 15 minutes followed by a distilled water rinse for 2 minutes.

(g) Return the platinizing solution to its container. This 2 ounces of solution should be sufficient for 50 treatments. It is expensive and should not be wasted. Replace it only when it will no longer deposit a layer of platinum black.

(h) Test probe and instrument with calibration solution. (See CALIBRATION.)



Replatinizing the Probe

CALIBRATION

Instrument

The Model 3000 is calibrated at the factory. There are no user adjustments inside the instrument. Should you suspect that your instrument is out of calibration, either send it to the factory for calibration or test it with the YSI 3040 Test Probe.

Remove the electronics and probe reel assemblies from the instrument housing and disconnect the probe.

First, check for the following readings with no probe connected:

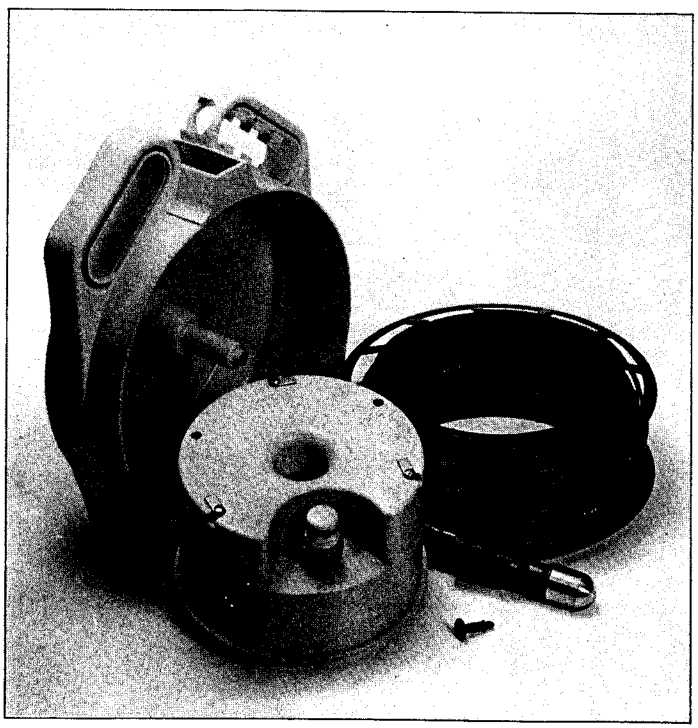
SWITCH POSITION	CORRECT READING
°C	−34.0 ±.2°C
2 m℧/cm	.000 ±.002 m℧/cm
20 m℧/cm	0.00 ±.02 m℧/cm
2 m℧/cm TC to 25°C	1.---
20 m℧/cm TC to 25°C	1.---

If these readings are observed, then plug the YSI 3040 Test Probe into the probe jack. The 3040 is a probe substitute that simulates a temperature and a conductivity. Test for the following readings:

SWITCH POSITION	CORRECT READING
°C	15.1 ±.2°C
2 m℧/cm	1.563 ±0.020 m℧/cm
20 m℧/cm	1.56 ±0.20 m℧/cm
2 m℧/cm TC to 25°C	1.954 ±0.040 m℧/cm
20 m℧/cm TC to 25°C	1.95 ±0.40 m℧/cm

Remove the Test Probe and reassemble the instrument.

If the instrument failed to meet these specifications, refer to Warranty and Shipping.



Electronics Housing with Test Probe Installed

Probe

The YSI 3050 Probe is calibrated at the factory. The cell constant of any conductivity probe may vary slightly with the conductivity of the solution being measured. Calibration may also be affected by electrode fouling, the need for replatinizing, or by mechanical shock. The Model 3050 Probe can be calibrated together with the Model 3000 Instrument as a system with YSI 3167 or 3168 Conductivity Calibrator Solutions. These solutions are specially packaged in unbreakable plastic one pint bottles for field use. They are packaged eight bottles to a box. The solutions are manufactured to approximately 1 m℧/cm or 10 m℧/cm concentrations with the accuracy printed on each label.

Confirm the calibration of the YSI 3000 system as follows:

(a) Rinse the probe with some of the solution to remove any contamination. Be careful to leave not less than 8 ounces of the solution in the bottle; it must be at least half full.

(b) Immerse the probe in the remaining solution, in its own bottle, and switch to either 2 m℧/cm TC to 25°C or to 20 m℧/cm TC to 25°C according to the range necessary for the solution used.

(c) Take note of the displayed value. By comparing this to the conductivity calibrator solution value, the accuracy of the YSI 3000 can be determined. If the displayed value is within 4% of the calibrator value, then the Model 3000 is within its specifications and can be used. The percent error calculated can also be used as a correction factor to improve the accuracy of measurement of the samples being tested. If the error is greater than 4%, the instrument should be tested with the YSI 3040 Test Probe (see Instrument Calibration). If it passes these tests, replatinize the probe (see Probe Maintenance).

The following shows how to make a corrected determination of improved accuracy. In this example, YSI 3167 Conductivity Calibrator Solution is used, and the T-L-C Meter is set to 2 m℧/cm TC to 25°C.

$$\text{Corrected Sample Value} = \frac{\text{Calibrator Value}}{\text{Displayed Value}} \times \text{Sample Value}$$

Displayed Value = .978 m℧/cm
Calibrator Value = .996 m℧/cm
Sample Value = .634 m℧/cm

(.996 m℧/cm) / (.978 m℧/cm) × (.634 m℧/cm) = .646 m℧/cm

(d) Once the accuracy of the Model 3000 has been determined, discard the calibrator solution. It has been contaminated and should not be reused.

WARRANTY AND SHIPPING INFORMATION

All YSI products are warranted for one year against defects in workmanship and materials when used for their intended purposes and maintained according to manufacturer's instructions. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. This warranty is limited to repair or replacement.

If Service Is Required:

Contact the YSI dealer from whom you bought the instrument, or the YSI Product Service Department. You may also call the factory; YSI's toll free number is (800) 343-4357 (343-HELP). Report the date purchased, model, serial number, and the nature of the failure. If the repair is not covered by warranty, you will be notified of the charge for repair or replacement.

When shipping any instrument, be sure that it is properly packaged and insured for complete protection. In communications regarding this instrument or accessories please mention the model and serial number.

CIRCUIT DESCRIPTION

Three board assemblies are used. By means of J101, J103 and P102, the Amplifier Board is connected to P201 on the Switch Board, to P302 on the probe, and to J402 on the Display Board. Each board can be purchased separately (see Replacement Parts).

Switch PC Board: This board controls the signal switching through S201, a 4p-6t switch. Section 1 of the switch controls the decimal point and the applied power from BT 101 through BT 106. When the switch is in other than the **OFF** mode, Q101 is forward biased via Q201, Q202 or Q203 and R201. This in turn generates +V for the instrument with −V always being present. This board also provides space for selected resistors. Other switch functions are described below.

Amplifier PC Board: This board controls signal conditioning for the instrument through the use of four basic circuits. U104, Q102, R114 and R115 take the 40 KHz clock from the display (M401) and frequency divide the signal down to 1000 (Y) and 2000(X) Hz. The 1000 Hz signal in turn is voltage limited and shaped by U101A. −B, and −C, R101, R102, R103 and C101 which form a modulator circuit. This circuit generates a 200 mv p/p square wave which will be the reference for the rest of the signal conditioning. This square wave is regulated to 100 mv DC by R105 and C103 for the temperature measuring circuit.

U102A and U102B are operational amplifiers that determine the voltage level to the display in proportion to the measured resistance of the thermistors in the probe. Gain is determined by R107, R109, R110, R111 and R112. C104, C107, and C108 provide circuit stability.

R301 and R302 are thermistors and with R303 form the temperature measuring sensor in the probe. When the instrument is in the temperature compensating modes, R202, R205 and R206 are placed in the circuit to form voltage divider networks which change the reference voltage to the display in proportion to the temperature shift away from 25°C. This is accomplished by sections 2 and 3 of S201. R106 buffers the output to the display.

The 200 mv square wave is coupled to the conductivity measuring circuit via R104 and C102. U105 is an operational amplifier which acts as a buffer and gain circuit for the conductivity probe. The gain of this circuit is determined by section 4 of S201 which selects R203 or R204 to set the instrument range.

A square wave is used across the electrodes (K301 and K302) of the probe to avoid a polarizing field between them.

U103, U101-d, C105 and C106 form a demodulating circuit using the 1000 and 2000 Hz signals to change the square wave into a DC voltage proportional to the conductivity of the fluid tested. R113 is used as a buffer to isolate the conductivity and temperature circuits. C110 helps provide circuit stability.

Display PC Board: This board has no user serviceable components. It supplies a 40 KHz signal for the amplifier board as well as the voltage common for the entire system. This common is 2.8 VDC below +V and is held constant to the rest of the "lo" inputs. The display receives the analog input and compares it with the 100 mv dc reference voltage supplied in the temperature circuit and in turn determines the value to be displayed by proportional comparison. When temperature compensation is selected, the reference voltage changes proportionally with the temperature.

TABLES

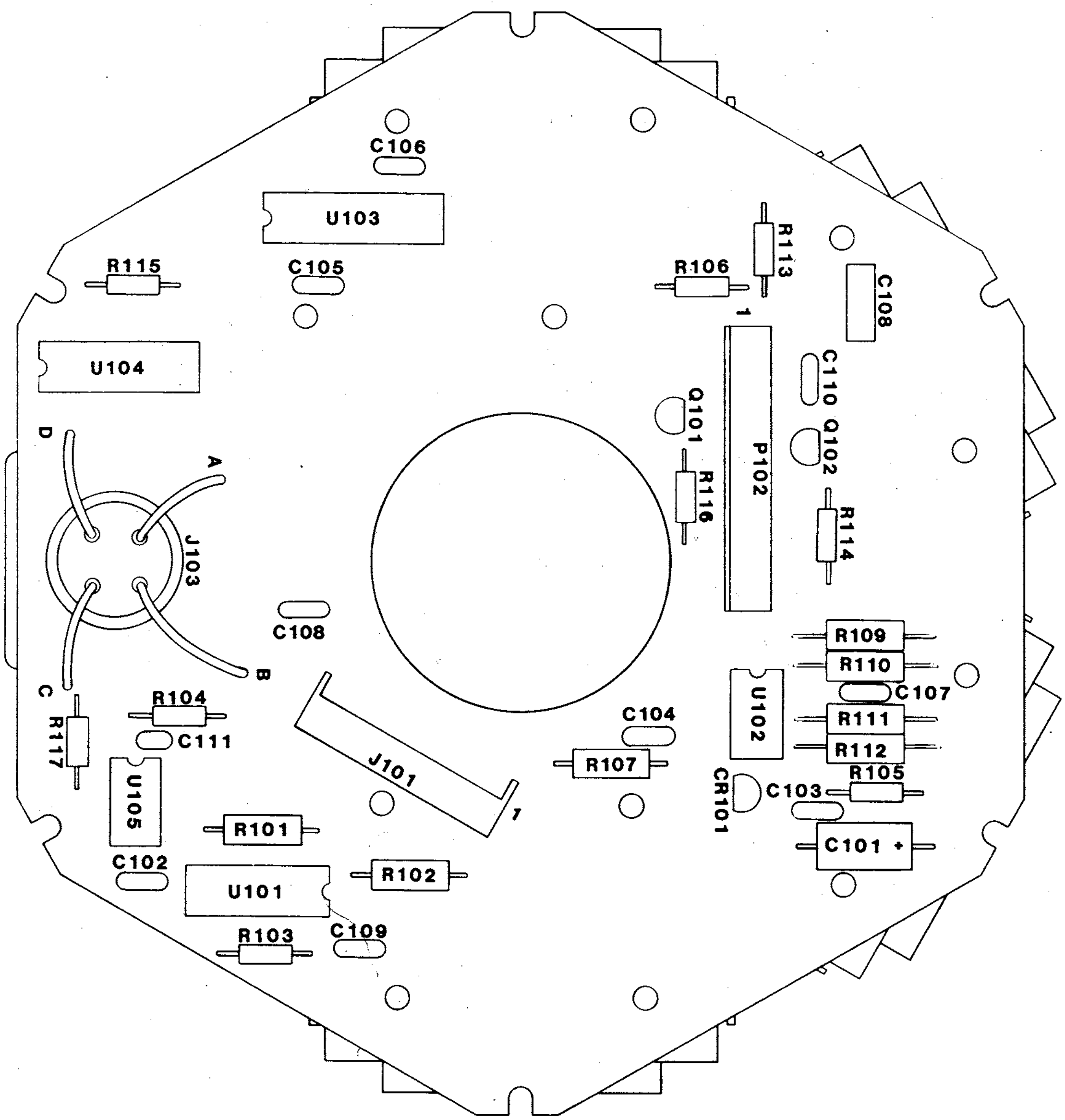
1 Temperature Correction Values Used for Automatic Temperature Compensation By the Model 3000

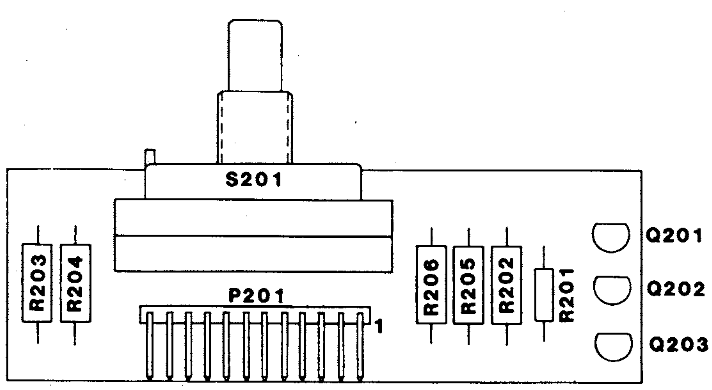
TEMPERATURE °C	CONDUCTIVITY in m℧/cm TC to 25°C
−5	2.500
0	2.000
+5	1.667
10	1.429
11	1.389
12	1.351
13	1.316
14	1.282
15	1.250
16	1.219
17	1.191
18	1.163
19	1.136
20	1.111
21	1.087
22	1.064
23	1.042
24	1.020
25	1.000
26	.980
27	.962
28	.943
29	.926
30	.909
35	.833
40	.769
45	.714
50	.667

2 Temperature Correction Value of Two Typical Solutions (0.007 Normal and 0.089 Normal Potassium Chloride)

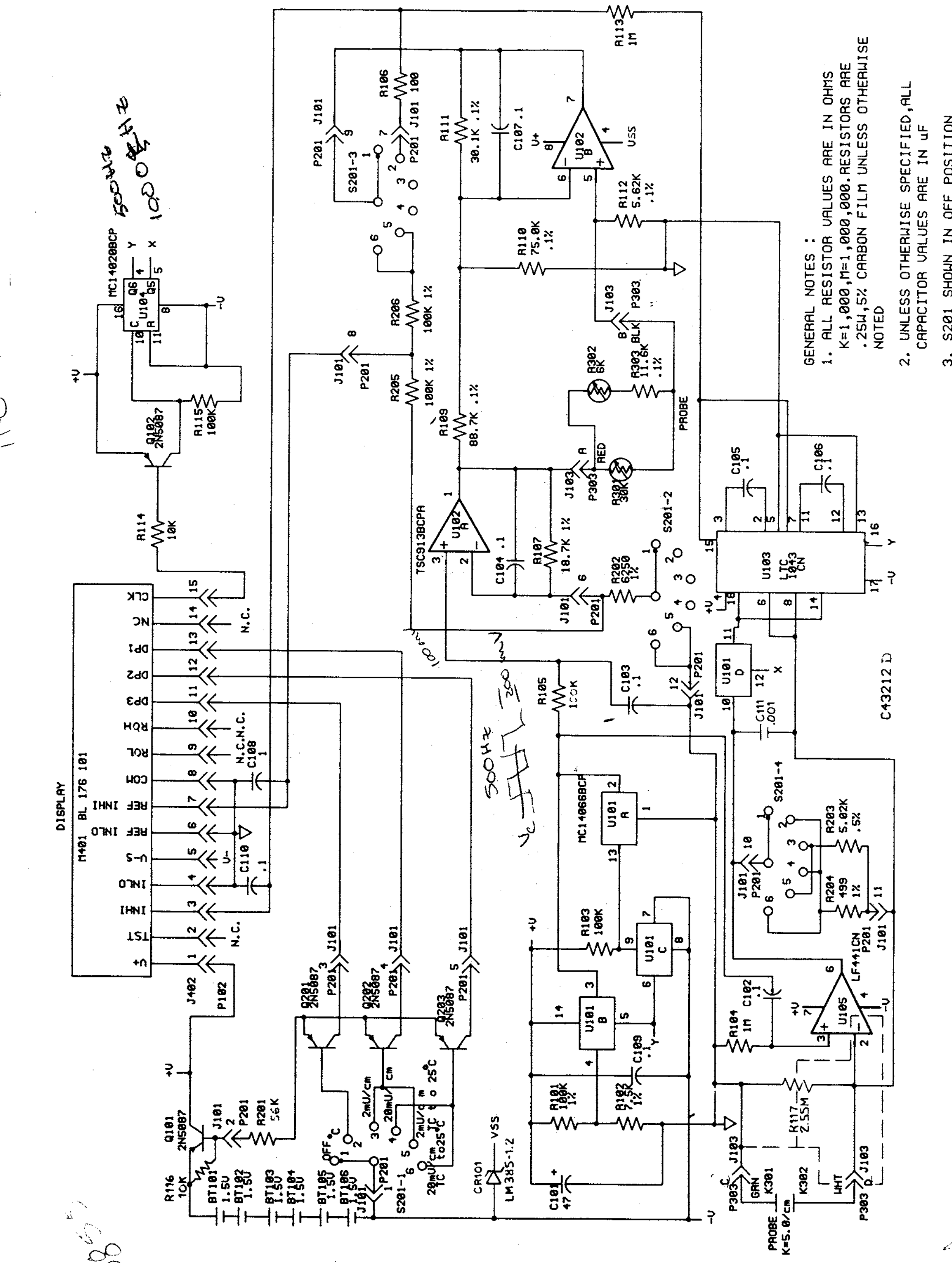
TEMPERATURE	0.007N KCl 1.000 m℧/cm	0.089N KCl 10.00 m℧/cm
−5	.455	4.71
0	.541	5.54
+5	.628	6.39
10	.718	7.26
11	.736	7.44
12	.754	7.61
13	.773	7.79
14	.791	7.97
15	.810	8.15
16	.829	8.33
17	.847	8.52
18	.866	8.70
19	.885	8.88
20	.904	9.07
21	.923	9.25
22	.942	9.44
23	.961	9.62
24	.981	9.81
25	1.000	10.00
26	1.020	10.19
27	1.039	10.38
28	1.059	10.57
29	1.079	10.76
30	1.098	10.96
35	1.199	11.93
40	1.302	12.93
45	1.406	13.95
50	1.513	14.99

AMPLIFIER BOARD AND SWITCH BOARD COMPONENTS





SCHEMATIC



This schematic is representative only, and may be slightly different from the circuit in your instrument.