

PORTABLE PRECISION THERMISTOR THERMOMETER

by

Barrett F. Robinson and LeRoy F. Silva

A thermistor thermometer is now available for ground truth and general purpose temperature measurements. The thermometer features digital display, battery operation, and accuracy.

For the convenience of the user, the thermometer is transported in a water-tight case which is safe and easy to handle under field measurement conditions. In addition to protecting the instrument from bumps and dirt, the loaded case will float.

Specifications

Accuracy: $\pm .4$ centigrade degrees from 0°C to 100°C

$\pm .1$ centigrade degrees from 15°C to 40°C

The device may be referenced to a standard thermometer for accuracies of $\pm .04$ centigrade degrees from 0°C to 100°C .

Operating temperatures (ambient):

15°C to 35°C for stated accuracy. The device will operate properly from 0°C to 50°C .

Weight: with case, 30 lbs.

without case, 17 lbs.

Dimensions: Case - $21 \times 19 \frac{1}{2} \times 6 \frac{1}{2}$ in³

Surface probe:

Yellow Springs Instrument Co., Inc. Part No. 709

Lead length - 10 feet

Water time constant 1.7 seconds

Completely immersible in water

Specifications (con't.)

Depth probe:

Yellow Springs Instrument Co., Inc. Part No. 703

Lead length - 10 feet

Water time constant 3.4 seconds

Immersible to 4 1/2 inches in water

Power requirements:

When line operated: 50-60 Hz, 115v, 13 watts

ELECTRONICS:

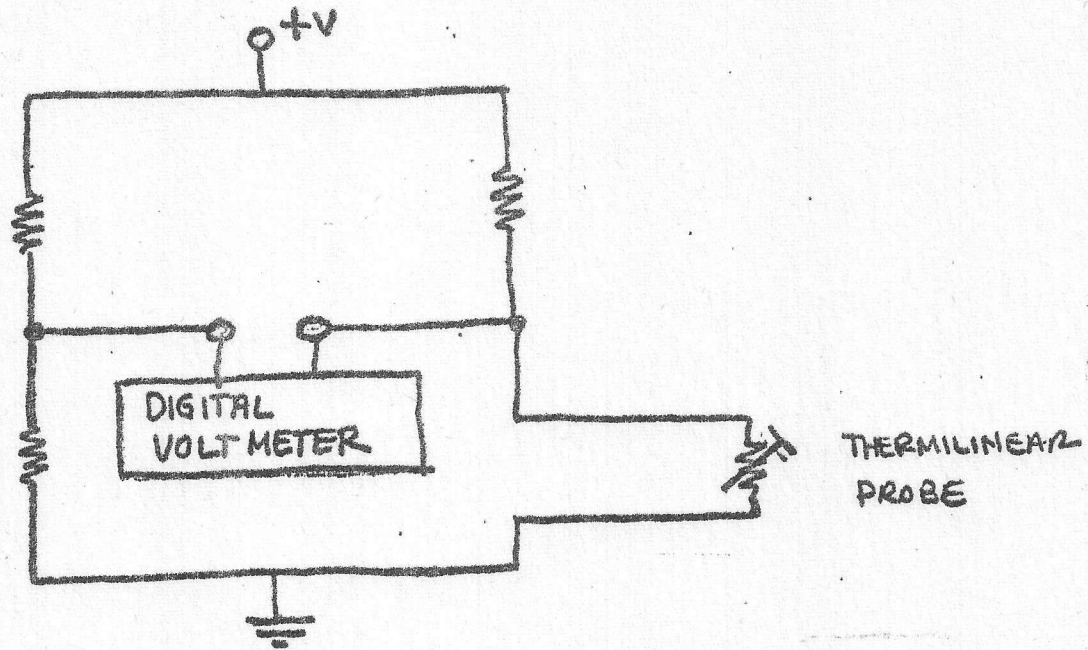


Figure 1. Bridge circuit for temperature to voltage conversion

A. Temperature to Voltage Converter: (Yellow Springs Thermivolt 741-1).

The sensing electronics may be simplified to the resistance bridge shown in Figure 1. The resistance of the probe causes the bridge to balance when the probe temperature is 0° centigrade. As the temperature increases, the resistance of the probe decreases until a difference voltage of 1000 millivolts is produced when the probe temperature is 100° centigrade.

The remaining electronics are devoted to providing an accurately adjusted and well regulated reference voltage, V. (See Figure 1 and 2).

B. Digital Voltmeter: (John Fluke 8100A).

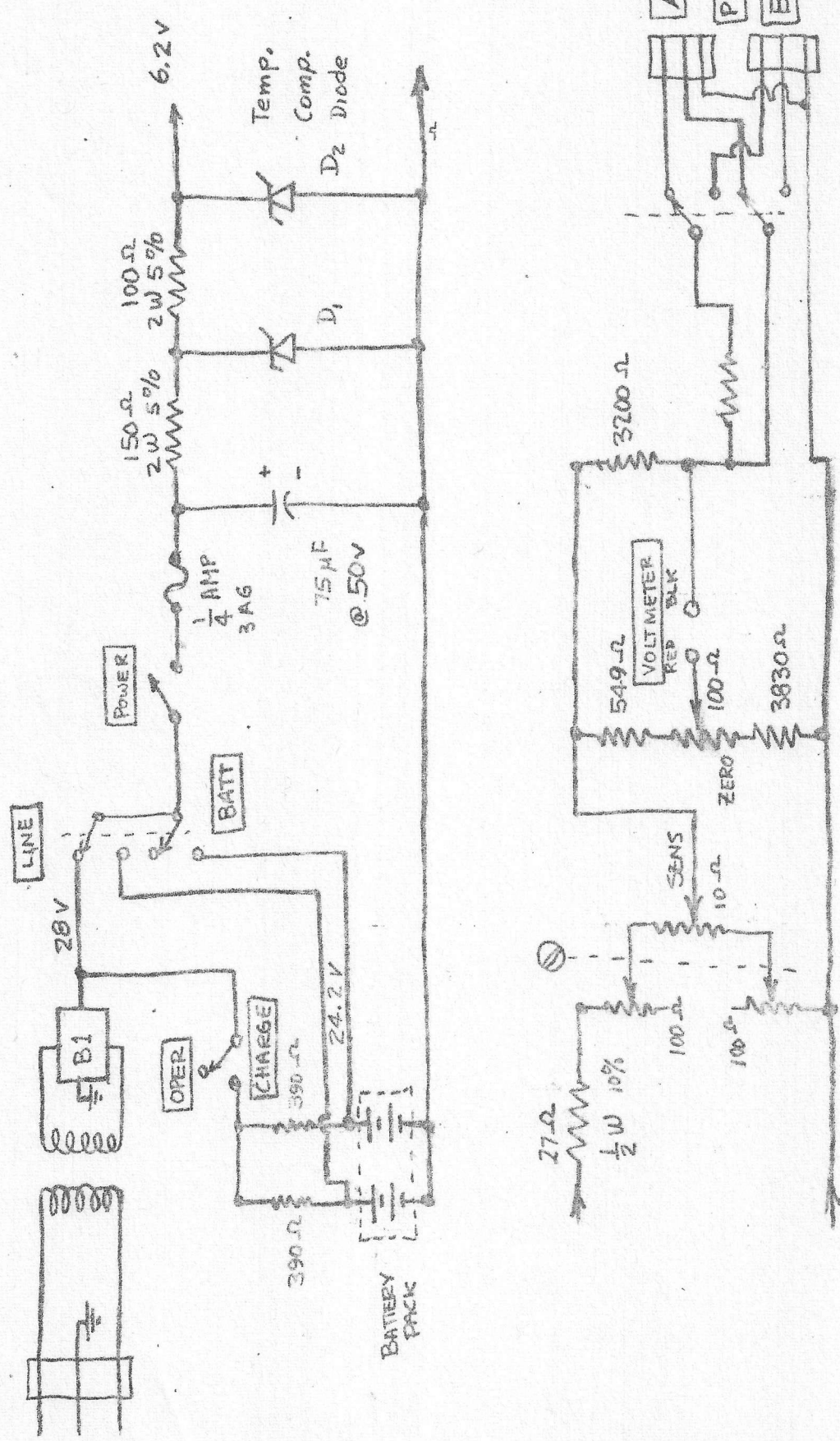


Fig. 2 Circuit Diagram for the Temperature to Voltage Converter.

$D_1 = 1N4743$, $D_2 = 1N823$, BATT. PACK = 4 each 10/B 450T, B1 = FULL WAVE 1A-100 PIV

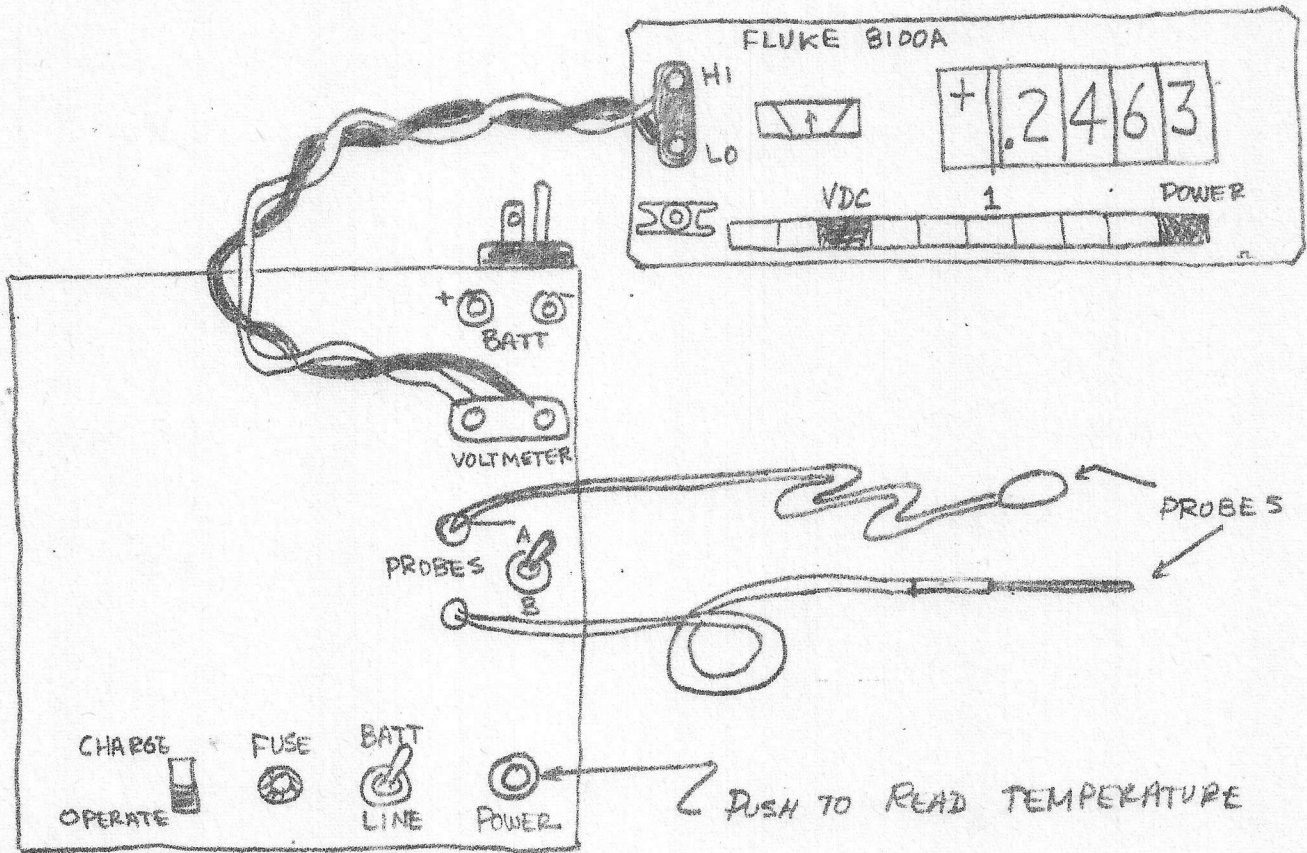


Fig. 3 Switch Positions and Connections for Battery Operation. Temperature Shown is 24.63 Degrees Centigrade.

Figure 3 shows the procedure for battery operation. For LINE operation, connect the power cords and plug them into three-wire, 115 volt, 50-60, Hz, AC receptacles. When switched ON, the Fluke 8100A digital voltmeter will automatically switch to line operation and the meter on the front panel will indicate this. To use temperature to voltage converter in the LINE mode, put the BATT-LINE switch in the LINE position and turn the POWER switch ON.

Operation:

A. Probes

1. General

a. Thermistors are faster than glass thermometers - much faster. Still, the time required for a probe to reach thermal equilibrium will depend on the thermal contact and the initial temperature difference. For example, 20 seconds should be adequate for most measurements in water. While one minute may not be sufficient for soil measurements and five minutes or more may be required for the measurement of air temperature.

b. As the ambient temperature changes, the temperature of the system being measured will change. Such changes will be reflected in your measurements. Therefore, if you assume a constant ambient temperature, prove it. Allow the depth probe to be immersed in the air for ten minutes. Then, record readings every minute for 20 minutes. Do not touch the probe or use it in any other way during this period.

c. In the open field, the temperature of plants, soils, etc. can change very rapidly with changing sun and wind conditions. Do not assume a constant temperature. Report the limits of your measurements. For example, suppose that, after a two or three minute waiting period, the temperature reading varies within the range +38.70° to +42.70° and then holds momentarily at 41.35°. The number 41.35 is of little use and is misleading. The user of the report will appreciate the result being stated in a scientific fashion:

$$40.7^{\circ} \pm 2.0^{\circ}$$

- The surface probe should be used with the shiny side touching the surface whose temperature you wish to measure. This probe may be used in sunlight. It may be taped or mechanically held to the surface provided the tape or mechanical device are reasonably bad conductors of heat: ie, wood and cloth.

Don't hold probe leads with your fingers. The probe and leads will conduct heat to the thermistors. Use chop sticks or an equivalent.

- The depth probe should be used with the tip inserted into or held against the substance whose temperature you wish to measure. The stainless steel pointer is a fairly bad conductor of heat so only moderate care need to be taken to avoid heating the thermistors with your fingers.

Don't immerse in liquids beyond 4 1/2 inches

B. Batteries

The battery voltage should be checked periodically. Inaccurate temperature readings will result if the battery voltage is less than 23 volts.

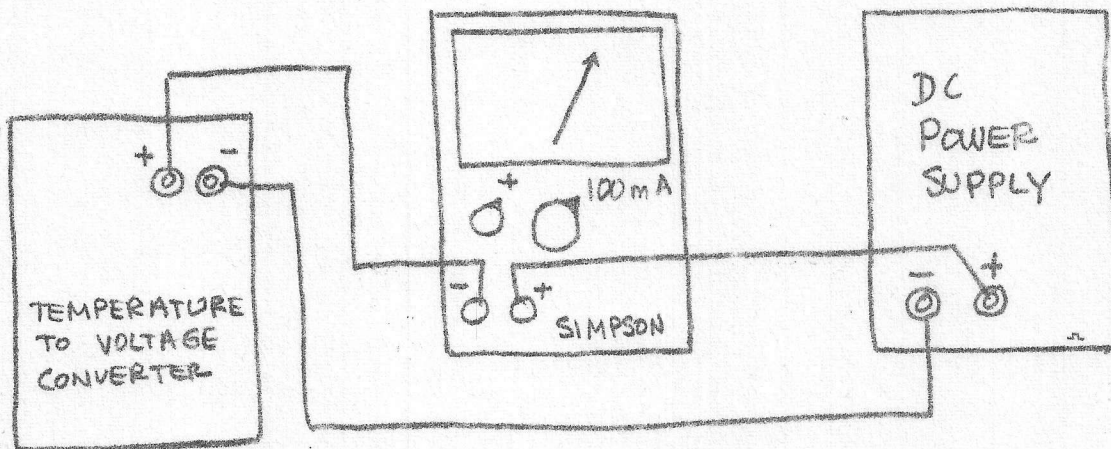


Fig. 4 Connections for Charging Battery in the Temperature to Voltage Converter.

Check the battery voltage by connecting the Fluke 8100A digital voltmeter (100 volt DC range) to the battery jacks (blue and yellow).

Battery Charging:

The batteries of the temperature to voltage converter may be charged in either of the following modes.

Trickle Charge - to "trickle charge" the batteries using the built-in circuit, use the following procedure:

1. Connect the AC line cord.
2. Place the BATT-LINE switch in the LINE position.
3. Place the CHARGE-OPERATE switch in the CHARGE position.
4. At this point, the batteries are being charged. To check the status of the charge, the battery voltage may be checked at the battery jacks by placing the BATT-LINE switch to the LINE position after reading the battery voltage.
5. Charging time in this mode is about 10-12 hours.
6. Upon completion (battery voltage 27-8 volts) return the CHARGE-OPERATE switch to the OPERATE position.

Quick Charge - the batteries may be charged in a shorter period of time by using an external power supply. The procedure for this mode is as follows:

1. Place the BATT-LINE switch to the BATT position. This connects the BATT jacks directly to the battery. The temperature to voltage converter should not be connected to the AC line during charging in this mode.
2. Place the CHARGE-OPERATE switch to the OPERATE position. The CHARGE position of this switch is used for "trickle" charging only.
3. Connect as shown in Figure 4.
4. Charge with 100 milliamperes for 2-4 hours. Then, charge with up to 50 milliamperes for 4 hours or, until the battery voltage is about 27.8 volts.

Storage:

When the temperature to voltage converter is not in use, or being charged, the switches should be in the following positions:

1. CHARGE-OPERATE switch in the OPERATE position.
2. BATT-LINE switch in the LINE position.

John Fluke 8100A:

Procedure - the batteries charge automatically during line operation.
Connect the power cord to 115V, 60 Hz, and turn the instrument on.