



Digital Thermometers

Instruction Manual
Models 865 and 866

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SPECIFICATIONS

MODEL 865 SPECIFICATIONS

TEMPERATURE SENSOR TYPE: Thermistor (2252 Ohm @ 77°F)

RANGE	TEMPERATURE SPAN	RESOLUTION	ACCURACY* (65° to 82°F; 1 year)
200°F	-40.0° to 199.9°	0.1°	±(0.3% rdg + 0.5°F)
	-70.0° to -40.1°	0.1°	±(0.3% rdg + 1.0°F)
300°F	-70° to 300°	1°	±(0.3% rdg + 1°F)

***ACCURACY:** Includes repeatability, temperature coefficient (65° to 82°F), time stability (1 year), and linearization conformity errors. Excludes probe errors; however probe errors around 32°F may be compensated by an internal adjustment.

REPEATABILITY: 0.2°F typical for 1 week at constant ambient temperature.

TEMPERATURE COEFFICIENT: 65° to 82°F; included in accuracy specification. From 14° to 65° and 82° to 122°F; less than ±(0.06% rdg + 0.01°F)/°F.

SENSOR VOLTAGE: 40mV rms maximum.

MODEL 866 SPECIFICATIONS

TEMPERATURE SENSOR TYPE: Thermistor (2252 Ohm @ 25°C)

RANGE	TEMPERATURE SPAN	RESOLUTION	ACCURACY* (18° to 28°C; 1 year)
150°C	-40.0° to 150.0°	0.1°	±(0.3% rdg + 0.3°C)
	-55.0° to -40.1°	0.1°	±(0.3% rdg + 0.6°C)

***ACCURACY:** Includes repeatability, temperature coefficient (18° to 28°C), time stability (1 year), and linearization conformity errors. Excludes probe errors; however probe errors around 0°C may be compensated by an internal adjustment.

REPEATABILITY: 0.1°C typical for 1 week at constant ambient temperature.

TEMPERATURE COEFFICIENT: 18° to 28°C; included in accuracy specification. From -10° to 18° and 28° to 50°C; less than ±(0.06% rdg + 0.01°C)/°C.

SENSOR VOLTAGE: 40mV rms maximum.

MODEL 865 and 866 GENERAL SPECIFICATIONS (unless specified):

DISPLAY: 3-1/2-digit LCD, 13mm (0.5") height. Polarity and decimal point indication.

CONVERSION RATE: 1.5 readings per second.

OPEN SENSOR INDICATION: Display reads between -100° and -199°.

OVERRANGE INDICATION: 3 least significant digits blanked.

MAXIMUM COMMON MODE VOLTAGE: 42V peak to earth.

COMMON MODE REJECTION: Less than 0.01°/volt at DC, 50Hz and 60Hz. (2k Ω unbalance, LO driven).

ENVIRONMENTAL LIMITS FOR OPERATING: -10° to 50°C, (14° to 122°F) less than 80% relative humidity up to 35°C (95°F); linearly derate 3% R.H./°C from 35° to 50°C (1.5% R.H./°F from 95° to 122°F).

ENVIRONMENTAL LIMITS FOR STORAGE: -35° to 60°C (-30° to 140°F), less than 90% relative humidity up to 35°C (95°F); linearly derate 3% R.H./°C from 35° to 60°C (1.5% R.H./°F from 95° to 140°F).

THERMISTOR LINEARIZATION: Ratiometric dual-slope A/D with continuous linearization.

INPUT CONNECTION: 1/4" (6mm) Phone Jack.

POWER: 9V alkaline or carbon-zinc (NEDA 1604) battery.

BATTERY LIFE, CONTINUOUS: 350 hours typical with alkaline battery; 200 hours typical with carbon-zinc battery.

BATTERY INDICATOR: Display indicates "LO BAT" when less than 10% of life remains.

DIMENSIONS, WEIGHT: 160mm long x 69mm wide x 31mm thick (6.3" x 2.7" x 1.2"). Net weight 210gm (7.5 oz.).

CONSTRUCTION: Heavy duty ABS plastic housing.

ACCESSORIES SUPPLIED: Battery and instruction manual.

Specifications subject to change without notice.

GENERAL INFORMATION

The Models 865 and 866 are handheld digital thermometers. Both instruments have large, easy to read, liquid crystal displays (LCD). The input connection for each instrument consists of a 1/4 inch phone jack. This input accommodates any one of the available accessory thermistor based probes and sensors. The resistance value of the thermistor at 25°C (77°F) is 2252Ω. The instruments are powered by a 9V battery. Continuous operation of 350 hours is typical with an alkaline battery or 200 hours typical with a carbon-zinc battery.

The Model 865 measures temperatures from -70°F to 300°F on two ranges. The 300°F range measures temperature from -70°F to 300°F with a resolution of 1°F. The accuracy of the 300°F range is $\pm(0.3\% + 1^\circ\text{F})$. The 200°F range measures temperature from -70°F to 199.9°F with a resolution of 0.1°F. The accuracy from -70°F to -40°F is $\pm(0.3\% + 1^\circ\text{F})$ and the accuracy from -40.0°F to 199.9°F is $\pm(0.3\% + 0.5^\circ\text{F})$.

The Model 866 measures temperature from -55° to 150°C on one range with a resolution of 0.1°C. The accuracy from -55° to -40.1°C is $\pm(0.3\% + 0.6^\circ\text{C})$. The accuracy from -40.0°C to 150.0°C is $\pm(0.3\% + 0.3^\circ\text{C})$.

MANUAL ADDENDA

Improvements or changes to this manual will be explained on an addendum included with the instrument.

UNPACKING AND INSPECTION

The Models 865 and 866 are inspected both mechanically and electrically by TEGAM before shipment. Upon receiving the instrument, unpack all items from the shipping container and check for any obvious damage that may have occurred during transit. Report any damage to the shipping agent. Retain and use the original packing materials if reshipment is necessary. The following items are shipped with all Model 865 and 866 orders:

- Instrument (865 or 866)
- Battery (NEDA 1604)
- Instruction Manual

OPTIONAL ACCESSORIES

Model 8660 Tilt Stand/Belt Clip/Probe Holder for the Model 865 or 866.

Model 8662 Encapsulated Thermistor for general purpose temperature measurements. Accuracy of $\pm .2^{\circ}\text{C}$ from 0°C to 70°C . Response time is 6 seconds in stirred liquids. The temperature range is -55°C to 150°C . The probe length is a 6 foot teflon cable.

Model 8663 General Purpose Immersion Probe for temperature measurements of liquids and general purpose applications. The accuracy is $\pm .2^{\circ}\text{C}$ from 0°C to 70°C . The temperature range is from -55°C to 150°C . The response time is 3 seconds in stirred liquids.

Model 8665 Surface Probe for temperature measurements of flat surfaces of solids. The temperature range is -55°C to 150°C . The accuracy is $\pm .2^{\circ}\text{C}$ from 0°C to 70°C . The response time is 5 seconds (brass block).

Model 8666 Air/Gas Probe – Exposed thermistor within a protective shroud responds to ambient temperature. The temperature range is -55°C to 150°C . The accuracy is $\pm .2^{\circ}\text{C}$ from 0°C to 70°C . The response time is 5 seconds (5m/sec airflow).

Model 8668 Soft Carrying Case is a padded vinyl carrying case that holds one handheld meter, a Model 8660 and a probe.

PREPARATION FOR USE

The Models 865 and 866 are supplied ready for use. To replace/install the battery, refer to the servicing information section. The thermometer is designed to work with any of the probes listed in the optional accessories section.

SAFETY SYMBOLS AND TERMS

The symbol  on the instrument denotes that the user should refer to the operating instructions.

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

OPERATION

Refer to Figures 1 and 2 for Models 865 and 866 control layouts.

ENVIRONMENTAL CONDITIONS

Operation of the Model 865 and 866 should take place at an ambient temperature which is stated in the specifications.

865 Operation

1. Turn power on by selecting the desired range.
 - A. 200°F range is the center position of the ON/OFF range switch.
 - B. 300°F range is the upper position of the ON/OFF range switch.
2. Select appropriate temperature probe and insert it into the input jack.
(Model 8662, 8663, 8665 or 8666.)
3. Make the measurement:
 - A. Touch the probe tip to the material to be measured.
 - B. Read the display. Reading is in degrees Fahrenheit.

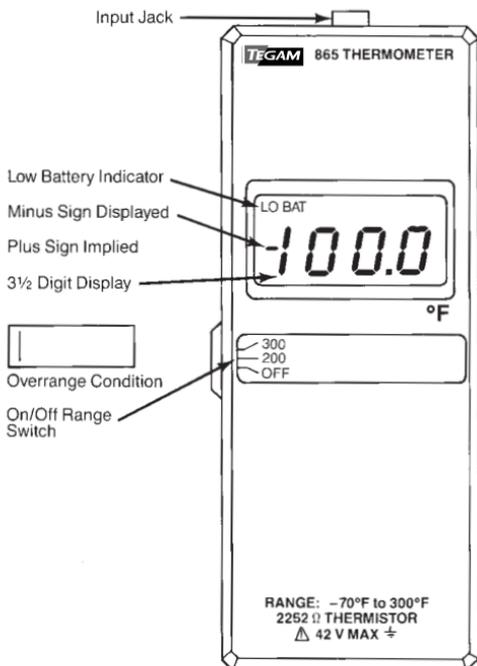


Figure 1. Model 865 Control Layout

NOTE

An open sensor is indicated by a reading on the display of between -100° and -199° .

WARNING

A shock hazard exists on the Model 865 input jack when probes or sensors are exposed to voltage levels greater than 42 volts peak to earth ground.

CAUTION

Do not attempt to measure temperatures beyond the range of the probe being used. Probe damage may occur. Maximum probe temperatures are given in the optional accessories section.

Safety Precautions:

1. Do not touch the probe tip when measuring excessively high or low temperatures.
2. Do not exceed 42 volts peak from the input jack to earth ground.

866 Operation

1. Set power on. The ON/OFF range switch is located on the side of the instrument. Turning power on also selects the 150°C measurement range.
2. Select appropriate temperature probe and insert it into the input jack.
3. Make the measurement:
 - A. Touch the probe tip to the material to be measured.
 - B. Read the display. Reading is in degrees Celsius.

NOTE

An open sensor is indicated by a reading on the display of between -100.0° and -199.9° .

WARNING

A shock hazard exists on the Model 866 input jack when probes or sensors are exposed to voltage levels greater than 42 volts peak to earth ground.

CAUTION

Do not attempt to measure temperatures beyond the range of the probe being used. Probe damage may occur. Maximum probe temperatures are given in the optional accessories section.

Safety Precautions:

1. Do not touch the probe tip when measuring excessively high or low temperatures.
2. Do not exceed 42 volts peak from the input jack to earth ground.

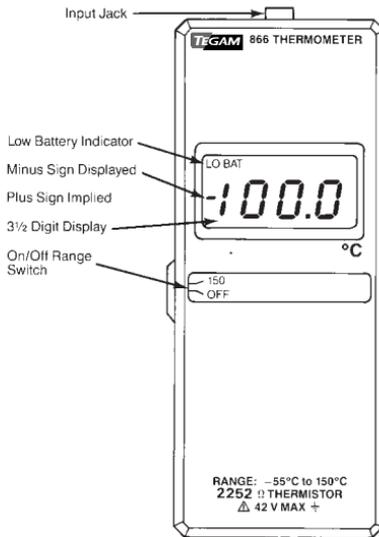


Figure 2. Model 866 Control Layout

SERVICING INFORMATION

VERIFICATION PROCEDURE

Functionality Check

At room temperature hold the tip of a probe sensor between your thumb and index finger. A reading ascending to between 25°C and 40°C should be realized for the Model 866 and a reading of 77°F to 104°F should be realized for the Model 865 to confirm the functionality of the instrument.

Accuracy Check

1. Set up the circuit shown in Figure 3. See Table 3 for recommended test equipment.
2. Follow Table 1 to verify the instrument's performance.

NOTE

The LO of the resistance box must be connected to the LO (sleeve) of the 1/4" phone jack. The HI of the resistance box must be connected to the HI (tip) of the 1/4" phone jack.

Table 1. Performance Verification

		Model 865	
Step	Setting	Decade Resistance	Allowable Reading
1	200°F	75,750 ohms	-39.4 to -40.6
2	200°F	245,700 ohms	-68.8 to -71.2
3	200°F	19,220 ohms	-00.5 to 00.5
4	200°F	220.8 ohms	188.9 to 191.1
5	300°F	43 ohms	298 to 302

		Model 866	
Step	Setting	Decade Resistance	Allowable Reading
1	150°C	75,790 ohms	-39.6 to -40.4
2	150°C	217,100 ohms	-54.2 to -55.8
3	150°C	7,355 ohms	-00.3 to 00.3
4	150°C	152.8 ohms	99.4 to 100.6
5	150°C	41.9 ohms	149.2 to 150.7

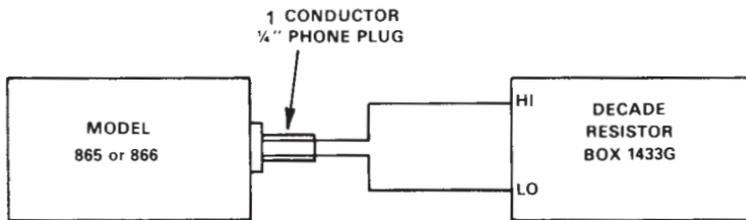


Figure 3. Calibration Set Up

SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

CMOS devices are designed to function at high impedance levels. Normal static charge can destroy these devices. Table 2 lists all static sensitive devices for the Model 865 and 866. Steps 1 through 7 provide instructions on how to avoid damaging these devices.

Table 2. Models 865 and 866 Static Sensitive Devices

Reference Designation	TEGAM Part Number
U101, U103 U102	IC-283 LSI-55

1. Devices should be handled and transported in protective containers, anti-static tubes, or conductive foam.
2. Use a properly grounded workbench and a grounding wriststrap.
3. Handle device by the body only; do not touch terminals, pins, etc.
4. PC boards must be grounded to bench while inserting devices.
5. Use antistatic solder suckers.
6. Use grounded tip soldering irons.
7. After devices are soldered or inserted into sockets, they are protected and normal handling can resume.

CALIBRATION

Calibration should be performed yearly or whenever the performance verification procedure indicates that the Model 865 or 866 is out of specification.

RECOMMENDED TEST EQUIPMENT

The recommended test equipment for calibration is listed in Table 3. Alternate test equipment may be used. However, the accuracy of the alternate test equipment must be a least equal to the specifications listed in Table 3.

Table 3. Recommended Test Equipment

Item	Description	Specification	MFR.	Model
A	Decade Resistance Box	Max 1,111,111 Ω .01% .1 Ω resolution	Gen Rad	1433G

ENVIRONMENTAL CONDITIONS

Calibration should be performed under laboratory conditions, having an ambient temperature of 23°C \pm 3°C and a relative humidity of less than 80%.

CALIBRATION PROCEDURE

Use the following procedure to calibrate the Model 865 or Model 866. To locate the adjustment points, remove the bottom cover and refer to Figure 5.

WARNING

To prevent a shock hazard, turn the instrument off and remove the input probe from the instrument before removing the bottom cover.

1. Turn the Model 865 or Model 866 on.
2. Connect the decade resistance box to the Model 865 or Model 866. Refer to Figure 3. Refer to Table 4 for Model 865 calibration. Refer to Table 5 for Model 866 calibration.
3. The calibration procedure is now complete. To verify correct calibration refer to the performance verification procedure.

Table 4. Model 865 Calibration

Step	Range	Input	Adjustment	Reading
A	200°F	19220 Ω	R111	00.0 \pm 0 counts
B	200°F	220.8 Ω	R110	190.0 \pm 1/2 counts
C	300°F	43 Ω	R112	300 \pm 0 counts
D	R110 and R112 are interactive. Repeat steps B and C until the results are repeatable.			

Table 5. Model 866 Calibration

Step	Range	Input	Adjustment	Reading
A	150°C	7355Ω	R111	00.0 ± 0 counts
B	150°C	152.8Ω	R110	100.0 ± 1/2 counts
C	150°C	41.9Ω	R112	150.0 ± 0 counts
D	R110 and R112 are interactive. Repeat steps B and C until the results are repeatable.			

DISASSEMBLY INSTRUCTIONS

WARNING

Turn the instrument off and disconnect the temperature probe before removing the bottom cover.

NOTE

When disassembling the instrument, handle the PC board by the edges. Body oil, dirt, and moisture can degrade the circuit performance. Keep the PC board clean and free of contaminants.

1. Place the unit face down on a bench or other similar surface and remove the screws from the bottom cover.
2. Separate the bottom cover from the rest of the instrument by grasping the top of the case (above the display) and gently lifting it away from the bottom cover.
3. Remove the battery.
4. Remove the standoff that secures the PC board to the case. (It is located in the center of the PC board.)
5. Remove the switch cover.
6. Lift the PC board out of the top cover (front panel).
7. The LCD is held in place on the PC board by a shock resistant mount and is assembled as shown in Figure 4.
8. To reassemble the unit, reverse the above procedure.

CAUTION

When removing the LCD from the PC board, be careful not to spread the four retaining hooks on the clear plastic bezel too far. Plastic bezel hooks may fracture.

WARNING

When reassembling the instrument, be sure to reinstall the switch cover. Common mode voltage may be present on the switch, creating a hazard if the cover is not reinstalled.

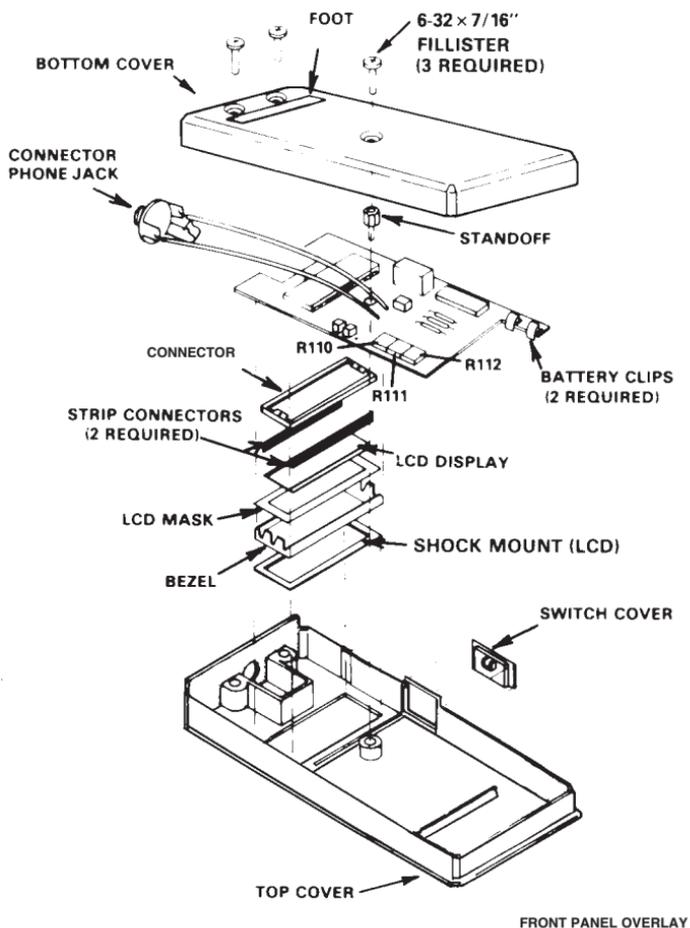


Figure 4. Models 865 and 866 Exploded View

BATTERY INSTALLATION/REPLACEMENT

To install/replace the battery:

1. Remove the bottom cover of the instrument (refer to the disassembly instructions).

WARNING

Turn the instrument off and disconnect the input probe before removing the bottom cover. Reinstall the cover before resuming use of the instrument.

2. Place the battery in the battery compartment. Observe proper polarity (Figure 5-3).
3. Reinstall the bottom cover before resuming use of the instrument.

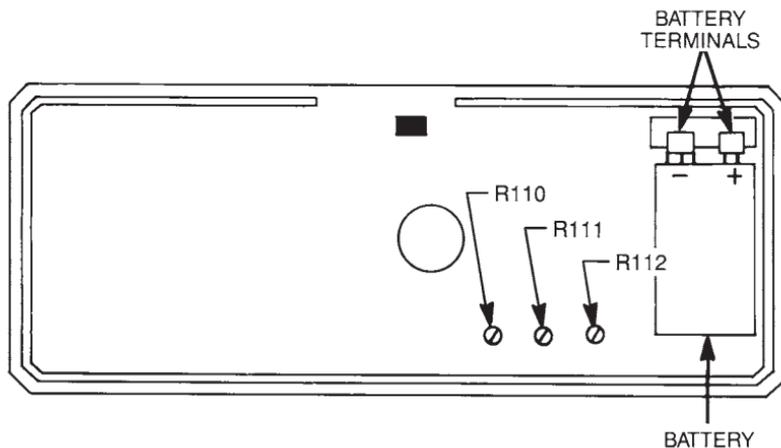


Figure 5. Battery Installation

THEORY OF OPERATION

Sensor

The temperature sensor used is a thermistor. The thermistor sensor is a negative temperature coefficient device. This means that as the temperature increases, the resistance of the thermistor decreases. This relationship is a logarithmic function. The current that flows through the sensor is inversely proportional to the resistance of the sensor (Ohm's Law).

Signal Conditioning

U104B and associated resistors minimize the “on” resistance of the gates of U101A and B. The input signal must be conditioned by the Log-Ratio amplifier before being digitized by the A/D converter. The Log-Ratio amplifier operates on two phases:

1. Signal Phase
2. Zero Phase

Each phase has a duration equal to 1/2 of the backplane period of the A/D converter (U102).

In the signal phase the following transpires (Refer to Figure 6). The source voltage, V_s , is connected to the sensor R_r . The current that flows through R_r also flows into the collector of Q101. The output voltage of U104C charges capacitor C106. Also, during this phase, the input to U104A is grounded and the voltage developed charges capacitor C105.

In the zero phase, the voltages on C105 and C106 are transferred to other parts of the circuit, as depicted by Figure 7. The source voltage, V_s is disconnected from the sensor and connected to a zero reference resistor, R_z . The current that flows through R_z also flows in the collector of Q101. The output voltage of U104C during the phase is connected to REF LO on U102 by way of C106 and U103B (Refer to the Schematic Diagram 866-106 or 865-106). The voltage that is applied to the input of U104A and across C111 is the difference of the output voltage of U104C and the voltage that was present on C106 during the signal phase.

The voltage present on C105 is now opposing the output of U104A and therefore transferred to C110. This is the voltage digitized by the A/D converter (U102). The fixed reference HI voltage for U102 is provided by current source U105 and its associated resistors. With all these voltages the transfer function for the 3-1/2 digit A/D would be:

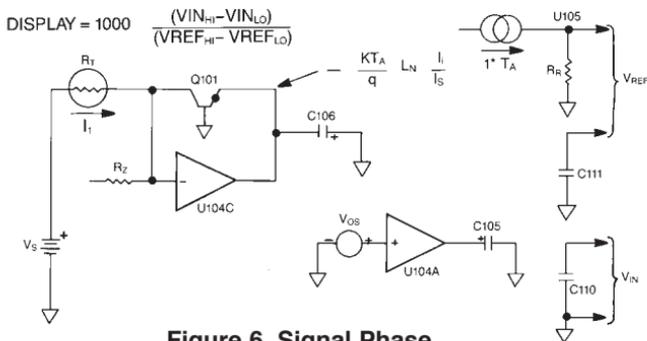


Figure 6. Signal Phase

1. Connect a stable input to the instrument under test. For example, 190°F for the Model 865 and 150°C for the Model 866.
2. Measure the voltage at U102 pin 31 (IN HI) and record the value.
3. Measure the voltage at U102 pin 30 (IN LO) and record the value.
4. Measure the voltage at U102 pin 35 (REF LO) and record the value.
5. Measure the voltage at U102 pin 36 (REF HI) and record the value.

NOTE

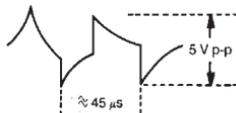
All the measurements in steps 2 through 5 are referenced to analog common.

6. Calculate the display reading using the measured voltages and the following formula; Display Reading (disregarding decimal point) =

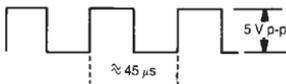
$$1000 \times \frac{(\text{Pin 31 voltage}) - (\text{Pin 30 voltage})}{(\text{Pin 36 voltage}) - (\text{Pin 35 voltage})}$$

WAVEFORM CHECKS: (Referenced to Analog Common)

1. U102 pin 40 (OSC 1)

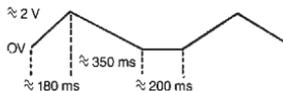


2. U102 pin 39 (OSC 2)

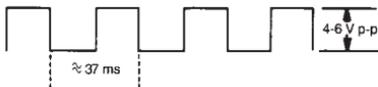


3. U102 pin 38 (OSC 3) (Same as step 2.)

4. U102 pin 27 (INTEGRATOR) (With negative full-scale input of approximately 1900 counts.)



5. U102 pin 21 (Backplane)



MODEL 865 AND 866 PARTS LIST

Circuit Desig.	Description	Schematic Location
BA101	9V Alkaline Battery, NEDA 1604	F1
C101	Capacitor Polypropylene, .047 μ F, 160V	E2
C102	Capacitor, .1 μ F, 50V, Ceramic	F1
C103	Capacitor, .1 μ F, 50V, Ceramic	G1
C104	Capacitor, .33 μ F, 20%, 63V, Metalized Polyester	E2
C105	Capacitor, .22 μ F, 20%, 63V, Metalized Polyester	D3
C106	Capacitor, .22 μ F, 20%, 63V, Metalized Polyester	D1
C107	Capacitor, Cer, .001 μ F, 1KV, Bent	C2
C108	Capacitor, .1 μ F, 50V, Ceramic	F1
C109	Capacitor, .33 μ F, 20%, 63V, Metalized Polyester	E3
C110	Capacitor, .33 μ F, 20% 63V, Metalized Polyester	E3
C111	Capacitor, .33 μ F, 20% 63V, Metalized Polyester	E1
C112	Capacitor, 47pF, 500V, Mica	E2
DS101	3-1/2 digit liquid crystal display	G4
J1001	Phone jack, 3 conductor	A1
J1002	Battery Clip	E1
J1003	Battery Clip	F1
Q101	Transistor, MPS8099	C2
R101	Resistor, 910k, 5%, 1/4W, Composition	E2
R102*	Resistor, 5.4k, .1%, 1/8W, T1, Metal Film	D4
R102**	Jumper, Circuit	—
R103	Factory selected, part of 865-600	B6
R104*	Resistor, 4.6k, .1%, 1/8W, Metal Film	D3
R104**	Resistor, 10k, .1%, 1/8W, T1, Metal Film	D3
R105*	Resistor, 44k, .1%, 1/8W, T1, Metal Film	D3
R105**	Resistor, 21.77k, .1%, 1/8W, T1, Metal Film	D3
R106*	Resistor, 16.5k, 1%, 1/8W, T0, Metal Film	C3
R106**	Resistor, 6.34k, 1%, 1/8W, T0, Metal Film	C3
R107	Thick Film Resistor Network	SEV
R108	Factory selected, part of 31410	E4
R109*	Resistor, 3.92k, 1%, 1/8W, T0, Metal Film	F5
R109**	Resistor, 3.65k, 1%, 1/8W, T0, Metal Film	F5
R110	Pot, seal, 200 ohm, 10%	E4

MODEL 865 AND 866 PARTS LIST (continued)

Circuit Desig.	Description	Schematic Locationr
R111*	Pot, single Trn, 5K ohm, 10%	C3
R111**	Pot, single Trn, 2K ohm, 10%	C3
R112	Pot, seal, 10 ohm, 10%	D1
R113	Resistor, 392k, 1%, 1/8W, Metal Film	E2
R114	Resistor, 47k, 5%, 1/4W, Composition	G5
S101	Switch	SEV
U101	IC, CMOS, MC14053 BCP	SEV
U102	3-1/2 Digit Low Power A/D Converter, ICL7136CPL	F2
U103	IC, CMOS, MC14053 BCP	SEV
U104	IC, LF444CN	SEV
U105	IC, LIN, LM334Z	E4
VR101	Zener Diode, 1N753	C1

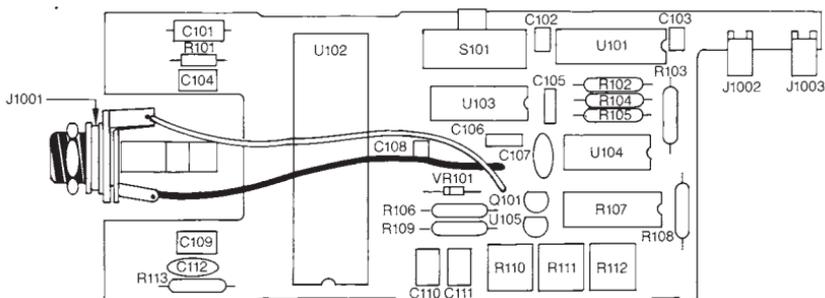
* Model 865

** Model 866

† Part of 865-600

‡ Part of 31410

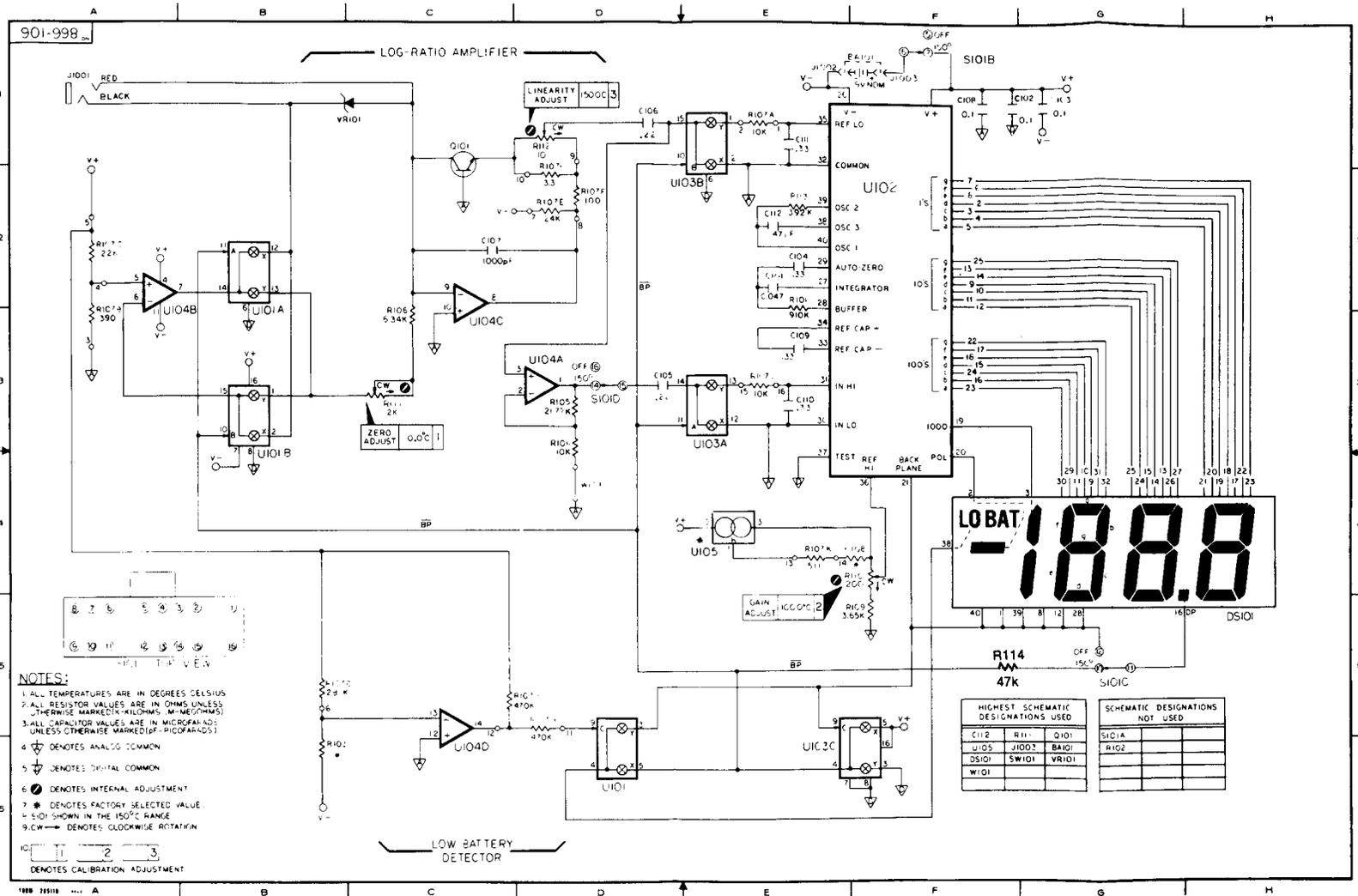
COMPONENT LAYOUT



NOTE

On the Model 866 Component Layout,
R102 should be W101.

MODEL 866 SCHEMATIC DIAGRAM



WARRANTY

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of three years from date of shipment. During the warranty period, we will at our option, either repair or replace any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of two years from date of shipment. During this period we will recalibrate any product that does not conform to the published accuracy specification.

To exercise this warranty, contact TEGAM, Inc., Ten TEGAM Way, Geneva, Ohio 44041/FAX (440) 466-6110/PHONE (440) 466-6100, M-F, 8 a.m.-5 p.m. ET. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned, transportation prepaid. Repaired products are warranted for the balance of the original warranty, or at least 90 days, whichever is longer.

LIMITATION OF WARRANTY

TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of any product or part. This warranty also does not apply to fuses, batteries, or damage from battery leakage.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular use. TEGAM, Inc. shall not be liable for any indirect, special or consequential damages.

STATEMENT OF CALIBRATION

This instrument has been inspected and tested in accordance with specifications published by TEGAM, Inc.

The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment which is calibrated at planned intervals by comparison to certified standards maintained in the Laboratories of TEGAM, Inc.

TEGAM Incorporated is a designer, manufacturer and world-wide marketer of electronic test equipment that tests, measures, sources and simulates electrical parameters. TEGAM has grown through a healthy mix of new product development and acquisition. At TEGAM, we manufacture the standards that you have come to know and trust. For example:

- Power Sensor Calibration Instruments
- Attenuator Calibration Instruments
- Resistance & Ratio Standards
- Oscilloscope Calibration Instruments
- TM500/5000 Modular Instruments
- Ohm & LCR Meters
- Temperature Measurement/Calibration Instruments
- Electrical Safety Instruments

Call us at 800-666-1010 to talk with one of our technical support or customer service representatives for additional information on any of these fine products.



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