$ 2.00

Owners Manual

PDT-590

Precision Digital Thermometer

OPTOELECTRONICS, inc.

I. INTRODUCTION

The PDT-590 Precision Digital Thermometer uses large-scale integrated circuitry and laser-trimmed temperature transducers to achieve state-of-the-art temperature-sensing capabilities. The two switch-selectable probes can be connected through hundreds of feet of cable to provide accurate temperature sensing in remote areas. Celsius or Fahrenheit measurement is switch-selectable with 0.1° resolution, with an accuracy better than ± 0.5°C (1.2°F) over a -50° to +150°C range (-60° to 200°F). Table 1 shows the digital thermometer specifications.

The digital thermometer can operate from a 117 volt to 9 volt plug transformer, 12 volt automotive or marine battery systems or from internal rechargeable Ni-Cad batteries for portable operation.

This thermometer has the range, flexibility and accuracy necessary for many useful applications.

TABLE 1—DIGITAL THERMOMETER SPECIFICATIONS

Range	−50° — +150°Celsius 60° — +200°Fahrenheit
Resolution	0.1°C 0.1°F
Sensor Linearity	±0.5°C, from −55° to +150°C
Meter Error	±1 count = ±0.1°C or F
Accuracy	Linearity error + calibration error + meter error
Probe Inputs	Two, switch-selectable
Sensor Probe	Number: 2 Type: temperature-dependent current source Response time: 3.4 seconds to reach 63.2% of step change in temperature in stirred liquid bath Voltage standoff: ±200V from sensor case to either active lead Cable length: 10 feet (can be extended to several hundred feet) Connector type: RCA phono plug
Meter Operating Temperature Range	0° - 50°C
Display	3½, 0.43-inch-high, high-intensity red LED digits
Size	1¼ H × 4¼ W × 5¼ inches D
Weight	14 oz. (20 oz. with batteries and charger)
Input Power	9-14 volts AC or DC, 175 mA, 1.7 watts

III CONTROLS AND CONNECTIONS

POWER - ON - "ON" position applies power to the circuit.
OFF - "OFF" position removes circuit power.

SCALE - °C - Temperature displayed is in Celsius units.
°F - Temperature displayed is in Fahrenheit units.

SENSOR - A - Sensor probe connected to "A" input is displayed.
B - Sensor probe connected to "B" input is displayed.

The A and B temperature probes should not be interchanged as they are calibrated for the A or B input only. Both probes should be plugged in even if only one is being used. If a probe is not plugged into the selected A or B input then a "1" will be displayed in the most significant digit with the lower order digits blanked. Erratic readings may result from poor electrical contact between the probe plug and input jacks.

Power input jack. 9 to 14 volts DC can be applied through the power input jack to power the PDT-590. A bridge rectifier input makes it unnecessary to observe polarity. A 1/2 AMP inline fuse should be used when operating from automotive 12V systems.

BATTERY SWITCH (Optional)

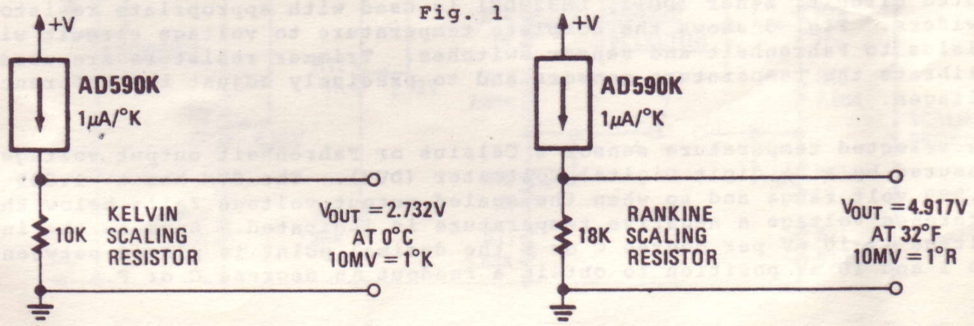
Charge: Switch in charge position connects Ni-cad batteries to charging circuit. The instrument will not operate from the Ni-cad batteries in the charge mode.

Run: Switch in run position allows instrument to operate from the Ni-cad battery pack. NOTE: The battery switch should not be left in the run position while the instrument is being operated from an external power supply.

EXTENDING THE SENSOR PROBE CABLES

The probe cables can be extended using an audio extension cable with phono plugs on each end. Use a phono plug to phono plug adapter to connect the cables. The probe cable may be extended by splicing in additional wire. Observe polarity and protect the connections against moisture. For long cable runs (over 100 feet) use a twisted pair for best results.

Fig. 1



IV. THEORY OF OPERATION

The AD590K temperature sensor (40255) is in fact an integrated circuit which when connected to a voltage source produces an output current that is proportional to temperature. The output current is equal to 1uA per degree Kelvin. The Kelvin degree is equal in size to the Celsius degree, however, the Kelvin temperature scale is offset 273.2^{o} higher than the Celsius scale with 0^{o}K (-273.2^{o}C) called absolute zero. Absolute zero is the coldest possible temperature where molecular motion is at a minimum. The relationship between the Kelvin, Celsius and Fahrenheit scales is as follows:

$$T^{o}C = T^{o}K - 273.2^{o}$$

$$T^{o}F = 9/5\ (T^{o}C)+32^{o}$$

$$T^{o}F = 9/5\ (T^{o}K-273.2)+32^{o}$$

There is also a little used Rankine temperature scale which starts at absolute zero with Fahrenheit size degrees and is offset 459.7^{o} from the Fahrenheit scale. Rankine to Fahrenheit conversion is as follows:

$$T^{o}F = T^{o}R-459.7^{o}$$

When the AD590K's output current is passed through the appropriate value scaling resistor the resulting output voltage is proportionsal to Kelvin or Rankine temperature as shown in Fig. 1. The scaling resistors can be combined as shown in Fig. 2 so that ^{o}K or ^{o}R can be switch selectable and read from a voltmeter. To generate an output voltage proportional to the more common Celsius and Fahrenheit scales we need to subtract 2.732 volts from the ^{o}K output and 4.597 volts from the ^{o}R outputs shown in Fig. 2. This is accomplished by having the voltmeter measure the difference between the scaled output voltage and the appropriate reference voltage.

The reference voltages must be very stable so a 6.9 volt precision, integrated circuit, Zener (D012, LM329DZ) is used with appropriate resistor dividers. Fig. 3 shows the complete temperature to voltage circuit with Celsius to Fahrenheit and sensor switches. Trimmer resistors are used to calibrate the temperature sensors and to precisely adjust the reference voltages.

The selected temperature sensor's Celsius or Fahrenheit output voltage is measured by a 3½ digit Digital Voltmeter (DVM). The DVM has a -1.999 to +1.999 volt range and so when the scaled output voltage falls below the reference voltage a negative temperature is indicated. Because the input voltage is 10 mV per degree C or F the decimal point is placed between the 1 and 10 mV position to obtain a readout in degrees C or F.

Fig. 2

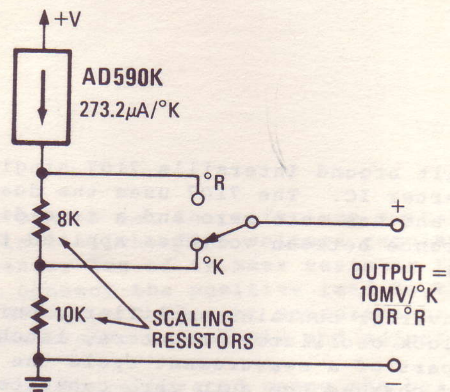
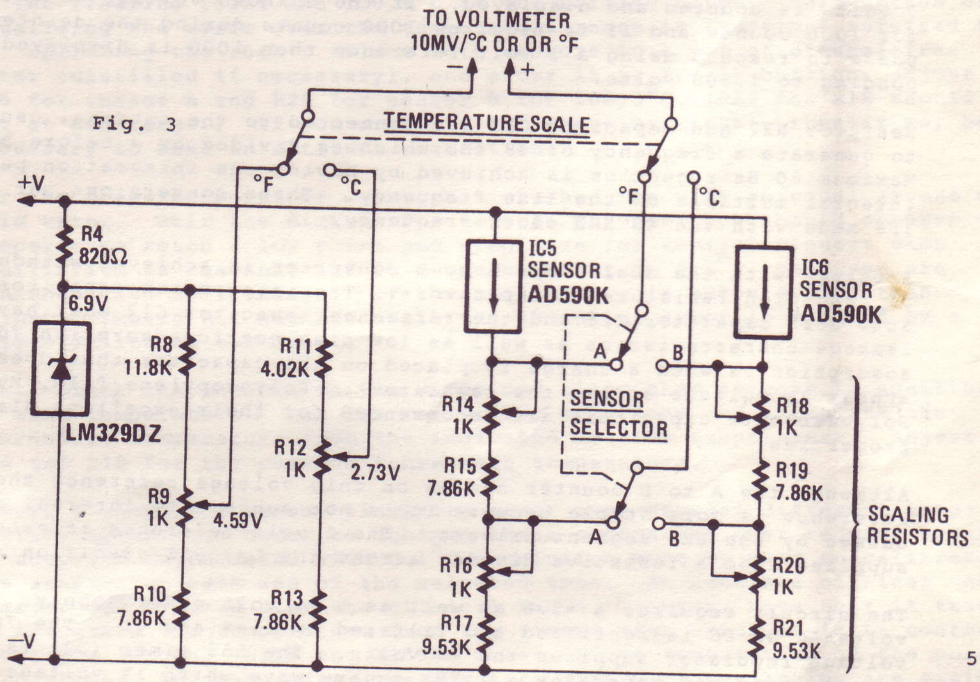

+V
AD590K
273.2μA/°K
°R
8K
°K
+
OUTPUT =
10MV/°K
OR °R
10K
SCALING
RESISTORS
–

Fig. 3


TO VOLTMETER
10MV/°C OR OR °F
+
TEMPERATURE SCALE
°F
°C
°F
°C
+V
R4
820Ω
6.9V
LM329DZ
R8
11.8K
R11
4.02K
R12
1K
2.73V
R9
1K
4.59V
R10
7.86K
R13
7.86K
–V
IC5
SENSOR
AD590K
IC6
SENSOR
AD590K
A
B
R14
1K
SENSOR
SELECTOR
R15
7.86K
A
B
R16
1K
R17
9.53K
R18
1K
R19
7.86K
R20
1K
R21
9.53K
SCALING
RESISTORS

The DVM is built around Intersil's 7107 single chip analog to digital (A to D) converter IC. The 7107 uses the dual slope integration method of conversion and has auto zero and a true differential input (measures the net difference between voltages applied to its input high and input low terminals).

The A to D converter contains amplifiers, buffers analog switches, a comparator, clock oscillator, counters, latches and LED segment drivers. In the first part of a measurement cycle the A to D internally shorts the inputs and charges the auto zero capacitor C15 to compensate for amplifier and integrator offset voltages. In the next phase the integrator output voltage increases at a rate proportional to the unknown input voltage for a fixed number of clock pulses. In the final phase the integrator output voltage is deintegrated at a rate proportional to the reference voltage that has been stored on the reference capacitor C12. The number of clock pulses required for the integrator to reach 0 volts is counted and displayed. If the unknown voltage is integrated for 1000 counts and if it requires 1000 counts during the deintegration phase to reach 0 using a 1 volt reference then 1000 is displayed corresponding to 1.000 volts.

Resistor R22 and capacitor C13 are connected to the internal oscillator to generate a frequency of 48 KHz which is divided by 4 before being used. Maximum 60 Hz rejection is achieved by having the integration period an integral multiple of the line frequency. Three conversions per second are made with the 48 KHz clock frequency.

Accuracy with the dual slope A to D converter is achieved without the use of precision resistors or capacitors. The integration capacitor C14, the auto zero capacitor C15 and the reference capacitor C12 must have low leakage characteristics as well as low diaelectric adsorption (diaelectric adsorption is when a charge is placed on the capacitor that does not appear as voltage across the capacitor). Polypropylene film, Mylar and Polycarbonate capacitors are recommended for their excellent diaelectric properties.

Although the A to D counter has an on chip voltage reference the off chip reference is more stable because it is not subject to internal chip heating caused by the LED segment drivers. The 1 volt reference is externally supplied from a resistive divider across the LM329DZ precision zener.

The circuit requires a +5.6 as well as a -5 volt power supply. 9 to 14 volts AC or DC is rectified and filtered by D1-4 and C1. The 7805 (U1) voltage regulator supplies the +5 volts. The 555 timer (U2) is in the astable mode and generates a 2 KHz square wave which is voltage doubled and clamped to produce the negative supply voltage which is regulated by the 7905 regulator (U3).

V. CALIBRATION

Calibration requires a DVM to set the reference voltages. With the negative DVM lead on pin 2 of the 7905 voltage regulator, connect the positive lead to the center lug of trimmer resistor R6 and adjust R6 for 1.000 volt. Next, connect the positive lead to the center lug of trimmer R9 and adjust R9 for a 2.73 volt measurement. Then, connect the positive lead to the center lug of R12 and adjust R12 for 4.59 volts.

The sensor probes are easily calibrated using the boiling point and freezing point of water for reference. To achieve $\pm 0.6^{\circ}C$ accuracy (or better), the sensor probes should be calibrated at both points and the error should be evenly split between them. For instance, if the meter is adjusted to read $0.0^{\circ}C$ at the freezing point of water and 101.0° at the boiling point of water, then the error will be $+1^{\circ}C$. The error would be $\pm 0.5^{\circ}C$ if the meter were readjusted to read $-0.5^{\circ}C$ at the freezing point and $100.5^{\circ}C$ at the boiling point. This method of equalizing the error over the temperature range is sometimes referred to as "splitting the rock". Place both sensors in a pot of mineral-free water (distilled if necessary), and after it is freely boiling, adjust R16 for sensor A and R20 for sensor B for $100.0^{\circ}C$. (R14 and R18 should be set at mid-range.) If you are very far above sea level, then it may be necessary to make an altitude correction.

For the freezing point of water, mix crushed ice with an equal amount of cold water. Stir the mixture for several minutes; you should observe the temperature reach a low point and stabilize for several minutes when equilibrium is reached. If it measures right on $0.0^{\circ}C$, then you are finished with calibration. If the temperature is below $0.0^{\circ}C$, then adjust trimmers R16 and R20 until the amount of error is reduced by a half--"splitting the rock".

Next, place the sensors in tap water and allow them to come to equilibrium at room temperature. Use the conversion equations and calculate the Fahrenheit temperature from the indicated Celsius temperature. Adjust R14 and R18 for the correct Fahrenheit temperature.

Figure 4 shows the sensor linearity error over several different temperature spans. In order to achieve these accuracies over reduced spans, an accurate thermometer with $0.1^{\circ}C$ resolution must be used to calibrate the sensors at each end of the selected span. An accurate clinical thermometer can be used over the clinical range, however, note that it tends to integrate the temperature from the tissue with which it is in contact along its length, while the AD590K measures the temperature of the point it contacts. Accurate glass thermometers with 0.1° resolution are available from most laboratory supply distributors for under $25, however, they are very fragile and require that a specific length of thermometer be immersed for accurate measurements. The glass thermometer should be used in a well-stirred water bath.

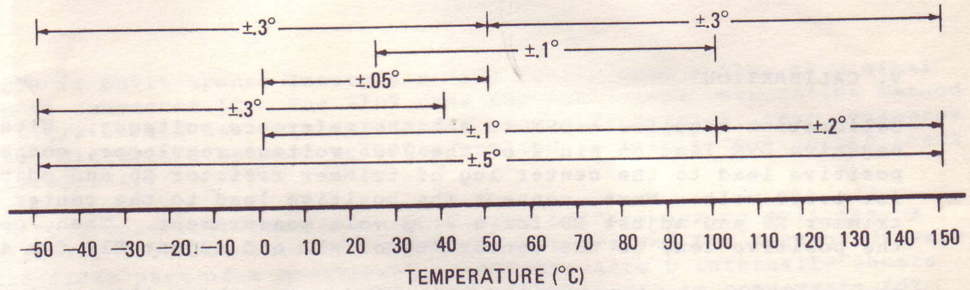

±.3°
±.3°
±.1°
±.05°
±.3°
±.1°
±.2°
±.5°
-50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
TEMPERATURE (°C)

Fig. 4

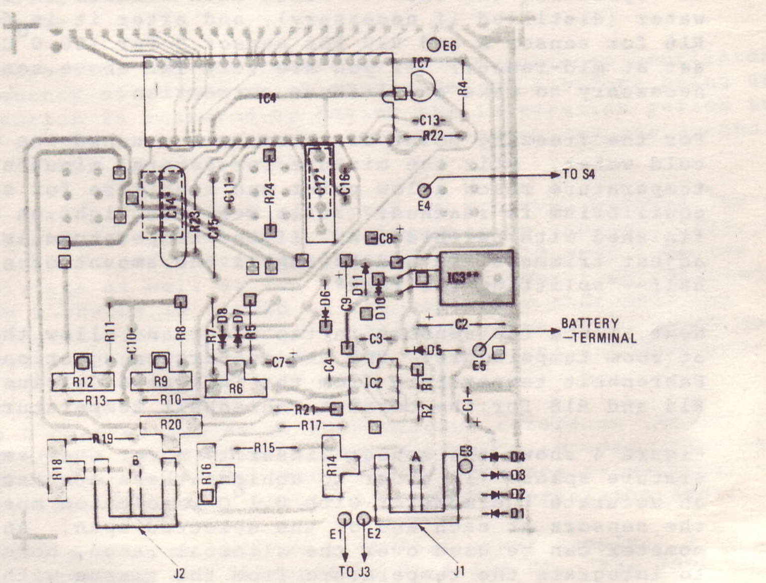
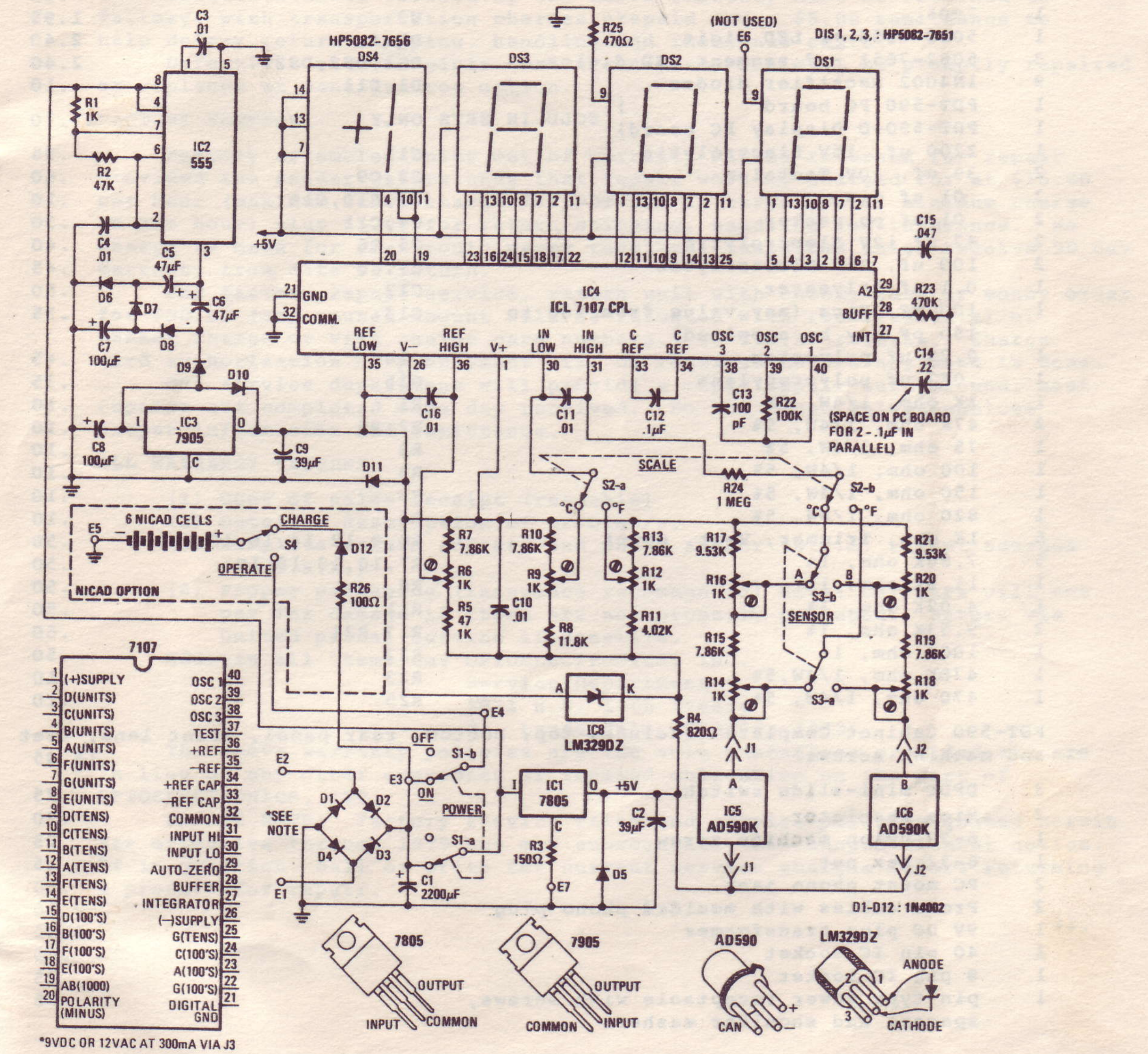

E6
IC7
IC4
R4
C13
R22
TO S4
E4
C14
R23
C15
C11
R24
C12
C16
C8
IC3
D11
D10
C9
D6
BATTERY
-TERMINAL
C2
E5
R11
C10
R8
D8
D7
R7
R5
C3
D5
C4
C7
R12
R9
R6
IC2
R1
R13
R10
R20
R21
R2
C1
R17
R19
R15
R18
R16
R14
E3
D4
D3
D2
D1
E1
E2
TO J3
J2
J1

Fig. 5



HP5082-7656
DS4
DS3
DS2
DS1
(NOT USED)
E6
DIS 1, 2, 3, : HP5082-7651
R25
470Ω
C3
.01
R1
1K
R2
47K
IC2
555
C4
.01
C5
47μF
C6
47μF
D6
D7
D8
C7
100μF
D9
D10
IC3
7905
C8
100μF
C9
39μF
D11
+5V
IC4
ICL 7107 CPL
GND
COMM.
REF LOW
V−
REF HIGH
V+
IN LOW
IN HIGH
C REF
C REF
OSC 3
OSC 2
OSC 1
A2
BUFF
INT
C15
.047
R23
470K
C14
.22
C16
.01
C11
.01
C12
.1μF
C13
100 pF
R22
100K
(SPACE ON PC BOARD FOR 2 - .1μF IN PARALLEL)
SCALE
S2-a
R24
1 MEG
S2-b
°C
°F
6 NICAD CELLS
CHARGE
E5
S4
OPERATE
NICAD OPTION
D12
R26
100Ω
R7
7.86K
R6
1K
R5
47
1K
R10
7.86K
R9
1K
C10
.01
R8
11.8K
R13
7.86K
R12
1K
R11
4.02K
R17
9.53K
R16
1K
R15
7.86K
R14
1K
R21
9.53K
R20
1K
R19
7.86K
R18
1K
S3-b
SENSOR
S3-a
IC8
LM329DZ
R4
820Ω
J1
J2
IC5
AD590K
IC6
AD590K
E4
OFF
S1-b
E2
E3
ON
POWER
S1-a
*SEE NOTE
D1
D2
D3
D4
E1
C1
2200μF
IC1
7805
R3
150Ω
E7
C2
39μF
D5
D1-D12 : 1N4002
7107
(+)SUPPLY
D(UNITS)
C(UNITS)
B(UNITS)
A(UNITS)
F(UNITS)
G(UNITS)
E(UNITS)
D(TENS)
C(TENS)
B(TENS)
A(TENS)
F(TENS)
E(TENS)
D(100'S)
B(100'S)
F(100'S)
E(100'S)
AB(1000)
POLARITY (MINUS)
OSC 1
OSC 2
OSC 3
TEST
+REF
−REF
+REF CAP
−REF CAP
COMMON
INPUT HI
INPUT LO
AUTO-ZERO
BUFFER
INTEGRATOR
(−)SUPPLY
G(TENS)
C(100'S)
A(100'S)
G(100'S)
DIGITAL GND
7805
OUTPUT
INPUT
COMMON
7905
OUTPUT
COMMON
INPUT
AD590
CAN
LM329DZ
ANODE
CATHODE
*9VDC OR 12VAC AT 300mA VIA J3

PDT-590 PRECISION DIGITAL THERMOMETER

PARTS LIST

QTY.	PART	REFERENCE NO.	PRICE EACH
1	ICL7107 CPL	U4	16.95
1	555	U2	.50
1	LM329DZ	D12	2.50
2	AD590K (may be labeled 40255)	U5,U6	9.50
1	7805	U1	.95
1	7905	U3	1.95
1	5082-7656 ±1 LED digit	DS-4	2.40
3	5082-7651 - 7 segment LED digits	DS1,DS2,DS3	2.40
9	1N4002 Rectifier diodes	D1-D11	.10
1	PDT-590 PC board)	SOLD IN SETS ONLY	17.70
1	PDT-590-D Display PC board)		
1	2200 uf, 16V Electrolytic	C1	.95
2	39 uf, 10V Tantalum	C2,C9	.60
3	.01 uf disc	C3,C10,C16	.10
2	.01 uf polyester	C4,C11	.30
2	47 uf 12V Electrolytic	C5,C6	.40
2	100 uf, 25V Electrolytic	C7,C8	.45
1	0.1 uf Polyester	C12	.50
1	100 pF, Mica (any value from 100 to 150 pF may be supplied)	C13	.35
1	0.22 uf polyester	C14	.45
1	.047 uf polypropylene	C15	.35
1	1K ohm, 1/4W, 5%	R1	.10
2	47K ohm, 1/4W, 5%	R2,R5	.10
1	75 ohm, 1/4W, 5%	R3	.10
1	100 ohm, 1/4W, 5%	R3	.10
1	150 ohm, 1/4W, 5%	R3	.10
1	820 ohm, 1/4W, 5%	R4	.10
6	1K ohm, Trimmer, Vert. mount	R6,9,12,14,16,18,20	.50
5	7.86K ohm, 1%	R7,10,13,15,19	.50
1	11.8K ohm, 1%	R8	.50
1	4.02K ohm, 1%	R11	.50
2	9.53K ohm, 1%	R17,R21	.50
1	100K ohm, 1%	R22	.50
1	470K ohm, 1/4W,5%	R23	.10
1	470 ohm, 1/4W, 5%	R25	.10

PDT-590 Cabinet Complete (includes top, bottom, rear panel, front lens, feet and machine screws) 14.95

QTY.	PART	PRICE EACH
3	DPDT mini-slide switch	.75
2	Mica insulator	.20
1	6-32 nylon machine screw	.25
1	6-32 hex nut	.15
2	PC mount phono jack	.50
2	Probe cables with moulded phono plug	2.50
1	9V DC plug transformer	4.95
1	40 pin IC socket	.75
1	8 pin IC socket	.25
1	pin type power receptacle with screws, spacers and shoulder washers	.95

Prices listed on this sheet are effective 6/79 and are subject to change without notice.

MODEL PDT-590 DIGITAL THERMOMETER SERVICE & WARRANTY INFORMATION

Optoelectronics, Inc. Model PDT-590 Factory Wired Digital Thermometers are warranted to the original purchaser for 6 months from date of purchase against defects in workmanship or failure of circuitry, provided no unauthorized repairs or modifications have been attempted or performed and unit has not been subjected to misuse or abuse.

Defective units covered by the above warranty must be returned to factory, with transportation charges prepaid and a $5.00 remittance to help defray return shipping, handling and insurance costs.

Defective units eligible for warranty service will be promptly repaired or replaced at manufactures option.

FACTORY SERVICE

Factory assembled units out of warranty may be returned for repair provided the sender understands that repair work is charged for at $15.00 per hour (maximum labor charge for PDT-590 is three hours, minimum charge is one hour) plus $5.00 for return shipping, handling and insurance. No charge is made for electronic parts required. Repaired units receive 90 day warranty from date of return.

For factory repair service, return unit with check, cash or money order for $50.00 (any unused amount will be refunded with repaired unit) or Master Charge or Visa charge card numbers. No C.O.D. returns. Charge card authorization or prepayment will be required before any work is done.

Our service department will provide a rapid repair turn-around, most repairs are completed same day received. Do not cause delays-enclose proper information and remittance.

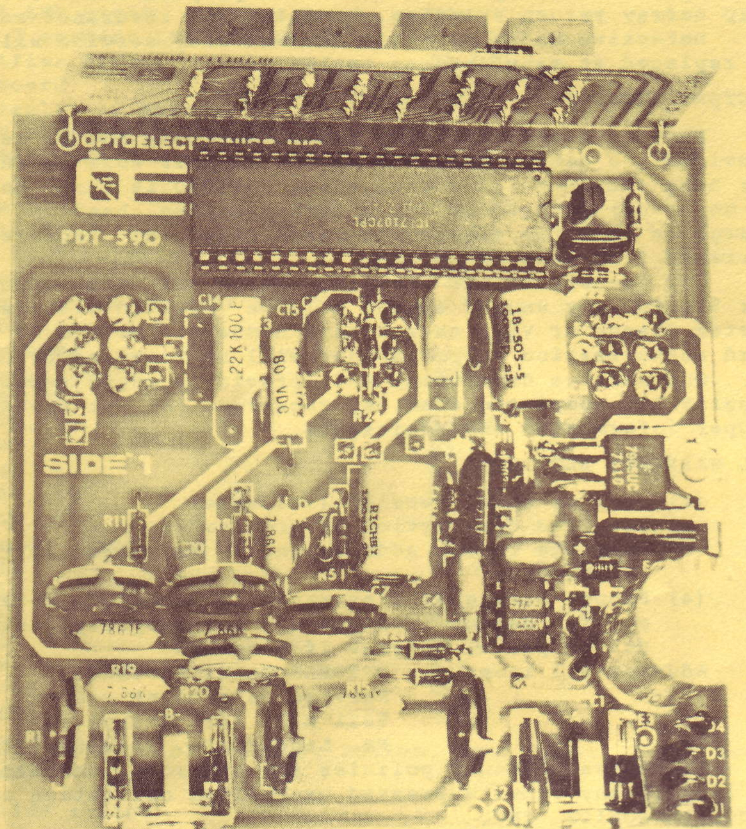
ALL WARRANTY RETURNS

(1) Copy of sales receipt (readable)
(2) Detailed description of problem/s.
(3) Complete return address and phone number (U.P.S. street address for U.S.A.)
(4) Proper packaging (insurance recommended) Note: Carriers will not pay for damage if items are not properly packaged. Return via United parcel service if possible.

Address all items to: OPTOELECTRONICS, INC.
Service Department
5821 N.E. 14th Avenue
Ft. Lauderdale, Florida 33334

The above warranty policies are the sole guarantees provided and are in lieu of any other expressed or implied obligation on the part of OPTOELECTRONICS, INC.

PLEASE NOTE: Factory service rates and service policies quoted herein are effective through 1979 but may subsequently be changed without notice. If in question, call or write for current service charges before returning a product for repair.



OPTOELECTRONICS INC
PDT-590
SIDE 1