

ELECTRICAL SAFETY

Service Manual

180



BIO-TEK[®] INSTRUMENTS, INC.

180 Electrical Safety Analyzer

Service Manual

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Revision History

Revision	Date	Change
A	4/99	Release to Production

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Chapter 1

General Information

This chapter presents the purpose and scope of this manual.

Purpose and Scope

This manual provides instructions for servicing the 180 Electrical Safety Analyzer. It includes the theory of operation, general information regarding scheduled maintenance and calibration, and the parts list, drawings, and schematics.

Safety Considerations

This instrument and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

WARNING! The “**WARNING!**” sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a “**WARNING!**” sign until the indicated conditions are fully understood and met.

CAUTION: The “**CAUTION:**” sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the instrument. Do not proceed beyond a “**CAUTION:**” sign until the indicated conditions are fully understood and met.



The symbol to the left is the operator’s manual symbol. When you see this symbol on the instrument, refer to the User’s Guide.

WARNING! Disconnect all patient connections before connecting the device to be tested to the analyzer.

Continued connection may jeopardize patient safety by possible application of measurement currents.

WARNING! Isolation test utilizes 120 or 240 vac applied to patient leads or to external connections which are accessible to the tester. Maintain care when making connections.

Although the voltage is current limited by 120 k Ω resistor per AAMI test procedure and is safe for healthy intact skin contact, it can be felt and can result in a startle reaction.

CAUTION: Be sure that the device under test power requirements are within the capabilities of the safety analyzer, labeled as 15 amps at 120 volts, and 10 amps at 240 volts.

The analyzer requires adapter cables to match the appropriate connector for line voltages other than 120V.

CAUTION: The 180 is not designed for continuous measurements. Do not leave the device under test connected and drawing high load current for extended periods.

To maintain its small hand-held size, the analyzer was not designed to provide its high current capability continuously and may overheat.

CAUTION: Be sure to pause in the off (middle) position when switching polarity from normal to reverse.

Inductive loads of the device under test may create high voltage transients when trying to reverse the direction of current flow instantaneously.

Relationship of This Manual to Other Publications

This manual is intended to be a companion to the ESA180 Operator's Manual, part number 1801000, and both manuals should be at hand when attempting to service this instrument.

Front Panel Description

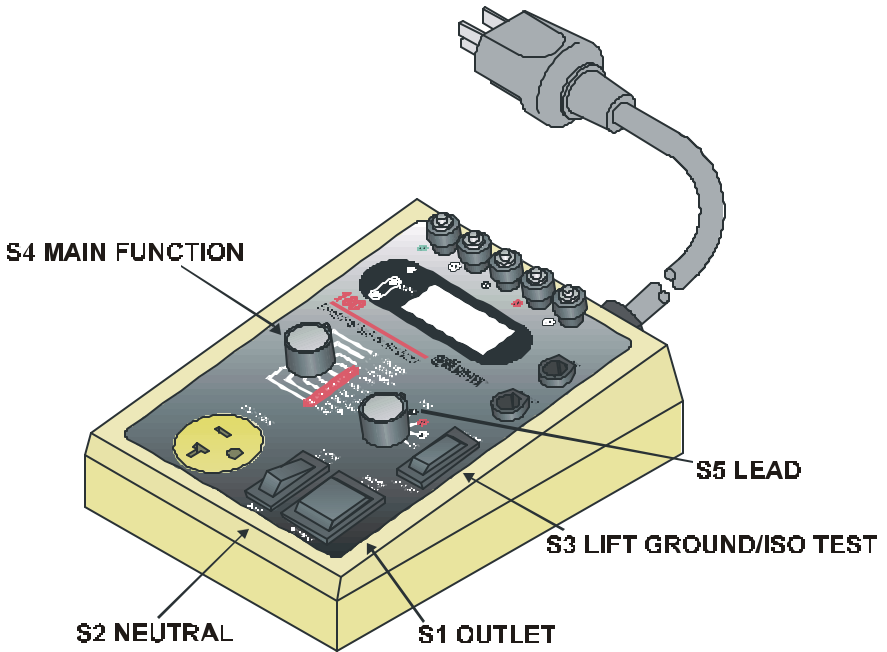


Figure 1-1. Bio-Tek 180 Electrical Safety Analyzer

S1: OUTLET SWITCH with center **OFF** position permits testing with both the **NORMAL** (FORWARD) and **REVERSED** polarity of the line. *It is recommended that the switch be paused in the center OFF position before changing polarity.*

S2: NEUTRAL SWITCH permits making leakage current measurements under the **OPEN** neutral condition as required by UL and IEC.

- S3: LIFT GROUND/ISO TEST** switch is a dual-function switch. The **LIFT GND** position will open ground to the device for leakage current measurements when the S4 Function Switch is in the Chassis Leakage mode. The **ISO TEST** position will energize the selected patient lead at 110% line voltage, current limited, to measure the isolation current when the main function switch is in the **LEAD ISOLATION** position. With the function switch in the **DUAL** position, the isolation test voltage is supplied to the **DUAL** connector for measuring the isolation current of a probe, transducer, or similar devices.
- S4: MAIN FUNCTION SWITCH** provides direct, one-step selection of the measurement to be made. These are line volts, instrument current, grounding resistance, ground (internal) and chassis (external) leakage currents, and the patient leakage currents. These include lead to ground (source), lead to lead (auxiliary) and isolation (sink) current. A dual position is provided to measure leakage current between two points or isolation current of probes and transducers independent of their instruments.
- S5: LEAD SWITCH** directs the selected patient lead measurement to the desired lead. When testing a 10-lead device, a second pass will be required for the C leads.

Chapter 2

Theory of Operation

This chapter provides information to support troubleshooting and equipment maintenance.

The 180 makes two basic measurements: current (leakage) and resistance. Except for the display, these measurements are independent and will be addressed separately.

CURRENT MEASUREMENT

Current is converted to millivolts (mV) by its drop across its input impedance of R21, 33, 22, 18, 24 and C21, which form an input equivalent to AAMI ES1-1993. The circuit provides an attenuation of $\frac{1}{2}$ to U5, AD637, a true RMS-to-DC converter. This leaves room within the ± 5 volt supply to take advantage of its crest factor of 3.

The output is further attenuated by R25, 29, and R28 to provide 200 mV to the display for a 2000 microampere (mA) full range input. R29 provides a gain trim to compensate for inherent errors. The display meter displays a number that is the ratio of two inputs, the signal input and a reference input. The signal input is to terminals 3 and 4, and the reference input to 6 and 7. While the meter is equipped with a 100 mV reference, terminals 9 and 10, the ESA180 buffers this through U4 and Q1, developing the 100 mV reference across R30.

The resulting display is

$$\text{display} = 1000 \times \frac{V_{3-4}}{V_{6-7}}$$

RESISTANCE MEASUREMENT

The resistance measurement uses the display meter's ratio technique to determine its reading. The 100 mV reference made via U4-Q1 is applied across R30 (10W), producing a constant current of 10 mA for the resistance measurement. At the same time, the drop across R30 is connected to the reference input while the drop across the unknown is applied to the signal input. Then, using the same equation as above with the same current through both resistances, the resulting display will read:

$$\text{display} = 1000 \times \frac{R_{\text{unknown}}}{R_{\text{reference}(10\text{ W})}}$$

The resulting accuracy is only dependent on the accuracy of the 10 W resistor.

Relay K4 is used to switch all inputs to the meter from its current connections to the resistance connections, and its selection will turn on Q2, pulling meter terminal 12 to +5 to turn on the decimal point. Connections to all resistors are made by two wires, one for the 10 mA excitation current, the other the signal potential.

MODE SELECTION

With the above methods for calculating current and resistance, the individual measurements are made as follows:

LINE VOLTAGE: The power transformer, T1, is provided with a separate winding to give a voltage 10 percent higher than the line.

This winding is shielded to reduce leakage current that might corrupt the measurement. For measurement, one end is grounded through a 1 mW resistor, while the other end is connected through the 1 kW input for current measurement.

INSTRUMENT CURRENT: Uses a current transformer with a single-turn primary provided by the hot wire to the instrument. Transformer produces 10 mV /1A into 100 ohms provided by R7 in parallel with the current input circuit. Q2 is turned on to add the decimal point.

RESISTANCE: Connection is made via the black cable in the CHASSIS connector. The cable is provided with two wires so that measurement is made at the point of contact on the chassis. The other terminal of the grounding resistor is found at the ground pin of the instrument connector. For point-to-point resistance, a second black cable is used in the DUAL connector. CR1 and CR2 provide isolation from a common ground in case that is one of the points to be tested.

EARTH CURRENT: K1 is energized opening the short across the current input circuit so that the leakage current is measured directly.

CHASSIS CURRENT: The mode switch connects the CHASSIS connector to the current input to measure the current with ground intact. OPEN GROUND switch will energize K1 to provide the open ground measurement.

LEAD TO GROUND CURRENT: The mode switch connects the LEAD switch to the current input to select the lead to be tested.

LEAD TO OTHER LEADS CURRENT: The mode switch connects the LEAD switch to the current input to select the lead to be tested and K2 is energized to disconnect the measurement circuit from ground and connect it to the other leads.

LEAD ISOLATION CURRENT: The bottom end of the high-voltage secondary connected to the current input circuit, the high end of the winding is connected through a second pole of the mode switch, R12 current limiting and K3 to the lead selector. Operation of the ISO TEST switch will energize K3 to finally apply the potential to the selected lead.

DUAL CONNECTION: The mode switch connects DUAL connector to the current input for connection to the red cable and K5 is energized to disconnect the measurement circuit from ground and connect it to the CHASSIS connector for point-to-point current measurement. For point-to-point ISO testing, operation of the ISO TEST switch will energize K3 to switch the bottom end of the high-voltage winding to the current input and also apply the high end to the DUAL connector through R12.

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Chapter 3

Decontamination

This chapter describes the decontamination procedure.

Under normal circumstances, no decontamination should be needed prior to servicing this instrument.

Chapter 4

Scheduled Maintenance

This chapter provides current maintenance requirements.

Scheduled Maintenance Requirements

Bio-Tek Instruments has determined that the ESA180 should be calibrated annually, using appropriate test instrumentation which can be traced to the National Institute of Science and Technology (N.I.S.T.), or the appropriate standards institution if the unit is being used outside of North America.

Please refer to **Chapter 5**, which contains the ESA180 Calibration Data Sheet and the Calibration Instruction Sheet. Note that the Calibration Instruction Sheet (ESA180-ST) contains information concerning required test equipment.

Chapter 5

Adjustments, Alignments, and Calibration Instructions

This chapter discusses performing adjustments, alignments, and calibration.

This chapter contains the ESA180 Calibration Data Sheet (ESA180-DS) and the Calibration Instruction Sheet (ESA180-ST).

Company: Bio-Tek Instruments, Inc.	Title: ESA180 Data Sheet
Division: Service	Doc. ID: ESA180-DS Rev 1 PROVISIONAL
Location: Winooski, VT	Page 1 of 2

Rev. Comments Date Approved by

1	Initial release	10/13/98	
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REFERENCE: 1800001STP

INSTRUCTIONS

1. This data sheet is to be used with the referenced documents for service of the ESA180.
2. The items in the section below labeled data are numbered to correspond with the referenced procedure.
3. Record the product serial number, date, and your signature in the space provided.
4. Record results in Table.

Serial Number	Technician	Date

UUT DATA

Step	Item	Requirement	As Received		Cal Data
2.0	Initial Zero of U4 - 0	-0.1 → +0.1 mV	N/A		
2.1	Initial zero of U5 - 0	-0.1 → +0.1 mV	N/A		
3.0	Gain Adjust	400	N/A		AC DC
4.0	Confirm Leakage Linearity	Check leakages at:	AC	DC	AC DC
	10	9 → 11	—	—	—
	50	49 → 51	—	—	—
4.1	100	98 → 102	—	—	—
	200	198 → 202	—	—	—
	1000	989 → 1011	—	—	—
4.2	1900	1880 → 1920	—	—	—
5.0	AAMI Roll-off -1V at:				
	60 Hz 1000	989 → 1011	—	—	—
	1 kHz 728	709 → 747	—	—	—
5.1	10 kHz 105	101 → 109	—	—	—
	50 kHz 23	21 → 25	—	—	—
6.0	Ground Leakage		AC	DC	AC DC
	10	9 → 11	—	—	—
	200	198 → 202	—	—	—
	1900	1882 → 1920	—	—	—
7.0	Dual-Lead test		AC	DC	AC

7.2	10	9 → 11	—	—	DC	
	50	49 → 51	—	—	—	—
	100	98 → 102	—	—	—	—
	200	198 → 202	—	—	—	—
	1000	989 → 1011	—	—	—	—
	1900	880 → 1920	—	—	—	—
			—	—	—	—

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Step	Item	Requirement	Before Cal	Cal Data
8.1	ECG Lead tests 10μA- GND RL	9 → 11	—	—
	RA		—	—
8.2	LA		—	—
	LL		—	—
	C		—	—
	ALL			
9.1	ECG Lead tests 10μA- GND Lead to Lead	9 → 11		
9.2	RL		—	—
	RA		—	—
9.3	LA		—	—
	LL		—	—
	C			
10.2	ECG Lead Isolation	Measure AC Supply Volts		
	RL	_____ VAC	—	—
10.3	RA	Calculated Range:	—	—
	LA		—	—
10.4	LL		—	—
	C	_____ → _____	—	—
	ALL			
11.0	Impedance 1000 ⚡	990 9 → 1010		
12.0	Resistance ⚡			
	0.50	0.469 → 0.54		
12.1	1.00	0.949 → 1.06	—	—
	5.00	4.749 → 5.26	—	—
	10.00	9.499 → 10.51	—	—
	15.00	140249 → 15.76	—	—
13.0	Confirm ACV Linearity			
	120 VAC	116 → 124		
	240 VAC	232 → 248		
14.0	Verify "O", "K", and "REV"	NPCG - OUTLET lights		
	neon polarity indicators.	NPOG - Off-On-Off		
14.1		RPOG - Off-On-Off		
		RPCG - On-On-Off		
15.0	Current Test			
15.1				
	@ -5A: _____	_____ → _____		
	@ -10A: _____	_____ → _____		
	@ -15A: _____	_____ → _____		

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1	Initial Release	10/13/98	

Equipment Required

DVM - TRMS	Fluke 45 Dual Multimeter or equivalent
Calibration Station	Fluke 5101B Calibration Station or equivalent
120/240 VAC Power Source	120-250 VAC Variac or equivalent
DUAL and CHASSIS Test Cables	P/N 48386 & 48385
Precision Resistances	Vector-VID WR-416 or equivalent
Load Source	Capable of providing 5, 10, 15 A of load.
Outlet Polarity Checker	A second ESA180, or equivalent.
ESA180 Data Sheet	ESA180-DS

- 1.0 With unit not yet powered, remove the four Phillips-head screws from the back side of the case, and set them aside. Carefully remove the back case of the 180 and identify locations of each test point and pot using the 180 board layout diagram.
- 2.0 Set the DVM to measure DC mV, and connect test leads to TP3 (-) and TP1 (+). Connect the 180 to a source of 120VAC, and select CHASSIS LEAKAGE with the function switch. Adjust R27 until the DVM reads 0.0 ± 0.1 mV.
- 2.1 Move the positive DVM probe to TP2. Adjust R36 until the DVM reads 0.0 ± 0.1 mV. Record both these readings on the data sheet. Disconnect all test leads between 180 and DVM.
- 3.0 Connect the CHASSIS cable (has two connection pins in the plug) to the 180 connection labeled CHASSIS. Connect the other end of this lead to the calibrator, and set it for DC 400 μ A 60~ AC output. Adjust R29 to read 400 on the 180. Record the result on the data sheet.
- 4.0 Set the calibrator output to 10 μ A 60 Hz. Set the 180 to read CHASSIS LEAKAGE, and record your reading on the data sheet.
- 4.1 In a like manner, set the calibrator to the other listed leakages, and record the readings for each.
- 4.2 Set the calibrator for DC, and record each reading again at DC.
- 5.0 Set the calibrator for 1VAC, 60 Hz. With the CHASSIS cable still connected as in 3.0, add a banana jack connected from the calibrator black (-) jack to the 180 accessory receptacle ground pin connection. Record the reading on the data sheet.
- 5.1 In a like manner, set the frequency to the other listed frequencies, and record the roll-off readings.
- 6.0 Remove the CHASSIS connector only - leave the banana plug connected to the 180. Connect the other end of the banana jack to the calibrator red (+) jack. Set the 180 function switch to GROUND LEAKAGE. Set the calibrator to 10 μ A 60 Hz output, read and record the 180's reading.
- 6.1 In a like manner, set up the other outputs, and record the 180 readings on the data sheet. Repeat at DC.

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- 7.0 Remove the banana jack from the 180 and set it aside. Reconnect the CHASSIS lead and the DUAL lead to the 180, and set its function switch to DUAL LEAKAGE. Connect the other ends of the leads to the calibrator output connections, and set the calibrator for 10 uA 60 Hz. output. Record the 180's reading on the data sheet.
- 7.1 Continue through the rest of the test leakage outputs, recording each on the data sheet.
- 7.2 Set the calibrator to output the same group of leakages at DC, and record the results on the data sheet.
- 8.0 Remove both leads from the calibrator and the 180. Connect the banana lead from the calibrator red (+) jack to the 180 RL ECG Jack. Set the 180's function switch to ECG LEAKAGE - GND, and the ECG select switch to RL. Set the calibrator for 10 uA DC output.
- 8.1 Record the 180's ECG leakage reading for lead RL on the data sheet, then move the banana jack from the 180 RL connector to the RA connector. Check to be sure the 180 reads "0", then turn the ECG select switch to RA and record the 180's reading for Lead RA. Record this reading on the data sheet.
- 8.2 Continue through the rest of the ECG Jacks, recording your results as you go.
- 8.3 After you record the C lead leakage, set the ECG select switch to ALL. On this setting, check to be sure the 180 reads 10 uA as you touch the banana lead to each ECG jack in turn. Return the ECG select switch to the RL position.
- 9.0 Place banana lead back into the 180's RL ECG jack, and connect a second banana lead between the 180's RA ECG jack and the calibrator black (-) output connection. Set the 180's function switch to lead-lead leakage. Configure the calibrator for 10 uA DC output.
- 9.1 Check that the 180 lead select switch is set to RL. The 180 should now be reading 10 uA $\pm$ 1. Record the reading on the data sheet.
- 9.2 Changing the lead select switch to RA should have no effect, since the connection you are measuring is between RL and RA. Check that this is so. Now move the banana lead in the RL jack to the LA jack. The 180 should again display 10 uA $\pm$ 1, since you are now measuring between RA and LA. Record your reading on the data sheet.
- 9.3 Using step 9.2 as a guide, check and record your results on the remaining ECG jacks. When this step is complete, disconnect the banana leads from the 180 and the calibrator.
- 10.0 Set your DVM to read line voltage, and monitor the AC line supply. Connect a banana jack from the 180's AC receptacle GND connection to the 180 RL ECG jack. Set the function switch to Lead Iso leakage, and the lead select switch to RL.
- 10.1 **WARNING: in all remaining lead isolation tests, be sure to keep your hands and all conductive tools, etc. clear of the area around the ECG jacks. Hazardous voltages will be present during portions of this test.**
- 10.2 Observe and record the line voltage in the appropriate spot on the data sheet. Multiply this voltage by 1.1, and divide the result by 0.120. Record the answer on the data sheet.
- 10.3 While looking at the 180's display, press and hold the ISO TEST switch, and record the result on the data sheet.

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- 10.0 In a like manner, connect the banana lead to each ECG jack in turn, and select the connected lead with the lead select switch, then press the ISO TEST switch and record the readings. Be sure the resulting readings match the results you figured in step 10.2 ± 100 . When testing is complete, disconnect the banana lead from the 180, and disconnect the DVM from the AC line.
- 11.0 Configure your DVM to read 1000 Ohms resistance. Connect the CHASSIS lead to the 180, and connect this lead to the DVM. Connect the other test lead from the DVM to the 180's receptacle ground. Place the 180 function switch in chassis leakage mode, and record the resistance shown on the DVM. You should read 1000 ohms, ± 10 . Disconnect the leads from the DVM, but keep them connected to the 180 as listed above.
- 12.0 Connect a precision resistance source to the 180 via the leads left in the 180 in step 11.0. Set the source to 0.50 Ohms, and the 180 function switch to Ω resistance. Record the resistance shown on the 180, and check to see it falls within the tolerance shown. **NOTE:** Short leads together first, and note any lead resistance - this should be deducted from resistance readings before recording them.
- 12.1 Continue to check all the other resistances shown, being sure they fall within tolerance, and recording the values on the data sheet. When this test is complete, remove and stow the test leads from the 180.
- 13.0 Set DVM to read 120VAC, and connect test leads to monitor line voltage. Set 180 function switch to LINE VOLTS, and read the voltage on the 180's LCD display. Adjust R8 to make 180 agree with AC Line ± 4 counts. Now set DVM to read 240 VAC, and connect 180 to a source of 240VAC, and confirm Line Voltage reading is accurate ± 8 counts. Readjust R8 as necessary to achieve best accuracy between 120 and 240 VAC, and record the result on the data sheet.
- 13.1 Reconnect the 180 to a 120VAC ± 1 VAC source. You will not need 240VAC for the rest of the tests.
- 14.0 Connect a polarity checking device to the accessory outlet on the 180, and check for proper operation of the Outlet Normal/Reversed switch, Neutral Open/Closed switch, and the Open Ground switch. Verify and record proper operation of Normal Polarity Closed Ground, Normal Polarity Open Ground, Reverse Polarity Open Ground, and Reverse Polarity Closed Ground configurations using neon indicator lights.
- 14.1 Connect 180 power cord to a device suitable for reversing polarity and opening ground. Verify proper operation of OUTLET indicator lights on 180 in normal and reversed polarity configurations, with both open and closed ground. Record your results on the data sheet.
- 14.2 Remove polarity reversal device, and reconnect 180 directly to 120VAC supply.
- 15.0 Connect a source of adjustable current to the 180 via the accessory outlet on the front of the 180. Set the 180 function switch to CURRENT, neutral switch closed, outlet switch set to supply normal polarity. Set the current source to draw approximately 5 A of current, and record the actual current setting. Now record the 180 display value, which should equal the actual current value $\pm 5\% \pm 1$ LSD.

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- 15.0 In a like manner, set the current source for 10 and 15 A loads, and check to see the 180 meets the accuracy specified. Record the 180 current readings in each case. When you are done, disconnect all leads and test devices from the 180, and disconnect the 180 from AC Mains power.
- 16.0 Carefully re-install the back case on the 180 using the four Phillips-head screws. Be sure unit is clean and mechanically correct. Affix CAL VOID and CALIBRATION DUE stickers, fill in information regarding test equipment used, and calibration due dates. Complete all paperwork associated with unit.

Chapter 6

Performance Verification

This chapter provides performance verification information.

Performance verification of the ESA180 is accomplished through use of the Test Procedure and Data Sheet contained in **Chapter 5**.

If performance discrepancies are suspected, also refer to **Chapter 2, Theory of Operation**.

Chapter 7

Troubleshooting

This chapter provides troubleshooting tips.

The following table represents approximately 80 percent of possible problems that the user may experience with the 180.

PROBLEM	SOLUTION
No Leakage reading, but everything else is operational.	Check the picofuse.
Display reads "BAT"	Check the +5 volt supply.
No line voltage reading	The transformer probably has no secondary output. Confirm this by checking the Lead Iso or External Iso modes.
Neither the Lead Iso nor External Iso mode function operates.	Open the case. Find and test the secondary output on the transformer.
Resistance reading too high. Also, point-to-point, using two cables touching each other, reads higher than 0.01 or 0.02.	The chassis cable is probably open. Try new cable(s).
The unit blows the customer's fuse or circuit breaker when in Reverse Polarity mode.	The polarity switch is probably defective, caused by running excessive current through the 180. Change the double-pole polarity switch. The neutral switch should be operational.
Intermittent reading on all functions.	Check the main function switch. The unit could have been dropped, thereby damaging the switch. Also check the lead switch.

Chapter 8

Installation

This chapter discusses installation requirements.

There is no installation procedure for the ESA 180; however, please refer to ***Chapter 1, Safety Considerations***.

Chapter 9

Parts Lists

*This chapter contains lists of
component parts sorted by
board assembly.*

This chapter contains two parts lists.

Page 9-3 provides an abbreviated listing of the most regularly needed parts, together with their Bio-Tek part numbers.

The complete parts listing follows this. These parts are not normally stocked as repair material at Bio-Tek, hence orders for parts not listed on page 9-3 will involve an extra few days of lead time.

DESC.	BIO-TEK P/N	DESCRIPTION
T1		Power Transformer
T2	61083	Transformer Current
Q1	26035	Transistor 2N4401
S1	54021	Switch On-Off-On
S2	54020	Switch On-Off-On
S3	54019	Switch Momentary -Off-Momentary
S4	51033	Switch Mode
S5	51034	Switch Lead Select
NE3	01015	Neon Light, Red
NE1,2	01014	Neon Light, Green
DISPLAY	04024	Display LCD 3 1/2 Digit
KNOB	45086	Knob Beige 3/4
BR1	21014	Bridge Rectifier, 1A
U5	25113	IC AD637LQ
U4	29159	IC AD712JN
U3	23111	IC MC79M05 -5V Regulator
U2	23110	IC MC78M05 +5V Regulator
F1	46097	Fuse - .50A Board Mount
CR4,5,23,24	21002	Diode 1N4001
CR6,7,8	21003	Diode 1N4004
CR1,2	21015	Diode 6A05
K2	62067	Relay SPST DC5V
K3	62068	Relay DPDT DC5V
K4	62069	Relay 4PDT DC5V
K1	62070	Relay DPDT DC5V
K5	62071	Relay SPST DC5V
	5382001	Post Cap ECG
	5382003	Post ECG
	5382002	Post Spring ECG
	48386	8-Foot Cable/Lg. Clamp
	48384	16-Foot Black Cable/Lg. Clamp
	48385	8-Foot Red Cable/Lg. Clamp
	48387	16-Foot Red Cable/Lg. Clamp
	97148	Soft Carrying Case
	1801000	User's Guide
	42729	20A Receptacle

MODEL ESA180 BILL OF MATERIALS - REV. A		
Description	Qty.	Ref. Designation
BRACKET HEAT SINK	1	
BUSHING INS 5V REG	1	
CAP .1UF 50V FOIL	5	C24,22,28,29,26
CAP 1.5UF 16V TANT	2	C4,5
CAP 10UF 16V TANT	2	C23,6
CAP 220UF 35V ELECT	2	C1,2
CAP .015UF 50V 2%FOIL	1	C21
CLIP BLACK	1	
CLIP RED SMALL	0	
CONNECTOR 10 POS	1	
CONNECTOR 3PIN HDR	1	
CORD SET 14AWG	1	
CRIMP TERM	2	
DIODE 1N4001	4	CR4,5,23,24
DIODE 1N4004	3	
DIODE 6A05	2	ON ELECTvrt CR1,2
FUSE .50 AMP	1	F1
HOUSING ESA180	1	FLAME RETARDNT
HOUSING MACHINED	1	
HOUSNG 3PIN RECPT	1	
IC 5VOLT REG	1	U2
IC -5VOLT REG	1	U3
IC AD637JQ	1	U5
IC AD712JN	1	U4
INSULATOR 5V REG	1	
KNOB BEIGE 3/4	2	
LABEL REAR INST	1	
MANUAL INSTRUCTION	1	
METER 3.5 DIGIT	1	
NEON GREEN	2	NE1,2
NEON HOLDER	1	
NEON RED	1	NE3

MODEL ESA180 BILL OF MATERIALS - REV. A (CONT.)		
Description	Qty.	Ref. Designation
NUT DRESS	2	
NUT WIRE	2	
OVERLAY	1	
PC BOARD MODEL 600	1	
PIN MALE	2	
PLUG BLACK COIL CRD	1	
POST CAP ECG	5	
POST ECG	5	
POST SPRING ECG	5	
POT 200 OHM	1	R29
POT 20K	1	R8
POT 500K	2	R27,36
QUICK DISCONCT	11	
RECEPTACLE	1	
RECEPTCL	2	
RECPTCL 15POS	1	
RECTIFIER BRIDGE 1A	1	BR1
RELAY 4PDT	1	K4
RELAY DPDT	1	K1
RELAY DPDT	1	K3
RELAY SPDT	1	K2
RELAY SPDT	1	K5
RES 1.91K 1% 1/4W	1	R28
RES 10 OHM .5% 1/4W	1	R30
RES 100 OHM 1% 1/4W	1	R24
RES 100K 1% 1/4W	1	R13
RES 10K 1% 1/4W	5	RR14,15,38,34,31
RES 10MEG 1/4W	1	R26
RES 113 OHM 1% 1/4W	1	R7
RES 121K 1% 1/4W	1	R12
RES 18K 1% 1/4W	1	R18

MODEL ESA180 BILL OF MATERIALS - REV. A (CONT.)		
Description	Qty.	Ref. Designation
RES 1K 1% 3W	1	R21
RES 1MEG 1% 1/4W	1	R11
RES 20K 1% 1/4W	1	R22
RES 210K 1/4W 1%	3	R2,4,6
RES 24.9 OHM 1% 1/4W	1	R33
RES 2K 1% 1/4W	1	R17
RES 301 OHM 1% 1/4W	1	R23
RES 332K 1/4W 1%	1	R35
RES 7.87K 1% 1/4W	1	R25
SCREW 2-56*1/2 PHL H	2	
SCREW 6-32*1/4 PHL H	5	
SOCKET 14POS	1	
SOCKET CRMP FMLE	5	
SOCKET IC 8POS	1	
SPACER 1/8L	2	
SPACER DISPLAY	2	
SPACER OUTLET	2	SHEET MTL SHM
SPACER SNAPS	5	
STRAIN RELIEF	1	
SWITCH LEAD SELECT	1	S5
SWITCH MODE	1	S4
SWITCH MOM-OFF-MOM	1	
SWITCH ON-OFF	1	
SWITCH ON-OFF-ON	1	
TERMINAL STRIP 15POS	1	
TEST POINT	3	
TRANS 2N4401	1	Q1
TRANS 2N4403	1	Q2
TRANSFORMER CURRENT	1	T2
TRANSFORMER POWER	1	T1
WASHER LOCK SPLIT #2	2	
WASHER LOCK SPLIT #6	5	

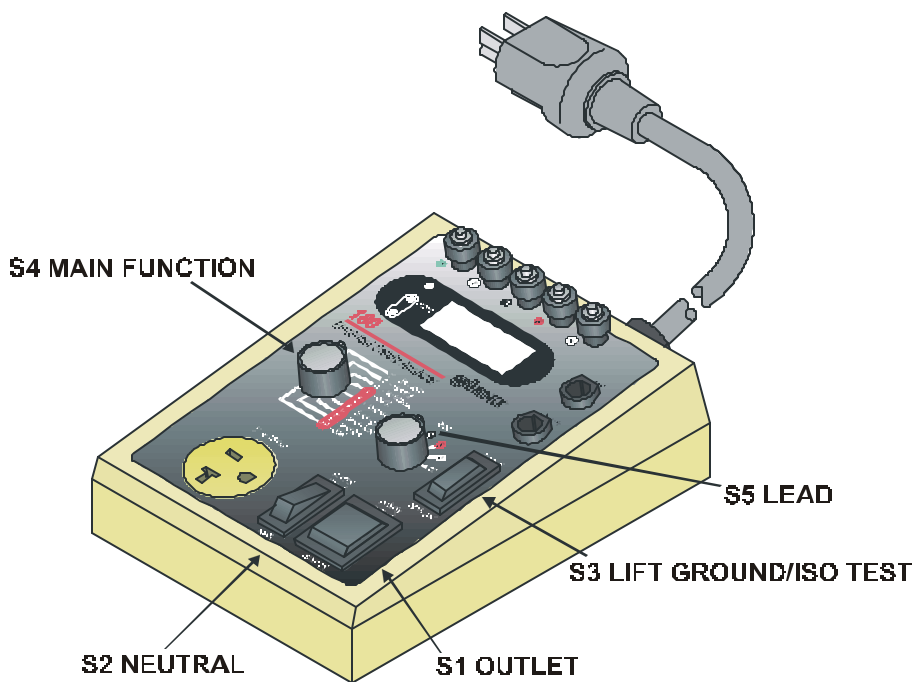
MODEL ESA180 BILL OF MATERIALS - REV. A (CONT.)		
Description	Qty.	Ref. Designation
WIRE 18AWG BLU	1	
WIRE 18AWG ORG	1	
WIRE 18AWG YEL	1	
WIRE 24AWG THN WL GR	1	
WIRE 24AWG THN WL OR	1	
WIRE 24AWG THN WL RE	1	
WIRE 24AWG THN WL VI	1	
WIRE 24AWG THN WL YE	1	
WIRE COIL 2COND 8FT	1	

Chapter 10

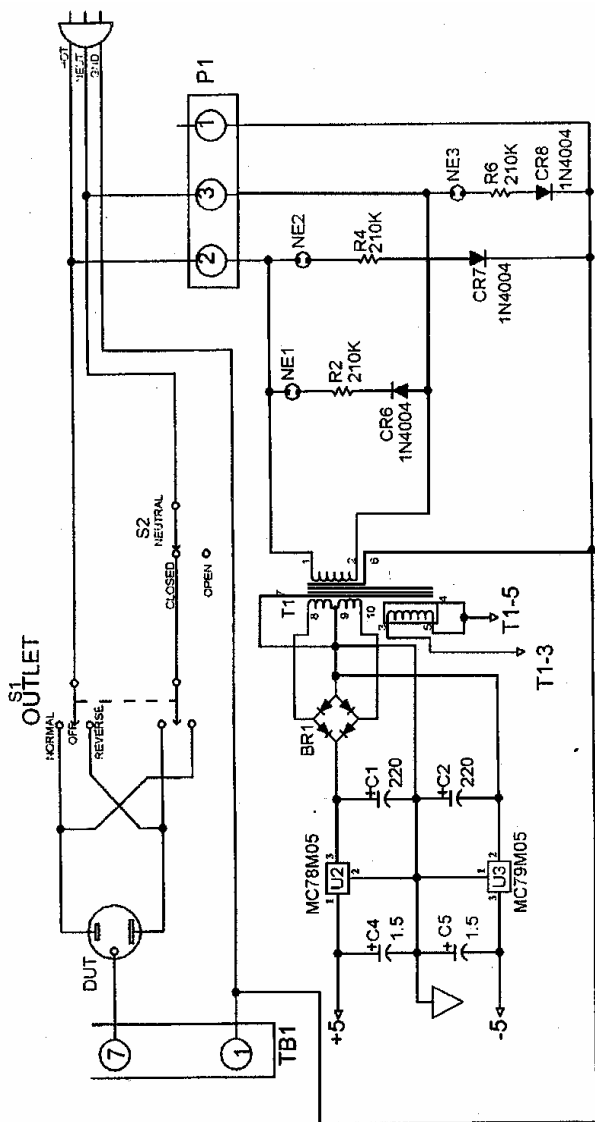
Drawings and Schematics

*This chapter contains diagrams for each section of the 180,
to assist with identification of parts
placement.*

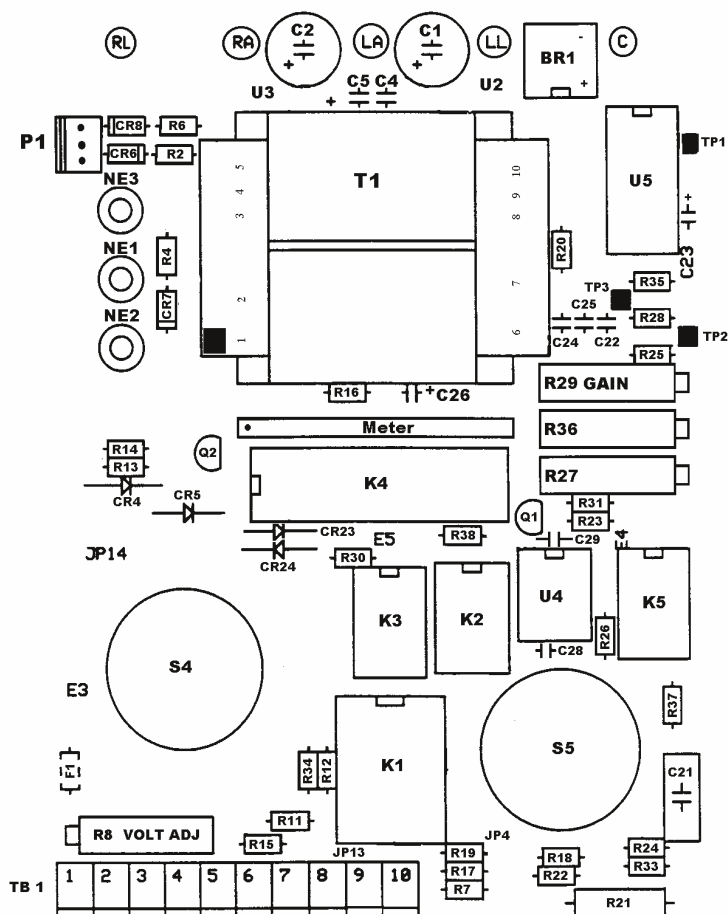
This chapter provides the 180 drawings and schematics.







DATE	CHANGE
SCHEMATIC MODEL 100-100	
SHEET 2 OF 2	



Chapter 11

Service Change Notices

*This chapter provides a list of
Service Change Notices.*

This is the first edition of this manual, therefore, no service change notices are available.

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