WARRANTY

TENNELEC, INC. warrants that the products or components manufactured by it shall be free from defects in material or workmanship for a period of one year from the date of delivery to purchaser. If such product or component is determined to be defective by TENNELEC, its sole warranty obligation shall be limited to either replacing or repairing such defective product or component or allowing credit therefor, at TENNELEC's option. Such warranty is further conditioned upon the purchaser's giving prompt notice of any such defect and satisfactory proof thereof to TENNELEC's customer service manager, thereafter upon TENNELEC's approval, the purchaser shall return such defective product or component to TENNELEC's factory at Oak Ridge, Tennessee, all transportation charges prepaid. TENNELEC shall be responsible only for transportation charges incurred in returning such product or component to purchaser. All customs, brokerage and duty charges shall be at the expense of the purchaser. Damage in transit due to inadequate packaging will be repaired at purchaser's expense. Any repairs or replacements by the purchaser without TENNELEC's approval, any willful abuse or any evidence that the product or component was not properly used and maintained, would automatically void this warranty.

TENNELEC makes no warranty whatsoever in respect to products or components not manufactured by it but instead the applicable warranties, if any, of the respective manufacturers thereof shall apply. Likewise fuses, batteries and input transistors in ultra low-noise amplifiers are specifically excluded from this warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, STATUTORY OR OTHERWISE, INCLUDING WARRANTY OF MERCHANTABILITY AND FITNESS.
1.0 INTRODUCTION

The TENNELEC TC 953 DUAL and TC 954 single HIGH VOLTAGE POWER SUPPLY (HVPS) provide a well regulated, low-noise, dc voltage source capable of supplying up to 100uA load current in a single-width NIM module. The TC 953 / TC 954 offers two output voltage ranges, 0 to ±100 volts or 0 to ±1000 volts at 0 to 100uA load current with a digital multimeter (DMM) for display of either current or voltage. The TC 953 dual supply has totally independent controls and displays for each channel. The load current can be displayed in three full-scale ranges of 1.000, 10.00, or 100.0uA. This is especially useful in alpha spectroscopy work as it allows for easy compensation of the voltage drop in the bias network due to detector leakage current.

Several features have been incorporated in the TC 953 / TC 954 to provide protection of fragile detectors. The TC 953 / TC 954 incorporates overvoltage protection at a level of 2 volts over the front-panel control on the 100 volt range and 20 volts over the front-panel control on the 1000 volt range. The rate of increase in the output voltage is limited to 30 volts per second on the 100 volt range and 300 volts per second on the 1000 volt range. The current limit is adjustable from 10% to 120% of the full-scale current range by a front-panel control. In the event of a failure due to an overvoltage or overcurrent condition, the TC 953/TC 954 will be disabled and the output voltage will decay to zero. The output voltage will be reset every 7 seconds until the fault is cleared or after the TC 953 / TC 954 VOLTAGE switch is cycled off and on. The mode of output voltage reset is user selectable.

The output voltage of the TC 953 / TC 954 may be controlled by a remote input. A 0 to ±10 volt dc signal will produce a full scale output on the TC 953 / TC 954. A remote disable input is available to reduce the output voltage to zero regardless of the front-panel control settings.
2.0 SPECIFICATIONS

2.1 PERFORMANCE

OUTPUT VOLTAGE 0 to ±100V or 0 to ±1000V.

OUTPUT CURRENT 0 to 100μA.

OUTPUT POLARITY Positive or negative, selectable through left side shield.

OUTPUT RIPPLE ≤ 1.0mV peak to peak, 5Hz to 50 MHz; typically < 300μV at full load.

OUTPUT REGULATION ≤ 0.001% or 1mV (whichever is greater) variation in output voltage for load and bin supply variations within operating range (0 to 100μA output current and ±1% variation in bin supply voltages).

OUTPUT INACCURACY ≤ ±0.25% of full scale due to nonlinearity of potentiometer; typically ≤ ± 0.1% of setting.

TEMPERATURE INSTABILITY ≤ ± 30ppm/°C, 0 to 50°C; typically ≤ ± 10ppm/°C.

LONG-TERM INSTABILITY ≤ 0.001% per 24 hour period at constant line, load, and temperature.

RESOLUTION 0.5V or better on 1000 volt range; 0.05V or better on 100 volt range.

RESETTABILITY Resettable to within 1V on 1000 volt range; resettable to within 0.1V on 100 volt range.

DISPLAY INACCURACY ≤ ± .05% ± 1 least significant digit for current and voltage.

DISPLAY TEMPERATURE INSTABILITY ≤ ± 50ppm/°C, typically ≤ ± 30ppm/°C.

OPERATING TEMPERATURE 0 to 50°C.
2.2 CONTROLS

2.2.1 FRONT-PANEL CONTROLS

DISPLAY Two-position toggle switch selects V (output voltage) or uA (output current) for display on DMM.

VOLTAGE Ten-turn precision potentiometer with linear calibration from 0.0 to 1000 corresponding to output voltages of 0 to 1000 volts or 0 to 100 volts depending on range selected.

RANGE Two-position locking toggle switch selects either 1000V or 100V full scale.

CURRENT LIMIT Single-turn potentiometer sets current limit from 10 to 120 percent of selected full scale current range.

CURRENT RANGE Three-position toggle switch (locking toggle on the TC 954) selects 100.0, 10.0, or 1.000uA full scale current range for display on DMM and CURRENT LIMIT range.

VOLTAGE Two-position toggle switch (locking toggle on TC 954) enables or disables the high voltage output. When in the OFF position, the high voltage circuit is disabled but power is applied to the low voltage section allowing the precision voltage reference to remain at a stable operating temperature. When the VOLTAGE switch is set to ON, the high voltage section is enabled.

2.2.2 INTERNAL CONTROLS

POLARITY Two-position switch (accessible through the module's left side shield) selects either positive (POS) or negative (NEG) high voltage polarity. Refer to Section 3.2 for instructions on changing the high voltage polarity. The TC 953 / TC 954 is shipped with the POLARITY switch in the POS position.

INT/EXT Two-position jumper selects either internal (INT) output voltage control or external (EXT) output voltage control. When the INT mode is selected, no external voltage control input is accepted. If the EXT
mode is selected, the output voltage is determined by
the external control voltage. The front panel VOLTAGE
control dial is not functional in the EXT mode.
The TC 953 / TC 954 is shipped with the INT/EXT jumper
in the INT position.

7s/PowOn Two-position jumper selects either 7 second
(7s) or power on (PowOn) reset mode of operation. When
in the 7s position, the TC 953 / TC 954 will recover
from a fault condition and restore normal operation
approximately 7 seconds after a fault condition was
sensed. If the initial fault was not cleared, the TC 953
/ TC 954 will continue resetting every 7 seconds until
the fault is cleared. When the TC 953 / TC 954 is oper-
ated in the PowOn position, the TC 953 / TC 954 will not
recover from a sensed fault condition until the VOLTAGE
control is cycled from ON to OFF and back to ON. Note
that the reset mode operates on sensed faults only and
not on the DISABLE input. The TC 953 / TC 954 is shipped
with the 7s/PowOn jumper in the 7s position.

2.3 CONNECTORS (Rear Panel)

OUTPUT SHV type connector provides 0 to ±100V or 0 to
±1000V output voltage. The connector is isolated from
the TC 953 / TC 954 chassis to aid in the prevention of
ground loops.

DISABLE BNC type connector accepts a NIM positive logic
zero or a short to ground through a resistance of 100
ohms or less to disable the high voltage section. A NIM
positive logic high, or an open circuit, is used to
enable the high voltage section.

REMOTE BNC type connector accepts an external control
signal to allow remote control of the TC 953 / TC 954
OUTPUT voltage. The external control voltage should not
exceed +10.0V. The REMOTE input is protected for
voltages exceeding +12V and negative voltages. The
input impedance of the REMOTE input is 10k ohms. Note
that only positive voltages are accepted and the OUTPUT
polarity is controlled by the internal POLARITY switch.

2.4 INDICATORS

2.4.1 FRONT-PANEL INDICATORS

NEG Red LED indicator is illuminated when the TC 953 /
TC 954 POLARITY switch is set to NEG.
POS  Red LED indicator is illuminated when the TC 953 / TC 954 POLARITY switch is set to POS.

ON  Red LED indicator is illuminated when the TC 953 / TC 954 VOLTAGE switch is set to ON.

DIS  Red LED indicator is illuminated when the TC 953 / TC 954 high voltage section is disabled. The disable signal can be generated externally and applied to the DISABLE input or internally generated. The internal signal can be generated by an overvoltage condition, overcurrent condition, or by setting the VOLTAGE switch to OFF.

2.4.2 DIGITAL DISPLAY

The TC 953 / TC 954 digital display is a 3 1/2 digit multimeter (DMM) that monitors either the output voltage or the output current. The inaccuracy of the DMM is .05% of full scale ± 1 least significant digit. This results in a worse case error of ± 1.5V on the 1000V range and a worse case error of ± .15V on the 100V range. The temperature instability of the DMM is not as low as the temperature instability of the output voltage. Any drift in the output voltage as indicated by the DMM is probably due to the instability of the DMM. Typically, the TC 953 / TC 954 output voltage temperature instability is less than 10ppm/°C and the DMM is typically less than 30ppm/°C.

2.5 POWER REQUIREMENTS (TC 953, same load both channels)

TC 953 (1000V, 100uA),  
+24V, 70mA  +12V, 270mA  +24V, 35mA  +12V, 135mA  
-24V, 40mA  -12V, 120mA  -24V, 20mA  -12V, 60mA

TC 954 (1000V, 100uA)

+24V, 70mA  +12V, 120 mA  +24V, 35mA  +12V, 60mA  
-24V, 40mA  -12V, 120 mA  -24V, 20mA  -12V, 60mA

2.6 OTHER INFORMATION

WEIGHT

<table>
<thead>
<tr>
<th></th>
<th>TC 953</th>
<th>TC 954</th>
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<tbody>
<tr>
<td>Shipping</td>
<td>5.0 lbs.</td>
<td>4.5 lbs.</td>
</tr>
<tr>
<td></td>
<td>2.3 kg.</td>
<td>2.1 kg.</td>
</tr>
</tbody>
</table>
- 6 -

Net \begin{align*}
3.0 \text{ lbs.} & \quad 2.5 \text{ lbs} \\
1.4 \text{ kg.} & \quad 1.2 \text{ kg.}
\end{align*}

DIMENSIONS Standard single-width NIM module (1.35 x 8.714 inch) per TID 20893 (Rev).

INSTRUCTION MANUAL One provided with each instrument ordered.

3.0 INSTALLATION

3.1 POWER CONNECTION

The TC 953 / TC 954 HVPS requires a bin and power supply, such as the TENNELEC TB3 / TC 911, for operation. The bin provides mechanical mounting and power supply distribution. Always turn the bin power supply OFF when inserting or removing any modules.

The TC 953 exceeds the maximum allowable per-module power limit of the +12V power supply when the TC 953 is heavily loaded. The +12V current requirements of each module should be totaled to ensure that the total current requirements do not exceed the capability of the bin. The TENNELEC bin provides power supply test points on the control panel for monitoring the dc voltage levels.

3.2 POLARITY SELECTION

The polarity of the output voltage is selected by a pushbutton switch accessible through the left side shield. The switch positions are labeled on the side shield and the printed circuit board. When changing the output polarity always follow the procedure below. Failure to do so is potentially dangerous and may damage the TC 953 / TC 954.

TO CHANGE THE OUTPUT POLARITY:

1) REDUCE DIAL SETTING TO ZERO.
2) SET VOLTAGE SWITCH TO OFF.
3) VERIFY OUTPUT VOLTAGE IS ZERO AS INDICATED BY THE FRONT PANEL DISPLAY.
4) REMOVE MODULE FROM NIM BIN and NIM BIN POWER.
5) SET HIGH VOLTAGE POLARITY SWITCH TO CORRECT POSITION.
3.3 CURRENT RANGE SELECTION

Current range selection will depend upon the detector leakage current. For normal operation, set the CURRENT RANGE control to the range covering the maximum expected operating current for your detector. Remember that the leakage current will vary as a function of temperature and could exceed the CURRENT RANGE limits if temperature variations are extreme.

3.4 CURRENT LIMIT

Unless a current limit of other than 120% of CURRENT RANGE is desired, it is recommended to operate the CURRENT LIMIT control at the 120% position as this will allow maximum utilization of the selected CURRENT RANGE.

3.5 OUTPUT CONNECTIONS

The TC 953 / TC 954 HVPS is compatible with all TENNELEC preamplifiers that include provisions to accept the high voltage bias for the detector. The output cables will require SHV type connectors at each end (For example, TENNELEC model NC-595-12 cable).

4.0 OPERATION

4.1 FIRST TIME OPERATION

Users will find it helpful to familiarize themselves with the TC 953 / TC 954 HVPS by conducting a few simple tests.

4.1.1 CONTROL SETTINGS

Set the TC 953 / TC 954 controls as follows:

FRONT PANEL
VOLTAGE SWITCH OFF
VOLTAGE RANGE 100V
CURRENT RANGE 100uA
CURRENT LIMIT 120% (FULLY CLOCKWISE)
VOLTAGE DIAL 0.0 (FULLY COUNTER CLOCKWISE)
DISPLAY V

INTERNAL CONTROLS (Factory Settings)
POLARITY POS
INT/EXT INT
7s/PowOn 7s
4.1.2 POWER SUPPLY OPERATION

Install the TC 953 / TC 954 in the bin and apply power. The digital display should momentarily indicate 88888 and then indicate 000.0 ±.2V. The 88888 indication is the POWER ON DISPLAY TEST. Upon application of bin power, the display will indicate 88888 in the 100V range and 8888 when in the 1000V range. Verify that the POS and DIS LED's are illuminated.

Set the VOLTAGE switch to ON. Verify that the DIS LED is not illuminated and the ON LED is illuminated. Increase the VOLTAGE dial to the desired value and observe the increase in output voltage indicated by the display. Set the DISPLAY switch to uA. The display should indicate 000.0 ±.1uA.

To verify operation of the 7 second delay for a fault condition, rapidly reduce the VOLTAGE dial setting until the DIS LED is illuminated. The DIS LED should remain illuminated for approximately 7 seconds and then extinguish. The output voltage should recover to the setting on the VOLTAGE dial. Note: this also verifies operation of the overvoltage protection mode.

To verify operation of the power on reset mode requires removal of the left side shield for access to the 7s/PowOn jumper. Place the jumper in the PowOn position and rapidly reduce the VOLTAGE dial setting as in the previous paragraph. The DIS LED should illuminate and the output should decay to zero. Wait at least 10 seconds to verify that the output does not recover and the DIS LED remains illuminated. To initiate reset, set the VOLTAGE switch to OFF, wait 2 seconds or longer, and return the VOLTAGE switch to ON. The DIS LED should extinguish and the output voltage should recover to the VOLTAGE dial setting. Return the 7s/PowOn jumper to the 7s position.

4.1.3 EXTERNAL CONTROL

Verification of operation using an external voltage source requires a stable, low-ripple, dc voltage source. Any low frequency noise present in the external control voltage will be amplified by a factor of 100 when operating the TC 953 / TC 954 on the 1000V range and by 10 when operating on the 100V range.
To operate under external voltage control, the TC 953 / TC 954 POLARITY switch must be set for the desired output polarity and the INT/EXT jumper set to EXT. The control voltage must be positive. The TC 953 / TC 954 is basically an operational amplifier with a gain of 10V/V or 100V/V. Note that the front panel VOLTAGE dial is disabled when operating in the EXT mode; however, setting the VOLTAGE dial to 0.0 is recommended. Setting the dial to zero will help prevent accidental application of bias when returning to INT control.

4.1.4 REMOTE DISABLE

The TC 953 / TC 954 rear-panel DISABLE input is designed to provide normal operation for a NIM positive logic one or an open input. The DISABLE input will inhibit operation of the TC 953 / TC 954 for a short to ground or a NIM positive logic zero. Operation of the DISABLE input can be verified by shorting the DISABLE input to ground using a BNC terminator such as a 50 ohm or 100 ohm terminator.

4.2 DETECTOR CONNECTION

ALWAYS VERIFY THAT THE TC 953 / TC 954 OUTPUT VOLTAGE, AS INDICATED ON THE DMM, IS ZERO BEFORE CONNECTING THE HIGH VOLTAGE OUTPUT TO A PREAMPLIFIER OR CONNECTING THE DETECTOR TO THE PREAMPLIFIER. CONSULT THE PREAMPLIFIER MANUAL FOR ANY NECESSARY PRECAUTIONS AND THE DETECTOR DATA SHEET FOR THE PROPER POLARITY, LEVEL OF BIAS VOLTAGE, AND ANY SPECIAL PRECAUTIONS FOR APPLYING BIAS AND HANDLING PROCEDURES.

For initial application of bias voltage, it is recommended that the VOLTAGE dial be set to 0.0 and the voltage gradually increased until the proper operating point is reached. The TC 953 / TC 954 has a maximum rate of increase in the output voltage of 30 volts per second in the 100V range and 300 volts per second in the 1000V range. The ramp feature should prove useful when removing bias from a detector and reapplying bias to the same detector as the VOLTAGE dial can be set to the proper voltage and the output controlled by the VOLTAGE switch. The ramp feature will reapply bias at a controlled rate which should be safe for the preamplifier and detector combination. The ramp feature is active on all output voltage increases including recovery from fault conditions.
4.3 DETECTOR LEAKAGE CURRENT MEASUREMENT

When initially applying bias voltage to a detector, operate the TC 953 / TC 954 with the CURRENT RANGE control in the range covering the maximum expected leakage current and with the CURRENT LIMIT control set to 120%. The DMM resolution is 0.1uA in the 100uA range, 0.01uA in the 10uA range and 0.001uA in the 1uA range. For most applications, operation on the 100uA or the 10uA range will give adequate resolution. When operating in the 1uA range, adequate time must be given for all capacitors in the preamplifier high voltage filter network to properly form at the operating voltage to obtain an accurate leakage current reading. Additionally, the final high voltage filter capacitor in the TC 953 / TC 954 must be allowed to form properly. This time will vary with applied voltage and is usually less than 2 minutes for voltages less than 500V. The typical error generated by not allowing for the current to settle to zero is less than 0.002uA.

4.4 LOADING EFFECTS

The TC 953 / TC 954 is, in effect, a noninverting operational amplifier and has a low output impedance. The feedback signal is taken directly at the output and the output impedance is approximately zero. The output voltage is essentially independent of load, with less than 0.01% variation (typically less than 0.003%) for a 0 to 100 uA change in output current.

To determine the actual voltage on a detector, the resistance between the output of the TC 953 / TC 954 and the detector itself must be identified. Since the bias voltage is usually supplied through a detector load resistor in the preamplifier and then to the detector, the resistance can usually be determined from the preamplifier schematic diagram. The actual detector voltage \( V_{DET} \) can be determined by

\[
V_{DET} = V_{HVPS} - I_{DET} R_L
\]

where \( V_{HVPS} \) is the TC 953 / TC 954 output voltage, \( I_{DET} \) is the detector leakage current as indicated by the TC 953 / TC 954 display in the uA mode, and \( R_L \) is the detector load resistance. The TC 953 / TC 954 provides a direct reading of the detector leakage current down to the nanoampere level.
5.0 MAINTENANCE

The TC 953 / TC 954 is a highly stable and precision power supply. Periodic calibration or adjustment is not necessary and is not recommended as a routine procedure. Precise measurement of the TC 953 / TC 954's performance requires specialized and expensive test equipment. If trouble should arise, it is strongly recommended that the unit be returned to TENNELEC for repair. If it is impossible to return the unit to TENNELEC for repair, a detailed Test Procedure is available upon request. Observe the following procedure before removing the TC 953 / TC 954 side shields.

CAUTION

DANGEROUS VOLTAGES & CURRENTS EXIST INSIDE THIS INSTRUMENT. BEFORE REMOVING SIDE SHIELD:

1) REDUCE DIAL SETTING TO ZERO.
2) SET VOLTAGE SWITCH TO OFF.
3) VERIFY OUTPUT VOLTAGE IS ZERO AS INDICATED BY THE FRONT PANEL DISPLAY.
4) REMOVE FROM NIM BIN AND NIM BIN POWER.
5) WAIT 10 SECONDS BEFORE REMOVING SIDE SHIELDS.

THE HIGH VOLTAGES PRESENT IN THIS INSTRUMENT ARE HAZARDOUS. DO NOT ATTEMPT ANY ADJUSTMENTS OR MAINTENANCE UNLESS YOU ARE EXPERIENCED WITH HIGH VOLTAGE CIRCUITS.

6.0 SHIPPING DAMAGE

Upon receipt of the instrument, examine it for shipping damage. Damage claims should be filed with the carrier. The claims agent should receive a full report: a copy of that report should be sent to TENNELEC, Inc., P.O. Box 2560, Oak Ridge, Tennessee 37831-2560. The model number and serial number of the instrument must be included in the report. Any remedial action taken by TENNELEC, Inc., will be based on the information contained in that report.

7.0 SERVICING

In the event of a component failure, replacement may be done in the field or the instrument may be returned to our plant for repair. There will be no charge for repairs that fall within the warranty.
8.0 WARRANTY

In connection with TENNELEC's warranty (inside front cover), TENNELEC suggests that if a fault develops, the customer should immediately notify the TENNELEC Customer Service Manager. He may be able to prescribe repairs and send replacement parts which will enable you to get the instrument operating sooner and at less expense than if you return it.

Should return prove necessary, the TENNELEC Customer Service Manager must be informed in WRITING, BY CABLE OR TWX of the nature of the fault and the model number and serial number of the instrument. Pack the instrument well and ship PREPAID and INSURED to TENNELEC, Inc., 601 Oak Ridge Turnpike, Oak Ridge, Tennessee 37830. As stated in the warranty DAMAGE IN TRANSIT WILL BE REPAIRED AT THE SENDER'S EXPENSE as will damage that obviously resulted from abuse or misuse of the instrument.

Quotations for repair of such damage will be sent for your approval before repair is undertaken.

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*                                             *
* TENNELEC'S Quality Assurance Program requires *
* that each and every instrument be fully aged, *
* vibrated, and electronically tested.          *
*                                             *
* Should the user require a copy of the Quality *
* Control Procedure and Test Record, please call *
* the Customer Service Department of TENNELEC.  *
* Both model number and serial number are      *
* required.                                    *
*                                             *
******************************************************************************************

MANUAL REV. 0

9/24/86 - Engineering and component improvements may be made after date of printing.