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SAFETY CONSIDERATIONS

A. INTRODUCTION
The apparatus to which this instruction manual applies has been supplied in a safe condition. This manual contains some information and warnings that have to be followed by the user to ensure safe operation and to retain the apparatus in a safe condition. The described apparatus has been designed for indoor use.

B. INSPECTION
Newly received apparatus should be inspected for shipping damage. If any is noted, immediately notify EG&G PARC and file a claim with the carrier. The shipping container should be saved for possible inspection by the carrier.

---

WARNING!
The protective grounding could be rendered ineffective in damaged apparatus. Damaged apparatus should not be operated until its safety has been verified by qualified service personnel. Damaged apparatus should be tagged to indicate to a potential user that it may be unsafe and that it should not be operated.

C. SAFETY MECHANISM
As defined in IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus, the Model 115 is Class I apparatus, that is, apparatus that depends on connection to a protective conductor to earth ground for equipment and operator safety. Before any other connection is made to the apparatus, the protective earth terminal shall be connected to a protective conductor. The protective connection is made via the cable that interconnects the M115 and the instrument with which it is used. If the M115 is not connected to a source of bias potential (M160 provides 200 V), there are no live potentials in the unit. Even then the ground connection between the M115 and the host instrument will still be required to provide a proper return for the power supplies.

D. VENTILATION
The Model 115 does not incorporate forced air ventilation. With a power consumption of less than 10 watts, this instrument can be operated on any laboratory bench. Alternatively, it can be rack mounted, if desired. The only requirement is that the ambient temperature be restricted to the range of 15°C to 45°C.

E. DEFECTS AND ABNORMAL STRESSES
Whenever it is likely that the protection provided by the connection to earth ground has been impaired, the apparatus shall be made inoperative and secured against any unintended operation. The protection is likely to be impaired if, for example, the apparatus:

1. Shows visible damage,
2. Fails to perform the intended measurement,
3. Has been subjected to prolonged storage under unfavorable conditions,
4. Has been subjected to severe transport stresses.

Such apparatus should not be used until its safety has been verified by qualified service personnel.
1.1 INTRODUCTION
This wideband preamplifier can be used to extend the sensitivity of the Model 160 or 162 Boxcar Integrator, or of the Model 5202 Lock-In Amplifier. The amplifier features a switch-selectable gain of X10 or X100, and a frequency response of dc to 70 MHz. An internal bias supply provides $-1 \text{ V}$ to $-100 \text{ V}$ of output dc (when used with Model 160 only), suitable for biasing a photodiode or other low-current device.

Both a $50 \Omega$ input and a $1 \text{ M}\Omega$ input are provided, the latter being well suited to use with a wideband high-impedance probe such as the Tektronix Model 6010 (may be purchased with instrument).

Other features include an overload detector and the capability of taking power from the instrument with which it is used. All power connections are made via the interface cable. Signal connections are made via BNC cables. With its convenience, versatility, and excellent performance, the Model 115 Preamplifier should find application wherever the Model 160, 162, or 5202 is in use.
### 1.2 SPECIFICATIONS

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>LOW IMPEDANCE INPUT</th>
<th>HIGH IMPEDANCE INPUT</th>
<th>HIGH IMPEDANCE INPUT w/10:1 PROBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT IMPEDANCE (dc to 50 MHz)</td>
<td>50 ohms (±10%)</td>
<td>1 megohm shunted by 20 pF</td>
<td>10 megohms shunted by 10 pF</td>
</tr>
<tr>
<td>INPUT COUPLING</td>
<td>dc, gnd.</td>
<td>dc, ac, gnd.</td>
<td>dc, ac, gnd.</td>
</tr>
<tr>
<td>MAXIMUM INPUT VOLTAGE</td>
<td>±5 V pk</td>
<td>±5 V pk</td>
<td>±500 V pk</td>
</tr>
<tr>
<td>INPUT NOISE (Rs = 50 ohms, f = 100 Hz, BW = 1 Hz)</td>
<td>20 nV/√Hz</td>
<td>50 nV/√Hz</td>
<td>4 μV/√Hz</td>
</tr>
<tr>
<td>INPUT NOISE (Rs = 50 ohms, BW = 50 MHz)</td>
<td>15 μV rms typ.</td>
<td>50 μV rms</td>
<td>500 μV rms</td>
</tr>
<tr>
<td>FREQUENCY RESPONSE +1 dB, -3 dB</td>
<td>dc to 70 MHz, +1 dB, -3 dB</td>
<td>dc to 50 MHz, +2 dB, -3 dB</td>
<td>dc to 50 MHz, +2 dB, -3 dB</td>
</tr>
<tr>
<td>RISE TIME</td>
<td>7 ns</td>
<td>7.5 ns</td>
<td>8.5 ns</td>
</tr>
<tr>
<td>VOLTAGE GAIN</td>
<td>x100 or x10 switch-selectable</td>
<td>x 10 or x1 switch-selectable</td>
<td></td>
</tr>
<tr>
<td>GAIN STABILITY</td>
<td>±0.5%</td>
<td>±0.5%</td>
<td>±1%</td>
</tr>
<tr>
<td>DC STABILITY (REF TO INPUT)</td>
<td>±100 μV/°C</td>
<td>±100 μV/°C</td>
<td>±1 mV/°C</td>
</tr>
<tr>
<td>OUTPUT VOLTAGE</td>
<td>±500 mV into 50 ohms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DETECTOR BIAS SUPPLY</td>
<td>−1 V to −100 V at 150 μA. Adjustable with front-panel control. Stability is ±2%.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POWER REQUIREMENTS</td>
<td>+12 V @ 100 mA, −12 V @ 80 mA, −200 V @ 0.5 mA. Supplied by Model 160*, Model 162, or Model 5202. External power supplies or batteries could also be used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEMPERATURE RANGE</td>
<td>10°C to 45°C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIMENSIONS</td>
<td>8.6'' W x 4.1'' H x 11.3'' D (21.84 cm x 10.14 cm x 28.70 cm).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEIGHT</td>
<td>5 lbs (2.27 kg).</td>
<td></td>
<td></td>
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*—200 V for bias supply provided by Model 160 only.
SECTION II
INITIAL CHECKS

2.1 INTRODUCTION
The following procedure is provided to facilitate initial performance checking of the Model 115 Preampifier. In general, the procedure should be performed after inspecting the instrument for any obvious shipping damage (any noted to be reported to the carrier and to Princeton Applied Research Corporation), but before using the instrument. Also, the Model 115 checks should be performed after the initial checks for the instrument with which it is to be used. These are not system checks; only the Model 115 is evaluated. The basic intention of these checks is simply to determine that the instrument has arrived in good working order, and not to demonstrate that it “meets specs”. Each instrument receives a painstaking checkout before leaving the factory, and one may safely assume that, if no shipping damage has occurred, it will in fact perform within the limits of the stated specifications. Before proceeding, check the inside back cover to see if there is an addendum that might influence the Initial Checks. If any problems are encountered in carrying out these checks, contact the factory or the proper factory authorized representative for aid.

2.2 EQUIPMENT NEEDED
(1) Model 160 Boxcar Integrator, or a Model 162 Boxcar Integrator with either a Model 163 or Model 164 Plug-In, or a Model 5202 Lock-In Amplifier.

(2) Interconnect cable for supplying power to the Model 115 from whichever of the above is available. For operation with a Model 160, a PARC 6020-0044-01 cable (drawing 4381-B-ESA) is required. For operation with either a Model 162 or a Model 5202, the required cable is a PARC 6020-0132-04 or a PARC 6020-0131-05. The former allows the dual-channel Model 162 to be operated with two Model 115 Preampifiers simultaneously. The latter is for operation with a single Model 115. The drawing for the “two headed” cable is 11198-C-ESA. That for the single-ended cable is 11197-C-ESA. Drawings for all three cables are provided in Section VII of this manual.

(3) Square wave generator with “fast” rise and fall time and able to drive 50 ohms is suitable for the basic 115 checks. If the user intends to extend these checks to system checks, it will be necessary to provide for trigger or reference signals, as required. If the square wave generator is followed by a step attenuator, with provision for taking off a trigger signal ahead of the attenuator, a satisfactory boxcar test signal can be readily synchronized. If driving a Model 5202 on the other hand, a sine wave generator operating in the frequency range of the Model 5202 will be required. As far as these simple Model 115 checks are concerned, either a sine wave or a square wave can be used. A fast rise time square wave of relatively low frequency (1 KHz) provides a good test of the Model 115’s bandwidth, provided the rise time is sufficiently fast. With a sine wave, spot measurements would be required to evaluate the M115’s frequency response.

(4) An oscilloscope suitable for measuring the Model 115 Output signal. Ideally, the oscilloscope should have a 50 Ω input impedance. If it does not, it will be necessary to connect a 50 Ω termination at the scope input.

(5) Coaxial cables for interconnecting the scope and the Model 115. The cables should have a characteristic impedance of 50 Ω.

2.3 PROCEDURE
(1) With the power off, interconnect the Model 115 and the Model 160, Model 162, or Model 5202 with which it is to be used. The various interconnecting cables are described in step 2 of Subsection 2.2, EQUIPMENT NEEDED.

(2) Connect a BNC cable from the Model 115 front-panel OUTPUT connector to the scope input. If the scope input impedance is not 50 ohms, use an external 50 ohm termination at the scope input.

(3) Set the signal generator controls to provide a 20 mV pk-pk square wave or sine wave output signal at some convenient frequency in the passband of the Model 115 (somewhere in the range of 1 kHz to 1 MHz will be perfectly suitable). Then connect this signal to the Model 115 1 MΩ INPUT connector.

(4) Set the Model 115 controls as follows.
   Detector Bias: fully counterclockwise
   Input Selector: 1 MΩ; GND
   Voltage Gain: X10
   Offset: setting immaterial at this point

(5) Turn on the power at the connected instrument and allow a five minute warmup.

(6) If the scope is dc coupled, take a moment to ground its input and vertically center the trace so that the scope can be used as a dc voltmeter. Once centered, reconnect the Model 115 output and note whether there is any dc offset (5 mV/division should be a suitable deflection factor). If there is, adjust the Model 115 front-panel OFFSET adjustment as required to recenter the trace.

   If the scope can’t be conveniently used as a dc voltmeter in this way, use a BNC “TEE” to monitor the Model 115 output line with a separate VTVM or DVM and make the necessary offset zero adjustment.

(7) Set the Input Coupling switch to 1 MΩ AC. With an
applied signal of 10 mV pk-pk and a selected gain of X10, the scope should show a 100 mV pk-pk replica of the input signal.

(8) Reduce the amplitude of the input signal to 5 mV pk-pk and set the gain to X100. The observed output signal should have an amplitude of 500 mV pk-pk.

(9) Transfer the input signal from the 1 MΩ input to the 50 Ω input. Then set the Coupling switch to 50 Ω DC. The output signal should be 500 mV pk-pk. Note that the changeover from a 1 MΩ input impedance to a 50 Ω input impedance may have caused attenuation in the amplitude of the applied signal. If this is the case, the attenuation must be taken into account in evaluating the observed signal. Also, since the input is now dc coupled, any offset in the input signal will appear at the output as well. If the input is unipolar, so will the output be unipolar.

(10) Increase the input signal level to where the output signal exceeds plus or minus 500 mV. The front-panel OVERLOAD indicator lamp should light. Then decrease the input signal to its original level. The OVERLOAD lamp will extinguish.

(11) If the power source instrument is a Model 160 (only), check the Detector Bias output as follows.

(a) Make provision for monitoring the voltage at the Detector Bias connector. The load resistance, including the input impedance of the monitoring instrument (scope, DVM, VTVM) should be no lower than 1 MΩ.

(b) Gradually rotate the Detector Bias adjustment clockwise. The monitoring instrument will indicate a negative voltage that varies linearly with the setting of the adjustment. Maximum output is −100 V. Leave the adjustment set to the fully counterclockwise setting.

(12) If desired, the high-impedance probe can be checked. The probe cable must be connected to the 1 MΩ input and a 1 kHz square-wave test signal should be applied. The scope compensation procedure is described in the TEKTRONIX manual supplied for the probe. Keep in mind that the probe introduces a 10:1 attenuation.

This completes the initial checks. If the indicated behavior has been observed, the user can be reasonably confident that his instrument has arrived in good working order. Having ascertained that the Model 115 is functioning normally, and assuming the Model 160, 162 or 5202 is functioning normally as well, the user may wish to conduct system checks in which the output of the Model 115 is applied to the input of the associated instrument. This can be easily done. The only constraints are to keep the frequency response and output excursion specifications of the Model 115 in mind. Note that the gain of the Model 115 is X10 or X100 only when the output drives a 50 Ω load. If the output is unloaded, the gain will be a factor of two high. Finally, when operating with the Model 5202, the user will probably note coherent pickup, particularly at frequencies above 10 MHz and with a gain of X100.
SECTION III
OPERATING INSTRUCTIONS

3.1 INTRODUCTION
Use of Model 115 Wideband Preamplifier as a low-noise front end is straightforward. The user interconnects the M115 with the M160, M162, or M5202, using the proper Interface cable, and then applies the signal to be processed. This signal is amplified by X10 or X100, and then routed to the signal recovery instrument for processing in the usual manner. A brief discussion of the germane operating considerations follows.

3.2 INSTALLATION AND POWER
The Model 115 rests on four rubber feet. It should be placed near the experiment so that the input cables can be short. Power is provided by the associated instrument through a cable that connects between the rear panels of the two instruments. If the instruments must be separated by more than five feet, a longer power cable will be required. A longer power cable may be obtained from the factory by special order, or the user may make up his own cable using the information provided in the cable drawings at the end of the book. If the instruments are separated beyond 50 feet (using #26 AWG wiring), cable voltage-drop considerations may indicate that voltage supplies located near the Model 115 should be used. Mercury batteries are a possible alternative power source. Needed are +12 V at 100 mA, −12 V at 100 mA, and −200 V at 0.5 mA (BIAS). The cable drawings in Section VII provide sufficient information to make up a cable or to connect to separate power supplies. Note that the cables designed for use with the M162 and M5202 have Zener diodes incorporated in the connector at the M115 end. These diodes reduce the ±15 V levels supplied by the M162 (M5202) to the ±12 V levels required by the M115.

3.3 INPUT CONNECTORS AND INPUT SELECTOR
Either the 1 MΩ input or the 50 Ω input may be used, with the choice of input depending on the impedance of the experiment. A low-impedance source would typically be applied to the 50 Ω input connector. If a long cable is used, the 50 Ω input matches the (50 Ω) cable impedance so that no power is reflected back to the source. If minimum loading of the experiment is desired, a short low-capacitance cable and the 1 MΩ input should be used.

If an even higher input impedance is required, the 10 MΩ probe supplied with the instrument should be used (connected to the 1 MΩ input). When using the probe, remember that it attenuates by a factor of 10, so that the overall voltage gain becomes X1 or X10. Even with these more modest gain capabilities, use of the probe has the advantage of presenting a low-capacitance, 10 MΩ input impedance at the tip of the probe. Refer to the specifications on page 1-2 for the characteristics and limitations of the different inputs. Note that the actual impedances are complex. This is important to consider at the higher frequencies, because the high-frequency signal amplitude may be reduced.

If a probe is to be used, be sure it is properly compensated. To compensate the probe, connect it directly to the Model 115's 1 MΩ input, and connect a 50 Ω feed-through terminator to the Model 115's output. Connect an oscilloscope to the terminator. Then, using a 1 kHz square wave calibration signal, adjust the probe according to the instructions given in the probe instruction book.

The input selector selects the input to which the amplifier is connected, and selects the mode of coupling for the 1 MΩ input. A ground position is included for each input, providing a convenient 0 V input for adjusting the offset control.

3.4 OUTPUT CONNECTOR AND VOLTAGE GAIN SELECTOR
The output connector should be connected to the 50 Ω input of the following instrument with a 50 Ω cable (BNC connectors) such as RG-58/U. If a very long cable is used, cable attenuation should be considered when determining the overall gain.

For best overall signal-to-noise performance, the voltage gain selector should be set to X100, if possible, without overloading the amplifier, even if this means operating the following instrument at less than maximum gain.

The Model 115 output must be connected to a 50 Ω load (such as the 50 Ω input of the Model 160) for the gain to be as indicated by the gain switch. The gain into an open output is approximately twice that indicated, and the high frequency response measured at the output end of an unterminated cable is a function of cable length.

3.5 OFFSET ADJUSTMENT
The offset control can be used to dc zero the output or to offset the output as desired. When dc zeroing the output, set the input selector at the ground position corresponding to the input to be used.

3.6 OVERLOAD INDICATOR
The overload indicator lights if the output voltage exceeds ±0.5 V when the output is terminated in 50 Ω. It lights at ±1 V when the output is open or terminated in a high impedance. This indicator lights fully even if the overload occurs as a fast transient. Typical overload recovery times are listed in Table III-1.

3.7 DETECTOR BIAS
Often the Preamplifier will be used to amplify signals obtained from a photodiode or similar device. An accessory
detector bias output is provided as a convenience for operating the detector. This voltage is regulated by the Model 115, and may be set anywhere between 0 V and −190 V by means of a screwdriver control. The maximum current that can be drawn is 150 μA. The user should connect a 1 μF capacitor across the supply at the detector end of the voltage line to insure a good ac ground reference.

### 3.8 TYPICAL DETECTOR WIRING

The following wiring diagram, Figure III-1, is a typical detector wiring arrangement that minimizes ground loops.

In any detector input situation, such as the one illustrated, the detector’s internal resistance, the cathode load resistance, and the total stray capacitance, including the detector’s intrinsic capacitance, will increase the rise time beyond the minimum that the probe alone is capable of. This “detector input” rise time is approximately equal to 5 RC, where R is the equivalent parallel resistance of the detector’s internal resistance and its cathode load resistance, and where C is the total stray capacitance. The total system rise time is approximately equal to the square root of the sum of the squares of the involved rise times. Therefore, to minimize rise time, the detector should be chosen for minimum internal resistance and minimum intrinsic capacity. In addition, the external stray capacitance should be minimized by proper circuit design, and the detector cathode load resistance should be as low as possible. However, since the signal amplitude out of the detector is roughly proportional to the value of the cathode load resistor, the operator is forced to compromise between signal amplitude and rise time in choosing the value of this resistor.
SECTION IV
CIRCUIT DESCRIPTION

4.1 BLOCK DIAGRAM DISCUSSION
The Model 115 is composed of four operational amplifiers, an overload detector circuit, and a detector-bias voltage regulator.

Refer to the wiring and block diagram on page VII-4. With the input selector in the 1 megohm position, amplifier A1 is used as a x0.98 first stage because it uses high impedance field-effect input transistors. In this position A2 is used as a x20.4 second stage. In the 50 ohm position, A1 is bypassed, and the input signal goes to A2. A2 is used as the input stage in the 50 ohm position because its input junction transistors have better low-noise characteristics at 50 ohms than do the FET's of A1. Resistors in the 50 ohm input circuit attenuate the signal slightly so that the effective gain of A2 in the 50 ohm position is x20. A balun in the 50 ohm signal input line improves the VHF common-mode rejection characteristics.

Offset is achieved by applying current to the summing input of A2.

A3 has a gain of x10, and is used when the amplifier is operated with an overall gain of x100. In the x10 gain mode, A3 is not used.

A4 is an output driver amplifier with an open-circuit gain of unity. Because a 50 ohm resistor is in series with the output of this amplifier, when properly loaded the effective gain is reduced to 0.5. An output balun eliminates signals that get into the ground line that are common to both the ground and signal output lines.

The overload detector circuit is connected to the output of A3 in front of the series output resistor. The indicator lights if the voltage to the detector circuit exceeds ±1 V.

The detector bias supply is simply a regulator that reduces the −200 V obtained from the Model 160 (only) to the required voltage.

4.2 A1 AMPLIFIER CIRCUIT DISCUSSION
Refer to the schematic on page VII-3. Q101A/B is the field-effect input transistor. Q102 and Q103 are current-source transistors that bias Q101A/B. Because Q102 and Q103 act as high value resistors in the source circuits, Q101A/B functions as a source-follower. Emitter followers Q104 and Q105 provide drive to the operational amplifier composed of Q106 through Q110. C110 provides positive feedback to compensate for loading of Q101A/B by Q102 at higher frequencies.

The emitter voltage of Q104 is equal to the signal plus dc bias voltage, and the emitter voltage of Q105 is equal to the dc bias voltage. C107 couples the ac component of the signal directly to the output, but the dc bias component must be gotten rid of and the dc component of signal retained. This is achieved by means of an operational amplifier. One half of the voltage appearing at the emitter of Q104 appears at the base of Q106, because of the divider action of R117 and R119. Assuming zero bias voltage at the output, we can see that R116 and R118 divide the bias voltage, appearing at the emitter of Q105, by two, so that the bias components at the two inputs of the operational amplifier are equal. These are amplified differentially to satisfy the requirement that no bias component appears at the output. Similarly, we remember that no signal appears at the emitter of Q105, because no signal is amplified by this half of the circuit. R116 and R118 therefore divide the signal voltage coupled to the output by C107 by two, so that the signal component appearing at the base of Q107 is equal to the signal component appearing at the base of Q106. The condition that the ac signal voltages at the two inputs of the operational amplifier are equal is therefore satisfied, so that the operational amplifier does not amplify the ac signal voltage. The dc component of signal is amplified by the operational amplifier, however. R117 and R118, being equal, determine the gain to be unity for the dc component of signal. The overall gain of A1 is 0.98.

4.3 A2 AMPLIFIER CIRCUIT
A2 is a conventional operational amplifier circuit. Q201 and Q202 are low-noise wideband transistors, which differentially amplify the input signal and feedback signal. Q200 combines the outputs of Q201 and Q202 and drives the emitter-follower output transistor Q203. R210 and R211 comprise the feedback divider. The action of the operational amplifier is such as to adjust its output voltage to the value required to make the voltage at the base of Q202 equal to the voltage at the base of Q201. The feedback divider therefore determines the gain to be 20.4.

4.4 A3 AMPLIFIER CIRCUIT
A3 is an operational amplifier with a circuit almost exactly the same as the A2 circuit. Feedback resistors R306 and R308 determine the gain to be x10.

4.5 A4 AMPLIFIER CIRCUIT
A4 is the output driver stage, consisting of two complementary NPN and PNP power transistors Q400 and Q401. R413 in series with the output determines the output impedance to be 50 ohms. R412, across R413, trims the overall loaded gain.

4.6 OVERLOAD DETECTOR CIRCUIT
The overload detector comprises Q402, Q403, and Q404. Q402 and Q403 are an emitter-coupled pair serving as a switch. CR403 unbalances the pair so that Q402 is normally on and Q403 normally off. A negative signal voltage is coupled to the base of Q402. When this voltage
becomes larger than two diode drops (about 1 V) Q402 turns off and, therefore, Q403 turns on. Similarly, a positive signal voltage is coupled to the base of Q403. When this voltage becomes larger than two diode drops (to counter the drops across CR403 and the emitter junction of Q402) Q403 turns on. When Q403 turns on, Q404 conducts heavily and turns the indicator lamp on. The large positive voltage suddenly applied to C402 is coupled by C402 and R410 back to the base of Q403. This regenerative feedback insures that the lamp lights solidly even for transient overloads. When C402 charges up sufficiently, the voltage coupled to the base of Q403 becomes too small to hold Q403, Q404, and the lamp on. CR406 provides a fast discharge path for C402 when Q404 turns off.

4.7 DECOUPLER
Two circuits reduce the plus and minus twelve volt line inputs to decoupled plus and minus ten volts. The +10 V decoupler is composed of Q500, Q501, and Q504. The −10 V decoupler is composed of Q502, Q503, and Q505. The two circuits are mirror images of each other, so only one need be discussed. R500, R501, and C501 provide a filtered reference voltage to the emitter-coupled differential pair Q500 and Q501. The reference voltage at the base of Q500 is compared at the base of Q501 to the +10 V line voltage. An error signal from the collector of Q500 controls the series regulator Q504 so that the +10 V line voltage remains constant. If the maximum allowable output current is approached, the voltage across R506 approaches one diode drop. This voltage plus the Q504 emitter junction drop therefore approaches the voltage across CR500 and CR501. Under this condition Q504 is no longer forward biased, so it begins to turn off. Current is thereby limited to 100 mA.

4.8 DETECTOR-BIAS REGULATOR
−100 V obtained from the Model 160 is reduced by a shunt regulator circuit, comprising Q506 and Q507, to a value between 0 V and −100 V. The 1 megohm front-panel-adjustable potentiometer R6 determines the bias on Q507, which in turn controls the shunt regulator transistor Q506. The current through Q506 causes part of the −200 V to be developed across R514 so that the required voltage appears at the detector bias output. Variations in the detector bias voltage, usually due to loading, are seen at the base of Q507, and coupled to the base of Q506 to complete the degenerative feedback loop. CR507 blocks positive voltages from the output when the −200 V line from the Model 160 is not connected.

SECTION V SAFETY NOTICE

WARNING! POTENTIALLY LETHAL VOLTAGES MAY BE PRESENT INSIDE THIS APPARATUS. THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO. Any adjustment, maintenance, or repair of the opened apparatus under voltage shall be avoided as far as possible and, if unavoidable, shall be carried out only by a skilled person who is aware of the hazard involved. When the apparatus is connected to a power source, terminals may be live, and the opening of covers or removal of parts is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, maintenance, or repair. Note that capacitors inside the apparatus may still be charged even if the apparatus has been disconnected from all voltage sources. Service personnel are thus advised to wait several minutes after unplugging the instrument before assuming that all capacitors are discharged.
SECTION V
ALIGNMENT PROCEDURE

NOTE: READ SAFETY NOTICE ON PRECEDING PAGE BEFORE PROCEEDING.

5.1 INTRODUCTION

The Model 115 Wideband Preamplifier is a stable and reliable instrument which should give long trouble-free service. Alignment will generally not be necessary unless troubleshooting is performed and components replaced.

The entire alignment should be performed in sequence, skipping those steps that the corresponding measurements indicate will not be improved by further adjustment.

If any difficulty is encountered in performing the alignment and assistance is needed, contact the factory or an authorized representative.

5.2 EQUIPMENT NEEDED

(1) Dc voltmeter capable of measuring 0 V to within 5 mV.

(2) 50 ohm (±0.1%) feedthrough terminator, such as Tektronix #011-0049-01.

(3) Rms voltmeter, capable of measuring 100 mV with 1% accuracy.

(4) Accurate 1 kHz, 1 V rms sinewave generator.

(5) Sine wave signal generator with a flat output response from 3 MHz to 70 MHz (Wavetek 3000).

(6) 50 Ω step attenuator (HP355D).

(7) Assorted metal film resistors; 500 ohm to 100 kilohm range.

(8) 10:1 0.1% attenuator. See 5.3(10) for discussion of impedance requirements.

(9) 1 kHz square wave generator.

(10) Oscilloscope, for measuring the 1 kHz square wave and for measuring sine waves at 3 MHz and 70 MHz. Response should be flat to 80 MHz (Tektronix 485).

5.3 PROCEDURE

(1) Remove the top cover by removing the screw under the lip at the rear and sliding the cover back.

(2) Connect the power as instructed in Section III, subsection 3.2.

(3) Check to be sure that the ±12 V dc lines are within ½ V of ±12 V.

(4) Offset Adjustment

   Connect the dc voltmeter to the output BNC connector. Set the input switch to the 50 ohms ground position. Set the gain switch to x100. Adjust the front-panel offset control for 0 V (±20 mV).

   (5) Q201 IB Compensation

   Alternate the input selector between the 50 ohm input and 50 ohm ground positions. Adjust R202 so that the dc level at the output is the same for both positions. Then repeat step 4.

   (6) R7 Selection (located on back of last wafer of Input switches)

      (a) Set the input switch to the 1 megohm ground position.

      (b) If the input FET's are changed, it may be necessary, when selecting R7, to wire R7 to the opposite supply voltage than formerly. Both supply voltages are available at the input function switch. Begin with no resistor, and note the voltage reading at the collector of Q110. If it is positive, R7 should be wired to the white-red wire. If negative, R7 should be wired to the yellow-white wire. In the former case, capacitor C107 should have its positive end toward printed circuit terminal pad #2. In the latter case, C107 should have its negative end toward terminal pad #2. C107 is located on the PC board.

      (c) Connect the emitter of Q104 to the emitter of Q105 using a short clip-lead. (To avoid accidental damaging the transistors, connect the clip lead to the tops of R114 and R115 -- see parts location diagram in Section VII.) Connect the dc voltmeter to the collector of Q110 (make connection at R127). Choose R7 so that the voltmeter reads zero (to within 500 mV). Remove the Q104-Q105 clip-lead after selecting R7.

(7) Repeat step 4.

(8) Low Frequency Stability

   Set the input function switch to the 1 megohm dc position, the gain switch to x10, connect a 50 ohm feedthrough terminator to the 50 ohm output, and connect an oscilloscope to the terminator output (dc couple the oscilloscope). Apply a 1 kHz square wave to the 1 megohm input, and adjust the low frequency stability potentiometer R120 for a properly compensated output square wave.

(9) FET Balance

   Adjust the FET balance potentiometer R106 for an output voltage that is the same in the 1 megohm ground position as is observed in the 50 ohm ground position (within 20 mV).

(10) Final Gain Trim
Set the gain switch to X10. Set the input selector to the 1 megohm dc position or to the 50 ohm dc position depending upon the attenuator impedances as described in the next paragraph. Apply a sinewave of approximately 1 kHz, 10 mV rms to the appropriate input connector. Connect the 50 ohm (±0.1%) feedback terminator to the output. Measure the input voltage with the rms voltmeter, then measure the output voltage. Select (or adjust if trimpot) R412 so that the output voltage is within 1% of 10 x the input voltage.

Because it is difficult to measure low-level ac accurately, it is best to use a 10:1 attenuator at the input (0.1% accurate). Select (or adjust) R412 so that the rms input to the attenuator and the Model 115 rms output voltage are exactly the same (use about 100 mV rms signal). This method has an additional advantage of not being subject to meter errors. When using an attenuator, it is very important that it be terminated properly at its output. Which Model 115 input is used depends upon the termination requirements of the attenuator.

(11) Bandwidth Adjustments

(a) Using a coaxial cable having a characteristic impedance of 50 Ω, connect the step attenuator (set to 30 dB) between the output of the signal generator and the Model 115 50 Ω Input.

(b) Set the M115 Input switch to 50 Ω and the Gain switch to × 10.

(c) Connect the oscilloscope input to the M115 Output. The input impedance of the oscilloscope must be 50 Ω. If the design input impedance of the oscilloscope is not 50 Ω, use a 50 Ω terminator at the scope input to establish the desired impedance.

(d) Set the oscilloscope Y axis deflection factor to 100 mV per major division.

(e) Set the sine wave generator to 3 MHz and adjust the generator amplitude control for an observed amplitude at the oscilloscope of five major divisions pk-pk. This step establishes the “100%” signal amplitude.

(f) Increase the frequency of the applied signal to 70 MHz and adjust C202 (× 10 Bandwidth Adj) for 3.5 divisions pk-pk at the oscilloscope. (3.5 divisions is 70% of 5 divisions, that is, C202 is adjusted so that the response is 3 dB down at 70 MHz).

(g) Increase the input attenuator setting to 50 dB. Then set the M115 Gain switch to × 100 and the frequency of the applied signal to 3 MHz.

(h) Note the oscilloscope indication. The amplitude of the displayed signal should be 5 major divisions pk-pk.

(i) Increase the frequency of the applied signal to 70 MHz and adjust C301 (× 100 Bandwidth Adj) for an observed amplitude of 3.5 divisions pk-pk.

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**SECTION VI SAFETY NOTICE**

**WARNING! POTENTIALLY LETHAL VOLTAGES ARE PRESENT INSIDE THIS APPARATUS. THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO. Any adjustment, maintenance, or repair of the opened apparatus under voltage shall be avoided as far as possible and, if unavoidable, shall be carried out only by a skilled person who is aware of the hazard involved. When the apparatus is connected to a power source, terminals may be live, and the opening of covers or removal of parts is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, maintenance, or repair. Note that capacitors inside the apparatus may still be charged even if the apparatus has been disconnected from all voltage sources. Service personnel are thus advised to wait several minutes after unplugging the instrument before assuming that all capacitors are discharged.**
SECTION VI
TROUBLESHOOTING

NOTE: READ SAFETY NOTICE ON PRECEDING PAGE BEFORE PROCEEDING.

6.1 INTRODUCTION
Although the Model 115 is a highly reliable instrument, component deterioration could eventually cause the instrument to no longer meet specifications, or even become inoperative. Should this occur, a partial or complete alignment (Section V) will sometimes restore proper operation. In those cases where a malfunction is the result of component failure, aligning the instrument will of course prove futile, and troubleshooting will be necessary. The procedures outlined in this section will be helpful.

Once the problem is isolated to a specific circuit or component, or before attempting any troubleshooting, the user should contact Princeton Applied Research Corporation for advice on the relative merits of repairing the instrument himself, as opposed to returning it to the factory for repair. In any case, if the instrument is still under warranty, it is particularly important that an authorized factory representative be contacted prior to attempting a field repair, as failure to do so could invalidate the warranty.

6.2 PROCEDURE
To speed the troubleshooting process, try to determine any external causes of the trouble, and ascertain the symptoms when the amplifier is properly connected and tested. The set-up and procedure given in the Initial Checks, Section II, will be helpful in determining the symptoms. Section IV, the circuit description, together with the block diagram, layout diagram, and schematic (Section VIII), should provide sufficient information for isolating the trouble. The ±12 V power input and the decoupled ±10 V should be checked before proceeding to check the amplifiers, overload circuit, and detector bias circuit. Note from the block diagram that the offset control may be used as a “signal” into A2, and the gain switch may be used to advantage in checking A3. Take special care to check the 50 ohm input resistors, as they may be damaged from excessive signal input levels. After signal checks isolate the trouble to a specific circuit, voltage and resistance checks can then specifically pinpoint the trouble. When doing resistance checks, it is sometimes possible to locate a bad transistor by checking the diode action of the base and collector junctions. While doing voltage checks, it is useful to remember that the base-to-emitter voltage of a forward biased silicon transistor (or diode junction) is roughly 0.6 V, and that the collector voltage of a saturated transistor is less than the base voltage (measured with respect to the emitter).

When troubleshooting and replacement of defective components is completed, it will probably be necessary to make some adjustments. Section V, the Alignment Procedure, should be consulted.

6.3 PRINTED CIRCUIT SOLDERING
If any components are removed from a printed-circuit board for inspection or replacement, be especially careful not to damage the print. To remove components cleanly requires considerable care. Either one of two methods can be used to remove the solder from a pad. One entails the use of a bulb-vacuum type solder remover, and the other the use of a “wick”. Both methods give good results. A brief description of each follows.

METHOD #1
Removing solder by means of a solder-remover is a simple process. The required equipment includes a bulb-vacuum operated solder remover (UNGAR type SOLDER-OFF #7805 recommended) and a good soldering iron of moderate power (WALL type 14 HDG40120 with type W14KS tip). Most of the components on the boards have bent leads. Because of this, the solder must be straightened before the component can be removed. To remove a component, proceed as follows: Heat the pad on the side opposite the component. As soon as the solder flows, use the solder remover to remove the solder from the pad and hole. Take care not to heat any longer than necessary. After the solder has been removed, straighten the lead. If enough solder has been removed so that the lead is free in the hole, pull the lead through the hole from the component side of the board, using suitable long-nose pliers. If the lead is not free, continue to apply heat while pulling the lead from the hole. A component with leads which cannot be removed one at a time must have all of its leads free in the holes simultaneously; if it is not possible to free all of the leads in the holes, the component can be removed by applying heat to one of the leads and “rocking” the component to pull the lead through the hole as far as possible, and successively repeating this for each of the unfree leads until the component is free from the board. After the component has been removed, use the solder remover to completely clear all solder from the holes.

METHOD #2
Wicking is a method which uses a length of stranded wire or shielding braid as a wick to draw up the molten solder from the pad. Exceptionally clean work can be achieved by this method. Equipment required includes a good soldering iron (that recommended in Method #1 is excellent), a supply of stranded braid, and some rosin base soldering flux (ALPHA 346-35 or equivalent). Proceed as follows: Dip a few inches of stranded wire or shielding braid into the rosin-base soldering flux. Then place the wire or braid on top of the joint to be unsoldered, allowing some of the flux to flow over the joint. NOTE: Under no circumstances use an acid base flux.

As shown in Figure VI-1, place a hot soldering iron on top of the stranded wire directly above the joint to be unsoldered. Within a few seconds, most of the solder in the joint will melt and flow quickly up the wick, leaving the joint area free of solder.
Lift the soldering iron and remove the wick before it freezes to the joint. Cut off the "filled" end of the wick (generally about ½ inch should be removed).

Inspect the joint. If any solder remains, repeat the procedure as required. Then straighten the lead and, while applying heat to keep the solder in the hole molten, pull it through the hole. Components with leads which cannot be removed one at a time, such as transistors and trim-potentiometers, can be removed by applying heat to one of the leads and "rocking" the component to pull the lead through the hole as far as possible, and successively repeating this for each of the leads until the component is free from the board. After the component has been removed, use wicking to completely clear all solder from the holes.

INSTALLING COMPONENTS
In returning the component or its replacement to the board, make sure the leads are bent on the proper centers and that they don't angle in or out. If they do not pass freely through the centers of the holes, they may catch the edge of the print and lift it. Bend and cut the leads after inserting the component; then solder the leads with a hot iron (no larger then 40 watts) and a good grade of rosin core 60/40 solder. Be sure to apply heat no longer than necessary to achieve a good joint (usually a few seconds).

Figure VI-1. SOLDER REMOVAL BY WICKING
SECTION VII
SCHEMATICS

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**REVISIONS**

<table>
<thead>
<tr>
<th>SYM.</th>
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<tr>
<td>A</td>
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**NOTE**

1. For material see 4357-A-MPL

**APPROVED FOR PROCUREMENT**

**POWER CABLE, INTERCONNECTING**
NOTE
FOR BILL OF MATERIALS SEE MPL 6020-0132

APPROVED FOR PROCUREMENT

CABLE ASSEMBLY
M142/2, M115 INTERFACE
NOTE:
FOR BILL OF MATERIALS SEE MPL 6020-0151.

APPROVED FOR PROCUREMENT  [Signature]

[Diagram of cable assembly with labels and specifications]

CABLE ASSEMBLY
M-162/M-115 INTERFACE
(1) Set the two Model 115’s on a bench side by side.

(2) Remove the top cover of both units. The cover is secured by a single screw located on the under surface of the lip at the rear of the top cover. This screw is most easily removed by using a long screwdriver (or an extraordinarily short one). Once the screw has been removed, simply slide the cover back to where it can be lifted free of the unit.

(3) Remove the bottom cover of both units. The bottom cover is held by the screws that secure the two rear rubber feet. When these screws are removed, the feet can be removed and the cover slid back and freed from the unit.

(4) From the sides that will be adjacent after mounting, remove the side decorative plate (secured by two screws) and the side panel. These will not be replaced. Do not remove the shim plates exposed when the decorative plates are removed.

(5) Using the two Allen head screws provided, secure the front coupling to one of the units. The shim plate exposed when the decorative strip was removed should be under the coupling.

(6) As shown in the photograph, install the locking screw in the other instrument, taking care to retain the shim.

(7) Lock the front of the two units together by sliding the head of the locking screw into the coupling slot.

(8) Insert the rear mounting flange to secure the rear of the instruments together. The flange is simply pushed into the assembly from the rear.

(9) Reinstall the bottom and top covers, securing the assembly. The two instruments can now be picked up and handled as a single assembly. This assembly can be mounted in any standard 19” rack. As long as the top and bottom covers of the individual instruments are secure, the two instruments will remain a single assembly. If the covers are removed, the two instruments will separate.
WARRANTY

EG&G Instruments Corporation warrants each instrument of its own manufacture to be free of defects in material and workmanship. Obligations under this Warranty shall be limited to replacing, repairing or giving credit for the purchase price, at our option, of any instrument returned, shipment prepaid, to our Service Department for that purpose within ONE year of delivery to the original purchaser, provided prior authorization for such return has been given by an authorized representative of EG&G Instruments Corporation.

This Warranty shall not apply to any instrument, which our inspection shall disclose to our satisfaction, to have become defective or unworkable due to abuse, mishandling, misuse, accident, alteration, negligence, improper installation, or other causes beyond our control. This Warranty shall not apply to any instrument or component not manufactured by EG&G Instruments Corporation. When products manufactured by others are included in EG&G Instruments Corporation equipment, the original manufacturer’s warranty is extended to EG&G Instruments Corporation’s customers.

EG&G Instruments Corporation reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF. THIS WARRANTY IS IN LIEU OF, AND EXCLUDES ANY AND ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING MERCHANTABILITY AND FITNESS, AS WELL AS ANY AND ALL OTHER OBLIGATIONS OR LIABILITIES OF EG&G INSTRUMENTS CORPORATION, INCLUDING, BUT NOT LIMITED TO, SPECIAL OR CONSEQUENTIAL DAMAGES. NO PERSON, FIRM OR CORPORATION IS AUTHORIZED TO ASSUME FOR EG&G INSTRUMENTS CORPORATION ANY ADDITIONAL OBLIGATION OR LIABILITY NOT EXPRESSLY PROVIDED FOR HEREIN EXCEPT IN WRITING DULY EXECUTED BY AN OFFICER OF EG&G INSTRUMENTS CORPORATION.

SHOULD YOUR EQUIPMENT REQUIRE SERVICE

A. Contact the Service Department (609-530-1000) or your local representative to discuss the problem. In many cases it will be possible to expedite servicing by localizing the problem to a particular plug-in circuit board.

B. If it is necessary to send any equipment back for service, we need the following information.

1. Model number and serial number.

2. Your name (instrument user).

3. Your address.

4. Address to which the instrument should be returned.

5. Your telephone number and extension.

6. Symptoms (in detail, including control settings).

7. Your purchase order number for repair charges (does not apply to repairs in warranty).

8. Shipping instructions (if you wish to authorize shipment by any method other than normal surface transportation.)

C. U.S. CUSTOMERS - Ship the equipment being returned to:

   EG&G PARC
   375 Phillips Blvd.
   Trenton, NJ 08618

D. CUSTOMERS OUTSIDE OF U.S.A. - To avoid delay in customs clearance of equipment being returned, please contact the factory or the nearest factory distributor for complete shipping information.

E. Address correspondence to:

   EG&G PARC
   P.O. Box 2565
   Princeton, New Jersey 08543-2565

   Phone: (609) 530-1000
   TELEX: 84-3409
   FAX: 883-7259