FACTORY CALIBRATION PROCEDURE

CONTENTS:

This is the guide for calibrating new instruments in Product Manufacturing. The procedure consists of 4 sections:

Equipment Required

Factory Test Limits - Factory Test Limits are limits an instrument must meet before leaving Manufacturing. These limits are often more stringent than advertised performance requirements. This is to insure that the instrument will meet advertised requirements after shipment, allows for individual differences in test equipment used, and (or) allows for changes in environmental conditions.

Short Form Procedure - The Short Form Procedure has the same sequence of steps and the same limits on checks or adjustments as the Main Procedure.

Main Procedure - The Main Procedure gives more detailed instructions for the calibration of the instrument. This procedure may require that some checks and adjustments be made so that performance is better than that required by the Factory Test Limits. This insures the Factory Test Limits will be met when side panels are added, permits some normal variation in test equipment and plug-in scopes, etc.

Abbreviations in this procedure will be found listed in TEKTRONIX STANDARD A-100. Definitions of terms used in this procedure may be found in TEKTRONIX STANDARD A-101.

In this procedure, all front panel control labels and Tektronix instrument names are in capital letters (VOLT/DIV, etc). Internal adjustment labels are capitalized only (Gain Adj, etc).

This procedure is company confidential

1A5

March 1969

For serial numbers B090000 and up.

CHANGE INFORMATION:

This procedure has been prepared by Product Manufacturing Staff Engineering. For information on changes made to this procedure, to make suggestions for changing this procedure, or to order additional copies: please contact PMSE, 39-307.

EQUIPMENT REQUIRED:

The following equipment is necessary to complete this procedure:

a. TEKTRONIX Instruments

1	TYPE R544 OSCILLOSCOPE (see Note)	NOTE: The risetime of the plug-in scope must be known in order to determine the minimum bandwidth required for the TYPE 1A5. A rackmount plug-in scope is required for access to some high frequency compensation adjustments.
1	TYPE 106 SQUARE-WAVE GENERATOR	
* 1	TYPE 191 CONSTANT AMPLITUDE SIGNAL GENERATOR	
1	TYPE 76-TU VOLTAGE CONTROL UNIT	

b. Test Fixtures and Accessories

* 1	Standard Amplitude Calibrator (SAC) (067-0502-00)
1	INPUT RC Normalizer (20pF) (067-0538-00)
* 1	LF Sine-wave Generator (067-0542-99)
1	67.5 Volt Bridge (PMIE Dwg #1008-A)
1	Dual Input Coupler (067-0525-00)
1	TYPE 111 Variable Attenuator (067-0511-00)
1	8" Plug-in Extension (013-0055-00)
1	42" 50Ω coaxial cable (012-0057-00)
2	GR 50Ω 10X Attenuator (017-0078-00)
1	GR 50Ω 5X Attenuator (017-0079-00)
1	GR 50Ω 2X Attenuator (017-0080-00)
1	Microphonics shock hammer (PMIE Dwg #1283-B)
1	GR to BNC female adapter (017-0063-00)
1	5ns GR cable (017-0502-00)
1	50Ω GR to BNC in line Termination (017-0083-00)
1	Test Fixture for differential probe connector (PMIE Dwg #1669-A)
1	50Ω Termination (011-0049-00)
1	Step Generator with attached probe (067-0600-00)

c. Other Equipment

* 1	Differential Voltmeter 0.02% or better accuracy
1	20,000Ω/VDC multimeter

d. Equipment for Sample Checks

1	Resistance bridge with 0.04% or better accuracy at 1MΩ

* Equipment must be traceable to NBS for certification of measurement characteristics.

Substitute test equipment may be used. The Plant Staff Engineer must approve any substitutions. All equipment listed must perform within its manufacturer's specifications, unless otherwise stated.

Factory Test Limits are qualified by the conditions specified in the main body of the Factory Calibration Procedure. The numbers and letters to the left of the limits correspond to the procedure steps where the check or adjustment is made. Steps without Factory Test Limits (setups, presets, etc.) are not listed. Instruments may not meet Factory Test Limits if calibration or checkout methods and test equipment differ substantially from those in this procedure.

2. VOLTAGES

c. Zener voltages: 20.7V ±1V; 6.2V ±10%

3. VERTICAL DC BALANCE

b. VAR BAL Range: ≥6cm
c. Position Range (R370): ≥4cm
d. STEP ATTEN BAL Range: ≥20mV
e. Output DC Level (R390): 67.5V ±1% of main frame +100V

4. GAIN

b. GAIN Range: + & -10% min
c. VARIABLE Range: ≥2.5:1
* d. VOLTS/CM Accuracy (A INPUT):
1mV -20mV: ±1.5%
50mV -20V: ±2%
* e. VOLTS/CM Accuracy (B INPUT):
50mV -20V: ±2%
f. POSITION Range: ≥12cm

5. COMMON MODE BAL

b. Common Mode Bal (R140):
≥25,000:1 rejection

6. INPUT AMPLIFIER

a. Microphonics: ≤100μV
b. Input Current: ≤0.2nA
c. Signal Resolution: ≤1mm

7. INPUT CAPACITANCE

b. Input Capacitance (C108, C208):
≤1% overshoot, rounding or tilt

8. INPUT TIME CONSTANT

a. B Input Time Constant:
≤1% overshoot, rounding or tilt
b. A Input Time Constant:
≤1% overshoot, rounding or tilt

10. COMMON MODE REJECTION

* b. Common Mode Rejection:
≥12,500:1 @1MHz (10V)
≥1250:1 @10MHz (1V)
* c. X1 CMRR:
≥2500:1 @5MHz (2V)
≥250:1 @20MHz (0.5V)
≥25,000:1 @100kHz (10V)

11. ATTENUATOR CMR

* b. X10 CMRR: ≥2500:1 @10kHz
* c. X100 CMRR: ≥2500:1 @10kHz

* 12. AC COUPLED CMR: ≥1250:1 @60Hz

13. HF COMPENSATION

b. HF Compensation: 1mV + & -2.5% aberrations in first 70ns, 2mV -20mV + & -2% aberrations in first 70ns, 1mV -20mV + & -0.5% aberrations after first 70ns

14. BANDWIDTH

* b. DC Coupled Bandwidth (upper limit):
1mV: ≥40MHz @ -3dB
2mV: ≥45MHz @ -3dB
5mV -20V: ≥50MHz @ -3dB
* c. AC Coupled Bandwidth (lower limit):
≤10Hz @ -3dB

15. INTERCHANNEL ISOLATION

b. Amplifier Isolation: ≥100:1
c. Total Isolation: ≥20:1

16. OVERDRIVE

b. DC shift in first 5s: ≤1% of overdrive signal or 10mV or less in 5V input signal range, whichever is smaller.

≤1% of overdrive signal or 0.1V or less in 50V input signal range, whichever is smaller.

≤1% of overdrive signal or 1.0V or less in 500V input signal range, whichever is smaller.

c. Overdrive Recovery Time: ≤0.15μs within 10mV

17. COMPARISON VOLTAGE

b. Vc Zero Error:
electrical: ≤2mV
mechanical: ≤1 minor dial div
* c. Comparison Voltage:
5V ±3mV (1mV -2V)
0.5V ±2mV (5V -20V)
* d. Vc Accuracy (5V -20V/CM):
±0.75% of indicated or ±0.75mV, whichever is greater
* e. Vc Accuracy (1mV -2V/CM):
±0.4% of indicated or ±6mV, whichever is greater.

18. AMPLIFIER STABILITY ≤300μV drift with line voltage change

19. DIFFERENTIAL PROBE

b. Input Connector Voltages:

PIN	VOLTAGE
K	-50V ±5%
F	+50V ±5%
E	+20.7V ±5%
D	+6.2V ±10%

THE FOLLOWING CHECK IS NOT MADE ON 100% OF THE INSTRUMENTS BUT IS DONE ON A SAMPLING BASIS.

20. INPUT RESISTANCE 1MΩ ±0.15%

THE END

* Indicates measurement characteristic; test equipment used must be traceable to NBS for instrument certification

This instrument must meet Factory Test Limits before it leaves Manufacturing; therefore, it must be possible to inspect to these limits. Because of normal variations in test equipment and plug-in scopes, addition of side panels, etc, this procedure may require that some checks and adjustments be made so that performance is better than that required by Factory Test Limits.

1. PRELIMINARY INSPECTION

a. Install Current Modifications
b. General Inspection
c. Preset front panel controls and midr internal adjustments
d. Check Amphenol Pin Resistances

2. VOLTAGES

b. Check Probe Power On Light
c. Check Zener voltages: 20.7V ±1V; 6.2V ±0.62V @5V/CM and pre-adjust Output DC Level (R390) for 60V at pin F on Output board.

3. VERTICAL DC BALANCE

a. Adjust DC Bal (R170) for no trace shift
b. Check VAR BAL Range for ≥6cm and adjust for no trace shift.
c. Check Position Range for ≥4cm and set the trace at graticule center.
d. Check STEP ATTEN BAL Range for ≥4cm and adjust for no trace shift.
e. Adjust Output DC Level (R390) for 67.5% of +100V supply.

4. GAIN

b. Check GAIN control for a range of + & - 10% min and set the GAIN for exactly 5cm.
c. Check VARIABLE Range for ≥2.5:1
d. Check VOLTS/CM Accuracy of (A INPUT)
for 1mV -20mV: ±1.5%
50mV -20V: ±2%
e. Check VOLTS/CM Accuracy of (B INPUT) for 50mV -20V: ±2%
f. Check POSITION Range for ≥12cm

5. COMMON MODE BAL

b. Adjust Common Mode Bal (R140) for optimum rejection (≥25,000:1)
c. Adjust Atten Bal (R105d, R106d) for min amplitude

6. INPUT AMPLIFIER

a. Check Microphonics: ≤100μV
b. Check Input Current: ≤0.2nA
c. Check Signal Resolution: ≤1mm
d. Check Input Protection

7. INPUT CAPACITANCE

b. Adjust Input Capacitance (C108, C208) for ≤1% overshoot, rounding or tilt

8. INPUT TIME CONSTANT

a. Adjust B INPUT Time Constant for ≤1% overshoot, rounding or tilt
b. Adjust A INPUT Time Constant for ≤1% overshoot, rounding or tilt

9. PRESET 20mV HF COMPENSATION

b. Adjust 20mV HF Comp for optimum transient response

10. COMMON MODE REJECTION

b. Adjust Common Mode Rejection for min amplitude
c. Check X1 CMRR for
≥2500:1 @5MHz (2V)
≥250:1 @20MHz (0.5V)
≥25000:1 @100kHz (10V)

11. ATTENUATOR CMR

b. Adjust X10 CMRR for min amplitude
c. Check X100 CMRR: ≥2500:1 @10kHz

12. AC COUPLED CMR

Check AC coupled CMRR for ≥1250:1

13. HF COMPENSATION

b. Adjust HF Compensation aberrations for optimum transient response and min risetime

14. BANDWIDTH

b. Check DC Coupled BANDWIDTH (upper limit):
1mV: ≥41MHz @ -3dB
2mV: ≥46MHz @ -3dB
5mV -20V: ≥51MHz @ -3dB
c. Check AC Coupled BANDWIDTH (lower limit): ≤10Hz @ -3dB

15. INTERCHANNEL ISOLATION

b. Check Amplifier Isolation: ≥100:1
c. Check Total Isolation: ≥20:1

16. OVERDRIVE

b. Check DC shift in first 5s for ≤1% shift of overdrive signal in 5V, 50V and 500V input signal ranges.
c. Check Overdrive Recovery Time: ≤0.15μs to within 10mV

17. COMPARISON VOLTAGE

b. Check Vc Zero Error:
electrical: ≤2mV
mechanical: ≤1 minor dial div

17. (Cont)

c. Adjust Comparison Voltage for null indication on differential voltmeter.
d. Check Vc Accuracy (5V -20V/CM): ±0.75% of indicated or ±.75mV, whichever is greater
e. Check Vc Accuracy (1mV -2V/CM): ±0.4% of indicated or ±6mV, whichever is greater

18. AMPLIFIER STABILITY

Check for ≤3mm of trace drift with line voltage change

19. DIFFERENTIAL PROBE

a. Adjust PROBE STEP ATTEN BAL for no trace shift
b. Check DIFFERENTIAL PROBE Input Connector voltages:

PIN	VOLTAGE
K	-50V ±5%
F	+50V ±5%
E	+20.7V ±5%
D	+6.2V ±10%

THE FOLLOWING CHECK IS NOT MADE ON 100% OF THE INSTRUMENTS BUT IS DONE ON A SAMPLING BASIS.

20. INPUT RESISTANCE

Check A & B INPUT's for an input resistance of 1MΩ ±0.15%

Check or readjust DC Bal before removing TYPE 1A5 from scope.

THE END

NOTES

1. PRELIMINARY INSPECTION

a. Install Current Modifications

b. General Inspection

Check for unsoldered joints, rosin joints, improper lead dress and long ends. Check for loose hardware and protruding parts. Check front panel controls for smooth mechanical operation, proper indexing and knob spacing from front panel. Check all internal adjustments for smooth mechanical operation.

Set the VOLTS/CM to .5 volts, pull the knob out and turn cw. Check that the attenuator switch is not engaged in the .1 and .2 volt positions and the switch is mechanically stopped at .1 volts. Return the VOLTS/CM to .5 volts.

Set the VOLTS/CM to 5mV, pull the knob out and turn cw. Check that the attenuator switch is not engaged in the 20 and 10mV positions and the switch is mechanically stopped at the 10mV position. Return the switch to 50mV.

Mechanically align the VC dial so it reads 0.00 at full ccw.

Mechanically align the STEP ATTEN BAL knob so there is equal ↑ and ↓ rotation when the indexing mark is in the center of the window.

1b. The detent action in the 50mV, .5V and 5V positions of the VOLTS/CM will be more rigid than the other positions.

c. Preset Controls

TYPE 1A5

VOLTS/CM	20mV
VARIABLE	CAL
POSITION	midr
GAIN	midr
VAR BAL	midr
PROBE STEP ATTEN BAL	midr
DISPLAY	A-B
A INPUT	GND
B INPUT	GND
COMPARISON VOLTAGE	
AMPLITUDE	0.00
POLARITY	0
All internal adjustments	midr

1c. (CONT)

TYPE R544 (plug-in scope)

HORIZONTAL DISPLAY	NORMAL (X1)
TIME/CM	.5mSEC
VARIABLE	CALIBRATED
TRIGGERING LEVEL	midr
TRIGGERING	
MODE	AUTO STABILITY
SLOPE	+
COUPLING	AC
SOURCE	INT, NORM

Leave controls and adjustments for any step as they were in the step preceding unless noted otherwise.

d. Check Amphenol Pin Resistance

Check the resistance between gnd and each pin on the amphenol plug. Connect the negative meter lead to gnd and use the X1K scale.

Pin No.	Approx Resistance
1	8kΩ
2	0Ω
3	8kΩ
4-8	Inf
9	13kΩ
10	5kΩ
11	10.5kΩ
12-14	Inf
15	3kΩ (varies with VOLTS/CM setting)
16	Inf

2. VOLTAGES

a. Setup

Install the TYPE 1A5, via the 013-0055-00 plug-in extension, in the TYPE R544 plug-in compartment. Pull out the plug-in sensing switch (SW 673, located at top right of the plug-in compartment). Apply power to the TYPE R544 via the TYPE 76TU LINE VOLTAGE CONTROL UNIT. Set the line voltage to 115 VAC. Allow 20 minutes operating time before making checks or adjustments.

2. (CONT)

b. Check Probe Power On Light

Depress the DIFFERENTIAL PROBE ON/OFF button several times. Check that the power light for the DIFFERENTIAL PROBE lights and extinguishes alternately. With the probe power light on check that the light remains on with the VOLTS/CM at 0.2V to 1mV and extinguishes at all other settings of the VOLTS/CM.

Return the VOLTS/CM to 5V and turn the probe power off.

c. Check Zener voltages: 20.7V ±1V
6.2V ±0.62V @ 5V/CM

Check for the following voltages with the Differential Voltmeter.

Location	Voltage
Emitter Q297	+20.7V ±1V
Collector Q297	+6.2V ±0.62V

Adjust Output DC Level (R390) for 60V at pin F on the Output PC board.

3. VERTICAL DC BALANCE

a. Adjust DC Bal (R170)

Change the VOLTS/CM to 20mV. Set the POSITION and STEP ATTEN BAL to midr. Adjust the DC Bal (R170) to bring the trace to graticule center. Adjust the DC Bal (R170) so there is no trace movement as the VOLTS/CM is changed from 20mV to 1mV. If necessary adjust the Position Range to keep the trace on the graticule area.

b. Adjust VAR BAL Range: ≥6cm

Set the VOLTS/CM to 20mV. Rotate the VAR BAL control throughout its range of adjustment. The trace must move a total of at least 6cm. Adjust the VAR BAL so there is no trace movement as the VARIABLE VOLTS/CM is rotated from end to end. Check that the UNCAL neon is lit when the VARIABLE is out of the CAL detent.

Return the VARIABLE to the CAL detent.

3. (CONT)

c. Adjust Position Range: ≥4cm

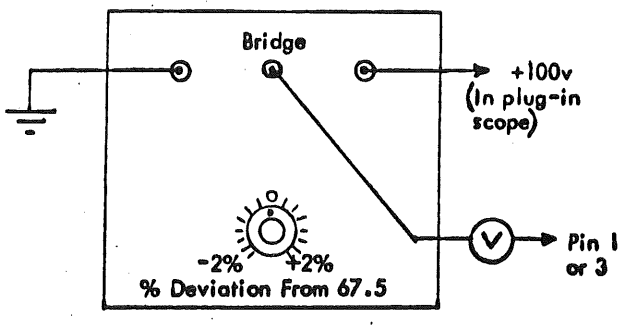
Rotate the Position Range (R370) throughout its range of adjustment. The trace must move a total of at least 4cm. Adjust the Position Range to bring the trace to the center graticule line.

d. Check STEP ATTEN BAL Range: ≥20mV

Change the VOLTS/CM to 5mV. Check that the STEP ATTEN BAL has sufficient range to position the trace at least 4cm (20mV). Readjust the STEP ATTEN BAL so there is no trace movement as the VOLTS/CM is changed from 20mV to 1mV.

e. Adjust Output DC Level (R390) 67.5% ±1% of main frame +100V supply

Connect the 67.5 volt bridge as shown:



Set the dial on the 67.5 volt bridge to 67.5V and the multimeter to the most sensitive DC volts scale.

Adjust the Output DC Level (R390) for 0 volts on the multimeter.

4. GAIN

a. Setup

Connect a Dual Input Coupler (067-0525-00) to A and B INPUT. Connect a 50Ω coaxial cable from the SAC OUTPUT to the Dual Input Coupler. Set the SAC AMPLITUDE to .1V. Set the front panel controls as follows:

4a. (CONT)

VOLTS/CM	20mV
DISPLAY	A-VC
A INPUT	DC
B INPUT	GND

b. Adjust GAIN Range: + & - 10% min

Check for smooth electrical operation as the GAIN control is rotated from end to end. The displayed amplitude at full cw must be at least 5.5cm. The displayed amplitude at full cw must be at least 5.5cm. The displayed amplitude at full ccw must be 4.5cm or less.

Adjust the GAIN for exactly 5cm deflection.

c. Check VARIABLE Range: ≥2.5:1

Rotate the VARIABLE ccw. Check for smooth gain change and no more than 2cm amplitude at full ccw. Return the VARIABLE to the CAL detent.

d. Check VOLTS/CM Accuracy (A INPUT):
1mV-20mV: ±1.5%
50mV-20V: ±2%

Check for the specified amplitude with the controls set as follows:

VOLTS/CM	SAC	AMPLITUDE
20mV	.1 V	5cm ±1.5%
10mV	50mV	5cm ±1.5%
5mV	20mV	4cm ±1.5%
2mV	10mV	5cm ±1.5%
1mV	5mV	5cm ±1.5%
50mV	.2 V	4cm ±2%
.1 V	.5 V	5cm ±2%
.2 V	1 V	5cm ±2%
.5 V	2 V	4cm ±2%
1 V	5 V	5cm ±2%
2 V	10 V	5cm ±2%
5 V	20 V	4cm ±2%
10 V	50 V	5cm ±2%
20 V	100 V	5cm ±2%

4. (CONT)

e. Check VOLTS/CM Accuracy (B INPUT): 50mV-20V: ±2%

Change the DISPLAY to VC-B, A INPUT to GND and B INPUT to DC. Check for the specified amplitude with the controls set as follows:

VOLTS/CM	SAC	AMPLITUDE
20V	100V	5cm ±2%
10V	50V	5cm ±2%
5V	20V	4cm ±2%
2V	10V	5cm ±2%
1V	5V	5cm ±2%
.5V	2V	4cm ±2%
.2V	1V	5cm ±2%
.1V	.5V	5cm ±2%
50mV	.2V	4cm ±2%

f. Check POSITION Range: ≥12cm

Change the B INPUT to AC and the SAC amplitude to .5V. Adjust the VARIABLE for 6cm deflection. Change the SAC to 1V. Rotate the POSITION control from full cw to full ccw. The top and bottom of the display must overlap. Return the VARIABLE to the calibrated detent.

5. COMMON MODE BAL

a. Setup

Set the front panel controls as follows:

VOLTS/CM	1mV
DISPLAY	A-B
INPUT (both)	DC

b. Adjust Common Mode Bal (R140): ≥25,000:1 rejection

Apply a 10V 1kHz sine-wave from the LF Sine-wave Generator to the Dual Input Coupler. Adjust Common Mode Bal (R140) for optimum common mode rejection. Display amplitude must not exceed 0.4cm (exclude amplifier noise).

5b. It may be necessary to adjust R140 for something less than optimum CMR in order to bring the 100kHz within CMR test limits (Step 9c).

5. (CONT)

c. Adjust Atten Bal (R105d, R106d)

Change the VOLTS/CM to 10mV extended range (set VOLTS/CM to 50mV, pull knob out and turn to 10mV) and the sine-wave amplitude to 50 volts. Adjust R105d for minimum amplitude.

Change the VOLTS/CM to .1 volt extended range (set VOLTS/CM to .5V, pull knob out and turn to .1 volts) and the sine-wave amplitude to 100 volts. Adjust R106d for minimum amplitude.

Remove the sine-wave signal.

6. INPUT AMPLIFIER

a. Check Microphonics: ≤100μV

Set the VOLTS/CM to 1mV, DISPLAY to A-VC and both INPUTS to GND. Rap on the TYPE 1A5 front panel. The microphonics produced must not exceed 1mm. Change the DISPLAY to VC-B and repeat the check.

b. Check Input Current: ≤0.2nA

Connect a 50Ω termination to the B INPUT jack. Change the B INPUT from GND to AC. The trace shift must not exceed 2mm caused by the input FET. (A leaky diode can add to input current.)

Change the DISPLAY to A-VC, connect the 50Ω termination to the A INPUT jack and repeat the check.

Remove the 50Ω termination.

c. Check Signal Resolution: ≤1mm

Connect the TYPE R544 CAL OUT...50 Ω coax cable...111 Variable Atten... 50Ω termination...A INPUT. Set the VOLTS/CM to 10mV and the A INPUT to DC. Set the TYPE R544 AMPLITUDE CALIBRATOR to .1V, TIME/CM to 50μSEC and free run the sweep.

a. If the amount of microphonics is in doubt, check as follows:

Install the TYPE 1A5 in the plug-in compartment and tighten the securing shaft. Set the VOLTS/CM to 1mV, DISPLAY to A-VC and both INPUTS to GND.

Place microphonics shock hammer on the top center front of the plug-in scope. Raise the weight to the top of the shaft and release it. The microphonics produced must not exceed 1mm.

Change the DISPLAY to VC-B and repeat the check.

c. Signal resolution is defined as: The minimum resolvable signal, from a 50Ω source, limited by periodic and random deviations originating within the TYPE 1A5.

If the minimum resolvable signal exceeds the test limit, install the TYPE 1A5 in the plug-in compartment and remeasure.

6c. (CONT)

Center the display and adjust the 111 Variable Attenuator for a displayed amplitude of exactly 1cm. Install two X10 attenuators between the 111 Variable Attenuator (do not change the 111 Variable Attenuator setting) and the 50Ω termination. Change the VOLTS/CM to 1mV.

There must be a dark line between the two noise bands; that is, there must be separation between the noise bands.

d. Check Input Protection

Change the VOLTS/CM to 20mV, both INPUTS to DC and position trace to graticule center. Set up the Multimeter to safely read +550 VDC, connect test leads to the DC MONITOR tip jacks on the STEP GENERATOR and set POLARITY switch to +. Depress the PRESS TO MONITOR button and adjust VOLTAGE control concurrently for a Multimeter reading of +550 VDC. Apply the attached probe to A INPUT, push THE PRESS TO INITIATE button momentarily, release and check that trace returns to graticule area after initial shift. Set the POLARITY switch to -, again push and release the PRESS TO INITIATE button and check that trace returns to graticule area after initial shift. Change the TYPE 1A5 DISPLAY to Vc-B, repeat the step with probe on B INPUT, then remove the setup.

7. INPUT CAPACITANCE

a. Setup

DISPLAY	A-VC
VOLTS/CM	20mV
A INPUT	DC
B INPUT	DC

7a. (CON'T)

Connect TYPE 106 HI AMPLITUDE OUTPUT--50Ω coaxial cable--10X attenuator--50Ω termination--20pF Input RX Normalizer--TYPE 1A5 A INPUT. Set the TYPE 106 frequency to 1kHz and adjust the amplitude for a 4cm display. Preset C122, C222, C123 and C223 for minimum capacitance.

b. Adjust Input Capacitance (C108, C208): ≤1% overshoot, rounding or tilt

Adjust C108 for optimum square corner on the top of the square-wave. Overshoot, rounding or tilt must not exceed 1%.

Change the DISPLAY to Vc-B and connect the Input RC Normalizer to the B INPUT. Adjust C208 for pptimum square corner on the bottom of the square-wave.

8. INPUT TIME CONSTANT

a. Adjust B Input Time Constant: ≤1% overshoot, rounding or tilt

Adjust as follows for optimum square corner and minimum tilt on the bottom of square wave. Adjust the TYPE 106 amplitude and remove the 10X attenuator when necessary to maintain a 4cm display.

VOLTS/CM	Adjust for Optimum Corner	Adjust for Minimum Tilt
20mV		C208
50mV	C205B	C205A
.5 V	C206B	C206A
5 V	C207B	C207A

Check all VOLTS/CM settings for no more than 1% overshoot, rounding or tilt.

9. PRESET 20mV HF COMPENSATION

a. Setup

Install the TYPE 1A5 in the TYPE R544 and tighten the securing bolt. Connect the TYPE 106 FAST RISE + OUTPUT--5ns cable--5X atten--50Ω GR to BNC in line termination--A INPUT. Change the VOLTS /CM to 20mV, DISPLAY to A and both INPUTS to DC.

Set the TYPE 106 frequency to 100kHz and adjust the amplitude for a 4cm display.

b. Adjust 20mV HF Compensation

Preset C161 and C261 to minimum capacitance. Adjust C379, R379, C389 and R389 for optimum transient response. Adjust C161 or C261 so the FAST RISE + OUTPUT applied to A INPUT matches the FAST RISE - OUTPUT when applied to B INPUT. (In most instruments it will be necessary to adjust only C161).

Remove the TYPE 106 hook-up and install the TYPE 1A5 on the plug-in extension.

b. Leave C161 and C261 at the min possible capacitance values necessary for match.

10. COMMON MODE REJECTION

a. Setup

Connect a Dual Input Coupler to the A and B INPUT. Connect the output of the TYPE 191 to the Dual Input Coupler and TYPE R544 EXTERNAL HORIZONTAL IN. Change the HORIZONTAL DISPLAY to EXT and the EXTERNAL HORIZONTAL VOLTS/CM to 10. Set the TYPE 191 frequency to 1MHz and adjust the amplitude for 10V (same setting as 5 volts except do not terminate in 50Ω).

10a. In all common mode rejection checks, change the TIME/CM and adjust the TRIGGERING LEVEL as necessary to obtain a readable display. Do not include amplifier noise as part of the common mode signal that is being measured; i.e., if the amplifier noise is a considerable percentage of the total displayed signal, measure the peak to valley amplitude of the display as the common mode signal.

b. Adjust Common Mode Rejection:
≥12500:1 @ 1MHz; ≥1250:1 @ 10MHz

Change the DISPLAY to A-B, both INPUTS to DC and VOLTS/CM to 1mV. Adjust C122, C222, C149 and C249 for minimum deflection: 0.8cm, max. (In most instruments it will be necessary to adjust only C222 and C149 with C122 and C249 set to minimum capacitance).

10b. Dress of C144, C244, C148 and C248 is critical at 100kHz to 1MHz CMR.

Change the TYPE 191 frequency to 10MHz and amplitude to 1 volt. Adjust C163, C263, C123 and C223 for minimum deflection: 0.8cm max. It may be necessary to readjust C161 or C261 to obtain maximum CMR.

Recheck the 1MHz CMR. It may be necessary to compromise between the adjustment of C122, C222 at 1MHz and C163, C263, C123, C223 at 10MHz to obtain optimum CMR.

c. Check X1 CMRR:
≥2500:1 @ 5MHz (2V)
≥250:1 @ 20MHz (0.5V)
≥25000:1 @ 100kHz (10V)

Change the TYPE 191 frequency to 5MHz and amplitude to 2 volts. The displayed signal amplitude must not exceed 0.8cm (0.8mV).

Change the TYPE 191 frequency to 20MHz and amplitude to 0.5 volts. The displayed signal amplitude must not exceed 2cm (2mV).

10c. (CONT)

Replace the TYPE 191 with the LF Sine Wave Generator. Set the frequency to 100kHz and amplitude to 10 volts. The displayed amplitude must not exceed 0.4cm (0.4mV). Repeat the check at 10kHz, 1kHz and 10Hz. Return the TYPE R544 HORIZONTAL DISPLAY to NORMAL (X1) and remove the connection to EXTERNAL HORIZONTAL IN.

The input capacitance has been affected by previous adjustments. Recheck or readjust the input capacitance as was done in step 7.

11. ATTENUATOR CMR

a. Setup

Leave the LF Sine Wave Generator connected as in the previous step. Set the VOLTS/CM to the 10mV extended range. (Set VOLTS/CM to 50mV, pull knob out and turn to 10mV).

b. Adjust X10 CMRR: ≥2500:1 @ 10kHz

Set the LF Sine Wave Generator frequency to 10kHz and amplitude to 100 volts. Adjust C205D for minimum deflection, 4cm max.

c. Check X100 CMRR: ≥2500:1 @ 10kHz

Change the VOLTS/CM to the .1V extended range. The displayed signal amplitude must not exceed 0.4cm.

12. AC COUPLED CMR ≥1250:1

Change the LF Sine Wave Generator frequency to 60Hz and amplitude to 10 volts. Change the VOLTS/CM to 10mV and both INPUTS to AC.

The displayed signal amplitude must not exceed 0.8cm.

Recheck the input capacitance (step 7).

13. HF COMPENSATION

a. Setup

Install the TYPE 1A5 in the TYPE R544 and tighten the securing bolt. Connect the TYPE 106 FAST RISE + OUTPUT--5ns cable-- 5X atten--50Ω GR to BNC in line termination-- A INPUT. Change the VOLTS/CM to 20mV, DISPLAY to A-Vc and both INPUTS to DC.

Set the TYPE 106 frequency to 100kHz and adjust the amplitude for a 4cm display.

b. Adjust HF Compensation: 1mV + & -2.5% aberrations in first 70ns, 2mV-20mV + & -2% aberrations in first 70ns, 1mV -20mV +&- 0.5% abberations after first 70ns

13b. Disregard the amplifier noise when measuring per cent of aberrations.

Adjust C161 or C261 for minimum difference in aberrations in INPUT A and B as in step 9b.

Adjust as follows for optimum transient response and minimum risetime. Overshoot, rounding, ringing and tilt must not exceed +2%, -2% (except +2.5%, -2.5% at 1mV/CM) in the first 70ns and +0.5%, -0.5% after the first 70ns. Change the attenuators in the signal path as directed.

VOLTS/CM	Adjust	*Risetime
20mV	C379, R379 C389, R389 C161, C261 (See notes)	≤7ns
Use 2X and 5X attenuation.		
10mV	R312, L312	≤7ns
Use 2X and 10X attenuation.		
5mV	R307, C309	≤7ns
Use 5X and 10X attenuation.		
2mV	R304, C305, C304	≤8ns
Use 2X, 5X and 10X attenuation.		
1mV	R301, C302	≤9ns

* If the instrument does not make or exceed the listed risetimes, it will probably be necessary to readjust the high frequency compensations in order t o make minimum bandwidth requirements.

Change the DISPLAY sw to V_C-B and connect the -OUTPUT from the TYPE 106 to B INPUT. Center the display on the graticule area. Check aberrations on the fast rise signal at 1mV to 20mV settings of the VOLTS/CM switch. Overshoot, rounding, ringing and tilt must not exceed +2%, -2% (except +2.5%, -2.5% at 1mV) in the first 70ns and +0.5%, -0.5% after the first 70ns.

14. BANDWIDTH

a. Setup

DISPLAY	A-V_C
A INPUT	DC
VOLTS/CM	1mV
V_C POLARITY	0

Connect the TYPE 191 OUTPUT--5ns cable--5X GR attenuator--50Ω GR to BNC Termination--A INPUT.

b. Check DC Coupled Bandwidth (upper limit):
1mV: ≥41MHz @ -3dB
2mV: ≥46MHz @ -3dB
5mV to 20V: ≥51MHz @ -3dB

Set the TYPE 191 frequency to 50kHz and adjust the amplitude for a 4cm display. Increase the frequency until the displayed amplitude is reduced to 2.8cm. The TYPE 191 frequency must be at least 41MHz. Repeat this method to check for the specified bandpass at the following VOLTS/CM settings:

VOLTS/CM	*Bandwidth
2mV	≥46MHz
5mV	≥51MHz
10mV	≥51MHz
20mV	≥51MHz

c. Check AC Coupled Bandwidth (lower limit): ≤ 10Hz @ -3dB

Connect the LF Sine Wave Generator output--50Ω coax--A INPUT. Change the A INPUT to AC. Set the LF Sine Wave Generator frequency to 50kHz and adjust the amplitude for a 4cm display. Decrease the frequency until the display amplitude is 2.8cm. The frequency must be 10Hz or lower.

*b. The bandwidth test limits are based on a plug-in scope risetime of 6.25ns. If the risetime is other than 6.25ns, use the table below to find test limits:

Plug-in Scope t_r	Bandwidth 1mV/CM	2mV/CM	5-20mV/CM
6.25ns	41MHz	46MHz	51MHz
6.00ns	42MHz	47.1MHz	52.5MHz
5.75ns	42.8MHz	48.2MHz	54MHz
5.50ns	43.7MHz	49.3MHz	55.7MHz
5.25ns	44.6MHz	51MHz	58.5MHz

15. INTERCHANNEL ISOLATION

a. Setup

VOLTS/CM	20mV
DISPLAY	VC-B
A INPUT	DC
B INPUT	DC

Connect the TYPE 191 OUTPUT through a 50Ω coaxial cable to the A INPUT.

b. Check Amplifier Isolation: ≥100:1

Set the TYPE 191 frequency to 50MHz and adjust the amplitude for 10 volts out (same setting as 5 volts when terminated in 50Ω). Change the TYPE 191 frequency from 50MHz to 50kHz. The displayed amplitude as seen with the DISPLAY in V_C-B must not exceed 100mV (5cm).

Change the DISPLAY to A-V_C, connect the TYPE 191 OUTPUT to the B INPUT and repeat the check.

c. Check Total Isolation: ≥20:1

Connect the TYPE 106 HI AMPLITUDE OUTPUT through a 50Ω coax cable, a 10X attenuator and a 50Ω termination to the A INPUT. Set the VOLTS/CM to 20mV, DISPLAY to A-B, A INPUT to DC and B INPUT to GND. Set the TYPE 106 frequency to 1kHz and adjust the amplitude for a 4cm display. Check for no more than 5% (0.2cm) rounding on the square-wave as the B INPUT is changed from GND to AC or DC.

16. OVERDRIVE

a. Setup

DISPLAY	A-V_C
VOLTS/CM	1
A INPUT	DC

16a. (CONT)

Connect the TYPE 106 HI AMPLITUDE OUTPUT--2X GR ATTEN--5ns cable--50Ω GR to BNC termination--A INPUT. Connect a 50Ω coaxial cable from the TYPE 106 TRIGGER OUTPUT to the plug-in scope external TRIGGER INPUT. Set the test scope TRIGGER SOURCE to EXT, TIME/CM to .1mSEC and adjust the TRIGGERING LEVEL for a triggered display. Set the TYPE 106 frequency to 1kHz and adjust the amplitude for 5 volts (5cm).

b. *Check DC Shift in first 5s: ≤1% of overdrive signal or 10mV or less in 5V input signal range, whichever is smaller*

≤1% of overdrive signal or 0.1V or less in 50V input signal range, whichever is smaller

≤1% of overdrive signal or 1.0V or less in 500V input signal range, whichever is smaller.

Change the A INPUT to GND and the VOLTS/CM to 10mV. Allow a few seconds for the amplifier to stabilize and position the trace to graticule center. Change the A INPUT to DC and observe the DC shift that occurs in the first 5 seconds. The back corner of the waveform must not shift from graticule center by more than 10mV (1cm).

Remove 2X GR attenuator.

Set VOLTS/CM to 10V. Set the TYPE 106 to 50V (5cm). Change A INPUT to GND and VOLTS/CM to 50mV. Position trace to graticule center. Change A INPUT to DC. The back corner of the waveform must not shift from graticule center by more than 0.1V (2cm) in the first 5 seconds.

16b. (CONT)

Set VOLTS/CM to 20V. Set the TYPE 106 to 100V (5cm). Change A INPUT to GND and VOLTS/CM to .5V. Position trace to graticule center. Change A INPUT to DC. The back corner of the waveform must not shift from graticule center by more than 1.0V (2cm) in the first 5 seconds.

c. Check Overdrive Recovery Time: ≤0.15μs to within 10mV

Change the TIME/CM to .2μSEC and the VOLTS/CM to 1V. Position the leading edge of the waveform so it coincides with the left edge of the graticule. Change the VOLTS/CM to 5mV and the TIME/CM to .1mSEC. Position the back corner of the waveform to the graticule center line. Change the TIME/CM back to .2μSEC. The waveform must return to within 10mV (2cm) of the graticule center within 0.15μs (referenced to left edge of graticule).

17. COMPARISON VOLTAGE

a. Setup

TYPE 1A5

DISPLAY	A-V_C
VOLTS/CM	1mV
V_C dial	full ccw
V_C POLARITY	0
A INPUT	DC

Connect the Differential Voltmeter between gnd and the MONITOR jack.

b. Check V_C Zero Error:
electrical: ≤2mV
mechanical: ≤1 minor dial div

Check that the V_C dial 0 is within 1 minor div of the index when the dial is full ccw.

Center the trace on the graticule. Change the V_C POLARITY to +. The trace must not shift more than 2cm (2mV).

17. (CONT)

c. Adjust Comparison Voltage:
full scale { 5V ±3mV (1mV-2V)
0.5V ±2mV (5V-20V)

Set the V_C dial and the differential voltmeter to read 5.00 volts. Adjust V_C Cal (R113) for a null indication on the differential voltmeter. Check for null at the 1mV through 2V settings of the VOLTS/CM switch.

Change the VOLTS/CM to 5V. Set the differential voltmeter and the V_C dial to read 0.500 volts. Adjust the V_C X10 Cal (R119) for a null indication on the differential voltmeter. Check for null at 5V through 20V settings of the VOLTS/CM switch.

d. Check V_C Accuracy (5V - 20V/CM): ±0.75% of indicated or ±0.75mV, whichever is greater

Set the VOLTS/CM to 5V. Check for the specified voltage with V_C dial set as follows:

VC dial	Voltage (diff voltmeter reading)
5.00	500mV ±2mV
4.00	400mV ±3.0mV
3.00	300mV ±2.25mV
2.00	200mV ±1.50mV
1.00	100mV ±0.75mV

e. Check V_C Accuracy (1mV-2V/CM): ±0.4% of indicated or ±6mV, whichever is greater

Change the V_C and the differential voltmeter polarity to minus (-). Change the VOLTS/CM to 2V. Check for the specified voltage with the V_C dial set as follows:

V_C dial	Voltage (diff voltmeter reading)
0.5	0.5V ±6mV
1.00	1.0V ±6mV
1.50	1.5V ±6mV
2.00	2.0V ±8mV
2.50	2.5V ±10mV
3.00	3.0V ±12mV
3.50	3.5V ±14mV
4.00	4.0V ±16mV
4.50	4.5V ±18mV
5.00	5.0V ±3mV

18. AMPLIFIER STABILITY ≤300μV drift

Set the front panel controls as follows:

INPUT (A & B)	GND
DISPLAY	A-B
VOLTS/CM	1mV

Set the line voltage to 105VAC. Allow 1 minute for the amplifier to stabilize, center the trace and increase the line voltage to 125VAC. The trace drift over a period of 1 minute must not exceed 3mm (300μV).

The TYPE 1A5 must be in the plug-in compartment with side panels installed on the mainframe when this check is made.

19. DIFFERENTIAL PROBE

a. Adjust PROBE STEP ATTEN BAL

Connect the Differential Probe Checker to the DIFFERENTIAL PROBE jack. Set the VOLTS/CM to 20mV and position the trace to graticule center. Turn the differential probe power on and adjust the PROBE STEP ATTEN BAL to bring the trace back to graticule center. Adjust the PROBE STEP ATTEN BAL so there is no trace shift as the VOLTS/CM is changed from 20mV to 1mV.

b. Check DIFFERENTIAL PROBE Input Connector

Check for the specified voltage at the following pins:

PIN	VOLTAGE
K	-50V ±5%
F	+50V ±5%
E	+20.7V ±5%
D	+6.2V ±10%

Check that the 6.2V is applied to pin D in the 1mV through the 20mV position of the VOLTS/CM sw and is not applied in the 50mV through the .2V positions.