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).

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. (HD)

This procedure is company confidential

454

Tek form number:
0-359
January 1968
For all serial numbers.

EQUIPMENT REQUIRED:

The following equipment is necessary to complete this procedure:

a. TEKTRONIX Instruments

1	TYPE 453 OSCILLOSCOPE
1	TYPE P6006 10X PROBE
1	TYPE P6028 1X PROBE
1	TYPE P6019 CURRENT PROBE
1	TYPE P6019 PASSIVE TERMINATION
1	TYPE CT-3 50-OHM SIGNAL PICKOFF
1	TYPE 109 PULSE GENERATOR
1	TYPE 113 DELAY CABLE
1	TYPE 106 SQUARE-WAVE GENERATOR
* 1	TYPE 184 TIME MARK GENERATOR
* 1	TYPE 191 CONSTANT AMPLITUDE SIGNAL GENERATOR

b. Test Fixtures and Accessories

* 1	STANDARD AMPLITUDE CALIBRATOR (SAC) (067-0502-00)
1	SINE-WAVE GENERATOR (067-0542-99)
* 1	CONSTANT AMPLITUDE GENERATOR (067-0532-00)
* 1	DC Voltage Bridge (067-0543-99)
2	50Ω BNC Terminations (011-0049-00)
1	50Ω GR to BNC Termination (017-0083-00)
1	50Ω GR 2X Attenuator (017-0080-00)
1	50Ω GR 5X Attenuator (017-0079-00)
1	50Ω GR 10X Attenuator (017-0078-00)
1	20pF Input RC Normalizer (067-0538-00)
2	GR RG8 5ns cables (017-0502-00)
2	50Ω 42" BNC cables (012-0057-00)
2	50Ω 18" BNC cables (012-0076-00)
1	BNC T connector (103-0030-00)
1	BNC female to female adapter (103-0028-00)
1	Dual Input Coupler (067-0525-00)
1	TU76 Line Voltage Control (067-0048-00)
1	454 Signal Insertion (067-0553-00)
1	Micro Shock Hammer (PMPE Dwg. #1283B)
1	2.2ns charge line (PMPE Dwg #1779-A)
1	4MHz FILTER (PMPE Dwg #1776-B)
1	Probe Power Checker (PMPE Dwg #1558-C)

c. Other equipment

1 20,000Ω/VDC Multimeter
1 250 ±0.25% resistor

SAMPLE CHECKS

1 TYPE C-40 camera with f1.3 1:0.5 lens with Polaroid Type 410 10,000 speed film
1 100MHz Ring 80x
1 Light source for back lighting photographs
1 Photograph of a 454 graticule taken with camera, cut in half.

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

It is assumed that all equipment is provided with BNC connectors; if equipment used has other than BNC connectors, adapters, not listed, may be needed.

QUALIFICATION

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 (set-ups, 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.

4. POWER SUPPLIES AND CALIBRATOR

b. -12 Volts: ±.02V, max
*c. Calibrator: 1V ±.002V, max
d. Output resistance: 0.5V across 250 load ±5mV
e. +12 Volts: +12V -0, +.2V
f. +75V ±.2V
h. Ripple: 2mV
Regulation: HI; 112 to 136VAC
M; 104 to 126VAC
LO; 90 to 110VAC

5. HIGH VOLTAGE ±2%

7. TRACE ALIGNMENT

a. TRACE ROTATION RANGE: 5.40, min
b. Y Axis alignment: .1 div, max
c. Geometry: .1 div max

8. SCALE ILLUM
No illumination ccw
max illumination cw

10. STEP ATTEN BAL

a. STEP ATTENUATOR BAL range: ≥16 div total; ≥1 div from proper setting
c. Trace shift through VOLTS/DIV range: ≤0.5 div between steps; 2 div max total shift

12. BALANCE

a. VARIABLE balance: within 1 div of graticule center with no VARIABLE trace shift
c. CH 2 INVERT balance: ±1 div of graticule center

13. GAIN

b. CH 1 and 2 GAIN Range: 350mV to 400mV
c. Output Amp Gain Range: 11V to 12V
d. Add gain: ±1%, max

14. VOLTS/DIV

*a. VOLTS/DIV accuracy: ±2%, max
b. VARIABLE range: 2.5:1 min

16. VERTICAL LINEARITY

Compression and expansion: .1 div, max

17. ALTERNATE: all sweep rates

18. MICROPHONICS, GRID CURRENT AND NOISE

a. Microphonics: 1 div, max; no ring type
b. Grid current: .2 div, max
c. Cascaded noise: .4 div P-P, max

19. VOLTS/DIV COMPENSATION

b. CH 1 compensation: ±1%, max
c. CH 2 compensation: ±1%, max

20. TRANSIENT RESPONSE

c,h.

VOLTS/DIV	Max aberrations
5mV	±5%; 5% P-P
10mV	±3%; 5% P-P
20mV	±3%; 3% P-P
50mV	±3%; 4% P-P
.1V	±5%; 5% P-P
.2V and .5V	±5%; 5% P-P
1V	±5%; 6% P-P
2V	±5%; 7.5% P-P
5V	±8%; 10% P-P
10V	±10%; 12% P-P

e,h. Risetime, CH 1 and CH 2: 2.2ns pulse amplitude ≥80%

f,h. - polarity aberrations, CH 1 and CH 2: ±3%, or within 2% of + polarity, whichever is greater

g,h. Position effect on aberrations, CH 1 and CH 2: 6%, max rounding

21. BANDWIDTH

*b. 10mV/DIV bandwidth: ≥110MHz at -3dB

*c. 20mV/DIV to 1V/DIV bandwidth: ≥160MHz at -3dB

*e. Added mode bandwidth: ≥160MHz at -3dB

*f. 5mV/DIV bandwidth: ≥63MHz at -3dB

22. CH 1 OUT

*b. CH ± cascaded with CH 2 Bandwidth: ≥33MHz at -3dB

c. Deflection factor: ≤1mV/div

23. VERTICAL POSITION RANGE

b. Vertical position range: + and - 10 to 15 div

24. COMMON MODE REJECTION RATIO

b. CMRR ≥10:1 at 50MHz

25. INTER-CHANNEL ISOLATION

b. Attenuator isolation: 10,000:1 at 50MHz

c. Amplifier isolation: ≥100:1 at 50MHz

26. TRIGGER LEVEL CENTERING

a. CH 1 DC out: 0V ±10mV

28. TRIGGERING

b. 20MHz Triggering

	INT	EXT
AC	.3 div	75mV
LF REJ	.3 div	75mV
DC	.3 div	75mV

c. 150MHz Triggering Jitter: .5ns, max

	INT	EXT
AC	1.5 div	375mV
LF REJ	1.5 div	375mV
DC	1.5 div	375mV

d. 60Hz Triggering

	INT	EXT
AC	.3 div	75mV
HF REJ	.3 div	75mV
HF REJ	.3 div of 50kHz not triggered at 1MHz	

f. LF REJ: triggered on .3 div of 50kHz not triggered at 60Hz

g. SINGLE SWEEP: same triggering level as in NORM

29. TRIGGERING LEVEL RANGE

b. EXT TRIGGERING LEVEL range: + & - 2V, min

c. EXT ÷ 10 LEVEL range: + & - 20V, min

30. LINE TRIGGER

b. LINE triggers on correct polarity

31. AUTO RECOVERY TIME

b. AUTO recovery time: 50ms to 100ms

33. DELAY-TIME MULTIPLIER LINEARITY

*a. DELAY-TIME linearity: ±1.5 minor div, max

36. X10 MAG

*a. Mag Gain: ±1%, max
*b. Linearity: ±4%, max
c. Mag Regis: ±.1 div, max

37. SWEEP LENGTH

a. A sweep length: ≤4 div to 11 ±.5 div
b. B sweep length: 11 ±.5 div

38. VARIABLE RANGE

a. B VARIABLE range: 2.5:1, min
b. A VARIABLE range: 2.5:1, min

39. POSITION RANGE

a. X1 position range: ends of sweep to graticule center
b. X10 FINE range: 5 to 8 div

41. & 42 SWEEP TIME/DIV

*a. MAG OFF timing: 8 div ±2%, max
2 div ±4%, max
*b. X10 MAG: ±3%, max

43. DELAY TIME ACCURACY

*a. DELAY-TIME MULTIPLIER accuracy:
1µs to 50ms: ±1%, max
.1s to 5s: ±2%, max

44. DELAY TIME JITTER

a. Delay time jitter: .3 div, max

45. X-Y INPUT

*b. X gain: ±1%, max
c. Phasing: 1.15°, max
*d. X Bandwidth: 2MHz

46. BEAM FINDER AND 5MHz SWITCH

a. 5MHz Bandwidth: ≥4MHz to 6MHz at -3dB
b. Beam finder: trace must not position off graticule

47. CHOPPED OPERATION

b. Chopping rate: 1MHz ±20%

48. CALIBRATOR

*b. Cal Freq: 1kHz ±0.1%
c. Duty cycle: 50% ±0.8%
*d. Risetime: 1µs, max

49. Z AXIS

b. Z axis sensitivity: 5V, min
c. Max usable Zaxis Frequency: 50MHz, min

51. OUTPUT WAVE FORMS

a. A Gate out: 12.0V ±5% to -0.6 ±10%
b. A SWEEP out: 10V ±5%
c. B GATE out: +12.0V ±5% to -0.6V ±10%

52. HOLDOFF

a. HF STAB: 10% change of holdoff
b. A sweep holdoff:

TIME/DIV	Holdoff
.05µs to 2µs	.5 - 2µs
5µs to 20µs	4 - 10µs
50µs to .5µs	40 - 100µs
1ms to 5ms	.4 - 1ms
10ms to 50ms	4 - 10ms
.1s to 5s	40 - 100ms

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

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

53. WRITING SPEED

a. Writing speed: 1350 div/μs

Factory TEST LIMITS are limits an instrument must meet 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, it is necessary to set up some circuits so their performance is better than required by Factory Test Limits. Therefore, the instructions given in the Factory Calibration Procedure may call for checks or adjustments which result in less error than that allowed by the Factory Test Limits.

1. PRELIMINARY INSPECTION

a. Make general inspection
b. Set DELAY TIME MULTIPLIER
c. Check fuses
d. Inspect CRT

2. TYPE 454 PRESETS

a. Preset external controls
b. Preset internal adjustments

3. RESISTANCE CHECKS

a. Check supplies
b. Check transformer primary

4. POWER SUPPLIES AND CALIBRATOR

a. Check Line Voltage Selector
b. Adjust -12 volts R1124: -12V
*c. Adjust +12 volts R1158: +1V (calibrator)
d. Check calibrator output resistance: .5V across 250 load ±4mV
e. Check +12 volts: +12V 0V ±0.2V
f. Adjust +75 Volts R1188: +75V
g. Check PROBE POWER jack
h. Check ripple and regulation
   Ripple: 2mV, max
   Regilation: HI; 112 to 136VAC
   M; 104 to 126VAC
   LO; 90 to 110VAC

5. HIGH VOLTAGE

Adjust High Voltage R1401:-1960V

6. CRT GRID BIAS

Adjust CRT Grid Bias: +12V

7. TRACE ALIGNMENT

a. Adjust TRACE ROTATION: Range 0.8 div
b. Adjust Y axis align R1485: ±.1 div, max
c. Adjust Geometry R1482: .1 div, max

8. SCALE ILLUM

Check SCALE ILLUM: No illumination, ccw; max illumination, cw

9. CRT

Check for CRT defects

10. STEP ATTEN BAL

a. Range: >16 div total; ≥1 div from proper setting
b. Adjust 100mV STEP ATTEN BAL (R128): no trace shift, 50mV to .1V
c. Check trace shift: no shift

11. VERTICAL POSITION CENTERING

a. Adjust centering R334: no trace shift CHOP to ADD
b. Adjust Position Center R40 (R140)

12. BALANCE

a. Check VARIABLE balance: ±1 div of graticule center with no variable trace shift
b. CH 2: repeat steps 10, 11b, 12a
c. Check CH 2 INVERT balance: ±1 div of graticule center

13. GAIN

a. Adjust R382: 2.9V, Q474 collector to emitter
b. Adjust CH 1 and CH 2 GAIN
Range: ≤350mV to ≥400mV
c. Adjust Output Amp Gain R365
Range: ≤11V to ≥12V
d. Check ADD gain: ±1%

14. VOLTS/DIV

*a. Check VOLTS/DIV accuracy: ±2%, max
b. Check VARIABLE range: 2.5:1, min

15. INPUT SWITCHES

Check AC-GND-DC switches

16. VERTICAL LINEARITY

Check compression and expansion: .1 div, max

17. ALTERNATE

Check ALT operation: all sweep rates

18. MICROPHONICS, GRID CURRENT AND NOISE

a. Check microphonics: 1 div, max; no ringing type
b. Check grid current: .2 div, max
c. Check cascaded noise: .4 div

19. VOLTS/DIV COMPENSATION

b. Adjust CH 1 compensation: ±1%, max
c. Adjust CH 2 compensation: ±1%, max

20. TRANSIENT RESPONSE

a. Adjust delay line compensation:
C402; min aberrations
R417, R419; optimum level
b. Adjust Output amplifier: optimum risetime and waveform
c. Adjust CH 1 preamp compensation:
5mV/DIV: ±5%, max; 5% P-P, max
10mV/DIV: ±3%, max; 5% P-P, max
20mV/DIV: ±3%, max; 3% P-P, max
50mV/DIV: ±3%, max; 4% P-P, max
.1V/DIV: ±5%, max; 5% P-P, max
d. Check CH 1 Attenuator aberrations:
.2V to .5V/DIV: ±5%, max; 5% P-P, max
1V/DIV ±5%, max 6% P-P, max
5V/DIV: ±8%, max; 10% P-P, max
10V/DIV: ±10%, max; 12% P-P, max
e. Check CH 1 risetime: 2.2ns pulse amplitude: 80%
f. Check - polarity aberrations: 3% or within 2% of polarity, whichever is greater
g. Check position effect on aberrations: 6%, max rounding
h. Repeat steps 20 c through 20 g for CH 2

21. BANDWIDTH

*b. Check 10mV/DIV bandwidth: ≥110 MHz at -3dB
*c. Check 20mV/DIV to 1V/DIV bandwidth: ≥160MHz at -3dB
*d. Repeat steps 21 b through 21 c for CH 2
*e. Check added mode bandwidth: ≥160 MHz at -3dB
*f. Check 5mV/DIV bandwidth, CH 1 and CH 2: ≥63MHz at -3dB

22. CH 1 OUT

*b. Check Bandwidth: 33MHz at -3dB
c. Check deflection factor: 1mV/div

23. VERTICAL POSITION RANGE

b. Check position range: + and - 10 to 15 div

24. COMMON MODE REJECTION RATIO

b. Check CMRR: ≥10:1 at 50MHz

25. INTER-CHANNEL ISOLATION

b. Check Attenuator isolation: ≥100,000:1 at 50MHz
c. Check amplifier: ≥100:1

26. CH 1 OUT AND TRIG DC LEVEL

a. Adjust CH 1 OUT DC Level R52: 0V
b. Adjust Trig Preamp DC Level R511: 0V
c. Adjust Norm Trig DC Level R272: 0V

27. TRIGGER LEVEL CENTERING

a. Adjust A Trig Level Cent R643: A SWEEP TRIG'D lights
b. Adjust B Trig Level Cent R843: stable display

28. TRIGGERING

b. Check 20MHz triggering: INT .3 div; EXT 75mV
c. Check 150MHz triggering: INT 1.5 div; EXT 375mV; Jitter 0.5ns, max
d. Check 60Hz triggering: INT .3 div; EXT 75mV
e. Check HF REJ: triggered .3 div of 50Hz; not triggered at 1MHz
f. Check LF REJ: triggered on .3 div of 50kHz; not triggered at 60Hz
g. Check SINGLE SWEEP: same triggering level as NORM

29. TRIGGERING LEVEL RANGE

b. Check EXT LEVEL range: + and - 2V, min
c. Check EXT ÷10 LEVEL range: + and - 20V, min

30. LINE TRIGGER

b. Check triggering: triggered on correct polarity

31. AUTO RECOVERY TIME

b. Check recovery time: 50ms to 100ms

32. SWEEP START, A SWEEP CAL

b. Rough adjust Sweep Start R956: set at 1.00
c. Rough adjust A Sweep Cal R743: set at 9.00
d. Fine adjust Sweep Start and A Sweep Cal

33. DELAY-TIME MULTIPLIER LINEARITY

*a. Check linearity: ±1.5 minor div, max

34. NORM GAIN

Adjust Norm Gain R1036: 1ms/div

35. B SWEEP CAL

Adjust B Sweep Cal R943: 1ms/div

36. X10 MAG

a. Adjust Mag Gain: .1ms/div
b. Check linearity: ±4%, max
c. Adjust Mag Regis R1053: no shift, X10 to OFF

37. SWEEP LENGTH

a. Check A sweep length: ≤4 div to 11 ±0.5 div
b. Check B sweep length: 11 ±0.5 div

38. VARIABLE RANGE

a. Check B VARIABLE range: 2.5:1, min
b. Check A VARIABLE range: 2.5:1, min

39. POSITION RANGE

a. Check X1 position range: ends of sweep to graticule center
b. Check X10 FINE range: 5 to 8 div

40. HIGH SPEED TIMING

a. Adjust C740C: 1µs/div
b. Adjust C940C: 1µs/div
c. Adjust C940A: .5µs/div
d. Adjust C740A: .5µs/div
e. Adjust C1081 and C1091: X10 linearity

41. A SWEEP TIME/DIV

a. Check MAG OFF timing: 8 div ±2%, max 2div ±4%, max
b. Check X10 MAG: ±3%, max

42. B SWEEP TIME/DIV

a. Check MAG OFF timing: 8 div ±2%, max 2 div ±4%, max
b. Check X10 MAG: ±3%, max

43. DELAY TIME ACCURACY

a. Check DELAY-TIME MULTIPLIER Accuracy: 1µs to 50ms: ±1%, max .1s to 5s: ±2%, max

44. DELAY TIME JITTER

a. Check delay time jitter: .3 div, max

45. X-Y INPUT

b. Adjust X-gain, R567: .02V/div
c. Adjust Phasing, L568, R569: .2 div, max opening
d. Check Bandwidth: ≥2MHz at -3dB

46. BEAM FINDER AND 5MHz SWITCH

a. Check 5MHz bandwidth: ≥4MHz to ≤6MHz at -3dB
b. Check Beam Finder: trace must not position off graticule

47. CHOPPED OPERATION

b. Check chopping waveform duration: .84 - 1.25µs segment duration: 400 - 600ns
c. Check blanking

48. CALIBRATOR

b. Adjust Cal Freq T1275: 1kHz
c. Check duty cycle: 50% ±.8%
d. Check risetime: 1µs, max
e. Check 5mA CURRENT LOOP

49. Z AXIS

a. Adjust compensation, C1352: optimum square-wave
b. Check sensitivity: 5V, min
c. Check maximum useable frequency: 50MHz, min

50. B ENDS A

b. Check B ENDS A operation

51. OUTPUT WAVEFORMS

a. Check A GATE: +12.0V ±5% to -0.6V ±10%
b. Check B SWEEP: 10V ±5%
c. Check B GATE: +12.0V ±5% to -0.6V ±10%

52. HOLDOFF

a. Check HF STAB: ≥10% change of holdoff
b. Check A sweep holdoff

53. WRITING SPEED

b. Check writing speed: 1350 div/µs

1. PRELIMINARY INSPECTION

a. Make General Inspection

Check for unsoldered joints, rosin joints lead dress and long ends. Check for loose hardware and protruding parts. Check controls for smooth mechanical operation, proper indexing and knob spacing from front panel. Check pin connectors for tightness and proper connection. Check graticule alignment and check that all current modifications are installed. Correct all defects found.

b. Set DELAY-TIME MULTIPLIER

Set DELAY-TIME MULTIPLIER full ccw until it hits the stop. Check for a dial reading of 0.1.

If dial does not read 0.1 at ccw stop, loosen dial set screw and reposition dial on shaft. Tighten set screw and check that dial operates smoothly without binding.

c. Check Fuses

F1101(115V)	2A	Fast-Blo
F1102(230V)	1A	Fast-Blo
F1437	2A	Fast-Blo
F1204	.25A	Fast-Blo

With line selector cover removed connect the power cord to a source of 115VAC power and turn POWER ON. Check that the pilot light is not lighted. Remove the power cord from 115VAC source and change the line selector to 230. Again plug the power cord into a source of 115VAC and check that the pilot light is not lighted. Remove the power cord from 115VAC source, return the line selector to 115 and replace the line selector cover.

d. Inspect CRT

Inspect CRT for physical defects: Phosphor defects, scratches, chips, cracks around neck pins, etc.

2. TYPE 454 PRESETS

a. Preset external controls

INTENSITY	ccw
FOCUS	midr
SCLAE ILLUM	midr
CH 1 and CH 2	
VOLTS/DIV	20mV
VARIABLE	CAL
POSITION	midr
INPUT SWITCH	DC
STEP ATTEN BAL	midr
GAIN	midr
MODE	CH 1
TRIGGER	NORM
INVERT	pushed in
DELAY-TIME MULTIPLIER	ccw
A AND B TIME/DIV	1ms
A VARIABLE	CAL
A SWEEP MODE	NORM TRIG
B SWEEP MODE	TRIGGERABLE AFTER DELAY TIME
HORIZ DISPLAY	A
MAG	OFF
A SWEEP LENGTH	FULL
POSITION	midr
A AND B TRIGGERING	
LEVEL	cw
SLOPE	+
COUPLING	AC
SOURCE	INT
POWER	ON
ASTIG	midr
TRACE ROTATION	midr
B TIME/DIV VARIABLE	CAL
X-GAIN	midr
LINE VOLTAGE SELECTOR	115
LINE VOLTAGE RANGE	LO

b. Preset internal adjustments

R417	ccw
R419	ccw
R394	700Ω
R494	700Ω

Set all remaining internal adjustments to midr.

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

b. PRESETTING INTERNAL ADJUSTMENTS

Do not preset internal adjustments for recalibration unless you are sure that a "start-from-scratch" policy is best.

3. RESISTANCE CHECKS

a. Check supplies

Check power supply resistances to ground at LV Regulator Board (+ meter lead to gnd).

SUPPLY	METER SCALE	APPROX RESISTANCE	Pin No.
-12V	X10	12Ω	E
+12V	X10	12Ω	L
+75V	X1k	1kΩ	C
+150V (unreg)	X1k	2.5kΩ	A

b. Check transformer primary

Measure resistance across the power plug at each setting of the Line Voltage Selector to check for correct wiring of the transformer primary.

Selector	Meter Scale	Approximate Resistance
115V LO	X1	3.5Ω
M	X1	4.0Ω
HI	X1	4.3Ω
230V HI	X10	17.2Ω
M	X10	16.0Ω
LO	X10	14.0Ω

4. POWER SUPPLIES AND CALIBRATOR

a. Check Line Voltage Selector

Connect TYPE 454 to variable line voltage source and set line voltage for 50V P to P at terminal 14 of T1101. Check P to P voltage at each setting of the Line Voltage Selector using test scope with 10X probe connected to terminal 14 of T1101.

Selector	P to P Voltage
230V LO	50V (set)
M	44V
HI	40V
115V HI	80V
M	88V
LO	100V

4. (cont'd)

Set Line Voltage Selector to 115V M and line voltage to 115V. Check that POWER ON light is lit.

b. Adjust -12 volts R1124

Connect Voltage Bridge to -12V on LV Pwr Supply Board and adjust R1124 for -12V.

* *c. Adjust +12 Volts R1158 +1V, (calibrator)*

Remove Q1275 from calibrator board. Connect Bridge to 1V CAL 1 kHz connector and adjust R1158 for 1V.

d. Check calibrator output resistance 250Ω , ±1%

Connect 250Ω ±0.25% resistor from calibrator output to ground. Check for 0.5V ±5mV at 1V CAL 1 kHz connector. Replace Q1275 and disconnect 250Ω resistor.

e. Check +12 volts +12V, -0 +.2V

Connect Bridge to +12V on the LV Pwr Supply board and check for 12.0 to 12.2 volts.

f. Adjust +75 volts R1188 ±.2V, max

Connect Bridge to +75V on LV Pwr Supply board and adjust R1188 for 75V.

g. Check PROBE POWER jacks

Check for +12V, -12V and gnd at the correct terminals of the PROBE POWER jacks.

h. Check ripple and regulation
Ripple: 2mV, max
HI: 112 to 136 VAC
M: 104 to 126 VAC
LO: 90 to 110 VAC

Check ripple on -12V, +12V and +75V supplies for 2mV, max, while changing line voltage over the indicated range for each setting of the LINE VOLTAGE SELECTOR.

Return line voltage to 115 VAC and LINE VOLTAGE SELECTOR to M.

Check +150V unreg for approx 2.5V of 120 Hz ripple.

5. HIGH VOLTAGE

Adjust High Voltage R1401

Connect Voltage Bridge to -1960V TP and adjust R1401 for -1960V. Check regulation from 104 to 126 VAC.

5. High Voltage

R1401 must be adjusted for no indicated error when using the Voltage Bridge to assure ±1% which is the initial setting requirement.

6. CRT GRID BIAS

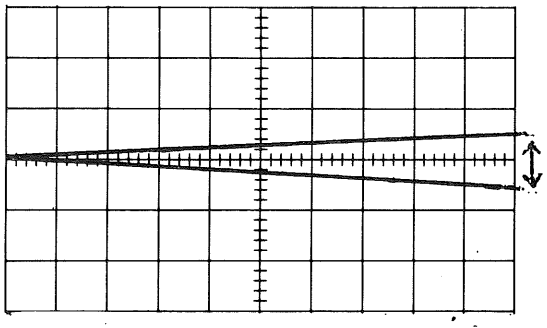
Adjust CRT Grid Bias R1447

Switch A SWEEP MODE to SINGLE SWEEP. Set INTENSITY for +12 volts at TP 1349. Adjust R1447 so spot is just visible.

7. TRACE ALIGNMENT

a. Adjust TRACE ROTATION Range: 5.4°, min

Set A SWEEP MODE to AUTO TRIG. Turn TRACE ROTATION full cw and ccw to check range of adjustment and that trace rotation is in same direction as pot rotation. Adjust to align trace with center horizontal gracticule line.



b. Adjust Y axis Align R1485 :
±.1 div, max

Connect .1ms and 1ms markers from TYPE 184 to CH1 INPUT. Set CH1 VOLTS/DIV so markers extend from bottom to top of graticule and set A TRIGGERING LEVEL for a stable display. Adjust ASTIG and FOCUS for well-defined markers. Adjust Y Axis Align to align marker with center vertical graticule line.

c. Adjust Geometry R1482
.1 div, max

Adjust Geometry for minimum curvature of the markers, .1 div, max. Recheck Y axis alignment at center of graticule and re-adjust if necessary.

Remove TYPE 184 signal. Position trace to top and bottom of graticule and note deviation from a straight line: .1 div, max.

8. SCALE ILLUM

Check SCALE ILLUM
No illumination ccw
max illumination cw

Rotate SCALE ILLUM through its range. Check for a smooth increase in illumination with no illumination at full ccw and max illumination at full cw.

9. CRT

Check for CRT defects

Check CRT for double-peaking, flare, grid emission, interface, charging, burrs and scan area.

9. CRT defects

These CRT checks are simplified. For further information on CRTs see the CRT Checkout Procedure or consult a trained CRT checker.

10. STEP ATTEN BAL

a. Adjust STEP ATTEN BAL
Range: ≥16 div total; ≥1 div from proper setting

Set VOLTS/DIV to 50mV and check range of STEP ATTEN BAL for 16 div, min. Adjust STEP ATTEN BAL for no trace shift when switching VOLTS/DIV from 50mV to 5mV. Final adjustment must leave at least 1 div of range in each direction with VOLTS/DIV at 50mV.

b. Adjust 100mV STEP ATTEN BAL R28 (R128): no trace shift, 50mV to .1V

Adjust 100mV STEP ATTEN BAL for no trace shift when switching VOLTS/DIV from 50mV to .1V.

c. Check trace shift

Switch VOLTS/DIV through its range and check trace shift for no trace shift.

11. VERTICAL POSITION CENTERING

a. Adjust centering R334: no trace shift CHOP to ADD

Set MODE to CHOP and position both traces to graticule center. Switch MODE to ADD and note position of trace. Adjust R334 to move trace an equal distance in the same direction from graticule center. Repeat this procedure until no shift occurs when switching from CHOP to ADD. Return MODE to CH 1.

b. Adjust Position Center R40 (R140)

Center the vertical POSITION control and adjust R40 (R140) for trace at graticule center.

11. b (continued)

Connect 50 kHz signal from TYPE 191 to INPUT CH 1 (CH 2) and set amplitude so bottom and top of sine-wave extend to the same point on the graticule when turning vertical POSITION control full cw and ccw. Make final adjustment of R40 (R140) so waveform extends to center of graticule at extremes of positioning range. Remove TYPE 191 signal.

12. BALANCE

a. Check VARIABLE balance ±1 div of graticule center

Set vertical POSITION for no trace shift when rotating VARIABLE VOLTS/DIV through its range. Must be within 1 div of graticule center.

b. CH 2

Set MODE to CH 2 and repeat steps 10, 11b and 12a.

c. Check CH 2 INVERT balance ±1 div of graticule center

Set CH 2 POSITION for no trace shift when pulling out and pushing in INVERT. Must be within 1 div of graticule center.

13. GAIN

a. Adjust R382: 2.9V, Q474 coll to emit

Set both VOLTS/DIV to 20mV and both VARIABLES to CAL. Set CH 2 POSITION for 0 V between collectors of Q394 and Q494. Adjust R382 for 2.9V from emitter to collector of Q474. Observe trace on CRT while making this adjustment as any oscillation in the amplifier could give an erroneous reading.

b. Adjust CH 1 and 2 GAIN
Range: ≤350mV to ≥400mV

Set SAC to .1 VOLT and connect OUTPUT to both INPUTS of TYPE 454 using the dual input coupler. Connect a 10X probe from test scope to delay line input and set test scope VOLTS/DIV to 10mV. Turn CH 2 GAIN full cw and ccw and check for a range of at least 3.5 to 4.0 div deflection on the test scope. Adjust GAIN for 3.75 div deflection.

Switch MODE to CH 1 and repeat GAIN range check and adjust for 3.75 div deflection.

c. Adjust Output Amp Gain R365
Range: ≤11V to ≥12V

Change test scope VOLTS/DIV to .5 and connect probe to CRT vertical deflection plate. Turn R365 full cw and ccw and check for a range of at least 2.2 to 2.4 div deflection on the test scope. Disconnect probe and adjust R365 for 5 div deflection on the TYPE 454.

13c. If R365 has insufficient range to adjust for 5 div deflection but meets the 11V to 12V requirement, check CRT deflection factor. A near borderline CRT may require a slight readjustment of the CH 1 and CH 2 GAIN.

d. Check ADD gain ±1%

Set MODE to ADD and pull out INVERT. Readjust CH 2 GAIN if necessary for signal cancellation.

Push in INVERT and set SAC to 50m VOLTS. Check deflection for 5 div ±1%.

14. VOLTS/DIV

* *a. Check VOLTS/DIV accuracy ±2%, max*

Set MODE to CH 1 and disconnect signal from INPUT CH 2. Check CH 1 VOLTS/DIV accuracy as in the table following:

VOLTS/DIV	SAC	Div Deflection	±Div
5mV	20mV	4	.08
10mV	50mV	5	.1
20mV	.1 V	5	.1
50mV	.2 V	4	.08
.1	.5 V	5	.1
.2	1 V	5	.1
.5	2 V	4	.08
1	5 V	5	.1
2	10 V	5	.1
5	20 V	4	.08
10	50 V	5	.1

b. Check VARIABLE range 2.5:1, min

Return VOLTS/DIV to 20mV and SAC to .1 VOLT. Turn VARIABLE VOLTS/DIV for min gain and note deflection: 2 div, max. UNCAL neon must be lit only when VARIABLE is out of detent. Return VARIABLE to CAL.

Disconnect signal from CH 1 and connect to CH 2. Change MODE to CH 2 and repeat VOLTS/DIV and VARIABLE checks for CH 2. Reconnect signal to both inputs.

15. INPUT SWITCHES

Check AC-GND-DC switches

Position the display so bottom is at center of graticule. Switch to GND and check for trace at graticule center and no signal displayed. Switch to AC and check for display approximately centered above and below graticule center.

Switch MODE to CH 1 and repeat check.

16. VERTICAL LINEARITY

Check Compression and expansion
.1 div, max

Change SAC to 50mV and use VARIABLE BOLTS/DIV to obtain exactly 2 div of deflection at graticule center. Position top of display to top graticule line and note compression or expansion: .1 div, max. Position bottom of display to bottom graticule line and again note compression or expansion: .1 div, max. Return VARIABLE to CAL.

Change MODE to CH 2 and repeat compression, expansion check. Remove SAC signal.

17. ALTERNATE

Check ALT operation. All sweep rates

Set MODE to ALT, A TRIGGERING LEVEL full cw and A SWEEP LENGTH for 4 div of sweep. Position the traces 2 div apart and check for alternate sweep at all TIME/DIV settings. Return A SWEEP LENGTH to FULL.

18. MICROPHONICS, GRID CURRENT AND NOISE

a. Check microphonics 1 div, max no ringing type

Set VOLTS/DIV to 5mV, MODE to CH 1 and input to GND. Place micro shock hammer at top center of front panel. Raise weight to top and let fall. Note microphonics: 1 div, max, with no ringing type.

b. Check grid current .2 div, max

Switch input from GND to DC and note trace shift: .2 div, max. Change MODE to CH 2 and repeat microphonics and grid current checks.

c. Check cascaded noise .4 div PTP max

Connect 18" BNC cable from CH 1 OUT to INPUT CH 2 and connect 50Ω Termination to INPUT CH 1. With both inputs to DC and TRIGGER to NORM check PTP noise on trace for .4 div, max.

Remove BNC cable and 50Ω Termination.

19. VOLTS/DIV COMPENSATION

a. Setup

TYPE 106 -- GR to BNC adapter -- 50 cable -- 50 Termination -- 20pF Standardizer -- CH 1 INPUT.

Set MODE to CH 1, VOLTS/DIV to .1V, INPUT to DC, TIME/DIV to .2ms and TRIGGERING LEVEL for a stable display. Adjust TYPE 106 for 4 div of 1 kHz signal.

b. Adjust CH 1 compensation ±1%, max

Adjust for best square-wave as in the following table, maintaining 4 div of signal. Top of square-wave must be within 1% of being flat.

VOLTS/DIV	Corner	Flat Top
.1		C9
.2	C5D	C5A
2	C6E	C6A

Check remaining positions of VOLTS/DIV switch for 1%, max deviation from being flat. Remove 50Ω Termination or add 10X Attenuator as needed to obtain 4 div signal.

c. Adjust CH 2 Compensation ±1%, max

Change MODE to CH 2 and TYPE 106 signal to CH 2 INPUT. Adjust for best square-wave as follows. Top of square-wave must be within 1% of being flat.

VOLTS/DIV	Corner	Flat Top
.1		C109
.2	C105D	C105A
2	C106E	C106A

Check remaining positions of VOLTS/DIV switch for 1%, max deviation from being flat. Remove 50Ω Termination or add 10X Attenuator as needed to obtain 4 div signal.

b. Use the 20_pF Input RC normalizer when asjusting or checking the shunt capacitor and remove the Input RC Normalizer when adjusting or checking the series capacitors.

c. (ditto note on b)

20. TRANSIENT RESPONSE

a. Adjust delay line compensation

Set MODE to CH 1 and VOLTS/DIV to 10mV. Connect TYPE 106 FAST RISE + OUTPUT to INPUT CH 1 using GR cable, 5X Attenuator and GR to BNC termination. Set TIME/DIV to .05μs and TYPE 106 for 4 div of 1 MHz waveform.

Adjust C402 for min aberrations occurring approx 280ns after rise of pulse. Adjust R417 and R419 for optimum level of top of waveform.

b. Adjust Output Amplifier: Optimum risetime and waveform

Remove connectors at input to delay line and connect signal insertion (067-0553-00) to delav line terminals and -12V. Connect TYPE 109 OUTPUT through the TYPE CT-3 to the signal insertion fixture. Connect TYPE CT-3 signal pickoff to A EXT TRIG INPUT and switch TRIGGERING SOURCE to EXT. Using the TYPE 113 for a charge line, adjust TYPE 109 for a 4 div pulse. Center display on graticule with R334.

Adjust C426, R426, C353, R353, L394, R394, L494 and R494 for optimum rise-time and waveform.

Disconnect signal insertion fixture and readjust R334 as described in Step 11a. Replace connectors at delay line input.

c. Adjust CH 1 Preamp compensation

Connect TYPE 109 OUTPUT to INPUT CH 1 using GR cable and GR to BNC 50Ω termination. Adjust preamp compensation for optimum square-wave response using 4 div of pulse amplitude from the TYPE 109.

20c. (continued)

VOLTS/DIV	Adjust	Max aberrations
10mV	R44, C45, C49F R49G and C78	±3%; 5% P-P
5mV	C49A and R49A	±5%; 5% P-P
20mV	C49H, R49H and C49J	±3%; 3% P-P
50mV	C49N, R49N, C60 and C43	±3%; 4% P-P
.1V	C25	±5%; 5% P-P

d. Check Attenuator aberrations

.2V to .5V/DIV: ±5%; ≤5% P-P
1V/DIV : ±5%; ≤6% P-P
2V/DIV : ±8%; ≤10%
5V/DIV : ±10%; ≤12%

Switch VOLTS/DIV from .2V through 1V maintaining 4 div of pulse amplitude and check that aberrations do not exceed limits listed above.

e. Check CH 1 risetime
2.2ns pulse amplitude: ≥80%

Connect a change line to one of the TYPE 109 50Ω CHG LINE connectors that will produce a pulse 2.2ns wide at the 50% amplitude point when measured with a sampling scope. With the TYPE 113 connected to the other 50Ω CHG LINE connector maintain 4 div of long pulse amplitude and check short pulse amplitude for at least 3.2 div with VOLTS/DIV at 1, 2, 5 and 10 VOLTS.

f. Check - polarity aberrations
±3% or within 2% of + polarity whichever is greater

Switch VOLTS/DIV to 50mV and A TRIGGERING SLOPE to -. Switch TYPE 109 PULSE POLARITY to - and set for 4 div pulse amplitude. Check that aberrations do not exceed ±.12 div, or .12 div PTP, or within .08 div of + polarity: whichever is greater.

g. Check position effect on aberrations
≤6% rolloff

Position bottom of waveform to top graticule line and check rolloff for .24 div, max. Switch TRIGGERING SLOPE to + and TYPE 109 PULSE POLARITY to +. Position top of waveform to bottom graticule line and check rolloff for .24 div, max.

20. (cont'd)

h. Repeat steps 20c through 20g for CH 2

Switch MODE to CH 2 and connect TYPE 109 pulse to INPUT CH 2. Adjust Preamp compensation for optimum square-wave response using 4 div of pulse amplitude.

VOLTS/DIV	Adjust	Max aberrations
10mV	R144, C145, C149F, R149G and C178	±3%; 5% P-P
5mV	C149A and R149A	±5%; 5% P-P
20mV	C149H, R149H and C149J	±3%; 3% P-P
50mV	C149N. R149N, C160 and C143	±3%; 4% P-P
.1 V	C125	±5%; 5% P-P

Repeat attenuator, risetime -polarity and position effect aberration checks for CH 2.

21. BANDWIDTH

a. Setup

067-0532-00 -- 10X Atten -- 5X Atten -- GR to BNC 50Ω Termination -- CH 1 INPUT.

Set MODE to CH 1 and VOLTS/DIV to 10mV.

b. Check 10mV/DIV bandwidth ≥110 MHz at -3dB

Adjust 067-0532-00 for 4 div of 3 MHz signal. Increase frequency until deflection is reduced to 2.8 div. Must be 110 MHz or greater.

21. (cont'd)

c. Check 20mV/DIV to 1 V/DIV bandwidth ≥160 MHz at -3dB

Change VOLTS/DIV to 20mV and adjust for 4 div of 3 MHz. Increase frequency until deflection is reduced to 2.8 div. Must be 160 MHz or greater.

Repeat bandwidth checks at 50mV, .1, .2, .5 and 1 VOLT/DIV, removing attenuators as needed to obtain 4 div of 3 MHz.

d. Repeat steps 21b through 21c for CH 2

Change MODE to CH 2 and signal to CH 2 INPUT. Repeat 10mV to 1 VOLT/DIV bandwidth checks for CH 2.

e. Check added mode bandwidth ≥160 MHz at -3dB

Set both VOLTS/DIV to 20mV, CH 1 INPUT to GND and MODE to ADD. Connect signal to CH 2 using a 50Ω Termination. Adjust for 4 div of 3 MHz. Increase frequency until deflection is reduced to 2.8 div. Must be 160 MHz or greater.

Change CH 2 INPUT to GND, CH 1 INPUT to DC and signal to CH 1 INPUT. Repeat added mode bandwidth check.

f. Check 5mV/DIV bandwidth, CH 1 and CH 2: ≥63 MHz at -3dB

Switch MODE to CH 1 and both VOLTS/DIV to 5mV. Connect TYPE 191 to CH 1 INPUT and adjust for 4 div of 50 kHz. Increase frequency until deflection is reduced to 2.8 div. Must be 63 MHz or greater.

Switch MODE to CH 2 and signal to CH 2 INPUT. Repeat 5mV/DIV bandwidth check for CH 2.

22. CH 1 OUT

a. Setup

Set both VOLTS/DIV to 5mV, MODE to CH2 and both inputs to DC. Connect CH1 OUT to CH2 INPUT with 18" BNC cable.

b. Check bandwidth $\geq$ *33MHz at -3dB*

With TYPE 191 connected to CH1 INPUT adjust for 4 div of 50kHz. Increase frequency until deflection is reduced to 2.8 div. Must be 33 MHz or greater.

c. Check deflection factor $\leq$*1mV/DIV*

Remove TYPE 191 and connect 5mV SAC signal to CH1 INPUT. Check vertical deflection for 5 div, min. Remove SAC signal. Remove 18" BNC cable.

23. VERTICAL POSITION RANGE

a. Setup

Set both VOLTS/DIV to 20mV and MODE to CH 1. Connect TYPE 191 to CH 1 INPUT.

b. Check position range + & - 10 to 15 div

Adjust TYPE 191 for 2.5 div of 50 kHz signal with AMPLITUDE RANGE to 50-500mV. Switch AMPLITUDE RANGE to .5-5V and turn CH 1 POSITION full ccw. Top of the waveform must be within 2.5 div of graticule center. Turn POSITION full cw and check that the bottom of the waveform is within 2.5 div of graticule center.

Change MODE to CH 2 and TYPE 191 signal to CH 2 INPUT. Repeat POSITION range check for CH 2.

24. COMMON MODE REJECTION RATIO

a. Setup

TYPE 191 -- GR cable -- GR to BNC Termination
-- Dual input coupler -- CH 1 INPUT
CH 2 INPUT

24a. (cont'd)

Set VOLTS/DIV to .1 and adjust TYPE 191 for 4 div of 50 kHz.

b. Check CMRR ≥10:1 at 50 MHz

Change VOLTS/DIV to 50mV, MODE to ADD and pull out INVERT. If necessary readjust CH 2 GAIN for signal cancellation. Increase TYPE 191 frequency to 50 MHz and check vertical deflection for .8 div, max.

Push in INVERT and remove dual input coupler.

25. INTER-CHANNEL ISOLATION

a. Setup

Set CH 1 VOLTS/DIV to 1, CH 2 VOLTS/DIV to 5mV MODE to CH 1 and CH 2 INPUT to GND. Connect TYPE 191 to CH 1 INPUT and adjust for 5 div of 50MHz.

b. Check attenuator isolation ≥10,000:1 at 50 MHz

Switch MODE to CH 2 and check vertical deflection for .1 div, max.

Change CH 1 VOLTS/DIV to 5mV, CH 2 to 1 VOLT and MODE to CH 1. Switch CH 1 input to GND and CH 2 input to DC. Apply TYPE 191 signal to CH 2 INPUT and check vertical deflection for .1 div, max.

c. Check amplifier isolation ≥100:1 at 50 MHz

Switch MODE to CH 2 and CH 2 VOLTS/DIV to 0.2. Set TYPE 191 for 2 div of 50 MHz. Change both VOLTS/DIV to 20mV and MODE to CH 1. Check vertical deflection for .2 div, max.

Change MODE to CH 2 and signal to CH 1 INPUT. Check vertical deflection for .2 div, max. Remove TYPE 191 signal.

26. CH 1 OUT AND TRIG DC LEVEL

a. Adjust CH 1 OUT DC Level R52

Connect CH 1 OUT to DC coupled vertical input of test scope. With MODE to CH 1, TRIGGER to NORM and trace positioned to graticule center adjust R52 for 0V at the test scope. Disconnect test scope from CH 1 OUT.

R52 is located on the vertical Preamp board

b. Adjust Trig Preamp DC Level R511

Switch TRIGGER to CH 1 ONLY and connect probe from test scope to pin CB on the Trigger Preamp portion of the A SWEEP BOARD. Adjust R511 for 0V at the test scope.

c. Adjust Norm Trig DC Level R272

Switch TRIGGER to NORM and adjust R272 for 0V at the test scope. Disconnect probe.

27. TRIGGER LEVEL CENTERING

a. Adjust A Trig Level Cent R643

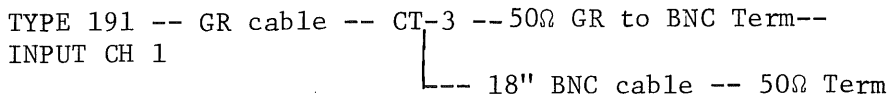
Connect .3 div of 50kHz from TYPE 191 to CH 1 INPUT. Position display to graticule center and set A TRIGGERING LEVEL to 0. Adjust R643 for stable display. Check that A SWEEP TRIG'D light is lit when sweep is triggered.

b. Adjust B Trig Level Cent R843

Set HORIZ DISPLAY to B, B TRIGGERING LEVEL to 0 and B SWEEP MODE to TRIGGERABLE AFTER DELAY TIME. Adjust R843 for stable display.

28. TRIGGERING

a. Setup



Set HORIZ DISPLAY to A, TIME/DIV to .05us and CH 1 VOLTS/DIV to 50mV.

b. Check 20 MHz Triggering *INT: .3 div*
EXT: 75mV

Adjust TYPE 191 for .3 div of 20 MHz signal. Switch A SWEEP MODE to NORM TRIG and check that a stable display can be obtained with A COUPLING in AC, LF REJ and DC. Switch A SWEEP MODE to AUTO TRIG and HORIZ DISPLAY to B (DELAYED SWEEP). Check that a stable display can be obtained with B COUPLING in AC, LF REJ and DC.

Set TYPE 191 AMPLITUDE for 75mV. Connect CT-3 and GR to BNC Termination to B EXT TRIG INPUT and CT-3 PICKOFF signal to INPUT CH 1 through the 18" cable and 50Ω Termination. Switch B TRIGGERING SOURCE to EXT and check that a stable display can be obtained. Connect CT-3 to A EXT TRIG INPUT and set HORIZ DISPLAY to A. Switch A TRIGGERING SOURCE to EXT and check that a stable display can be obtained. Remove CT3.

c. Check 150 MHz Triggering *INT: 1.5 div*
EXT: 375mV
Jitter: 0.5ns, max

Connect 067-0532-00 to CT-3 and connect CT-3 to INPUT CH 1 through 10X attenuator and 50Ω GR to BNC Termination. Set both TRIGGERING SOURCE switches to INT and adjust 067-0532-00 for 1.5 div of 150MHz signal. Switch MAG to X10 and check that stable triggering can be obtained with COUPLING in AC, LF REJ and DC with no more than .1 div jitter. Switch HORIZ DISPLAY to B (DELAYED SWEEP) and repeat triggering check.

28c. (cont'd)

Change VOLTS/DIV to .1 and adjust 067-0532-00 for 3.75 div of 3 MHz. Connect CT-3 and 50Ω GR to BNC Termination to B EXT TRIG INPUT and CT-3 pickoff signal to INPUT CH 1 through 18" cable and 50Ω Termination. Switch B TRIGGERING SOURCE to EXT and set 067-0532-00 to 150 MHz. Check that stable triggering can be obtained with no more than .1 div jitter. Connect CT-3 to A EXT TRIG INPUT and switch HORIZ DISPLAY to A. Switch A TRIGGERING SOURCE to EXT and check that stable triggering can be obtained. Remove 067-0532-00 signal.

d. Check 60 Hz triggering *INT: .3 div*
EXT: 75mV

Connect 60 Hz from sine-wave Generator (067-0542-99) to INPUT CH 1 and A EXT TRIG INPUT using T connector and 18" cable. Check for stable triggering with COUPLING in AC and HF REJ using 75mV of signal with SOURCE to EXT and .3 div with SOURCE to INT. Change HORIZ DISPLAY to B and connect signal to B EXT TRIG INPUT. Repeat 60 Hz triggering checks.

e. Check HF REJ: .3 div of 50 kHz not triggered at 1 MHz

Set sine-wave generator for .3 div of 50 kHz. Switch triggering to HF REJ, INT and check that stable triggering can be obtained. Change to 1 MHz and check that sweep will not trigger.

Change HORIZ DISPLAY to A and repeat.

f. Check LF REJ: .3 div of 50 kHz not triggered at 60 Hz

Change sine-wave generator to 50 kHz and trigger COUPLING to LF REJ. Check for stable triggering. Change to 60 Hz and check that sweep will not trigger.

Repeat for B sweep. Return COUPLING to AC.

28. (cont'd)

g. Check SINGLE SWEEP: same triggering level as in NORM

Change sine-wave generator to 1 kHz, switch HORIZ DISPLAY to A and A SWEEP MODE to NORM TRIG. Adjust A TRIGGERING LEVEL so display is just triggered. Remove signal from INPUT and switch to SINGLE SWEEP. Push RESET button and check that light comes on. Reapply signal to INPUT and check that sweep runs and light extinguishes. Push RESET button while signal is connected. Observe one properly triggered, normal trace. Return A SWEEP MODE to NORM TRIG.

29. TRIGGERING LEVEL RANGE

a. Setup

Set VOLTS/DIV to 1, TIME/DIV to .5ms, TRIGGERING SOURCE to EXT and coupling to DC. Set Sine-Wave Generator for 4 div of 1kHz signal.

b. Check EXT LEVEL range + and - 2V, min

With SLOPE to + and - check that the display can be triggered on any point on the positive and negative going portions of the waveform with the LEVEL control.

c. Check EXT ÷ 10 LEVEL range: + and -20V, min

Change source to EXT ÷ 10, VOLTS/DIV to 10 and Sine-Wave Generator for 4 div signal. Check that display can be triggered at any point on waveform.

Switch A SWEEP MODE to AUTO TRIG, HORIZ DISPLAY to B (DELAYED SWEEP) and connect signal to B EXT TRIG INPUT. Repeat EXT and EXT ÷ 10 LEVEL range checks for B trigger.

Remove Sine-wave Generator signal.

30. LINE TRIGGER

a. Setup

Set TIME/DIV to 2ms and TRIGGERING SOURCE to LINE. Connect 10X probe from CH1 INPUT to line voltage source.

b. Check triggering: triggered on correct polarity

Switch SLOPE to + and - and check that triggering occurs at correct polarity of waveform.

Switch HORIZ DISPLAY to A and repeat line triggering check. Remove probe and return TRIGGERING SOURCE to INT.

31. AUTO RECOVERY TIME

a. Setup

Set TYPE 184 for 50ms markers and connect to CH1 INPUT. Switch TIME/DIV to 50µs.

b. Check recovery time: 50ms to 100ms

With A SWEEP MODE in AUTO check that stable triggering can be obtained with the LEVEL control.

Change TYPE 184 to .1s and check that the sweep is not triggered properly on the leading edge of the time marker.

32. SWEEP START, A SWEEP CAL

a. Setup

A TIME/DIV	1mS
B TIME/DIV	5µS
B SWEEP MODE	B STARTS AFTER DELAY TIME
HORIZ DISPLAY	A INTEN DURING B

Set TYPE 184 for 1ms markers.

b. Rough adjust Sweep Start R956

Set DELAY-TIME MULTIPLIER to 1.00. Adjust R956 so intensified portion starts at 2nd marker.

c. Rough adjust A Sweep Cal R743

Set DELAY-TIME MULTIPLIER to 9.00. Adjust R743 so intensified portion starts at 10th marker.

d. Fine adjust Sweep Start and A Sweep Cal

Set HORIZ DISPLAY to B (DELAYED SWEEP) and DELAY-TIME MULTIPLIER to 1.00. Adjust R956 so displayed pulse starts at the beginning of the sweep.

Set DELAY-TIME MULTIPLIER to 9.00 and adjust R743 so displayed pulse starts at beginning of the sweep.

Repeat Sweep Start and A Sweep Cal adjustments as necessary due to interaction.

33. DELAY-TIME MULTIPLIER LINEARITY

a. Check linearity ±1.5 minor div, max

Set DELAY TIME MULTIPLIER to 8.00. Rotate the dial as necessary to position start of pulse to beginning of sweep. Note deviation of dial reading from 8.00: 1.5 minor div, max.

Repeat check for each major div of the DELAY-TIME MULTIPLIER dial between 8.00 and 2.00 for 1.5 minor div max deviation.

34. NORM GAIN

Adjust Norm Gain R1036: 1ms/div

Set HORIZ DISPLAY to A and adjust R1036 for 1 marker per div.

Unless noted otherwise, use the middle 8 horizontal div when adjusting or checking timing.

35. B SWEEP CAL

Adjust B Sweep Cal R943: 1ms/div

Set DELAY-TIME MULTIPLIER full ccw, B SWEEP MODE to TRIGGERABLE AFTER DELAY TIME, HORIZ DISPLAY to B (DELAYED SWEEP) and B TIME/DIV to 1mS. Adjust R943 for 1 marker per div.

36. X10 MAG

a. Adjust Mag Gain R1047 .1ms/div

Change TYPE 184 to .1ms markers. Set HORIZ DISPLAY to A and MAG to X10. Adjust R1047 for 1 marker per div.

b. Check linearity ±4%, max

Timing error over any 2 div interval of sweep must not exceed ±4% (.08 div).

c. Adjust Mag Regis R1053: no shift, X10 to OFF

Change TYPE 184 to 5ms markers. Position middle marker to graticule centerline.

Switch MAG to OFF and adjust R1053 so marker is at graticule centerline.

Repeat adjustment until no shift occurs when switching MAG from X10 to OFF.

37. SWEEP LENGTH

a. Check A sweep length ≤4 div to 11 ±.5 div

Set TYPE 184 for 1ms and .1ms markers. With A SWEEP LENGTH at FULL check sweep length for 10.5 to 11.5 div. Turn A SWEEP LENGTH full ccw and check length for 4 div, max.

Return A SWEEP LENGTH to FULL.

b. Check B sweep length 11 ±.5 div

Set HORIZ DISPLAY to B (DELAYED SWEEP) Set A TIME/DIV to 2ms and B TIME/DIV to 1ms. Check B sweep length for 10.5 to 11.5 div.

38. VARIABLE RANGE

a. Check B VARIABLE range 2.5:1, min

Change TYPE 184 to 10ms markers.

Turn B VARIABLE full ccw and note distance between markers: 4 div, max.

38a. (cont'd)

Check that UNCAL neon is lit when VARIABLE is out of detent. Return VARIABLE to CAL.

b. Check A VARIABLE range 2.5:1, min

Set A TIME/DIV to 1ms, and HORIZ DISPLAY to A. Turn A VARIABLE full ccw and note distance between markers: 4 div, max.

Check that UNCAL neon is lit when VARIABLE is out of detent. Return VARIABLE to CAL.

39. POSITION RANGE

a. Check X1 position range: ends of sweep to graticule center

Turn horizontal POSITION full cw. Start of sweep must be to the right of graticule center. Turn POSITION full ccw. End of sweep must be to the left of graticule center.

b. Check X10 FINE range 5 to 8 div

Set MAG to X10 and check range of FINE position. Must be between 5 and 8 div. Return MAG to OFF.

40. HIGH SPEED TIMING

a. Adjust C740C: 1μs/div

With HORIZ DISPLAY to A, set TIME/DIV to 1μS and TYPE 184 for 1μS markers. Adjust C740C for 1 mark per div.

b. Adjust C940C: 1μs/div

Switch HORIZ DISPLAY to DELAYED SWEEP (B) and adjust C940C for 1 mark per div.

c. Adjust C940A: .5μs/div

Set TIME/DIV to .5μS and TYPE 184 to .5μS Adjust C940A for 1 cycle per div.

d. Adjust C740A: .5μs/div

Switch HORIZ DISPLAY to A and adjust C740A for 1 cycle per div.

40. (cont'd)

e. Adjust C1081 and C1091: X10 linearity

Set TYPE 184 to 10ns and TIME/DIV to .05µs. With MAG OFF position display so sweep starts at left edge of graticule. Switch MAG to X10. Adjust C1081 and C1091 equally to obtain equal spacing between each cycle to the left and right of graticule center.

41. A SWEEP TIME/DIV

a. Check MAG OFF timing *8 div: ±2%, max*
2 div: ±4%, max

Switch MAG to OFF and check TIME/DIV accuracy for ±2% over the center 8 div and ±4% over any 2 div interval within the center 8 div.

A TIME/DIV	TYPE 184	CHECK FOR
.05µs	50nS	1 cycle/div
.1µs	.1µS	1 mark/div
.2µs	.1µS	2 marks/div
.5µs	.5µS	1 mark/div
1µs	1µS	1 mark/div
2µs	1µS	2 marks/div
5µs	5µS	1 mark/div
.1s	.1S	1 mark/div
.2s	.1S	2 marks/div
.5s	.5S	1 mark/div
1s	1S	1 mark/div
2s	1S	2 marks/div
5s	5S	1 mark/div

b. Check X10 MAG *±3%, max*

Switch MAG to X10 and check accuracy of entire sweep except as noted:

A TIME/DIV	TYPE 184	CHECK FOR	DISREGARD
.05µs	10n S	1 cycle/2 div	first 14 and last 7 div
.1µs	10n S	1 cycle/div	first 7 and last .5 div
.2µs	20n S	1 cycle/div	first 3.5 and last 1.5 div
.5µs	50n S	1 cycle/div	first div
1µs	.1µS	1 mark/div	first div
2µs	.1µS	2 marks/div	first div
5µs	.5µS	1 mark/div	first div

42. B SWEEP TIME/DIV

a. Check MAG OFF timing *8 div: ±2%, max*
2 div: ±4%, max

Set DELAY TIME MULTIPLIER full ccw and HORIZ DISPLAY to B (DELAYED SWEEP). Check B sweep timing as follows:

B TIME/DIV	TYPE 184	CHECK FOR
.05µs	50nS	1 cycle/div
.1µs	.1µS	1 mark/div
.2µs	.1µS	2 marks/div
.5µs	.5µS	1 mark/div
1µs	1µS	1 mark/div
2µs	1µS	2 marks/div
5µs	5µS	1 mark/div
10µs	10µS	1 mark/div
20µs	10µS	2 marks/div
50µs	50µS	1 mark/div
.1m s	.1m S	1 mark/div
.2m s	.1m S	2 marks/div
.5m s	.5m s	1 mark/div
1m s	1m S	1 mark/div
2m s	1m S	2 marks/div
5m s	5m S	1 mark/div
10m s	10m S	1 mark/div
20m s	10m S	2 marks/div
50m s	50m S	1 mark/div
.1 s	.1 S	1 mark/div
.2 s	.1 S	2 marks/div
.5 s	.5 S	1 mark/div

b. Check X10 MAG *±3%, max*

Set MAG to X10 and check accuracy of entire sweep except as noted.

A TIME/DIV	TYPE 184	CHECK FOR	DISREGARD
.05µs	10nS	1 cycle/2 div	first 14 and last 7 div
.1µs	10nS	1 cycle/div	first 7 and last 3.5 div
.2µs	20nS	1 cycle/div	first 3.5 and last 1.5 div
.5µs	50nS	1 cycle/div	first div
1µs	.1µS	1 mark/div	first div
2µs	.1µS	2 marks/div	first div
5µs	.5µS	1 mark/div	first div

43. DELAY TIME ACCURACY

a. Check DELAY-TIME MULTIPLIER accuracy:
1μs to 50ms: ±1%, max
.1s to 5s: ±2%, max

Set HORIZ DISPLAY to B (DELYAED SWEEP) and B SWEEP MODE to B STARTS AFTER DELAY TIME.

Check the following sweep speeds by adjusting DELAY-TIME MULTIPLIER so start of sweep occurs at top of 2nd marker (approx 1.00). Note dial error from 1.00.

Turn dial so start of sweep occurs at top of 10th marker (approx 9.00). Error difference between 2nd and 10th markers may now be determined from the dial.

A TIME/DIV	B TIME/DIV	TYPE 184	Max error on dial
1μs	.1μs	1μS	±8 minor div
2μs	.1μs	1μS	
5μs	.5μs	5μS	
10μs	1μS	10μS	
20μs	1μs	10μS	
50μs	5μs	50μS	
.1ms	10μs	.1mS	
.2mS	10μs	.1mS	
.5ms	50μs	.5mS	
1ms	.1ms	1mS	
2ms	.1ms	1mS	
5ms	.5ms	5mS	
10ms	1ms	10mS	
20ms	1ms	10mS	
50ms	5ms	50mS	
.1s	10ms	.1S	±16 minor div
.2s	10ms	.1S	
.5s	50ms	.5S	
1s	.1s	1S	
2s	.1s	1S	
5s	.5s	5S	

44. DELAY TIME JITTER

a. Check delay time jitter: .3 div, max

Set A TIME/DIV to 1mS and B TIME/CM to 1 S. Set TYPE 184 for 1ms markers and line voltage to 126VAC.

Adjust DELAY TIME MULITPLIER to about 1.00 to display pulse on screen. Note jitter on pulse leading edge: .3 div, max.

44. (cont'd)

Adjust DELAY TIME MULTIPLIER to about 9.00 to display pulse on screen. Note jitter on pulse leading edge: .3 div, max.

Remove TYPE 184 signal and return line voltage to 115VAC.

45. X-Y INPUT

a. Setup

CH 1 POSITION	midr
CH 1 VOLTS/DIV	20mV
TRIGGER	CH 1 ONLY or X-Y
HORIZ DISPLAY	X-Y

b. Adjust X-Gain, R567: .02V/div

Apply .1 volt SAC signal to CH 1 INPUT. Adjust R567 for 5 div horizontal deflection. Remove SAC signal.

c. Adjust phasing .2 div, max opening

Connect 2MHz from TYPE 191 through 4MHz Filter to CH 1 and CH 2 INPUTS using the dial input coupler. Set CH 1 VOLTS/DIV to 10mV, CH 2 to 20mV and set TYPE 191 for 10 div horizontal deflection.

Adjust L568 for minimum opening of displayed waveform. Switch TYPE 191 FREQUENCY RANGE to .75-1.6, .35-.75 and 50kHz adjusting R569 for minimum opening. Repeat adjustment of L568 at 2MHz and R569 at lower frequencies until phasing is optimized. Maximum opening as measured along the center horizontal graticule line is .2 div with 10 div of signal centered on graticule.

d. Check Bandwidth $\geq$2MHz at -3dB

Remove signal from CH 2 INPUT. Set TYPE 191 to 50kHz and adjust for 6 div of horizontal deflection. Increase frequency until deflection is reduced to 4.2 div. Must be 2MHz or greater.

45d. (cont'd)

Recheck adjustment of X-Gain and correct if necessary due to interaction of phasing adjustments.

46. BEAM FINDER AND 5MHz SWITCH

a. Check 5MHz bandwidth: ≥4MHz to ≤6MHz at -3dB

Switch HORIZ DISPLAY to A and BEAM FINDER -5MHz switch to 5MHz. Set TYPE 191 for 4 div of 50kHz. Increase frequency until deflection is reduced to 2.8 div. Must be equal to or between 4MHz and 6MHz.

b. Check Beam Finder trace must not position off graticule

Remove TYPE 191 signal. Hold switch in BEAM FINDER position while turning vertical and horizontal POSITION controls full cw and ccw. Check that trace remains within graticule area.

47. CHOPPED OPERATION

a. Setup

MODE	CHOP
TRIGGER	NORM
TIME/DIV	.2μS
HORIZ DISPLAY	A

b. Check chopping waveform duration: .84-1.25μs segment duration: 400-600ns

Position the traces 4 div apart and adjust LEVEL for a stable display. Check the duration of one complete cycle of chopped waveform for .84 to 1.25μS with each segment being 500ns ±20%.

b. When checking the length of each segment make measurement from beginning of next so blanked portion is included.

c. Check blanking

Check for complete blanking of switching transients between chopped segments.

48. CALIBRATOR

a. Setup

Set MODE to ALT and TIME/DIV to 1mSEC. Connect CAL OUT to CH1 INPUT and TYPE 184 to CH2 INPUT. Set TYPE 184 for 1ms markers. Adjust TRIGGERING LEVEL and POSITION for stable display.

b. Adjust Cal Freq T1275 1 kHz

Adjust T1275 for one cycle of calibrator waveform for each 1ms marker.

Switch TRIGGER to CH1 ONLY and adjust T1275 to stop first of time marks.

Remove time marks and set MODE to CH1.

c. Check duty cycle 50% ±.8%

Set A TIME/DIV to .1mSEC. Center displayed waveform on graticule and switch MAG to X10. Switch A TRIGGERING SLOPE to + and - and note horizontal shift between rising and falling portions of waveform. Must not be more than 1.6 div.

d. Check risetime 1μs, max

Set MAG to OFF, A TIME/DIV to .2μSEC and A TRIGGERING SLOPE to +. Check 10% to 90% risetime of calibrator waveform for 1μSEC, max. Remove cable from CAL out and CH 1 INPUT.

e. Check 5mA CURRENT LOOP

Connect P6019 current probe and termination to CH 1 INPUT. Set termination to 2mA/mV, CH 1 VOLTS/DIV to 5mV and TIME/DIV to .5mSEC. Connect probe to CURRENT PROBE CAL and check for waveform .5 div in amplitude. Remove probe and termination from CH 1 INPUT.

49. Z AXIS

a. Adjust compensation C1352

Set TIME/DIV to .05μSEC, A SWEEP MODE to AUTO TRIG and A TRIGGERING LEVEL cw. Connect 10X probe from test scope to TP1349 and set test scope VOLTS/DIV to .5 and TIME/DIV to .1μSEC. Adjust INTENSITY so displayed waveform amplitude is 3 div. Adjust C1352 for optimum square-wave. (Adjusted to level)

b. Check sensitivity 5V, min

Connect 5 volt SAC signal to Z AXIS INPUT and A EXT TRIG INPUT using T connector and clip lead to BNC adapter. Remove GND strap and connect black lead of adapter to GND post. Set TIME/DIV to .5mSEC and A TRIGGERING SOURCE to EXT. Check for trace modulation at normal intensity.

c. Check max usable frequency 50MHz, min

Disconnect SAC signal and connect 5V of 50MHz signal from TYPE 191 to T connector. Set TIME/DIV to .2μSEC and MAG to X10. Reduce INTENSITY to a low level and check for noticeable intensity modulation of the trace.

Disconnect signal and replace GND strap.

50. B ENDS A

a. Setup

A TIME/DIV	1mSEC
B TIME/DIV	.1mSEC
A SWEEP MODE	AUTO TRIG
B SWEEP MODE	B STARTS AFTER DELAY TIME
HORIZ DISPLAY	A INTEN DURING B
A SWEEP LENGTH	B ENDS A.

b. Check B ENDS A operation

Turn DELAY-TIME MULTIPLIER thru its range and check that A sweep ends after intensified portion.

50b. (cont'd)

Return A SWEEP LENGTH to FULL and HORIZ DISPLAY to A.

51. OUTPUT WAVEFORMS

a. Check A GATE +12.0V ±5% to -0.6V ±10%

With A SWEEP MODE in AUTO turn LEVEL full cw. Connect A GATE to test scope INPUT.

Check for 12.6V ±5% gate waveform the duration of which will be the total sweep length of the TYPE 454.

b. Check A SWEEP 10V ±5%

Connect A SWEEP to test scope INPUT and check for positive going sawtooth, 10V ±5% in amplitude.

c. Check B GATE 12.0V ±5% to 0.6V ±10%

Set HORIZ DISPLAY to DELAYED SWEEP (B) and DELAY-TIME MULTIPLIER full ccw. Connect B GATE to test scope INPUT.

Check waveform for 12.6V ±5% amplitude.

52. HOLDOFF

a. Check HF STAB ≥10% change of holdoff

Set HORIZ DISPLAY to A and connect A GATE to test scope input. Set A TIME/DIV to .05μSEC and check change in duration of negative portion of waveform while adjusting HF STAB for at least 10% of total duration.

Leave HF STAB set for min duration of waveform.

b. Check A sweep holdoff

Check duration of negative portion of gate waveform at all sweep speeds as follows:

TIME/DIV	Holdoff
.05μS to 2μS	.5-2μs
5μS to 20μS	4-10μs
50μS to .5mS	40-100μs
1mS to 5mS	.4-1ms
10mS to 50mS	4-10ms
.1 S to 5 S	40-100ms

53. WRITING SPEED

a. Presets

TYPE 454

VOLTS/DIV	20mV
TIME/DIV	.1μs
MAG	X10
HORIZ DISPLAY	A
A SWEEP MODE	SINGLE SWEEP
SCALE ILLUM	ccw

TYPE C40

shutter speed	bulb
lens	f/1.3
focused for scope being tested	

b. Check writing speed: 1350 div/μs

Adjust INTENSITY so spot is just extinguished.

Connect 100MHz Ring Box to vertical INPUT and TYPE 109 to Ring Box.

Switch A SWEEP MODE to NORM TRIG. Adjust A TRIGGERING LEVEL for a stable display. Adjust the TYPE 109 AMPLITUDE for 6 div P-P amplitude at the beginning of the damped waveform. Adjust FOCUS and ASTIG for best display.

Switch A SWEEP MODE to SINGLE SWEEP. Swing camera into closed position. Wait 5 full minutes.

After 5 minutes, open camera shutter. Press RESET once. Wait 5 seconds and close camera shutter.

Develope film for 10 seconds and remove from camera.

Mask out sinewave peaks. Starting from the left, find the first rising or falling portion of the waveform that is entirely present.

Measure the P-P excursion with half a graticule photograph. The P-P amplitude should be 4 div or more.

b. If necessary an average of 5 photos using different rolls of film may be used to determine writing speed.