FACTORY CALIBRATION PROCEDURE

CONTENTS:

310

GENERAL:

This is not a field recalibration procedure as is the procedure in your instruction manual. This is a guide in calibrating brand-new instruments just assembled--instruments which have never been turned on before. Therefore, it calls out many procedures and adjustments that are rarely required for subsequent recalibration.

Even though we wrote this procedure primarily for our own factory test department, it may prove valuable to our customers also if used with some caution:

For all serial numbers below 10,000

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1. **Special test equipment,** if mentioned, is not available from Tektronix unless it also is listed in our current catalog. This special equipment is used in our test department to speed calibration. Usually you can either duplicate its function with standard equipment in your facility or devise alternate approaches.

2. **Factory circuit specifications** are not guaranteed unless they also appear as catalog or instruction manual specifications. Factory circuit specs usually are tighter than advertised specs. This helps insure the instrument will meet or exceed advertised specs after shipment and during subsequent field recalibrations over several years of use. Your instrument may not meet factory circuit specs but should meet catalog or instruction manual specs.

3. **Presetting controls,** if mentioned, usually is unnecessary. This is helpful for "first-time" calibration only. If internal controls are preset, you will have to perform a 100% recalibration. So don't preset controls unless you're certain a "start-from-scratch" policy is the best.

4. **Omissions** are sometimes called out. Factory calibration procedures are for our test department calibrators who first calibrate the instrument. Quality control men then check the initial calibration and perform additional fine points such as trimming resistor leads, installing shields, etc. You will need to perform most of the omissions as a part of your recalibration.

In this procedure, all front panel controls are in capital letters (SENSITIVITY) and internal adjustments are capitalized only (Gain Adj).

FACTORY CIRCUIT SPECIFICATIONS

Factory circuit specifications are not guaranteed unless they also appear as catalog or instruction manual specifications. Factory circuit specs usually are tighter than advertised specs. This helps insure the instrument will meet or exceed advertised specs after shipment and during subsequent field recalibrations over several years of use. Your instrument may not meet factory circuit specs but should meet catalog or instruction manual specs.

1. POWER SUPPLIES:

All regulated voltages must be within ± 3% of their rated value and must regulate between 105 and 125 v ac line.

2. CALIBRATOR:

Must be set to 100 v with an accurate voltmeter.

Symmetry: ± 10% max (voltmeter should read between 45 and 55 v with the CALIBRATOR set to 100 VOLTS).

Accuracy: ± 2% max.

3. VERTICAL:

Attenuator accuracy: ± 2% max.

Gain change between AC input and DC input: ± 2% max.

Shift due to gas: 1 minor division max.

Shift due to preamp output coupling capacitor leakage: .5 minor division max.

VERTICAL POSITION control range: 5.5 major divisions above and below graticule center min.

Compression: .5 minor division max.

Expansion: .75 minor division max.

Hum due to tubes or crt shield: .25 minor division (one spot diameter) max.

Spike on 1 kc square wave through a properly adjusted 10X probe: 1% max.

Bandwidth: main amp 4.1 mc min; preamp 3.5 mc min.

4. HORIZONTAL:

Timing accuracy (mag on or off): 2% max except .5 usec mag on which is 5% max.

Timing linearity (mag on or off): 1% max.

Total timing error caused by the three timing resistors: 1.5% max.

External horizontal sensitivity: 1.5 v/major divisions min.

5. TRIGGER:

INT AC: Must trigger on .25 major division using TRIG LEVEL control, both + and - trigger mode.
Must trigger on 1 major division *without* using TRIG LEVEL control, both + and - trigger mode.

INT DC: Must trigger on 1 major division within ± 2 major divisions of graticule center, both + and - trigger mode.

INT AUTO: Must trigger on .25 major division, both + and - trigger mode.

EXT AC, DC, and AUTO: Must trigger on .2 v.

1. RECOMMENDED EQUIPMENT:

Special calibration shield

2. PRELIMINARY INSPECTION:

3. RESISTANCE CHECKS:

Check power supply for shorts between supplies.
Check resistances to ground:

SUPPLY	APPROX READING
- 150 v	10 kΩ
+ 100 v	12 kΩ
+ 300 v	16 kΩ

4. 310 PRESETS:

PWR	OFF
INTENSITY	ccw
black TRIGGER	+INT
red TRIGGER	AC
TRIG LEVEL	midrange
STABILITY	ccw
black TIME/DIV	100 μSEC
red TIME/DIV	cw
MAG	X1
AC-DC	AC
black VOLTS/DIV	.1
red VOLTS/DIV	cw
CALIBRATOR	OFF
HORIZONTAL POSITION	midrange
VERTICAL POSITION	midrange
Sweep Length (lower left side)	midrange
HV Adj (HV printed board)	ccw
C175B (TIME/DIV switch)	midrange
C205 (behind TIME/DIV switch)	midrange
C213 (behind C205)	midrange

5. LOW VOLTAGE POWER SUPPLY:

Turn power on and quick-check the value of the - 150, + 100 and + 300 v supplies. This detects gross overloads, etc. that could damage the scope. Set - 150 v Adj for exactly - 150 v.

SUPPLY	TOLERANCE AT 117 VAC LINE	RIPPLE
- 150 v	adjustable	10 mv ptp max, 120 cps
+ 100 v	± 3%	10 mv ptp max, 120 cps
+ 300 v	± 3%	10 mv ptp max, 120 cps

All supplies should remain within ± 2% of their measured value between 105 and 125 vac line. Ripple shouldn't exceed maximum limits given above between 105 and 125 vac line.

6. CALIBRATOR:

Use 117 vac line. Set CALIBRATOR to OFF and adjust Cal Adj for exactly 100 volts at V250 pin 2 or 7. Turn CALIBRATOR on. The voltage should now read 45 to 55 volts (indicating symmetry of ± 10%).

7. HIGH VOLTAGE POWER SUPPLY:

Adjust HV Adj for - 1675 volts at anode of V730 (5642 hv rectifier).

Leave meter connected. Change line volts to 105, turn FOCUS ccw, and turn INTENSITY cw. Meter reading should not change (hv isn't regulating properly if it does).

Change line volts to 125, leave FOCUS ccw, change INTENSITY to ccw. Meter reading should not change (hv isn't regulating properly if it does).

8. PRELIMINARY PERFORMANCE CHECK:

Turn INTENSITY control slowly from ccw to cw until a spot or glow appears on crt face. Position spot on crt face with HORIZONTAL and VERTICAL POSITION controls. It might be necessary to adjust VERT GAIN (scope rear) to position spot on crt face.

Turn STABILITY control cw to get a trace (sweep generator free-running). Set FOCUS and INTENSITY controls for a trace with suitable brightness and definition.

Rotate the crt so the trace is parallel with the horizontal graticule lines, push up against graticule and clamp in position. Recheck trace position; the crt often shifts when the clamp is tightened.

Apply a .2 VOLT CALIBRATOR signal to VERTICAL AMP INPUT coax connector. Obtain a stable trace by adjusting TRIGGERING LEVEL and STABILITY controls. Adjust FOCUS, INTENSITY and ASTIGMATISM (scope rear) controls for well-defined display. Remove CALIBRATOR signal.

Check main vertical amplifier for microphonics.

9. DC BALANCE:

Set black VOLTS/DIV to .1 and ground VERTICAL AMP INPUT coax connector. Adjust DC Bal (scope top) so that trace doesn't move up and down while rotating the red VOLTS/DIV control back and forth through its range.

10. GAIN:

Set black VOLTS/DIV to .1, red VOLTS/DIV cw and AC-DC to AC. Apply a .5 CALIBRATOR signal to VERTICAL AMP INPUT connector. Adjust Vert Gain Adj (scope rear) for 5 major divisions of vertical deflection.

Change AC-DC to DC. The vertical deflection should still be 5 major divisions ± 2%.

11. VERTICAL COMPRESSION:

Set AC-DC to AC and apply exactly 2 major divisions of CALIBRATOR signal with the display centered vertically. Position the display to the top and to the bottom of the graticule. There should still be 2 major divisions of display ± .75 minor division.

12. PREAMP GAIN:

Set black VOLTS/DIV to .01, red VOLTS/DIV cw and AC-DC to AC. Apply a .05 VOLT CALIBRATOR signal to VERTICAL AMP INPUT connector. Adjust Preamp Gain (preamp printed board) for 5 major divisions of vertical deflection.

Check preamplifier for microphonics.

13. VERTICAL ATTENUATOR ACCURACY:

Set black VOLTS/CM to .01, red VOLTS/CM cw and AC-DC to DC. Apply a .05 VOLT CALIBRATOR signal to VERTICAL AMP INPUT connector. Deflection should be as follows ± 2%:

VOLTS/DIV	CALIBRATOR (volts)	DEFLECTION (major divisions)
.01	.05	5
.02	.1	5
.05	.2	4
.1	.5	5
.2	1	5
.5	2	4
1	5	5
2	10	5
5	20	4
10	50	5
20	100	5
50	100	2

14. VERTICAL ATTENUATOR COMPENSATION:

black TRIGGER	+INT
red TRIGGER	AC
black TIME/DIV	1 MSEC
red TIME/DIV	cw
MAG	X1
black VOLTS/DIV	.1
red VOLTS/DIV	cw
AC-DC	AC

Connect a 10X probe to the VERTICAL AMP INPUT connector. Insert the probe into the CAL OUT binding post and set the CALIBRATOR for about 5 major divisions of vertical deflection.

Set TRIG LEVEL and STABILITY controls for a stable display. Adjust the probe for the best square-wave response. Compensate attenuators for best square-wave response (all steps are with the red VOLTS/DIV control cw except the second step):

VOLTS/DIV	ADJUST
.2	C309 C310
.2	C413 red VOLTS/DIV ccw
.2	retouch C310
.5	C306 C307
1	C303 C304
10	C300 C301
.01	C320

15. LOW FREQUENCY:

Set black VOLTS/DIV to .1, red VOLTS/CM cw and TIME/DIV to 5 MSEC. Set AC-DC to AC (important).

Connect a 52Ω terminating resistor to the 105 output connector, a 52Ω cable to the terminating resistor, and terminate the cable with a 52Ω terminating resistor. Attach this to the 310 VERTICAL AMP INPUT connector.

Set the 105 for 6 to 8 major divisions of a 50 cps signal. Adjust the 310 TRIG LEVEL and STABILITY controls for a stable display. Note the amount of wave-top slope.

Change black VOLTS/DIV to .01 and readjust 105 output for same deflection as before. Adjust LF Adj (scope top) for same wave-top slope as above.

16. MAIN AMPLIFIER HIGH FREQUENCY:

Set black VOLTS/CM to .1, red VOLTS/CM cw, AC-DC to AC, and black TIME/DIV to .5 μSEC.

Connect the 105 to the 310 VERTICAL AMP as before, except use a 5:1 52Ω L pad at the 310 end instead of a 52Ω terminating resistor. Set the 105 for about 6 major divisions of a 400 kc signal. Adjust the 310 TRIG LEVEL and STABILITY controls for a stable display.

Adjust L409, L418, L450, and L451 (scope left) so waveform appears as shown. The 105 waveform is square only on the positive portions of the square wave; therefore ignore the negative portions when adjusting the 310 HF response.

A small hump followed by a small dip after the leading edge is normal. The top of the hump should be even with the general level of the rest of the waveform (dotted lines above). Try to get the leading edge as steep as possible without causing either excessive hump or dip.

L409 and L418 affect the leading edge. L450 and L451 affect the portion just following the leading edge. L450 and L451 present a good waveform when the slugs are in either one of two positions: most of the way out or most of the way in. Set them so the slugs are most of the way in.

All four coils should be adjusted so that each pair of slugs is at approximately the same height (L409 even with L418 and L450 even with L451; however L409 won't necessarily be even with L450).

17. PREAMPLIFIER HIGH FREQUENCY:

Set black VOLTS/DIV to .01. Apply about 6 major divisions of a 200 to 400 kc signal from the 105 to the 310 VERTICAL AMP INPUT connector.

Adjust L325 (scope left side) and L341 (VOLTS/DIV switch) for a waveform as nearly like that of step 16 as possible. Again try to get the leading edge as steep as possible without causing either excessive hump or dip.

L341 affects the leading edge and L325 affects the general level.

18. MAIN AMPLIFIER PASSBAND:

Set black VOLTS/DIV to .1, red VOLTS/DIV cw, and AC-DC to AC. Free-run the sweep by turning STABILITY cw. Set TIME/DIV to 1 MSEC.

Apply exactly 4 major divisions of a 350 kc sine wave from the 190 to the 310 VERTICAL AMP INPUT connector. Increase the 190 frequency until there are only 2.8 major divisions of 310 vertical deflection. This is the - 3 db point. The frequency should be at least 4.1 mc.

19. PREAMPLIFIER PASSBAND:

Leave the 190 connected, change black VOLTS/DIV to .01, and repeat step 18, second part. The - 3 db point should be at least 3.5 mc.

20. HIGH FREQUENCY SYNC:

Leave the 190 connected and apply 3 major divisions of a 3.5 mc signal. Set black TRIGGER to +INT, red TRIGGER to AC, and black TIME/DIV to .1 μSEC.

Center the TRIG LEVEL control. You should be able to adjust the STABILITY control for a stable display.

21. SLOW SWEEP TIMING:

Set AC-DC to AC, black TIME/DIV to 1 MSEC and the MAG to X1. Apply 1 msec markers from the 180 to the 310 VERTICAL AMP INPUT connector. Adjust black VOLTS/DIV for about 4 major divisions of 180 signal. Adjust TRIG LEVEL and STABILITY controls for a stable display.

Adjust Sweep Cal (scope rear) for exactly 1 marker per major division over the entire horizontal graticule distance. Do this in a way that one marker is exactly aligned with the first vertical graticule line and one is exactly aligned with the last. The markers within the first and last graticule lines should align with other graticule lines ± 2%.

22. SWEEP LENGTH:

Leave the 180 connected and set Sweep Length adjust (scope left side) for a trace (sweep) length of 10.5 major divisions.

23. MAG CENTER:

Leave the 180 connected, change the MAG to X5 and with the HORIZONTAL POSITION control, place the second marker on the center vertical graticule line.

Change MAG back to X1 and recenter the second marker to the center graticule line with Mag Center control (scope rear).

Change MAG to X5 and again center the second marker with the HORIZONTAL POSITION control. The first and third markers should fall at the ends of the graticule ± 2%.

Check the MAG X5 linearity by positioning successive markers to the center of the graticule with the HORIZONTAL POSITION control. In each case the markers to the left and to the right of the center marker should fall at the first and last graticule lines ± 2%.

23. MAG CENTER:

If the first and third markers fail to align with the first and last graticule lines, R213 and R214 (rear of MAG switch) may be out of tolerance.

24. PRELIMINARY TIMING ACCURACY:

Leave the 180 connected, change MAG back to X1, and change TIME/DIV to 500 μSEC. Position the first 1 millisec marker to the first graticule line with the HORIZONTAL POSITION control. There should be a marker every other graticule line, and the last (sixth) marker should fall on the last graticule line ± 2%.

Change TIME/DIV to 2 MSEC. Position the first marker to the first graticule line. There should be 2 markers per major graticule division, and the last (21st) marker should fall on the last graticule line ± 2%.

24. PRELIMINARY TIMING ACCURACY:

If the Swp Cal was correctly set for the 1 MSEC/DIV range (step 21) and the sweep speeds are out of tolerance for the 500 μSEC or 2 MSEC ranges, change R175A, R175B, or R175C; any one or all may be out of tolerance.

25. SLOW SWEEP TIMING ACCURACY:

Leave the 180 connected and check the remaining slow sweep ranges:

TIME/DIV	180 MARKS	MARKS PER DIV	TOLERANCE
100 μSEC	100 μsec	1	±1%
200 μSEC	100 μsec	2	±2%
500 μSEC	500 μsec	1	±2% (step 24)
1 MSEC	1 msec	1	exact (step 21)
2 MSEC	1 msec	2	±2% (step 24)
5 MSEC	5 msec	1	±2%
10 MSEC	10 msec	1	±1%
20 MSEC	10 msec	2	±2%
50 MSEC	50 msec	1	±2%
.1 SEC	100 msec	1	±1%
.2 SEC	100 msec	2	±2%

26. 10 μSEC TIMING:

Leave the 180 connected and set it for 10 μsec markers. Set the 310 TIME/DIV to 10 μSEC, turn MAG to X5 and turn HORIZONTAL POSITION ccw. Adjust C175B (on TIME/DIV switch) for 1 marker per 5 major divisions.

Turn the HORIZONTAL POSITION cw to display the left end of the trace. Adjust C205 (to rear of TIME/DIV switch) for 1 marker per 5 major divisions. C175B and C205 interact; repeat both adjustments as necessary.

Change MAG to X1. Adjust C213 for best linearity of the first tenth of the trace (first major division).

27. 1 μSEC TIMING:

Leave the 180 connected, set it for 1 μsec markers and change the 310 black TIME/DIV to 1 μSEC. Adjust C175A (on TIME/DIV switch) for 1 marker per major division.

28. .5 μSEC TIMING:

Leave the 180 connected and set it for 10 mc sine wave markers and 100 kc triggers. Connect the triggers to the 310 TRIG INPUT and set the 310 black TRIGGER to +EXT. Set TRIG LEVEL and STABILITY controls for a stable 10 mc display.

You should have 1 cycle of 10 mc per major division ± 5%. Adjust C250 (left, rear) for spacing between the first few cycles.

You can change wire dress to affect .5 μsec timing also. Change the position of the wt-rd and wt-gn wires that are connected to the TIME/DIV switch and run through the grommets near the switch. If you change the dress of these wires you'll have to recheck step 27.

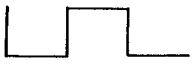
29. INTERNAL TRIGGERING:

black TRIGGER	+INT
red TRIGGER	AC
TRIG LEVEL	midrange
black TIME/DIV	500 μSEC
red TIME/DIV	cw
MAG	X1
black VOLTS/DIV	.1
red VOLTS/DIV	cw
AC-DC	AC
CALIBRATOR	.1 VOLT

Connect the CAL OUT to the VERTICAL AMP INPUT. You should have 1 major division of vertical deflection. Set TRIG LEVEL and STABILITY controls for a stable display.

With TRIG LEVEL control in one position you should be able to obtain a stable display in either the +INT or - INT setting of the black TRIGGER knob. The TRIG LEVEL control should be midrange at this point. If it isn't, loosen the knob on its shaft, set it to midrange, and tighten it again. In +INT the start of the trace should be the rising portion of the CALIBRATOR waveform.

In - INT the start should be the falling portion of the CALIBRATOR waveform.



You should be able to maintain a stable trace with as little as 1 minor division of vertical deflection. Some resetting of TRIG LEVEL control between +INT and - INT is necessary with these small signals, however.

Again obtain 1 cm of vertical deflection and set TRIG LEVEL control so you obtain a stable display on both +INT and - INT with one setting of TRIG LEVEL control. Center the display vertically.

Set black TRIGGER control to +INT and change red TRIGGER control to DC. If you don't have a stable display (or any display) rotate the VERTICAL POSITION control cw (move trace up). A stable display should appear not more than 2 major divisions above vertical center. Change the black TRIGGER control to - INT. Rotate the VERTICAL POSITION control ccw (move trace down). A stable display should appear not more than 2 major divisions below vertical center.

Turn red TRIGGER control to AUTO. Adjustment of STABILITY control should produce a stable display.

30. LINE TRIGGERING:

Leave red STABILITY control at AUTO and change black TRIGGER control to +LINE. Change black TIME/DIV to 2 MSEC and change black VOLTS/DIV to 10.

Disconnect CAL OUT from VERTICAL AMP INPUT. Connect VERTICAL AMP INPUT to a source of 60 cycles. This source can be a tube filament or stray 60-cycle pickup (leave a short length of unshielded wire attached to the VERTICAL AMP INPUT with nothing attached to the other end; grasp it in the hand for more amplitude).

Adjust TRIG LEVEL and STABILITY controls for a stable display. Change black TRIGGER control to - LINE. The 60-cycle display should invert.

31. EXTERNAL TRIGGERING:

Change black TIME/DIV back to 500 μSEC, black VOLTS/DIV back to .1, and reconnect CAL OUT to the VERTICAL AMP INPUT. Also connect CAL OUT to TRIG INPUT. Set CALIBRATOR to .2 VOLTS.

Change black TRIGGER to +EXT and obtain a stable display with TRIG LEVEL and STABILITY controls. The start of the trace should be the rising portion of the CALIBRATOR waveform. Change black TRIGGER to - EXT. Obtain a stable trace; this time the start of the trace should be the falling portion of the CALIBRATOR waveform.

32. EXTERNAL HORIZONTAL:

Set 310 to HORIZ INPUT (scope rear) and HORIZ GAIN control (scope rear) cw. Connect CAL OUT to HORIZ INPUT (scope rear). With CALIBRATOR set to 10 VOLTS you should have at least 6-2/3 major divisions of horizontal deflection, controllable by the HORIZ GAIN control.

33. CRT CATHODE:

Set MAG to X1. Remove the strap (scope rear) between CRT CATHODE and GND. Remove the calibrator lead from HORIZ INPUT and connect it to the VERTICAL AMP INPUT connector. Set black VOLTS/DIV to 2 and set the triggering controls for a stable display.

Connect another lead from CAL OUT and insert this one into the CRT CATHODE binding post (scope rear). With an average INTENSITY setting the calibrator signal should intensity modulate the crt so the display brightens on the bottom and dims on the top.

Reconnect the strap.

34. THE END.