

TYPE 541 OSCILLOSCOPE

F A C T O R Y

C A L I B R A T I O N P R O C E D U R E

Quick check for long ends, unsoldered joints, wire dress, etc. Preset all pots and trimmers to mid-range, except delay line. Check to see that the crt pin connections are tight. Tighten set screws in TRIGGER LEVEL knob just snug enough that the knob can be turned on the shaft. Install TEST LOAD UNIT switched to LO LOAD with the scope in upright position and turn the INTENSITY and SCALE ILLUM. controls full left (ccw). If, during the calibration there is any question concerning tolerances or limits of any of the circuits refer to the Factory Specifications on Type 541 and 545 Oscilloscopes.

1. CHECK POWER SUPPLY RESISTANCE TO GROUND.

The 100 v will be more than 400Ω to ground, the -150 v more than $K\Omega$, 225 v more than $5K\Omega$, 350 v more than $10K\Omega$ and the 500 v supply above $25K\Omega$. Check transformer primary for infinite resistance to ground.

2. CHECK TIME DELAY RELAY.

Turn the scope on and check time delay relay (15 to 45 seconds).

3. CHECK VOLTAGES AND MEASURE RIPPLE AND REGULATION.

Adjust -150 v supply with -150 ADJ. Check 100 v, 225 v, 350 v and 500 v supplies. ($\pm 2\%$) Check elevated heater supplies at transformer terminals. (100 v at 22 and 23, 225 v at 27 and 28, 350 v at 9 and 16, -hv at 24 and 25.)

4. SET CAL. ADJ.

With the SQUARE-WAVE CALIBRATOR OFF adjust CAL. ADJ. for 100 v at CAL. TEST PT. Turn CALIBRATOR ON. Voltage at CAL. TEST PT. must read between 45 v and 55 v. (Calibrator symmetry $\pm 10\%$.)

Check power supplies for proper regulation with line at 105 v, TEST LOAD UNIT switched to HI LOAD, and also, line at 125 v, TEST LOAD UNIT switched to LO LOAD. The ripple on each supply in regulation will be approximately as follows: -150 v, 5 millivolts; 100 v, 5 millivolts; 225 v, 3 millivolts; 350 v, 6 millivolts; 500 v, 7 millivolts. (Measured with a test scope.)

5. SET HV ADJ.

Turn scope to an upright position and adjust H.V. ADJ. control for -1350 v. Read at front of the 27K resistor at the forward ceramic strip located above the crt shield. This adjustment can be made conveniently on the 1200 v scale on the meter by measuring the respect to -150 v instead of ground. Turn off the scope and install shield over high voltage supply. (If protective slide rails are being used, install a modified shield.) With TIME/CM switch at 1 MILLISEC advance STABILITY and INTENSITY controls and position the trace on the crt with the VERTICAL and HORIZONTAL POSITION controls.

6. CHECK SCALE ILLUM. AND POSITIONING CONTROLS.

Check the SCALE ILLUM. control. Check position controls against the position-indicating neon lights. Check scope for microphonics. Align trace with horizontal graticule lines, push crt forward against graticule and tighten crt clamp. Check hv regulation by varying line from 105 v to 125 v. There should be no trace blooming.

7. SET CRT GEOM. ADJ.

Insert from the SQUARE-WAVE CALIBRATOR enough signal so that only the rising and falling portions of the signal are visible within the graticule. Adjust STABILITY and TRIGGERING LEVEL controls for a stable display. (The trigger circuit has not been adjusted so, if it is not possible to obtain a stable display, adjust the TRIG. SENS. and/or TRIGGERING LEVEL CENTERING pot.) Adjust GEOM. ADJ. (on F&I chassis directly below rear handle), to obtain minimum curvature of the vertical traces.

8. CHECK DISTRIBUTED AMPLIFIER BIAS.

Invert the scope and place a volt meter across the grid lines of the distributed amplifier. Adjust VERTICAL POSITION to the point where there is zero volts from one grid line to the other. With the plus probe of the meter, check either cathode of each stage in the amplifier for at least one volt of bias.

9. CHECK VERTICAL AMPLIFIER BALANCE.

Short the crt vertical deflection plates to determine the crt electrical center. Short the grid lines together and observe the trace shift. This shift should not exceed 2mm in all of the 6DK6 stages combined. Next, short the grids of the 6DJ8's and then the 12BY7's. No more than 1 cm of unbalance in these stages and overall amplifier unbalance should not exceed 1.5 cm. Adjust the graticule positioning cam to align the graticule center line with the center of the usable area of the crt.

10. CHECK VERTICAL COMPRESSION OR EXPANSION.

Position 2 cm of calibrator signal up and down within the graticule lines. Allowable compression or expansion is ± 0.5 mm.

11. SET VERTICAL GAIN ADJ.

Switch TEST LOAD UNIT to 250:1 and apply a 100 v signal from SQUARE-WAVE CALIBRATOR and adjust AMPL. GAIN for 4 cm of vertical deflection. Switch SQUARE-WAVE CALIBRATOR to 0.2 v, TEST LOAD UNIT to 1:1 and check for 2 cm of vertical deflection.

12. CHECK ALTERNATE SWEEP OPERATION.

Check scope for ALTERNATE SWEEP operation by switching TEST LOAD UNIT to DUAL TRACE. Remove the TEST LOAD UNIT and install a 53/54 K PLUG-IN UNIT.

13. CHECK SQUARE-WAVE CALIBRATOR AND VOLTS TO MILLIVOLTS DIVIDER.

Check accuracy of SQUARE-WAVE CALIBRATOR voltage steps with the K Unit VOLTS/CM step switch. Compare the VOLTS range to the MILLIVOLTS range.

14. ADJUST DC SHIFT COMPENSATION.

Vertically deflect the trace with enough dc voltage to move the trace about 4 cm. This is a very slow drift and must be watched for a few seconds to see the direction of drift.

15. SET TRIGGERING LEVEL CONTROL.

Set the trigger controls to +INT and DC TIME/CM to 100 μSEC, STABILITY full left (ccw) but not to PRESET. Set the test scope VERTICAL INPUT to .05 VOLTS/CM, DC, set the trigger on LINE, AUTOMATIC and set the sweep TIME/CM switch to 1 MILLISEC, X2. Use a 10X probe properly adjusted. Center the trace on the test scope for a zero reference. Connect the probe to the grid end of the 470K resistor from the arm of TRIGGERING LEVEL pot on scope under calibration and set pot to zero volts. Physically center knob and tighten set screw. Leave TRIGGERING LEVEL control at zero volts during succeeding adjustments.

16. SET INT. TRIG. D.C. LEVEL ADJ.

Position the trace of the scope under calibration to the center of the graticule, recheck the test scope zero reference, and connect the probe to R8, 47Ω to pin 7 of V8. This point should be at zero volts. Now switch the scope under calibration from +INT to -INT and adjust INT. TRIG. D.C. LEVEL ADJ. for zero volts as indicated on the test scope.

17. ADJUST TRIGGER LEVEL CENTERING.

Set TRIGGERING MODE switch to AC SLOW and TRIGGER SLOPE switch to +LINE. Switch test scope VOLTS/CM switch to 0.2 VOLTS/CM, AC. Connect probe to pin 1 of V20, on scope under calibration, and adjust TRIGGERING LEVEL CENTERING so that the waveform on the test scope is symmetrical. For final adjustment switch test scope MAGNIFIER, ON and horizontally center switching portion of the multi waveform. Now switch the TRIGGER SLOPE switch, of the scope under calibration, back and forth from +LINE to -LINE and at the same time readjust TRIGGERING LEVEL CENTERING until there is no horizontal shifting of the switching position of the multi waveform.

18. ADJUST TRIGGER SENS.

Turn the TRIG. SENS. pot to the right (cw) until oscillation occurs at the leading and trailing edges of the multi waveform. (Test scope probe should still be as in Step 17.) Note the amplitude of the spike on the waveform just at the point of oscillation. Now turn the TRIG. SENS. left (ccw) until this spike is slightly less than one-half (0.5) of the original size.

19. ADJUST PRESET STABILITY.

Turn TRIGGERING MODE to AUTOMATIC, +LINE. Turn the PRESET STABILITY control clockwise until the sweep triggers. The center arm of the control should read about 80 v on a meter. Now continue turning PRESET STABILITY until the sweep free-runs (trace will brighten), the center arm on the control should be between 15 v and 25 v higher. Turn the control back until the meter reads half way between the two readings obtained.

20. CHECK TRIGGER CIRCUIT FOR PROPER OPERATION.

Obtain 2 mm of vertical deflection from the calibrator and see that the trigger circuit will work properly in all positions, except LINE and HF SYNC, of the TRIGGER SLOPE and TRIGGERING MODE switches.

21. ADJUST DELAY LINE AND HF COMPENSATIONS.

With the VOLTS/CM switch at 0.05, variable VOLTS/CM control full right (cw), insert into the K Unit from a properly terminated fast rise-time square-wave generator, a 400kc signal of about 3 cm of vertical deflection. A Type 53/54 P Unit can also be used. Switch the TIME/CM to 1 μSEC, X5. Adjust the trimmers in the delay line with an insulated tool for optimum square-wave response. The variable coils control the amount of spike on the leading edge of the waveform.

22. MEASURE VERTICAL RESPONSE.

Measure the bandwidth with a constant amplitude sine-wave generator, for example, Tektronix Type 190. Turn the generator to 500 kc and insert enough signal for 4 cm of vertical deflection, increase the frequency to 30 mc. The signal should still be at least 2.8 cm in amplitude.

23. CHECK HF SYNC.

Turn the signal generator to 30 mc, switch TRIGGERING MODE to HF SYNC. A stable display should be obtained with about 2 cm or less of vertical deflection by adjusting the MAIN SWEEP STABILITY.

24. ADJUST SWEEP CAL.

Apply 1 millisecc time marks to INPUT. TIME/CM switch set to 1 MILLISECC. Adjust SWEEP CAL. for one time-mark per cm. When any timing adjustments are made always make them from the 1 cm line to the 9 cm line on the graticule.

25. ADJUST SWEEP LENGTH.

Adjust SWP LENGTH control for approximately 10.5 cm of horizontal sweep.

26. ADJUST MAG GAIN.

With TIME/CM switch at 1 MILLISEC insert 1 millisecc and 100 μ sec markers from the time mark generator. Turn MAGNIFIER, ON and adjust MAG GAIN for 5X magnification. (1 large mark every 5 cm and 2 small marks every cm. Check magnifier linearity over the entire sweep length.

27. ADJUST SWP/MAG REGIS.

With MAGNIFIER ON, position the trace so that the first time mark falls on the center line of the graticule. Turn MAGNIFIER OFF and adjust SWP. MAG/REGIS., so that the first time mark again falls on the center line of the graticule. Check to see that the MAG. ON and MAG. OFF positions register properly in the middle and at the end of the sweep.

28. ADJUST EXT. SWP. AMPL. D.C. BAL.

Connect SAWTOOTH OUT into vertical INPUT. With MAG. ON switch HORIZONTAL DISPLAY to EXT. SWEEP adjust EXT. SWP. AMPL. D.C. BAL. for no horizontal shift of vertical trace when turning EXT. SWEEP ATTENUATOR 1-10 back and forth.

29. ADJUST EXT. SWEEP AMP. COMP.

Apply a 0.5 v of square wave to EXT. SWP. IN. With MAGNIFIER ON, externally trigger sweep. Adjust C240 (this will be a long time-constant compensation) for optimum square-wave response. Turn MAGNIFIER, OFF and adjust C254 (short time constant). Adjust C267, mica trimmer on the pot bracket. (Very fast time-constant.) C254 and C267 will be adjusted again for a linear sweep using a 10 mc sine wave. Switch HORIZONTAL DISPLAY to X10, MAGNIFIER ON and adjust C101 for optimum flat top.

30. CHECK EXT. SWEEP IN DEFLECTION FACTOR.

With 0.2 v of calibrator signal fed into the EXT. SWEEP IN, EXT. SWEEP ATTENUATOR switch X1, variable control full right (cw), with MAG ON at least one cm of horizontal deflection must be observed. Increase calibrator signal of 2 v, switch the attenuator to X10 and check X10 attenuator accuracy ($\pm 2\%$).

31. CHECK SWEEP RATES.

Check the SWEEP rates as follows:

<u>TIME/CM</u>	<u>MULTIPLIER</u>	<u>TIME MARK GEN.</u>	<u>ACTION</u>
<u>100 μSEC</u>	<u>X1</u>	1 millisecc	Check sweep rate
<u>100 μSEC</u>	<u>X2</u>	1 millisecc	Check multiplier
<u>100 μSEC</u>	<u>X5</u>	1 millisecc	Check multiplier

32. CHECK SWEEP RATE VARIABLE CONTROL.

Check MULTIPLIER on the 2.5-1, 5-2, 12-5 positions for sufficient range.

<u>10 MILLISEC</u>	<u>X1</u>	10 millisecc	Check sweep rate
<u>100 MILLISEC</u>	<u>X1</u>	100 millisecc	Check sweep rate
<u>1 SEC</u>	<u>X1</u>	1 sec	Check sweep rate
<u>1 SEC</u>	<u>X2</u>	1 sec	Check multiplier
<u>1 SEC</u>	<u>X5</u>	1 sec	Check multiplier

33. ADJUST SWEEP TIMING.

Adjust the fast SWEEP timing rates as follows:

10 μ SEC	X1	10 μ sec	adjust C99F
1 μ SEC	X1	1 μ sec	adjust C99H
1 μ SEC	X2	1 μ sec	check multiplier
1 μ SEC	X5	5 μ sec	check multiplier
.1 μ SEC	X5	1 μ sec	adjust C99J Position first marker to the left off the Graticule.
.1 μ SEC	X1	10 mc	adjust for linearity C254 and C267
.1 μ SEC	X1 <u>MAG ON</u>	50 mc	adjust for linearity C278 and C286

There will be interaction between the linearity adjustment of C267 and C254 and the timing adjustment of C99H and C99J so it will be necessary to go back and readjust these steps over again until the timing is correct.

34. CHECK HOLD-OFF

Connect a probe from test scope, set for DC input, to the right hand end of C240. Set STABILITY full right (cw). Check all ranges of TIME/CM switch for sufficient hold-off.

35. CHECK THE FRONT PANEL WAVEFORMS.

With a test scope set for DC input, using a 1X (straight thru) probe, check +GATE OUT for a gate waveform of about 20 v amplitude with its base on the zero volt reference line on the test scope. SAWTOOTH OUT should be about 150 v in amplitude with its base line on a zero reference except on the two fastest speeds where the base line should raise about 20 v. Out of the VERT. SIG. OUT there should be approximately 2 v of signal for every cm of vertical deflection on the scope under calibration.

36. CHECK CRT CATHODE INPUT.

Remove CRT CATHODE GND. strap from rear of scope and insert signal from calibrator and check sweep for intensity modulation. With normal intensity, 20 v of calibrator signal will modulate the trace.

37. MAKE A NOTE OF CRT TYPE AND SERIAL NUMBER AND RECORD ON CALIBRATION RECORD.