TYPE 535A 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 both TRIGGER LEVEL knobs just snug enough so 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 Types 531 and 535 Oscilloscopes.

1. CHECK POWER SUPPLY RESISTANCE TO GROUND

   The 100 v will be more than 400Ω to ground, the -150 v more than 2.5K, 225 v more than 5KΩ, 350 v more than 10KΩ, and the 500 v supply above 25KΩ. Check transformer primary for infinite resistance to ground (pin 1, 2, 3, 4).

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 (±2%). Check elevated heater supplies at transformer terminals. (100 v at 22 & 23, 225 v at 27 & 28, 350 v at 9 & 16, -hv at 24 & 25.)

   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.)

4. SET CAL. ADJ.

   With the AMPLITUDE 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 ±10%.)

5. SET HV ADJ.

   Turn scope to an upright position and adjust HV 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 with 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 AMPLITUDE 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. to obtain minimum curvature of the vertical traces.

8. CHECK VERTICAL AMPLIFIER BALANCE

Short crt vertical deflection plates to determine crt electrical center, then the 12BY7 plates, etc. through each vertical stage. Allowable unbalance per stage is 0.75 cm. Determine overall balance by pressing TEST LOAD UNIT, SHORT button. Maximum overall unbalance ±2 cm.

9. CHECK VERTICAL COMPRESSION OR EXPANSION

Position 2 cm of calibrator signal up and down within the graticule lines. Allowable compression or expansion is 1 mm.

10. SET VERTICAL GAIN ADJ.

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

11. CHECK ALTERNATE SWEEP OPERATION

Check scope for ALTERNATE SWEEP operation by switching TEST LOAD UNIT to DUAL TRACE. Check for operation on both A and B sweeps.

12. CHECK AMPLITUDE CALIBRATOR

Remove the TEST LOAD UNIT and install a 53/54 K PLUG-IN UNIT. Check accuracy of AMPLITUDE CALIBRATOR voltage steps with the K UNIT.

13. SET TIME BASE "A" 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 2 MILLISEC. 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.

14. SET TIME BASE "A" TRIG. DC LEVEL CONTROL

Position the trace of the scope under calibration to the center of the graticule. Re-check the test scope zero reference and connect the probe to R 22, 47Ω to pin 7 of V 24. This point should be at zero volts. Now switch the scope under calibration from +INT to -INT and adjust INT. TRIG. DC LEVEL ADJ. for zero volts as indicated on the test scope.

15. ADJUST TIME BASE "A" TRIGGER LEVEL CENTERING

Set TRIGGERING MODE switch to AC and TRIGGER SLOPE switch to +LINE. Switch test scope VOLTS/CM switch to 0.2 VOLTS/CM, AC. Connect probe to pin 6 of V45B, on scope under calibration, and adjust TRIGGER 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 re-adjust TRIGGER LEVEL CENTERING until there is no horizontal shifting of the switching portion of the multi waveform.

16. ADJUST TIME BASE "A" 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 16.) 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.

17. ADJUST TIME BASE "A" PRESET ADJUST

Turn TRIGGERING MODE to AUTOMATIC, +LINE. Turn the PRESET ADJUST control clockwise until the sweep triggers. The center arm of the control should read about -80 v on a meter. Now continue turning PRESET ADJUST 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.

18. SET TIME BASE "B" 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 2 MILLISEC. 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 470 K 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.

19. SET TIME BASE "B" INT. TRIG. DC LEVEL CONTROL

Position the trace of the scope under calibration to the center of the graticule. Re-check the test scope zero reference and connec the probe to 100 Ω to pin 2 V 74. This point should be at zero volts. Now switch the scope under calibration from +INT to -INT and adjust INT. TRIG. DC LEVEL ADJ. for zero volts as indicated on the test scope.

20. ADJUST TIME BASE "B" TRIGGER LEVEL CENTERING

Set TRIGGERING MODE switch to AC and TRIGGER SLOPE switch to +LINE. Switch test scope VOLTS/CM switch to 0.2 VOLTS/CM, AC. Connect probe to pin 6 of V 95, 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 re-adjust TRIGGER LEVEL CENTERING until there is no horizontal shifting of the switching portion of the multi waveform.

21. ADJUST TIME BASE "B" PRESET ADJUST

Turn TRIGGERING MODE to AUTOMATIC, +LINE. Turn the PRESET ADJUST control clockwise until the sweep triggers. The center arm of the control should read about -80 v on a meter. Now continue turning PRESET ADJUST 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.

22. CHECK BOTH TRIGGER CIRCUITS FOR PROPER OPERATION

Obtain 2 mm of vertical deflection from the calibrator and see that the trigger circuits will work properly in all positions, except LINE and HF SYNC, of the TRIGGER SLOPE and TRIGGERING MODE switches. Check Line Trigger for proper phasing of 6.3 VAC to Trigger Switch.

23. 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 400 kc signal of three cm of vertical deflection. A type 53/54 P unit can also be used. Switch the TIME BASE A TIME/CM to optimum square-wave response. The variable coils control the amount of spike on the leading edge of the waveform.

24. MEASURE VERTICAL RESPONSE

Measure the bandwidth with a constant amplitude sine-wave generator, for example, Tektronix Type 190. Turn the generator to 50 KC and insert enough signal for 3 cm of vertical deflection, increase the frequency to 15 mc. The signal should still be at least 2.1 cm in amplitude.

25. 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 TIME BASE A STABILITY.

26. ADJUST MAG GAIN

With the HORIZONTAL DISPLAY switch on TIME BASE "B", turn the TIME BASE B TIME/CM switch to 1 MILLISEC and insert 1 millisec and 100 µsec 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. Check Mag. indicating neon.

27. ADJUST SWEEP CAL.

After adjusting MAG GAIN, switch HORIZONTAL DISPLAY to TIME BASE B, TIME BASE B TIME/CM switch set to 1 MILLISEC, MAG off. 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.

28. ADJUST TIME BASE "A" TO TIME BASE "B" TIMING

Switch HORIZONTAL DISPLAY to TIME BASE "A", TIME BASE "A" TIME/CM at 1 MILLISEC and adjust R 160 Z for the same timing, ±5%, as TIME BASE B. (R 160 Z is on the TIME BASE A TIME/CM bracket.)

29. ADJUST TIME BASE "A" SWEEP LENGTH

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

30. 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.

31. ADJUST EXT HORIZ. DC BAL.

Connect TIME BASE A SAWTOOTH into vertical INPUT and switch HORIZONTAL DISPLAY to EXT. HORIZ. INPUT. Adjust EXT HORIZ. DC BAL. for no horizontal shift of vertical trace when turning VARIABLE HORIZ. INPUT.

32. ADJUST EXT. HORIZ. INPUT COMP.

Apply a 1 v square wave to HORIZ. INPUT. With HORIZONTAL DISPLAY SWITCH on X1, externally trigger sweep. Adjust C330 for optimum square-wave response. Switch HORIZONTAL DISPLAY to X10 and increase square-wave amplitude to 10 v, adjust C301C for optimum flat top.

33. CHECK EXT. HORIZ. INPUT DEFLECTION FACTOR

With 0.2 v of calibrator signal fed into the EXT. HORIZ. INPUT, VARIABLE HORIZ. INPUT control full right (cw), HORIZONTAL DISPLAY EXT. X1, at least one cm of horizontal deflection must be observed. Increase calbrator signal to 2 v, switch HORIZONTAL DISPLAY to X10 and check X10 attenuator accuracy (±2%).

34. CHECK TIME BASE "A" SWEEP RATES

Check TIME BASE "A" sweep rates as follows:

34. Con't.

With MAGNIFIER OFF

1 MILLISEC	1 millisec	1 marker/cm
2 MILLISEC	1 millisec	2 marker/cm
5 MILLISEC	5 millisec	1 marker/cm
10 MILLISEC	10 millisec	1 marker/cm
20 MILLISEC	10 millisec	2 marker/cm
50 MILLISEC	50 millisec	1 marker/cm
.1 SEC	100 millisec	1 marker/cm
.2 SEC	100 millisec	2 marker/cm
.5 SEC	500 millisec	1 marker/cm
1 SEC	1 sec	1 marker/cm
2 SEC	1 sec	2 marker/cm
5 SEC	5 sec	1 marker/cm

35. CHECK VARIABLE TIME/CM CONTROL AND UNCALIBRATED NEON

Check VARIABLE TIME/CM for smooth operation and a complete range of control between the TIME/CM steps. The UNCALIBRATED neon must light whenever the VARIABLE TIME/CM is moved away from the full cw position.

36. ADJUST TIME BASE "A" SWEEP RATES, 50 µsec/cm to .02 µsec/cm

Set TIME BASE "A" TIME/CM to 100 µSEC and apply 10 µsec markers to the vertical INPUT. Turn 5X MAGNIFIER ON and horizontally position the trace so the sweep starts at the center graticule line. Switch TIME/CM to 50 µsec and observe the shift in sweep start. Adjust C330 until both the 100 µSEC and 50 µSEC sweeps start at the same point. Turn 5X MAGNIFIER OFF and TIME BASE "A" TIME/CM to 10 µSEC.

Adjust the fast sweep timing rates as follows:

Time/cm	Time Mark Gen.	Adjustments	Observe
10 µSEC	10 µsec	adjust C160E	1 marker/cm
1 µSEC	1 µsec	adjust C160C	1 marker/cm
.5 µSEC	1 µsec	adjust C160A	Position first marker to left of graticule. 1 marker/2 cm
.1 µSEC	10 mc	adjust for linearity C375 and C348	1 marker/cm
2 µSEC	1 µsec	check timing range	2 markers/cm
5 µSEC	5 µsec	check timing range	1 marker/cm
.1 µSEC X5	50 mc	Adjust for linearity C364 and C384	1 marker/cm

There will be interaction between the linearity adjustment of C348 and C375 and the timing adjustment of C160C and C160A so it will be necessary to go back and readjust these steps over again until the timing is correct.

37. SET TIME BASE "B" SWEEP LENGTH

Switch HORIZONTAL DISPLAY to TIME BASE B, TIME/CM to .5 MILLISEC and install the sweep LENGTH control limiting resistors. R277 (usually 12K to 18K) shunts the LENGTH control. R 278 (usually 47K to 68K) shunts the 12K resistor between the LENGTH control pot and -150 v.

38. SET DELAY START ADJ AND DELAY STOP ADJ

Switch HORIZONTAL DISPLAY to "B" INTENSIFIED BY "A". From the time-mark generator feed 500 µsec markers to the INPUT. Adjust STABILITY and TRIGGERING LEVEL for a stable display. Turn TIME BASE A STABILITY full right (cw) to free-run sweep. Check DELAY-TIME MULTIPLIER dial for mechanical zero. By turning the DELAY-TIME MULTIPLIER, a brightened portion of the sweep can be moved along the trace. The size of this bright portion depends on the TIME BASE A sweep speed. Turn the DELAY-TIME MULTIPLIER to 1.00. Adjust DELAY START ADJ. till the bright portion just reaches the first time mark. Turn the DELAY-TIME MULTIPLIER to 9.00 and adjust DELAY STOP ADJ. so that the bright spot reaches the ninth time mark. There will be interaction between these adjustments so it will be necessary to go back and forth several times. Switch HORIZONTAL DISPLAY to "A" DEL'D BY "B" and make final adjustments. Check linearity of the DELAY-TIME MULTIPLIER at all major divisions.

39. CHECK TIME BASE "B" SLOW SWEEP RATES

When timing or checking any other than 500 µsec ranges of the TIME BASE B sweep first turn the DELAY-TIME MULTIPLIER to 1.00 and notice the error in delay start, this is due to the trigger circuit. Now turn the DELAY-TIME MULTIPLIER back to 9.00 plus the error noted at 1.00. When adjusting or checking the faster sweep ranges this trigger error may be as much as 15 minor divisions. The difference in error must not exceed ± 5 minor divisions except for the 3 slowest ranges where the error may be ± 8 minor divisions.

40. ADJUST TIME BASE "B" FAST SWEEP RATES

TIME BASE B TIME/CM	TIME MARK GEN.	*HORIZONTAL DISPLAY	TIME BASE A TIME/CM
50 µsec	50 µsec	"A" DEL'D BY "B"	1 µsec
5 µsec	5 µsec	"A" DEL'D BY "B"	1 µsec

Check all delay sweep rates for operation.

* Make rough adjustments in "B" INTENSIFIED BY "A".

41. CHECK DELAY-TIME MULTIPLIER LINEARITY

Check DELAY-TIME MULTIPLIER on 50 µsec and 5 µsec ranges for linear sweep. (two minor-division error allowed from 1.00 to 9.00.)

42. CHECK "A" DEL'D BY "B" JITTER

Set the TIME BASE B TIME/CM switch to 1 MILLISEC, and TIME BASE A TIME/CM switch to 1 µSEC. Display 1 millisec markers with the HORIZONTAL DISPLAY switch at "B" INTENSIFIED BY "A". Set the DELAY-TIME MULTIPLIER so that the brightened portion of the sweep coincides with the marker at the 1 cm graticule line. Switch the HORIZONTAL DISPLAY control to "A" DEL'D BY "B". The horizontal jitter should not exceed 2 mm. Repeat the process at the 9 cm graticule line, jitter at this position should not exceed 4 mm.

43. SET LOCKOUT LEVEL ADJUST (R125)

Set HORIZONTAL DISPLAY to "B" INTENSIFIED BY "A" with TIME BASE B STABILITY full right (cw), set TIME BASE A TIME/CM switch to 100 µSEC. Turn the TIME BASE A STABILITY control until a trace first appears. Connect a test scope through a 10X probe to pin 3 of V133 and observe a composite sawtooth and gate waveform. Adjust R125 to the point where the sawtooth portion of the waveform is about two-thirds of the amplitude of the gate portion. The gate portion of the waveform must be at least 9 v in amplitude. Each time the setting of R 125 is changed, readjust the TIME BASE A STABILITY as above or an erroneous adjustment of R 125 will result.

Switch HORIZONTAL DISPLAY to A. Obtain a stable trace with any suitable signal. Switch HORIZONTAL DISPLAY to SINGLE SWEEP. Pressing the RESET button should produce a single trace. Remove the signal from the input. Press the RESET button. The READY light should now ignite. Re-connect the signal to the input. The READY light should now go out and a single trace should be produced.

44. CHECK TIME BASE A HOLD-OFF

Connect a probe from test scope, set for DC input, to the right-hand end of C330. Set TIME BASE A STABILITY full right (cw). Check all ranges of TIME BASE A TIME/CM switch for sufficient hold-off.

45. CHECK TIME BASE B HOLD-OFF

Now switch HORIZONTAL DISPLAY to TIME BASE B and repeat the last step.

46. CHECK FRONT PANEL WAVEFORMS

With a test scope set for DC input, using a 1X (straight through) probe, check +GATE A for a gate waveform of about 20 v amplitude with its base on the zero-volt reference line on the test scope. SAWTOOTH A should be about 150 v in amplitude with its base line on a zero reference, except on the two fastest speeds where its base line should raise about 20 v. DEL'D TRIG. from TIME BASE A of TIME BASE B sweep should be a spike of at least 5 v on all sweep rates. +GATE B, 20 v, zero reference. Out of the VERT. SIG. OUT there should be 2 v of signal for every cm of vertical deflection on the scope under calibration.

47. 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.

48. CHECK DUAL TRACE CHOPPED BLANKING

Insert 53/54 C PLUG-IN UNIT. Operate MODE switch to CHOPPED and obtain two traces with VERTICAL POSITION controls. With TIME/CM switch at 5 µSEC obtain a stable display. With normal operating INTENSITY, operate CRT CATHODE SELECTOR switch to DUAL TRACE CHOPPED BLANKING, transient spikes should be blanked out.

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