DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR OSCILLOSCOPES, 08-46/U-SERIES, OS-5001/U-SERIES, AND DUMONT/FAIRCHILD MODELS 304-A AND 304-AR

Headquarters, Department of the Army, Washington, D.C.
9 February 1973

SECTION I
GENERAL

1. Purpose and Scope. This bulletin provides instructions for the calibration of Oscilloscopes OS-46/U-Series, OS-500/ U-Series, and Dumont/Fairchild Models 304-A and 304-AR. The manufacturer's instructions manual and TM 11-5131 were used as the prime data source in compiling these instructions. The oscilloscope will be referred to as the “test instrument" throughout this bulletin.

a. Model Variations. Variations among models are described in text.

*This bulletin supersedes TB 9-6625-358-50, 18 September 1969, including all changes.

b. Time and Technique. The time required for this calibration is approximately 4 hours, using the dc and low frequency technique.

2. Calibration Data (DA Form 2416). Maintenance forms, records, and reports which are to be used by calibration personnel at all calibration levels are listed in and prescribed by TM 38-750.

3. Reporting of Equipment Publication Improvements. The reporting of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications) and forwarded direct to Commander, US Army Electronics Command, ATTN: AMSEL-MA-CRA, Fort Monmouth, N.J. 07703.

4. Calibration Description. Test instrument parameters and performance specifications which pertain to this calibration are listed in table 1.

Table 1. Calibration Description

Test instrument parameters	*Performance specification*
Power input requirement	115 or 230v, ±10%: 50 to 400 Hz, 110w.
Sinusoid frequency response:	
Ac or dc coupling	Max. deviation down: 10% at 100,000 Hz; 50% at 3000,000 Hz.
Input impedance[1]	2.2 megohms, paralleled by 50 mmf.
Linear Sweep:	
Frequency	2 to 30.000 Hz.
Amplitude	4-in. min. undistorted.
Expansion	6 times full screen.
Horizontal deflection	1.2 vdc full scale through amplifier at full gain.
Voltage:	
Range	0 to 1,000 vdc.
Scales	0.1, 1, 10, and 100, ±2%.
Multiplier range	X1 and X10 ±5%.
Calibration Voltage:	
Amplitude	0.1v pp
Accuracy	±5%

[1]This specification is for information only and is not necessarily verified in this bulletin.

SECTION II
EQUIPMENT REQUIREMENTS

5. Equipment Required. Table 2 identifies the specific equipment used in this calibration procedure. This equipment is issued with secondary transfer calibration standards set 4931-621-7877 and AN/TSM-55 calibration set 4940900-2615 and is to be used in performing this procedure. Alternate items may be used by the calibration activity when the equipment listed in table 2 is not available. The items selected must be verified to perform satisfactorily prior to use and must bear evidence of current calibration. The equipment must meet or exceed the minimum use specifications listed in table 2. The accuracies listed in table 2 provide a four-to-one accuracy ratio between the standard and test instrument. Where the four-to-one ratio cannot be met, the actual accuracy of the equipment selected is shown in parentheses.

6. Accessories Required. The accessories listed in table 3 are issued with secondary transfer calibration standards set 4931-621-7877 and AN/TSM-55 calibration set, 4940-400-2615 and are to be used in this calibration procedure. When necessary, these items may be substituted by equivalent items unless specifically prohibited.

Table 2. Minimum Specifications of Equipment Required

Item	*Common name*	*Minimum use specifications*	*Manufacturer, model and part No.*[1]
A1	AC VOLTAGE STANDARD	Range: .033583 to .037118 vrms at 1 kHz. Accuracy: ±0.75%	Hewlett-Packard, Model 745A-C90 (MIS-10342) (John Fluke Model 760A or Hewlett-Packard, Model 6290B)
A2	AC/DC VOLTMETER	Range: 0.353vrms and +108.0 to 111.1 Accuracy: ±1.25% ac +0.25% dc	John Fluke, Model 887AB (MIS-10216) (John Fluke, Model 883)
A3	AUTOTRANSFORMER	Range: 105 to 125 vac Accuracy: ±1%	General Radio, Model W10MT3AS3 (7910809) (General Radio, Model W10MT3A (6120-054-7794))
A4	SQUARE-WAVE GENERATOR	Range: 10 Hz to 300 kHz Risetime: 0.02µsec or less	Hewlett-Packard, Model 211AR (85989658-2) (Fairchild, Model 791 (6625-098-6482))
A5	TEST OSCILLATOR	Range: 100 to 300,000 Hz at 0.3535 vrms Accuracy: ±2.5%	Preston, Model 134A (MIS-10224) (Hewlett-Packard, Model 652A (6625-935-4214))

[1]Items listed in parentheses denote Transportable Maintenance Calibration Facilities equipment.

Table 3. Accessories Required

Item	*Common name*	*Description*
B1	ADAPTER	General Radio, Model 274-QBJ (7909402)
B2	CABLE[1]	30-in. RG-58( )/U; double banana plug terminations (7907470)
B3	VOLTAGE DIVIDER	Hewlett-Packard, Model 11047A (7911560)
B4	LEAD	24-in., No. 18; single banana plug terminations (7907497)

[1]Two required.

SECTION III
PRELIMINARY OPERATIONS

7. Preliminary Instructions. *a.* The instructions outlined in this section are preparatory to the calibration process. Personnel should become familiar with the entire bulletin before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name and item identification number as listed in tables 2 and 3. For the identification of equipment referenced by item numbers prefixed with A, see table 2, and for prefix B, see table 3.

WARNING

HIGH VOLTAGE is used during the performance of this calibration. DEATH ON CONTACT may result if personnel fail to observe safety precautions.

8. Equipment Setup. *a.* Remove protective cover from test instrument.

b. Connect test instrument to autotransformer (A3).

c. Connect autotransformer to 115-volt ac source and adjust output for 115 volts ac.

d. Position test instrument controls as listed in (1) through (13) below:

(1) SCALE control fully clockwise.
(2) INTENSITY control fully counterclockwise.
(3) Y POSITION control to midrange.
(4) X POSITION control to midrange.
(5) SYNC SELECTOR switch in INT.
(6) Y AXIS VOLTS FULL SCALE switch to OFF.
(7) MULTIPLIER control fully counterclockwise.
(8) X SELECTOR switch to OFF.
(9) X AMPLITUDE control fully counterclockwise.
(10) SWEEP RANGE switch to EXT CAP.
(11) SWEEP VERNIER control fully counterclockwise.
(12) SYNC AMPLITUDE control to midrange (0).
(13) FOCUS control to midrange.

e. Energize equipment and allow 10 minutes for equipment to warm up and stabilize.

f. Position spot to the center of crt, using X and Y POSITION controls. Adjust INTENSITY control as required.

g. Turn MULTIPLIER switch to 1 and adjust Y AXIS D-C BAL control to return trace to same

position as in *f* above.

h. Turn MULTIPLIER switch throughout its range. There will be no vertical moment of trace. If trace moves, repeat *f* and *g* above.

i. Repeat *f* through *h* above for X axis, using horizontal controls.

NOTE

It may not be possible to eliminate all movement of spot in *i* above.

SECTION IV
CALIBRATION PROCESS

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met before continuing with the calibration.

9. Voltage Calibrator. *a. Performance Check.*

(1) Connect ac voltage standard (A1) to test instrument Y INPUT, using cable (B2).

(2) Position test instrument controls as listed in *(a)* through *(e)* below:

(a) VOLTS FULL SCALE switch to 0.1 AC.

(b) MULTIPLIER switch to 1.0.

(c) X SELECTOR switch to SWEEP RECUR.

(d) SWEEP RANGE switch to 50 - 250.

(e) SYNC SELECTOR switch to LINE.

(3) Press CALIBRATOR switch and record vertical deflection on crt.

(4) Vary autotransformer (A3) between 105 and 125 volts. Vertical deflection will remain within ±5 percent of value recorded in (3) above. If not, perform *b* below.

(5) Adjust autotransformer for 115 volts.

(6) Press CALIBRATOR switch and adjust ac voltage standard frequency to 1 kHz and output amplitude for the same vertical deflection recorded in (3) above. Ac voltage standard will indicate between .033583 and .037118 vrms. If not, perform *b* below.

b. Adjustments.

(1) Adjust ac voltage standard frequency to 1 kHz and output amplitude to .03535 vrms.

(2) Record vertical deflection.

(3) Press CALIBRATOR switch and adjust CAL ADJ R602 (fig 1 or 2) for same vertical deflection recorded in (2) above.

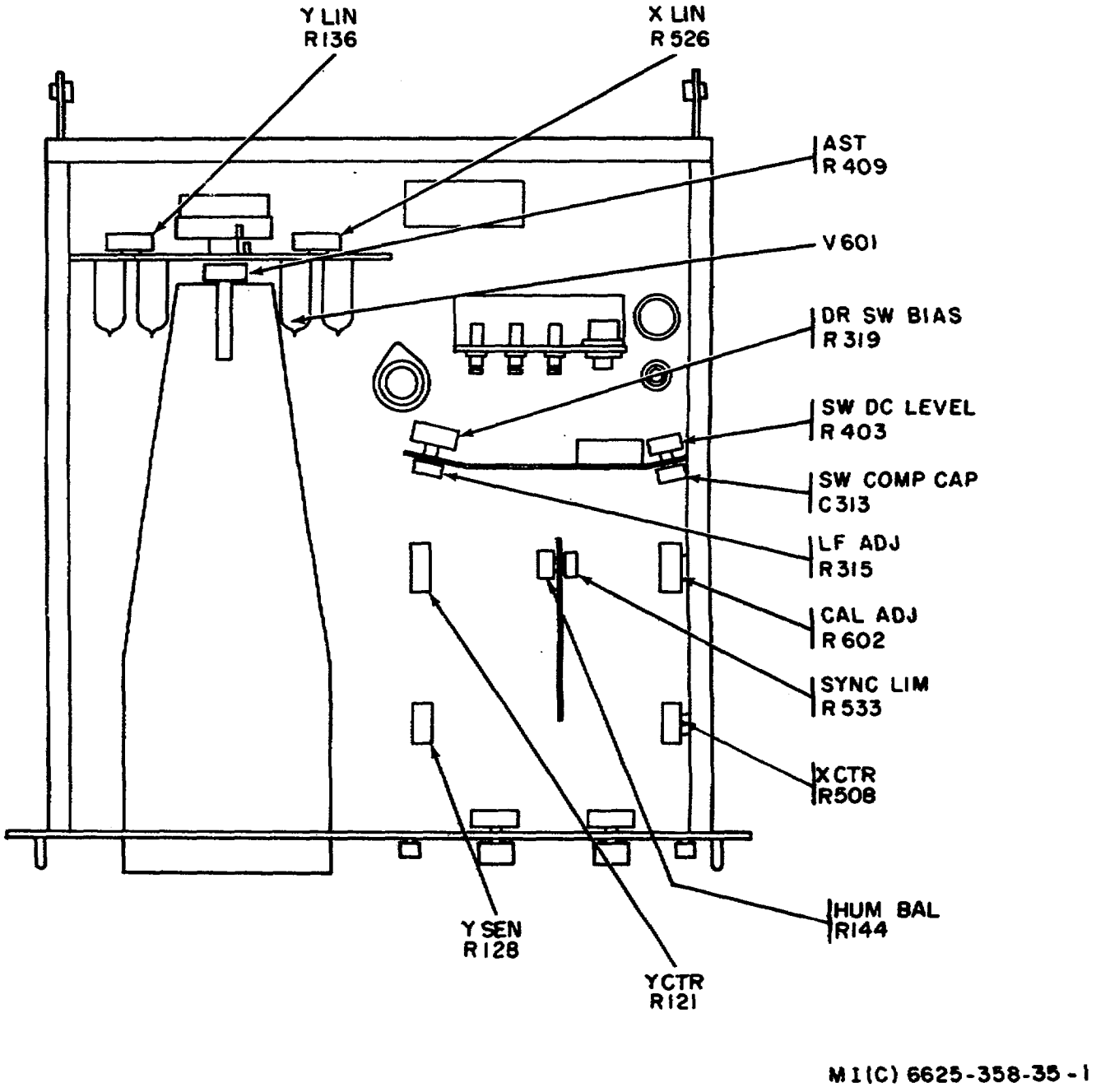

Figure 1. Oscilloscope - top view (OS-5001/4-series and 304-A).

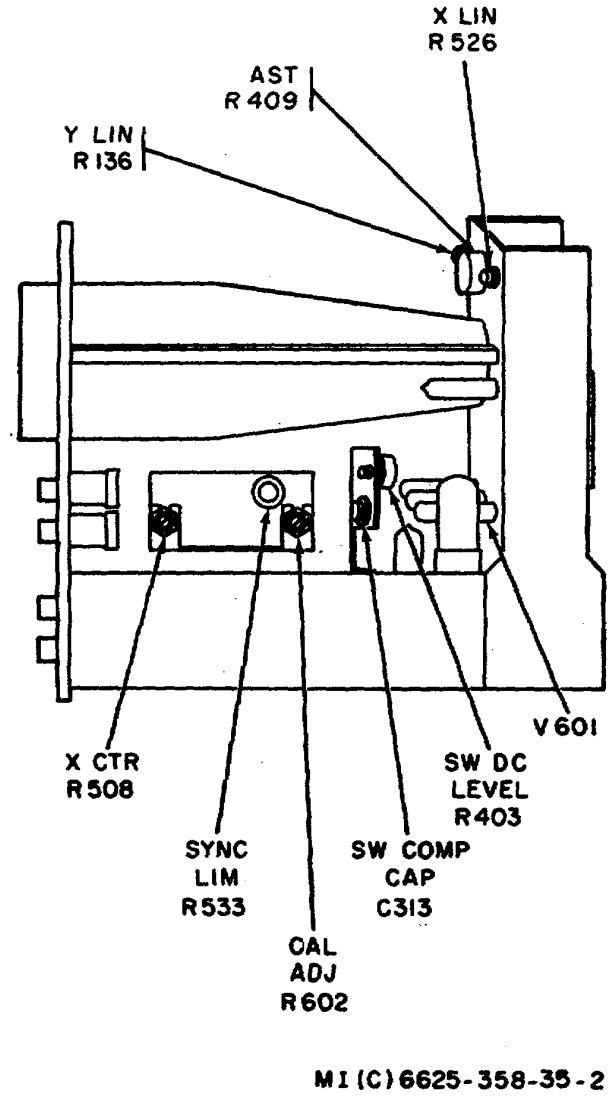

Figure 2. Oscilloscope - right view (OS-46/U-series and 304-A).

(4) Adjust Y SEN R128 (fig. 1 or 3) until vertical deflection is 4 inches.

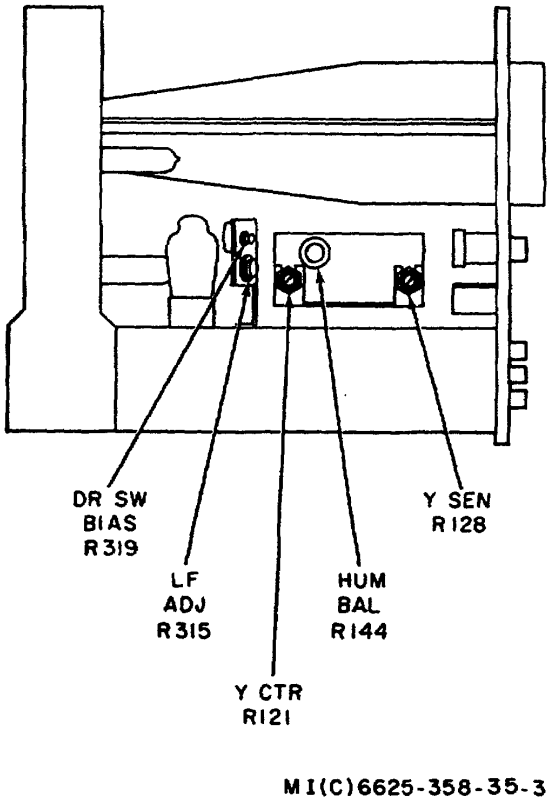

Figure 3. Oscilloscope - left view (OS-46/U-series and 304-A).

(5) Press CALIBRATOR switch.

10. Hum Balance. *a. Performance Check.*

(1) Shield Y INPUT, using adapter (B1).

(2) Turn VOLTS FULL SCALE switch to 0.1 DC. Ripple on crt will be less than 0.02 inch. If not, perform b below.

b. Adjustments. Adjust HUM BAL R144 (fig. 1 or 3) for minimum ripple. Ripple will be less than 0.02 inch.

11. Position and Focus. *a. Performance Check.*

(1) Turn X SELECTOR and VOLTS FULL SCALE switches to OFF.

(2) Adjust INTENSITY and FOCUS controls until a sharp spot is observed on crt.

(3) Turn X POSITION control so index marker is pointing up. Spot on crt will be within 1/2 inch of horizontal center. If not, perform *b*(1) below.

(4) Turn Y POSITION control so index marker is pointing up. Spot on crt will be within 1/2 inch of vertical center. If not, perform *b*(2) below.

(5) Turn Y and X POSITION controls to center the spot on crt.

(6) Turn FOCUS control fully clockwise. Spot on crt will be nearly circular. If not, perform *b*(3) below.

b. Adjustments.

(1) Adjust X CTR R508 (fig. 1 or 2) until spot is entered horizontally.

(2) Adjust Y CTR R121 (fig. 1 or 3) until spot is entered vertically.

(3) Adjust AST R409 (fig. 1 or 2) until spot is as circular as possible.

NOTE

It may be necessary to readjust FOCUS control and R409 simultaneously to maintain best beam focus.

12. Vertical Linearity. *a. Performance Check.*

(1) Connect square-wave generator (A4) to test instrument Y INPUT, using cable and voltage divider (B2 and B3).

(2) Position test instrument control as listed in *(a)* through *(f)* below:

(a) VOLTS FULL SCALE switch to 0.1 DC

(b) SWEEP RANGE switch to 6K-30K.

(c) X SELECTOR switch to SWEEP RECUR.

(d) SYNC SELECTOR switch to INT.

(e) INTENSITY and FOCUS controls for a sharp trace.

(f) X AMPLITUDE control fully counterclockwise.

(3) Adjust square-wave generator frequency to 10 kHz and output amplitude to 0.1 volt as indicated on crt.

(4) Adjust SYNC AMPLITUDE, Y POSITION, and MULTIPLIER controls for a vertical deflection of 1 inch with equal portions above and below horizontal center graticule.

(5) Adjust Y POSITION control to position crt pattern 1 1/2 inches up and then 1 1/2 inches down. Vertical deflection will remain the same in each position as at the center position. If not, perform b below.

b. Adjustments. Adjust Y LIN R136 (fig. 1 or 2) until a minimum change in vertical deflection occurs when pattern is positioned 1 1/2 inches up and 1 1/2 inches down, using Y POSITION control.

NOTE

If R136 is adjusted, repeat paragraphs 9 and 11.

13. Vertical Input Attenuator Compensation. *a. Performance Check.*

(1) Turn VOLTS FULL SCALE switch to 0.1 AC and X AMPLITUDE control for full-scale horizontal deflection.

(2) Adjust SYNC AMPLITUDE, SWEEP VERNIER, and MULTIPLIER controls for a stable display and a vertical deflection of 2 inches. Adjust square-wave generator (A4) output as necessary. Square-wave display will have flat top (no slopes) and square upper left corner.

(3) Repeat technique at (1) and (2) above for VOLTS FULL SCALE switch positions 1 AC, 10 AC, and 100 AC. If necessary, perform b below.

NOTE

It may not be possible to obtain 2 inches of deflection at the 100 AC position.

b. Adjustments.

(1) Turn VOLTS FULL SCALE switch to 1 AC.

(2) Repeat *a*(2) above.

(3) Adjust COMPENSATOR CAPACITOR C106 (fig. 4) for minimum distortion of square wave.

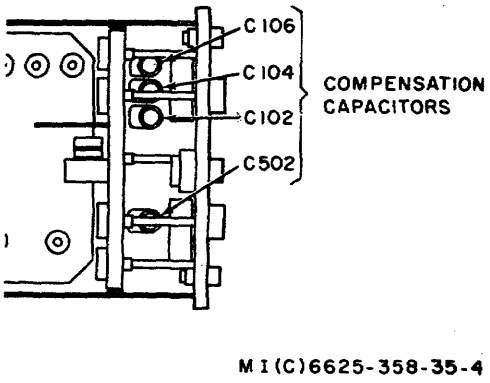

Figure 4. Oscilloscope - bottom view.

(4) Turn VOLTS FULL SCALE switch to 10 AC.

(5) Repeat a(2) above.

(6) Adjust COMPENSATOR CAPACITOR C104 (fig. 4) for minimum distortion of square wave.

(7) Turn VOLTS FULL SCALE switch to 100 AC.

(8) Repeat *a*(2) above.

(9) Adjust COMPENSATOR CAPACITOR C106 (fig. 4) for minimum distortion of square wave.

14. Vertical Amplifier Frequency Response. *a. Performance Check.*

(1) Connect equipment as shown in figure 5.

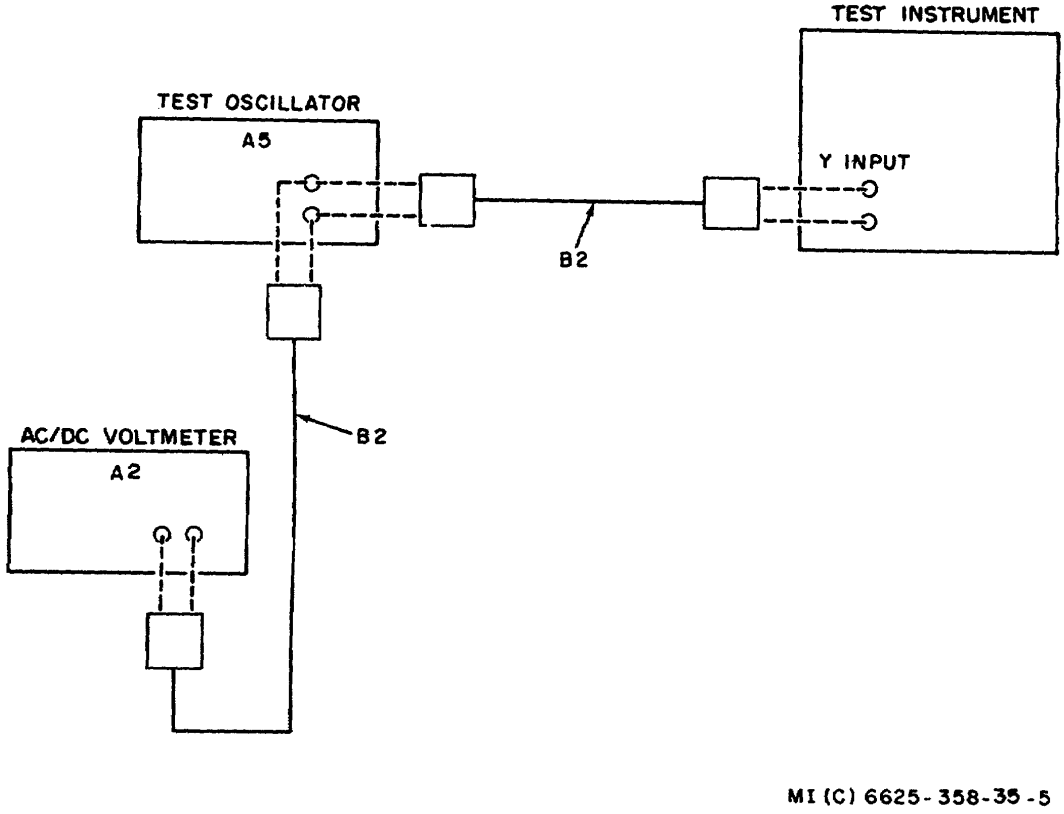

Figure 5. Vertical amplifier - equipment setup.

(2) Position test instrument controls as listed in *(a)* through *(c)* below:

(a) VOLTS FULL SCALE switch to 1 AC.

(b) SWEEP RANGE switch to 50-250.

(c) INTENSITY and FOCUS controls for sharp trace,

(3) Adjust test oscillator (AS) frequency to 100 Hz and output voltage to 0.3535 volt rms as indicated on ac/dc voltmeter (A2).

(4) Adjust test instrument SYNC AMPLITUDE and MULTIPLIER controls for a stable pattern and vertical deflection of 2 inches.

(5) Turn test oscillator to frequencies and test instrument to sweep ranges listed in table 4, while maintaining output voltage of test oscillator in (3) above. Amplitude of pattern will remain within limits specified.

Table 4. Vertical Amplifier

Test oscillator frequency (Hz)	*Test instrument SWEEP RANGE switch settings*	*Allowable Maximum amplitude decrease (inches)*
5,000	1250 - 6K	0.2
50.000	6K - 30K	0.2
100,000	6K - 30K	0.2
300,000	6K - 30K	1.0

b. Adjustments. No adjustments can be made.

15. Horizontal Amplifier. *a. Performance Check.*

(1) Connect square-wave generator (A4) to X INPUT terminals, using cable and voltage divider (B2 and B3).

(2) Position test instrument controls as listed in *(a)* through *(d)* below:

(a) X SELECTOR switch to OFF.

(b) X AMPLITUDE control fully clockwise.

(c) Y POSITION and X POSITION controls to center the spot on crt.

(d) X SELECTOR switch to 1 AC.

(3) Adjust square-wave generator frequency to 10 kHz and amplitude for a 4-inch horizontal deflection on crt.

(4) Connect ac/dc voltmeter (A2) to square-wave generator output, using cable (B2). Record voltage.

(5) Turn X AMPLITUDE control fully counterclockwise.

(6) Horizontal deflection will be between 0.1 and 0.4 inch.

(7) Turn X AMPLITUDE control fully clockwise.

(8) Increase square-wave generator frequency and maintain same output as recorded in (4) above until horizontal deflection decreases to 3.2 inches. Square-wave generator frequency will be at least 200 kHz.

(9) Adjust square-wave generator frequency to 10 kHz and amplitude output for 1 inch of horizontal deflection on crt. Position trace to center, using X POSITION control.

(10) Adjust pattern 1 1/2 inches to the left and then 1 1/2 inches to the right, using X POSITION control. Horizontal amplitude of pattern will remain the same in each position as at the center. If not, perform b(1) below.

(11) Turn X SELECTOR switch to OFF and center the electron spot on crt with X POSITION control.

(12) Turn X AMPLITUDE control from fully clockwise to fully counterclockwise position. There will be no horizontal shift of electron spot. If so, perform *b*(2) through (6) below.

(13) Turn X SELECTOR switch to RECUR SWEEP.

(14) Starting from fully counterclockwise position, turn X AMPLITUDE control in a clockwise direction and observe that the sweep expands equally in both directions. If not, perform *b*(7) below.

(15) Disconnect equipment form X INPUT terminals and connect to Y INPUT terminals.

(16) Adjust square-wave generator for 10 Hz.

(17) Turn SWEEP RANGE switch to 2-10.

(18) Turn SWEEP VERNIER control between 40 and 100 and check for a one-cycle pattern on screen. If not, perform *b*(8) below.

b. Adjustments.

(1) Adjust X LIN R526 (fig. 1 or 2 until sweep has the same horizontal amplitude when moved 1 1/2 inches to the left and 1 1/2 inches to the right with X POSITION control.

(2) Turn X AMPLITUDE control to 10 (fully counterclockwise).

(3) Adjust X POSITION control so that electron spot is horizontally centered on screen.

(4) Turn X AMPLITUDE control to 100 (fully clockwise).

(5) Adjust X AXIS DC BAL control to return trace to its previous position.

(6) Repeat (4) through (7) above until X AMPLITUDE control can be turned to its extremities with no horizontal shift of electron spot.

(7) Adjust SW DC LEVEL R403 (fig. 1 or 2) until sweep expands equally in both directions as the X AMPLITUDE control is turned clockwise.

(8) Adjust LF ADJ R315 (fig. 1 or 3) for a one-cycle pattern on crt.

16. Horizontal Attenuator Compensation. *a. Performance Check.*

(1) Connect square-wave generator (A4) to X INPUT, using cable (B2).

(2) Adjust signal generator for 10 kHz.

(3) Turn X SELECTOR switch to 10 AC and X AMPLITUDE control to 100 (fully clockwise).

(4) Adjust square-wave generator output to observe an intensified dot at each end of horizontal trace. If intensified dot at each end cannot be obtained, perform below.

b. Adjustments. Adjust COMPENSATOR CAPACITOR C502 (fig. 4) until dots at each end of horizontal trace are of maximum relative intensity and in sharp focus.

17. Sync Stability. *a. Performance Check.*

(1) Connect square-wave generator (A4) to Y INPUT, using cable (B2).

(2) Position test instrument controls as listed in *(a)* through *(c)* below:

(a) X SELECTOR switch to RECUR SWEEP.

(b) SYNC AMPLITUDE control to zero.

(3) VOLTS FULL SCALE to 10 AC.

(3} Adjust square-wave generator frequency to 10 Hz and amplitude output for approximately 1 inch of deflection on crt.

(4) Adjust SWEEP VERNIER control for a pattern as stationary as possible.

(5) Turn SYNC AMPLITUDE control in a clockwise and then counterclockwise direction. It will be possible to lock the pattern as a positive-going pulse and a negative-going pulse. If not, perform *b* below.

(6) Repeat technique of (4) and (5) above, using values listed in table 5.

Table 5. Synch Stability Frequency Range

Square-wave generator frequency (Hz)	*Test instrument SWEEP RANGE switch setting*
30	10 - 50
150	50 - 250
750	250 - 1250
2,500	1250 - 6K
20,000	6K - 30K

(7) Connect lead (B4) between Y INPUT and EXTERNAL SYNC terminals.

(8) Turn SYNC SELECTOR switch to EXT. SWEEP RANGE to 2-10, and repeat (2) through (6) above.

b. Adjustments.

(1) Position test instrument controls as listed in *(a)* through *(c)* below:

(a) SWEEP RANGE switch to 2 - 10.

(b) SYNC AMPLITUDE control to zero.

(c) SWEEP VERNIER control to 10 (fully clockwise).

(2) Turn SYNC LIM R533 (fig. 1 or 2) fully counterclockwise.

(3) Press CALIBRATOR switch and adjust MULTIPLIER control for a 0.5 inch of vertical deflection.

(4) Turn X SELECTOR switch to DRIVEN SWEEP and adjust DR SW BIAS control R319 (fig. 1 or 3) until sweep just stops and a vertical bar appears.

(5) Turn SWEEP VERNIER control to 10 (fully counterclockwise) and observe that pattern does not change.

(6) Turn X SELECTOR switch to RECUR SWEEP and observe that adjustment of the DR SW BIAS control did not affect normal operation of the sweep.

(7) Turn SYNC SELECTOR switch to INT.

(8) With the SWEEP VERNIER control fully counterclockwise turn SYNC AMPLITUDE control either way from 0 setting and observe that "driven sweep" can be triggered.

(9) Adjust pattern for 0.5 inch of vertical deflection and turn SYNC AMPLITUDE control just enough to trigger the sweep.

(10) Turn R53 clockwise until sweep stops and then counterclockwise until sweep just starts again end remains stable.

(11) Press CALIBRATOR switch.

(12) Repeat *a*(1) through (8) above.

18. Sweep Generator. *a. Performance Check.*

(1) Position test instrument controls as listed in *(a)* through *(e)* below:

(a) SWEEP RANGE switch to 2-10.

(b) SYNC AMPLITUDE control to zero.

(c) SWEEP VERNIER control fully clockwise.

(d) SYNC SELECTOR switch to LINE.

(e) X SELECTOR switch to DRIVEN SWEEP.

(2) Turn SYNC AMPLITUDE control either way from zero and observe that "driven sweep" can be triggered.

(3) Turn SWEEP VERNIER control fully counterclockwise.

(4) Turn SYNC AMPLITUDE control either way from zero and observe that sweep is present.

(5) Turn X SELECTOR switch to RECUR SWEEP.

(6) Turn SWEEP RANGE switch to 250-1250.

(7) Adjust X AMPLITUDE switch for 2 inches of horizontal deflection.

(8) Connect lead (B4) from SAWTOOTH OR EXT CAP terminal to Y INPUT terminal and adjust for 2 inches of vertical deflection, using MULTIPLIER control. Sawtooth will have optimum linearity and minimum tail or overshoot. If not, perform *b* below.

b. Adjustments. Adjust SW COMP CAP C313 (fig. 1 or 2) for a minimum tail or overshoot on sawtooth waveform displayed on crt screen.

19. Power Supply.

a. Performance Check.

NOTE

Do not perform the power supply check if all other parameters are within tolerance.

(1) Connect ac/dc voltmeter (A2) between pin 5 of V601 (fig. 1 or 2) and chassis ground. Ac/dc voltmeter will indicate between 108.9 and 111.1 volts dc.

(2) Vary autotransformer (A3) output between 105 and 125 volts. A/dc voltmeter will remain within limits in (1) above.

(3) Adjust autotransformer for 115 volts.

b. Adjustments. No adjustments can be made.

20. Final Procedure. *a.* Deenergize and disconnect all equipment and reinstall protective cover on test instrument.

b. In accordance with TM 38-750, annotate and affix DA Label 80 (U.S. Army Calibration System). When the test instrument cannot be adjusted within tolerance, annotate and affix DA Form 2417 (Unserviceable or Limited Use).

By Order of the Secretary of the Army:

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