# ENGINEERING INSTRUMENT SPECIFICATION 

# TYPE 454/R454 <br> OSCILLOSCOPE 

FOR INTERNAL USE ONLY
TEKTRONIX, INC.

## ENGINEERING

## INSTRUMENT SPECIFICATION

TYPE 454/R454
OSCILLOSCOPE

Prepared by Engineering Writing Dept.


FOR INTERNAL USE ONLY
TEKTRONIX, INC.

PREFACE

This Engineering Instrument Specification is the reference document for all company activity concerning the electrical, environmental, and physical characteristics of the subject instrument. This document is printed in two issues: a tentative copy printed on or before Prototype Release of the instrument, and a final copy printed following Engineering Release. Occasionally, if justified by the number of changes, the final copy is updated and reissued following Pilot Production.

The major function of the Engineering Instrument Specification is to provide electrical, environmental, and physical characteristics to the following departments:
Manuals
Product Technical Information
Engineering Product Reliability
Marketing Technical Training
Product Manufacturing Staff
Engineering

Advertising
International Manufacturing Technical Support
International Marketing
Manufacturing Quality Assurance
Manufacturing Management
Electrical and environmental characteristics listed in Section 1 are worst case, and are to be treated as described on page 1-1. Factory test limits are excluded from the Engineering Instrument Specification. Factory test limits are established by Product Manufacturing Staff Engineering, and appear in documents issuing from that department.

Periodically, an Engineering Instrument Specification may be revised and reprinted. The revised Engineering Instrument Specification will then have a 3-digit specification number followed by a capital letter printed in the upper right corner of the front cover, e.g. 000A for the first revision, 000B for the second revision, etc.

Changes in the Engineering Instrument Specification may be made only via the Instrument Performance Characteristic Change Request form of which 3 are included at the back of this document (contact the PE\&M Engineering Writing Department for additional forms).

Abbreviations and symbols appearing in the Engineering Instrument Specification conform to Tektronix Standard No. A-100, Recommended Short Forms.

CHANGE INFORMATION LOG
This page is used as a guide to insure that all change pages have been inserted. When change pages are received, log them on this page, then insert the change pages in their appropriate place. Change numbers (located in upper right corner of Change Notice form) are assigned in sequence. Absence of a number from the sequence indicates a change which has not been inserted.

| CHANGE NOTICE <br> NUMBER | EFFECTIVE DATE <br> OF CHANGE | DESCRIPTION |
| :---: | :---: | :---: |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

## INTRODUCTION

Description ..... I
Function of Controls, Indicators, and Connectors ..... I
SECTION 1 CHARACTERISTICS
1.1 Electrical ..... 1-2
1.1.1 Vertical Amplifier CH 1 \& CH 2 ..... 1-2
1.1.2 Time Base A \& B ..... 1-9
1.1.3 Variable Time Delay ..... 1-11
1.1.4 X-Y Mode ..... 1-12
1.1.5 Triggering A \& B ..... 1-13
1.1.6 Calibrator ..... 1-15
1.1.7 Z Axis Input ..... $1-16$
1.1.8 Signal Outputs ..... 1-17
1.1.9 Power Source ..... 1-18
1.1.10 Internal Power Supply ..... 1-20
1.1.11 CRT Display ..... 1-22
1.2 Environmental ..... 1-24
1.3 Physical ..... $1-26$
SECTION 2 ELECTRICAL PERFORMANCE VALIDATION
2.1 Test Equipment Required ..... $2-1$
2.2 Vertical Amplifier ..... $2-1$
2.3 Time Base A \& B ..... $2-6$
2.4 Variable Time Delay ..... $2-7$
2.5 X-Y Mode ..... 2-9
2.6 Triggering A \& B ..... 2-9.
2.7 Calibrator ..... 2-10
2.8 Z Axis Input ..... 2-11
2.9 Signal Outputs ..... 2-12
2.10 Power Source ..... 2-12
2.11 Internal Power Supply ..... 2-12
2.12 CRT Display ..... 2-13
SECTION 3 ENVIRONMENTAL PERFORMANCE VALIDATION
3.1 Temperature ..... 3-1
3.2 A1titude ..... 3-1
3.3 Humidity ..... 3-2
3.4 Vibration ..... 3-2
3.5 Shock ..... 3-3
3.6 Electromagnetic Interference (MOD 163D) ..... 3-3
3.7 Transportation ..... 3-4


THIS IS A PHOTO OF AN ENGINEERING MODEL AND MAY DIFFER FROM THE
PRODUCTION INSTRUMENT.

## INTRODUCTION

This is the Engineering Instrument Specification for the Type 454/R454 Oscilloscope.

## Description

The Type $454 / \mathrm{R} 454$ is a general-purpose, environmentalized, high-performance, portable, wide-band oscilloscope featuring DC to 150 MHz bandwidth combined with a dual-channel vertical amplifier and delaying sweep. The Type $454 / \mathrm{R} 454$ has a 5 ns sweep rate with X10 magnifier, stable triggering to bandwidth limits, and calibrated $X-Y$ capabilities. A 5 MHz bandwidth limiter switch provides for viewing low-frequency, low-level signals with reduced noise and RF interference.

Functions of Controls, Indicators, and Connectors
POWER ON Switch
Turns instrument on or off.
1 V CAL 1 kHz Connector
BNC connector for calibrator cutput signal.
INTENSITY Control
Controls brightness of writing beam.
FOCUS Control
Permits adjustment of beam for optimum definition.

## SCALE ILLUM Control.

Controls light level of graticule.
BEAM FINDER 5 MHz BW Switch
Down position compresses trace within graticule area independent of position control settings or signal applied. Center position permits normal operation. Up position limits main vertical amplifier bandwidth to $\simeq$ 5 MHz .

PROBE POWER
Two connectors provide correct operating voltages for P6045 FET probes.

CH 2

Displays CH 2 only.

## ALT

Selects alternate mode of operation (triggered electronic switching between channels during the beam retrace interval).

CHOP

Displays both vertical channels simultaneously by electronic switching.

ADD
Algebraically adds CH 1 and CH 2 input signals.
MODE Switch
TRIGGER
Selects NORM (normal or CH 1 ) as an internal trigger source. CH 1 ONLY OR X-Y must be selected for $X-Y$ operation.

CH 1 Indicator

Lights when TRIGGER switch is set at CH 1 ONLY.
CH 1 and CH 2
VOLTS/DIV Switch
Selects calibrated deflection factors from $5 \mathrm{mV} / \mathrm{div}$ to $10 \mathrm{~V} / \mathrm{div}$ in a 1-2-5 sequence.

VARIABLE VOLTS/DIV Control
Provides uncalibrated continuously variable deflection factor to $\simeq 2.5 \mathrm{X}$ the calibrated setting (uncalibrated deflection factor range is extended to $25 \mathrm{~V} / \mathrm{div}$ ).

GAIN Control

Screwdriver adjustment allows calibration of vertical deflection factor.

STEP ATTEN BAL Control

Screwdriver adjustment balances the Input Amplifier in the 5, $10,20 \mathrm{mV}$ and 50 mV positions of the VOLTS/DIV switch.

Input Selector Switch

AC
Capacitively couples input signal to vertical amplifier.

GND
Grounds input attenuator.
DC
Signal is directly coupled to vertical amplifier.
INPUT CH 1 OR X Connector
BNC connector for applying external signals.

INPUT CH 2 OR $Y$ Connector
BNC. connector for applying external signals.

POSITION Controls
Vertically positions the display. In $X-Y$ mode, CH 1 positions in X axis, CH 2 positions in $Y$ axis.

INVERT PULL Switch (CH 2 only)
Inverts CH 2 display.

## HORIZ-DISPLAY Switch

A
Displays A sweep.
A INTEN DURING B
Displays A sweep, intensified (after the delay time) for the duration of $B$ sweep.

DELAYED SWEEP (B)

Displays DELAYED SWEEP (B)
$X-Y$
Permits $X-Y$ operation only when vertical TRIGGER switch is set to CH 1 ONLY OR X-Y. Signals applied to CH 2 are displayed in the $Y$ axis. (Overrides vertical MODE switch setting).

MAG Switch

Expands the horizontal display from graticule center by a factor of 10 . Extends the fastest sweep rate to $5 \mathrm{~ns} / \mathrm{div}$. Inoperative in $\mathrm{X}-\mathrm{Y}$ mode.

A \& B TRIGGERING

SOURCE Switch

INT

Uses a portion of the signal applied to the vertical channels as a triggering signal when TRIGGER is set at NORM. Uses a portion of the CH 1 signal as a triggering signal when TRIGGER is set at CH 1 ONLY.

LINE

Uses a portion of line-frequency voltage as a trigger signal.
EXT

Permits triggering on signals applied to the EXT TRIG INPUT connector.

EXT $\div 10$

Attenuates external trigger signal 10 times.

COUPLING Switch

AC

Blocks the DC component of the triggering signal and allows triggering only on the $A C$ portion of the signal.

LF REJ

Attenuates triggering signal below about 30 kHz , allowing the trigger circuit to respond only to higher frequencies.

HF REJ

Rejects DC, passes signals between 30 Hz and 50 kHz , and attenuates all other signals.

DC

Couples triggering signals from DC to at least 150 MHz .

EXT TRIG INPUT Connector

BNC connector providing input for external triggering.

SLOPE Switch

+ and -

Permits triggering the sweep on the positive-or-negative-going portion of the trigger signal.

HF STAB (A only)
Decreases display jitter when triggering on frequencies above 40 MHz .
LEVEL Control
Selects amplitude point on the triggering signal where sweep-triggering occurs.

A SWEEP TRIG'D Indicator
Lights when A sweep is triggered.
A SWEEP MODE Switch
AU'O TRIG
Permits normal triggering on waveforms with repetition rates at least 20 Hz . Sweep free-runs with no trigger signal or with a lower repetition rate.

NORM TRIG
Permits normal triggering.
SINGLE SWEEP
Displays one sweep only until reset.
RESET
Pushbutton resets sweep circuits when in Single Sweep mode.
A SWEEP LENGTH Control
Varies A sweep length from 4 divisions or less to $\simeq 11$ divisions in FULL position. In B ENDS A position, A sweep is reset at the end of $B$ sweep. DELAY-TIME MULTIPLIER 1-10 Control

Delays $B$ sweep start from 0.1 to 10.1 X the Time Base A TIME/DIV setting after A sweep start.

B SWEEP MODE Switch
TRIGGERABLE AFTER DELAY TIME
Permits B (DELAYED SWEEP) triggering after delay time.
B STARTS AFTER DELAY TIME
B (DELAYED SWEEP) starts after delay time.
A TIME/DIV AND DELAY TIME Switch
Selects calibrated sweep rates and delay range from $5 \mathrm{~s} / \mathrm{div}$ to $0.05 \mu \mathrm{~s} / \mathrm{div}$ in a 1-2-5 sequence.

A VARIABLE Control
Provides uncalibrated continuously variable $A$ sweep rate to $\simeq 2.5 \mathrm{X}$ the calibrated setting (uncalibrated sweep rate is extended to $12.5 \mathrm{~s} / \mathrm{div}$ ).

B TIME/DIV Switch
Selects calibrated sweep rates and delay range from $0.5 \mathrm{~s} / \mathrm{div}$ to $0.05 \mu \mathrm{~s} / \mathrm{div}$ in a $1-2-5$ sequence.

POSITION (horizontal) Control
Horizontally positions trace. Inoperative in $X-Y$ mode.

SIDE PANEL
B TIME/DIV VARIABLE Control
Provides uncalibrated continuously variable $B$ sweep rate to $\simeq 2.5 X$ the calibrated setting (uncalibrated sweep rate is extended to $1.25 \mathrm{~s} / \mathrm{div}$ ).

TRACE ROTATION Adjustment
Screwdriver adjustment aligns trace with horizontal graticule lines.
ASTIG Control
Screwdriver adjustment of beam for optimum definition.
X-GAIN (X-Y)
Screwdriver adjustment permits calibration of Ciil (X) in $\mathrm{X}-\mathrm{Y}$ mode.

CH 1 OUT
BNC connector providing a portion of CH 1 signal.
B + GATE
BNC connector providing a positive-going squarewave coincident with $B$ sweep.
A + GATE
BNC connector providing a positive-going squarewave coincident with A sweep.
A SWEEP
BNC connector providing a portion of $A$ sawtooth generator signal.
CURRENT PROBE CAL
Current Loop providing five-milliampere square-wave current from calibrator circuit.

REAR PANEL

Z AXIS INPUT
5-way input connector for intensity modulation of the CRT display.
Line Voltage Selector
Screw-down cover contains 2 fuses, a 2 A SLOW for 115 VAC operation and a 1 A SLOW for 230 VAC. Two range selector plugs inside can be switched to desired range.

Line Cord
Power cord is a 3-wire, permanently attached cable, approximately 7.5 feet in length

## SECTION 1

## CHARACTERISTICS

Characteristics are attributes or capabilities of a product described in terms of acceptable qualitative or quantative limits. The characteristics in this section are categorized as electrical, environmental and physical.

The electrical and environmental characteristics together with their related validation procedures in Section 2 and 3 comprise a complete statement of the electrical and environmental performance of a calibrated instrument. Thus, the electrical and environmental characteristics are valid only: (1) if the instrument is operating under the conditions described in this section and in Section 2 and 3, and (2) if the instrument is calibrated and operating in a calibrated system.

Information in this section is tabulated as follows:

1. ITEM
2. QUOTABLE
3. MAINTENANCE \& OPERATION
4. TEST RATE
5. VAL. STEP
6. ENGINEERING NOTES

Titles of specific attributes or capabilities of a product.
Characteristics describing the measurement capabilities or limitations and physical attributes of a product. These characteristics are considered necessary to qualify a product for a particular application(s). These characteristics are a commitment between Tektronix, Inc., and the customer.
Characteristics that, when met, will insure optimum instrument operation. These characteristics may be given to a customer as maintenance or operational aids, but are not a commitment between Tektronix, Inc., and the customer
Engineering's recommendations (not binding on Manufacturing) regarding the minimum percentage of instruments which are tested for specific characteristics; i.e. $100 \%, 10 \%, 1 \%$ or $0.1 \%$. These recommendations are based on confidence level, and on the importance of the characteristic.

The step number in Section 2 or 3 where the validation procedure for the characteristic can be found.
Reserved for Engineering information. This information is not to be printed in any publication normally available to the customer and may not be given to a customer except under special circumstances. This information is not intended to be a commitment between the customer and Tektronix, Inc.
NOTE

ELECTRICAL

| 1.1.1 VERTICAL AMPLIFIER CH 1 \& CH 2 (cont) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ITEM | QUOTABLE | MAINTENANCE \& OPERATION | TEST <br> RATE | VAL. <br> STEP | ENGINEERING NOTES |
| R365 (Main Amp) <br> CW |  | At least 24 V P-P at CRT deflection plates measured differentially | 100\% | 2.2.5 |  |
| CCW |  | 22 V P-P or less at CRT deflection plates measured differential1y |  |  |  |
| Frequency Response <br> Bandwidth (VARIABLE <br> VOLTS/DIV at CAL) CH 1 <br> and CH 2 | See Table, page 1-6 |  | 100\% | 2.2 .6 |  |
| Added Mode (4 Div <br> Reference) | See Table page 1-6 |  |  |  |  |
| AC (Capacitive) Coupled (4 Div Reference) Lower Bandwidth Frequency | 10 Hz or less at all deflection factors (with P6047 1 Hz or less at all deflection factors) |  |  |  |  |
| Cascaded (CH 1 OUT Connected to INPUT CH 2 OR Y) | DC to at least $33 \mathrm{MHz}\left(50 \Omega 18^{\prime \prime} \mathrm{RG}\right.$ $58 \mathrm{~A} / \mathrm{U}$ cable and TRIGGER set to NORM) |  |  |  |  |
| Step Response CH 1 and CH 2 <br> Risetime | See Table, page 1-6 |  | 100\% | 2.2 .7 |  |

ELECTRICAL



Minimum Bandwidth and Maximum Risetime

| $0^{\circ} \mathrm{C}$ to $+40^{\circ} \mathrm{C}$ |  |  | $-15{ }^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}$ |  |
| :---: | :---: | :---: | :---: | :---: |
| Deflection Factor | $\text { P6047 or } 25 \Omega$ Source Z | P6045 | P6047 or $25 \Omega$ Source Z | P6045 |
| $5 \mathrm{mV} / \mathrm{div}$ | $\begin{aligned} & 60 \mathrm{MHz} \\ & 5.9 \mathrm{~ns} \end{aligned}$ | $\begin{array}{r} 58 \mathrm{MHz} \\ 6 \mathrm{~ns} \end{array}$ |  |  |
| $10 \mathrm{mV} / \mathrm{div}$ | $\begin{gathered} 100 \mathrm{MHz} \\ 3.5 \mathrm{~ns} \end{gathered}$ | $\begin{aligned} & 95 \mathrm{MHz} \\ & 3.7 \mathrm{~ns} \end{aligned}$ |  |  |
| $20 \mathrm{mV} / \mathrm{div}$ to $10 \mathrm{~V} / \mathrm{div}$ | $\begin{gathered} 150 \mathrm{MHz} \\ 2.4 \mathrm{~ns} \end{gathered}$ | $\begin{gathered} 130 \mathrm{MHz} \\ 2.7 \mathrm{~ns} \end{gathered}$ | - |  |


(1) $0 \%$ Amplitude reference level
(2) $100 \%$ Amplitude reference level, Aberration reference level

| 1.1.1 VERTICAL AMPLIFIER CH 1 \& CH 2 (cont) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ITEM | QUOTABLE | MAINTENANCE \& OPERATION | TEST RATE | VAL. STEP | ENGINEERING NOTES |
| Common-Mode Rejection Ratio <br> AC (Capacitive) and DC (Direct) Coupled | At least 10:1 at 50 MHz for common mode signals $400 \mathrm{mV} \mathrm{P}-\mathrm{P}$ or less with optimized setting of GAIN at 50 MHz at $50 \mathrm{mV} / \mathrm{div}$ |  | 100\% | 2.2 .10 |  |
| Maximum Input Voltage <br> DC (Direct) Coupled and AC (Capacitive) Coupled | $600 \mathrm{~V}(\mathrm{DC}+$ peak AC), 600 V ( $\mathrm{P}-\mathrm{P} A C$ ) at 1 kHz or less |  | 0.1\% | 2.2 .11 |  |
| Input R and C <br> Input Resistance | $1 \mathrm{M} \Omega$ within $2 \%$ |  | 100\% | 2.2 .12 |  |
| Input Capacitance | 20 pF within 1 pF |  |  |  |  |
| Input Grid Current | 2 nA or less ( 0.4 div at $5 \mathrm{mV} / \mathrm{div}$ ) |  | 100\% | 2.2 .13 |  |
| STEP ATTEN BAL $5 \mathrm{mV} / \mathrm{Div} \text { to } 10 \mathrm{~V} / \mathrm{Div}$ | Within 1 div trace shift when deflection factor switch is changed to adjacent setting |  | 100\% | 2.2 .14 |  |
| Range |  | least 16 div when ning STEP ATTEN fully cw to fully at $50 \mathrm{mV} / \mathrm{div}$ |  |  |  |
| INVERT Zero |  | hin 1 div from ticule center | 100\% | 2.2 .15 |  |

ELECTRICAL
1.1
VERTICAL AMPLIFIER CH $1 \&$ CH 2 (cont)

ELECTRICAL

ELECTRICAL
TIME BASE A \＆B（cont）

| 安总 | $\begin{aligned} & \stackrel{\rightharpoonup}{N} \\ & \stackrel{\sim}{\mathrm{~N}} \end{aligned}$ | $\begin{aligned} & \stackrel{\mu}{n} \\ & \dot{\sim} \end{aligned}$ | $\begin{aligned} & \dot{\sim} \\ & \dot{\sim} \\ & \dot{N} \end{aligned}$ |  |  | $\begin{aligned} & \stackrel{n}{n} \\ & \dot{\sim} \end{aligned}$ | $\begin{aligned} & \stackrel{\rightharpoonup}{\mathrm{N}} \\ & \dot{\sim} \end{aligned}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { 易胃 } \\ & \text { 垵 } \end{aligned}$ | $\begin{aligned} & \text { 응 } \\ & \stackrel{1}{1} \end{aligned}$ | $\begin{aligned} & \text { 응 } \\ & \text { O} \end{aligned}$ | $\begin{aligned} & \text { 음 } \\ & \text { O } \end{aligned}$ |  |  | $\begin{aligned} & \text { 응 } \\ & \text { O } \end{aligned}$ | $\begin{aligned} & \text { 응 } \\ & \text { - } \end{aligned}$ |  | 응 |  |
|  | $\begin{aligned} & \underset{\sim}{\sim} \\ & \ddot{\sim} \\ & \sim \\ & u \\ & \tilde{\sim} \\ & \sim \\ & \sim \\ & \ddot{4} \end{aligned}$ |  |  |  |  |  |  |  | $\begin{aligned} & \text { 品 } \\ & \infty \\ & o \\ & + \\ & \text { H } \\ & : H \\ & 0 \end{aligned}$ |  |
| 썩 总 吕 |  |  |  |  |  |  |  |  |  |  |
| 苳 |  |  |  |  |  |  |  |  |  |  |

ELECTRICAL
VARIABLE TIME DELAY
ITEM

ELECTRICAL
1.1

ELECTRICAL





ELECTRICAL

| CALIBRATOR |
| :--- |
| ITEM |


| 1.1.6 CALIBRATOR |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ITEM | QUOTABLE | MAINTENANCE \& OPERATION | TEST <br> RATE | VAL. STEP | ENGINEERING NOTES |
| Output Voltage (1 V) |  |  |  |  |  |
| $0^{\circ} \mathrm{C}$ to $+40^{\circ} \mathrm{C}$ | Within 1\% | Adjusted for 1 V within $0.3 \%$ at $25^{\circ} \mathrm{C}$ within $5^{\circ} \mathrm{C}$ | 100\% | 2.7 .1 |  |
| $-15^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}$ | Within 1.5\% |  | 0.1\% |  |  |
| Output Current ( 5 mA ) |  |  |  |  |  |
| $0^{\circ} \mathrm{C}$ to $+40^{\circ} \mathrm{C}$ | Within 1\% |  | 100\% | 2.7 .2 |  |
| - $-15^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}$ | Within 1.5\% |  | 0.1\% |  |  |
| Repetition Rate ( 1 kHz ) |  |  |  |  |  |
| $0^{\circ} \mathrm{C}$ to $+40^{\circ} \mathrm{C}$ | Within 0.5\% | Adjusted for 1 kHz within $0.1 \%$ at $25^{\circ} \mathrm{C}$ within $5^{\circ} \mathrm{C}$ | 100\% | 2.7 .3 |  |
| $-15^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}$ | Within 1\% |  | 0.1\% |  |  |
| Risetime | $1 \mu \mathrm{~s}$ or less |  | 100\% | 2.7 .4 |  |
| Duty Cycie | 49\% to $51 \%$ |  | 100\% | 2.7 .5 |  |
| Output Resistance | $250 \Omega$ within $1 \%$ |  | 100\% | 2.7 .6 |  |
|  |  |  |  |  |  |


1.1 ELECTRICAL

ELECTRICAL
1.1

1.1
ELECTRICAL

ELECTRICAL

| 1.1.11 CRT DISPLAY |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ITEM | QUOTABLE | MAINTENANCE \& OPERATION | TEST | VAL. STEP | ENGINEERING NOTES |
| Horizontal Resolution | At least 15 lines in 1 div |  | 100\% | 2.12.2 |  |
| Vertical Resolution | At least 15 lines in 1 div |  | 100\% | 2.12 .2 |  |
| Display Area | $6 \times 10 \mathrm{div}$ ( $0.8 \mathrm{~cm} / \mathrm{div}$ ) |  | 100\% | 2.12 .3 |  |
| Geometry | 0.1 div or less |  | 100\% | 2.12 .4 |  |
| Trace Rotation Range |  | At least $5.4^{\circ}$ | 100\% | 2.12 .5 |  |
| Beam Locate | Positions trace within graticule area |  | 100\% | 2.12 .6 |  |
| Electrode Voltage Range to Ground |  |  |  |  |  |
| Heater Voltage (Pins 1 and 14) |  |  |  |  | 6.3 RMS at 103 mA (elevated to -1960 V) |
| Overall Accelerating Potential |  |  |  |  | 14 kV |
| Post Accelerator |  |  |  |  | +12 kV |
| $\begin{aligned} & \text { Cathode } \\ & \text { (Pin 2) } \\ & \hline \end{aligned}$ |  | . |  |  | -1960 V |
| Post Accelerator Mesh (Pin 9) . |  |  |  |  | 0 V |
| $\begin{aligned} & \text { D1-D2 Def1ection Shield } \\ & \text { (Geometry Pin 9) } \end{aligned}$ |  |  |  |  | 0 V to +90 V |


| 1.1 ELECTRICAL |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1.1.11 CRT DISPLAY (cont) |  |  |  |  |  |
| ITEM | QUOTABLE | MAINTENANCE \& OPERATION | TEST <br> RATE | VAL. STEP | ENGINEERING NOTES |
| Average of Deflection Plates |  |  |  |  |  |
| Horizontal |  |  |  |  | +65 V |
| Vertical |  |  |  |  | +41 V |
| Astigmatism (Pin 5) |  |  |  |  | 0 V to +75 V |
| $\begin{aligned} & \text { Accelerator (1st Anode) } \\ & \text { (Pin } 7) \end{aligned}$ |  |  |  |  | +41 V |
| $\begin{aligned} & \text { Focus } \\ & \quad(\text { Pin 4) } \end{aligned}$ |  |  |  |  | -1450 V to -1800 V |
| $\begin{array}{r} \text { Grid No. } 1 \\ (\text { Pin } 3) \end{array}$ | . |  |  |  | -2093 V to -1960 V |
| CRT Deflection Factor |  |  |  |  |  |
| Vertical |  |  |  |  | $\begin{aligned} & \text { 4.3 V/div to } \\ & \text { 4.9 V/div } \end{aligned}$ |
| Horizontal | . |  |  |  | $11 \mathrm{~V} / \mathrm{div}$ to $12.6 \mathrm{~V} / \mathrm{div}$ |
| Photographic Writing Speed (Without Film Fogging Techniques) |  |  |  | 2.12 .7 |  |
| C31 Camera with fl. 2 <br> lens, and 1:0.5 object-to-image ratio | At least $1600 \mathrm{div} / \mu \mathrm{s}(1280 \mathrm{~cm} / \mu \mathrm{s})$ with Polaroid ${ }^{*}$ type 410 film ( 10,000 ASA) and type P31 CRT phosphor | , |  |  |  |

ELECTRICAL

ENVIRONMENTAL
1.2

| ITEM | QUOTABLE | MAINTENANCE \& OPERATION | TEST <br> RATE | VAL. STEP | ENGINEERING NOTES |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Temperature |  |  |  |  |  |
| Nonoperating | $-55^{\circ} \mathrm{C}$ to $+75^{\circ} \mathrm{C}$ |  | 0.1\% | 3.1 |  |
| Operating | $-15^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}$ |  | 0.1\% | 3.1 |  |
| Altitude |  | May be tested during nonoperating temperature tests |  |  |  |
| Nonoperating | To 50,000 feet |  | 0.1\% | 3.2 |  |
| Operating | To 15,000 feet; maximum allowable ambient temperature decreased by $1^{\circ} \mathrm{C} / 1000$ feet from 5,000 feet to 15,000 feet |  | 0.1\% | 3.2 |  |
| Humidity |  |  |  |  |  |
| Nonoperating | 5 cycles ( 120 hours) of MIL-STD-202C, Method 106B. Omit Freezing and Vibration and allow 24 hour post-test drying period at $25^{\circ} \mathrm{C}$ within $5^{\circ} \mathrm{C}$ at $20 \%$ to $80 \%$ relative humidity |  | 0.1\% | 3.3 |  |
| Vibration |  |  |  |  |  |
| Operating | 15 minutes along each of the 3 major axes at a total displacement of $0.025^{\prime \prime}$ P-P ( 4 g 's at $55 \mathrm{c} / \mathrm{s}$ ) with frequency varied from 10 to 55 to $10 \mathrm{c} / \mathrm{s}$ in 1minute sweeps. Hold for 3 minutes at $55 \mathrm{c} / \mathrm{s}$. All major resonances must be above $55 \mathrm{c} / \mathrm{s}$ | . | 0.1\% | 3.4 |  |


PHYSICAL

PHYSICAL (cont)
1.3


## SECTION 2

## ELECTRICAL PERFORMANCE VALIDATION

### 2.1 Test Equipment Required



### 2.2 Vertical Amplifier

### 2.2.1 Deflection Factor CH 1 and CH 2 Accuracy

Connect Standard Amplitude Calibrator to INPUT CH 1 OR X. Use either 4 or 5 div of displayed signal depending upon combination of calibrator signal and VOLTS/DIV setting to check each setting of VOLTS/DIV switch. Repeat for CH 2. Repeat with P6047. Repeat for ADD mode.

### 2.2.2 VARIABLE Range

Connect SAC to INPUT CH 1 OR X. Set vertical deflection factor to $1 \mathrm{~V} / \mathrm{div}$ and apply 5 V from SAC. Turn VARIABLE VOLTS/DIV fully ccw. Check for VARIABLE Range. Repeat for CH 2.

### 2.2.3 Low-Frequency Linearity

Connect SAC to INPUT CH 1 OR X. Set vertical deflection factor to $1 \mathrm{~V} / \mathrm{div}$ SAC to 2 V , and center the display. Position bottom of waveform to bottom graticule line and note change in pulse amplitude. Position top of waveform to top graticule line and note change in pulse amplitude. Linearity is the maximum change in pulse amplitude occurring at the defined limits.

### 2.2.4 GAIN (preamp)

Connect 1 V CAL signal to INPUT CH 1 OR X. Set deflection factor to 0.2 V/Div, Input Selector to DC, and position display about graticule center. Monitor delay line input with test scope in differential mode. Turn GAIN fully cw and check for at least 800 mV . Turn GAIN fully ccw and check for 700 mV or less. Adjust GAIN for 750 mV . Repeat for CH 2.
2.2.5 R365 (main amp)

Connect 1 V CAL signal to INPUT CH 1 OR X. Set deflection factor to 0.2 V/Div, Input Selector to $D C$, and position display about graticule center. Monitor CRT deflection plates with test scope in differential mode. Turn R365 cw and check for at least $24 \mathrm{~V} P-\mathrm{P}$. Turn R365 ccw and check for 22 V or less. Adjust R365 for 5 div display. NOTE: It may be necessary to adjust GAIN to obtain 5 div display.

### 2.2.6 Bandwidth

Check bandwidth from $5 \mathrm{mV} / \mathrm{DIV}$ and cascade using Type 191. Set Type 191 to 50 kHz and obtain 4 div of display. Increase frequency until 2.8 div are displayed. Note frequency. From $10 \mathrm{mV} / \mathrm{DIV}$ to 1 V/DIV connect Constant Amplitude Signal Generator (067-0532-00). Obtain 4 div of display at 3 MHz . Increase frequency until 2.8 div are displayed. Note frequency. 1 V/DIV to $10 \mathrm{~V} / \mathrm{DIV}$ bandwidth is calculated from risetime.

Set TRIGGER to NORM to check CH 1 OUT. CH 1 OUT connected to INPUT CH 2 OR Y to check cascaded bandwidth.

### 2.2.7 Risetime

Risetime from $5 \mathrm{mV} / \mathrm{DIV}$ to $0.5 \mathrm{~V} / \mathrm{DIV}$ is calculated from bandwidth. Risetime from $1 \mathrm{~V} / \mathrm{DIV}$ to $10 \mathrm{~V} / \mathrm{DIV}$ is measured using the short pulse method. Connect an open-circuit charge line to Type 109 $50 \Omega$ CHG LINE that will produce a pulse 2.33 ns wide at the $50 \%$
amplitude point. NOTE: Pulse width must be verified with a sampling system. Connect Type 113 Delay Cable to Type $10950 \Omega$ CHG LINE 2. Connect from Type $10950 \Omega$ OUTPUT---RG-8 A/U cable $--50 \Omega 2 \mathrm{~W}$ termination---INPUT CH 1. Set CH 1 OR X deflection factor for $1 \mathrm{~V} / \mathrm{div}$, and adjust AMPLITUDE of Type 109 for a 4 div display. Adjust LEVEL to display 4 div reference pulse and short pulse. The short pulse amplitude must be at least 3.2 div. Repeat for 2 V/DIV, $5 \mathrm{~V} / \mathrm{DIV}$ and $10 \mathrm{~V} / \mathrm{DIV}$.

Repeat for CH 2. Repeat to check ADD mode.

### 2.2.8 Aberrations

(For this check, it is essential that the geometry and trace rotation adjustments be optimized.) Connect 113 via an airline elbow to $10950 \Omega$ CHG LINE 2. Short $50 \Omega$ CHG LINE 1 to ground. Connect $10950 \Omega$ OUTPUT---RG 213/U cable---50 $\Omega$ Termination--INPUT CH 1. Center display and set sweep rate to $10 \mathrm{~ns} / \mathrm{div}$. Select attenuators to provide a 4 div display from $5 \mathrm{mV} / \mathrm{DIV}$ to 10 V/DIV. Measure total $P-P$ pulse aberration in the form of overshoot, rounding, ringing, or tilt, during the aberration interval, expressed as a percentage of pulse amplitude. The pulse amplitude reference level is the average level in the $40-50 \mathrm{~ns}$ period after the step (see figure on pg 1-6). Return oscilloscope to $20 \mathrm{mV} / \mathrm{DIV}$ setting and again note aberrations with a 4 div display. Switch Type 109 to negative output and again center display. Check that negative step response is within specifications. Repeat for CH 2.

### 2.2.9 Position Effect on Aberrations

Connect Type 109 to INPUT CH 1 OR X. Connect Type 113 to $50 \Omega$ CHG LINE 1. Set vertical deflection factor to $20 \mathrm{mV} / \mathrm{div}$, and apply 4 div of supply from Type 109. Position top of waveform to bottom of graticule and measure total pulse aberration.

Set PULSE POLARITY to - . Position bottom of waveform to top of graticule and measure pulse aberration.

Repeat to check CH 2.
2.2.10 Common Mode Rejection Ratio

Apply 400 mV of 50 kHz from a Type 191 to CH 1 and CH 2 vertical input connectors. Set CH 1 and $\mathrm{CH} 2 \mathrm{VOLTS} / \mathrm{DIV}$ to 50 mV . Invert CH 2 , set MODE to ADD and adjust CH 2 GAIN for maximum CMRR (minimum deflection). Increase frequency of generator to 50 MHz and note the $P-P$ amplitude. Set MODE to CH 1 and check $\mathrm{P}-\mathrm{P}$ amplitude. CMRR is the ratio of the $\mathrm{CH} 1 \mathrm{P}-\mathrm{P}$ amplitude to the $\mathrm{P}-\mathrm{P}$ amplitude in the ADDED position.

### 2.2.11 Maximum Input Voltage

Set Input Coupling to DC, A SWEEP MODE to AUTO TRIG, and MODE to CH 1. Apply 600 VDC and switch deflection factor from $5 \mathrm{mV} / \mathrm{div}$ to $10 \mathrm{~V} / \mathrm{div}$. There must be no physical damage, discoloration of any component, or change in value of any component beyond its rated tolerance. The Type 454 must operate within its electrical characteristics after the Maximum Input Voltage test.
2.2.12 Input $R$ and $C$

Connect ESI 250 DA Bridge to vertical input connector. Measure resistance and capacitance of INPUT CH 1 OR X and INPUT CH 2 OR Y.
2.2.13 Input Grid Current

Set vertical deflection factor to $5 \mathrm{mV} / \mathrm{div}$. Position trace to graticule center. Set Input Selector to Gnd. Switch Input Selector to DC and note trace deflection. Indicated voltage is divided by $1 \mathrm{M} \Omega$ input resistance to determine grid current. Trace shift must be 0.4 div or less
2.2.14 STEP ATTEN BAL

Set A SWEEP MODE to AUTO TRIG, sweep rate to $1 \mathrm{~ms} / \mathrm{div}$, and position trace to graticule center. Check trace shift when deflection factor switch is changed to adjacent setting from $5 \mathrm{mV} / \mathrm{div}$ to $10 \mathrm{~V} / \mathrm{div}$.

Set CH 1 deflection factor to $50 \mathrm{mV} / \mathrm{div}$, STEP ATTEN BAL fully cw and position trace to top of graticule. Turn STEP ATTEN BAL fully ccw and check range.

### 2.2.15 Invert Zero Shift Point

Set vertical deflection factor to $20 \mathrm{mV} / \mathrm{div}$, Input Selector to GND. Adjust CH 2 POSITION to obtain a minimum trace shift while switching PULL TO INVERT from normal to inverted. When balanced, note trace position from graticule center.
2.2.16 Position Range

Set LEVEL fully cw. TRIGGER SOURCE to EXT, MODE to AUTO, sweep rate to $1 \mathrm{~ms} / \mathrm{div}$, vertical deflection factor to $0.1 \mathrm{~V} / \mathrm{div}$. Position trace to graticule center. Set Input Selector to AC. Connect Type 106 output to 10 X atten---50 $\Omega$ Termination---CH 1 vertical input connector. Adjust Type 106 amplitude and symmetry
controls to obtain a 6 div display centered on screen. Set Vertical deflection factor to $50 \mathrm{mV} / \mathrm{div}$. Turn POSITION fully cw . Top waveform must position between graticule center and 3 div down from graticule center.

Turn POSITION fully ccw. Bottom of waveform must position between graticule center and 3 div up from graticule center. Repeat for CH 2.
2.2.17 Microphonics at $5 \mathrm{mV} / \mathrm{Div}$

Set deflection factor to $5 \mathrm{mV} / \mathrm{div}$. Ground input through P6047. Place Micro-Shock Hammer on top on instrument. Operate MicroShock Hammer and check microphonic noise.

### 2.2.18 Channel Isolation

Set CH 1 vertical deflection factor to $0.2 \mathrm{~V} / \mathrm{div}$ and apply 50 MHz signal from Type 191. Adjust amplitude of Type 191 to obtain 2 div display. Set CH 1 and CH 2 VOLTS/DIV to $20 \mathrm{mV} / \mathrm{DIV}$ and Input Selector to CH 2. Check for 0.2 div or less of amplifier crosstalk. Repeat to check CH 2.
2.2.19

Attenuator Isolation
Set CH 1 Input Selector to DC, deflection factor to $1 \mathrm{~V} / \mathrm{div}$. Set Ch 2 Input Selector to AC, deflection factor to $5 \mathrm{mV} / \mathrm{div}$. Apply 50 MHz , 5 div signal from Type 191 to CH 1 vertical input connector. Set Vertical Mode to CH 2 and check for 0.1 div or less of deflection. Repeat above to check CH 1.

### 2.2.20 Chopped Repetition Rate

Set sweep rate to $0.5 \mu \mathrm{~s} / \mathrm{div}$ and vertical MODE to CHOPPED. Adjust CH 1 and CH 2 POSITION to obtain 2 div of display. Adjust LEVEL Control to trigger display. Set INTENSITY to an above normal setting. Check for one-cycle over 1.6 div to 2.4 div of calirated sweep.

Check Channel Time Segment by noting duration of one-half cycle of chopped waveform including blanked portion. Turn intensity to normal and check Display Factor by comparing duration of unblanked one-half cycle to Channel Time Segment duration.
2.2.21 5 MHz Bandwidth

Set bandwidth limiter switch to 5 MHz BW . Set CH 1 vertical deflection factor to $1 \mathrm{~V} / \mathrm{div}$ and connect Type 191 to INPUT CH 1

OR X. Set Type 191 to 50 kHz and obtain 4 div of display. Increase frequency until 2.8 div are displayed. Check that frequency is within specifications.

Connect Constant Amplitude Signal Generator (067-0532-00) to Type 454 INPUT CH 1. Set BW to FULL and adjust generator amplitude for a 5 div display. Set generator frequency to 65 MHz and BW to 5 MHz . Check for 0.5 div or less. Increase generator frequency to 200 MHz and check for 0.5 div or less.

### 2.3 Time Base A \& B

### 2.3.1 Sweep Accuracy

Connect Type 184 to INPUT CH 1 OR X. Time marks and graticule line are counted beginning with zero (0-1-2-3 etc.). Time marks should be selected so there is 1 mark/div at all "1,5,10" ranges, and 2 marks/div at all 2 and 20 ranges. All timing measurements are made over middle 8 div of graticule. The first and last div should not be included in the measurement.
2.3.2 Variable Range

Connect Type 184 to INPUT CH 1 OR X. Apply 10 ms time marks from Type 184. Set sweep rate to $1 \mathrm{~ms} / \mathrm{div}$ and obtain a stable display. Two 10 ms time marks will be displayed. Position the lst mark behind the zero graticule line and the $2 n d$ marker behind the 10 th graticule line. Turn VARIABLE fully cow and note the 2nd mark positions on, or to the left of, the 4 th graticule line.

### 2.3.3 Sweep Length A

Connect Type 184 to INPUT CH 1 OR X. Apply 1 ms and $100 \mu \mathrm{~s}$ time marks from Type 184. Set sweep rate to $1 \mathrm{~ms} / \mathrm{div}$. Each $100 \mu \mathrm{~s}$ time mark represents $1 / 10$ th of a major div. Turn A SWEEP LENGTH fully cw and note A sweep length. Turn A SWEEP LENGTH ccw, not to detent, and note sweep length.
2.3.4 A Sweep Hold-Off Time

Monitor the + A GATE with test scope. Measure interval between + GATE waveforms to determine hold-off time.

### 2.3.5 Normal/Magnified Registration

Connect Type 184 to INPUT CH 1 OR X. Apply 5 ms time marks from Type 184. Set sweep rate to $1 \mathrm{~ms} / \mathrm{div}$ and MAG to X10. Horizontally position sweep so middle time mark falls behind the center vertical graticule line. Switch MAG to NORM and note the deviation of the 5 ms time mark from graticule center.

### 2.3.6 Position Range

Sweep Length must be within its performance requirements prior to position range check. Connect Type 184 to INPUT CH 1 OR X. Apply 1 ms and 100 us time marks from Type 184. Set sweep rate to $1 \mathrm{~ms} / \mathrm{div}$, HORIZ DISPLAY to A and A SWEEP MODE to AUTO. Turn coarse and FINE Horizontal POSITION fully cw and note start of sweep must position to right of graticule center.

Turn coarse and FINE Horizontal POSITION fully ccw and note that the end of sweep positions to left of graticule center. Set MAG to X10, FINE fully ccw, and horizontally position a 1 ms time mark to zero graticule line with coarse control. Turn FINE fully cw. The 1 ms time mark must position 5 div to 8 div to the right.
2.4 Variable Time Delay
2.4.1 Delay Time Accuracy

Connect Type 184 to INPUT CH 1 OR X. Set A sweep rate to $1 \mathrm{~ms} / \mathrm{div}$, HORIZ DISPLAY to A INTEN DURING B, B SWEEP MODE to B SWEEPS AFTER DELAY TIME, and B sweep rate to $10 \mu \mathrm{~s} / \mathrm{div}$. Apply 1 ms time marks from Type 184. Set DELAY-TIME MULTIPLIER to 100 , and note the first time mark is intensified. Set HORIZ DISPLAY to DELAYED SWEEP (B) and adjust DTM so the 1 st 1 ms time mark is at start of sweep. Note dial setting of DTM. Set HORIZ DISPLAY to A INTEN DURING B, and DTM to 900. The 9th time mark will be intensified. Set HORIZ DISPLAY to DELAYED SWEEP (B) and adjust DTM so the 9th, 1 ms time mark is at start of sweep. Subtract first dial reading from 2nd dial reading. Delay time accuracy is the percent of deviation from 800 div. Check from 5 s/DIV to $1 \mu s / D I V$.

### 2.4.2 Jitter

Connect Type 184 to INPUT CH 1 OR X. Set A sweep rate to $1 \mathrm{~ms} / \mathrm{div}$, HORIZ DISPLAY to A INTEN DURING B, B SWEEP MODE to B SWEEPS AFTER DELAY-TIME, and B sweep rate to $1 \mu \mathrm{~s} / \mathrm{div}$. Set DTM to 100 and note that 1 st, 1 ms time mark is intensified. Set. HORIZ DISPJ.AY to DELAYED SWEEP (B). Measure the horizontal excursion of the 1 ms time mark disregarding the drift.

Set HORIZ DISPLAY to A INTEN DURING B, and DTM to 900, and note the 9 th, 1 ms time mark is intensified. Set HORIZ DISPLAY to DELAYED SWEEP (B). Measure the horizontal excursion of the 1 ms time marks disregarding the drift.

### 2.4.3 DTM Incremental Linearity

Determine DTM dial difference between the first and the ninth markers by the same procedure as in Par 2.4.1. Divide this dif-ference by 8. (Delay Range checked). The result is the dial divisions/marker. To calculate ideal linearity points for each marker, start with 100 (first marker point) and add the dial divisions/marker figure determined above, to obtain the 2nd marker dial reading. Add the dial divisions/marker and the 2nd marker reading to determine the 3rd marker point; then add the dial division/marker to the 3rd marker point to get the 4th marker point and so on. (See example below). Align each marker to a reference point on the graticule and check that dial readings are within 4 divisions of the calculated values.

Example: first marker at 100
ninth marker at 908
difference: $\quad 808$ divided by $8=101$ dial divisions/ marker

Ideal Linearity Points Actual Readings Divisions of Devi-- ation

|  | 100 | 100 |
| ---: | ---: | ---: |
| $100+101=201$ | 200 | 0 |
| $201+101=302$ | 301 | -1 |
| $302+101=403$ | 401 | -2 |
| $403+101=504$ | 502 | -2 |
| $504+101=605$ | 603 | -2 |
| $605+101=706$ | 705 | -1 |
| $706+101=807$ | 806 | -1 |
| $807+101=908$ | 908 | 0 |

The dial reading between any two markers shall be within 4 divisions of the difference between the calculated dial readings of these markers. (See example below).

8th marker at 807
3rd marker at 302
difference: 505 divisions within 4 divisions

## $2.5 \mathrm{X}-\mathrm{Y}$ MODE

### 2.5.1 Deflection Factor

Connect Standard Amplitude Calibrator to INPUT CH 1 OR X. Use either 4 or 5 div of displayed signal depending upon combination of calibrator signal and VOLTS/DIV setting to check each setting of VOLTS/DIV switch. Repeat to check CH 2.
2.5.2 Input $R$ and $C$

Connect ESI 250 DA Bridge to INPUT CH 2 OR Y. Measure resistance and capacitance.
2.5.3 Bandwidth

Connect Type 191 to INPUT CH 1 OR X. Connect A SWEEP to INPUT CH 2 OR Y. Set HORIZ DISPLAY to X-Y. Adjust Type 191 amplitude to display 4 div of 50 kHz signal. Increase frequency until 2.8 div are displayed. Note frequency.

### 2.5.4 Phase Shift

Connect Type 191---Dual-Input Coupler (067-0525-00)---INPUT CH 1 OR X---INPUT CH 2 OR Y. Set CH 1 and CH 2 deflection factors to $20 \mathrm{mV} / \mathrm{div}$, Type 191 to 2 MHz , and amplitude for a 6 div display. Set HORIZ DISPLAY to X-Y, MODE to CH 2 , and TRIGGER to CH 1 ONLY OR X-Y. Measure the maximum separation of displayed ellipse along the vertical graticule line. The maximum separation measured vertically must be 0.15 div or less.

### 2.6 Triggering A \& B

### 2.6.1 Trigger Sensitivity

## Internal

Connect Type 191 ro 067-0532-00 generator to INPUT CH 1 OR X. Select proper mode of coupling, signal frequency, and amplitude as shown in Section 1.1.5. Trigger Sensitivity is defined as the minimum $P-P$ signal required to obtain a stable display with an adjustment of LEVEL while switching from + slope to - slope.

To measure lower point of AC coupling, use the 067-0542-99 oscillator. Monitor the amplitude of the oscillator with a DC coupled test scope to insure constant amplitude.

## External

Use same procedure as Internal Trigger Sensitivity except apply signal to INPUT CH 1 OR X and EXT TRIG INPUT.

### 2.6.2 Jitter

Connect Constant Amplitude Signal Generator (067-0532-00) to INPUT CH 1 OR X. Set generator frequency to 150 MHz , vertical deflection factor to $20 \mathrm{mV} / \mathrm{div}$, and obtain 4 div of deflection. Set A SWEEP MODE to NORM TRIG, A TRIGGERING COUPLING to AC, sweep rate to $0.05 \mu \mathrm{~s} / \mathrm{div}$, MAG to X10, and A TRIGGERING SOURCE to INT. Adjust LEVEL and HF STAB to obtain a stable display. Check for 0.2 div or less of jitter.

### 2.6.3 Maximum Input Voltage

Apply 500 VDC to EXT TRIG connector. There must be no physical damage, discoloration of any component, or change in value of any component beyond its rated tolerance. The instrument must trigger within its performance requirements after the input voltage test.
2.6 .4 R and C

Connect ESI 250 DA Bridge to EXT TRIG INPUT. Measure resistance and capacitance.
2.6.5 Leve1 Range

Connect Type 191 to INPUT CH 1 OR X---EXT TRIG INPUT. Set vertical deflection factor to $1 \mathrm{~V} / \mathrm{div}$, A TRIGGERING SOURCE to EXT, A TRIGGERING COUPLING to AC, A SWEEP MODE to AUTO. Adjust LEVEL to obtain a stable display. Turn LEVEL fully cw and ccw. Display must free-run with LEVEL fully cw and fully ccw.

Set vertical deflection factor to $10 \mathrm{~V} /$ div and A TRIGGERING SOURCE to EXT $\div 10$. Connect Type 106 to INPUT CH 1 OR X---A EXT TRIG INPUT. Set Type 106 amplitude to 40 V . Display must free-run at the extremes of LEVEL.

Check B TRIGGER LEVEL using the same procedure as above. Set B SWEEP MODE to TRIGGERABLE AFTER DELAY TIME. HORIZ DISPLAY to A INTEN DURING B, DTM to 5.00, B TRIGGERING SOURCE to EXT, and B TRIGGERING COUPLING to AC. Adjust LEVEL until the last half of display intensifies. The display must return to normal intensity at extremes of LEVEL. Set vertical deflection factor to $10 \mathrm{~V} / \mathrm{div}$ and B TRIGGERING SOURCE to EXT $\div 10$. Connect Type 106 to INPUT CH 1 OR X---B EXT TRIG INPUT. Set Type 106 amplitude to 40 V . Display must return to normal intensity at extremes of LEVEL.

### 2.7 Calibrator

2.7.1 Output Voltage (1 V)

Connect Standard Amplitude Calibrator to 1 V CAL 1 kHz . Set SAC to + DC, MIXED, and 1 V . Connect output of SAC to test scope. Set test scope vertical deflect on factor to $5 \mathrm{mV} / \mathrm{div}$ and note difference in chopped levels.

### 2.7.2 Output Current ( 5 mA )

Monitored with a Current Probe. If the calibrator voltage accuracy is within its performance requirements and a current is present in the current loop, it is within its performance requirement.

### 2.7.3 Repetition Rate ( 1 kHz )

Connect Type 184 to INPUT CH 1 OR X. Connect 1 V CAL 1 kHz to INPUT CH 2 OR Y. Set CH 1 and CH 2 deflection factors to $0.5 \mathrm{~V} / \mathrm{div}$, TRIGGER MODE to NORM, MODE to ALT, sweep rate to $1 \mathrm{~ms} / \mathrm{div}$, and adjust LEVEL for stable display. Position last time mark to graticule center and set MAG to X10. Note displacement of leading edge of Calibrator signal from leading edge of 1 ms time mark. The displacement must be $1 / 2$ div or less.

### 2.7.4 Risetime

Monitor 1 V CAL 1 kHz with test scope. Measure the time interval between the $10 \%$ and $90 \%$ amplitude points on the leading edge of the calibrator signal.

### 2.7.5 Duty Cycle

Connect 1 V CAL 1 kHz to INPUT CH 2 OR Y. Set CH 2 deflection factor to $0.5 \mathrm{~V} / \mathrm{div}$, A sweep rate to $50 \mu \mathrm{~s} / \mathrm{div}$ and obtain a stable display. Vertically position display about graticule center. Adjust A VARIABLE to obtain 5 div of positive half-cycle. Invert CH 2 and note displayed half-cycle is 5 div within 0.1 div.
2.7.6 Output Resistance

Connect Special $250 \Omega$ within $0.25 \%$ resistor from 1 V CAL 1 kHz out to ground. Check for 0.5 V within 5 mV with DC VOLTAGE BRIDGE.

### 2.8 Z Axis Input

### 2.8.1 Sensitivity

Remove ground strap from $Z$ Axis Input and connect SAC--ZZ Axis Input---INPUT CH 1 OR X. Set SAC to 5 V , A sweep rate to 0.5 ms/div, CH 1 vertical deflection factor to $1 \mathrm{~V} / \mathrm{div}$, and obtain a stable display. The positive portion of squarewave must dim at normal intensity.

### 2.8.2 Usable Frequency Range

Remove ground strap from Z Axis Input and connect Type 191--Z Axis Input---INPUT CH 1 OR X. Set A SWEEP MODE to NORMAL, A TRIGGERING SOURCE to EXT, and adjust LEVEL to obtain an intensity modulated sweep. Set frequency of Type 191 to 50 MHz , sweep rate to $0.1 \mu \mathrm{~s} / \mathrm{div}$, and MAG to X10. Check for 50 MHz intensity modu1ation.

### 2.8.3 Maximum Input Voltage

Apply 200 VDC to Z AXIS INPUT. There must be no physical damage, discoloration of any component, or change in value of any component beyond its rated tolerance. The Type 454 must operate within its electrical characteristics after the Maximum Input Voltage test.
2.9 Signal Outputs
2.9.1 A Sweep Output Voltage

Monitor A SWEEP with test scope.
2.9.2 A \& B Gates Output Voltages

Monitor A \& B GATE with test scope.
2.9.3 CH 1 OUT (DC Direct Coup1ed)

Output Voltage
Connect 1 V CAL 1 kHz to INPUT CH 1 OR X. Set CH 1 deflection factor to $0.2 \mathrm{~V} / \mathrm{div}$. Monitor CH 1 OUT with test scope.

## Bandwidth

Connect Type 191 to INPUT CH 1 OR X. Set TRIGGER to NORM, MODE to CH 2 , and connect CH 1 OUT to INPUT CH 2 OR Y. Set Type 191 frequency to 50 kHz and adjust amplitude to obtain 4 div of deflection. Increase frequency until 2.8 div are observed. Note frequency.
2.10 Power Source
2.10.1 Line Voltage Ranges

Vary line voltage with 76 TU . Monitor regulated DC power supplies with test scope.
2.10.2 Line Frequency

Connect Type 454/R454 line cord to Tel-Instrument Type 4100-I-H10S. Monitor regulated DC supplies with test scope at frequency limits
2.11 Internal Power Supply

### 2.11.1 Initial Setting

The $-12 \mathrm{~V},+75 \mathrm{~V}$, and High Voltage are set using DC Voltage Bridge. The +12.1 V is measured after 1 V CAL OUT is adjusted.

```
2.11.2 Long Term
The supplies, when measured with DC Voltage Bridge, will be within given tolerances at \(25^{\circ} \mathrm{C}\) within \(5^{\circ} \mathrm{C}\) for any 500 hour period after the first 200 hours.
2:11.3 Ripp1e
Monitor DC supplies with test scope. Measure P-P ripple.
2.11.4 Variation from \(25^{\circ} \mathrm{C}\) within \(5^{\circ} \mathrm{C}\)
Measured during environmental test phase.
2.11.5 High Voltage Accuracy (CRT Cathode)
Measure High Voltage with DC Voltage Bridge.
```

2.12 CRT Display
2.12.1 Horizontal Resolution

Connect Type 184 to INPUT CH 1 OR X. Set sweep rates to $1 \mathrm{~ms} / \mathrm{div}$ and apply 1 ms and 100 us time marks from Type 184. Adjust VARIABLE TIME/DIV for three 1 ms time marks every 2 div. Observe no overlap of $100 \mu \mathrm{~s}$ time marks over the scan area when center 4 div are focused.
2.12.2 Vertical Resolution

Connect 1 V CAL 1 kHz to INPUT CH 1 OR X . Set vertical deflection factor to $10 \mathrm{~V} / \mathrm{div}$, sweep rate to $0.1 \mathrm{~ms} / \mathrm{div}$, A SWEEP MODE to AUTO TRIG, and LEVEL fully cw, and position free-running trace over the vertical scan area. Check for no overlap of trace.
2.12.3 Display Area

Connect Type 191 to INPUT CH 1 OR X. Set sweep rate to $1 \mathrm{~ms} / \mathrm{div}$, A SWEEP MODE to AUTO TRIG, and LEVEL fully cw. Check that the raster produced exceeds graticule limits.
2.12 .4

Geometry
Connect Type 184 to INPUT CH 1 OR X. Apply 1 ms and $100 \mu \mathrm{~s}$ time marks and adjust deflection factor so time marks exceed graticule scan area. Set sweep rate to $1 \mathrm{~ms} / \mathrm{div}$. The $100 \mu \mathrm{~s}$ time marks will be 0.1 div apart. Position $100 \mu \mathrm{~s}$ time marks to bottom of a vertical graticule line. The adjacent $100 \mu$ s time marks must not cross the top of the same vertical graticule line.

Position a $0.5 \mathrm{~ms} / \mathrm{div}$, free-running sweep to top and bottom of graticule, and check the amount of sweep bowing.

### 2.12.5 Trace Rotation Range

Turn Trace Rotation (R1480) fully cw. Vertically center a freerunning trace, and position start of trace to 0 graticule line. Note where trace intersects 10th graticule line below graticule center. Turn Trace Rotation fully ccw. Note where trace intersects 10th graticule line above graticule center. Total dispacement must be at least 0.95 div.

### 2.12.6 Beam Locate

Set A SWEEP MODE to AUTO TRIG, CH 1 POSITION fully cw, and horizontal POSITION fully cw. Set BEAM FINDER to down position. Check that trace is compressed to within graticule area. Set CH 1 POSITION fully ccw. Check that trace is compressed to within graticule area. Set horizontal POSITION fully ccw. Check that trace is compressed to within graticule area. Set CH 1 POSITION fully cw. Check that trace is compressed to within graticule area.

### 2.12.7 Writing Speed

## C-31 Camera System

Set A SWEEP MODE to SINGLE SWEEP and adjust INTENSITY until a spot is just visible at sweep start. Decrease intensity setting so spot just extinguishes. Connect Damped Sinewave Generator to INPUT CH 1 OR X. Set A SWEEP MODE to NORM TRIG. Adjust LEVEL for a stable display and set sweep rate to display three cycles/div. Adjust FOCUS for optimum definition. Attach C-31 camera and set lens to fl.2. Use Polaroid Type 410 speed film ( 10,000 ASA). Focus camera on waveform. Turn SCALE ILLUM fully ccw. Close camera shutter. Set A SWEEP MODE to SINGLE SWEEP, remove signal and reset A sweep. Wait 5 minutes for phosphor to decay. Open camera shutter, and apply signal. Wait 5 seconds and close shutter. Develop film for 10 seconds. Make five exposures on five different rolls of film.

With the same setup, but no signal applied, photograph the graticule. Cut this photograph in half along the horizontal center line to use as a measuring scale.

Mask out sinewave peaks on each waveform photograph, leaving the central third amplitude visible. View photographs while backlighted. Determine first completely visible half cycle on each photograph. Remove the masks and measure peak-to-peak amplitudes of the selected half cycles with the previously prepared measuring scale. Calculate writing speed in div/us (sw) from the formula sw $=\pi$ ( $P-P$ amplitude) (frequency). Average results from the five photographs.

## C-30 Camera System

Use the procedure outlined on the preceding page for the $\mathrm{C}-31$ Camera System except:
a. Attach C-30 camera to bezel.
b. Set camera lens to fl.9.
c. Use Polaroid 3,000 speed film.

## C-40 Camera System

Use the procedure outlined on the preceding page for the $C-31$ Camera System except:
a. Attach C-40 camera to bezel.
b. Set camera lens to f1.3.

### 3.1 Temperature

Perform all tests in a single chamber and, when changing chamber ambient temperature, do not exceed a change rate of $5^{\circ} \mathrm{C}$ per minute.

Nonoperating
Perform all electrical tests, described in Section 2, at $25^{\circ} \mathrm{C}$. Then turn the instrument off and store at $-55^{\circ} \mathrm{C}$ ambient for 4 hours. Change ambient temperature to $+75^{\circ} \mathrm{C}$ and again store for 4 hours. Return the ambient temperature to $25^{\circ} \mathrm{C}$, allow 4 hours for stabilization, and again perform all electrical tests.

Failure Criteria: Instrument and components must meet performance requirements before and after storage. If necessary, internal or external adjustments may be performed to meet required accuracies. Cracking, warping, discoloration or any deformation which interferes with a normal mechanical function also constitutes failure.

Operating
Perform all electrical tests, described in Section 2, at $-15^{\circ} \mathrm{C}$. With the instrument turned off, change ambient temperature to $0^{\circ} \mathrm{C}$ and allow the instrument to stabilize for 4 hours. At the end of this period, turn the instrument on, allow 20 minutes for warm-up, then check accuracy and operation of all front-panel functions. With the instrument operating, change the chamber ambient temperature to $+55^{\circ} \mathrm{C}$ and allow 4 hours for stabilization. At the end of 4 hours, again check the accuracy and operation of all front-panel functions. Return the instrument to $25^{\circ} \mathrm{C}$, allow 4 hours for stabilization, then perform all electrical tests described in Section 2.

Failure Criteria: Instrument must meet performance requirements at each step in the test. Controls and switches must operate normally.

### 3.2 Altitude

Altitudes described in this section are referred to sea level. "Normal altitude", when used, refers to the natural elevation (outside the chamber) of the test facility site.

## Nonoperating

Perform all electrical tests described in Section 2 at $25^{\circ} \mathrm{C}$ and normal altitude. Then store, with the instrument turned off, for 4 hours at 50,000 feet. Return chamber to normal altitude and $25^{\circ} \mathrm{C}$ and allow 30 minutes for stabilization. At the end of this period, repeat the electrical tests. This test may be combined with the nonoperating temperature test (3.1).

### 3.2 Altitude (cont)

Failure Criteria: The instrument must meet performance requirements before and after the altitude test, and must experience no cracking or warping, nor any deformation which interferes with a normal mechanical function.

## Operating

Perform all electrical tests described in Section 2 at $25^{\circ} \mathrm{C}$ and at normal altitude. Operate the instrument for 4 hours at 15,000 feet. At the end of this period, maintain that altitude and measure accuracy and operation of front-panel functions. When necessary, open the vacuum chamber and perform required switching as rapidly as possible. Then return chamber to the specified altitude and allow 1 hour for stabilization before continuing the tests. Return the instrument to normal altitude and repeat all electrical tests described in Section 2.

Failure Criteria: Instrument will meet performance requirements before, during, and after the operating altitude tests. Any evidence of malfunction constitutes failure.
3.3 Humidity

Nonoperating
Perform 5 cycles ( 120 hours) of MIL-STD-202C, Method 106B. Delete freezing and vibration. Allow to dry for 24 hours at room ambient conditions $\left(25^{\circ} \mathrm{C}\right.$ within $5^{\circ} \mathrm{C}, 20 \%$ to $80 \%$ relative humidity) prior to operating. Allow one hour warm-up before making measurements.

Failure Criteria: There shall be no significant deterioration of components, materials or finishes. Type $454 / \mathrm{R} 454$ and its components must meet their electrical performance requirements before and after the humidity test. Deformation which interferes with normal mechanical function will not be permitted.

### 3.4 Vibration

## Operating

Perform all electrical tests described in Section 2 before vibrating the instrument. Remove any resilient mounting feet and fasten the instrument securely to the vibration platform. With the instrument operating, vibrate for 15 minutes along each of the three axes at a total displacement of 0.025 inches with the frequency varied from 10-$50-10 \mathrm{c} / \mathrm{s}$ in 1 minute cycles. Hold at any resonant point for 3 minutes in each axis for a total vibration time of about 55 minutes. Turn off the vibration platform and repeat all electrical tests described in Section 2.

### 3.4 Vibration (cont)

Failure Criteria: The instrument must meet performance requirements before and after the vibration tests. (Sporadic output during vibration is permissible.) Mechanical failures are indicated by:

Broken leads
Broken chassis
Broken components
Loose parts
Excessive wear
Component fatigue
Change in component value outside rated tolerance Deformation which interferes with a normal mechanical function

Test will be completely rerun after repairing any of these failures.

### 3.5 Shock

Nonoperating
Perform all electrical tests described in Section 2 before proceeding with the shock tests. Subject the instrument to shock of 30 g 's, $1 / 2$ sine, 11 ms duration; 2 such shocks each direction along each of the 3 major axes for a total of 12 shocks.

Failure Criteria: The instrument will meet performance requirements before and after the shock tests. There must be no cracked or broken chassis, components, or leads; component deformation of 0.100 inches or more; nor any deformation which interferes with a normal mechanical function.
3.6 Electromagnetic Interference (MOD 163D)

Operating
Use the test set-up procedures and limits described in specification MIL-I-6181D. The tests will be performed within an electrically shielded enclosure. The instrument must be equipped with a CRT mesh filter. EMI will be check over the following frequency range.

Radiated Interference - from the instrument under test 14 kHz to 1000 MHz
Conducted Interference - through the power cord 150 kHz to 30 MHz

### 3.7 Transportation

Perform all tests described in Section 2 before conducting the transportation tests, then place the instrument in the carton in the manner in which it is normally shipped.

Transportation tests performed in accordance with National Safe Transit Committee Test Procedure 1A.

After the transportation tests, repeat all electrical tests described in Section 2.

Failure Criteria: The instrument must meet performance requirements before and after the transportation tests. There must be no broken components, leads, or chassis members, nor any deformation which interferes with a normal mechanical function.
lis form requests changes in the Engineering Instrument Specification (EIS) or in performance characteristics quoted to the customer via publications such as the Catalog or Instruction Manual. When the instrument has an Engineering Instrument Specification, then it is the controlling document.

Return completed form to Product Evaluation and Modification Engineering Writing 50/425 for approval and distribution.

Instrument Type: $\qquad$
Publication affected: $\qquad$ No. Dated

Requested by: $\qquad$ Dept. $\qquad$ Date $\qquad$ $\triangle$

Change: Item Page No.

From: $\qquad$
$\qquad$
$\qquad$

To: $\qquad$
$\qquad$
$\qquad$

Reason for change: $\qquad$
$\qquad$
$\qquad$


Approval: (Initial in proper space)

| Recomuended Action | Proj. <br> Mgr. | Proj. <br> Eng. | Eval. <br> Mgr. | Eval. <br> Eng. |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Make change immediately |  |  |  |  |  |  |
| Make change at next rewrite |  |  |  |  |  |  |
| Reject |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

is form requests changes in the Engineering Instrument Specification (EIS) or in performance characteristics quoted to the customer via publications such as the Catalog or Instruction Manual. When the instrument has an Engineering Instrument Specification, then it is the controlling document.

Return completed form to Product Evaluation and Modification Engineering Writing 50/425 for approval and distribution.

Instrument Type: $\qquad$
Publication affected: $\qquad$ No. $\qquad$ Dated

Requested by: $\qquad$ Dept. $\qquad$ Date $\qquad$ (1) Change: Item Page No.

From: $\qquad$
$\qquad$
$\qquad$

To: $\qquad$
$\qquad$
$\qquad$
$\qquad$
Reason for change: $\qquad$
$\qquad$
$\qquad$ =
Approval: (Initial in proper space)

| Recomulended Action | Proj. <br> Mgr. | Proj. <br> Eng. | Eval. <br> Mgr. | Eval. <br> Eng. |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Make change immediately |  |  |  |  |  |  |
| Make change at next rewrite |  |  |  |  |  |  |
| Reject |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

'is form requests changes in the Engineering Instrument Specification (EIS) or in performance characteristics quoted to the customer via publications such as the Catalog or Instruction Manual. When the instrument has an Engineering Instrument Specification, then it is the controlling document.

Return completed form to Product Evaluation and Modification Engineering Writing 50/425 for approval and distribution.

Instrument Type: $\qquad$
Publication affected: $\qquad$ No. $\qquad$ Dated

Requested by: $\qquad$ Dept. $\qquad$ Date $\qquad$ $\triangle \mathrm{Cl}$ Change: Item_P_P_ Page No. $\qquad$
From: $\qquad$
$\qquad$
$\qquad$

To:
$\qquad$
$\qquad$

Reason for change: $\qquad$
$\qquad$
$\qquad$
L
Approval: (Initial in proper space)

| Recomanded Action | Proj。 <br> Mgr. | Proj. <br> Eng. | Eval. <br> Mgr. | Eval. <br> Eng. |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Make change immediately |  |  |  |  |  |
| Make change at next rewrite |  |  |  |  |  |
| Reject |  |  |  |  |  |

1
8
8
8
8
8

