# ENGINEERING INSTRUMENT SPECIFICATION 

# TYPE 4S2A DUAL-TRACE SAMPLING UNIT 

FOR INTERNAL USE ONLY TEKTRONIX, INC.

## ENGINEERING

INSTRUMENT SPECIFICATION
TYPE 4S2A
DUAL-TRACE SAMPLING UNIT

Prepared by Technical Writing Dept.


Earl Neuman


FOR INTERNAL USE ONLY
TEKTRONIX, INC.

## PREFACE

This Specification is the reference document for all company activity concerning performance criteria of the instrument herein described. Changes in instrument performance data are accomplished only via the change request forms appearing in the back of this book.

One of the major functions of this Specification is to provide preliminary information to the following departments:

| Manuals | Advertising |
| :--- | :--- |
| Product Information | International Manufacturing Support |
| Product Engineering Reliability | International Marketing |
| Field Training | Manufacturing Quality Assurance |
| Manufacturing Staff Engineering | Manufacturing Management |

This document is printed in two issues: a rough draft published following Prototype Release of the instrument, and a final draft following Engineering Release. Occasionally, if justified by the number of changes, the final draft is updated and reissued following Pilot Production.

Performance Requirements are coded in accordance with page 1-1, and are customer performance requirements. Factory test limits are excluded. Those items coded for "Internal Use Only" are for use in Tektronix Manufacturing Quality Assurance and Field Engineering Offices, and are not to be interpreted as Factory Test Limits.

Factory Test Limits are established by Manufacturing Staff Engineering and are published only in documents issuing from that department; those documents being the Factory Calibration Procedure and the Instrument Performance Checkout Procedure.

This page is used as a guide to insure that all changes to the main body of this book have been made. When a change notice is received, log it on this page, then write in the actual change information on the appropriate page. Change Notice numbers are assigned in sequence. Absence of a number from the sequence indicates a change which has not been entered.

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This is the Instrument Specification for the Type 4S2A $50 \Omega$ Dual-Trace Sampling Unit, and is the reference document for all company activity concerning performance requirements. This specification is for internal use only.

## General Information

The Type 4S2A is an improved version of the Type 4S250 $\Omega$ Dual-Trace Sampling Unit, and is also operated in the Type 661 Oscilloscope. Improvements include faster risetime, addition of an internal trigger source for the timing unit, and due to a redesigned sampling bridge the Type 4S2A exhibits better aberration characteristics.

Functions of Controls and Connectors

MODE
A ONLY
B ONLY
DUAL TRACE

ADDED ALGEB.

A VERT. B. HORIZ.

VERT. POSITION
MILLIVOITS/CM

VARIABLE

SMCOTHING

Selects one of five operating modes.
Only CHANNEL A is displayed.
Only CHANNEL B is displayed.
Both channels display separate signals simultaneously, switched at approximately 50 kHz .

Both channels are combined to display the algebraic sum of two signals as a single trace.

Permits X-Y operation at full bandwidth. CHANNEL A controls vertical deflection and CHANNEL B controls horizontal deflection.
(Both channels)-Controls vertical movement of trace.
(Both channels)-Selects the desired vertical deflection factor.
(Both channels)-Varies vertical deflection factor for adjusting display amplitude between steps of MIIUIVOLTS/CM switch. Extends deflection factor of $2 S / C M(2 \mathrm{mV} / \mathrm{cm})$ position to approximately $2 / 3 \mathrm{mV} / \mathrm{CM}$.
(Both channels)-A gain control in the AC amplifier that decreases loop gain, thereby reducing noise without changing vertical deflection factor.

DC CFFSET

OFFSET MONITOR

DISPLAY

INFUT $50 \Omega$

FROBE POWER
$A-B$ BAL.
(Both channels)-Positions the display vertically on oscilloscope CRT, screen by adding an internal DC voltage to the vertical signal.
(Both channels)-Provides a front-panel jack for monitoring the amount of DC voltage applied to the signal by the DC OFFSET control. The voltage at the jack will be 100 times greater than the offset voltage applied to the vertical signal.
(Both channels)-In the NORMAL position the displayed signal will be the same polarity as the applied signal. In the INVERTED position the displayed signal is the applied signal inverted. With one DISPLAY switch at NORMAL and the other at INVERTED, the MODE switch at ADDED ALGEB., the Type 4 S2A can be used as a differential unit.
(Both channels)-GR 847 connector to a $50 \Omega$ termination for applying signal to input circuit of vertical system. Each channel is a separate system.
(Both channels)-Provides filament, plate voltage and ground return for operation of cathode-follower probe.

Screwdriver adjustment of the CHANNEL A gain. (CHANNEL B gain adjustment is internal). The A-B BAL. control permits the gain of CHANNEL A to be adjusted to match the gain of CHANNEL B.

SECTION 1

## PERFORMANCE REQUIREMENTS

### 1.1 Electrical Characteristics

## IMPORTANT

The following performance requirements and their related validation procedures in Section 3 apply only to a calibrated instrument operating within the environmental limits specified in 1.2, Environmental Characteristics, unless stated otherwise.

Performance requirements are validated by Engineering according to Sections 3 and 4. Production test methods may differ.

Conditions under which a performance requirement is valid may be listed under Supplemental Information or in Section 3 (Electrical Performance Validation). These conditions are an essential part of the performance requirement.

The following codes are used to categorize performance requirements:
G (General Use) This performance requirement may be quoted to a customer.

I (Internal Use Only) This is a customer-type performance requirement (not a factory test limit), but will not be quoted to a customer.

A (All)
$S$ (Sampled) This performance requirement carries a high confidence level and may be tested. on a sample basis.

N (Not Tested)
NOTE: Code colum also provides step number of related validation procedure.

| 1.1 .1 TYPE 4S2A |  |  |  |
| :---: | :---: | :---: | :---: |
| Characteristic | Performance Requirement | Code | Supplemental Information |
| Risetime | $\leq 90 \mathrm{ps}$ | 3.2 .1 | Bridge Volts may have to be readjusted above and below ambient temperature. |
| Input Resistance | $50 \mathrm{~s}, \pm 0.5 \Omega$ | $\begin{gathered} 3.2 .2 \\ \mathrm{GA} \\ \hline \end{gathered}$ | Paralleled by $\approx 0.4 \mathrm{pF}$. |
| MILLIVOLTS/CM |  | 3.2 .3 |  |
| Range | 200 mV to 2 mV in a $1,2,5$ sequence |  |  |
| Accuracy | $\pm 3 \%$ | GA | Checked with $50 \Omega$ signal source. |
| VARIABLE MILLIVOLTS/CM Range | $\geq 1: 3$ | $\underset{\mathrm{GA}}{3.2}$ | VARIABLE increases sensitivity. |
| Displayed Signal change with SMOOTHING | $\leq 1 \%$ | $\begin{gathered} 3.2 .5 \\ \text { IS } \end{gathered}$ |  |
| Dot Transient Response Change with SMOOTHING | $\leq 0.3: 1$ to $\geq 1.05: 1$ | $\begin{gathered} 3.2 .6 \\ I A \end{gathered}$ | Bridge Volts may have to be readjusted.below $20^{\circ} \mathrm{C}$. <br> These performance requirements do not apply above $35^{\circ} \mathrm{C}$. |
| Dot Transient Response | Adjustable to $1.0 \pm 5 \%$ with 0.5 V input | $\begin{gathered} 3.2 .7 \\ \text { IA } \end{gathered}$ |  |
| Sampling Diode Capacitive Feed-Through (Blow-By) | $\pm 1 \%$ | $\begin{gathered} 3.2 .8 \\ \text { IA } \end{gathered}$ |  |

See page l-1 for coding legend

| 1.2 ENVIRONMENTAL CHARACTERISTICS |  |  |  |
| :---: | :---: | :---: | :---: |
| Characteristic | Performance Requirement | Code | Supplemental Information |
| The Type 4S2A is a laboratory instrument. The following environmental limits apply when tested as described in Section 4. |  |  |  |
| Temperature |  |  |  |
| Nonoperating | $-40^{\circ} \mathrm{C}$ to $+65^{\circ} \mathrm{C}$ | GS |  |
| Operating | $0^{\circ} \mathrm{C}$ to $+50^{\circ} \mathrm{C}$ | GS | Except as noted in Section 1.1 |
| Altitude |  |  |  |
| Nonoperating | To 50,000 feet | GS | May be tested during nonoperating temperature tests |
| Operating | To 15,000 feet | GS |  |
| Vibration |  |  |  |
| Operating | 15 minutes along each axis at $0.015^{\prime \prime}$ with the frequency varied from $10-50-10 \mathrm{c} / \mathrm{s}$ in 1-minute cycles. Three minutes at any resonant point or at $50 \mathrm{c} / \mathrm{s}$ | GS | Tested with instrument secured to vibration platform. |
| Shock |  |  |  |
| Nonoperating | $30 \mathrm{~g}, 1 / 2$ sine, 11 ms duration, 1 shock per axis | GS | Guillotine type shocks. |
| Transportation |  |  |  |
| Package Vibration | 1 hour, slightly in excess of 1 g | GS | Package should just leave vibration surface. |
| Package Drop | 30 inches on 1 corner, all edges radiating from that corner and all flat surfaces | GS | Total of 10 drops. |

[^0]
## SECTION 2

## MISCELLANEOUS INFORMATION

2.1 Ventilation
No special ventilation required. Ventilation adequate for main frame is adequate for Type 4S2A.

### 2.2 Finish

Front panel is anodized aluminum.
2.3 Dimensions
Fits any 4 series plug-in compartment.
2.4 Connectors
INPUT $50 \Omega$ OFFSET MONITOR PROBE POWER
GR 874
Banana jack
Multi-pin

### 2.5 Warm-up

Twenty minutes for rated accuracies at $25^{\circ} \mathrm{C} \pm 5^{\circ} \mathrm{C}$.
2.6 Weight
9 pounds, 9 ounces.

## SECTION 3

## ELECTRICAL PERFORMANCE VALIDATION

3.1 ERUIPMENT RBQUIRED

Plug-in Oscilloscope

| 1 | Type 661 | Tektronix Oscilloscope |
| :--- | :--- | :--- |
| 1 | Type 5T3 | Tektronix Timing Unit |

Test Equipment

| 1 | 540 series | Tektronix Oscilloscope |
| :---: | :---: | :---: |
| 1 | 1 Al | Tektronix Dual-Trace Plug-in Unit |
| 1 | 1S2 | Tektronix Sampling Unit or Type 661, Type 4S2A and Type 5T3 |
| 1 | Type 106 | Tektronix Square-Wave Generator |
| 1 | -- | $50 \Omega$ Standard Amplitude Calibrator |
| 1 | 067-0513-00 | Calibration Fixture, TD Pulse Generator |
| 1 | - - - - | $50 \Omega$ Resistance Bridge |
| 1 | Model 801 | John Fluke Differential DC Voltmeter |
| 1 | 262 or | Simpson meter, 20,000 $3 / \mathrm{V}$ |
|  | 630 | Triplett meter, $20,000 \mathrm{~s} / \mathrm{V}$ |

Test Accessories
1 012-0057-00
1 012-0064-00
1 012-0070-00
$50 \Omega$ Cable, BNC

1 017-0080-00
2 017-0079-00
4 017-0078-00
2 017-0505-00
2 017-0502-00
2 017-0501-00
Flexible Extension
$50 \Omega$ Gremar Cable
2X GR Attenuator
5X GR Attenuator
10X GR Attenuator
2 ns Cable, GR
5 ns Cable, GR
2 017-0064-00 Adapter, GR to BNC
10 ns Cable, GR
1 017-0069-00
$50 \Omega$ GR Tee
012-0069-00 4S1/4S2 Sub-Chassis Extension Board

-     -         - . - GR, 30 cm Air Line

1 - - - - - GR, 30 cm Air Line
1 - - . - - Type 111 Variable Attenuator
2 - . . . . - Special Subminax to GR adapter

### 3.2.1 Risetime

Performance Requirement: $\leq 90 \mathrm{ps}$
Measurment: Connect a 30 ps TD Pulse Generator through a 30 cm air line to INPUT 50 . . Connect a GR cable from the 30 ps TD Pulse Generator trigger output to Type 5T3, $50 \Omega$ EXT TRIG INPUT. Set Type 5T3 ERUIVALENT TIME/CM to 20 psec and adjust TRIG LEVEL for a stable display. Adjust VARIABLE MILLIVOLTS/CM for an 8 cm display. Check Risetime to be within the limits stated in the performance requirement. Check both $A$ and $B$ channel.

### 3.2.2 Input Resistance

Performance Requirement: $50 \Omega \pm 0.5 \Omega$
Measurement: The instrument must be turned off for this measurement. A resistance bridge, with an accuracy of $\pm 0.1 \%$, is connected between INPUT $50 \Omega$ and ground. Deviation from $50 \Omega$ is noted.

### 3.2.3 MILLIVOLIS/CM

Performance Requirement: Accuracy $\pm 3 \%$
Measurement: Connect $50 \Omega$ Standard Amplitude Calibrator to INPUT $50 \Omega$. Connect trigger signal from SAC to Type $5 \mathrm{~T} 350 \Omega$ EXT TRIG INPUT. Each MILLIVOLIS/CM setting is checked for correct amplitude. Error is the deviation from correct amplitude expressed as a percentage of correct amplitude.

### 3.2.4 VARIABLE MILLIVOLTS/CM Range

Performance Requirement: $\geq 1: 3$
Measurement: Measure with same signal as in 3.2.3, MILLIVOLTS/CM is set at 100 . The $50 \Omega$ SAC is set at 120 mV . VARIABLE MILLIVOLTS/ CM is turned fully cw and signal amplitude is checked for 3.6 cm or more.
3.2.5 Displayed Signal change with SMOOTHING

Performance Requirement: $\leq 1 \%$
Measurement: Checked with a Type 106 HI AMPLITUDE OUTPUT. Set for 5 cm display with SMOOTHING at NORMAL. Set SMOOTHING ccw and note the amplitude change. Change in pulse amplitude is noted and expressed as a percentage of 5 cm .

### 3.2.6 Dot Transient Response Change with SMOOTHING <br> Performance Requirement: $\leq 0.3: 1$ to $\geq 1.05: 1$

Measurement: Set Type 106 for 100 mV output into A INPUT $50 \Omega$. Set Type 5 T 3 SAMPLES/CM at 5. Adjust Type 5T3 so Type 106 step transition is made between dots. Set SMOOTHING fully cw. The first dot after the step must be $5 \%$ higher than the following dots. Rotate SMOOTHING ccw, and note the first dot to be less than $30 \%$ of the total squarewave amplitude. Check both the + and - edges of the squarewave.

Repeat this check in CHANNEL B.

### 3.2.7 Dot Transient Response

Performance Requirement: Adjustable to $1.0 \pm 5 \%$ with 0.5 V input.

Measurement: Set Type 106 to 1 kHz repetition rate and AMPLITUDE to 0.5 V into A INPUT. Set 5 T 3 to REAL TIME, 100 kHz Sampling Rate and check if DTR is adjustable to unity gain for both + and - edges of the squarewave. If DTR is unity on + edge, it must be within $\pm 10 \%$ of unity on - edge. Repeat this check in CHANNEL B.

### 3.2.8 Sampling Diode Capacitive Feed-through (Blow-by)

Performance Requirement: $\pm 1 \%$
Measurement: Set MILLIVOLIS/CM at 100 and Type 5 T3 EQUIVALENT TIME/CM at $.2 \mu \mathrm{~s}$. Connect a signal from Type 106 HI AMPLITUDE OUTPUT through a 10 X attenuator to the Type 4S2A INPUT 50 s. Adjust Type 106 Repetition Rate for approximately 100 kHz and AMPLITUDE for 5 cm . Change MILLIVOLTS $/ C M$ to 5 . Each cm of vertical signal now represents $1 \%$ of total signal amplitude. Note deviation from flat portion of pulse top and express as a percentage.

### 3.2.9 Noise (Tangential)

Performance Requirement: $\leq 4 \mathrm{mV}$ at $D T R=$ Unity s 2 mV SMOOTHING full ccw

Measurement: Set MILLIVOLIS/CM at 100. A Type 106 signal is connected to Type 4S2A INPUT $50 \Omega$, through two 10X attenuators. Set DTR to unity with the SMOOTHING control. Set MILLIVOITS/CM to 5. The POSITION control and variable attenuator are used to adjust the signal so that approximately $10 \%$ of the baseline dots are above a horizontal line and approximately $10 \%$ of the dots are below the same line (see drawing). Signal-to-noise ratio is now lil.


### 3.2.9 Noise (Tangential) (cont.)

One of the 10X attenuators is then removed from the network, causing pulse amplitude to be increased by a factor of 10. Noise is then calculated by dividing the pulse amplitude by ten.
3.2.10 Dynamic Range

Performance Requirement: + and - IV
Measurement: Set Type 661 Amplitude-Time calibrator to 1000 mV and $0.01 \mu \mathrm{~s} /$ cycle. Connect to A INPUT and Type $5 \mathrm{~T} 350 \Omega$. The waveform observed should be an undistorted replica of the calibrator signal. Check for possible distortion by rotating Calibrator Amplitude switch to 100 and note waveshape.
3.2.11 Baseline Shift (with repetition rate change).

Performance Requirement: $\leq 10 \mathrm{mV}, 10 \mathrm{~Hz}$ to 100 kHz
Measurement: Set MILLIVOLTS/CM to 5. Connect Type 106 to Type 5 T 350 \& EXT TRIG INPUT. Set Type 106 Repetition Rate just below 100 kHz . Adjust Type $5 T 3$ TRIG LEVEL control for stable triggering. Slowly decrease Type 106 Repetition Rate to 10 Hz and note trace shift.
3.2.12 Memory Slash

Performance Requirement: $\leq 0.2 \mathrm{~cm}$ slash at 50 Hz No slash visible above 150 Hz

Measurement: Checked with MILLIVOLIS/CM at 200. Connect Type 106 as in 3.2.11. Set Type 106 Repetition Rate to 50 Hz and note vertical amplitude of slash. Increase Type 106 Repetition Rate to 150 Hz and check for no slash lines.
3.2.13 VERT. POSITIION Range

Performance Requirement: $\geq+$ and -5 cm
Measurement: Checked at 200 MILLIVOLTS/CM with free-running no-signal trace. Position control is set fully ccw. DC OFFSET is used to place the trace at the bottom graticule line. VERT. POSITION is rotated cw to move the trace 5 cm upward. DC OFFSET is again used to move the trace to the graticule bottom line. Full cw rotation of the VERT. POSITION control must move the trace upward 5 cm or more.

### 3.2.14 OFFSET MONITOR

Performance Requirement: Range : - $100 \mathrm{~V}, \pm 5 \%$ to $+100 \mathrm{~V}, \pm 5 \%$
Accuracy: $\pm 1 \%$
Measurement: (Range) Using a John Fluke differential voltmeter, the OFFSET MONITOR Range is checked to the limits stated in the performance requirement while the DC OFFSET is rotated through its range.
(Accuracy) The DC OFFSET is adjusted for zero volts at OFFSET MONITOR. Set MILLIVOLIS/CM at 5. Position at mid-screen trace with VERT. POSITION control. A 600 mV signal from a $50 \Omega$ SAC is connected to Type 4S2A INPUT. Using the DC OFFSET only, the signal top is positioned to a mid-screen reference point, and the OFFSET MONITOR voltage measured. Deviation from 60 volts is expressed as a percentage of 60 volts.
3.2.15 Co-Channel Time Coincidence

Performance Requirement: $\leq 20 \mathrm{ps}$
Measurement: Connect 30 ps TD Pulse Generator to both $A$ and $B$ Channels through a 30 cm air line, a GR Tee and two 5 ns cables. Trigger Type 5 T3 externally from TD Pulse Generator pretrigger output. Set Type 5 T 3 EQUIVALENT TIME/CM to 20 pSEC. Set Type 4S2A MODE switch to DUAL TRACE. Display 8 cm of vertical signal and position top baselines to upper graticule line.

Adjust for zero time difference between channels by sliding the connection of one of the cables out of the GR Tee. Reverse the cables at the Type 4S2A INPUTS. Be sure the two upper baselines coincide at the upper graticule line and note the time difference.
3.2.16 Strobe Kickout

Performance Requirement: $\leq \pm 50 \mathrm{mV}$ into $50 \Omega$
Measurement: Set system under test 5 T3 at FREE RUN and Type 661 HORIZONTAL DISPLAY at MANUAL SCAN. Connect DELAYED PULSE $50 \Omega$ to test scope Type $5 \mathrm{~T} 350 \Omega$ EXT TRIG INPUT. Connect A or B INPUT $50 \Omega$ of system under test to test scope A INPUT 50 . . Trigger test scope Type 5 T 3 and check amplitude of kickout signal to be within the performance requirement.
3.2.17 Trigger output

Performance Requirement: Amplitude: $\geq 0.1 X$ signal voltage Risetime : $\leq 1 \mathrm{~ns}$ from $10 \%$ to $50 \%$ Points

Measurement: Connect 30 ps TD Pulse Generator to A INPUT $50 \Omega$. Observe trigger output of Type 4 S 2 A with test scope 4 S 2 A through a special Subminax to GR cable. Check risetime and amplitude to be within the performance requirement.

## SECTION 4

ENVIRONMENTAL PERFORMANCE RE\&UIREMENTS

### 4.1 Temperature

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

### 4.1.1 Nonoperating

Perform all electrical tests, described in Section 3, at $25^{\circ} \mathrm{C}$. Then turn the instrument off and store at $-40^{\circ} \mathrm{C}$ ambient for 4 hours.

Change the ambient temperature to $+65^{\circ} \mathrm{C}$ 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.
4.1.2 Operating

Perform all electrical tests, described in Section 3, at $25^{\circ} \mathrm{C}$.
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 $+50^{\circ} \mathrm{C}$ 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 3.

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

### 4.2 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.

### 4.2.1 Nonoperating

Perform all electrical tests described in Section 3, at $25^{\circ} \mathrm{C}$ and normal altitude. Then store, with the instrument turned off, for 4 hours at 50,000 feet and $-40^{\circ} \mathrm{C}$.

Return chamber to normal altitude and $25^{\circ} \mathrm{C}$ and allow 4 hours for stabilization. At the end of this period, repeat the electrical tests.

This test may be performed with the nonoperating temperature test (4.1.1).

## 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.

### 4.2.2 Operating

Perform all electrical tests described in Section 3, 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 the 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 3.

## Failure Criteria

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

### 4.3 Vibration

### 4.3.1 Operating

Perform all electrical tests described in Section 3 before vibrating the instrument.

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 $0.015^{\prime \prime}(1.9 \mathrm{~g}$ at $50 \mathrm{c} / \mathrm{s}$ ) and with the frequency varied from $10-50-10 \mathrm{c} / \mathrm{s}$ in 1 minute cycles. Hold at any resonant point for three minutes.

If no resonances are present, vibrate at $50 \mathrm{c} / \mathrm{s}$ for three minutes in each axis for a total vibration time of about fifty-five minutes.

Turn off the vibration platform and repeat all electrical tests described in Section 3.

Failure Criteria
The instrument must meet performance requirements before and after the vibration tests. (Sporadic output during vibration is permissable.)

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 except vacuum tubes. Vacuum tubes may be replaced and the test continued at the point of failure. (This does not apply to cathode ray tubes or transistors.)
4.4 Shock
4.4.1 Nonoperating

Perform all electrical tests described in Section 3 before proceeding with the shock tests.

Subject the instrument to guillotine type shocks of $30 \mathrm{~g}, 1 / 2$ sine, 11 ms duration; 1 shock each direction along each of the 3 major axis for a total of 6 shocks.

Repeat all electrical tests described in Section 3.

## 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 " or more; nor any deformation which interferes with a normal mechanical function.
4.5

Transportation
Perform all tests described in Section 3 before conducting the transportation tests, then place the instrument in the carton in the manner in which it is normally shipped.
4.5.1 Package vibration

Vibrate for 1 hour in a manner causing the package to must leave the vibration platform (slightly in excess of l g ).

### 4.5.2 Package Drop

Drop the package from a height of $30^{\prime \prime}$ on one cormer, on all edges radiating from that corner, and on all flat surfaces for a total of 10 drops.

After the transportation tests, repeat all electrical tests described in Section 3.

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.

## ENGINEERING

## INSTRUMENT SPECIFICATION

CHANGE REQUEST

Changes to Engineering Instrument Specifications are initiated on this form. Mail the completed form to PREPROD. ENG. EVAL. TECH. WRITING. The request will be processed by that organization and, if approved, the revision accomplished.

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## ENGINEERING

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## 4S2A CIRCUIT DESCRIPTION

## Genera1 - Comparison with old 4S2

The major modification which transforms a $4 S 2$ sampler into a 4 S 2 A is composed of changes in the gate generator and sampler, with minor wiring harness alterations.

The gate generator still uses a high voltage silicon avalanche transistor to drive a snap-off diode. The memory gate driver has been changed to a circuit which is not affected by avalanche volts adjustment. The bridge volts and balance circuits have been removed from this chassis and placed on the sampler chassis.
The sampler chassis holds a very high gain preamp with good + and - going ability. This preamp works on a charge collected from a two-diode sampling gate. The normal blow-by problems inherent in samplers are taken care of by a charge-nulling technique which uses an inverting amplifier and variable coupling cap (labeled transient response). A trigger pick-off amplifier is included in Channel A only. It uses an inverted signal from the charge-nulling amplifier for that channel. Bridge volts and balance controls act much as before.

## Gate Generator

Two basic circuits are contained on this EC board -- the strobe generator and the memory gate driver.
The strobe generator uses a base triggered NPN silicon avalanche transistor to turn off a normally forward biased snap-off diode. The avalanche transistor (Q1054) is set for optimum operation with the emitter follower (Q1053) controlled by the 100 k pot. The avalanche transistor is collector-coupled to the snap-off circuit through a small 22 pf capacitor. The 10 k collector load thus assures ample recovery to within a few tenths of a percent when operated at a 100 kHz rep rate.

The snap-off diode forward bias current is set by the Q1063 emitter follower and its 10 k base pot. It is set for maximum output strobe, or sampling efficiency. The 5-turn bifilar transformer changes the single-ended avalanche drive pulse into a push-pull signal which reverse biases the snap-off diode. This diode is mounted in a very low inductance system of balanced clip lines and $50 \Omega$ strip transmission lines for close control of the width and balance of the plus and minus strobe signals.
The Memory Gate Driver
The memory gate driver circuit uses a 2 N 1304 (Q1064) saturated pulse standardizer to switch a 2 N741A (Q1074) output transistor. The coupling circuit between the 2 N1304 collector and the 2 N741A base consists of a ramp circuit. The height of the ramp is set by the memory gate width pot and its duration is determined by its height, the 100 pf charging cap, and the 4.7 k long-tail resistor connected to +19 .

Before the reception of a start sample signal from the timing unit, both of the memory driver transistors are off. 4 mA flows from +19 through the 4.7 k resistor to the series 6185 diode. There the current splits into two paths. Two mA flows through the 10 k resistor to -19 and the other two flow through the shunt 6185 diode. The collector voltage of the 2 N1304 is set by the memory gate width pot.

The arrival of a start sample pulse saturates the 2 N1304. This transistor stays saturated for several hundred nanoseconds, until the circuit has completed its memory drive pulse and is ready to recover. The negative collector excursion is AC coupled to the 2N741A base through the 100 pf cap and the series 6185 diode. The diode turns off, and the base side of the 100 pf cap falls as many volts as the 2 N 1304 collector travels. The shunt 6185 diode turns off, and the 2 mA from the 10 k resistor is now switched into the 2 N 741 A , causing it to saturate. A memory drive pulse is thus started.
After this initial switching action, the base side of the 100 pf cap starts charging toward +19 V from the current supplied to it by the 4.7 k resistor. It makes it an far as +0.3 V , at which point the merian 6185 diode turna on again and switches the charging current into the base of the 2 N 741 A , pulling it off and ending the memory drive pulse. (This transistor is used because of its very fast saturation recovery characteristic.) Sometime later the 2N1304 comes out of saturation, allowing the collector side of the 100 pf cap to charge back toward voltage value selected by the pot.

## Sampler

Four basic circuits are contained on the two etched circuit boards which form the sampler. These are the charge-nulling inverting amplifier, the two-diode gate, the bridge voltage and balance circuitry, and the preamplifier.

The two-diode sampling gate operates much the same way as a four-diode gate without the back two diodes. An RC network replaces the back two diodes so that differential error signal from the sampling process can be coupled to the grid of the preamp.
There are several reasons for going to a two-diode gate in the 4S2A. Among the chief reasons are:

1. Simpler equivalent circuit.
2. Fewer transit time problems across the gate. The signal transit time across the old four-diode gate board was not much shorter than the sampling interval.
3. A simpler diode matching problem exists with only two diodes in the gate.
The main disadvantage to the two-diode gate is the old sampling problem known as blow-by. In a four-diode gate, the total gate capacity from signal source to preamp grid was reduced to an extremely small value, except for very high frequency components. This small shunt $C$ was made possible by connecting the corners of the gate to ground through low impedance RC networks.
In a two-diode gate, the shunt $C$ is the parallel $C$ of the two diodes. Blowby charge is thus equal to this shunt $C(\simeq 0.5 \mathrm{pf})$ times the signal step size. In terms of percentage, roughly $50-100 \%$ blowby effects are seen with an uncompensated or un-nulled two-diode gate.
Blowby is seen as a false response of the sampler to a transient signal and is seen in signals with long term components in the $100-300 \mathrm{nSec}$ region. The false response is caused by the preamp and amplifier acting on the charge blown into the preamp grid through the shunt $C$ of the sampling gate by the signal voltage.
A gate with extremely bad blowby problems looks very good when used to look at a short, 2 nSec wide pulse or a 100 MHz signal. The reason is that the relatively slow preamplifier does not have a chance to operate on the blown-in
charge before it is sucked back out again. The charge-nulling system used in the 4 S 2 A operates on an input signal in much the same way to cancel out all lower frequency blowby components. If a squarewave of $V$ is presented to the sampler gate, $C_{D} V$ amount of charge is blown into the preamp grid, where $C_{D}$ is the gate shunt C. A small sample of the realtime squarewave signal is taken off through the $390 \Omega$ resistor in the termination and inverted in the termination and inverted in the 151-0138-00 inverter amplifier. The signal appearing at the $51 \Omega$ collector load is -51 V , (see Channel B). If a cap of the correct size is placed between $\backslash \overline{390+51} /$ the output of the inverting amplifier and the grid, then the blown-in charge $C_{D} V$ will be pulled back out by this amplifier. Its value is $C_{\text {al }}\left(\frac{390+51}{51}\right)$. The squarewave will thus blow a CDV quantity of charge $\mathrm{C}_{\text {null }}=\left(\frac{51}{51}\right) \%$ into the preamp grid, which charge gets sucked back out in about 2 nSecs by the inverting amplifier.

The bridge volts control adjusts the reverse bias on the two-gate diodes. A higher reverse voltage allows the sampler diodes to be turned on for a shorter period of time. A lower voltage gives a slower risetime. Feedback is brought into the bridge balance pot, which is adjusted to compensate for diode, strobe, and other system unbalance signals in synchronism with the strobe generator.
The preamplifier uses a single 6688 tube (V2033) triode connected and run at a $g_{m}$ of 25,000 . This tube is used to drive an emitter follower (Q2043) for impedance transformation. The emitter follower drives another emitter of a common base stage (Q2044) through a $0.015 \mu f$ capacitor. Operation is very simple; a small sampled charge from the gate charges the grid-to-ground capacitance to a small value of voltage, $V$. This same voltage is made to appear across the $0.015 \mu \mathrm{f}$ coupling cap in the transistor emitters. This voltage change causes a charge of $V \times 0.015 \times 10^{-6}$ coulombs to be dumped into the $500 \Omega$ equivalent load of the output (Q2044) transistor. A charge gain roughly equal to the ratio of emitter coupling $C$ to grid $C$ is thus achieved. Risetime is about 40 nSecs. By operating both the emitter follower and the common base stages at the same quiescent current levels, the amplifier has very close to the same response for both plus and minus signals.
In Channel A the output load for the Q1004 inverter amplifier is tied to the emitter of the Q1014 PNP grounded-base isolation amplifier. This amplifier is used to supply AC coupled trigger information to the timing unit. No delay line is incorporated, of course, so the leading edge of a pulse may not be viewed without a pretrigger. The pickoff is useful for sinewave viewing, or for high rep rate pulses.

George Frye
18 Oct. 1965




[^0]:    See page l-l for coding legend

