## WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

## TEKTRONIX



INSTRUCTIDN MANUAL

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All requests for repairs and replacement parts should be directed to the TEKTRONIX Field Office or representative in your area. This will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

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## TABLE OF CONTENTS

PAGE
LIST OF ILLUSTRATIONS ..... iv
LIST OF TABLES ..... v
SECTION 1 GENERAL INFORMATION
Introduction. ..... 1-1
Specifications ..... 1-1
Standard Accessories ..... 1-3
TM 500-Series Instruments ..... 1-3
Installation and Repackaging ..... 1-4
Interface Information. ..... 1-6
Rear Interface Information ..... 1-6
LA 501W Interface Connectors ..... 1-6
SECTION 2 OPERATING INSTRUCTIONS
Safety Information ..... 2-1
Functions of Controls, Connectors, and Indicators. ..... 2-1
First Time Operation ..... 2-3
Data Acquisition ..... 2-3
Word Recognition ..... 2-4
Trigger Output and Delay ..... 2-5
SECTION 3 PERFORMANCE CHECK
Index to Performance Check ..... 3-2
Preliminary Procedure ..... 3-2
Performance Check Procedure ..... 3-2
SECTION 4 CIRCUIT DESCRIPTION
WR 501 System Description ..... 4-1
Detailed Circuit Description ..... 4-3
Input and Pattern Matching Circuits ..... 4-3
Output from Probe ..... 4-3
Data Inputs and Pattern Matching ..... 4-3
Data Pickoff for the LA 501 ..... 4-3
Qualifier Input ..... 4-4
Clock Input ..... 4-4
Threshold Setting Circuit ..... 4-4
Clock and Qualifier Circuits ..... 4-5
Word Qualifier ..... 4-5
Clock Qualifier ..... 4-5
Clock Gate . ..... 4-6
Clock LED Driver ..... 4-6
Word Recognition ..... 4-7
Filter Circuit ..... 4-7
Word Recognition (Wired OR) ..... 4-7
Delay Events Selector. ..... 4-7
Trigger Delay Detector ..... 4-8
Delay Counters ..... 4-9
Count Start Circuit ..... 4-10
Count Gate ..... 4-10
LSB Counter ..... 4-10
TTL Counter Gate ..... 4-10

## TABLE OF CONTENTS (cont)

PAGE
SECTION 4 CIRCUIT DESCRIPTION (cont)
TTL Counters ..... 4-10
TTL Load ..... 4-11
99990 Hold ..... 4-11
End of Count Output ..... 4-11
Delay Counters Reset and Load ..... 4-11
Reset After the Delay Count Ends ..... 4-11
Manual Reset ..... 4-12
Trigger Output ..... 4-13
Trig Out ECL/TTL Converter ..... 4-13
Trig Out LED Driver ..... 4-14
LA 501 Trigger Signal ..... 4-14
Power Supply ..... 4-14
-4.9 V Power Supply ..... 4-14
+15 V and -15 V Power Supplies ..... 4-15
-2 V Power Supply ..... 4-15
+5 V Power Supply ..... 4-15
LA 501 Interface. ..... 4-16
Z-Axis Circuit (Generation of the Cursor) ..... 4-16
SECTION 5 MAINTENANCE
Preventive Maintenance ..... 5-1
Cleaning ..... 5-1
Visual Inspection. ..... 5-1
Lubrication ..... 5-1
Semiconductor Checks ..... 5-1
Adjustment After Repair ..... 5-1
Troubleshooting ..... 5-2
Troubleshooting Equipment ..... 5-2
Troubleshooting Aids ..... 5-2
Troubleshooting Techniques ..... 5-4
Corrective Maintenance ..... 5-6
Replacement Parts ..... 5-6
Soldering Techniques ..... 5-6
Component Removal and Replacement ..... 5-7
Fuse Replacement ..... 5-7
Switch Replacement ..... 5-7
Semiconductor Replacement ..... 5-7
Interconnecting Cable and Pin Connector Replacement ..... 5-7
Daughter Board Replacement ..... 5-8
Main Board Replacement ..... 5-9
Switch Board Replacement ..... 5-9
SECTION 6 ADJUSTMENTS
Adjustment Conditions ..... 6-1
Limits and Tolerances ..... 6-1
Test Equipment Required ..... 6-1
Preliminary Procedure ..... 6-2
A. Power Supplies ..... 6-2
B. Filter. ..... 6-3
SECTION 7 ELECTRICAL REPLACEABLE PARTS

# TABLE OF CONTENTS (cont) 

| SECTION 8 | OPTIONS |
| :--- | :--- |
| SECTION 9 | DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS |
| SECTION 10 | MECHANICAL REPLACEABLE PARTS |
| SECTION 11 | ACCESSORIES |
| CHANGE INFORMATION |  |

## LIST OF ILLUSTRATIONS

FIGURE NO. PAGE
1.1 Installing a WR 501 in a TM 500 Power Module ..... 1-4
1 -2 Location of P125 ..... 1-6
1 . 3 Location of P25 and P446. ..... 1-7
2.1 WR 501 front panel controls, connectors, and indicators. ..... 2-1
$2 \cdot 2$ WR 501 front panel controls connectors, and indicators ..... 2-2The P6451 Data Acquisition Probe has retractable probe tips2-4
3.1 Test setup for checking threshold voltages ..... 3-2
$3 \cdot 2$
Adjusting pulse generator for ECL voltage levels ..... 3-4
Test setup for minimum input swing and pulse width ..... 3-4
Test oscilloscope displays for Minimum Input Swing and Pulse Width Checks ..... 3-5
Oscilloscope displays for the Delay Counters check ..... 3-8
Test setup for Clock Qualifier check ..... 3-11
Test setup for word (combintaion of channels) check ..... 3-12
Signal interconnection for word check ..... 3-12
4.1 Simplified Block Diagram ..... 4-2
Ch 5 Input timing diagram ..... 4-3
Ch 5 Input circuit ..... 4-4
Simplified diagram of one channel in the P6451 Data Acquisition Probe ..... 4-5
Clock Qualifier timing diagram ..... 4-6
Timing Diagram showing the Clock Gate output ..... 4-7
Word timing in ASYNC and SYNC modes ..... 4-8
ASYNC and SYNC paths thru the Word Recognizer ..... 4-9
Automatic reset after delay count is finished ..... 4-12
Manual Reset ..... 4-13
-4.9 V Power Supply Block Diagram ..... 4-14
4-11
-4.9 V Power Supply Timing Diagram ..... 4-15
5-1 Color Code for resistors and capacitors ..... 5-3
5-2 Lead configuration for semiconductor devices. ..... 5-4
5-3
Multi-connector holder orientation ..... 5-4
5-4
Pin connector replacement ..... 4-7
5-5 Location of circuit boards. ..... 5-8
5-6 Location of connectors on Main board ..... 5-9
6-1 Adjustment Locations and test points ..... 6-2
6-2 Test point locations on back of Main board ..... 6-4

## LIST OF TABLES

| TABLE |  | PAGE |
| :---: | :---: | :---: |
| 1-1 | Electrical. | 1-1 |
| 1-2 | Environmental | . 1-2 |
| 1-3 | Information about Interface Connectors, P25 and P125 | . 1-7 |
| 1-4 | Interface Connectors and Pin Assignment. | . 1-8 |
| 3-1 | Test Equipment | 3-1 |
| 3-2 | Propagation Delay . | . 3-5 |
| 5-1 | Power Supply Tolerances | . 5 5-5 |
| 6-1 | Test Equipment . . . | 6-1 |



## GENERAL INFORMATION

This section contains general information, specifications, accessories, and installation instructions.

## INTRODUCTION

The WR 501 is a 16 -channel word recognizer with delay, packaged in a TM 500 plug-in. The WR 501 can provide a trigger signal for an oscilloscope or provide a trigger signal and data acquisition for the LA 501 Logic Analyzer.

Word recognition occurs on a word pattern match in ASYNC mode and on the coincidence of a clock input edge and a word pattern match in SYNC mode. A word pattern match occurs when the data and qualifier inputs match the HI, LO, and $X$ (don't care) settings of the WORD SELECTOR Switches. In the ASYNC mode the WR 501 recognizes only words of longer duration than the filter setting.

The WR 501 can delay the trigger output pulse from 0 to 99,999 clock pulses or words. A word is counted each time word recognition occurs.

Two nine-channel active probes (Tektronix P6451) provide inputs to the WR 501-16 data input channels, one clock (CLK) input, and one qualifier (QUAL) input. A threshold control is provided for each probe-one for 15-8, QUAL inputs and one for 7-0, CLK inputs.

The front panel trigger output signal is TTL compatible and allows an oscilloscope to trigger on a specific digital word.

An internal circuit can be connected to provide data, clock, and trigger signals to the LA 501 Logic Analyzer.

More information about the various uses of the WR 501 can be found in the LA 501W Operators Manual.

## SPECIFICATIONS

The following instrument specifications apply over an ambient temperature range of $0^{\circ}$ to $+50^{\circ} \mathrm{C}$ unless otherwise indicated. The adjustment procedure in Section 6, when performed completely, allows the WR 501 to meet the electrical specifications listed in Table 1-1.

TABLE 1-1
Electrical

| Characteristics |  |
| :--- | :--- |
| CLOCK, DATA, and QUALIFIER INPUTS |  |
| Probe, clock, data, and qualifier <br> Inputs: <br> Input RC |  |
| Threshold voltage (referenced to the <br> probe tip) | $1 \mathrm{M} \Omega \pm 5 \%$, Paralleled by $5 \mathrm{pF} \pm 1 \mathrm{pF}$. |
| $\frac{\text { TTL }}{\mathrm{ECL}}$ |  |
| VAR | Fixed at $+1.4 \mathrm{~V} \pm 0.2 \mathrm{~V}$. |

## General Information-WR 501 Service

TABLE 1-1 (cont)
Electrical

| Characteristics | Performance Requirement |
| :---: | :---: |
| CLOCK, DATA, and QUALIFIER INPUTS (cont) |  |
| Probe, Clock data, and Qualifier Inputs: (cont) <br> Minimum Input Swing | ( 500 mV plus $2 \%$ of threshold voltage) p-p or less centered about the threshold voltage. |
| Maximum Logic Swing | -60 V or less, to at least threshold voltage plus 10 V . |
| Maximum Non-Destructive Input Voltage | -60 V to +60 V. |
| Clock Input Minimum Clock Period | 20 ns or less - HI for at least 10 ns and LO for at least 10 ns . |
| Data and Qualifier Inputs SYNC word mode Minimum Setup time Minimum Hold time | 18 ns or less. |
| ASYNC word mode <br> Minimum Input Pulse Width for 5 ns Output Pulse <br> Any single channel | 10 ns or less. |
| Any combination of channels (word) | 15 ns or less. |
| Filter | At least 300 ns , continuously variable to a minimum of less than 5 ns . |
| Input Delay Difference Between Channels and/or Qualifier | 7 ns or less. |
| Delay by Clock mode Minimum Clock Period | 20 ns or less -HI for at least 10 ns and LO for at least 10 ns . |
| Delay by Word mode Minimum Word Period | 30 ns or less -HI for at least 15 ns and LO for at least 15 ns . |

## TRIG OUT BNC

| Level | HI Level $\geqslant 2.2 \mathrm{~V}$. <br> LO Level $\leqslant 0.6 \mathrm{~V}$. |
| :--- | :--- |
| Delay <br> SYNC mode | Trigger out $\leqslant 50$ ns after edge of clock input and word <br> pattern match at the probe tips. |
| ASYNC mode | Trigger out $\leqslant 50 \mathrm{~ns}+$ filter time after word pattern match <br> at the probe tips. |
| Output Impedance | $50 \Omega \pm 10 \%$. |

TABLE 1-1 (cont)

## Electrical

| Characteristics | Performance Requirement |
| :--- | :--- |

POWER SOURCE

| Line Voltage Ranges | Refer to TM500 Power Module performance requirements. |
| :--- | :--- |

TABLE 1-2
Environmental

| Characteristics | Performance Requirement |
| :--- | :--- |
| Temperature |  |
| Operating | $0^{\circ}$ to $+50^{\circ} \mathrm{C}$ in TM506 mainframe. <br> $0^{\circ}$ to $+40^{\circ} \mathrm{C}$ in other mainframes. |
| Storage | $-40^{\circ}$ to $+75^{\circ} \mathrm{C}$. |
| Altitude |  |
| Operating | to $4.5 \mathrm{~km}(15,000 \mathrm{ft}).$. |
| Storage | to $15 \mathrm{~km} \mathrm{(50,000} \mathrm{ft).}$. |
| Shock | Qualified under National Safe Transit Committee Test <br> Procedure 1A, Category 11. |

## STANDARD ACCESSORIES

| Operators Manual-LA 501W Operators <br> $\quad$ Manual | $070-2169-00$ |
| :--- | :--- |
| Service Manual-WR 501 Service |  |
| $\quad$ Manual | $070-2168-00$ |
| P4651 Data Acquisition Probes (2) | $010-6451-01$ |

## TM 500-SERIES INSTRUMENTS

## Introduction

The WR 501 Word Recognizer/Delay is a member of Tektronix's growing TM 500 line of Test and Measurement Instruments. The TM 500-Series consists of power module
mainframes and plug-in units. The power modules have 1, $3,4,5$, and 6 compartments. The plug-in units include digital multimeters, counter-timers, variable dc power supplies, pulse generators, function generators, calibration sources, oscilloscopes, signal processors, and others.

The power module mainframes provide power and housing for the plug-in units. Using various combinations of power modules and plug-ins, you can assemble a portable test station to use on a bench, to move around on a cart, or carry on field trips.

For more information contact your Tektronix representative.

## LA 501W Logic Analyzer

The WR 501 is also available as part of the LA 501W. In an LA 501W the WR 501 provides data acquisition and a trigger signal for the LA 501. The LA 501W with an SC 502 in a TM 515 provides a portable logic analyzer system. Consult your Tektronix representative for more information about the LA 501W.

## INSTALLATION AND REPACKAGING

## Installation In TM 500 Power Modules

The WR 501 is calibrated and ready for use when received. We designed it to operate properly in a TM 500 Power Module.

Turn the power module off before inserting or removing the WR 501 to prevent damage to the WR 501.

To install the WR 501 in a power module, align the upper and lower rails of the WR 501 with the tracks in the power module (see Fig. 1-1). Now insert the WR 501 into the power module. The front panel will be flush with the front of the power module when the WR 501 is properly installed.

To remove the WR 501 from the power module, pull on the release latch at the bottom of the front panel. The WR 501 will unlatch and you can pull it out of the power module by pulling gently on the release latch.

## Repackaging For Shipment

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm who can be contacted, complete instrument serial number, and a description of the service required.

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:


Fig. 1-1. Installing a WR 501 in a TM 500 Power Module.

1. Obtain a carton of corrugated cardboard having inside dimensions of not less than six inches more than the instrument dimensions; this will allow for cushioning. Refer to the following table for carton test strength requirements.
2. Surround the instrument with polyethylene sheeting to protect the finish of the instrument.
3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between carton and instrument, allowing three inches on all sides.
4. Seal carton with shipping tape or industrial stapler.

## SHIPPING CARTON TEST STRENGTH

Gross Weight (Ib)
0-10
200
10-30
275
$30-120 \quad 375$
120-140
500
$140-160$
600

## REAR INTERFACE INFORMATION

For information concerning the rear interface connector and pin assignments, refer to the power module instruction manual.

## LA 501W INTERFACE CONNECTORS

In instruments used as part of an LA 501W, the data, clock, and trigger signals are sent to the LA 501 via interconnecting cables. These cables go around the rear of the instrument. See Fig. 1-2 and 1-3 for the location of the connectors in the WR 501. Table 1-3 lists information about the signals from the WR 501. For the location of the connectors in the LA 501, refer to the LA 501 Instruction Manual. Table 1-4 lists the pin assignments of the connectors in the WR 501 and the corresponding pin numbers in the LA 501. Notice that P446 in WR 501 connects to P120 in the LA 501. P25 and P125 in WR 501 connect to P100 in the LA 501.


Fig. 1-2. Location of P125.

Table 1-3
Information about Interface
Connectors, P25 and P125

| FUNCTION | INFORMATION |
| :--- | :--- |
| External Clock Output <br> Level | $\mathrm{HI}: \geqslant-0.950 \mathrm{~V}$ <br> LO: $\leqslant-1.600 \mathrm{~V}$ |
| Ch 15 through Ch 0 <br> Data Outputs <br> Level | $\mathrm{HI}: \geqslant-0.950 \mathrm{~V}$ <br> LO: $\leqslant-1.600 \mathrm{~V}$ |
| Delay after clock <br> Output (data and <br> clock inputs driven <br> simultaneously) | $\geqslant 15 \mathrm{~ns}$ |
| Trigger Output <br> Level | HI: $\geqslant-0.950 \mathrm{~V}$ <br> LO: $\leqslant-1.600 \mathrm{~V}$ |
| Delay |  |
| SYNC Mode | Trigger out $\leqslant 15 \mathrm{~ns}$ after edge <br> of clock output (at P125) and <br> word pattern match. |
| ASYNC Mode | Trigger out $\leqslant 45 \mathrm{~ns}$ plus <br> Filter time after word pattern <br> match at the probe tips. |



Fig. 1-3. Location of P25 and P446.

Table 1-4
Interface Connectors and Pin Assignment

| P25 (in WR 501) | Function | P100 (in LA 501) |
| :---: | :---: | :---: |
| Pin 1B | Data channel 13 | Pin 4 |
| Pin 2B | Data channel 12 | Pin 2 |
| Pin 3B | Data channel 9 | Pin 3 |
| Pin 4B | Data channel 8 | Pin 1 |
| Pin 5B | Data channel 11 | Pin 7 |
| Pin 6B | Data channel 10 | Pin 5 |
| Pin 7B | Data channel 15 | Pin 8 |
| Pin 8B | Data channel 14 | Pin 6 |
| Pins 1 A through 8A | Common Ground | Pin 13 |
| P125 (in WR 501) | Function | P100 (in LA 501) |
| Pin 1B | Data channel 5 | Pin 17 |
| Pin 2B | Data channel 4 | Pin 15 |
| Pin 3B | Data channel 1 | Pin 16 |
| Pin 4B | Data channel 0 | Pin 20 |
| Pin 5B | Data channel 3 | Pin 14 |
| Pin 6B | Data channel 2 | Pin 21 |
| Pin 7B | Data channel 7 | Pin 18 |
| Pin 8B | Data channel 6 | Pin 19 |
| Pin 9B | External Clock | Pin 22 |
| Pin 10B | Trigger Output | Pin 9 |
| Pin 11B |  | Pin 25 |
| Pin 12A \& 12B | Clock Status (from LA 501) | Pin 23 |
| Pin 13B | Threshold (ECL) | Pin 10 |
| Pins 1A through 11A, 13A | Common Ground | Pin 13 |
| P446 (in WR 501) | Function | P120 (in LA 501) |
| Pin 1 | Display clock (from LA 501) | Pin 3 |
| Pin 2 | Flag (from LA 501) | Pin 14 |
| Pin 3 | Signal Connection | Pin 17 |
| Pin 4 | Z-axis Control to LA 501 | Pin 16 |

For the LA 501 to function as part of an LA 501W, the internal jumpers must be set as follows:

P100, pin 1 to pin 2.
P101, pin 2 to pin 3
P120, pin 1 to pin 2
P136, pin 1 to pin 2
P608, pin 3 to pin 4
P629, pin 1 to pin 2
P831, pin 3 to pin 4

For more information, see the LA 501 Instruction Manual.

A modification kit is available to join a WR 501 and an LA 501 together as an LA 501W. Contact your Tektronix representative for ordering information.

## OPERATING INSTRUCTIONS

The WR 501 is designed to operate in a TM 500-Series Power Module. We recommend a power module with forced-air cooling, such as a TM 506 or TM 515. During normal operating conditions, the WR 501 should be plugged in to a TM 500 Power Module.

## Safety Information

The WR 501 should not be operated with an extender cable during normal operation. It is designed to operate safely only while plugged into a TM 500-Series Power Module.

Always disconnect the WR 501 from the power source before replacing components to prevent electrical shock.

Refer servicing to qualified service personnel.

## FUNCTIONS OF CONTROLS, CONNECTORS, AND INDICATORS

Refer to Figure 2-1.

CH 7-0, CLK and CH 15-8, QUAL Connectors: Input connectors for the probes. Inputs are the data, qualifier, and clock channels. The clock and the 7-0 data channels come through the right-hand probe. The qualifier and the 15-8 data channels come through the left-hand probe. The WR 501 requires P6451 Data Acquisition probes.

THRESHOLD Selector Switches: Select different logic threshold levels at the probe tips. Each switch controls the threshold level for the probe connected directly beneath it. The voltage levels are:
ECL: fixed at -1.26 V .
TTL: fixed at +1.4 V .
VAR: variable from +10 V to -10 V . Controlled by the THRESHOLD VAR control.
(3) THRESHOLD VAR Control: Varies the threshold voltage level for the probes when the THRESHOLD Selector switch is in the VAR position. Consists of
concentric controls-the inner knob is for Channels $15-8$ and the qualifier inputs, and the outer knob is for Channels 7-0 and clock inputs.

Monitor Pin Jacks: The threshold voltages for each probe are present on these jacks. Used for setting the VAR Threshold voltage of each probe.

POWER Indicator: Comes on whenever there is power to the WR 501.
(6) Ground Pin Jack: A ground point for an oscilloscope or DVM probe.


Fig. 2-1. WR 501 front panel controls, connectors, and indicators.

## Operating Instructions-WR 501 Service

TRIG OUT BNC Connector: The trigger output connector. The WR 501 puts out a trigger signal after word recognition and the delay selected by the Delay Count switches. If the DELAY Selector switch is in the OFF position (or the Delay Count switches are set to 00000), the trigger signal is output right after word recognition occurs.

TRIG OUT Indicator: Comes on momentarily whenever there is a trigger signal present at the TRIG OUT BNC connector.
(9) WORD MODE: Determines whether word recognition occurs synchronously (SYNC) or asynchronously (ASYNC).

SYNC: Word recognition occurs on the coincidence of a word pattern match (the data and qualifier inputs match the settings of the WORD SELECTOR and QUALIFIER Value switches) and the selected clock edge.

ASYNC: Word recognition occurs when the data and qualifier inputs match the settings of the WORD SELECTOR and QUALIFIER Value switches. Only words of longer duration than the FILTER setting are recognized, however.
(10) FILTER: A variable pulse-width filter that operates only in the ASYNC WORD MODE. In the ASYNC mode, words must be of longer duration than the FILTER setting for word recognition to occur. The required duration can be varied from less than 5 ns to 300 ns .

CLOCK: Determines which edge of the external clock signal is used by the word recognizer, the delay counter.
$\int$ Word recognition and data storage occur on the positive-going edge of the clock signal ( LO to HI transition).

工. Word recognition and data storage occur on the negative-going edge of the clock signal ( HI to LO transition).

CLOCK Indicator: Comes on whenever an external clock signal is available for word recognition, the delay counters.
(13) QUALIFIER Value Switch: Determines the logic level that the incoming qualifier signal is compared to, $\mathrm{HI}, \mathrm{LO}$, or OFF. The incoming qualifier signal must match the setting of the QUALIFIER Value
switch before either word recognition or the clock is qualified.
(14) QUALIFIER Selector Switch: Determines whether word recognition, the external clock signal, or both are qualified.

CLOCK: Both the clock and qualifier signals must be present for either SYNC word recognition to occur or clock pulses to be counted by the Delay Counters. The qualifier signal must also match the setting of the QUALIFIER Value switch.

WORD: The qualifier signal must match the setting of the QUALIFIER Value switch and the data must match the settings of the WORD SELECTOR Switches before word recognition occurs. Acts like a 17 th data input.


Fig. 2-2. WR 501 front panel controls, connectors, and indicators.

BOTH: Both the clock signal and word recognition are qualified by the qualifier signal.
(15)

WORD SELECTOR Switches: Each three position switch selects the logic level that the corresponding data channel is compared to. The incoming data must match the HI or LO settings of the switches before word recognition occurs. When a switch is in the X (don't care) position, the corresponding channel is ignored.

Delay Selector Switch: Determines the source of the events used by the delay counter.

CLOCK: The delay counter counts external clock pulses. Be sure you have the CLK lead (C input) of the probe connected to an external clock source. The CLOCK switch determines which edge is counted.

OFF: The delay counter is turned off and a trigger signal is output every time word recognition occurs.

WORDS: The delay counter counts word recognition events. A word is counted once for each word recognition regardless of duration.
(17) DELAY Indicator: Comes on whenever a delay count is in progress.

RESET Push Button: When pushed in, interrupts the delay count and resets the delay counters. Word recognition must occur again in order to start the delay count.

Delay Count Switches: Five switches that set the delay count. Pushing a lower push button once increases the corresponding digit by 1 . Pushing an upper push button once decreases the corresponding digit by 1. The delay count can be set from 00000 to 99999.

## FIRST TIME OPERATION

Use this procedure when you turn your instrument on for the first time. It allows you to get a trigger output. You should return to this procedure whenever you have problems getting an output from the WR 501. You need P6451 Data Acquisition Probe(s), a $50 \Omega$ cable, an oscilloscope with probe, and a periodic signal source. The calibrator signal from the oscilloscope can be used as a signal source.

A complete performance check is in Section 3 and a complete adjustment procedure is in Section 6.

## NOTE

Turn off the power to the TM 500-Series Power Module, before inserting, or removing the WR 501.

Install the WR 501 in the TM 500-Series Power Module.

Initial control settings:

\left.| WORD SELECTOR | X (don't care) - the |
| :--- | :--- |
| Switches (all) | center position |$\right]$| DELAY Switch | OFF |
| :--- | :--- |
| OUALIFIER | OFF |
| WORD MODE | ASYNC |
| FILTER | < ns (fully counter- <br>  <br> clockwise) |
| Delay Count Switches | 00000 |

The settings of the THRESHOLD and CLOCK controls depend on the signal source. If you have a TTL voltage source, you can use the TTL setting of the THRESHOLD Control. Otherwise, set the THRESHOLD Control to VAR, and adjust knobs-one for channels 15-8 and the other for channels 7-0-until the threshold level is set at the midpoint of the signal. The CLOCK Control can be set to either position.

Install the P6451 Data Acquisition Probes in the Data Input Connectors.

Connect the TRIG OUT BNC to the oscilloscope input using the oscilloscope probe.

Refer to the Operating Instructions for the oscilloscope to find out how to set the oscilloscope controls.

Connect Channel 0 (on the 7-0, CLK probe) to the signal source and the GND lead to signal source ground.

Set the Channel 0 WORD SELECTOR Switch to HIup position.

## DATA ACOUISITION

Data is acquired via the P6451 Data Acquisition Probes. The P6451 Data Acquisition Probes are active probes that minimize loading of the circuit under test. Each probe has 10 leads-8 data channels, one for a qualifier or clock signal (labeled O or C on the probes) and one ground lead. The probe leads are connected to the probe pod with colored wires that allow the user to identify the leads. Each probe tip has a retractable hook that grasps a lead or wire firmly.

## Operating Instructions-WR 501 Service

To use the retractable probe tip, push the base of the probe tip until the hook appears. See Fig. 2-3. The hook can be attached to a lead, wire, or test point in a circuit.

The probe in the right-hand connector of the WR 501 provides the data inputs for channels 7 through 0 and for the external clock signal (labeled C on the probe). The probe in the left-hand connector of the WR 501 provides the data inputs for channels 15 through 8 and for the qualifier signal (labeled Q on the probe).

To insure proper operation of the P6451 Data Acquisition Probes, the ground leads should always be connected to a ground point in the circuit under test.

## Setting the Threshold Levels

There are two THRESHOLD controls on the WR 501 one for each probe. The THRESHOLD Selector switches select TTL, ECL, or VAR (variable) voltage levels to which the probes compare the incoming signals. The TTL level is fixed at +1.4 V (about the midpoint of TTL voltage swings) and the ECL level is fixed at -1.26 V (about the midpoint of ECL voltage swings). The VAR (variable) level can be varied from -10 V to +10 V .

To set the VAR levels, connect a digital multimeter to the Monitor jack above the connector of the probe level to be set. Put the THRESHOLD Selector switch in VAR
position. Adjust the THRESHOLD VAR control until the digital multimeter indicates the desired voltage.

## WORD RECOGNITION

The WR 501 recognizes digital words of up to 16 bits by comparing the incoming data from the probes with the settings of the WORD SELECTOR switches. The data must match the settings of the WORD SELECTOR switches before word recognition occurs. Word recognition can occur either synchronously or asynchronously. The trigger signal is generated after word recognition, with or without a delay.

## Setting the WORD SELECTOR Switches

The WORD SELECTOR switches set the logic levels for each of the 16 data channels. The incoming data must match the HI, LO, or X (don't care) settings of the WORD SELECTOR switches before word recognition occurs. Note that the HI and LO levels are with respect to the voltages set by the THRESHOLD controls. For example when the THRESHOLD Selector switch is set to ECL, ground is a HI logic level. When a WORD SELECTOR switch is in the X (don't care) position, the signal or lack of signal on that particular input channel is ignored. The data must be present at the probe tips for a time greater than the minimum for the data to be recognized by the WR 501. Refer to Section 1, General Information, for more information.


Fig. 2-3. The P6451 Data Acquisition Probe has retractable probe tips.

## Word Mode

The WORD MODE switch selects either asynchronous (ASYNC) or synchronous (SYNC) word recognition. In the ASYNC mode the data and qualifier inputs must match the settings of the WORD SELECTOR and QUALIFIER Value switches (a word pattern match) for word recognition to occur. In the SYNC mode word recognition occurs on the coincidence of a word pattern match and a selected clock edge.

ASYNC WORD MODE. In the ASYNC mode the FILTER control selects the required duration of the word recognized by the WR 501. Only words of duration longer than the control setting are recognized. Thus, you can set the WR 501 to ignore narrow words or pulses that you don't want to trigger on.

SYNC WORD MODE. In the SYNC mode an external clock signal must be present at the clock input of the 7-0, CLK probe (the one on the right). The CLOCK control determines which edge of the clock signal that word recognition occurs on.

## Using the Qualifier

The Qualifier can enable the external clock, word recognition, or both. To use the Qualifier to enable word recognition, set the QUALIFIER Selector switch to WORD and the QUALIFIER Value switch to either HI or LO and connect a signal to the Qualifier input of the 15-8, QUAL probe (the left one). To use the Qualifier to enable the clock, set the QUALIFIER Selector switch to CLOCK with a signal connected to the Qualifier input. When the QUALIFIER Value switch is in the OFF position, the qualifier signal is ignored.

When the QUALIFIER Selector switch is in the WORD position, word recognition occurs when the 16 data inputs match the settings of the WORD SELECTOR switches and the qualifier input matches the setting of the QUALIFIER Value switch. The Qualifier input acts like a 17th data input.

When the QUALIFIER Selector switch is in the CLOCK position, the Qualifier signal enables the clock signal. The clock signal is blocked unless the qualifier signal matches the setting of the QUALIFIER Value switch. The same clock signal that is used for word recognition can also be used by the delay counters.

When the QUALIFIER Selector switch is in the BOTH position, the qualifier signal enables both the clock and word recognition.

## TRIGGER OUTPUT AND DELAY

The trigger signal is generated after word recognition, with or without a delay.

## Delay by Clock

To delay the trigger output by clock pulses, set the DELAY Selector switch to CLOCK, enter a number on the Delay Count switches, and connect the clock input to a signal. The external clock signal can be any signal that you want to use. The delay counters count clock signal transitions - either positive going or negative going. The CLOCK switch determines which transition is used. A word-recognition event must occur before the delay counters start counting clock pulses. The DELAY indicator will come on as soon as the delay count starts. When the delay count is finished the WR 501 will generate a trigger signal and the TRIG OUT indicator will come on.

## Delay by Words

To delay the trigger output by word recognition events (words), set the DELAY Selector switch to WORDS and enter a number on the Delay Count switches. The DELAY Indicator will come on as soon as the delay count starts. As soon as the delay count is finished the WR 501 will generate a trigger signal and the TRIG OUT indicator will come on momentarily. A word is counted each time word recognition occurs regardless of duration provided it is longer that the FILTER setting in the ASYNC mode.

## Manual Reset of the Delay Count

To interrupt the delay count, push the RESET button. Pushing the RESET button causes the delay counters to be reset and to start counting again from the next wordrecognition event.

## Using the Trigger Output

To use the trigger output signal to trigger an oscilloscope, connect a $50 \Omega$ cable between the TRIG OUT connector and the oscilloscope external trigger input. Set the oscilloscope for external trigger and connect the oscilloscope vertical input to a signal.

You can trigger your oscilloscope from either edge of the trigger signal. When the oscilloscope is set to trigger on the positive slope, triggering occurs on the occurance of word recognition. When the oscilloscope is set to trigger on the negative slope, triggering occurs when word recognition ends.

## PERFORMANCE CHECK

This procedure allows you to make a covers-on, incoming-inspection check of the basic performance of the WR 501. In this case, covers-on means installed in a TM 500 Power Module. We recommend that you check the performance of your instrument every 1000 hours of operation, every 6 months, or after replacing components. Adjustments and repairs should be referred to qualified service presonnel.

## Limits and Tolerances

Tolerances given are for the instrument under test and do not include test equipment error. Limits and tolerances in this performance check are instrument specifications
only if they are called out as performance requirements in the Specifications section.

## Test Equipment Required

You will need the test equipment listed in Table 3-1 or the equivalent to perform a complete Performance Check of the WR 501. The specifications given for the equipment are the minimum necessary for accurate results. The Performance Check is written using the items of test equipment listed in the Examples of Applicable Test Equipment column in Table 3-1. If other equipment is used, control settings or test setups may have to be altered. The test equipment listed also includes standard accessories for the instrument. For example, the oscilloscope includes two probes.

TABLE 3-1
Test Equipment

| Description | Minimum Specification | Usage | Examples of Applicable <br> Test Equipment |
| :--- | :--- | :--- | :--- |
| 1. Precision DC <br> Voltmeter with <br> probes (2) | Range, 0 to $\pm 16$ V; accuracy, <br> within 0.1\%. Digital volt- <br> meter must have at least <br> $31 / 2$-digit readout. | Check threshold levels. | a. Tektronix DM 501 Digital Multi- <br> meter (operates in a TM 500-Series <br> Power Module) |
| 2. Pulse Generator <br> with cable | Pulse duration, 10 ns to <br> 1 ms; pulse period, $0.1 \mu \mathrm{~s}$ <br> to 10 ms; risetime, 2 ns or <br> less; output amplitude <br> $-3 \mathrm{~V} \mathrm{to} \mathrm{+3} \mathrm{~V}$ with at <br> least $\pm 2 \mathrm{~V}$ of dc offset. | Check minimum input swing, <br> setup and hold, qualifier, <br> filter, delay counters, and <br> word. | a. Tektronix PG 502 Pulse Gene- <br> rator (operates in a Tektronix <br> TM 500-Series Power Module) |
| 3. Oscilloscope with <br> probes (2) | Bandwidth, dc to 200 MHz; <br> minimum deflection factor, <br> $20 \mathrm{mV/div;} \mathrm{accuracy}, \mathrm{with-}$ <br> in 3\%. | Used to display the output of <br> the pulse generator and the <br> output of the WR 501. | a. Tektronix 475 Oscilloscope |
| 4. Adapter, BNC <br> to probe tip |  | Signal interconnection. | Tektronix part 013-0084-01 |
| 5. Adapter, BNC <br> female to BNC <br> female |  | Signal interconnection. | Tektronix part 103-0028-00 |

TABLE 3-1 (cont)
Test Equipment

| Description | Minimum Specification | Usage | Examples of Applicable <br> Test Equipment |
| :--- | :--- | :--- | :--- |
| 7. Adapter, BNC <br> female to dual <br> banana |  | Signal interconnection. | Tektronix part 103-0090-00 |
| 8. Adapter, BNC <br> male to dual binding <br> post |  | Signal interconnection. | Tektronix part 103-0035-00 |
| 9. Special BNC Con- <br> nector, BNC male <br> connector with con- <br> ductor wire. | Signal interconnection. | Tektronix part 131-0602-00 with <br> solder lug and hex nut <br> $(.375-32 \times .500)$ |  |
| 10. Termination | Impedance, $50 \Omega ;$ BNC <br> connectors. | Signal termination. | Tektronix part 011-0049-01 |

## INDEX TO PERFORMIANCE CHECK

1. Threshold Levels . . . . . . . . . . . . . . . . . . . . . . 3-3
2. Minimum Input Swing and Pulse . . . . . . . . . . . 3-3

Width
3. Word Qualifier Check. . . . . . . . . . . . . . . . . . . 3-6
4. Input Delay Difference Between Channels . . . . . 3-6
5. Filter Check . . . . . . . . . . . . . . . . . . . . . . . . . 3-6
6. Delay Counters Check (Delay by Words) . . . . . . 3-6
7. Manual Reset Check. . . . . . . . . . . . . . . . . . . . 3-7
8. Delay by Clock Check . . . . . . . . . . . . . . . . . . 3-7
9. Setup and Hold Check . . . . . . . . . . . . . . . . . . 3-9
10. Clock Qualifier Check . . . . . . . . . . . . . . . . . . 3-10
11. BOTH Qualifier Check . . . . . . . . . . . . . . . . . . 3-10
12. Word (Combination of Channels) Check . . . . . . 3-12

## PRELIMINARY PROCEDURE

Use the following steps to put your instrument into a basic operating mode before proceding with the Performance Check.

1. Plug instrument into a TM 500 Power Module with the power off.
2. Plug P6451 Data Acquisition Probes into WR 501.
3. Connect your TM 500 Power Module to line voltage and turn it on.
4. Let WR 501 warmup for at least 20 minutes before starting Performance Check procedure. This instrument should be checked at an ambient temperature between $20^{\circ}$ and $30^{\circ} \mathrm{C}$ for best overall accuracy.
5. Set controls as follows:

| Delay Count Switches | 00000 |
| :--- | :--- |
| DELAY Selector | OFF |
| $\quad$ Switch |  |
| WORD SELECTOR | X (don't care) |
| Switches (all)  <br> WORD MODE ASYNC <br> FILTER $<5$ ns (fully counter- <br>  clockwise) <br> QUALIFIER OFF <br> THRESHOLD (both) ECL <br> THRESHOLD Variable -10 V (fully counter- <br> (both) clockwise). |  |

6. All oscilloscope vertical control settings are for 1 X probes.

## PERFORMANCE CHECK PROCEDURE

This procedure is continuous. Change control settings or disconnect equipment only where indicated.

## 1. Threshold Levels

Checks threshold levels at the Monitor jacks.
a. Connect digital voltmeter HI input to $15-8$, QUAL Monitor jack and LO input to WR 501 ground jack. See Fig. 3-1.
c. b. CHECK-Threshold voltage is between -1.16 V and -1.36 V .
c. Set:

15-8, QUAL
TTL THRESHOLD
d. CHECK - Threshold voltage is between +1.25 V and +1.55 V .
e. Set:

| 15-8, QUAL | VAR |
| :--- | :--- |
| THRESHOLD |  |
| 15-8, QUAL | -10 V |
| THRESHOLD Variable |  |

f. CHECK-THRESHOLD Variable control varies threshold voltage from less than -10 V to greater than +10 V .

C g. Move voltmeter digital HI input to 7-0, CLK monitor jack.
h. Repeat steps $b$ through f for the 7-0, CLK threshold levels.


Fig. 3-1. Test setup for checking threshold voltages.
i. Disconnect digital voltmeter from WR 501.

## 2. Minimum Input Swing and Pulse Width

This step checks the minimum input swing and pulse width for a 5 ns output pulse, the trigger output levels, the progation delay through the instrument, and the input delay difference between channels.
a. Set the oscilloscope controls as follows: coupling to dc (both channels), horizontal to $10 \mathrm{~ns} /$ div, channel 1 to $0.2 \mathrm{~V} / \mathrm{div}$, channel 2 to $0.5 \mathrm{~V} / \mathrm{div}$, and trigger from channel 1. Set Vert Mode to channel 1 and trigger on the + (positive) slope.
b. Set both THRESHOLD controls to ECL.
c. Connect oscilloscope channel 1 probe to 7-0, CLK monitor jack. Center trace on oscilloscope screen using channel 1 vertical position control.
d. Move channel 1 oscilloscope probe to pulse generator output. See Fig. 3-2. Be sure to ground the probe.
e. Adjust the pulse generator frequency to 10 MHz , pulse width to 5 ns , variable control for 10 ns ( 1 div ) pulse duration, and back termination at the output. Using only the controls on the pulse generator, adjust the pulse generator output for a p-p amplitude of 520 mV ( 2.6 div) centered on the oscilloscope screen.
f. Connect oscilloscope channel 2 probe to the TRIG OUT BNC (on WR 501) via a BNC-to-probe-tip adaptor. Set the oscilloscope for alternate dual trace.
g. Connect Ch 0 probe tip of 7-0, CLK probe to pulse generator output and GND lead to ground on pulse generator. See Fig. 3-3.
h. Set:

Ch 0 WORD
SELECTOR Switch
HI
i. Using only the channel 2 position control, center WR 501 output waveform ( $\mathrm{p}-\mathrm{p}$ ) on oscilloscope screen.
j. Set oscilloscope channel 2 input coupling to Gnd and note the location of the 0 V reference line. Return the oscilloscope coupling to dc.


Fig. 3-2. Adjusting pulse generator for ECL voltage levels.
k. CHECK-Output waveform has a LO voltage level of less than 0.6 V and a HI voltage level of at least 2.2 V (at least 4.4 div from 0 V reference line).
I. CHECK-Output waveform is in the same direction as input waveform. See Fig. 3-4a.


Fig. 3-3. Test setup for minimum input swing and pulse width.
m . CHECK-Width of output pulse at the $50 \%$ point is greater than 5 ns . If the waveform is centered vertically, you should be able to read pulse width along center horizontal graticule line as shown in Fig. 3-4a.
n. CHECK-Time from initial edge of input pulse (at the $50 \%$ point) to initial edge of output pulse (at $50 \%$ point) is less than 50 ns . Refer to Fig. 3-4a.
o. Set:

## Ch 0 WORD SELECTOR Switch

p. Use oscilloscope channel 2 position control to center output waveform ( $p-p$ ) around center horizontal graticule line.
q. Set oscilloscope channel 2 input coupling to Gnd and note location of trace at 0 V reference line. Return oscilloscope coupling to dc.
r. CHECK-Output waveform has a LO voltage of less than 0.6 V and a HI voltage level of at least 2.2 V (at least 4.4 div from 0 V reference line).
s. CHECK-Output waveform is in the opposite direction from input waveform. See Fig. 3-4b.
t. CHECK-Width of output pulse at $50 \%$ point is greater than 5 ns . See Fig. 3-4b.
u. CHECK-Time from initial edge of input pulse (at the $50 \%$ point) to initial edge of output pulse (at $50 \%$ point) is less than 50 ns. Refer to Fig. 3-4b. Record time to the nearest nanosecond in Table 3-2 for later reference.
v. Set:

Ch 0 WORD
SELECTOR Switch

TABLE 3-2 Propagation Delay
(A) WORD SELECTOR SWITCH IN THE HI POSITION.

(B) WORD SELECTOR SWITCH IN THE LO POSITION.

NOTE: WAVEFORMS ARE IDEALIZED.
2168-34
Fig. 3-4. Test oscilloscope displays for Minimum Input Swing and Pulse Width Checks.

## Performance Check-WR 501 Service

w. Disconnect Ch 0 probe tip.
x. Repeat substeps g through w for channels 1 through 7 .
y. Connect oscilloscope channel 1 probe to 15-8, QUAL monitor jack. Center trace on oscilloscope screen using vertical position control. Return the channel 1 probe to the pulse generator output.
z. Repeat substeps g through w for channels 8 through 15.

## 3. Word Qualifier Check

This step checks the word qualifier for minimum input swing and pulse width for a 5 ns output pulse, propagation delay through the instrument, and trigger output levels. Use the test setup given in steps 2a through 2f.
a. Set:

| QUALIFIER Selector | WORD |
| :--- | :--- |
| Switch <br> QUALIFIER Value | HI |
| Switch |  |
| WORD DELECTOR | X (don't care) |
| Switches (all) |  |
| Delay Selector Switch | OFF |
| THRESHOLD (both) | ECL |
| WORD MODE | ASYNC |
| FILTER | $<5 \mathrm{~ns}$ |

b. Connect QUAL input (labeled Q on probe) of 15-8, QUAL probe to output of pulse generator and GND lead to pulse generator ground. Refer to Fig. 3-3.
c. Repeat steps 2 i through 2 u for Qualifier.

## 4. Input Delay Difference Between Channels

Checks the propagation delay difference between the data and qualifier input channels.
a. Using the numbers recorded in Table 3-2 for propagation delay for each data and qualifier input channel, find minimum and maximum propagation delays.
b. CHECK - The difference between the minimum and maximum propagation delay is less than or equal to 7 ns .

## 5. Filter Check

Checks the operation of the FILTER control. Use same test setup as the Word qualifier check.
a. Change the pulse generator output frequency to 1 MHz and pulse width to 50 ns .
b. Adjust the oscilloscope horizontal controls for $50 \mathrm{~ns} /$ div and adjust pulse generator variable duration for a 400 ns pulse width ( 8 divisions). Set oscilloscope vert mode to channel 2.
c. Set:

FILTER 300 ns (fully clockwise)
d. CHECK-Output pulse width decreases by at least 300 ms (6 divisions).
e. Return FILTER Control to $<5 \mathrm{~ns}$ (fully counterclockwise).

## 6. Delay Counters Check (Delay by Words)

Checks delay counters operation. Use the test setup given in steps 2 a through $2 f$ and the Qualifier input.
a. Set the oscilloscope for $10 \mathrm{~ns} / \mathrm{div}$. Adjust the pulse generator for a 100 MHz squarewave that is HI for 15 ns and LO for 15 ns .
b. Set oscilloscope Vert Mode to channel 2, horizontal to $20 \mathrm{~ns} / \mathrm{div}$ and trigger from channel 2. Adjust horizontal variable control so that leading edge of each pulse starts on a vertical graticule line.
c. Set:

| Delay Selector Switch | WORD |
| :---: | :---: |
| Delay Count Switches | 00000 |
| QUALIFIER Selector Switch | WORD |
| QUALIFIER Value Switch | HI |
| WORD SELECTOR Switches | X (don't care) |
| THRESHOLD (both) | ECL |
| WORD MODE | ASYNC |
| FILTER | $<5 \mathrm{~ns}$ |

d. CHECK-Display is unchanged - still one output pulse per division.
e. Sequence Delay Count Switch (ones position) from 00001 to 00009. Be sure you release switch completely each time.
f. CHECK-Output is delayed by count on Delay Count Switches. See Fig. 3-5.
g. Set:

Delay Count Switches 00009
h. Change oscilloscope setting to $.2 \mu \mathrm{~s} / \mathrm{div}$ and adjust horizontal variable control for one output pulse per division.
i. Sequence Delay Count Switch (tens position) from 00019 to 00099. Be sure you release the switch completely each time.
j. CHECK-Output is delayed by count on Delay Count Switches. See Fig.3-5.
k. Set:

Delay Count Switches 00099
I. Change oscilloscope setting to $2 \mu \mathrm{~s} / \mathrm{div}$. You may want to adjust intensity and move baseline off screen (down) for better viewing. Adjust horizontal variable control for one output pulse per division.
m. Sequence Delay Count Switch (hundreds position) from 00199 to 00999 . Be sure you release switch completely each time.
n. CHECK-Output is delayed by count on Delay Count Switches. See Fig. 3-5.
o. Set:

Delay Count Switches
00999
p. Change the oscilloscope setting to $20 \mu \mathrm{~s} / \mathrm{div}$. You may want to adjust intensity or use a viewing hood. Adjust horizontal variable control for one output pulse per division.
q. Sequence Delay Count Switch (thousands position) from 01999 to 09999. Be sure to release switch completely each time.
r. CHECK-Output is delayed by count on Delay Count Switches. See Fig. 3-5.
s. Set:

Delay Count Switches 09999
t. Change oscilloscope setting to $.2 \mathrm{~ms} / \mathrm{div}$. You may want to adjust intensity and use a viewing hood. Adjust horizontal variable control for one output pulse per division.
u. Sequence Delay Count Switch (ten-thousands position) from 19999 to 99999 . Be sure to release the switch completely each time.
v. CHECK-Output is delayed by count on Delay Count Switches. See Fig. 3-5.
w. Return oscilloscope horizontal to calibrated position.

## 7. Manual Reset Check

Checks the manual RESET function. Use the same test setup as the Delay Counters Check.
a. Set:

Delay Count Switches 90009
b. Adjust the pulse generator frequency to 100 kHz .
c. Notice that the TRIG OUT indicator blinks periodically (about every 9 s ).
d. Watch the TRIG OUT indicator. Immediately after it blinks, change the Delay Count Switches to 00009.
e. Push RESET.
f. CHECK-The TRIG OUT indicator is on continuously immediately after RESET is pushed.

## 8. Delay By Clock Check

Checks delay by clock pulses. Use test setup given in steps 2a through 2f.

## Performance Check-WR 501 Service


(A) 00000, 00009, 00099, 00999, 09999, 99999.

(B) 00001, 00019, 00199, 01999, 19999.

(C) 00002, 00029, 00299, 02999, 29999.

(D) 00003, 00039, 00399, 03999, 39999.

(E) 00004, 00049, 00499, 04999, 49999.

(F) 00005, 00059, 00599, 05999, 59999.

(G) 00006, 00069, 00699, 06999, 69999.

(H) 00007, 00079, 00799, 07999, 79999.

(I) 00008, 00089, 00899, 08999, 89999.

(J) 00009, 00099, 09999, 99999.

Fig. 3-5. Oscilloscope displays for the Delay Counters check.
a. Set oscilloscope to $10 \mathrm{~ns} /$ div, channel 1 to $.2 \mathrm{~V} / \mathrm{div}$, channel 2 to $.5 \mathrm{~V} / \mathrm{div}$, vert mode to channel 1. Trigger from channel 1.
b. Connect oscilloscope channel 1 probe to pulse generator output via BNC adaptor used in Minimum Input Swing and Pulse Width Check. See Fig. 3-2 for details.
c. Adjust pulse generator frequency to 100 MHz and pulse duration to 5 ns . Adjust pulse generator for a square wave that is HI for at least 10 ns and LO for at least 10 ns .
d. Set:

| Delay Selector | OFF |
| :--- | :--- |
| Delay Count Switches | 00000 |
| QUALIFIER Value | OFF |
| FILTER | $<5$ ns (fully counter- |
|  | clockwise) |
| THRESHOLD (both) | ECL |
| WORD SELECTOR | X (don't care) |
| Switches  <br> WORD MODE ASYNC |  |

e. Connect Ch 0 and CLK probe tips to the output of the pulse generator.
f. CHECK-CLOCK indicator is on with CLOCK switch in either position.
g. Set:

Ch 0 WORD
SELECTOR Switch
h. CHECK-TRIG OUT indicator is on.
i. Connect oscilloscope channel 2 probe to TRIG OUT connector via a BNC to probe tip adaptor. Adjust oscilloscope for $20 \mathrm{~ns} / \mathrm{div}$ and vert mode to channel 2. Trigger from channel 2.
j. Adjust oscilloscope horizontal variable control until there is one pulse per division on display screen.
k. Set:

Delay Selector Switch CLOCK
I. CHECK-Display is unchanged.
m. Sequence Delay Count Switch (the ones position) from 00001 to 00009. Be sure to release switch completely each time.
n. CHECK-Delay between adjacent pulses is increased by one division for each count on Delay Count Switch starting with 00001.
o. Adjust oscilloscope for $.2 \mu \mathrm{~s} / \mathrm{div}$ and adjust horizontal variable control until there is one output pulse per division.
p. Sequence Delay Count Switch (the tens position) from 00019 to 00099 . Be sure to release switch completely each time.
q. CHECK-Delay between adjacent pulse is increased by one division for each count on Delay Count Switch starting with 00019.

## 9. Setup and Hold Check

Checks the setup and hold times between the data and the clock in the SYNC mode.
a. Set:

| THRESHOLD (both) | ECL |
| :--- | :--- |
| Delay Selector Switch | OFF |

b. Connect oscilloscope channel 1 to Ch 7-0, CLK Monitor jack via the probe. Set oscilloscope channel 1 to $.2 \mathrm{~V} / \mathrm{div}$, input coupling to dc, and horizontal to $10 \mathrm{~ns} / \mathrm{div}$.
c. Using channel 1 position control, center trace on screen.
d. Move channel 1 oscilloscope probe to pulse generator output using connector used in the Minimum Input Swing and Pulse Width Check. See Fig. 3-2.
e. Using only pulse generator controls, adjust pulse generator for a 560 mV ( 2.8 div ) square wave that is HI for 18 ns ( 1.8 div ) and LO for 18 ns and centered about the center horizontal graticule line.
f. Connect the WR 501 TRIG OUT BNC connector to digital voltmeter input via an adaptor and a BNC cable.

## Performance Check-VVR 501 Service

g. Connect Ch 0 and $\operatorname{CLK}(\mathrm{C})$ probe tips to the pulse generator output. Be sure to connect GND lead to ground on pulse generator.

```
h. Set:
\begin{tabular}{lc} 
WORD MODE & SYNC \\
CLOCK & \\
Ch O WORD & \\
\multicolumn{2}{l}{ SELECTOR Switch }
\end{tabular}
```

i. CHECK-HI level at TRIG OUT BNC connector is greater than +2.2 V with the TRIG OUT indicator continuously off.
j. Set:

CLOCK
Ch 0 WORD
SELECTOR Switch HI
k. CHECK-HI level at TRIG OUT BNC connector is greater than +2.2 V, with TRIG OUT indicator continuously off.
I. Disconnect Ch 0 probe tip.
m. Set:

Ch 0 WORD
SELECTOR Switch $\quad X$ (don't care)
n. Repeat steps 9 g through 9 m for channels 1 through 7.
o. Move oscilloscope channel 1 probe to 15-8, QUAL

Monitor jack. Using channel 1 position control, center trace on screen.
p. Move oscilloscope channel 1 probe back to pulse generator output.
q. Using only pulse generator controls, adjust pulse generator for a 560 mV ( 2.8 div) square wave that is HI for 18 ns ( 1.8 div ) and LO for 18 ns and centered about center horizontal graticule line.
r. Repeat steps 9 g through 9 m for channels 8 through 15 and the qualifier.

## 10. Clock Qualifier Check

Checks that the Qualifier enables the Clock. Use the test setup given in steps 9 a through 9 .
a. Connect qualifier and clock inputs to pulse generator output. See Fig. 3-6. Connect GND leads of both probes to ground lug on pulse generator.
b. Set:

| QUALIFIER Value | HI |
| :--- | :--- |
| QUALIFIER Selector | CLOCK |
| CLOCK |  |
| WORD MODE | SYNC |
| Delay Selector | OFF |

c. CHECK-CLOCK indicator is on.
d. Set:

QUALIFIER Value LO
e. CHECK-CLOCK indicator is off.
f. Set:

CLOCK
g. CHECK-CLOCK indicator is on.
h. Set:

QUALIFIER Value
HI
i. CHECK-CLOCK indicator is off.

## 11. BOTH Qualifier Check

Checks that the Qualifier enables both words and clock. Use test setup given in steps 9a through 9f.
a. Connect Ch 0 probe tip to output of pulse generator.
b. Set:

| QUALIFIER Selector | BOTH |
| :--- | :--- |
| WORD MODE | ASYNC |
| Ch O WORD | HI |
| SELECTOR |  |
| QUALIFIER Value | HI |

c. CHECK-TRIG OUT and CLOCK indicators are on.


Fig. 3-6. Test setup for Clock qualifier check.
d. Set: QUALIFIER Value

LO
e. CHECK-TRIG OUT indicator is off.
f. Set:

Ch 0 WORD SELECTOR LO
g. CHECK-TRIG OUT indicator is on.
h. Set:

QUALIFIER Value
HI
i. CHECK-TRIG OUT indicator is off.

## j. Set: <br> Ch O WORD SELECTOR HI WORD MODE SYNC CLOCK

k. CHECK-CLOCK indicator is on.
I. Set:

QUALIFIER Value LO
m. CHECK-CLOCK indicator is off.
n. Set:

CLOCK
o. CHECK-CLOCK indicator is on.
p. Set:

QUALIFIER Value HI
q. CHECK-CLOCK indicator is off.
r. Set:

CLOCK
s. CHECK-CLOCK indicator is on.
t. Disconnect test setup.

## Performance Check-WR 501 Service

## 12. Word (Combination of Channels) Check

Checks the output when all data channels are used-a word.
a. Connect output of pulse generator to data (all 16 channels) and qualifier inputs and to one channel of oscilloscope. Set Fig. 3-7 and Fig. 3-8. The arrangement for signal interconnection allows you to hook up all 16 data inputs and qualifier input at the same time.
b. Adjust pulse generator for a 15 ns -wide pulse that has at least a 1 V amplitude centered about threshold level (center of screen).
c. Connect second oscilloscope channel to TRIG OUT BNC connector and set oscilloscope for alternate dual trace.
d. Set:

| QUALIFIER Value | HI |
| :--- | :--- |
| WORD SELECTOR (all) | HI |
| WORD MODE | ASYNC |
| Delay Selector | OFF |
| QUALIFIER Selector | WORD |

e. CHECK-Output pulse width is at least 5 ns.
f. Set:

QUALIFIER Value LO WORD SELECTOR (all) LO
g. CHECK-Output pulse width is at least 5 ns .
h. Disconnect test equipment.

Fig. 3-7. Test setup for word (combination of channels) check.


Fig. 3-8. Signal interconnection for word check.

## CIRCUIT DESCRIPTION

## INTRODUCTION

The following are some general comments about the WR 501 circuitry. Keep them in mind as you read through this description.

1. All Tektronix descriptions use positive logic. For the WR 501 HI is -0.8 V and LO is -1.8 V unless otherwise noted.
2. The circuitry uses emitter-coupled logic (ECL hereafter) unless otherwise noted.
3. $100 \Omega$ terminating resistors are used on most transmission lines to prevent ringing and noise from interfering with the signal and to sink current from the open emitter outputs of the ECL devices. Some lines use $50 \Omega$ terminating resistors.
4. Some ECL devices have both inverted and noninverted outputs.
5. Schematics are drawn according to the functions the devices perform in the circuit.
6. Inputs of the ECL devices used in the WR 501 have internal pulldown resistors. Unused inputs do not have to be tied to external voltages unless otherwise noted. All unused inputs are at a logic LO.
7. ECL allows use of wired logic. The outputs of several gates are tied together to perform an OR function.

## WR 501 SYSTEM DESCRIPTION

The WR 501 acquires 16 channels of information, recognizes a specific parallel digital word, and outputs a trigger signal with or without delay. Fig. 4-1 shows the basic configuration of the WR 501. The lines between the blocks are main signal lines, and the blocks are the main circuitry sections in the WR 501.

With the Delay Selector Switch in the OFF position, or the Delay Count Switches set to 00000: the signal goes from the Inputs, to the Word Recognizer, to the Trigger Output circuit. With the Delay Selector Switch in the WORDS or CLOCK position, and a nonzero delay count: the signal goes from the Inputs, to the Word Recognizer, to the Delay Events Switching circuit, to the Delay Counters, to the Trigger Output circuit. The following paragraphs describe the functions of the various blocks and their relations to one another.

The Data Inputs compare the data from the probes with the HI, X (don't care), and LO settings of the WORD SELECTOR Switches. When the data matches the settings of the WORD SELECTOR Switches, a word-pattern-match signal goes to the Word Recognizer. The actual threshold voltage levels are selected by the THRESHOLD ControlTTL (+1.4 V), ECL ( -1.26 V ), or VAR (+10 V to -10 V ).

The Clock Input allows the WR 501 to operate synchronously with the system under test. The CLOCK Switch selects either the positive or negative-going edge of the clock signal. The clock signal goes to the Word Recognizer and the Delay Events Switching circuit.

The Qualifier Input compares the qualifier signal with the HI, LO, and OFF (don't care) settings of the QUALIFIER Switch. The Qualifier enables the external clock, the data inputs, or both. With the QUALIFIER Switch in the


Fig. 4-1. Simplified Block Diagram.

CLOCK position, the clock is enabled when the QUALIFIER input signal matches the setting on the QUALIFIER Switch. With the QUALIFIER Switch in the WORD position word recongition occurs only when the Qualifier and data inputs match the WORD SELECTOR and QUALIFIER Switch settings (a word-pattern-match). In the BOTH position, word recognition occurs when the QUALIFIER enables both the clock and data inputs.

When word recognition occurs, the Word Recognizer puts out a word signal. Word recognition occurs on a word pattern match in ASYNC mode, and on the coincidence of a clock input edge and a word pattern match in SYNC mode. A word pattern match occurs when the data and qualifier inputs match the HI, LO, and $X$ (don't care) settings of the WORD SELECTOR Switches. In the ASYNC mode the WR 501 recognizes only words of duration longer than the FILTER setting.

The word signal goes to the Trigger Output circuit when the DELAY Switch is in the OFF position or the Delay Count Switches are set to 00000 . The word signal goes to the Delay Events Switching circuit when the DELAY Switch is in the WORDS or CLOCK position.

When the Delay Selector Switch is in the WORDS or CLOCK position, the Delay Events Switching circuit routes either word signals or clock pulses to the Delay Counters. The Delay Events Switching circuit also prevents the Trigger Output circuit from generating a trigger signal until the delay count is finished. When the delay count is finished, the next event causes the Trigger Output circuit to generate a trigger signal.

The Count Switches set the delay count and the Delay Selector Switch selects which events-words or clock pulses -are to be counted. The Delay Counters count either words or clock pulses. A word is counted each time word recognition occurs. Clock pulses are counted whenever external clock pulses are routed to the Delay Counters. Clock pulses are provided by the circuit under test via the probe.

## Interface Circuits

When the WR 501 is used as part of an LA 501W, the WR 501 provides data acquisition and a trigger signal for the LA 501. Fig. 4-1 shows the connections to the LA 501.

The same data that is used for word recognition goes to the LA 501.

The external clock signal is also sent to the LA 501. The Clock Status signal from the LA 501 tells the WR 501 when to send the clock signal.

The WR 501 uses the Flag and Display Clock signals from the LA 501 to produce the Cursor when the Delay Selector Switch is in the OFF position. To produce the cursor the WR 501 generates a z-axis control signal to send to the LA 501.

# DETAILED CIRCUIT DESCRIPTION 

## INPUT AND PATTERN MATCHING CIRCUITS

## Output From Probe

The outputs from the probe (P6451 Data Acquisition probe) are differential signals. The non-inverted and inverted signals (including the clock and qualifier inputs) travel from the probe pod to the WR 501 input circuits through twisted pair lines. The probes operate between -4.9 V and ground, and the signals from the probe pod to the WR 501 input are centered around -1.2 V . The WR 501 provides the power supply voltage for the probes. The probes send a reference voltage back to the WR 501, which is used to establish the threshold voltages at the probe tips.

## Data Inputs and Pattern Matching

The data signals from the probe go to the input line receivers, which convert the signals to ECL voltage levels. The signals are then compared with the settings of the WORD SELECTOR Switches. When the incoming signals match the settings of the WORD SELECTOR Switches, a word-pattern-match occurs. The word-pattern-match signal is a LO output from the Pattern Matching circuit to the Word Recognition circuit.

Since all 16 of the data input circuits are the same, only one of them is described in detail here.

CH 5 INPUT LINE RECEIVER. Refer to Fig. 4-2 and 4-3. The input line receiver U120B converts the data signals to complementary ECL levels. Pin 7, the output of U120B, tracks the signal at the probe tip-when the signal is HI , pin 7 is HI . The output at pin 6 of U120B is inverted with respect to the signal at the probe tip.

CH 5 PATTERN MATCHING CIRCUIT. U135A and U135B together with the WORD SELECTOR Switch, S330, determine which signal-inverted or noninverted or neither-will be used by the Word Recognizer. If S 330 is in the HI position, pin 5 of U135A is HI and the inverted
signal is gated through U135A. At the same time pin 7 of U135B is LO which blocks the noninverted signal. If S330 is in the LO position, pin 7 of U135B is HI and the noninverted signal is gated through U135B to the Word Recognizer. Now pin 5 of U135A is LO, which blocks the inverted signal. When S 330 is in the X (don't care) position, pin 5 of U135A and pin 7 of U135B are LO.

WIRED OR. All the outputs of the Pattern Matching circuits are tied together to form a wired OR. When all of the signals into the wired OR are LO, the signals at the probe tips match the pattern selected by the WORD SELECTOR Switches. This LO signal then goes to the Word Recognition circuit.

## Data Pickoff For The LA 501

The LA 501 Data Pickoff circuits are present only in instruments which are part of the LA 501W. Again, only the CH 5 circuit is described here.


Fig. 4-2. Ch 5 Input timing diagram.


Fig. 4-3. Ch 5 Input circuit.

The non-inverted input signal is picked off at pin 7 of U120B; DL115G delays the signal for 10 ns . U118D and associated circuitry is a buffer stage that drives the interface cable to the LA 501. The output of U118D is back terminated by R137, R138, and C138. This back termination drives the interface cable to the LA 501. Refer to the LA 501 Service manual for a description of LA 501 operation.

## Qualifier Input

The qualifier signal goes from the probe to an input line receiver. The input line receiver U10C converts the qualifier signal to complementary ECL levels. Pin 15, the output of U10C, tracks the signal at the probe tip-when the signal is HI, pin 15 is HI . The output at pin 14 of U10C is inverted with respect to the signal at the probe tip. From the line receiver the signal goes to the Word Qualifier and Clock Qualifier circuits.

## Clock Input

The clock signal goes from the probe to an input line receiver. The input line receiver U110C converts the clock signal to complementary ECL levels. Pin 15 of U110C tracks the signal at the probe tip-when the signal is HI , pin 15 is HI . The output at pin 14 of U110C is inverted with respect to the signal at the probe tip. From the line receiver, the clock signal goes to the Clock Gate and Clock Qualifier circuits.

## THRESHOLD SETTING CIRCUIT

The Threshold Setting circuit sets the threshold voltage that the probes respond to. The probes compare the incoming signal with the threshold voltage at the probe tips and generate a signal to send to the input line receivers.

Operational amplifiers U676A, U676B, U680A, and U680B and associated circuitry provide the threshold voltages for the probes. The voltage level is selected by S670 and S685TTL, ECL, or VAR. The following description is for Ch 7-0, CLK; the circuit numbers in parentheses are for Ch 15-8, QUAL.

With S670 (S685) set to TTL, the voltage divider R675/ R676 (R690/R691) sets the input level of U676A (U676B) to +1.4 V , the TTL level. U676A (U676B) is a high input impedance voltage follower with unity gain. With S670 (S685) set to ECL, R674 (R689) shifts the input of U676A (U676B) to -1.26 V , the ECL level. With S670 (S685) set to VAR, R672A (R672B) adjusts the output of U676A (U676B) from +10 V to -10 V .

U680A (U680B) and associated circuitry use feedback via the reference voltage ( $-V_{E E} R E F$ ) from the probe to compensate for variations between probes, changes in the power supply voltage, and losses in the power supply line to the probes.

Fig. 4-4 is a simplified diagram of an input channel in the P6451 Data Acquisition Probe. The threshold voltage at the probe tip of the P6451 Data Acquisition Probe is -4 times the threshold control voltage with respect to the $-\mathrm{V}_{\mathrm{EE}}$ voltage ( -4.9 V ) at the probe pod. The threshold control voltage is furnished at the output of U608A (U680B). Consequently the output of U676A (U676B) must be attenuated by $-1 / 4$ with respect to the $-V_{E E}$ REF voltage from the probe pod before it is transferred to the probe as the threshold control voltage. U680A (U680B) and associated circuitry provide the $-1 / 4$ attenuation of the threshold voltage for the Ch 7-0, CLK (Ch 15-8, QUAL) probe.


Fig. 4-4. Simplified diagram of one channel in the P6451 Data Acquisition Probe.

## CLOCK AND QUALIFIER CIRCUITS

## Word Qualifier

When the QUALIFIER Selector switch is in the WORD or BOTH positions, the Word Qualifier and Clock Qualifier circuits compare the signal from the input line receiver with the settings of the QUALIFIER Value switch-HI, LO, or OFF. With the QUALIFIER Switch in the WORD position, the Word Qualifier is enabled; in the CLOCK position, the Clock Qualifier circuit is enabled. In the BOTH position, both the Clock Qualifier and the Word Qualifier circuits are enabled.

The Word Qualifier circuit consists of U412A and U412C and associated circuitry. U412A and U412C compare the signal from the input line receiver with the settings of the QUALIFIER Switch S348-HI, LO, or OFF. With the QUALIFIER Switch S348 in the OFF position, pin 14 of U412C and pin 10 of U412A are pulled HI by CR416 (through R413 and R415), disabling the Word Qualifier Circuit. With the QUALIFIER Switch S348 in either the HI or LO position, a LO signal enables one of the gates. U412A and U412C output a LO when the incoming qualifier signal matches the settings of S348-HI, LO, or OFF. When S344, the QUALIFIER Selector Switch, is in the CLOCK position, the Word Qualifier is disabled by HI signals on pin 11 of U412A and on pin 12 of U412C.

## Clock Qualifier

The qualifier signal can enable the clock when the QUALIFIER Selector switch S344 is in the CLOCK or BOTH position. The qualifier signal must match the HI, LO, or OFF settings of the QUALIFIER Value switch S348 for the clock signal to allow word recognition on the selected clock edge. See Fig. 4-5. The Clock Qualifier compares the incoming signal with the switch setting and synchronizes the qualifier signal with the clock signal so only whole clock pulses go through the Clock Gate. The output of the Clock Qualifier allows clock signals through the Clock Gate only when the qualifier signal is present and the QUALIFIER Selector switch is in the CLOCK or BOTH positions.

The first stage of the Clock Qualifier consists of U414A and U414C and the second stage consists of U409B, U416A, U416B, U416C, U416D, U412B and U414B. U414A and U414C compare the incoming signal with the HI, LO, OFF settings of the QUALIFIER Value switch S348 and output a LO when the incoming qualifier signal matches the setting of S348. When S344 is in the WORD position, pin 10 of U414A and pin 12 of U414C are held HI disabling the Clock Qualifier.

## Circuit Description-WR 501 Service

The second stage of the Clock Qualifier synchronizes the qualifier signal with the clock signal so only whole clock pulses go through the Clock Gate. See Fig. 4-5. U412B and U414B sample the incoming clock signal. Pin 3 of U412B and pin 3 of U414B form a wired OR that goes to pin 7 of U416B and pin 11 of U416C. When the CLOCK Switch S346 is in the $\mathcal{L}$ position, U412B is disabled and when S346 is in the 5 position, U414B is disabled. U409 introduces a delay so that a qualifier signal coincident with a word pattern match will qualify the pertinent clock edge. This delay also maintains zero hold time between the qualifier signal and the clock signal. The clock signal from the wired OR (pin 3 of U412B and pin 3 of U414B) clocks the signal from pin 14 of U409B through the two flip-flops, U416A/U416B and U416C/ U416D. Fig. 4-5 shows the timing between the clock signal at the wired OR and the qualifier signal at pin 14 of U409B. The output signal of the Clock Qualifier has the same polarity as the signal from pin 14 of U409B but is synchronized with the clock signal.

## Clock Gate

The Clock Gate allows the selected clock edge through to the Word Recognition circuit, to the LA 501 (present only in instruments used as part of an LA 501W), to the Delay Events Selector, and to the Clock LED Driver. Since the Word Recognition circuit requires a LO to HI transition to clock data through its SYNC path, the Clock Gate converts the incoming clock signal into a LO to HI transistion. The Clock Qualifier circuit can be used to qualify the clock edge selected by the CLOCK switch S346. Refer to the preceding paragraph on the Clock Qualifier. A part of the Clock Gate, U405B, passes a clock signal to the LA 501 only when pins 12 and 13 of U432D are HI. (The LA 501 sends these HI levels to the WR 501 when the sample interval switch on the LA 501 is in the external position.)

U418A and U418B convert the clock signal from the input line receivers to a LO to HI transistion. With the QUALIFIER Selector switch in the OFF position, pin 11 of U418B and pin 5 of U418A are both LO. The CLOCK switch S346 determines which edge of the clock signal is used. With S346 in the $工$ position ( HI to LO edge) pin 6 of U418A is held HI and pin 9 of U481B is LO. U418B outputs a LO to HI transition on each HI to LO transition of the incoming clock signal. When S346 is in the ک position (LO to HI edge), pin 6 of U418A is LO and pin 9 of U 418 B is HI . Now U418A uses the HI to LO transition of the Ext Clock signal to output a LO to HI transition. See Fig. 4-6. U418B uses the Ext Clock signal from the input line receiver and U418A uses its complement, the Ext Clock signal.

The Clock Status signals from the LA 501 tell the Clock Gate when the LA 501 controls are set for an external clock source. U432D and U405B allow clock pulses through to the LA 501 as long as the Clock Status signals from the LA 501 are HI. Both outputs of U405B are used to drive the transmission line between the WR 501 and the LA 501.

## Clock LED Driver

The Clock LED Driver circuit produces an indication momentarily whenever a HI signal is present at the output of the Clock Gate. As long as the clock repetition rate is faster than the decay time of the one shot multivibrator (O420, Q424, and associated circuitry), the CLOCK indicator on the front panel stays on.


Fig. 4-5. Clock qualifier timing diagram.

## word RECOGNITION

The Word Recognition circuit outputs a LO signal when word recognition occurs. The WORD MODE switch S350 selects one of two paths through the Word Recognition circuit. One path is for the ASYNC mode and the other is for the SYNC mode. Word recognition occurs in ASYNC mode when the data and qualifier inputs match the switch settings, a pattern match. In SYNC mode, word recognition occurs on the coincidence of a word-pattern match and a clock edge. Refer to Fig. 4-7. The output of the Word Recognition circuit (both SYNC and ASYNC) goes to the word recognition line (a wired OR). In the ASYNC mode the Filter circuit adjusts the length of the word recognized by the circuit.

Fig. 4-8 shows the two paths through the Word Recognition circuit. With the WORD MODE switch S350 in the SYNC position, the SYNC path consists of U405A, U409A, and U430B. In SYNC mode pin 5 of U436A is held HI disabling the ASYNC path. The signal is transferred through U430B by the clock signal (from the Clock Gate) to the wired OR. In ASYNC, the path consists of U405A, U436A and U452D with the Filter circuit controlling the word length. In the ASYNC mode pin 12 of U430B is held HI, disabling the SYNC path. The signal is transferred to the wired OR as it comes in.

Word Recognition must occur before anything else hap-pens-either a trigger signal is output or a delay count starts.

## Filter Circuit

The Filter circuit prevents glitches and noise from getting through as signals by rejecting words of shorter duration than the FILTER setting. The duration of a signal that goes through to the wired OR is controlled by R400, Q410A, Q410B, and C409. When the output of U436A goes from HI to LO, C409 starts charging. The rate at which C409 charges is determined by the current through Q410B which in turn is controlled by the setting of R400. When the voltage across C 409 reaches about -4.9 V , the output of U452D switches from HI to LO. As the FILTER control R400 is turned toward 300 ns , the current available to C409 decreases so it takes longer to charge C409. R409, the Filter adjustment, and R408 mask the effect of the internal pulldown resistor inside U452D.

## Word Recognition (Wired OR)

The output signal of the Word Recognition circuit is a LO that goes to the Trigger Output circuit, the Delay Events Selector, and the Count Start circuit.

## DELAY EVENTS SELECTOR

The Delay Events Selector determines whether or not there is a delay before the Trigger Output generates a signal, and which events are counted-words or clock pulses. When the Delay Selector switch S342 is in the OFF position or the delay count is set to 00000 , the counters are bypassed. When the Delay Selector switch S342 is in the CLOCK or WORDS position and the counters are set to some count other than zero, the Delay Events Selector routes either clock pulses or words to the counters.


NOTE: QUALIFIER SWITCH S348 IS IN OFF POSITION.

Fig. 4-6. Timing Diagram showing the Clock Gate output.


Fig. 4-7. Word timing in ASYNC and SYNC modes.

In the LA 501W, when the LA 501 is in the display mode and the Delay Selector switch is in the OFF position, the Delay Events Selector uses the Flag and Display Clock signals from the LA 501 to generate a cursor. Refer to the interface paragraphs.

When the Delay Selector switch S342 is put into the WORDS position and the counters are set to some count other than zero, the following happens:

Pin 7 of U432B goes LO preventing the clock pulses (from the Clock Gate) from going through the Count Gate.

Pin 11 of U436C goes HI allowing words through to the Count Gate.

Pin 12 of U450D goes HI, the LO from pin 15 of U450D enables the Count Start circuit, and the HI from pin 9 of U450D goes to pin 7 of U470A to prevent the Trigger Output from generating a signal until the delay count is finished.

Whenever word recognition occurs, the Delay Events Selector routes words to the Count Gate. The Count Start circuit enables the Count Gate which gates events through to the counters. The Delay Events selector also enables the End of Count Output circuits.

When the Delay Selector switch S342 is put into the CLOCK position and the counters are set to some count other than zero, the following happens:

Pin 7 of U432B goes HI allowing clock pulses from the Clock Gate through to the Count Gate.

Pin 13 of U450D goes HI, the LO from pin 15 of U450D enables the Count Start circuit, and the HI from pin 9 of U450D goes to pin 7 of U470A to prevent the Trigger Output from generating a signal until the delay count is finished.

Pin 11 of U436C goes LO, preventing words from the Word Recognition circuit from going through the Count Gate.

Clock pulses from the Clock Gate are routed to the Count Gate and from there to the counters. The Delay Events Selector enables the End of Count Output circuit.

The Delay Selector switch S342 switches the Trigger Delay Detector in and out of the circuit.

## Trigger Delay Detector

The Trigger Delay Detector senses whether or not there is a count on the Delay Count switches. When the Delay Count switches are set to 00000, the Trigger Delay Detector outputs a LO. This LO disables the Delay Events


Fig. 4-8. ASYNC and SYNC paths thru the Word Recognizer.

Selector and allows a trigger signal to be generated without a delay. When the Delay Count switches are set to some number other than zero, the Trigger Delay Detector outputs a HI. This HI enables the Delay Events Selector and the trigger signal is generated after a delay. The Delay Selector switch must be in either the WORDS or CLOCK position.

The Trigger Delay Detector has two parts: One for the LSB (least significant bit) Counter and one for the TTL Counters. The part for the LSB Counter consists of U432C and U452B. The part for the TTL Counters consists of U545, which is a TTL gate. The outputs of the two parts are tied together to form a wired OR through a TTL to ECL level shifter. Whenever there is a number on any of the Delay Count switches, the output of either part is HI so the output to Delay Selector switch S342 and the Delay Events Selector is HI.

## DELAY COUNTERS

When a number is selected on the Delay Count switches the counters are set to the 9's complement of that number by the logic within the Delay Count switches. The LSB Counter is ECL and the rest of the Counters are TTL. The output of the LSB Counter goes through the TTL Counter Gate to the first TTL Counter. The counters count the events coming from the Count Gate, starting with the 9's complement of the number of the count switches.

Each counter counts up from the 9's complement of the number on the respective Delay Count switch first. Then the counters count until they reach 99999 . For example suppose the Count switches are set to 00784 . The counters are set to 99215 -the 9 's complement of 00784 . The LSB Counter (the one's counter) counts from 5 to 9 , then on the next event, puts out a signal (zero). The first TTL Counter (the ten's counter) goes from 1 to 2 on this event. Then the LSB Counter goes from 0 to 9 . Now the first TTL Counter goes from 2 to 3 . This continues until the

## Circuit Description-WR 501 Service

first TTL Counter reaches 9 and the LSB Counter has also reached 9. On the next event the Second TTL Counter (the hundred's counter) goes from 2 to 3 . This cycle repeats itself until the count is 99990 . The LSB Counter has one more counting cycle to complete. When the LSB Counter reaches 9 and the count is 99999, the End of Count Output is enabled and the next event to the Delay Events Selector triggers an output.

## Count Start Circuit

The Count Start circuit generates the enabling signal for the Count Gate which gates the events thru to the counters. The LO signal from the Delay Events Selector enables the Count Start circuit. The next word recognition event triggers the Count Start circuit which generates a LO signal to send to the Count Gate. The Count Start circuit also enables the End of Count Output.

The LO signal from the Delay Events Selector (from pin 15 of U450D to pin 12 of U460D) enables U460D. The next LO signal from the Word Recognition circuit causes pin 15 of U460D to go HI . This transition from LO to HI on pin 6 of U430A transfers the HI on pin 7 (it's wired HI) to the output and a LO to pin 3 of U430A. This LO to pin 10 of U460C allows the events (coming into the Count Gate from the Events Switching circuit) through to the Counters.

The HI on pin 2 of U430A goes to U454C which inverts it to a LO. The LO enables the End of Count Output. The connection between pin 2 of U456A and pin 4 of U430A resets U430A after the end of count signal ends.

Delay LED Driver. The Delay LED Driver turns the DELAY Indicator on during the delay count. The Delay Events Selector enables the Delay LED Driver whenever there is a delay. The Count Start circuit turns the Delay LED Driver on at the beginning of the delay count and off when the end of count signal ends.

When there is a delay, the LO on pin 15 of U450D goes to pin 7 of U436B. This LO enables the Delay LED Driver. When pin 6 of U436B goes LO (the output of the Count Start circuit goes LO), pin 3 of U436B goes HI. The base of Q446 goes HI at the same time which turns DS496 on. DS496 is on until the Count Start circuit is reset. When pin 6 of U436B goes HI (the output of the Count Start circuit goes HI), pin 3 of U436B goes LO and turns DS469 off.

## Count Gate

The Count Gate gates events to the counters. The Count Start circuit enables the Count Gate at the beginning of the count. The Count Gate then gates incoming events from the Delay Events Selector to the LSB Counter.

The signal from the Count Start circuit goes to pin 10 of U460C. When pin 10 of U460C is LO, the Count Gate is enabled and events from the Delay Events Selector are gated through to the LSB counter. The input to the Count Gate, pin 5 of U460A, is from the Delay Events Selector. U460A is an inverter. The output of the Count Gate at pin 14 of U460C goes to the LSB Counter.

## LSB Counter

The LSB Counter U530 is the one's counter. It counts each incoming event starting with the 9's complement of the number on the Delay Count switch S510E. When it reaches 9, it outputs a LO signal for one count to the TTL Counter Gate and to the End of Count Output.

The LSB Counter requires that an enabling signal be present before it can be loaded with the 9's complement of the number on the Delay Count switch S510E. Thus it requires two signals to reset the LSB Counter-an LSB load enable signal and a load signal. The LSB Load Enable generates the load enable signal after the delay count is finished or when the RESET button is pushed. The event that causes a trigger output also loads the LSB Counter with the 9's complement of the count on the Delay Count switch S510E. For more details refer to the reset and load paragraphs.

## TTL Counter Gate

The TTL Counter Gate gates events from the LSB Counter to the TTL Counters and shifts the voltage levels from ECL to TTL. When the TTL Counters reach the 99990 count, the 99990 Hold circuit disables the TTL Counter Gate until the LSB Counter finishes counting. The 99990 Hold circuit enables the TTL Counter Gate when the 99990 Hold circuit is reset after the trigger output.

The output from the LSB Counter goes to pin 12 of U436D. The output from pin 9 of U436D goes to the base of Q458. Both inputs to U436D must be LO before pin 9 of U436D goes LO. 0458 and associated circuitry shift the voltage level of the signal from ECL levels to TTL levels (a LO of -4.9 V ). The signal from the collector of Q458 goes to the first TTL Counter U525.

## TTL Counters

The TTL Counters are the tens, hundreds, thousands, and ten-thousands counters. The input to the first TTL Counter, U525, is from the TTL Counter Gate. The output of the first TTL Counter goes to the second TTL Counter U520 and to the output gate U550. The output of the second TTL Counter goes to the third TTL Counter U515 and to the output gate U550. The output of the third TTL Counter goes to the fourth TTL Counter and the output gate U550. The output of the fourth TTL Counter goes to the output gate U550. When all of the TTL Counters reach 9 (the 99990 count) U550 puts out a LO signal to the TTL Load circuit and to the 99990 Hold circuit.

## TTL Load

The TTL Load circuit generates the signal that loads the TTL Counters with the 9 's complement of the number on the Delay Count switches, S510A, S510B, S510C, and S510D. The TTL Counters are loaded immediately after the 99990 count is reached. The 99990 count also goes to the 99990 Hold circuit. This is to ensure that the TTL Counters are ready when the LSB Counter is ready to output on the next counting cycle.

When the TTL Counters reach 99990, all of their outputs are HI , which causes pin 8 of U550 to go LO. This LO goes to the 99990 Hold circuit and to pin 4 of U446B. Pin 5 of U446B is HI until RESET is pushed and the output of U446C (an inverter) goes to the TTL Counters. When pin 8 of U446C goes LO, the TTL Counters are loaded with the 9's complement of the count on the Delay Count switches.

The signal level from U550 to the 99990 Hold circuit is shifted from TTL to ECL. (The counter voltage levels are negative voltage TTL: $L O$ is -4.9 V .)

## 99990 Hold

The 99990 Hold circuit holds the 99990 count from the TTL Counters while the LSB Counter finishes counting. The 99990 Hold circuit disables the TTL Counter Gate and enables the End of Count output after the TTL Counters reach the 99990 count. This allows the TTL Counters to be reloaded and ready when the next counting cycle begins. When the LSB Counter finishes counting on the 10 count, the End of Count Output outputs a signal. Now the 99990 Hold circuit is reset after the End of Count Output generates a signal, and the 99990 Hold circuit enables the TTL Counter Gate and disables the End of Count output.

Before the 99990 count is reached, pin 15 of U456B is LO, enabling the TTL Counter Gate, and pin 14 of U456B is HI, disabling the End of Count Output. When the TTL Counters reach the 99990 count, U550 outputs a LO signal. This LO signal goes to the 99990 Hold circuit. A voltage divider, R446/R447/R448, shifts the signal from TTL to ECL voltage levels before the signal reaches U450B. U450B inverts the signal and 'sets' U456B. Now pin 15 of U456B goes HI, disabling the TTL Counter Gate, and pin 14 of U456B goes LO, enabling the End of Count Output.

After the End of Count Output circuit puts out a trigger signal, the 99990 Hold circuit is reset. Now pin 15 of U456B goes LO enabling the TTL Counter, and pin 14 goes HI disabling the End of Count Output.

## End of Count Output

The End of Count Output circuit generates the trigger signal after the delay count is finished. The End of Count Output is disabled until after the 99990 count occurs. When the 99999 count occurs, the End of Count Output circuit puts out a signal to the Trigger Output when the next event arrives.

The inputs to the End of Count Output circuit are from the Count Start circuit, the 99990 Hold circuit, the LSB Counter, and the Delay Events Selector. Pin 14 of U454C and pin 14 of U456B (in the 99990 Hold circuit) are tied together to form a wired OR. On the 99990 count pin 14 of U456B goes LO enabling U454B. Now when the LSB Counter finishes the delay count, pin 7 of U454B goes LO. Pin 3 of U454B goes HI which causes pin 7 of U456A to go HI. The next event from the Delay Events Selector clocks a HI through to pin 2 of U456A and a LO to pin 3 of U456A. The LO from pin 3 of U456A goes to the Trigger Output circuit and to pin 7 of U460B. U460B resets U456A when the triggering event ends. The HI from pin 2 of U456A, resets the Count Start and 99990 Hold circuits on the triggering event. Refer to the reset and load paragraphs for further detials.

## DELAY COUNTERS RESET AND LOAD

The delay counters are reset automatically at the end of the delay count, or they can be reset manually.

## Reset After the Delay Count Ends

Once the delay count ends, several circuits must be reset before a new delay count starts. The circuits that must be reset are Count Start, End of Count Output, LSB Counter, TTL Counters, 99990 Hold, and TTL Counter Gate. A complete reset cycle uses the 99990 count, the 99999 count (the last delay count), and the event that generates the trigger signal. The TTL Load circuit reloads the TTL Counters when the 99990 count occurs (U550 outputs a LO). The LSB Load Enable produces the load enable signal (LO) for the LSB Counter when the 99999 count occurs. The event that generates the trigger signal resets the remaining circuits.

## Circuit Description-WVR 501 Service

When the End of Count Output circuit generates a trigger signal (a LO at pin 3 of U456A), the signal is fed back to enable U460B to reset U456A when the trigger event ends. The output of U460B is a narrow pulse. Fig. 4-9 shows the various reset paths. The signal from pin 2 of U456A (HI) resets the Count Start and 99990 Hold circuits. The 99990 Hold circuit subsequently enables the TTL Counter Gate. The trigger event also passes to the LSB Counter and loads the LSB Counter with the count on the Delay Count switch. The LSB Counter was enabled by the 99999 count. The next word recognition event starts a delay count.

## Manual Reset

Pushing RESET interrupts the delay count and resets the counters. When the delay count is interrupted, the counters and other circuits must be reset before word recognition will start a new delay count. The Manual Reset circuit is in two parts. The first part resets the TTL

Counters and the second part resets the LSB Counter, the Count Start, and the 99990 Hold circuits.

Pushing the RESET pushbutton S446, causes pin 1 of U446A to go from LO to HI to LO again through the action of R440, C440, and R442. Pin 3 of U446A goes from HI to LO and then HI . This LO-going pulse to pin 5 of U446B in the TTL Load circuit (see Fig. 4-10) resets the TTL Counters. This LO signal also goes through inverter U454A and resets the 99990 Hold and the Count Start circuits. The same LO signal from pin 3 of U446A goes through U450C to the LSB Load Enable circuit, U450A. U450A produces the load enable signal for the LSB Counter. The LO signal from pin 3 of U446A goes through U446D and U454D and generates the load signal for the LSB Counter. Since the load enable signal must be present when the load signal for the LSB Counter arrives, the path for the load signal has an additional TTL gate (U446D) that guarantees a valid load sequence.


Fig. 4-9. Automatic reset after delay count is finished.


Fig. 4-10. Manual Reset.

## TRIGGER OUTPUT

The Trigger Output gates the trigger signal to the Trig Out ECL/TTL Converter, to the Trig Out LED Driver, and to the LA 501. When the Delay Selector switch is in the OFF position or the Delay Count switches are set to 00000, the Trigger Output gates word recognition events through as trigger signals, bypassing the delay counters. When the Delay Selector switch is in the WORDS or CLOCK position and the Delay Count switches are set to some count other than zero, the Trigger Output gates signals from the End of Count Output circuit through as trigger signals.

The Trigger Output consists of two gates, U470A and U470B. Control signals from the Delay Events Selector determine which gate functions. When there is no delay, U470B is disabled by a HI from pin 15 of U450D. U470A
gates through word recognition events. When there is a delay, U470A is disabled by a HI from pin 9 of U450D. U470B gates output signals from the End of Count Output.

The outputs of both gates go to the same circuits-the Trig Out ECL/TTL Converter, the Trig Out LED Driver, and to the LA 501.

## Trig Out ECL/TTL Converter

The Trig Out ECL/TTL Converter generates a TTL compatible signal at the TRIG OUT BNC Connector on the front panel. The signal is at positive voltage TTL levels ( $\mathrm{HI} \geqslant+2.2 \mathrm{~V}, \mathrm{LO} \leqslant+0.6 \mathrm{~V}$ ).

Q472 and Q474 convert the trigger signal from the Trigger Output circuit to TTL voltage levels. As long as the output from the End of Count Output circuit is LO, Q472 is OFF and Q474 is ON and the output to TRIG OUT is LO. When the Trigger Output circuit generates a HI trigger signal, Q472 turns ON and Q 474 turns OFF. Now the output to TRIG OUT is HI.

## Circuit Description-WR 501 Service

## Trig Out LED Driver

The Trig Out LED Driver circuit generates a light momentarily whenever a signal is present at the TRIG OUT connector on the front panel.

Q480 and Q484 and associated circuitry comprise a one-shot multivibrator. When the Trigger Output circuit generates a HI trigger signal the one-shot multivibrator turns DS488 on and holds it on for about 20 milliseconds.

## LA 501 Trigger Signal

The trigger signal goes to the LA 501 via an interconnecting cable in instruments used in the LA 501 W .

## POWER SUPPLY

The power supplies provide regulated voltages for the circuits in the WR 501.

## -4.9 V Power Supply

The -4.9 V power supply is a series-switching, regulated power supply.

The voltage from the mainframe, 25 V ac, is rectified by CR620, then filtered by several capacitors and an inductor. The resulting voltage is then converted to -4.9 V dc by the power supply.

Q629 is switched on and off while the output voltage and current are held constant by capacitors and inductors. When Q629 is off CR629, a Schottky Barrier diode, is on and provides the current path from T641. The switching is fast enough so that the output capacitors don't have time to discharge and the output voltage and current are constant.

A differential comparator consisting of Q640 and Q644 compares the output voltage with a reference voltage. As the output voltage varies, Q640 and $\mathbf{Q 6 4 4}$ turn on and off which switches the base current for 0629 which turns it on and off.

The reference voltage is provided by Q632, VR630, VR633 and associated circuitry. R635 is adjusted to set the output voltage of the power supply to -4.9 V . 0632 and VR630 provide constant current to VR633 to establish the reference voltage.

Let's go through a switching cycle. Start with Q629 on (saturated). When Q629 is on, Q640 and Q628 are on. The collector of 0629 is about -30 V and the current has stored energy in the magnetic field of T641. When the output voltage on the base of $\mathbf{Q 6 4 4}$ is more negative than the reference voltage on the base of Q640, Q644 starts to turn on. See Fig. 4-11. As $\mathbf{Q} 644$ turns on, Q 640 starts to turn off, which starts to turn Q628 and Q629 off. As the collector of Q629 starts to go more positive, the voltage change at pins 1 and 6 of T641 is coupled back through C 638 and R638 to the base of Q640. This positive feedback turns Q640 off faster. R627 and R626 sink the base current from Q629 and Q628 turning them off faster.


Fig. 4-11. -4.9 V Power Supply Block Diagram.

After Q629 has turned off, the current in T641 goes thru CR629, a Schottky barrier diods. When Q629 is off, Q628 and Q640 are off, too. Now, when the output voltage on the base of Q644 goes more positive than the reference voltage, Q644 starts to turn off. As soon as Q644 starts to turn off, Q640 starts to turn on. The negative-going voltage at the collector of Q629, as it turns on, is coupled back through T641 via C638 and R638 to Q640 base. This positive feedback turns Q 640 on faster. Now Q 629 and Q628 are on and the current to T641 is provided by 0629. And the cycle starts over. C641, C642, C644, and L644 filter the voltage. See Fig. 4-12.

VR647 and Q648 provide over-voltage protection. As long as the output voltage is less negative than the zener voltage of VR647 (about 6 V ), Q 648 (an SCR) is off. When the output voltage goes below -6 V, VR647 turns on and turns on Q648. This draws a large current which opens F625 and prevents damage to the rest of the circuitry.

## +15 V and -15 V Power Supplies

U660 is a dual tracking voltage regulator. 0650 and Q655 pre-regulate input voltage to $U 660$ to prevent excess dissipation in U660. R654 adjusts the magnitude of the output voltage and R663 adjusts the balance between the +15 V and -15 V outputs.

## -2 V Power Supply

Q610 and Q615 with an npn series pass transistor in the mainframe provide -2 V output.

## +5 V Power Supply

Q602 and Q605 with a pnp series pass transistor in the mainframe provide +5 V output.


NOTE: WAVEFORMS ARE IDEALIZED. REFER TO THE VOLTAGE AND WAVEFORMS IN THE DIAGRAMS
SECTION.

## Circuit Description-WR 501 Service

## LA 501 INTERFACE

The LA 501 Interface consists of the Data Pickoff, Zaxis circuit, and signals between the WR 501 and the LA 501. In the LA 501W the connections are internal. The signals from the WR 501 to the LA 501 are data, external clock, trigger signal, z-axis control signal for the cursor, and a reference voltage. The signals from the LA 501 to the WR 501 are clock status, display clock, and flag. The flag is a control signal (HI) generated at the start of each line of the LA 501 display. There is also a ground connection between the instruments. The clock status signals enable U405B (in the Clock Gate) when the LA 501 is set for an external sample interval, and the external clock signal goes to the LA 501. When the LA 501 is set for an internal sample interval, the clock status signal disables U405B and prevents the external clock signal from going to the LA 501. The display clock, the flag, the Z-axis circuit, and the delay counters generate the delay count for the cursor when the LA 501 is in the display mode.

## Z-Axis Circuit (Generation of The Cursor)

When the Delay Selector switch is set to OFF, the Zaxis circuit is enabled. The flag from the LA 501 (indicates the beginning of a trace) goes to pin 4 of U432A in the Count Start circuit. The display clock from the LA 501 goes to the Delay Events Selector. A LO from pin 9 of U450D, when the Delay Selector switch S342 is set to OFF, goes to pin 11 of U452C to enable this gate. The Count Start circuit starts a delay count when the flag arrives. The Delay Events Selector gates the display clock to the delay counters. The delay counters count the display clock pulses until they reach the count set on the Delay Count Switches. The End of Count Output generates an output signal (LO) when the next display clock pulse arrives. The output signal goes to pin 10 of U452C and causes pin 14 of U452C to go HI. Q492 and associated circuitry drive the interface line. The Z -axis control signal goes to the LA 501 via the internal connection.

## MAINTENANCE

The following information is provided to help you keep your WR 501 in good condition. We recommend that servicing be done by qualified service personnel only. You can, if you like, send your instrument to a Tektronix Service Center for readjustment and repair. Contact your local Tektronix representative for information about the service centers in your area.

## PREVENTIVE MAINTENANCE

Preventive maintenance consists primarily of cleaning the instrument regularly and inspecting it occasionally for broken or damaged parts. Regular maintenance will improve the reliability of your instrument and help prevent breakdowns.

## CLEANING

Accumulations of dirt and dust on components act as an insulating blanket preventing efficient heat dissipation. Dust on circuit boards and wires can cause arcing and short circuits, resulting in damage to components or even instrument failure. Clean your instrument before this happens.


> Avoid the use of chemical cleaning agents containing benzene, toluene, zylene, acetone or similar solvents. These chemicals may damage the plastics used in this instrument. Recommended cleaning agents are isopropyl alcohol or Kelite (1 part Kelite, 20 parts water).

## Exterior

Dust the cabinet off with a soft cloth. Dust the front panel controls with a small soft paint brush. Dirt clinging to the surface of the cabinet may be removed with a soft cloth dampened with a mild detergent and water solution. Avoid using abrasive cleaners. They may scratch the cabinet and front panel.

## Interior

Dust in the interior of the instrument should be removed before it builds up enough to cause arcing and short circuits during periods of high humidity. Dust is best removed from the interior by dry, low-pressure air (approximately $9 \mathrm{lbs} / \mathrm{in}^{2}$ ). Dirt clinging to the surfaces may be removed with a soft paint brush or cloth dampened with a mild detergent and water solution. Use a cotton-tipped applicator for cleaning in narrow spaces and on the circuit boards.

## VISUAL INSPECTION

Inspect the interior occasionally for broken connections, improperly seated semiconductors, damaged or improperly installed circuit boards, heat damaged components, etc. If heat damaged components are found, find the cause of the excessive heat and take measures to prevent recurrence of damage.

## LUBRICATION

Most of the potentiometers are permanently sealed. The lever type switches are installed with proper lubrication where necessary. Therefore, periodic lubrication is not recommended and only rarely should lubrication even be necessary.

## SEMICONDUCTOR CHECKS

Periodic checks of the semiconductor devices in this instrument are not recommended. The best check of semiconductor performance is actual operation in the instrument.

## ADJUSTMENT AFTER REPAIR

Re-adjust the instrument whenever the Performance Check indicates the instrument is not meeting specifications. After any electrical component has been replaced, the performance of the instrument should be checked to see if it requires further adjustment.

## TROUBLESHOOTING

If you do preventive maintenance on a regular basis, you should catch most problems before your instrument breaks down. Occasionally, you may have to troubleshoot. In addition to the following information, you may find information in the Theory of Operation and Diagrams sections useful.

## TROUBLESHOOTING EQUIPMENT

The following equipment is useful for troubleshooting:

## Multimeter

Description: Voltmeter, $10 \mathrm{M} \Omega$ input impedance and a range from 0 V to at least 50 V dc; accuracy, within $0.1 \%$. Ohmmeter, 0 to $20 \mathrm{M} \Omega$. Test probes should be insulated to prevent accidental shorting.

Purpose: Check voltage and resistance.

## Test Oscilloscope

Description: Frequency response, dc to 100 MHz minimum; deflection factor, 5 mV to $5 \mathrm{~V} /$ div. A 10X, $10 \mathrm{M} \Omega$ voltage probe should be used to reduce circuit loading.

Purpose: Check operating waveforms.

## Variable Autotransformer

Description: Output variable from 0 to $140 \mathrm{~V}, 2$ Amps minimum rating. Must have three-wire power cord, plug, and receptacle.

Purpose: Vary input line voltage when troubleshooting in the power supply.

## TROUBLESHOOTING AIDS

## Troubleshooting Chart

Use the troubleshooting chart (in the diagram section) to help locate problem areas.

## Diagrams

Complete circuit diagrams are located on the foldout pages in the Diagrams section. The component number and electrical value of each component in the instrument are shown on the diagrams (see the first page of the Diagrams section for definitions of the reference designators used to identify components). Each main circuit is assigned a series of component numbers to assist in identifying circuit
location. Important voltages and waveforms are also shown on the diagrams. Also, a heavy line encloses the portion of the circuit mounted on a circuit board.

## Color Codes

The resistors used in this instrument are either composition or precision metal-film resistors. The resistors are color-coded with the EIA color-code (some metal-film resistors may have the value printed on the body). Refer to Fig. 5-1. For thick-film resistor values, refer to the Parts List.

The capacitance value of common disc and some small electrolytic capacitors is marked on the side of the component body. The white ceramic capacitors are color-coded using a modified EIA code (see Fig. 5-1).

The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes, or a dot.

## Semiconductor Lead Configuration

Fig. 5-2 shows the lead configuration of the semiconductor devices used in this instrument.

## Multi-connector Holders

The multi-connector holder is keyed with two triangles, one on the holder and one on the circuit board. When a connection is made perpendicular to a circuit board surface, the orientation of the triangle and the slot numbers on the connector holder is determined by the direction of the nomenclature marking (see Fig. 5-3).

## Extender Cable

An extender cable, part number 067-0645-01, is available.


METAL-FILM RESISTORS


COMPOSITION
RESISTORS

COLORS IDENTIFY SIGNIFICANT DIGITS IN TEKTRONIX PART NUMBER (EGG. BROWN, GRAY, GREEN STRIPES INDICATE PART NUMBER 152-0185-00)
(1) 2 and (3) 1ST, 2ND, AND 3RD SIGNIFICANT FIGS.

MULTIPLIER


TOLERANCE;
(B) TOLERANCE; $F= \pm 1 \%, J=5 \%, K=10 \%, M=20 \%$
(T) AND/OR TC COLOR CODE MAY NOT BE PRESENT ON SOME CAPACITORS;
(TC) TEMPERATURE COEFFICIENT.



Fig. 5-1. Color code for resistors and capacitors.


L TRANSISTORS $\qquad$ 1


## SILICON-CONTROLLED RECTIFIER



Fig. 5-2. Lead configuration for semiconductor devices.

## TROUBLESHOOTING TECHNIQUES

The following checklist is arranged so that you check the simple things before you take the instrument apart. Start at the beginning.

1. Check the Control Settings. See the Operating Instructions and the Operators Manual for the correct control settings.
2. Check associated Equipment and Connectors. Check to see that the signal source is properly connected and that interconnecting cables are not defective. Also check the power cord plug, and the power source for defects.
3. Check the Performance of the Instrument. If the instrument does not meet specifications, the trouble may be corrected by re-adjusting the instrument. See the Adjustment procedure, Section 6, for instructions.
4. Visual Check. A visual check may reveal broken connections, damaged components, semiconductors not firmly mounted, damaged circuit boards, etc.
5. Isolate the Trouble to a Circuit. To isolate trouble to a particular circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is
located. For example: when trouble symptoms appear in more than one circuit, check affected circuits by taking voltage and waveform readings.

Incorrect operation of all circuits often indicates trouble in the power supply. Check first for correct voltage of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power supply trouble and may also affect the operation of the other circuits. Table 5-1 lists the tolerance of the power supplies. Voltages are measured between the power supply


Fig. 5-3. Multi-connector holder orientation.
test points and ground. If a power supply voltage is within the listed tolerance assume that the supply is working correctly.

TABLE 5-1
Power Supply Tolerances

| Supply | Accuracy <br> $\left(+20^{\circ}\right.$ to $\left.+30^{\circ} \mathrm{C}\right)$ | With Temperature <br> Drift <br> $\left(\mathbf{0}^{\circ}\right.$ to $\left.+50^{\circ} \mathrm{C}\right)$ | Ripple |
| :---: | :---: | :---: | :---: |
| -5 Volt | $-4.9 \mathrm{~V} \pm 0.1 \mathrm{~V}$ | $-4.9 \mathrm{~V} \pm 0.15 \mathrm{~V}$ | Less than <br> 100 mV p-p |
| -2 Volt | $-2.0 \mathrm{~V} \pm 0.05 \mathrm{~V}$ | $-2.0 \mathrm{~V} \pm 0.10 \mathrm{~V}$ |  |
| +5 Volt | $5.1 \mathrm{~V} \pm 0.15 \mathrm{~V}$ | $5.1 \pm 0.20 \mathrm{~V}$ | Less than <br> 100 mV p-p |
| -15 Volt | $-15 \mathrm{~V} \pm 0.2 \mathrm{~V}$ |  |  |
| +15 Volt | (The +15 V Supply is adjusted so that the ECL <br> threshold levels are within specifications. Refer <br> to Section 6, adjustments, for instructions.) |  |  |

Use the troubleshooting chart to locate trouble. Not all problems appear on the chart. Continue with this checklist in those cases.
6. Check Voltages and Waveforms. Often a defective component can be located by checking for the correct voltages and waveforms in a circuit.

## NOTE

Voltages and waveforms given on the diagrams are not absolute and therefore may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the voltage and waveform setup procedure in the Diagrams section. Individual deviations should be noted on the schematics for future reference.
7. Check the individual components. Remember that the best check of semiconductors-transistors, diodes, IC'sand thick-film resistors is actual operation in a circuit. If you suspect that a semiconductor is bad, substitute a new one. Before you start checking IC's, read the part of the Theory of Operation that explains the circuit.

## WARNING

The power must be turned off before removing or replacing components to prevent electrical shock or circuit damage.

Resistors. Check the resistors for discoloration. Disconnect one end from the circuit and check with an ohmmeter. Check the Electrical Parts List for the tolerance of the resistors used in this instrument. Resistors normally need not be replaced unless the measured value varies widely from the specified value.

Inductors. Check inductor continuity with an ohmmeter (it may be helpful to disconnect one end of the inductor). Shorted or partially shorted inductors can also be found by checking the waveform response to high-frequency signals. Partial shorting often reduces high-frequency response (increases roll-off).

Capacitors. A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter, on the highest scale, after disconnecting one end from the circuit. Do not exceed the voltage rating of the capacitor (some ohmmeters use a 30 volt source). The resistance reading should be high after initial charge of the capacitor. An open capacitor can also be detected with a capacitance meter or by checking whether the capacitor passes ac signals.
8. After repairing a circuit or replacing components, check the performance of the instrument. If the Performance Check is within specifications, it is not necessary to re-adjust the instrument. If the instrument does not meet the specifications, perform the Adjustment Procedure in Section 6.

## CORRECTIVE MAINTENANCE

Corrective maintenance consists of repair and parts replacement. This section contains component replacement information and general information.

## REPLACEMENT PARTS

All of the parts for the WR 501 can be ordered from your local Tektronix Field Office, but many of the components are standard items that may be more readily available locally. Check the Parts List for value, tolerance, ratings, and description before you replace any components.

When ordering parts from Tektronix, include the following information:

1) Instrument type.
2) Instrument serial number.
3) A description of part (if electrical, include the circuit number).
4) Tektronix part number.

## NOTE

Be sure you are familiar with the soldering techniques and parts replacement procedures before replacing any components.

## SOLDERING TECHNIQUES

## WARNING

To prevent electrical shock or damage to the instrument, always disconnect the instrument from the power source before soldering.

The WR 501 uses multilayer boards-circuit wiring is laminated between top and bottom layers over the top of which more wiring is etched. Care must be used to prevent the layers from seperating or to avoid breaking the connections to the center conductors.

For soldering, use ordinary 60/40 solder and a 15 W pencil-type soldering iron. Using a soldering iron with a higher wattage rating on etched circuit boards can cause the etched circuit wiring to separate from the board base material.

Use the following technique to replace a component on an etched circuit board. Refer to the component removal and replacement instructions later in this section for circuit board removal instructions.

1. Grip component lead with long-nose pliers. Touch soldering iron to lead at solder connection. Do not lay iron directly on board.
2. When solder begins to melt, pull lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object (e.g., a toothpick) into the hole to clean it. A vacuum-type desoldering tool can also be used for this purpose.
3. Bend leads of new component to fit the holes and the spacing on the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they protrude just through the board. Insert the leads into the holes in the board with the component firmly seated against the board (or as positioned originally). If it does not seat properly, heat the solder and gently press the component into place.
4. Touch the iron to the connection and apply a small amount of solder to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of longnosed pliers or other heat sink.
5. Clip any excess lead the protrudes through board (if not clipped in step 3 above).
6. Clean the area around the solder connection with flux-remover solvent and air dry.

## COMPONENT REMOVAL AND REPLACEMENT

## WARNING

To prevent electrical shock or damage to the instrument, disconnect the instrument from the power source before replacing components.

In order to replace parts on any of the circuit boards in the WR 501, you must remove the daughter board from the instrument. Refer to the part on removal and installation of the circuit boards. Be sure you are familiar with the soldering techniques used on multi-layer circuit boards before you attempt to replace components.

## Fuse Replacement

The fuse for the -4.9 V Power Supply is located on the daughter board. The fuse for the $+5 \mathrm{~V},-15 \mathrm{~V}$ and +15 V power supplies are on the main board near the rear connector. The +15 V fuse is also used for the +5 V supply reference. Refer to the circuit board illustrations in the diagrams section for the location of the fuses. Refer to the parts list for the parts values.

## Switch Replacement

Since the front panel switches are mounted on a Switch Board behind the front panel, the removal and replacement instructions for the various switches are included in the removal instructions for the Switch Board.

## Semiconductor Replacement

Replacement of semiconductors may affect the adjustment of this instrument. After replacing semiconductors, especially if using parts other than those listed in the parts list, check the performance of the instrument to be sure that the performance has not been degraded.

Replacement semiconductors should be of the original types or direct replacements. Lead configurations of the semiconductors used in this instrument are shown in the troubleshooting portion of this section. Some plastic case transistors have lead configurations which do not agree with those shown there. If a replacement transistor is made by a manufacturer other than the original, check the manufacturer's basing diagram for correct basing. Most transistors are in Berg miniature sockets. Power transistors and other semiconductors having heat radiators (in this instrument a Schottky Barrier diode) use silicone grease to increase heat transfer. Replace the silicone grease when replacing these parts.

## WARNING

Handle silicone grease with care to avoid getting silicone grease in your eyes. Wash hands thoroughly after use.

## Interconnecting Cable and Pin Connector Replacement

The interconnecting cable assemblies are factory assembled. They consist of machine-installed pin connectors mounted in plastic holders. The plastic holders are easily replaced as individual items, but if the connectors are faulty, the entire cable should be replaced.

It is possible for the pin connectors to become dislodged from the plastic holders. If this happens, the connector can be re-installed as follows (see Fig. 5-4):

1. Bend grooved portion of holder away from cable as shown.
2. Re-insert connector into its hole in plug-in portion of holder. Wires are positioned in holder according to a color-code system, (see note below)

## NOTE

Holder positions are numbered (number one is identified with a triangle). The wires are EIA color coded to match the numbers on the holder. For example, brown stripe for position 1 (triangle), red stripe for position 2, yellow stripe for position 4, etc.


Fig. 5-4. Pin connector replacement.

## Maintenance-WR 501 Service

Refer to Fig. 5-5 for the location of the various circuit boards in the WR 501.

## Daughter Board Replacement

1. Remove the side covers - they snap out.
2. Remove the 4 screws from the rear bracket and remove the bracket.
3. Remove the screw in the groove on the bottom panel.
4. Disconnect from the daughter board: P12, P13 (both near the Switch Board); P38, P39 (near the rear connector); P20, P18 (next to the power supply shield).
5. Disconnect the TRIG OUT BNC cable from the Main board.
6. Take out the 4 screws holding the daughter board to the main board.
7. Slide the daughter board straight out the rear of the instrument moving cables out of the way where necessary.

To replace the daughter board, reverse the above procedure. Put the connectors on the main board and feed them through the holes in the daughter board as you slide the board forward into place. The probe connector should fit smoothly into its holder.


2168-18

Fig. 5-5. Location of circuit boards.

## Main Board Replacement

1. Remove the daughter board following the instructions in the preceding paragraph.
2. Remove P112, P113, P114 (all near the switch board, P510, P515, P525, and P530.
3. Remove the THRESHOLD variable knobs.
4. Remove the ground lug in the front, bottom corner of the board.
5. Remove the remaining 3 screws holding the main board to the chassis.
6. Slide the main board out the rear of the instrument. Be careful not to break or bend the probe connector.

To replace the main board, reverse the above procedure. You will have to replace the connectors before you slide the board into place and bolt it down. See Fig. 5-6 for the locations of the connectors.

## Switch Board Replacement

1. Remove daughter board.
2. Remove main board.
3. Remove the FILTER knob.
4. Remove the 3 screws holding the switch board to the front subpanel.
5. Slide the switch board out. Be careful not to tangle the connector cables.

To replace the switch board reverse the above procedure.

Delay Count Switches. The Delay Count Switch assembly is a unit that is held in place by a spring after the switch board has been removed. To remove the Delay Count Switches:

1. Loosen the nut on the RESET button and remove it from the front panel. All the cables are in one cable harness.
2. Push the Delay Count Switch assembly forward until it clears the front panel.

Note: If you replace the Delay Count Switches, you must resolder the wires to the new Delay Count Switches in the same positions as the wires were connected to the old ones.

Word Selector Switches. To remove a Word Selector Switch, unsolder all 3 leads and pull the switch out of the switch board. When you replace a Word Selector Switch make sure that it is aligned properly. If any of the Word Selector Switches are out of alignment, the switch board won't fit into the front panel. The switch board is a multilayer board and requires the use of careful soldering techniques.


Fig. 5-6. Location of connectors on Main board.

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## ADJUSTMENTS

## IMPORTANT - Please read before using this procedure.

This procedure allows you to adjust the instrument to its original performance specifications. Any trouble you find should be corrected before continuing. The Adjustment Procedure is not intended as a troubleshooting guide. Refer to the Maintenance section for troubleshooting information.

## ADJUSTMENT CONDITIONS

The WR 501 must be adjusted at an ambient temperature between $+20^{\circ}$ and $+30^{\circ} \mathrm{C}$ to be within the environmental limits described in the Specifications.

## LIMITS AND TOLERANCES

Limits and tolerances are instrument specifications only if they are called out as performance requirements in the Specifications. Tolerances given are for the instrument under test and do not include test equipment error.

## TEST EQUIPMENT REQUIRED

The test equipment listed in Table 6-1, or the equivalent, is required for complete calibration of the WR 501. Specifications given for the equipment are the minimum necessary for accurate calibration.

TABLE 6-1
Test Equipment

| Description | Minimum Specifications | Usage | Examples of Applicable Test Equipment |
| :---: | :---: | :---: | :---: |
| 1. Precision DC Voltmeter | Range, +2 V to +50 V ; accuracy, within $0.1 \%$. Digital voltmeter must have at least $41 / 2$-digit readout. | Check and Adjust power supply; check input threshold voltage. | a. Tektronix DM 501 Digital Multimeter (operates in Tektronix TM 500-Series Power Module). <br> b. Fluke Model 825A Differential DC Voltmeter. |
| 2. Pulse Generator | Pulse duration, 50 ns to 1 ms ; pulse period, $0.1 \mu \mathrm{~s}$ to 10 ms ; risetime, 2 ns or less; output amplitude, $-3 V$ to +3 V with dc offset. | Adjust Filter duration. | a. Tektronix PG 502 Pulse Generator (operates in a Tektronix TM 500-Series Power Module). |
| 3. Flexible Extender Cable | Compatible with TM 500-Series plug-ins. | Provides access to internal test points and adjustments. | a. Tektronix part 067-0645-01. |
| 4. Variable Line Voltage Source | Output, 200 W at 120 V; accuracy, within $3 \%$. | Adjust -4.9 V supply. | a. General radio W8MT3 VM Variac Autotransformer. |
| 5. Oscilloscope with probes (2). | Bandwidth, dc to 200 MHz ; minimum deflection factor, $20 \mathrm{mV} /$ div; accuracy, within 3\%. | Adjust Filter duration. | a. Tektronix 475 Oscilloscope. |
| 6. BNC-to-Probe Tip Adaptor |  | Provide connection from TRIG OUT connector to probe tip. | a. Tektronix part 013-0084-01. |
| 7. BNC Adaptor |  | Provide connection from pulse generator to P6451 probe tip. | a. Tektronix part 131-0602-00. |

## PRELIMINARY PROCEDURE

## WARNING

Dangerous potentials exist at several points inside your instrument. To prevent electrical shock, do not touch exposed connections or components.

1. Remove the side covers from the WR 501.
2. Connect the WR 501 to the TM 500 Power Module using the flexible extender cable (Tektronix Part 067-0645-01). Be sure to connect the cable correctly.
3. Install the P6451 Data Acquisition Probes.
4. Connect the TM 500 Power Module to a variable line-voltage source and adjust the output voltage for 120 V $\pm 3 \mathrm{~V}$.
5. Turn the power on. Allow at least 20 minutes warmup before starting the adjustment procedure.

## A. POWER SUPPLIES

## A. 1 -5 V Power Supply

## NOTE

Do not change the setting of the -4.9 V adjustment unless you intend to re-adjust the entire instrument.
a. Connect the digital voltmeter between -4.9 V test point (see Fig. 6-1) and ground. If the meter does not read between -4.85 V and -4.95 V , continue with step b .
b. ADJUST-R635 (see Fig. 6-1) for -4.90 V .
c. Disconnect digital voltmeter.

## A. 2 -2 V Power Supply

a. Connect digital voltmeter between -2 V test point (see Fig. 6-2) and ground.
b. $\mathrm{CHECK}-$ Voltage is between -1.95 V and -2.05 V .
c. Disconnect digital voltmeter.


Fig. 6-1. Adjustment Locations and test points.

## A. 3 Threshold Levels

a. Connect digital voltmeter between 15-8, QUAL monitor jack and ground jack on the front panel.
b. Set both THRESHOLD Switches to ECL.
c. CHECK-Threshold voltage is from -1.16 V to -1.36 V .
d. Move the digital voltmeter to the 7-0, CLK monitor jack.
e. CHECK-Threshold voltage is from -1.16 V to -1.36 V .
f. If the threshold voltages are within the specified limits proceed to part A.5, otherwise go to part A.4.

## A. $4 \pm 15$ V Power Supplies

a. Connect digital voltmeter between -15 V test point (see Fig. 6-2) and ground.
b. ADJUST-R654, -15 V Adjust (see Fig. 6-1) for -15.00 V.
c. Connect digital voltmeter between 15-8, QUAL monitor jack and ground.
d. Set THRESHOLD Selector Switches to ECL.
e. ADJUST-R663 +15 V Adjust (see Fig. 6-1) for an ECL threshold level of -1.26 V .
f. Connect the digital voltmeter between the 7-0, CLK monitor jack and ground.
g. CHECK-ECL threshold level is from -1.16 V to -1.36 V .
h. Disconnect the digital voltmeter.

## A. 5 +5 V Power Supply

a. Connect digital voltmeter between +5 V test point (see Fig. 6-2) and ground.
b. CHECK - Voltage is between +4.95 V and +5.25 V .
c. Disconnect digital voltmeter.

## B. FILTER

a. Set

| FILTER | $<5$ ns (fully counter- <br> clockwise) |
| :--- | :--- |
| Delay Count Switches | 00000 |
| DELAY Selector Switch | OFF |
| WORD SELECTOR | X (don't care) |
| Switches (all) |  |
| WORD MODE | ASYNC |
| QUALIFIER | OFF |
| THRESHOLD | TTL |

b. Set the pulse generator pulse duration for $0.5 \mu \mathrm{~s}$, frequency for 1 MHz . Set the oscilloscope for $.1 \mu \mathrm{~s} / \mathrm{div}$ and $.5 \mathrm{~V} / \mathrm{div}$.
c. Connect channel 0 lead to the output of the pulse generator and the ground lead to ground on the pulse generator.
d. Connect channel 1 of the oscilloscope to the output of the pulse generator. Adjust the pulse generator for an output pulse amplitude from 0 V to about +3 V and a pulse duration of 500 ns .
e. Connect channel 2 of the oscilloscope to the TRIG OUT connector via the probe and a BNC-to-probe-tip adaptor. Trigger the oscilloscope from channel 1 but look at only the channel 2 display.
f. Set

Ch O WORD
SELECTOR Switch
FILTER
HI
300 ns (fully clockwise)
g. Adjust the oscilloscope horizontal position so that the trailing edge (the HI to LO transition) of the waveform is on the center graticule line.
h. ADJUST-R409, Filter, (see Fig. 6-1) for a 175 ns wide pulse on the oscilloscope screen.
i. Disconnect the test equipment.

Adjustments-WR 501 Service


Fig. 6-2. Test point locations on back of Main board.

# REPLACEABLE <br> ELECTRICAL PARTS 

## PARTS ORDERING INFORMȦION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number
00X Part removed after this serial number

ITEM NAME
In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

| Mfr. Code | Manufacturer | Address | City, State, Zip |
| :---: | :---: | :---: | :---: |
| 0000L | MATSUHITA ELECTRIC | 200 PARK AVENUE, 54TH FLOOR | NEW YORK, NY 10017 |
| 01121 | ALLEN-BRADLEY COMPANY | 1201 2ND STREET SOUTH | MILWAUKEE, WI 53204 |
| 01295 | TEXAS INSTRUMENTS, INC., SEMICONDUCTOR |  |  |
|  | GROUP | P O BOX 5012, 13500 N CENTRAL EXPRESSWAY | DALLAS, TX 75222 |
| 03508 | GENERAL ELECTRIC COMPANY, SEMI-CONDUCTOR |  |  |
|  | PRODUCTS DEPARTMENT | ELECTRONICS PARK | SYRACUSE, NY 13201 |
| 03888 | KDI PYROFILM CORPORATION | 60 S JEFFERSON ROAD | WHIPPANY, NJ 07981 |
| 04713 | MOTOROLA, INC., SEMICONDUCTOR PROD. DIV. | 5005 E MCDOWELL RD,PO BOX 20923 | PHOENIX, AZ 85036 |
| 07263 | FAIRCHILD SEMICONDUCTOR, A DIV. OF |  |  |
|  | FAIRCHILD CAMERA AND INSTRUMENT CORP. | 464 ELLIS STREET | MOUNTAIN VIEW, CA 94042 |
| 07910 | TELEDYNE SEMICONDUCTOR | 12515 CHADRON AVE. | HAWTHORNE, CA 90250 |
| 09353 | C AND K COMPONENTS, INC. | 103 MORSE STREET | WATERTOWN, MA 02172 |
| 12697 | CLAROSTAT MFG. CO., INC. | LOWER WASHINGTON STREET | DOVER, NH 03820 |
| 14752 | ELECTRO CUBE INC. | 1710 S. DEL MAR AVE. | SAN GABRIEL, CA 91776 |
| 27014 | NATIONAL SEMICONDUCTOR CORP. | 2900 SEMICONDUCTOR DR. | SANTA CLARA, CA 95051 |
| 32293 | INTERSIL, INC. | 10900 N. TANTAU AVE. | CUPERTINO, CA 95014 |
| 32997 | BOURNS, INC., TRIMPOT PRODUCTS DIV. | 1200 COLUMBIA AVE. | RIVERSIDE, CA 92507 |
| 49956 | RAYTHEON CO. | 141 SPRING ST. | LEXINGTON, MA 02173 |
| 50579 | LITRONIX INC. | 19000 HOMESTEAD RD. | CUPERTINO, CA 95014 |
| 53184 | XCITON CORPORATION | 5 HEMLOCK STREET | LATHAM, NY 12110 |
| 56289 | SPRAGUE ELECTRIC CO. |  | NORTH ADAMS. MA 01247 |
| 71279 | CAMBRIDGE THERMIONIC CORP. | 445 CONCORD AVE. | CAMBRIDGE, MA 02138 |
| 71400 | BUSSMAN MFG., DIVISION OF MCGRAW- |  |  |
|  | EDISON CO. | 2536 W. UNIVERSITY ST. | ST. LOUIS, MO 63107 |
| 72982 | ERIE TECHNOLOGICAL PRODUCTS, INC. | 644 W. 12TH ST. | ERIE, PA 16512 |
| 73138 | BECKMAN INSTRUMENTS, INC., HELIPOT DIV. | 2500 HARBOR BLVD. | FULLERTON, CA 92634 |
| 75915 | LITTELFUSE, INC. | 800 E. NORTHWEST HWY | DES PLAINES, IL 60016 |
| 80009 | TEKTRONIX, INC. | P O BOX 500 | BEAVERTON, OR 97077 |
| 81073 | GRAYHILL, INC. | 561 HILLGROVE AVE., PO BOX 373 | LA GRANGE, IL 60525 |
| 81483 | INTERNATIONAL RECTIFIER CORP. | 9220 SUNSET BLVD. | LOS ANGELES, CA 90069 |
| 91418 | RADIO MATERIALS COMPANY, DIV. OF P.R. |  |  |
|  | MALLORY AND COMPANY, INC. | 4242 W BRYN MAWR | CHICAGO, IL 60646 |
| 91637 | DALE ELECTRONICS, INC. | P. O. BOX 609 | COLUMBUS, NE 68601 |
| 95146 | ALCO ELECTRONICS PRODUCTS, INC. | P. O. BOX 1348 | LAWRENCE, MA 01842 |


| Ckt No. | Tektronix Part No. | Serial/Model No. <br> Eff Dscont | Name \& Description | Mfr Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{Al}^{1}$ | 670-4904-00 |  | CKT BOARD ASSY:DAUGHTER | 80009 | 670-4904-00 |
| $\mathrm{Al}^{2}$ | 670-4621-00 |  | CKT BOARD ASSY:DAUGHTER | 80009 | 670-4621-00 |
| A2 ${ }^{1}$ | 670-4903-00 |  | CKT BOARD ASSY:MAIN | 80009 | 670-4903-00 |
| A2 ${ }^{2}$ | 670-4620-00 |  | CKT BOARD ASSY:MAIN | 80009 | 670-4620-00 |
| A3 | 670-4622-00 |  | CKT BOARD ASSY:SWITCH | 80009 | 670-4622-00 |
| C8 | 290-0776-00 |  | CAP.,FXD, ELCTLT: 22UF, $+50-10 \%, 10 \mathrm{~V}$ | 0000L | ECE-AlOV22L |
| C9 | 281-0775-00 |  | CAP , FXD, CER DI:0.1UF,20\%.50V | 72982 | 8005H9AABZ5U104M |
| C 12 | 281-0808-00 |  | CAP. ,FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C15 | 281-0775-00 |  | CAP.,FXD, CER DI: $0.1 \mathrm{UF}, 20 \%$,50V | 72982 | 8005H9AABz5U104M |
| C18 | 281-0808-00 |  | CAP.,FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C20 | 281-0775-00 |  | CAP. ,FXD, CER DI:0.1UF, 20\%,50V | 72982 | 8005H9AABZ5U104M |
| C22 | -281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100v | 72982 | 8015-D-COG709M |
| C28 | 281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C30 | 281-0775-00 |  |  | 72982 | 8005H9AABZ5U104M |
| C32 | 281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C35 | 281-0775-00 |  | CAP., FXD, CER DI:0.1UF, 20\%,50V | 72982 | 8005H9AABZ5U104M |
| C38 | 281-0808-00 |  | CAP., FXD, CER DI:7PF,20\%,100V | 72982 | 8015-D-COG709M |
| C42 | 281-0808-00 |  | CAP. , FXD, CER DI: 7 PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C45 | 281-0775-00 |  | CAP.,FXD, CER DI:0.1UF,20\%,50V | 72982 | 8005H9AABZ5U104M |
| C48 | 281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100v | 72982 | 8015-D-COG709M |
| Cl01 | 281-0775-00 |  | CAP.,FXD, CER DI: $0.10 \mathrm{~F}, \mathbf{2 0 \%}$, 50V | 72982 | 8005H9AABZ5U104M |
| C108 | 290-0776-00 |  | CAP. ,FXD, ELCTLT: $22 \mathrm{UF},+50-10 \%$,10V | 0000L | ECE-A10V22L |
| C109 | 281-0775-00 |  | CAP., FXD, CER DI:0.1UF,20\%,50V | 72982 | 8005H9AABZ5U104M |
| Cl12 | 281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| Cl18 | 281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C122 | 281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C128 | 281-0808-00 |  | CAP., FXD, CER DI:7PF,20\%,100V | 72982 | 8015-D-COG709M |
| C132 | 281-0808-00 |  | CAP., FXD, CER DI:7PF, 20\%,100V | 72982 | 8015-D-COG709M |
| C138 | 281-0808-00 |  | CAP., FXD, CER DI: 7 PF, $208,100 \mathrm{~V}$ | 72982 | 8015-D-COG709M |
| C142 | 281-0808-00 |  | CAP. ,FXD, CER DI: $7 \mathrm{PF}, 20 \%$,100v | 72982 | 8015-D-COG709M |
| C145 | 281-0775-00 |  | CAP., FXD, CER DI:0.1UF,20\%,50v | 72982 | 8005H9AABz5U104M |
| C148 | 281-0808-00 |  | CAP.,FXD, CER DI:7PF,20\%,100v | 72982 | 8015-D-COG709M |
| C405 | 281-0759-00 |  | CAP., FXD, CER DI: $22 \mathrm{PF}, 10 \%$,100V | 72982 | 390-049x5P0220K |
| C409 | 281-0763-00 |  | CAP. , FXD, CER DI:47PF,10\%,100V | 72982 | 390049x5P0470K |
| C412 | 281-0775-00 |  | CAP. , FXD, CER DI: $0.1 \mathrm{lfF}, 20 \%$, 50 V | 72982 | 8005H9AABZ5U104M |
| C416 | 281-0775-00 |  | CAP . ,FXD, CER DI:0.1UF,208,50V | 72982 | 8005H9AABZ5U104M |
| C418 | 281-0775-00 |  | CAP. , FXD, CER DI:0.1UF,20\%,50V | 72982 | 8005H9AABZ5U104M |
| C419 | 283-0023-00 |  | CAP.,FXD, CER DI: $0.1 \mathrm{UF},+80-20 \%, 12 \mathrm{~V}$ | 91418 | MX104z1201R0 |
| C421 | 283-0109-00 |  | CAP. , FXD, CER DI:27PF, $5 \%, 1000 \mathrm{~V}$ | 56289 | $20 C 376$ |
| C422 | 290-0517-00 |  | CAP. , FXD, ELCTLT: $6.8 \mathrm{FF}, \mathbf{2 0 \% , 3 5 V}$ | 56289 | 196D685x0035 KAl |
| C428 | 281-0791-00 |  | CAP., FXD, CER DI:270PF, 10\%,100V | 80009 | 281-0791-00 |
| C435 | 281-0775-00 |  | CAP. , FXD, CER DI:O.1UF, 20\%,50V | 72982 | 8005H9AABz5U104M |
| C436 | 283-0065-00 |  | CAP., FXD, CER DI:0.001UF, $5 \%$,100v | 72982 | 805-505B102J |
| C440 | 281-0773-00 |  | CAP., FXD, CER DI:0.01UF,10\%,100v | 72982 | 8005H9AADW5R103K |
| C450 | 281-0775-00 |  | CAP. , FXD, CER DI:0.1UF, 20\%,50V | 72982 | 8005H9AABZ5U104M |
| C451 | 283-0023-00 |  |  | 91418 | mX104z1201R0 |
| C454 | 281-0775-00 |  | CAP., FXD, CER DI:0.1UF,20\%,50V | 72982 | 8005H9AABZ5U104M |
| C456 | 281-0773-00 |  | CAP., FXD, CER DI:0.01UF,10\%,100V | 72982 | 8005H9AADW5R103K |
| C471 | 281-0808-00 |  | CAP.,FXD, CER DI:7PF,20\%,100V | 72982 | 8015-D-COG709M |
| C475 | 281-0775-00 |  | CAP. , FXD, CER DI: 0.1 l | 72982 | 8005H9AABZ5U104M |
| C476 | 283-0023-00 |  | CAP., FXD, CER DI: $0.1 \mathrm{UF},+80-20 \%$, 12V | 91418 | MX104z1201R0 |
| C477 | 290-0776-00 |  | CAP., FXD, ELCTLT: $22 \mathrm{UF},+50-108,10 \mathrm{~V}$ | 0000L | ECE-AlOV22L |
| C478 | 281-0775-00 |  | CAP., FXD, CER DI: $0.10 \mathrm{~F}, 20 \%$, 50 V | 72982 | 8005H9AABZ5U104M |

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[^1]| Ckt No. | Tektronix Part No. | Serial/Model No. <br> Eff Dscont | Name \& Description | Mfr Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| L625 | 108-0337-00 |  | CoIt,RF:25UH | 80009 | 108-0337-00 |
| L644 | 108-0336-00 |  | COIL, RF: 100 UH | 80009 | 108-0336-00 |
| Q $410 \mathrm{~A}, \mathrm{~B}$ | 151-0353-00 |  | TRANSISTOR:SILICON,NPN,DUAL MONOLITH | 32293 | ITS1251 |
| Q420 | 151-0325-00 |  | TRANSISTOR:SILICON, PNP,SEL FROM 2 N4258 | 80009 | 151-0325-00 |
| 2424 | 151-0325-00 |  | TRANSISTOR:SILICON,PNP,SEL FROM 2 24258 | 80009 | 151-0325-00 |
| Q436 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 80009 | 151-0190-00 |
| 2458 | 151-0325-00 |  | TRANSISTOR:SILICON, PNP,SEL FROM 2 N4258 | 80009 | 151-0325-00 |
| Q466 | 151-0188-00 |  | TRANSISTOR:SILICON,PNP | 01295 | 2N3906 |
| Q474 | 151-0472-00 |  | TRANSISTOR: SILICON, NPN | 80009 | 151-0472-00 |
| 2472 | 151-0472-00 |  | TRANSISTOR:SILICON, NPN | 80009 | 151-0472-00 |
| 2480 | 151-0325-00 |  | TRANSISTOR:SILICON, PNP,SEL FROM 2 N4258 | 80009 | 151-0325-00 |
| Q484 | '151-0325-00 |  | TRANSISTOR:SILICON,PNP,SEI FROM 2N4258 | 80009 | 151-0325-00 |
| 2492 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 80009 | 151-0190-00 |
| Q602 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 80009 | 151-0190-00 |
| 2605 | 151-0190-00 |  | TRANSISTOR:SILICON, NPN | 80009 | 151-0190-00 |
| Q610 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 01295 | 2N3906 |
| 2615 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 01295 | 2N3906 |
| 9628 | 151-0183-00 |  | TRANSISTOR:SILICON, NPN | 80009 | 151-0183-00 |
| Q629 | 151-0621-01 |  | TRANSISTOR:SILICON,NPN | 80009 | 151-0621-01 |
| 2632 | 151-0302-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N2222A |
| Q640 | 151-0220-00 |  | TRANSISTOR:SILICON, PNP | 80009 | 151-0220-00 |
| 9644 | 151-0220-00 |  | TRANSISTOR:SILICON, PNP | 80009 | 151-0220-00 |
| Q648 | 151-0506-00 |  | TRANSISTOR:SILICON,SCR | 03508 | C106B2 |
| 2650 | 151-0444-00 |  | TRANSISTOR:SILICON,NPN | 80009 | 151-0444 |
| Q655 | 151-0443-00 |  | TRANSISTOR:SILICON, PNP | 04713 | MPS-A92 |
| R1 | 307-0525-00 |  | RES. ,NETWORK:THK FILM, (9) 56 OHM, $28,0.25 \mathrm{~W}$ | 91637 | CSP10G01560G |
| R2 | 307-0110-00 |  | RES. , FXD, CMPSN: 3 OHM, $58,0.25 \mathrm{~W}$ | 01121 | С83065 |
| R3 | 307-0110-00 |  | RES. ,FXD, CMPSN:3 OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB30G5 |
| R5 | 307-0525-00 |  | RES., NETWORK:THK FILM, (9) 56 OHM, 28,0.25W | 91637 | CSP10G01560G |
| R7 | 307-0488-00 |  | RES,NTWK,FXD, FT: 100 OHM, 208,0.75w | 32997 | 4406R001101 |
| R8 | 307-0488-00 |  | RES, NTWK, FXD, FI: 100 OHM, 20\%,0.75W | 32997 | 4406R001101 |
| R10 | 315-0511-00 |  | RES.,FXD,CMPSN:510 OHM, 5\%,0.25W | 01121 | CB5115 |
| R12 | 315-0910-00 |  | RES.,FXD,CMPSN:91 OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB9105 |
| R15 | 307-0488-00 |  | RES,NTWK, FXD, FI:100 OHM, 208,0.75W | 32997 | 4406R001101 |
| R17 | 315-0511-00 |  | RES.,FXD,CMPSN:510 ОHM, 58,0.25W | 01121 | CB5115 |
| R18 | 315-0910-00 |  | RES.,FXD,CMPSN:91 онM,5\%,0.25W | 01121 | CB9105 |
| R20 | 315-0511-00 |  | RES.,FXD,CMPSN:510 OHM, 58,0.25W | 01121 | CB5115 |
| R22 | 315-0910-00 |  | RES.,FXD, CMPSN:91 OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB9105 |
| R25 | 307-0488-00 |  | RES,NTWK.FXD,FI:100 ОНM, 208,0.75W | 32997 | $4406 \mathrm{ROOH1} 101$ |
| R27 | 315-0511-00 |  | RES., FXD, CMPSN:510 OHM, 58,0.25w | 01121 | CB5115 |
| R28 | 315-0910-00 |  | ReS.,FXD,CMPSN:91 OHM, 58,0.25W | 01121 | CB9105 |
| R30 | 315-0511-00 |  | RES., FXD, CMPSN:510 OHM, 58,0.25W | 01121 | CB5115 |
| R32 | 315-0910-00 |  | RES.,FXD,CMPSN:91 OHM , $58,0.25 \mathrm{~W}$ | 01121 | CB9105 |
| R35 | 307-0488-00 |  | RES, NTWK, FXD, FI: 100 OHM, 20\%,0.75W | 32997 | $4406 \mathrm{ROOH1} 101$ |
| R37 | 315-0511-00 |  | RES.,FXD,CMPSN:510 ОНM, 58,0.25w | 01121 | CB5115 |
| R38 | 315-0910-00 |  | RES.,FXD, CMPSN:91 OHM, 58, 0.25 W | 01121 | CB9105 |
| R40 | 315-0511-00 |  | RES., FXD, CMPSN:510 OHM, 5\%,0.25W | 01121 | CB5115 |
| R42 | 315-0910-00 |  | RES.,FXD,CMPSN:91 ОНM, $58,0.25 \mathrm{~W}$ | 01221 | CB9105 |
| R45 | 307-0488-00 |  | RES,NTWK, FXD, FI:100 OHM, 208,0.75W | 32997 | 4406R001101 |
| R47 | 315-0511-00 |  | RES.,FXD,CMPSN:510 ОНM,5\%,0.25W | 01121 | CB5115 |
| R48 | 315-0910-00 |  | Res.,FXD,CMPSN:91 OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB9105 |
| R100 | 307-0525-00 |  | RES.,NETWORK:THK FILM, (9) 56 OHM, 28,0.25W | 91637 | CSP10G01560G |


| Ckt No. | Tektronix Part No. | Serial/Model No. <br> Eff <br> Dscont | Name \& Description | Mfr Code | Mfr Part Number |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| R101 | 307-0110-00 |  | RES.,FXD, CMPSN:3 OHM,5\%,0.25W | 01121 | CB30G5 |  |
| R102 | 307-0110-00 |  | RES., FXD, CMPSN: 3 OHM, 5\%,0.25W | 01121 | CB30G5 | 13 |
| R105 | 307-0525-00 |  | RES.,NETWORK:THK FILM, (9) 56 OHM, 2\%,0.25W | 91637 | CSP10G01560G |  |
| R107 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM, 20\%,0.75W | 32997 | 4406R001101 |  |
| R108 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM, 20\%,0.75W | 32997 | 4406R001101 | 7 |
| R110 | 315-0511-00 |  | RES., FXD, CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R112 | 315-0910-00 |  | RES.,FXD,CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 |  |
| R115 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM, 20\%,0.75W | 32997 | 4406R001101 | - |
| R117 | 315-0511-00 |  | RES.,FXD, CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R118 | 315-0910-00 |  | RES. , FXD, CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 | , |
| R120 | 315-0511-00 |  | RES.,FXD, CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R122 | 315-0910-00 |  | RES., FXD, CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 |  |
| R125 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM, 20\%,0.75W | 32997 | 4406R001101 |  |
| R127 | 315-0511-00 |  | RES.,FXD, CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R128 | 315-0910-00 |  | RES. ,FXD,CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 |  |
| R130 | 315-0511-00 |  | RES.,FXD,CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R132 | 315-0910-00 |  | RES.,FXD,CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 |  |
| R135 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM,20\%,0.75W | 32997 | $4406 \mathrm{R001101}$ |  |
| R137 | 315-0511-00 |  | RES.,FXD, CMPSN:510 ОНM, 5\%,0.25W | 01121 | CB5115 |  |
| R138 | 315-0910-00 |  | RES. ,FXD, CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 |  |
| R140 | 315-0511-00 |  | RES.,FXD, CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R142 | 315-0910-00 |  | RES.,FXD,CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 |  |
| R145 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM, 20\%,0.75W | 32997 | 4406R001101 | 7 |
| R147 | 315-0511-00 |  | RES., FXD, CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R148 | 315-0910-00 |  | RES. ,FXD,CMPSN:91 OHM,5\%,0.25W | 01121 | CB9105 | L |
| R302 | 315-0201-00 |  | RES. ,FXD, CMPSN:200 OHM,5\%,0.25W | 01121 | CB2015 |  |
| R304 | 315-0102-00 |  | RES.,FXD, CMPSN:1K OHM,5\%,0.25W | 01121 | CB1025 |  |
| R348 | 315-0511-00 |  | RES., FXD, CMPSN:510 OHM,5\%,0.25W | 01121 | CB5115 |  |
| R400 | 311-1927-00 |  | RES., VAR,NONWIR:50K OHM, $10 \%, 0.50 \mathrm{~W}$ | 12697 | OBD |  |
| R402 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM, 20\%,0.75W | 32997 | 4406R001101 |  |
| R403 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM, 20\%,0.75W | 32997 | 4406R001101 |  |
| R407 | 307-0489-00 |  | RES,NTWK, FXD,FI:THICK FILM,100 OHM, 20\%,1W | 32997 | 4408R0011010 |  |
| R408 | 315-0153-00 |  | RES.,FXD,CMPSN:15K OHM,5\%,0.25W | 01121 | CB1535 |  |
| R409 | 311-1551-00 |  | RES.,VAR,NONWIR:TRMR,IM OHM,0.50W | 73138 | 91A RIMEG |  |
| R410 | 315-0271-00 |  | RES.,FXD, CMPSN:270 OHM,5\%,0.25W | 01121 | CB2715 | $\Gamma$ |
| R413 | 315-0241-00 |  | RES.,FXD,CMPSN:240 OHM,5\%,0.25W | 01121 | CB2415 | $\square$ |
| R415 | 315-0241-00 |  | RES.,FXD.CMPSN:240 OHM,5\%,0.25W | 01121 | CB2415 |  |
| R416 | 315-0102-00 |  | RES.,FXD, CMPSN:IK OHM,5\%,0.25W | 01121 | CB1025 |  |
| R419 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM,20\%,0.75W | 32997 | 4406R001101 |  |
| R420 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM,20\%,0.75W | 32997 | 4406R001101 |  |
| R421 | 315-0132-00 |  | RES.,FXD, CMPSN:1.3K OHM,5\%,0.25W | 01121 | CB1325 |  |
| R424 | 315-0301-00 |  | RES. ,FXD, CMPSN:300 OHM,5\%,0.25W | 01121 | CB3015 |  |
| R428 | 315-0182-00 |  | RES.,FXD,CMPSN:1.8K OHM,5\%,0.25W | 01121 | CB1825 |  |
| R429 | 315-0241-00 |  | RES.,FXD,CMPSN:240 OHM,5\%,0.25W | 01121 | CB2415 | L |
| R432 | 307-0489-00 |  | RES,NIWK,FXD,FI:THICK FILM, 100 OHM, 20\%,1W | 32997 | 4408R0011010 |  |
| R434 | 307-0488-00 |  | RES,NTWK,FXD,FI:100 OHM,20\%,0.75W | 32997 | 4406R001101 |  |
| R435 | 315-0181-00 |  | RES.,FXD,CMPSN:180 OHM,5\%,0.25W | 01121 | CB1815 |  |
| R436 | 315-0102-00 |  | RES ,FXD, CMPSN:1K OHM, 5\%,0.25W | 01121 | CB1025 |  |
| R437 | 307-0489-00 |  | RES,NTWK,FXD,FI:THICK FILM, 100 OHM, 20\%,1W | 32997 | 4408R0011010 |  |
| R438 | 315-0391-00 |  | RES , FXD, CMPSN:390 OHM,5\%,0.25W | 01121 | CB3915 |  |
| R440 | 315-0205-00 |  | RES. ,FXD,CMPSN:2M OHM,5\%,0.25W | 01121 | CB2055 | $\underline{\square}$ |
| R442 | 315-0471-00 |  | RES., FXD, CMPSN: 470 OHM, 5\%,0.25W | 01121 | CB4715 |  |
| R443 | 315-0271-00 |  | RES., FXD, CMPSN:270 OHM,5\%,0.25W | 01121 | CB2715 |  |



|  | Tektronix | Serial/Model No. |  |  | Mfr |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Ckt No. | Part No. | Eff | DSCOnt |  | Name \& Description | Code | Mfr Part Number


| Ckt No. | Tektronix Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| S350 | 260-1335-00 |  | SWITCH, TOGGLE : SPDT, 0.4A, 20VDC | 09353 | 7101SHCI |
| S446 | 260-0735-00 |  | SWITCH, PUSH:SPST | 81073 | 39-1 |
| S510 | 260-1855-00 |  | SWITCH,PUSH:10 POSN,BIN CODED DEC | 95146 | SMC-C9C-5-P |
| S670 | 260-1809-00 |  | SWITCH,TOGGLE:SPTT, 0.4A,20V | 09353 | 7103SYCB |
| S685 | 260-1809-00 |  | SWITCH,TOGGLE: SPTT, 0.4A,20V | 09353 | 7103SYCB |
| T641 | 120-1086-00 |  | TRANSFORMER,RF:SWITCHING REGULATOR | 80009 | 120-1086-00 |
| U10 | 156-0369-00 |  | MICROCIRCUIT,LI:TRIPLE LINE RE | 80009 | 156-0369-00 |
| U15 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MC10104L |
| U18 | 156-0759-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT OR GATE | 04713 | MC10103 L OR P |
| U20 | 156-0369-00 |  | MICROCIRCUIT,LI:TRIPLE LINE RE | 80009 | 156-0369-00 |
| U25 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MCl0104L |
| U30 | 156-0369-00 |  | MICROCIRCUIT,LI:TRIPLE LINE RE | 80009 | 156-0369-00 |
| U35 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MC10104L |
| U38 | 156-0759-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT OR GATE | 04713 | MC10103 L OR P |
| U45 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MC10104L |
| Ull0 | 156-0369-00 |  | MICROCIRCUIT,LI:TRIPLE LINE RE | 80009 | 156-0369-00 |
| U115 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL IOK QUAD AND GATE | 04713 | MC10104L |
| U118 | 156-0759-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT OR GATE | 04713 | MC10103 L OR P |
| U120 | 156-0369-00 |  | MICROCIRCUIT,LI:TRIPLE LINE RE | 80009 | 156-0369-00 |
| U125 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MC10104L |
| U130 | 156-0369-00 |  | MICROCIRCUIT,LI:TRIPLE LINE RE | 80009 | 156-0369-00 |
| U135 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MC10104L |
| U138 | 156-0759-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT OR GATE | 04713 | MC10103 L OR P |
| U145 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MC10104L |
| U405 | 156-0848-00 |  | MICROCIRCUIT,DI:DUAL 3-INP 3-OUT GATE | 04713 | MCl0212P |
| U409 | 119-0857-00 |  | DELAY LINE:DUAL, 7.5NS AND 5.0NS,100 OHM | 80009 | 119-0857-00 |
| U412 | 156-0252-00 |  | MICROCIRCUIT,DI:TRIPLE 4-3-3 INP NOR GATE | 80009 | 156-0252-00 |
| U414 | 156-0252-00 |  | MICROCIRCUIT,DI:TRIPLE 4-3-3 INP NOR GATE | 80009 | 156-0252-00 |
| U416 | 156-0226-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE | 80009 | 156-0226-00 |
| U418 | 156-0757-00 |  | MICROCIRCUIT,DI:DUAL 3-IN,3-OUT GATE | 04713 | MC10211 P OR L |
| U430 | 156-0230-00 | B010100 B010349 | MICROCIRCUIT,DI:DUAL D MA-SLAVE FLIP-FLOP | 80009 | 156-0230-00 |
| U430 | 156-0880-00 | B010350 | MICROCIRCUIT, DI:DUAL D MASTER SLAVE FF | 80009 | 156-0880-00 |
| U432 | 156-0458-00 |  | MICROCIRCUIT,DI:ECL 10K QUAD AND GATE | 04713 | MC10104L |
| U436 | 156-0205-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE | 80009 | 156-0205-00 |
| U446 | 156-0721-00 |  | MICROCIRCUIT,DI:ST POS-NAND GATES W/TP OUT | 27014 | DM74LSI32N |
| U450 | 156-0205-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE | 80009 | 156-0205-00 |
| U452 | 156-0205-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE | 80009 | 156-0205-00 |
| U454 | 156-0205-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE | 80009 | 156-0205-00 |
| U456 | 156-0230-00 |  | MICROCIRCUIT,DI:DUAL D MA-SLAVE FLIP-FLOP | 80009 | 156-0230-00 |
| U460 | 156-0205-00 | B010100 B010349 | MICROCIRCUIT.DI: QUAD 2-INPUT NOR GATE | 80009 | 156-0205-00 |
| R460 | 156-0226-00 | B010350 | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE | 80009 | 156-0226-00 |
| U470 | 156-0757-00 |  | MICROCIRCUIT,DI:DUAL 3-IN,3-OUT GATE | 04713 | MC10211 P OR L |
| U510 | 156-0727-00 |  | MICROCIRCUIT,DI:30 MHZ PRESETTABLE DECADE | 27014 | DM74LS196N |
| U515 | 156-0727-00 |  | MICROCIRCUIT,DI:30 MHZ PRESETTABLE DECADE | 27014 | DM74LS196N |
| U520 | 156-0727-00 |  | MICROCIRCUIT,DI:30 MHZ PRESETTABLE DECADE | 27014 | DM74LS196N |
| U525 | 156-0727-00 |  | MICROCIRCUIT,DI:30 MHZ PRESETTABLE DECADE | 27014 | DM74LS196N |
| U530 | 156-0870-00 |  | MICROCIRCUIT,DI:BCD DECADE COUNTER | 07263 | F10010DC |
| U545 | 156-0035-00 |  | MICROCIRCUIT,DI:SGL 8-INPUT POS NAND GATE | 80009 | 156-0035-00 |
| U550 | 156-0035-00 |  | MICROCIRCUIT,DI:SGL 8-INPUT POS NAND GATE | 80009 | 156-0035-00 |
| U660 | 156-0496-00 |  | MICROCIRCUIT,LI:V RGTR,DUAL TRKG | 49956 | RC4194DC |
| U676 | 156-0158-00 |  | MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER | 80009 | 156-0158-00 |


| Ckt No. | Tektronix Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr <br> Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| U680 | 156-0158-00 |  | MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER | 80009 | 156-0158-00 |
| VR630 | 152-0514-00 |  | SEMICOND DEVICE:ZENER, 0.4W,10V | 80009 | 152-0514-00 |
| VR633 | 152-0317-00 |  | SEMICOND DEVICE:ZENER,0.25w,6.2v,5\% | 81483 | 1N3497 |
| VR647 | 152-0175-00 |  | SEMICOND DEVICE:ZENER, $0.4 \mathrm{~W}, 5.6 \mathrm{~V}$,5\% | 80009 | 152-0175-00 |
| VR651 | 152-0304-00 |  | SEMICOND DEVICE:ZENER.0.4W, 20v,5\% | 04713 | 1N968B |
| VR656 | 152-0304-00 |  | SEMICOND DEVICE:ZENER, $0.4 \mathrm{~W}, 20 \mathrm{~V}, 5 \%$ | 04713 | 1N968B |

## OPTIONS

Information on any subsequent options may be found in the CHANGE INFORMATION section in the back of this manual.

## DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

## Symbols and Reference Designators

Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors $=\quad$| Values one or greater are in picofarads $(\mathrm{pF})$. |
| :--- |
| Values less than one are in microfarads $(\mu \mathrm{s})$. |

Resistors $=\quad$ Ohms $(\Omega)$.

Symbols used on the diagrams are based on ANSI Standard Y32.2-1975.
Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

| A | Assembly, separable or repair- <br> able (circuit board, etc.) |
| :--- | :--- |
| AT | Attenuator, fixed or variable |
| B | Motor |
| BT | Battery |
| C | Capacitor, fixed or variable |
| CB | Circuit breaker |
| CR | Diode, signal or rectifier |
| DL | Delay line |
| DS | Indicating device (lamp) |
| E | Spark Gap |
| F | Fuse |
| FL | Filter |


| H | Heat dissipating device (heat <br> sink, heat radiator, etc.) |
| :--- | :--- |
| HR | Heater |
| HY | Hybrid circuit |
| J | Connector, stationary portion |
| K | Relay |
| L | Inductor, fixed or variable |
| LR | Inductor/resistor combination |
| M | Meter |
| P | Connector, movable portion |
| Q | Transistor or silicon-controlled |
| rectifier | Resistor, fixed or variable |


| RT | Thermistor |
| :--- | :--- |
| S | Switch |
| T | Transformer |
| TC | Thermocouple |
| TP | Test point |
| U | Assembly, inseparable or non- |
|  | repairable (integrated circuit, |
|  | etc.) |
| V | Electron tube |
| VR | Voltage regulator (zener diode, |
|  | etc.) |
| Y | Crystal |
| Z | Phase shifter |

The following special symbols are used on the diagrams:



Figure 9-1. A1-Daughter circuit board with component locations.

| $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORRD } \end{aligned}$ | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRD <br> COORD | $\begin{aligned} & \text { CKT } \\ & \text { NOO } \end{aligned}$ | GRID <br> COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \mathrm{NO} \end{aligned}$ | GRID COORD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C8 | 41 | C624 | 1D | F625 | 3A | 0629 | 5D | R15 | 3 F | R45 | 5 F | T641 | 3 C | VR630 | 2 C |
| c9 | 31 | C625 | 2 F |  |  | 0632 | 2 C | R17 | 3F | R47 | 5 F |  |  | VR633 | 2 C |
| C12 | 3F | C626 | 4B | L625 | 5 C | 0640 | 2 E | R18 | 3 F | R48 | 5 F | TP-4.9V | 2 C | VR647 | 2 C |
| C15 | 2 E | C627 | 5 C | L644 | 3 D | $\bigcirc 644$ | 2D | R20 | 4 F | R626 | 4 D | TP18 | 5 E |  |  |
| C18 | 3 F | C634 | 2 D |  |  | 0648 | 4 B | R22 | 4 F | R627 | 4 D | TP20 | 3 E |  |  |
| C20 | 5H | C638 | 2 D | P12 | 2 H |  |  | R25 | 4 F | R630 | 2 C |  |  |  |  |
| C22 | 4 F | C641 | 3 C | P13 | 2 H | R1 | 3 H | R27 | 4 F | R632 | 2 D | U10 | 4 H |  |  |
| C28 | 4 F | 6645 | зв | P18 | 5 E | R2 | 4 H | R28 | 4 F | R633 | 2 D | U15 | 3 F |  |  |
| c30 | 4 G | C646 | зв | P20 | 3 E | R3 | 4 G | R30 | 4 F | R634 | 2 E | U18 | 3 G |  |  |
| C32 | 3 F | C647 | 2 C | P25A | 2 C | R5 | 4 H | R32 | 3 F | R635 | 2 E | U20 | 3 H |  |  |
| C35 | 2 E |  |  | P25B | 2 C | R7 | 3 G | R35 | 3 F | R636 | 2D | U25 | 4 F |  |  |
| C38 | 2 F | CR629 | 5D | P36 | 4 A | R8 | 4 G | R37 | 2 F | R637 | 2 D | U30 | 4 H |  |  |
| C42 | 5 F |  |  | P38 | 4A | R10 | 3 F | R38 | 2 F | R638 | 2 D | U35 | 2 E |  |  |
| C45 | 5 F | DL15 | 4 G |  |  |  |  | R40 | 5 F | R642 | 2 D | U38 | $5^{5 G}$ |  |  |
| C48 | 4F |  |  | 0628 | 2 D | R12 | 3 F | R42 | 5F | R647 | 2 C | U45 | 4 G |  |  |



## WAVEFORM CONDITIONS

The waveforms below were taken with a Tektronix 7704 Oscilloscope, 7B71 Time Base, and a 7A16 Amplifier. The oscilloscope input coupling was set to dc. Waveforms may vary as much as $\pm 20 \%$.

The input signal was a square wave that was HI for 50 ns and LO for 50 ns 2 V p-p centered around -1.26 V , the ECL threshold voltage. CH 0 , the clock lead, and the qualifier lead were connected to the same signal source. A Tektronix PG 502 provided the signal.

The WR 501 controls were set as follows:

| Ch 0 WORD SELECTOR Switch | LO |
| :--- | :--- |
| Rest of WORD SELECTOR Switches | X (don't care) |
| THRESHOLD | ECL |
| WORD MODE | ASYNC |
| FILTER | 5 ns |
| QUALIFIER | OFF |
| Delay Selector Switch | OFF |
| CLOCK | $\Gamma$ |




| $\begin{array}{\|l\|l\|} \hline \text { CKTT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{array}{\|l\|l\|} \hline \text { CKT } \\ \text { NT } \end{array}$ | GRID coord | $\begin{array}{\|l\|l\|l\|l\|l\|l\|l\|l\|l\|} \hline \text { NOT } \end{array}$ | GRID COORD | $\begin{array}{\|l\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NOT } \end{array}$ | GRID COORD | $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|c\|c\|} \hline \text { CKT } \\ \text { No } \end{array}$ | GRID COORD | $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C101 | 41 | C454 | 5 C | CR477 | 5 F | P138 | 5B | 0484 | 5 E | R128 | 4 G | R425 | 3A | R473 | 5 F | R610 | 5A | R682 | ${ }^{1 J}$ | U125 | 4 G | U525 | 1 B |
| C108 | 4 K | C456 | 2 B | CR484 | 5D | P425 | 2 B | 0492 | 2B | R130 | 4 G | R426 | 3A | R474 | 5 F | R612 | 5B | R684 | 1 J | U130 | 41 | U530 | 5D |
| C109 | 4 J | C471 | 3 E | CR490 | 2B | P430 | 3D | 0602 | 4A | $\mathrm{R}^{132}$ | 4 G | R429 | 3B | R475 | ${ }^{5 F}$ | R614 | 4 B | R685 | 2 l | U135 | ${ }^{36}$ | U545 | 2 E |
| C112 | 3 G | 6475 | 51 | CR496 | 1 F | P446 | 2 B | 0605 | 4A | R135 | 3 G | R432 | 3E | R477 | 5 F | R651 | 2 G | R687 | 2 J | U138 | 5 H | U550 | 2 D |
| C118 | 3 G | 6476 | 5 G | CR530 | 5B | P474 | 5 F | 0610 | 5B | R137 | 3 G | R434 | 3D | R478 | 5G | R653 | 2 G | R689 | 3J | U145 | 5G | U660 | 1 G |
| C122 | 4 G | 6477 | 5 E | CR620 | 3B | P477 | 51 | 0615 | 5B | ${ }^{\mathrm{R} 138}$ | ${ }^{2 G}$ | R435 | 2C | R482 | 4 D | R654 | 1 G | R690 | 11 | U405 | 4 E | 0676 | 1 H |
| C128 | 4 G | C478 | 5D |  |  | P510 | 1 E | 0650 | 1 G | R140 | 5G | R436 | 2 C | R483 | 5D | R656 | 2 H | R691 | 11 | U409 | 2 E | U680 | 2 J |
| C132 | 3 G | C482 | 5 E | DL115 | 4H | P515 | 1 D | 0655 | 2 H | R142 | 5G | R437 | 4D | R485 | 5 D | R657 | 1H | R692 | 11 | U412 | 4 E |  |  |
| C138 | 2 G | C488 | 5 E |  |  | P520 | 2 B |  |  | R145 | 5 G | R440 | 3C | R487 | 5D | R660 | 2 F | R694 | 1 J | U414 | 3 E | VR651 | 2 G |
| C142 | 5 G | C497 | 2 B | F600 | 4 A | P525 | 2 B | R100 | 41 | R147 | 5 G | R442 | 2 C | R488 | 5 E | R662 | 1 G | R695 | ${ }^{1} \mathrm{~J}$ | U416 | 4 E | VR656 | 2 H |
| C145 | 5 F | C515 | 2D | F650 | 3 B | P530 | 5 C | R101 | 4H | R148 | 5 F | R443 | 4 B | R492 | 28 | R663 | $1{ }^{1+}$ | R696 | 2 J | U418 | 3 E |  |  |
| C148 | 5 G | C525 | 2A | F655 | 3B | P680 | 2 H | R102 | 41 | R402 | 5 E | R444 | 4B | R494 | 28 | R664 | 2 G | R698 | 1 J | U430 | 3 E |  |  |
| C405 | 5 E | C530 | 5 D |  |  | P655 | 3 B | R105 | ${ }_{31}^{41}$ | R403 | 4 E | R445 | ${ }_{2}^{4 C}$ | R495 | ${ }^{28}$ | R666 | $2{ }^{2 \mathrm{H}}$ | R699 | 2 J | U432 | $\begin{array}{r}3 \mathrm{C} \\ \hline \text { D }\end{array}$ |  |  |
| C409 | 2 C | C610 | ${ }^{5 B}$ | J110 | 5 K | P680 | 2 H | R107 | $3 \mathrm{3H}$ 5 | R407 | 4 E 1 F | R447 | ${ }_{2}^{2 C}$ | R497 | 28 10 | ${ }_{\text {R670 }}^{\text {R672A }}$ | 2 J 4 J | TP-15V | 1H | U436 U446 | 2D 3 C |  |  |
| C412 | $\stackrel{4}{45}$ | ${ }^{\text {C6652 }}$ | ${ }_{2}^{4 \mathrm{~B}}$ | P112 | 21 | 0410 | 2 F | R108 R110 | ${ }_{3 G}$ | R409 | 1 F | R448 | ${ }_{4}^{2 \mathrm{C}}$ | R520 | 1 B | R672B | 4 J | TP-2V | 5B | U450 | 3 C |  |  |
| C 418 | 3 F | C657 | 1 G | P113 | 21 | 0420 | 3B | R112 | 3 G | R410 | 1 F | R451 | ${ }_{4}^{4 C}$ | R530 | 5 5 | R673 | 2 J | TPGND | 2 H | U452 | 2 C |  |  |
| 6419 | 3 E | C660 | 2 H | P114 | 3 J | 0424 | 3B | R115 | 4 G | R413 | 4 F | R454 | 4 C | R R 532 | 5C 50 | R674 | 4 J | TP+15V | 1 G | U454 | 4 C |  |  |
| C421 | зв | C666 | 2 H | P115 | 3 J | 0436 | 2 C | R117 | ${ }^{3 G}$ | R415 | 4 F | R457 | ${ }^{2 B}$ | R R536 | ${ }_{5}^{5 C}$ | R675 | 1 H | TP+5.1V | 4B | U456 | 4 D |  |  |
| C422 | 2 C |  |  | P118 | 4 F | 0458 | 2 F | R118 | 3G |  |  | R458 | ${ }_{3}^{2 B}$ | R542 | 2 E |  | ${ }_{11}$ |  |  |  | ${ }^{4 \mathrm{D}}$ |  |  |
| C435 $\mathrm{C436}$ | 2 E 10 |  | ${ }_{2}^{4 F}$ |  | 4 F 2 F | O466 | 2 F 5 F |  |  | R419 | 3 E 3 B | R460 | ${ }^{3 C}$ | R544 R546 | ${ }_{2}^{2 \mathrm{E}}$ | R678 R679 | 11 1 J |  | ${ }_{31}^{41}$ | U470 | 3 E 1 E |  |  |
| C436 $\mathrm{C440}$ | 10 ${ }^{10}$ | CR424 CR436 | ${ }^{28}$ | P125A P125B | 2 F 2 F | 0472 0474 | 5F 5 | R122 | 4 G 4 | R420 | 3 B 3 B | R466 | ${ }_{3 \mathrm{~F}}^{1 \mathrm{~F}}$ | R546 R606 | ${ }_{4}^{2 E}$ | R679 R 680 | ${ }_{2 J}^{1 J}$ | U115 | 3 GH <br> 3 | U510 | 1 D |  |  |
| C440 | 3 C 3 C | CR456 | ${ }_{2 B}$ | P136 | ${ }_{4 B}$ | 0480 | 5 E | R127 | 4 G | R424 | зв | R472 | 3 E | R608 | 4 B | R681 | 2 J | U120 | 31 | U520 | 1 E |  |  |



## WAVEFORM CONDITIONS

The waveforms below were taken with a Tektronix 7704 Oscilloscope，7B71 Time Base，and a 7A16 Amplifier．The oscilloscope input coupling was set to dc．Waveforms may vary as much as $\pm 20 \%$ ．

The input signal was a square wave that was HI for 50 ns and LO for 50 ns 2 V p－p centered around -1.26 V ，the ECL threshold voltage． CH 0 ，the clock lead，and the qualifier lead were connected to the same signal source．A Tektronix PG 502 provided the signal．

The WR 501 controls were set as follows：
CH 0 WORD SELECTOR Switch
Rest of WORD SELECTOR Switches
THRESHOLD
WORD MODE
FILTER
QUALIFIER
Delay Selector Switch
CLOCK

LO
X（don＇t care）
ECL
ASYNC
5 ns
OFF
OFF
$\varsigma$
1

| 100 mV |  |  |  | 50 | ns |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ．．．． | ．．．． | ．．．． | 圭．．． | －．．． | ．．．． |  |  |
|  |  |  | 走 |  |  |  |  |
| $\mathrm{HN}$ |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| － |  |  |  |  |  |  |  |
| M |  | 1 |  |  | $m$ |  | 1 |
|  |  |  | 圭 |  |  |  |  |

2


3




Figure 9-3. A3-Switch circuit board with component locations.

| On some early Switch boards: | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \end{aligned}$ | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | CR304 | 4C | R304 | 4C | S334 | 3B |
|  | CR350 | 3A | R348 | 3B | S336 | 3B |
|  |  |  | R400 | 4A | S338 | 3 C |
|  | DS302 | 4C |  |  | S340 | 3 C |
|  | DS429 | 3 C | S310 | 2A | S342 | 1C |
| P302 was P12, | DS488 | 1C | S312 | 2A | S344 | 3B |
| P303 was P13, | DS496 | 4A | S314 | 2A | S346 | 3 C |
| P312 was P112, |  |  | S316 | 2B | S348 | 3 B |
| P313 was P113, | P302 | 2A | S318 | 2B | S350 | 3A |
| P314 was P114, | P303 | 2A | S320 | 2B | S670 | 4B |
| P315 was P115. | P312 | 2B | S322 | 2 C | S685 | 4B |
|  | P313 | 2B | S324 | 2 C |  |  |
|  | P314 | 4B | S326 | 3A |  |  |
|  | P314 | 4B | S328 | 3A |  |  |
|  |  |  | S330 | 3A |  |  |
|  | R302 | 4C | S332 | 3B |  |  |




| $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \\ \hline \end{array}$ | $\begin{aligned} & \hline \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { cKT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l} \text { CKT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { cKT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { cKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|l\|} \hline \text { CKT } \\ \text { NO } \\ \hline \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { cKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|} \hline \text { CKT } \\ \hline \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|} \hline \begin{array}{l} \text { CKT } \\ \text { NO } \end{array} \\ \hline \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { CKTT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { cKT } \\ \text { NO } \\ \hline \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C101 | 41 | C454 | 5 C | CR477 | 5 F | P138 | 5 B | 0484 | 5 E | $\mathrm{R}^{128}$ | 4 G | R425 | 3A | R473 | 5 F | R610 | 5A | R682 | 1 J | U125 | 4 G | U525 | 1B |
| C108 | 4 K | C456 | 2 B | CR484 | 5D | P425 | 2B | 0492 | 2B | R130 | 4 G | R426 | 3A | R474 | 5 F | R612 | 5B | R684 | 1 J | U130 | 41 | U530 | 5D |
| C109 | 4 J | C471 | 3E | CR490 | 2B | P430 | 3D | 0602 | 4A | R132 | 4G | R429 | 3B | R475 | 5 F | R614 | 4 B | R685 | ${ }^{2 J}$ | U135 | 3G | U545 | 2 E |
| C112 | 3 G | C475 | 51 | CR496 | 1 F | P446 | 2B | 0605 | 4A | R135 | 3 G | R432 | 3E | R477 | 5 F | R651 | 2 G | R687 | 2 J | U138 | 5 H | U550 | 2D |
| C118 | 3 G | C476 | 5 G | CR530 | 5B | P474 | 5 F | 0610 | 5B | R137 | 3 G | R434 | 3D | R478 | 5 G | R653 | 2 G | R689 | 3J | U145 | 5 G | U660 | 1 G |
| C122 | 4 G | C477 | 5 E | CR620 | 3B | P477 | 51 | 0615 | 5B | R138 | ${ }^{2 G}$ | R435 | 2 C | R482 | 4D | R654 | 1 G | R690 | 11 | U405 | 4E | 0676 | 1H |
| C128 | 4 G | C478 | 5D |  |  | P510 | 1 E | 0650 | 1G | R140 | 5 G | R436 | 2 C | R483 | 5D | R656 | 2 H | R691 | 11 | U409 | 2E | U680 | 2 J |
| C132 | 3 G | C482 | 5 E | DL115 | 4 H | P515 | 1D | 0655 | 2 H | R142 | 5G | R437 | 4D | R485 | 5D | R657 | 1H | R692 | 11 | U412 | 4E |  |  |
| C138 | 2 G | C488 | 5 E |  |  | P520 | 2B |  |  | R145 | 5 G | R440 | 3C | R487 | 5D | R660 | 2 F | R694 | 1 J | 0414 | 3E | VR651 | 2 G |
| C142 | 5 G | C497 | 2B | F600 | 4A | P525 | 2 B | R100 | 41 | R147 | 5 G | R442 | 2 C | R488 | 5 E | R662 | ${ }^{1 G}$ | R695 | ${ }^{1}$ | 0416 | 4 E | VR656 | 2 H |
| C145 | 5 F | C515 | 2 D | F650 | 3 B | P530 | 5 C | R101 | 4 H | R148 | 5 G | R443 | 4 B | R492 | 2B | R663 | 1H | R696 | 2 J | U418 | 3E |  |  |
| C148 | 5 G | C525 | 2A | F655 | 3B | P680 | 2 H | R102 | 41 | R402 | 5 E |  |  | R494 | 2 B | R664 | 2 G | R698 | 1 J | U430 | 3E |  |  |
| C405 | 5 E | C530 | 5D |  |  |  |  | R105 | 41 | R403 | 4E | R445 | ${ }_{2}^{4 \mathrm{C}}$ | R495 | 2B | R666 | 2 H | R699 | 2 J | U432 | 3 C |  |  |
| ${ }_{6} 409$ | 2 E | C610 | ${ }^{5 B}$ | J110 | 5 K |  |  | R107 | 3 H 5 | R407 | 4E | R446 R447 | ${ }_{2}$ | R497 | 28 | R670 | 2 LJ |  |  | U436 | 2 D 3 |  |  |
| ${ }_{C} 412$ | 4 4 | C620 | 48 2 G |  |  |  |  | R108 | ${ }_{3}^{5 \mathrm{H}}$ | R408 R409 | 1 F | R448 | 2 C | R510 | ${ }^{1 \mathrm{D}}$ | R672A | 4 J | $\stackrel{\text { TP-15V }}{\text { TP-2V }}$ | 1 H 5 B | U446 U450 | $3 C$ 30 |  |  |
| C416 | ${ }_{3}^{4 \mathrm{E}}$ | C652 | 2 G 1 G | ${ }_{\text {P112 }}$ | 21 | -410 | ${ }_{38}^{2 F}$ | R110 R112 | 3G 3 | R409 | 1F | R451 | ${ }_{4}^{4 C}$ | R5230 | ${ }^{18}$ | ${ }_{\text {R }} \mathrm{R} 673$ | ${ }_{2 J}$ | TPGND | ${ }_{2}^{5 \mathrm{H}}$ | U452 | - 2 c |  |  |
| C419 | 3 E | c660 | 2 H | P114 | 3J | 0424 | 3в | R115 | 4 G | R413 | 4F | R454 | 4 C | R532 | 5 5 | R674 | 4J | TP+15V | 1 G | U454 | 4 C |  |  |
| C 421 | 3B | C666 | 2 H | P115 | 3 J | 0436 | 2 C | R117 | 3 G | R415 | 4F | R457 | 2B | ${ }^{\text {R5534 }}$ | ${ }^{5 C}$ | R675 | 1H | TP+5.1V | 4B | U456 | 4D |  |  |
| C422 | 2 C |  |  | P118 | 4 F | $\bigcirc 458$ | 2B | R118 | 3 G | R416 | 4G | R458 | ${ }^{2 B}$ | R | ${ }_{2}$ | R676 | 1H |  |  | U460 | 4 D |  |  |
| C 435 | 2 E | CR416 | 4 F | P120 | 4 F | $\bigcirc 466$ | 2 F | R120 | 4 4 | R419 | 3 E | R460 | 3C | R544 | 2 E | R678 | 11 | U110 | ${ }^{41}$ | U470 | 3 E |  |  |
| C436 | 1 C | CR424 | 2B | P125A | 2 F | $\bigcirc 472$ | 5 F | R 122 | 4 G | R420 | 3B | R466 | 1 F | R546 | 2 E | R679 | ${ }^{1 J}$ | 4115 | ${ }^{36}$ | U510 | 1 E |  |  |
| C440 | ${ }_{3 C}^{3 C}$ | CR436 CR456 | ${ }_{2 \mathrm{~B}}^{2 \mathrm{C}}$ | P125B | ${ }_{4}^{2 F}$ | O474 $\mathrm{O480}$ | ${ }_{5}^{5 \mathrm{~F}}$ | R125 R127 | $\begin{aligned} & 4 \mathrm{G} \\ & 4 \mathrm{G} \end{aligned}$ | R421 R424 | $\begin{aligned} & 3 B \\ & 3 B \end{aligned}$ | R471 R472 | ${ }^{3 \mathrm{E}}$ | R606 | ${ }_{4}^{4 B}$ | R680 | $2 J$ $2 J$ | $\begin{array}{\|l\|l\|} \hline \mathbf{U 1 1 8} \\ \text { U120 } \end{array}$ | $\begin{aligned} & 3 \mathrm{H} \\ & 31 \end{aligned}$ | U 515 U 520 | 18 |  |  |
| C450 | 3 C | CR456 | 2 B |  |  | Q480 | 5 E | R127 | 4G | R424 | 3B | R472 | 3 E | R608 | 4B | R681 | 2 J | U120 |  | U520 | 1E |  |  |

## WAVEFORM CONDITIONS

The waveforms below were taken with a Tektronix 7704 Oscilloscope, 7 B71 Time Base, and a 7A16 Amplifier. The oscilloscope input coupling was set to dc. Waveforms may vary as much as $\pm 20 \%$.

The input signal was a square wave that was HI for 50 ns and LO for 50 ns 2 V p-p centered around -1.26 V , the ECL threshold voltage. CH 0 , the clock lead, and the qualifier lead were connected to the same signal source. A Tektronix PG 502 provided the signal.

The WR 501 controls were set as follows:

```
Ch O WORD SELECTOR Switch
Rest of WORD SELECTOR Switches
THRESHOLD
WORD MODE
FILTER
QUALIFIER
Delay Selector Switch
CLOCK
```



2


LO
X (don't care)
ECL
ASYNC
5 ns
OFF
OFF」

For waveforms 4 through 8 , the Delay Selector Switch was set to WORDS and the Delay Count Switches were set to 00015 .

4


5


6


7





Figure 9-6. A2-Main circuit board with component locations.

| $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|} \hline \text { CKTT } \\ \hline \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COOORD } \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \hline \text { GRID } \\ & \text { COORD } \end{aligned}$ | $\begin{array}{\|l\|l\|l\|l\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { CKKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|l\|} \hline \text { CKTT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { ckT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { CKT } \\ \text { NO } \end{array}$ | GRID COORD | $\begin{array}{\|l\|l\|} \hline \text { CKKT } \\ \mathrm{NO} \end{array}$ | $\begin{aligned} & \text { GRID } \\ & \text { COORD } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { CKTT } \\ \text { NO } \\ \hline \end{array}$ | GRID COORD | $\begin{array}{\|l\|l\|} \hline \text { cKT } \\ \mathrm{NO} \\ \hline \end{array}$ | GRID COORD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C101 | 41 | C454 | 5 C | CR477 | 5 F | P138 | 5B | 0484 | 5 E | R128 | 4 G | R425 | 3A | R473 | 5 F | $R 610$ | 5A | R682 | 1 J | U125 | 4G | 0525 | 18 |
| C108 | 4 K | C456 | 2 B | CR484 | 5D | P425 | 2B | 0492 | 2 B | R130 | 4 G | R426 | 3A | R474 | 5 F | R612 | 5B | R684 | 1 J | U130 | 41 | U530 | 5D |
| C109 | 4 J | C471 | 3E | CR490 | 2 B | P 430 | 3D | 0602 | 4A | R132 | 4 G | R429 | 3B | R475 | 5 F | R614 | 48 | R685 | 2J | U135 | 3 G | U545 | 2E |
| C112 | 3 G | 4475 | 51 | CR496 | 1 F | P446 | 2B | 0605 | 4A | R135 | 3 G | R432 | 3E | R477 | 5F | R651 | 2 G | R687 | 2 J | U138 | 5H | U550 | 2D |
| C118 | 3 G | C476 | 5 G | CR530 | 5B | P474 | 5 F | 0610 | 5 B | R137 | 3 G | R434 | 3D | R478 | 5G | R653 | 2 G | R689 | 3J | U145 | 5G | U660 | 1G |
| C122 | 4 G | 6477 | 5 E | CR620 | 3в | P477 | 51 | 0615 | 5B | R138 | 2 G | R435 | 2c | R482 | 4D | R654 | 1 G | R690 | 11 | 0405 | 4E | 0676 | 1H |
| C128 | 4 G | C478 | 5D |  |  | P510 | 1E | 0650 | 1 G | R140 | 5G | R436 | 2 C | R483 | 5D | R656 | 2 H | R691 | 11 | U409 | 2 E | U680 | 2 J |
| C132 | 3 G | C482 | 5 E | DL115 | 4 H | P515 | 1D | 0655 | 2 H | R142 | 5G | R437 | 4D | R485 | 5D | R657 | 1H | R692 | 11 | 0412 | 4E |  |  |
| C138 | 2 G | C488 | 5 E |  |  | P520 | 2B |  |  | R145 | 5 G | R440 | 3C | R487 | 5D | R660 | 2 F | R694 | 1 J | U414 | 3E | VR651 | 2G |
| C142 | 5 G | C497 | 2B | F600 | 4A | P525 | 2B | R100 | 41 | R147 | 5 G | R442 | 2 C | R488 | 5 E | R662 | 1 G | R695 | 1 J | 0416 | 4E | VR656 | 2 H |
| C145 | 5 F | C515 | 2D | F650 | 3B | P530 | 5 C | R101 | 4H | R148 | 5G | R443 | 4B | R492 | 2B | R663 | 1H | R696 | 2 J | 0418 | 3E |  |  |
| C148 | 5 G | C525 | 2 A | F655 | 3B | P680 | 2 H | R102 | 41 | R402 | 5 E | R444 | 4 B | R494 | 2B | R664 | 2 G | R698 | 1 J | 0430 | 3E |  |  |
| C405 | 5 E | C530 | 5D |  |  |  |  | R105 | 41 | R403 | 4 E | R445 | 4 C | R495 | 2B | R666 | 2 H | R699 | 2J | 0432 | 3 C |  |  |
| C409 | 2 E | C610 | 58 | J110 | 5K |  |  | R107 | 3H | R407 | 4 E | R446 | ${ }_{2}^{2 C}$ | R497 | 2B | R670 | 2 J |  |  | U436 | 2D |  |  |
| C412 | 4 F | C620 | 4 B |  |  |  |  | R108 | 5 H | R 408 | 1 F | R447 | ${ }_{2}^{2 C}$ | R510 | 1D | R672A | 4 J | TP-15V | 1H | U446 | 3 C |  |  |
| C416 | 4 E | C652 | ${ }^{2 \mathrm{G}}$ | P112 | 21 | 0410 | 2 F | R110 | 3G | R409 | 1 F | R448 R451 | ${ }_{4}^{2 C}$ | R520 | ${ }^{18}$ | ${ }^{\text {R672B }}$ | 4 J | TP-2V | ${ }^{58}$ | U450 | 3 c |  |  |
| C418 | 3 F | $\mathrm{C} 657$ | 1 G 2 H | P113 | 21 31 | $0420$ | 38 38 | R112 | 3 C 4 G | R410 R413 |  | R453 | 4 C | R530 | 5C 50 | R673 | $2 J$ $4 J$ | TPGND | ${ }_{1}^{2 \mathrm{H}}$ | U452 U454 | 2 C 4 C |  |  |
| C419 | 3 E 3 B | C660 | $2 \mathrm{2H}$ 2 H | P114 | 3 JJ 3 J | 0424 0436 | 38 2 C | R115 | 4G 3 | R413 R415 | ${ }_{4}^{4 F}$ | R454 R457 | ${ }_{2 B}^{4 C}$ | R532 | ${ }^{5 C}$ | R674 | ${ }_{1}^{4 \mathrm{H}}$ | TP+15V | 1G | 0454 0456 | $4 C$ 4 D |  |  |
| C422 | 2 C |  |  | P118 | 4 F | 0458 | 2 B | R118 | 3 G | R416 | 4 G | R458 | ${ }_{2 B}$ | R536 | ${ }^{5 \mathrm{E}}$ | R676 | 1 H |  |  | U460 | 4 D |  |  |
| C435 | 2 E | CR416 | 4F | P120 | 4 F | 0466 | 2F | R120 | 4G | R419 | 3E | R460 | 3 C | R544 | 2 E | R678 | 11 | U110 | 41 | U470 | 3E |  |  |
| C436 | 1 C | CR424 | 2B | P125A | 2 F | 0472 | 5 F | R122 | 4 G | R420 | 3B | R466 | 1 F | R546 | 2 E | R679 | 1 J | U115 | 3 G | U510 | 1 E |  |  |
| C440 | 3 C | CR436 | 2 C | P125B | 2 F | 0474 | 5 F | R125 | 4 G | R421 | 3B | R471 | 3E | R606 | 4B | R680 | 2 L | U118 | 3 H | U515 | 1D |  |  |
| C450 | 3 C | CR456 | 2 B | P136 | 4B | 0480 | 5E | R127 | 4 G | R424 | 3в | R472 | 3 E | R608 | 4B | R681 | 2 J | U120 | 31 | U520 | 1E |  |  |

## WAVEFORM CONDITIONS

The waveforms below were taken with a Tektronix 7704 Oscilloscope, 7B71 Time Base, and a 7A16 Amplifier. The oscilloscope input coupling was set to dc. Waveforms may vary as much as $\pm 20 \%$.

The input signal was a square wave that was HI for 50 ns and LO for 50 ns 2 V p-p centered around -1.26 V , the ECL threshold voltage. CH 0, the clock lead, and the qualifier lead were connected to the same signal source. A Tektronix PG 502 provided the signal.

The WR 501 controls were set as follows:

| Ch 0 WORD SELECTOR Switch | LO |
| :--- | :--- |
| Rest of WORD SELECTOR Switches | X (don't care) |
| THRESHOLD | ECL |
| WORD MODE | ASYNC |
| FILTER | 5 ns |
| QUALIFIER | OFF |
| Delay Selector Switch | WORDS |
| CLOCK | 5 |
| Delay Count Switches | 00015 |

1


2



## WR 501 Service




Figure 9-8. A2-Main circuit board with component locations.

| $\begin{aligned} & \text { CKT } \\ & \text { NO. } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD | $\begin{aligned} & \text { CKT } \\ & \text { NO } \end{aligned}$ | GRID COORD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C610 | 5B | Q605 | 4A | R653 | 2G | R673 | 2 J | R689 | 3J | TP+15V | 1G |
| C620 | 4B | 0610 | 5B | R654 | 1G | R674 | 4J | R690 | 11 | TP+5.1V | 4B |
| C652 | 2G | 0615 | 5B | R656 | 2 H | R675 | 1H | R691 | 11 |  |  |
| C657 | 1G | 0650 | 1G | R657 | 1H | R676 | 1H | R692 | 11 | U660 | 1G |
| C660 | 2 H | Q655 | 2 H | R660 | 2F | R678 | 11 | R694 | 1J | U676 | 1H |
| C666 | 2 H |  |  | R662 | 1G | R679 | 1 J | R695 | 1 J | U680 | 2 J |
| CR620 | 3B | R606 | 4B | R663 | 1H | R680 | 2 J | R696 | 2 J |  |  |
|  |  | R608 | 4B | R664 | 2G | R681 | 2 J | R698 | 1 J | VR651 | 2G |
| F600 | 4B | R610 | 5A | R666 | 2H | R682 | 1 J | R699 | 2 J | VR656 | 2 H |
| F650 | 3B | R612 | 5B | R670 | 2 J | R684 | 1J |  |  |  |  |
| F655 | 3B | R614 | 4B | R672A | 4J | R685 | 2 J | TP-15V | 1H |  |  |
| 0602 | 4A | R651 | 2G | R672B | 4J | R687 | 2 J | TP-2V | 5B |  |  |



〈9) yэMOd87ddns




# REPLACEABLE MECHANICAL PARTS 

## PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number
00X Part removed after this serial number

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

12345
Name \& Description
Assembly and/or Component
Attaching parts for Assembly and/or Component
.- * -. -
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
-- - * - -
Parts of Detail Part
Attaching parts for Parts of Detail Part
$\qquad$

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol ---*---indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

| ABSREMAATOMS |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| " | INCH | ELCTRN | ELECTRON | IN | INCH | SE | SINGLE END |
| \# | NUMBER SIZE | ELEC | ELECTRICAL | INCAND | INCANDESCENT | SECT | SECTION |
| ACTR | ACTUATOR | ELCTLT | ELECTROLYTIC | INSUL | INSULATOR | SEMICOND | SEMICONDUCTOR |
| ADPTR | ADAPTER | ELEM | ELEMENT | INTL | INTERNAL | SHLD | SHIELD |
| ALIGN | ALIGNMENT | EPL | ELECTRICAL PARTS LIST | LPHLDR | LAMPHOLDER | SHLDR | SHOULDERED |
| AL | ALUMINUM | EQPT | EQUIPMENT | MACH | MACHINE | SKT | SOCKET |
| ASSEM | ASSEMBLED | EXT | EXTERNAL | MECH | MECHANICAL | SL | SLIDE |
| ASSY | ASSEMBLY | FIL | FILLISTER HEAD | MTG | MOUNTING | SLFLKG | SELF-LOCKING |
| ATTEN | ATTENUATOR | FLEX | FLEXIBLE | NIP | NIPPLE | SLVG | SLEEVING |
| AWG | AMERICAN WIRE GAGE | FLH | FLAT HEAD | NON WIRE | NOT WIRE WOUND | SPR | SPRING |
| BD | BOARD | FLTR | FILTER | OBD | ORDER BY DESCRIPTION | SQ | SQUARE |
| BRKT | BRACKET | FR | FRAME or FRONT | OD | OUTSIDE DIAMETER | SST | STAINLESS STEEL |
| BRS | BRASS | FSTNR | FASTENER | OVH | OVAL HEAD | STL | STEEL |
| BRZ | BRONZE | FT | FOOT | PH BRZ | PHOSPHOR BRONZE | SW | SWITCH |
| BSHG | BUSHING | FXD | FIXED | PL | PLAIN or PLATE | T | TUBE |
| CAB | CABINET | GSKT | GASKET | PLSTC | PLASTIC | TERM | TERMINAL |
| CAP | CAPACITOR | HDL | HANDLE | PN | PART NUMBER | THD | THREAD |
| CER | CERAMIC | HEX | HEXAGON | PNH | PAN HEAD | THK | THICK |
| CHAS | CHASSIS | HEX HD | HEXAGONAL HEAD | PWR | POWER | TNSN | TENSION |
| CKT | CIRCUIT | HEX SOC | HEXAGONAL SOCKET | RCPT | RECEPTACLE | TPG | TAPPING |
| COMP | COMPOSITION | HLCPS | HELICAL COMPRESSION | RES | RESISTOR | TRH | TRUSS HEAD |
| CONN | CONNECTOR | HLEXT | HELICAL EXTENSION | RGD | RIGID | $V$ | VOLTAGE |
| COV | COVER | HV | HIGH VOLTAGE | RLF | RELIEF | VAR | VARIABLE |
| CPLG | COUPLING | IC | INTEGRATED CIRCUIT | RTNR | RETAINER | W/ | WITH |
| CRT | CATHODE RAY TUBE | ID | INSIDE DIAMETER | SCH | SOCKET HEAD | WSHR | WASHER |
| DEG | DEGREE | IDENT | IDENTIFICATION | SCOPE | OSCILLOSCOPE | XFMR | TRANSFORMER |
| DWR | DRAWER | IMPLR | IMPELLER | SCR | SCREW | XSTR | TRANSISTOR |


| Mfr. Code | Manufacturer | Address | City, State, Zip |
| :---: | :---: | :---: | :---: |
| $\begin{aligned} & 00779 \\ & 01295 \end{aligned}$ | AMP, INC. | P O Box 3608 | HARRISBURG, PA 17105 |
|  | texas Instruments, INC., SEMICONDUCTOR GROUP | P O BOX 5012, 13500 N CENTRAL |  |
|  |  | EXPRESSWAY | DALLAS, TX 75222 |
| 07111 | PNEUMO DYNAMICS CORPORATION | 4800 PRUDENTIAL TOWER | BOSTON, MA 02199 |
| 08261 | SPECTRA-STRIP CORP. | 7100 LAMPSON AVE. | GARDEN GROVE, CA 92642 |
| 12327 | FREEWAY CORPORATION | 9301 allen drive | CLEVELAND, OH 44125 |
| 22526 | BERG ELECTRONICS, INC. | Youk Expressway | new Cumberland, PA 17070 |
| 22670 | G.M. NAMEPLATE, INC. | 2040 15th avenue west | SEAttile, wa 98119 |
| 23499 | GAVITT WIRE AND CABLE, DIVISION OF RSC INDUSTRIES, INC. | 455 N. QUINCE ST. | ESCONDIDO, CA 92025 |
| 71159 | BRISTOL SOCKET SCREW, DIV. OF |  |  |
|  | AMERICAN CHAIN AND CABLE CO., INC. | P O box 2244, 40 BRISTOL ST. | WATERBURY, CT 06720 |
| 73743 | FISCHER SPECIAL MFG. CO. | 446 MORGAN ST. | CINCINNATI, OH 45206 |
| 73803 | texas instruments, inc., metallurgical MATERIALS DIV. | 34 FOREST STREET | Attleboro, MA 02703 |
| 78189 | ILIINOIS TOOL WORKS, INC. |  |  |
|  | SHAKEPROOF DIVISION | St. Charles road | ELGIN, IL 60120 |
| 79807 | WROUGHT WASHER MFG. CO. | 2100 S. O BAY ST. | MILWAUKEE, WI 53207 |
| 80009 | TEKTRONIX, INC. | P O box 500 | BEAVERTON, OR 97077 |
| 83385 | CENTRAL SCREW CO. | 2530 CRESCENT DR. | BROADVIEW, IL 60153 |
| 98978 | INTERNATIONAL ELECTRONIC RESEARCH CORP. | 135 W. MAGNOLIA BLVD. | BURBANK, CA 91502 |

Fig. \&


Fig. \&




## STANDARD ACCESSORIES

Fig. \&
Index Tektronix Serial/Model No.

|  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- |
| Qty | 12345 | Name \& Description | Code | Mfr Part Number |
|  |  |  |  |  |
| 1 | MANUAL, TECH:SERVICE | 80009 | $070-2168-00$ |  |
| 1 | MANUAL,TECH:OPERATORS |  | 80009 | $000-2169-00$ |
| 2 | PROBE,DIGITAL:P6451,MULTI LEAD,W/ACCESS | 80009 | $010-6451-01$ |  |

## PE451 DATA ACOUISITIDN PROBE



The P6451 is a nine-channel active probe designed for use with digital circuit analysis instruments. The P6451 consists of two hybrid integrated circuits that comprise nine FET amplifiers with differential ECL outputs. All input channels of the hybrid circuits are protected from damage by static discharges. An input resistance of 1 megohm allows the circuit under test to perform close to normal operating conditions.

Probe input threshold levels are established by a voltage source supplied by the test instrument. The P6451 outputs are compatible with test instruments having differential ECL line receivers (i.e., type 10115 or 10216) with 75 ohm differential input termination.

All probe-input lead connectors lock into the probe head when the lead is pulled on, but are easily detached by pulling only on the connector. The signal leads come in a set of 10 colors.

## WARRANTY

All TEKTRONIX instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty should be taken up with your TEKTRONIX Field Engineer or representative.

All requests for repairs and replacement parts should be directed to the TEKTRONIX Field Office or representative in your area. This will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

Specifications and price change privileges reserved.

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U.S.A. and foreign TEKTRONIX products covered by U.S. and foreign patents and/or patents pending.

TEKTRONIX is a registered trademark of Tektronix, Inc.

## SPECIFICATIONS

## Electrical

| Input Resistance | $1 \mathrm{M} \Omega$ within $5 \%$. |
| :--- | :--- |
| Input Capacitance | 5 pF within 1 pF. |
| Maximum Dynamic Input Voltage | 10 V above input threshold level. |
| Maximum Nondestructive Voltage to Input | 60 V (dc + peak ac). |
| Power Requirements |  |
| $\quad$ Voltage | 4.7 V to 5.3 V. |
| Current | $\leqslant 260 \mathrm{~mA}$ at 5 V. |

## Environmental

Temperature
Storage
Operating

Altitude
Storage
Operating

## Physical

Weight (Probe Only)
Length
Probe Head and Cable

Input Leads

204 gms (7.1 oz).
$2 \mathrm{~m}(6.5 \mathrm{ft})$.

40 cm (15.7 in).

## OPERATING CONSIDERATIONS




#### Abstract

Make sure the probe connector is correctly aligned with the test instrument connector. Damage to the terminals can result from forcing the connector into the test instrument connector.


## Probe Input Leads

To insert a probe lead, push the connector into the probe head as shown in Figure 1. Be sure the correct side of the connector is facing upward. To remove a probe lead, place your fingernail on the connector and pull.

To minimize the pickup of electromagnetic interference, input leads should be kept as short as possible. However, to avoid adding errors to critical timing measurements, input leads should all be the same length.


To avoid damage to the probe, do not connect the ground lead to a voltage source above or below ground reference.


Figure 1. Installation of input lead connectors.

## MAINTENANCE INSTRUCTIONS

Only qualified service personnel should use the following service instructions. Unless you are qualified to do so, do not perform maintenance in this instrument.

The P6451 Probe is designed to withstand normal operation and handling. However, if the probe fails or breaks, replacement parts are available. See Replaceable Parts List for part numbers.

## Cleaning

Dirt that accumulates on the probe head can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.


Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. In particular, avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

Recommended cleaning agents are isopropyl alcohol (Isopropanol) or ethyl alcohol (Fotocol or Ethanol).

Contaminated contact areas of the connectors, hybrids, and circuit board can be cleaned with a cottontipped applicator dipped in a recommended cleaning agent.

## Probe Head Component Access

1. Remove 4 screws from the probe body.
2. While pulling apart the 2 halves of the probe body, note which half of the body covers which side of the circuit board.
3. Replace the defective components.
4. When reinstalling the circuit board in the probe body, be sure the body half with the channel identification label covers the circuit-board side with the channel input pins.
5. Replace the 4 screws that hold the probe body together.

## Troubleshooting

The following information is provided to help troubleshoot the P6451. Troubleshooting information contained in the associated test-instrument instruction manual should be used with the following information to aid in locating the trouble.

1. ISOLATE TROUBLE TO A CIRCUIT. To determine if the trouble is in the probe or the test instrument, use the troubleshooting information in the instruction manual for the test instrument. If the probe is found to be defective, proceed with step 2.
2. VISUAL CHECK. Remove the 2 halves of the probe body (refer to Probe Head Component Access procedure). Check the probe for visible indications such as broken wires, damaged circuit board, damaged components, etc. Repair or replace any of these defects. If there are no visible indications of a defect, proceed with step 3.
3. CHECK SUPPLY VOLTAGE. The supply voltage to the P6451 can have various values depending upon the voltage level used in the test instrument. Refer to the probe schematic and the test instrument instruction manual for the supply voltage assigned to the probe.

If all the channels are affected by the trouble, check the supply voltages VCC, VDD, and VEE. If one or more of the channels are operating correctly, proceed with step 4.

## NOTE

Supply voltages are measured with respect to the test instrument chassis ground.

## +VCC = Chassis Ground

-VEE $=$ Chassis Ground

Typical Voltage
$+\mathrm{VCC}=0 \mathrm{~V}$
$+\mathrm{VDD}=-0.5 \mathrm{~V}$
$-\mathrm{VEE}=-5 \mathrm{~V}$

## Typical Voltage

$+\mathrm{VCC}=+5 \mathrm{~V}$
$+\mathrm{VDD}=+4.5 \mathrm{~V}$
$-\mathrm{VEE}=0 \mathrm{~V}$
a. If VCC does not have its assigned voltage, check the VCC cable wire (RED) for continuity. No continuity in cable, proceed to step 5.
b. If VEE does not have its assigned voltage, check the VEE cable wire (VIO) for continuity. No continuity in cable, proceed to step 5.
c. If the voltage at VDD is the same as VEE, check diode CR4 for open. Diode open, replace CR4.
d. If the voltage at VDD is the same as VCC, check diode CR4 for short. Diode shorted, replace CR4.
4. CHECK HYBRID OPERATION. If the supply voltages are correct, check for a defective channel on one of the hybrids.
a. Set the input threshold level of the test instrument to 0 volts.
b. Connect a signal lead from a channel input on the probe to a +1 volt to -1 volt, 1 KHz square-wave signal source.
c. With a test oscilloscope, check the + output (noninverting) and - output (inverting) for the correct output waveform. See Figure 2 for typical waveforms.
d. If an output signal is present on the circuit board, but not present at the cable connector, check the cable wire for continuity.
e. If the hybrid is found to be defective, proceed to step 5.

-VEE ASSIGNED TO CHASSIS GROUND


+ VCC ASSIGNED TO CHASSIS GROUND

Figure 2. Typical channel output waveforms vs. supply voltage assigned.
5. OBTAINING REPLACEMENT PARTS. All electrical and mechanical part replacements for the P6451 can be obtained through your local Tektronix Field Office or representative.

When ordering replacement parts from Tektronix, Inc., include the following information:
(a) Instrument type.
(b) Instrument date code.
(c) A description of the part (if electrical, include circuit number).
(d) Tektronix part number.

For more information or assistance on troubleshooting the P6451, contact your local Tektronix Field Office or representative.


Figure 3. Probe connector pin assignment (end view).


Fig. 4 Component Locations on Circuit Board


Fig. 5 Cable Installation Diagram



REPLACEABLE PARTS LIST
Fig. \&


[^2]

STANDARD ACCESSORIES

| -14 | 012-0655-02 | 1 | LEAD SET,ELEC:INPUT,W/11,20 CM L,WIRES | 80009 | 012-0655-02 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| -15 | 206-0222-00 | 10 | TIP, PROBE:MICROCIRCUIT TEST | 80009 | 206-0222-00 |
| -16 | 334-1636-00 | 2 | BAND, MARKER: ORANGE | 80009 | 334-1636-00 |
|  | 334-1636-01 | 2 | BAND, MARKER: RED | 80009 | 334-1636-01 |
|  | 334-1636-05 | 2 | BAND, MARKER:SILVER GRAY | 80009 | 334-1636-05 |
|  | 334-1636-06 | 2 | BAND,MARKER:YELLOW | 80009 | 334-1636-06 |
| -17 | 334-2855-00 | 2 | MARKER, IDENT: 0-7 | 80009 | 334-2855-00 |
|  | 334-2856-00 | 2 | MARKER,IDENT:8-15 | 80009 | 334-2856-00 |
|  | 016-0521-00 | 1 | POUCH, ACCESSORY: | 05006 | OBD |
|  | 062-2372-00 | 1 | DATA, SHEET: P6451 | 80009 | 062-2372-00 |
| -18 | 352-0473-01 | 1 | HOLDER, PROBE :W/HANGER | 80009 | 352-0473-01 |

## CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

| Mfr. Code | Manufacturer | Address | City, State, Zip |
| :---: | :--- | :--- | :--- |
| O1121 | ALLEN-BRADLEY COMPANY | 1201 2ND STREET SOUTH | MILWAUKEE, WI 53204 |
| O5006 | TWENTIETH CENTURY PLASTICS, INC. | 415 E WASHINGTON BLVD. | LOS ANGELES, CA 90015 |
| 22526 | BERG ELECTRONICS, INC. | YOUK EXPRESSWAY | NEW CUMBERLAND, PA 17070 |
| 72982 | ERIE TECHNOLOGICAL PRODUCTS, INC. | 644 W. 12TH ST. | ERIE, PA 16512. |
| 80009 | TEKTRONIX, INC. | P. O. BOX 500 | BEAVERTON, OR 97077 |



## PERFORMANCE CHECK AND ADJUSTMENT (SUPPLEMENT TO WR 501 MANUAL)

The LA 501W Logic Analyzer consists of an LA 501 Logic Analyzer and a WR 501 Word Recognizer/Delay. These two units are attached to form a three-compartment wide TM 500-Series plug-in.

Operating Information and Specifications are contained in the LA 501W Operators Manual.
Maintenance Information, Circuit Descriptions, and diagrams are contained in the WR 501 Service Manual and in the LA 501 Instruction Manual.
I. WR 501

To calibrate the WR 501 part of an LA 501W, perform the procedures in the Performance Check and Adjustment procedures in the WR 501 Service Manual.

## II. LA 501

To calibrate the LA 501 part of an LA 501W, use the following procedure.

This section contains information necessary to perform a performance check and adjustment. Limits given in the procedure are adjustment guides and should not be interpreted as performance requirements unless preceded by a check mark ( $\sqrt{ }$ ). Where possible, instrument performance is checked before an adjustment is made.

## PRELIMINARY INFORMATION

## Adjustment Interval

To maintain instrument accuracy, check the performance of the LA 501W every 1000 hours of operation, or every 6 months if used infrequently. Before complete adjustment, thoroughly clean and inspect this instrument as outlined in Section 4, Maintenance.

## Tektronix Field Service

Tektronix Field Service Centers and the Factory Service Center provide instrument repair and adjustment services. Contact your Tektronix Field Office or representative for further information.

## Using This Procedure

This Performance Check and Adjustment procedure can be used either for complete adjustment or as a check of instrument performance. Completion of each step in the procedure ensures that the instrument is correctly adjusted and operating within specified limits. Refer to the following discussion for instructions on a complete or partial check and adjustment.

INDEX. An index precedes the procedure to aid in locating Performance Check and Adjustment steps.

PERFORMANCE CHECK. Instrument performance can be checked by performing the complete Performance Check and Adjustment procedure and omitting only the ADJUST parts of the steps. A check mark $(\sqrt{ })$ preceding a CHECK indicates that the limit given is a performance requirement specified in Section 2, Specification.

ADJUSTMENT. Completion of each step in the Performance Check and Adjustment procedure ensures that the instrument is correctly adjusted and performing within specified limits. Where possible, instrument performance is checked before an adjustment is made. For best overall performance when performing the complete adjustment procedure, make each adjustment to the exact setting indicated.

PARTIAL PROCEDURES. The following procedure is written to completely check and adjust the instrument to the Performance Requirements listed in Section 2, Specification. If the applications for which the instrument is used do not require the full available performance, the procedures and the required equipment list can be shortened accordingly.

A partial performance check and adjustment may be desirable after replacing components, or to touch up the adjustment of a portion of the instrument. To check or adjust only part of the instrument, refer to the Equipment Required list which precedes that portion of the procedure to be performed. To avoid unnecessary adjustment of other parts, adjust only if the tolerance given in each CHECK is not met.

## TEST EQUIPMENT REQUIRED

The test equipment listed in Table S-1 is required for a complete performance check and adjustment of this instrument. The specifications given in Table S-1 for test equipment are the minimum required to meet the Performance Requirements listed in Section 2, Specification. Detailed operating instructions for test equipment are omitted in this procedure. Refer to the test equipment instruction manual if more information is needed.

## Special Fixtures

Special fixtures are used only where they facilitate instrument adjustment. These fixtures are available from Tektronix, Inc. Order by part number from Tektronix Field Offices or representatives.

## Test Equipment Alternatives

The test equipment listed in the Examples of Applicable Test Equipment column, Table S-1, is required to check and adjust this instrument. The Performance Check and Adjustment procedure is based on the first item of equipment. given as an example. If other equipment is substituted, control settings or setups may need to be altered. If the exact item of equipment given as an example is not available, refer to the Minimum Specifications column to determine if other equipment may be substituted. Then check the Purpose column. If you determine that your measurement requirements will not be affected, the item and corresponding step(s) can be deleted.

TABLE S-1
Test Equipment

| Description | Minimum Specifications | Purpose | Examples of Applicable Test Equipment |
| :---: | :---: | :---: | :---: |
| 1. Test Oscilloscope ${ }^{1}$ | Bandwidth, dc to 100 MHz ; minimum deflection factor, 10 $\mathrm{mV} / \mathrm{div}$; accuracy, within $3 \%$. Dual-channel with chopped display mode. | Check triggers, display formats, vertical, horizontal, and Z-axis. Check and adjust dc balance and data inputs. | a. Tektronix 7603 Oscilloscope system with 7A26 Amplifier and 7B70 Time Base. <br> b. Tektronix 465 Oscilloscope. |
| 2. Monitor | Bandwidth, dc to 500 kHz ; deflection factor, $50 \mathrm{mV} / \mathrm{div}$ (vertical) and $100 \mathrm{mV} /$ div (horizontal) both dc coupled. Graticule, $8 \times 10$ div. External Z-axis input. | Check triggers, display formats, vertical and horizontal, and Z -axis. | a. Any Tektronix 600-series display unit that meets bandwidth requirements. |
| 3. Precision Dc Voltmeter | Range, $\pm 2 \mathrm{~V}$ to $\pm 50 \mathrm{~V}$; accuracy, within 0.1\%. Digital voltmeter must have at least $41 / 2$-digit readout. | Check power supply, threshold voltages, and internal clock. Check and adjust dc balance and data inputs. | a. Tektronix DM 501 Digital Multimeter (operates in Tektronix TM 500-series power module). <br> b. Fluke Model 825A Differential DC Voltmeter. |
| 4. Pulse Generator | Pulse duration, 10 ns to 1 ms ; pulse period, $0.1 \mu \mathrm{~s}$ to 10 ms ; risetime, 2 ns or less; output amplitude, -3 V to +3 V with dc offset. | Check triggers, display formats, vertical and horizontal, and Z -axis. Check and adjust dc balance and data inputs. | a. Tektronix PG 502 Pulse Generator (operates in Tektronix TM 500-series power module). |
| 5. Frequency Counter | Frequency range, 40 MHz to 55 MHz ; accuracy, within 10 parts in $10^{6}$. | Check internal clock. | a. Tektronix DC 501110 MHz Counter (operates in Tektronix TM 500-series power module). <br> b. Tektronix 7D14 Digital Counter (operates in any Tektronix 7000-series oscilloscope except those without readout). |
| 6. Delay Generator | Delayed events, 0 to 1024; trigger level range and slope, $\pm 1 \mathrm{~V}$; minimum detectable pulse width, $0.5 \mu \mathrm{~s}$. | Check Z-axis intensify. | a. Tektronix DD 501 Digital Delay (operates in TM 500series power module. <br> b. Tektronix 7D11 Digital Delay (operates in any Tektronix 7000-series oscilloscope with readout). |
| 7. 10X Probes (4 required) | Compatible with test oscilloscope used. | Check triggers and Z-axis. Check and adjust dc balance and data inputs. | a. Tektronix P6108 or P6054A probes. |
| 8. $1 \times$ Probe | Compatible with test oscilloscope used. | Check internal clock. | a. Tektronix P6028 or P6062A probes ( 3.5 foot). |

[^3]TABLE S-1 (CONT.)
Test Equipment

| Description | Minimum Specifications | Purpose | Examples of Applicable Test Equipment |
| :---: | :---: | :---: | :---: |
| 9. Variable Line Voltage Source | Output, 110 V ac (or 220 V ac) 200 W; accuracy, within 3\%. | Adjust -4.8 V supply. | a. General Radio W8MT3 VM Variac Autotransformer. |
| 10. $50-\mathrm{Ohm}$ Termination | Impedance, 50 ohms; accuracy, within 2\%; connectors, BNC. | Output termination for signal generators. | a. Tektronix part 011-0049-01. |
| 11. BNC-to-Probe Tip Adapter | Adapt to Tektronix probes used. | Provide connection from pulse generator to probe tip. | a. Tektronix part 013-0084-01. |
| 12. BNC T Connector | BNC to BNC. | Provide cable and probe connection to pulse generator. | a. Tektronix part 103-0030-00. |
| 13. Coaxial Cables (5 required) | Impedance, 50 ohms; type, RG 58/U; length, 42 inches; connectors, BNC. | Provide signal interconnections. | a. Tektronix part 012-0057-01 (3 supplied with LA 501). |
| 14. Flexible Extender Cable | Compatible with TM 500series plug-ins. | Provide access to test points and adjustments. | a. Tektronix part 067-0645-01. |
| 15. Screwdriver | 3 -inch shaft, 3/32-inch bit. | Adjust power supply and dc balance. | a. Xcelite R-3323. |

## INDEX TO PERFORMANCE CHECK AND ADJUSTMENT PROCEDURE

PAGEA. POWER SUPPLY ..... S-6

1. Adjust -4.8 Volt Supply (R925) ..... S-6
2. Check -2 Volt Supply ..... S-6
3. Check +5.1 Volt Supply ..... S-6
B. THRESHOLD VOLTAGES AND INTERNAL ..... S-7
CLOCK
4. Check 10X Probe Threshold Voltages ..... S-7
5. Check Threshold Monitor Output ..... S-7
6. Check EXT TRIG Input (10X) Threshold ..... S-7
Voltages
7. Check Internal Clock ..... S-7
C. TRIGGERS ..... S-8
8. Check External Trigger Level and ..... S-8Minimum Pulse Width2. Check Display Time RangeS-8
9. Check Trigger Holdoff ..... S-9
10. Check WR Triggers ..... S-9
11. Check Trigger Slope ..... S-9
D. DISPLAY FORMATS ..... S-10
12. Check WR 501 Data Input Display ..... S-10
E. VERTICAL AND HORIZONTAL
13. Check Vertical Output ..... S-11
14. Check Raster Shift With Format ..... S-11
15. Check Sweep Length ..... S-11
16. Check Horizontal Magnifier and ..... S-11
Position
17. Check Horizontal Linearity ..... S-12
F. DC BALANCE AND DATA INPUTS ..... S-13
18. Adjust EXT TRIG Input (10X) DC ..... S-13
Balance (R845)
19. Adjust Channel 0 DC Balance (R25) ..... S-13
20. Adjust Channel 1 DC Balance (R45) ..... S-14
21. Adjust Channel 2 DC Balance (R65) ..... S-14
22. Adjust Channel 3 DC Balance (R85) ..... S-14
23. Check High-Impedance Data Inputs ..... S-14
24. Check WR 501 Data Inputs ..... S-15
25. Check High-Impedance Data Input Delays ..... S-15PAGE
G. Z-AXIS ..... S-17
26. Check Retrace Blanking Time ..... S-17
H. CURSOR ..... S-18
PRELIMINARY PROCEDURE
Perform the following steps before proceeding with thePerformance Check and Adjustment procedure.
27. Connect LA 501 and WR 501 to power module withflexible extender cables (Tektronix part 067-0645-01).
28. Pull apart the LA 501 and WR 501 and leave them apart.
29. Remove LA 501 side covers.
30. Pull PWR button on left or right edge of power module to apply power to LA 501W. Allow at least 15 minutes warmup.

## NOTE

Titles for external LA 501W controls and connectors are capitalized in this procedure (e.g., SAMPLE INTERVAL, EXT CLOCK). Internal controls, connectors, and adjustments are initial capitalized (e.g., Blanking Switch, Ch O DC Bal adjustment, Low-Impedance Data Input connector).

## A. POWER SUPPLY

## Equipment Required

1. Precision dc voltmeter
2. Three-inch screwdriver
3. Variable line-voltage source

## See TEST POINT AND

in the Diagrams section of LA 501 Service manual.

## A1. ADJUST -4.8 VOLT SUPPLY (R925)

a. With power module PWR button pushed in, connect power module line cord to variable line voltage source.
b. Set variable line voltage source for 110 (or 220) volts ac and pull PWR button out.
c. Press ECL button and set DISPLAY TIME control fully counterclockwise (1 s).
d. Set SAMPLE INTERVAL switch to 50 ns and press CH 0-15 X256 button.
e. Check that interface connectors are firmly seated.
f. Connect precision dc voltmeter between TP933 and chassis ground.
g. CHECK-Voltmeter for reading from -4.796 volts to -4.834 volts.
h. ADJUST-R925, ( -4.8 volts adjustment) for a voltmeter reading of exactly -4.800 volts.
i. INTERACTION-Any change in setting of R925 may affect operation of all circuits in instrument.

## A2. CHECK -2 VOLT SUPPLY

a. Connect precision dc voltmeter between pin 2 of P5 and chassis ground.
b. CHECK - Voltmeter for reading from -1.90 volts to -2.10 volts.

## A3. CHECK +5.1 VOLT SUPPLY

a. Connect precision dc voltmeter between pin 3 of P4 and ground.
b. CHECK -Voltmeter for reading from +4.845 volts to +5.355 volts.

## B. THRESHOLD VOLTAGES AND INTERNAL CLOCK

## Equipment Required

1. Frequency counter
2. $1 \times$ probe
3. Precision dc voltmeter

## See TEST POINT AND in the Diagrams section ADJUSTMENT LOCATIONS of LA 501 Service manual.

$\sqrt{ }$ B1. CHECK 10X PROBE THRESHOLD VOLTAGES
a. Press VAR and INPUTS buttons.
b. Connect precision dc voltmeter between pin 5 of U48 and chassis ground.
$\sqrt{ }$ c. CHECK-Voltmeter reading for a range of at least -1 volt to +1 volt as THRESHOLD control is rotated from fully counterclockwise to fully clockwise.
d. Press TTL button.
$\sqrt{ }$ e. CHECK-Voltmeter for reading from +0.115 volt to +0.165 volt.
f. Press ECL button.
$\sqrt{ }$ g. CHECK - Voltmeter for reading from -0.121 volt to -0.129 volt.

## B2. CHECK THRESHOLD MONITOR OUTPUT

a. Press VAR button.
b. Connect precision dc voltmeter between INPUT MONITOR jack and chassis ground.
$\sqrt{ }$ c. CHECK-Voltmeter reading for a range of at least -10 volts to +10 volts as THRESHOLD control is rotated from fully counterclockwise to fully clockwise.
d. Press TTL button.
$\sqrt{ }$ e. CHECK-Voltmeter for reading from +1.12 volts to +1.70 volts.
f. Press ECL button.
$\sqrt{ }$ g. CHECK-Voltmeter for reading from -1.17 volts to -1.33 volts.

## B3. CHECK EXTERNAL TRIG (10X) THRESHOLD

 VOLTAGESa. Press VAR button and place internal Ext Clock Threshold switch, S848, in Front Panel (up) position.
b. Connect precision dc voltmeter between pin 11 of U830 and chassis ground.
$\sqrt{ }$ c. CHECK-Voltmeter reading for a range of at least -1 volt to +1 volt as THRESHOLD control is rotated from fully counterclockwise to fully clockwise.
d. Press TTL button.
$\sqrt{ }$ e. CHECK-Voltmeter for reading from +0.115 volt to +0.165 volt.
f. Press ECL button.
$\sqrt{ }$ g. CHECK-Voltmeter for reading from -0.121 volt to -0.129 volt.
h. Place internal Ext Clock Threshold switch, S848, to ECL (down) position.
$\sqrt{ }$ i. CHECK-Voltmeter for reading from -0.122 volt to -0.128 volt.

## $\sqrt{ }$ B4. CHECK INTERNAL CLOCK

a. Set SAMPLE INTERVAL switch to 20 ns and connect frequency counter to TP138 with a 1 X probe.

[^4]
## C. TRIGGERS

## Equipment Required

1. Test oscilloscope or monitor
2. BNC-to-probe tip adapter
3. Pulse generator
4. 50 -ohm BNC cables (4)
5. 10X probe
6. 50 -ohm termination
in the Diagrams section of LA 501 Service manual.
$\sqrt{ }$ C1. CHECK EXTERNAL TRIGGER LEVEL AND MINIMUM PULSE WIDTH
a. Set controls as follows:

## LA 501

| INPUT | TTL (button in) |
| :--- | :--- |
| FORMAT | CH $0 \cdot 3 \times 1024$ |
|  | (button in) |
| TRIGGER SOURCE | EXT (button in) |
| DISPLAY TIME | Fully counterclock- <br>  <br> wise (1 s) |
| CHANNEL SELECT | OFF |
| SAMPLE INTERVAL | 50 ns |
| Vertical MAG | Fully counter- <br> clockwise |
| Horizontal MAG | Fully counter- <br> clockwise |
| Display Clock | Down |
| S835 (internal) |  |

c. Connect 50 -ohm cables from $X$ HORIZ OUT, Y VERT OUT, and Z BLANK OUT connectors to corresponding test oscilloscope or monitor inputs.
d. Connect 50 -ohm termination to EXT TRIG (TTL) connector.
e. Set pulse generator for a TTL level (approximately 0 to +3 volts), 10-nanosecond duration, 10 -millisecond period, pulse output.
f. Connect 50 -ohm cable from pulse generator output to 50 -ohm termination at EXT TRIG connector.

## NOTE

Determine the $Z$-axis input blanking polarity required by the test oscilloscope or monitor. Place internal Blanking Polarity switch, S720, up for positive blanking, down for negative blanking.
$\sqrt{ }$ g. CHECK-For visible display on test oscilloscope or monitor and that TRIG'D indicator is lit. Note that TRIG'D indicator blinks off momentarily with auto record pulse.

Test Oscilloscope or Monitor

| Mode | $X-Y$ |
| :--- | :--- |
| Deflection Factor |  |
| or Gain |  |
| $X$ | $50 \mathrm{mV} /$ div |
| $Y$ | $100 \mathrm{mV} / \mathrm{div}$ |

b. Position a low-intensity spot at the vertical and horizontal center of test oscilloscope or monitor graticule.

## C2. CHECK DISPLAY TIME RANGE

$\sqrt{ }$ a. CHECK-That test oscilloscope or monitor display alternately blanks then reappears for approximately 1 second.
b. Set DISPLAY TIME control fully clockwise (not in detent).
$\sqrt{ }$ c. CHECK-That test oscilloscope or monitor display alternately blanks, then reappears for approximately 10 seconds.
d. Set DISPLAY TIME control to $\infty$ (detent) position.
e. Disconnect pulse generator output from EXT TRIG connector.
$\sqrt{ }$ f. CHECK-For stable display on test oscilloscope or monitor.

## $\sqrt{ }$ C3. CHECK TRIGGER HOLDOFF

a. Press and release MANUAL button.
$\sqrt{ }$ b. CHECK-For no display on test oscilloscope or monitor and that TRIG'D indicator is not lit.
c. Connect 50 -ohm cable from pulse generator output to EXT TRIG connector.
$\sqrt{ }$ d. CHECK-For display on test oscilloscope or monitor and that TRIG'D indicator is lit.
e. Remove 50 -ohm cable between pulse generator output and EXT TRIG connector.

## C4. CHECK WR TRIGGER

a. Set LA 501 controls as follows:

| SAMPLE INTERVAL | 50 ns |
| :---: | :---: |
| FORMAT | CH 0-3 X1024 (button in) |
| TRIGGER SLOPE | + (button out) |
| TRIGGER SOURCE | WR (button out) |
| INPUTS | PROBE (button out) |
| TRIGGER | CENTER (button in) |
| DISPLAY TIME | Fully counterclockwise (1 s) |

b. Set WR 501 controls as follows:

| WORD MODE | ASYNC |
| :--- | :--- |
| Delay Selector | OFF |
| Qualifier | OFF |

Ch 0 WORD SELECTOR HI
Switch
Rest of WORD $\quad X$ (don't card)
SELECTOR Switches
THRESHOLD FILTER

TTL
$<5$ ns (fully counterclockwise)
c. Set pulse generator for a TTL level (approximately 0 to +3 volts), 1 -microsecond duration, 10 -millisecond period, pulse output.
d. Connect P6451 channel 0 lead to 50 -ohm termination at pulse generator output.

## NOTE

To make it easier to connect the P6451 probe to the 50 -ohm termination at the pulse generator output, connect a BNC-to-banana plug adapter (such as the Tektronix part 103-003500 ) to the 50 -ohm termination. Attach a short length of bus wire to the center conductor terminal and clip the probes to the bus wire.
e. CHECK-Display for 4 lines with generator output pulse edge displayed near center of channel 0 line.
f. Press POST button.
g. CHECK-That generator output pulse edge is displayed near left edge of channel 0 line.
h. Press PRE button.
i. CHECK-That generator output pulse edge is displayed near right edge of channel 0 line.

## C5. CHECK TRIGGER SLOPE

a. Press CENTER button.
b. Position left edge of generator output pulse to graticule vertical center line.
c. Press SLOPE button.
d. CHECK-That displayed generator output pulse shifts to left side of graticule vertical center line.

## D. DISPLAY FORMATS

## Equipment Required

1. Test oscilloscope or monitor
2. $50-$ ohm BNC cables ( 3
3. Pulse generator
4. 50 -ohm termination
in the Diagrams section of LA 501 Service manual.

## D1. CHECK WR 501 DATA INPUT DISPLAY

a. Set WR 501 controls as follows:

THRESHOLD (both) TTL
QUALIFIER Selector OFF Delay Selector OFF WORD MODE ASYNC FILTER <5ns Ch 0-Ch 7 WORD HI SELECTOR Switches
b. Set SAMPLE INTERVAL switch to 50 ns and press CH 0-3 X1024 button.
c. Connect 50 -ohm cables from $X$ HORIZ OUT, Y VERT

OUT, and Z BLANK OUT connectors to corresponding test oscilloscope or monitor inputs.
h. Return MAG and POS controls to fully counterclockwise (X1) position.
i. Press $\mathrm{CH} 0-7 \times 512$ button.
$\sqrt{ }$ j. CHECK-Display for 2 groups of 4 lines each with about twice the pulse width noted in part (g). Examine display for no breaks or abnormalities in display pattern. Set Horizontal and Vertical MAG and POS controls to allow close examination of display.
k. Return MAG and POS controls to fully counterclockwise (X1) position.
I. Press $\mathrm{CH} 0-15 \times 256$ button.
d. Set pulse generator for a TTL level (approximately 0 to +3 volts) 1 -microsecond duration, 10 -millisecond period, pulse output.
e. Connect 50 -ohm termination to pulse generator output.
f. Connect P6451 probe channel 0 through 7 leads to 50 -ohm termination at pulse generator output.

## NOTE

The output of the Tektronix PG 502 will feed 8 channels simultaneously without pulse degradation. A BNC-to-banana plug adapter (such as Tektronix part 103-0035-00) with a short length of bus wire attached to the centerconductor terminal can be used to connect the P6451 probe leads to the pulse generator.
$\sqrt{ }$ g. CHECK-Display for 4 lines with no breaks or abnormalities in display pattern. Set Horizontal and Vertical MAG and POS controls to allow close examination of display.

## NOTE

When using a Tektronix 502 Pulse Generator, check the remaining channels by disconnecting the P6451 probe channel 0 through 7 leads from the pulse generator. Connect the channel 8 through 15 leads, change the WORD SELECTOR Switches to HI, and check display as described in part ( $m$ ).

## E. VERTICAL AND HORIZONTAL

## Equipment Required

1. Test oscilloscope or monitor
2. Pulse generator
3. 50 -ohm termination
4. 50 -ohm cables ( 3 )

## See

## $\sqrt{ }$ E1. CHECK VERTICAL OUTPUT

a. Set LA 501W controls as follows:
in the Diagrams section of LA 501 Service manual.
$\sqrt{ }$ h. CHECK-That Vertical POS control positions display smoothly anywhere within graticule area.
i. Set Vertical MAG fully counterclockwise (X1).

| SAMPLE INTERVAL | 50 ns |
| :--- | :--- |
| INPUT | TTL (button in) |
| FORMAT | CH 0-15 X256 |
|  | (button in) |
| TRIGGER SOURCE | WR (button out) |
| INPUTS | PROBE (button out) |
| Vertical MAG | Fully counterclock- |
|  | wise (X1) |
| THRESHOLD | TTL |

b. Connect 50 -ohm cables from $X$ HORIZ OUT, $Y$ VERT OUT, and Z BLANK OUT connectors to corresponding test oscilloscope or monitor inputs.
c. Connect 50 -ohm termination to pulse generator output.
d. Connect P6451 probe channel 0 lead to 50 -ohm termination on pulse generator.
e. Set pulse generator for a TTL level (approximately 0 to +3 volts), 1 -microsecond duration, 10 -millisecond period, pulse output.
$\sqrt{ }$ f. CHECK-For vertical display of from 6.3 to 7.7 divisions.
$\sqrt{ }$ g. CHECK-That Vertical MAG control expands display by 5 times within $10 \%$ in fully clockwise (X5) position.
$\sqrt{ }$ E3. CHECK SWEEP LENGTH
a. Set Horizontal MAG control fully counterclockwise (X1).
$\sqrt{ }$ b. CHECK - That displayed sweep length is from 9 to 11 divisions.
$\sqrt{ }$ E4. CHECK HORIZONTAL MAGNIFIER AND POSITION
a. Set LA 501 controls as follows:

TRIGGER
SAMPLE INTERVAL
POST (button in) 10 ns
a. (Continued)
TRIGGER SOURCE
DISPLAY TIME
FORMAT

CH O (button out) $\infty$ (fully clockwise) CH 0-3 X1024 (button in)
b. Set pulse generator for a symmetrical 1-megahertz, TTL-level (approximately 0 to +3 volts), square-wave output.
c. Press MANUAL button momentarily to obtain a continuous data display on channel 0 .
d. Set test oscilloscope or monitor horizontal deflection factor for a 1 division displayed pulse width.
e. Set Horizontal MAG control fully clockwise (X10).
$\sqrt{ }$ f. CHECK-That displayed pulse width is from 9 to 11 divisions.
g. Reset test oscilloscope horizontal deflection factor for 50 millivolts/division.
h. Rotate Horizontal POS control fully counterclockwise.
$\sqrt{ }$ i. CHECK - That right edge of magnified display can be positioned to within 2 divisions of graticule center.
j. Rotate Horizontal POS control fully clockwise.
$\sqrt{ }$ k. CHECK-That left edge of magnified display can be positioned to within 2 divisions of graticule center.

## $\sqrt{ }$ : E5. CHECK HORIZONTAL LINEARITY

a. Set SAMPLE INTERVAL switch to $1 \mu \mathrm{~s}$, Horizontal MAG control fully clockwise (X10), and press POST button.
b. Press and release MANUAL button.
c. Disconnect 50 -ohm cable from $Z$ BLANK OUT connector.
d. Horizontally position display so that left $10 \%$ of display is off screen.
e. Set test oscilloscope or monitor horizontal deflection factor for an even number of data bits displayed in center 6 graticule divisions.
f. Horizontally position right end of display so that it fills center 6 graticule divisions.
$\sqrt{ }$ g. CHECK-That number of data bits in center 6 graticule divisions is within $10 \%$ of the number displayed in part (e).
h. Set test oscilloscope or monitor horizontal deflection factor for 50 millivolts/division.

## F. DC BALANCE AND DATA INPUTS

## Equipment Required

1. Pulse generator
2. BNC-to-probe tip adapter
3. Test oscilloscope
4. 50 -ohm termination
5. Precision dc voltmeter
6. 50 -ohm cables (4)
7. 10 X probes (4)
8. Three-inch screwdriver
9. BNC T connector

## See TEST POINT AND ADJUSTMENT LOCATIONS

## in the Diagrams section.

## $\sqrt{ }$ F1. ADJUST EXT TRIG Input (10X) DC BALANCE (R845)

a. Connect 50 -ohm termination and BNC-to-probe tip adapter to pulse generator output.
b. Set pulse generator for a symmetrical 50-megahertz, minimum ECL level ( -1.55 to -0.95 volts), square-wave output.
c. Connect 10X probe from EXT TRIG (10X) connector to BNC-to-probe tip adapter. (Compensate probe as described in the LA 501W Operators Manual.)
d. Set SAMPLE INTERVAL switch to EXT and press ECL button.
e. Set test oscilloscope sweep rate for 5 nanoseconds/ division and connect a 10 X probe to test oscilloscope vertical input.
f. CHECK-For waveform at J 838 with test oscilloscope probe.

## NOTE

If no signal is present at J838, check that internal Clock Polarity selector, P831, is connected to pin 15 of U830.
g. ADJUST-R845 (Ext Clock DC Bal) for a clean, symmetrical, 50-megahertz ECL display.
h. Place internal Ext Clock Threshold switch, S848, in front panel (up) position.
i. Press VAR button and adjust THRESHOLD for same display obtained in part (g).
j. Connect precision dc voltmeter to INPUT MONITOR jack and note voltmeter reading.
k. Position display as shown in Figure S-1(A). Set test oscilloscope trigger level for stable display.
I. Set THRESHOLD control for a voltmeter reading 60 millivolts above reading noted in part (i).
$\sqrt{ }$ m. CHECK-Display for 5 nanoseconds or less of threshold level uncertainty as shown in Figure $\mathrm{S}-1(\mathrm{~B})$.
n. Set THRESHOLD control for a voltmeter reading 60 millivolts below reading noted in part (i).
$\sqrt{ }$ o. CHECK-Display for 5 nanoseconds or less of threshold level uncertainty as shown in Figure S-1(C).
p. Reset THRESHOLD control for voltmeter reading noted in part (i).

F2. ADJUST CHANNEL 0 DC BALANCE (R25)
a. Disconnect 10X probe from EXT TRIG (10X) connector and connect to $\mathrm{CH} O \mathrm{BNC}$ connector.
b. Press INPUTS button.
c. Set pulse generator for a symmetrical 33-megahertz, minimum ECL level ( -1.55 to -0.95 volts), square-wave output.
d. CHECK-For waveform at J24 with test oscilloscope probe.


Fig. S-1. Typical threshold level waveform at J838.
e. ADJUST-R25 (CH 0 DC Bal) for a clean symmetrical 33-megahertz ECL display.

## F3. ADJUST CHANNEL 1 DC BALANCE (R45)

a. Disconnect 10 X probe from CH 0 BNC connector and connect to CH 1 BNC connector.
b. CHECK-For waveform at J44 with test oscilloscope probe.
c. ADJUST-R45 (CH 1 DC Bal) for a clean, symmetrical, 33-megahertz ECL display.

## F4. ADJUST CHANNEL 2 DC BALANCE (R65)

a. Disconnect 10X probe from CH 1 BNC connector and connect to CH 2 BNC connector.
b. CHECK-For waveform at J64 with test oscilloscope probe.
c. ADJUST-R65 (CH 2 DC Bal) for a clean, symmetrical, 33-megahertz ECL display.

## F5. ADJUST CHANNEL 3 DC BALANCE (R85)

a. Disconnect 10X probe from CH 2 BNC connector and connect to CH 3 BNC connector.
b. CHECK-For waveform at J84 with test oscilloscope probe.
c. ADJUST-R85 (CH 3 DC Bal) for a clean, symmetrical, 33-megahertz ECL display.
$\sqrt{ }$ F6. CHECK HIGH-IMPEDANCE DATA INPUTS
a. Disconnect 10X probe from CH 3 BNC connector and connect to CH 0 connector.
b. Set pulse generator for a 15-nanosecond duration, 0.5 -microsecond period, minimum ECL level ( -1.55 to -0.95 volts), pulse output.
c. Connect 50 -ohm cable from pulse generator trigger output to EXT TRIG (TTL) connector.
d. Connect 50 -ohm cables from $X$ HORIZ OUT, Y VERT OUT, and Z BLANK OUT connectors to corresponding test oscilloscope or monitor inputs.
e. Set SAMPLE INTERVAL switch to 10 ns , DISPLAY

TIME control fully counterclockwise ( 1 s ), and press
CH 0-3 X1024, POST, and SOURCE buttons.
$\sqrt{ }$ f. CHECK-Channel 0 line for data bits spaced evenly across entire display with no holes.
g. Repeat part (e) with $10 \times$ probe connected to CH 1 , CH 2 , and CH 3 BNC connectors respectively.

## F7. CHECK WR 501 DATA INPUTS

a. Press to release INPUTS button and connect P6451 probe channel 0 lead to 50 -ohm termination at pulse generator output. (Make sure P6451 probe ground lead is connected to suitable ground.)
b. CHECK-Channel 0 line for data bits spaced evenly across entire display with no holes.
c. Repeat part (b) with P6451 probe channel 1 through 3 leads connected, one at a time, to 50 -ohm termination at pulse generator output.
d. Set pulse generator for a 25 -nanosecond duration, 0.5 -microsecond period, pulse output.
e. Set SAMPLE INTERVAL switch to 20 ns and press CH 0-7 X512 button.
f. Repeat part (b) with P6451 probe channel 4 through 7 leads connected, one at a time, to 50 -ohm termination at pulse generator output.
g. Set pulse generator for a 55-nanosecond duration, 0.5 -microsecond period, pulse output.
h. Set SAMPLE INTERVAL switch to 50 ns and press CH 0-15 X256 button.
i. Repeat part (b) with P6451 probe channel 8 through 15 leads connected, one at a time, to 50 -ohm termination at pulse generator output.
j. Disconnect P6451 probe lead from pulse generator output.
k. Disconnect 50 -ohm cable from EXT TRIG connector.

## / F8. CHECK HIGH-IMPEDANCE DATA INPUT DELAYS

a. Press INPUTS button.
$\sqrt{ }$ b. CHECK-Channel 0 through 3 delays by connecting a 10X probe from front-panel High-Impedance Data Input connectors, one at a time, to pulse generator output, and probes from test oscilloscope channel 1 and 2 to test points as outlined in Table S-2. Test oscilloscope channel 2 displayed waveform should be within 0 to 14 nanoseconds before the test oscilloscope channel 1 displayed waveform.

Table S-2
High-Impedance Data Input Delays

| Test Oscilloscope <br> Channel 1 Probe <br> Test Point | Test Oscilloscope <br> Channel 2 Probe <br> Test Point | High-Impedance <br> Data Input <br> Connected to Pulse <br> Generator Output |
| :---: | :---: | :---: |
| U235, Pin 4 | U235, Pin 12 | CH 0 |
| U335, Pin 4 | U335, Pin 12 | CH 1 |
| $U 435, \operatorname{Pin} 4$ | U435, Pin 12 | CH 2 |
| $U 535, \operatorname{Pin~4~}$ | U535, Pin 12 | CH 3 |

## F9. P6451 SETUP AND HOLD TO STORE CHECK

a. Set the pulse generator for a square wave that is HI for 18 ns and LO for 18 ns and has a voltage swing of between -0.8 V and -1.6 V .
b. Connect $50 \Omega$ cables from $X$ HORIZ OUT, Y VERT OUT, and Z BLANK OUT connectors to corresponding test oscilloscope or monitor inputs.
c. Connect the clock and Ch 0 inputs to the output of the pulse generator. Connect the 10X EXT TRIG Connector to the output of the pulse generator.
d. Set the WR 501 controls as follows:

CLOCK
THRESHOLD (both
WORD SELECTOR
Switches (all)
QUALIFIER Selector OFF
WORD MODE ASYNC
FILTER
Delay Selector
$\stackrel{\Gamma}{\mathrm{ECL}}$
ECL HI
< 5 ns (fully counterclockwise)
OFF
e. Set the LA 501 controls as follows:

| SAMPLE INTERVAL | EXT |
| :--- | :--- |
| Data Position |  |
| pushbuttons | CENTER |
| SOURCE |  |
| FORMAT | EXT |
| INPUT | Ch $0-7 \times 512$ |
| DISPLAY TIME | PROBE |
|  | 1 s |

f. CHECK-Ch 0 displayed on the screen is a steady HI level.
g. Set CLOCK. $\sqrt{ }$
h. CHECK-Ch 0 displayed on the screen is a steady LO level.
i. Disconnect Ch 0 input from the pulse generator.
j. Set CLOCK. $~ Z$
k. Connect Ch 1 input to the output of the pulse generator.
I. CHECK-Ch 1 display on the screen is a steady HI level.
m . Disconnect Ch 1 input from the pulse generator.
n. Repeat steps k through m for Ch 2 through Ch 7.
o. Set FORMAT Ch $0.15 \times 256$
p. Adjust the pulse generator for a swuare wave that is HI for 23 ns and LO for 23 ns .
q. Connect Ch 8 input to the output of the pulse generator.
r. CHECK-Ch 8 display on the screen is a steady HI level.
s. Repeat steps q through r for Ch 9 through Ch 15.
t. Disconnect test setup.

## G. Z-AXIS

## Equipment Required

1. Test oscilloscope or monitor
2. Pulse generator
3. 50 -ohm termination
4. 50 -ohm BNC cables (3)

## See TEST POINT AND ADJUSTMENT LOCATIONS

in the Diagrams section of LA 501 Service manual.

## G1. CHECK RETRACE BLANKING TIME

a. Connect 50 -ohm termination to pulse generator output.
b. Set pulse generator for a TTL level (approximately 0 to +3 volts), 10-nanosecond duration, 10 -millisecond period, pulse output.
c. Connect 50 -ohm cable from 50 -ohm termination at pulse generator output to EXT TRIG (TTL) connector.
d. Connect 50 -ohm cable from $Z$ BLANK OUT connector to test oscilloscope vertical input.
e. Press CH 0-3 $\times 1024$ button and set SAMPLE INTERVAL switch to $1 \mu \mathrm{~s}$.
f. CHECK-Display for + or -4 to 6 volt pulse (depending on position of internal Blanking Polarity switch, S720) with a duration of 3.5 to 5 microseconds.

1
g. Press $\mathrm{CH} 0-7 \times 512$ button.
h. CHECK-Display for pulse duration from 1.7 to 2.7 microseconds.
i. Press CH 0-15 X256 button.
j. CHECK-Display for pulse duration from 0.9 to 1.5 microseconds.

## Equipment Required

1. Test oscilloscope or monitor
2. BNC cables (3)

See


## in the Diagrams section of LA 501 Service manual.

a. Set the LA 501 controls as follows:

| SAMPLE INTERVAL | 50 ns |
| :--- | :--- |
| FORMAT | Ch $0-15 \times 256$ |
| DISPLAY TIME | $\infty$ |

b. Set the WR 501 Delay Selector Switch to OFF.
c. Connect the oscilloscope or monitor to the output of the LA 501 via the BNC cables.
d. Push the SLOPE Switch twice to get a display.
e. CHECK-The intensified bit on the screen is at the $\mathrm{n}+1$ bit where n is the number on the Delay Count Switches.
f. Set FORMAT to Ch 7-0 $\times 512$.
g. CHECK-The intensified bit on the screen is at the nth bit where n is the number on the Delay Count Switches.
h. Set FORMAT to Ch 0-3 $\times 1026$.
i. CHECK-The intensified bit on the screen is at the nth bit where $n$ is the number on the Delay Count Switches.

This completes the Performance Check and Adjustment procedure.

## MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

## SERVICE NOTE

Because of the universal parts procurement problem, some electrical parts in your instrument may be different from those described in the Replaceable Electrical Parts List. The parts used will in no way alter or compromise the performance or reliability of this instrument. They are installed when necessary to ensure prompt delivery to the customer. Order replacement parts from the Replaceable Electrical Parts List.

## CALIBRATION TEST EQUIPMENT REPLACEMENT

## Calibration Test Equipment Chart

This chart compares TM 500 product performance to that of older Tektronix equipment. Only those characteristics where significant specification differences occur, are listed. In some cases the new instrument may not be a total functional replacement. Additional support instrumentation may be needed or a change in calibration procedure may be necessary.

Comparison of Main Characteristics

| DM 501 replaces 7D13 |  |  |
| :---: | :---: | :---: |
| PG 501 replaces 107 | PG 501 - Risetime less than 3.5 ns into $50 \Omega$. <br> PG 501-5 V output pulse; 3.5 ns Risetime. <br> PG 501 - Risetime less than $3.5 \mathrm{~ns} ; 8 \mathrm{~ns}$ Pretrigger pulse delay. <br> PG 501- $\pm 5 \mathrm{~V}$ output. <br> PG 501 - Does not have Paired, Burst, Gated, or Delayed pulse mode; $\pm 5 \mathrm{~V}$ dc Offset. Has $\pm 5 \mathrm{~V}$ output. | 107 - Risetime less than 3.0 ns into $50 \Omega$. <br> 108-10 V output pulse; 1 ns Risetime. <br> 111 - Risetime 0.5 ns; 30 to 250 ns Pretrigger Pulse delay. <br> $114- \pm 10 \mathrm{~V}$ output. Short proof output. <br> 115 - Paired, Burst, Gated, and Delayed pulse mode; $\pm 10 \mathrm{~V}$ output. Short-proof output. |
| $\begin{array}{r} \hline \text { PG } 502 \text { replaces } 107 \\ 108 \\ 111 \\ \\ 114 \\ 115 \\ \\ \\ \\ \\ \end{array}$ | PG 502-5 V output <br> PG 502 - Risetime less than $1 \mathrm{~ns} ; 10 \mathrm{~ns}$ Pretrigger pulse delay. <br> PG 502- $\pm 5$ V output <br> PG 502 - Does not have Paired, Burst, Gated, Delayed \& Undelayed pulse mode; Has $\pm 5 \mathrm{~V}$ output. <br> PG 502 - Does not have Paired or Delayed pulse. Has $\pm 5 \mathrm{~V}$ output. | 108-10 V output. <br> 111 - Risetime $0.5 \mathrm{~ns} ; 30$ to 250 ns Pretrigger pulse delay. <br> $114- \pm 10 \mathrm{~V}$ output. Short proof output. <br> 115 - Paired, Burst, Gated, Delayed \& Undelayed pulse mode; $\pm 10 \mathrm{~V}$ output. Short-proof output. <br> 2101 - Paired and Delayed pulse; 10 V output. |
| PG 506 replaces 106 067-0502-01 | PG 506 - Positive-going trigger output signal at least 1 V ; High Amplitude output, 60 V . <br> PG 506 - Does not have chopped feature. | 106 - Positive and Negative-going trigger output signal, 50 ns and 1 V ; High Amplitude output, 100 V . <br> 0502-01 - Comparator output can be alternately chopped to a reference voltage. |
| $\begin{array}{r} \hline \text { SG } 503 \text { replaces } 190, \\ 190 \mathrm{~A}, 190 \mathrm{~B} \\ 191 \\ 067-0532-01 \end{array}$ | SG 503 - Amplitude range 5 mV to $5.5 \mathrm{~V} \mathrm{p}-\mathrm{p}$. <br> SG 503 - Frequency range 250 kHz to 250 MHz . <br> SG 503 - Frequency range 250 kHz to 250 MHz . | 190B - Amplitude range 40 mV to 10 V p-p. <br> 191 - Frequency range 350 kHz to 100 MHz . <br> $0532-01$ - Frequency range 65 MHz to 500 MHz . |
| TG 501 replaces 180, 180A <br> 181 <br> 184 <br> 2901 | TG 501 - Marker outputs, 5 sec to 1 ns . Sinewave available at 5,2 , and 1 ns . Trigger output - slaved to marker output from 5 sec through 100 ns . One time-mark can be generated at a time. <br> TG 501 - Marker outputs, 5 sec to 1 ns . Sinewave available at 5,2 , and 1 ns . <br> TG 501 - Marker outputs, 5 sec to 1 ns . Sinewave available at 5,2 , and 1 ns . Trigger output - slaved to marker output from 5 sec through 100 ns . One time-mark can be generated at a time. <br> TG 501 - Marker outputs, 5 sec to 1 ns . Sinewave available at 5,2 , and 1 ns . Trigger output - slaved to marker output from 5 sec through 100 ns . One time-mark can be generated at a time. | 180A - Marker outputs, 5 sec to $1 \mu \mathrm{~s}$. Sinewave available at 20,10, and 2 ns. Trigger pulses 1, 10, $100 \mathrm{~Hz} ; 1,10$, and 100 kHz . Multiple time-marks can be generated simultaneously. <br> 181 - Marker outputs, 1, 10, 100, 1000, and $10,000 \mu \mathrm{~s}$, plus 10 ns sinewave. <br> 184 - Marker outputs, 5 sec to 2 ns . Sinewave available at $50,20,10,5$, and 2 ns . Separate trigger pulses of 1 and $.1 \mathrm{sec} ; 10,1$, and .1 ms ; 10 and $1 \mu \mathrm{~s}$. Marker amplifier provides positive or negative time marks of 25 V min. Marker intervals of 1 and $.1 \mathrm{sec} ; 10,1$, and $.1 \mathrm{~ms} ; 10$ and $1 \mu \mathrm{~s}$. <br> 2901 - Marker outputs, 5 sec to $0.1 \mu \mathrm{~s}$. Sinewave available to 50,10 , and 5 ns . Separate trigger pulses, from 5 sec to $0.1 \mu \mathrm{~s}$. <br> Multiple time-marks can be generated simultaneously. |

TEKTRONIX
technical excellence

PRODUCT WR 501
070-2168-00

CHANGE REFERENCE
C1/177
DATE 1-12-77

CHANGE:

## DESCRIPTION

EFF SN B010100
ELECTRICAL PARTS LIST AND SCHEMATIC CHANGES
Change to:

| C421 | 283-0109-00 | CAP.,FXD, CER DI:27PF,5\%,1KV |
| :---: | :---: | :---: |
| C422 | 290-0517-00 | CAP.,FXD,ELCTLT:6.8UF, 20\%,35V |
| C482. | 283-0144-00 | CAP.,FXD, CER DI:33PF, $1 \%, 500 \mathrm{~V}$ |
| C488 | 290-0517-00 | CAP., FXD, ELCTLT : 6.8UF, 20\%, 35v |
| R421 | 315-0132-00 | RES.,FXD, CMPSN: 1.3 K OHM , $5 \%, 0.25 \mathrm{~W}$ |
| R429 | 315-0241-00 | RES., FXD, CMPSN:240 ОНM, $5 \%, 0.25 \mathrm{~W}$ |
| R482 | 315-0132-00 | RES.,FXD, CMPSN:1.3K OHM, $5 \%, 0.25 \mathrm{~W}$ |
| R488 | 31.5-0271-00 | RES.,FXD, CMPSN:270 OHM, 5\%, 0.25W |
| U660 <br> MOVE: | 156-0496-01 | MICROCIRCUIT,LI:V RGTR, DUAL TRKG, CHECKED |
| CR436 | 152-0141-02 | SEMICOND DEVICE:SILICON, 30V,150MA, 1N4152 |
| R425 | 315-0130-00 | RES.,FXD, CMPSN:13 ОHM, 5\%,0.25W |
| R426 | 315-0202-00 | RES., FXD, CMPSN:2K OHM, 5\%, 0.25W |
| R485 | 315-0130-00 | RES.,FXD, CMPSN:13 ОHM,5\%,0.25W |
| R487 | 315-0202-00 | RES.,FXD, CMPSN:2K OHM,5\%,0.25W |
| D: |  |  |
| C428 | 281-0791-00 | CAP.,FXD, CER DI:270PF, $10 \%$, 100V |
| C451 | 283-0023-00 | CAP.,FXD, CER DI:0.1UF, $+80-20 \%$, 10 V |
| CR420 | 152-0141-02 | SEMICOND DEVICE:SILICON,30V,150MA,1N4152 |
| CR480 | 152-0141-02 | SEMICOND DEVICE:SILICON,30V,150MA,1N4152 |
| R428 | 315-0182-00 | RES.,FXD, CMPSN:1.8K OHM,5\%,0.25W |
| R438 | 315-0391-00 | RES.,FXD,CMPSN:390 ОНM, $5 \%, 0.25 \mathrm{~W}$ |

$\qquad$
$\qquad$ C1/177



EFF SN B010320-up


ELECTRICAL PARTS LIST AND SCHEMATIC CHANGES

CHANGE TO:

| U430 | 156-0880-00 | MICROCIRCUIT,DI:DUAL D MASTER-SLAVE FLIP-FLOP |
| :--- | :--- | :--- |
| U460 | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE,MC1662 |  |

U430 and U460 are located on the MAIN circuit board assembly and are shown on diagram 4 WORD RECOGNIZER.


[^0]:    ${ }_{2}^{1}$ LA501w only
    ${ }^{2}$ WR501 only

[^1]:    ${ }^{1}$ part of Al
    $2_{\text {part of }}$ A2

[^2]:    $1_{\text {Available }}$ under 010-6451-01 only.
    2Available under 380-0463-02 only.

[^3]:    ${ }^{1}$ Can be used instead of monitor throughout procedure.

[^4]:    $\sqrt{ }$ b. CHECK-Counter for readout from 49.99750 to 50.00250 megahertz.

