HP 16515A/16516A

1 GHz TIMING ANALYZER MODULE
for THE HP 16500A LOGIC ANALYSIS SYSTEM

Getting Started Guide

HEWLETT PACKARD

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How to Use This Manual

This manual explains the basic operation of the HP 16515A/16A
1 GHz Timing Analyzer Module of the HP 16500 Logic Analysis
System. It is organized in a task-oriented format that guides you
through front-panel setups and basic measurements to solve digital
system problems.

You should read and perform the learning tasks in this manual after
you have become familiar with the operation of the HP 16500A
mainframe.

If you are an experienced HP logic analyzer user and want to go
directly to the reference manual, you still might find the first few
chapters of this book helpful. These chapters will only take a few
minutes and you will find the user interface of the HP 16500A Logic
Analysis System to be very friendly and easy to learn.

The first chapter gives you a brief overview of the HP 16515A/16A
module, along with a list of its key features. Chapter 2 introduces
you to the probes that connect the HP 16515A/16A module to the
test system, and chapters 3 through 7 acquaint you with the front
panel and its operation.

Chapters 8 and 9 show you how to solve basic digital problems using
the functions and features of the HP 16515A/16A module.

Chapter 10 invites you into the *HP 16515A/16516A Front-Panel
Operation Reference* manual where all the features and functions are
described in detail.

Table of Contents

Table of Contents (Continued)

Chapter 4:   **The Format Menu**

Chapter 5:   **The Trace Menu**

Chapter 6:   **Acquiring Data**

Table of Contents (Continued)

Table of Contents (Continued)

Chapter 10:   **What's Next?**

Introduction

Welcome to the Hewlett Packard Logic Analysis System. The
HP 16500A Logic Analysis System has been designed to be the
easiest logic analyzer to use, ever. In addition, because of its con-
figurable architecture, it can easily be tailored to your specific logic
design and debug needs.

The user interface of the HP 16500A is designed to make its
operation as intuitive as possible. Pop-up menus and color graphics
lead you through setups and measurements step-by-step, eliminating
the need to memorize a lot of steps. As you read this manual and
the other manuals about the mainframe and acquisition modules,
you will see just how easy the HP 16500A is to use. When you are
ready to get into more complex measurements, you can rely on the
HP 16515A/16516A Front-Panel Operation Reference manual to
answer your questions and to get a more detailed description of the
functions and features you are using.

If you haven't already read "How to Use This Manual," please do so
before continuing.

If you are new to logic analyzers, or just need a refresher, you will
find *Feeling Comfortabe With Logic Analyzers* valuable reading. It
will eliminate any misconceptions or confusion you may have about
their application, and will show you how to get the most out of your
logic analyzer.

1   What is the HP 16515A/16516A?

The HP 16515A/16A module is a timing analyzer with a 1 GHz sample rate that plugs into the HP 16500A Logic Analysis System mainframe. The HP 16515A is the master card, offering the user up to 1 GHz sample rate on 16 channels with 8k of memory per channel. The HP 16516A expansion card offers an additional 16 channels for a maximum of 32 channels per module set or 80 channels per HP 16500A (with the appropriate combination of HP 16515A and HP 16516A cards).

The key features of the HP 16515A/16A are:

- 1 GHz sample rate
- 1 ns single-shot resolution
- 8k memory depth
- 16 channels per HP 16515A (master)
- 16 channels per HP 16516A (expansion)
- up to 32 channels per module set
- up to 80 channels per HP 16500A mainframe (with the appropriate combination of HP 16515A and HP 16516A cards)
- Time correlated measurements between modules using the intermodule bus
- Easy setup with full color touch screen or mouse
- Lightweight, passive probes
- ECL and TTL presets
- Time measurement between X and O markers
- Automatic pattern search
- Statistical time-interval analysis
- Pattern and edge triggering
- Delayed trigger
- Store and recall configurations for fast setup

2

Probes

Introduction

This chapter describes the probes that connect the HP 16515A/16A module to your test system. If your system was ordered without the cards (PC boards) installed, or if you want to move the cards to another instrument, refer to the *HP 16515A/16516A Front-Panel Operation Reference* manual.

What Probes Are Included?

The probe assemblies listed below are already connected to the instrument when you receive it and exit out of the rear panel of the instrument. Rubber probe clips separate the probe assemblies into groups of eight. Each card (master and expansion) comes with:

- 16 - 5 ft probe assemblies with blue tips.
  (HP part number 16515-61604)

Each card (master or expansion) comes with two bags of leads (HP part number 16515-69502) and two bags of twenty grabbers (HP part number 5959-0288). Each bag of leads contains:

- 8 - signal leads

- 8 - ground leads
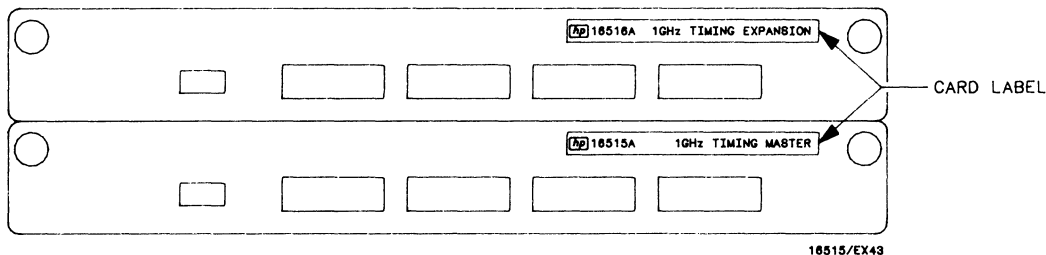
Probe Assembly Identification

The illustration shown below identifies the different probes and assemblies you use to connect to a test system.

GRABBER

SIGNAL LEAD (BLUE)

GROUND LEAD (BLACK)

PROBE ASSEMBLY

RUBBER PROBE CLIP
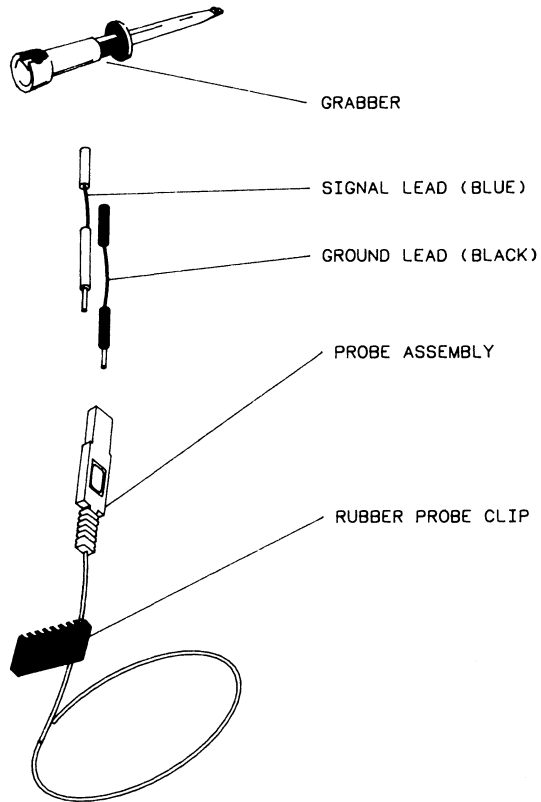
16515/EX40

Identifying Cards and Probes

On the upper-right corner of the rear panel of each master or expansion card is a label that identifies that card.

CARD LABEL

16515/EX43

To identify each probe assembly, look at the rear panel of HP 16515A master or HP 16516A expansion card. The probe assemblies are identified on the rear panel according to both probe and pod number.

MODULE REAR PANEL

POD NUMBER

PROBE NUMBERS

16515/EX37
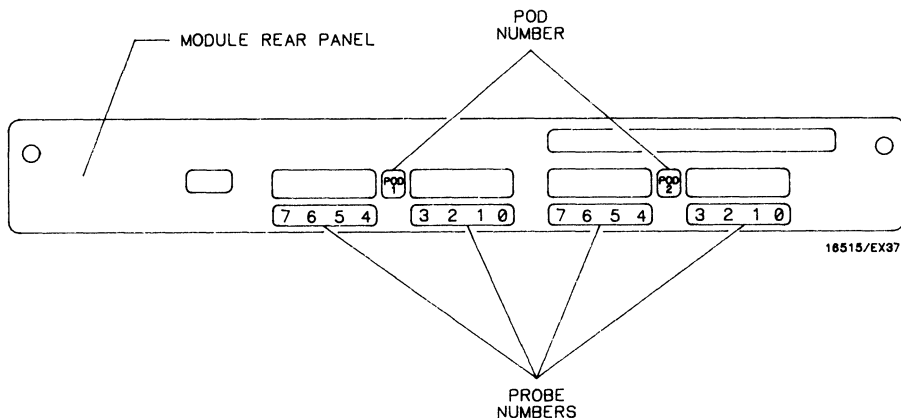
Starting from the far right of the rear panel of the card, probes 0 through 3 of pod 2 exit out of the first slot, probes 4 through 7 exit out of the next slot, and probes 0 through 7 of pod 1 exit out of the next two slots. The probes assemblies can also be identified by color coded labels on each probe tip.

LABEL IDENTIFYING PROBE (0-7)

16515/EX38
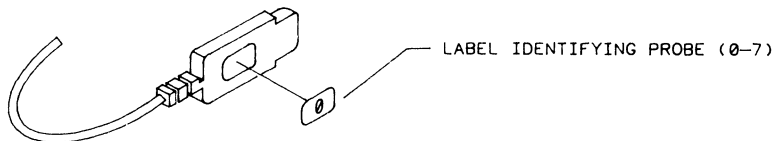
Probes
2-3

The letter displayed on screen with the pod number represents the slot in which the card is located. For example, if the master card was located in slot D of the mainframe, then the probes that exit out of the first two slots closest to the edge of the rear panel would be for pod D2. The probes that exit out of the third and fourth slots from the edge would be for pod D1.

Labeling Pods To identify pods quickly and easily, color coded, self adhesive labels for you to attach to the rubber probe clips that separate the probe assemblies are included with each card. To label pods, identify each group of probe assemblies according to the pod number on the rear panel and the slot in which the card resides. Then remove the appropriate stick-on label provided and place it on the recessed area on the rubber probe clip closest to the probe tips. The brown labels are for pod 1 and the red labels are for pod 2. The other labels are not used for this module.
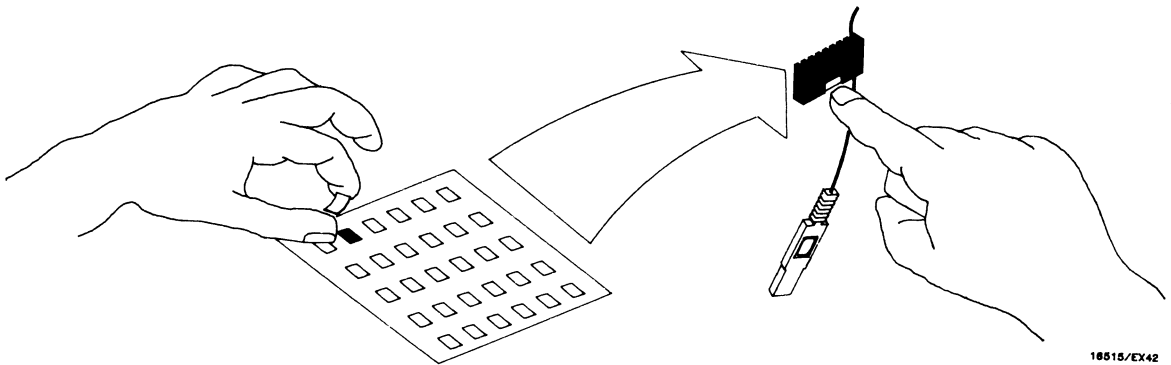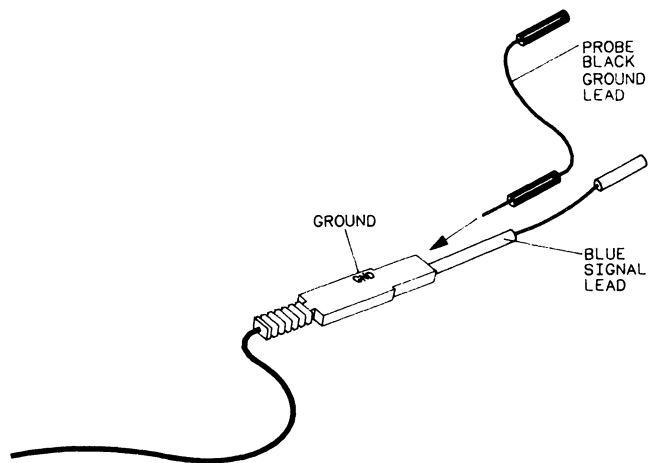

16515/EX42

Connecting Probe Assemblies

The individual probe ground and signal input of the probe assembly should be connected directly to the test points on the system under test. Since each probe assembly has a signal and ground recessed socket, it can be connected directly to square (0.63 mm) or round (0.66 mm) test points. The ground side of the probe assembly is identified by an embossed symbol (GND) on the probe body.

When the probe assembly cannot be connected directly to the test system, short leads are provided to connect the signal and ground sockets to the test points or to grabbers. The short blue lead incorporates a damping resistor and connects to the signal socket. The black lead connects to the ground socket (GND) of the probe assembly.

PROBE
BLACK
GROUND
LEAD

GROUND

BLUE
SIGNAL
LEAD

16515/EX41

Connecting Grabbers to Probe Leads

Connect the grabbers to the probe leads by putting the connector at the end of the lead onto the recessed pin in the side of the grabber.
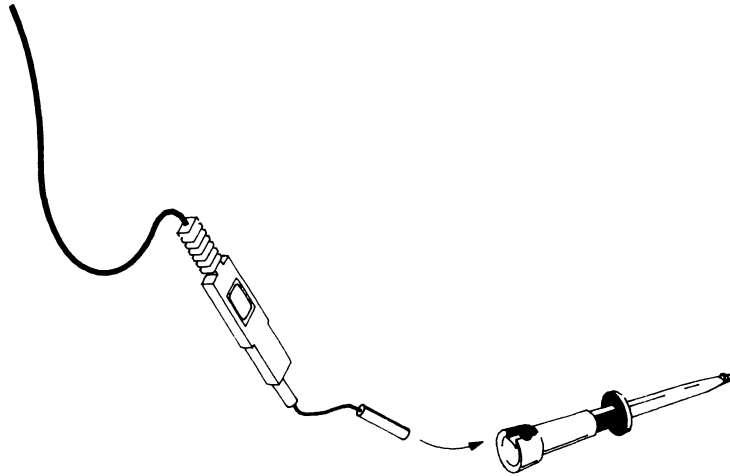
16515/EX20

Connecting Grabbers to Test Points

The grabbers have a hook that fits around IC pins and component leads. To connect the grabber, push on the rear of the grabber to expose the hook, hook the test lead, and then release the rear of the grabber.
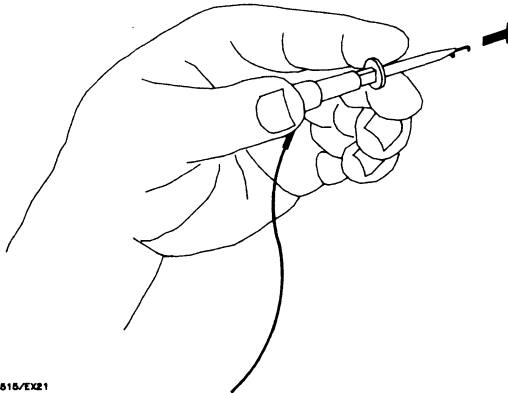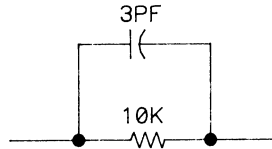
16515/EX21

Signal Line Loading

Any signal line that you intend to connect to a probe must be able to supply a minimum of 500 mV to the probe tip. If the signal line is not capable of this, you will not be able to make a reliable measurement and the probe connection may load down the system under test.

The probe tip has an input impedance of 10k ohms shunted by 3 pF.

16515/M601

Summary

This chapter acquainted you with:

- the probes included with the module;

- identifying the different probe assemblies;

- identifying probes;

- labeling pods;

- connecting probe assemblies to test points;

- connecting leads to probe assemblies;

- connecting and using grabbers; and

- the minimum output for a signal line that you want to measure.

For more information on the probes, refer to the *HP 16515A/16516A Front-Panel Operation Reference* manual.

3

Basic User Interface Information

User Interface Devices

The HP 16500A has three user interface devices: the knob on the front panel, the touch-sensitive screen, and the optional mouse. If you are unfamiliar with any of these, read this chapter. It covers the basic concepts of their use. For more detailed information, refer to the *HP 16500A Reference Manual*.

System Power Up

When the HP 16500A system is powered up, the menu you see should look similar to the one shown below.
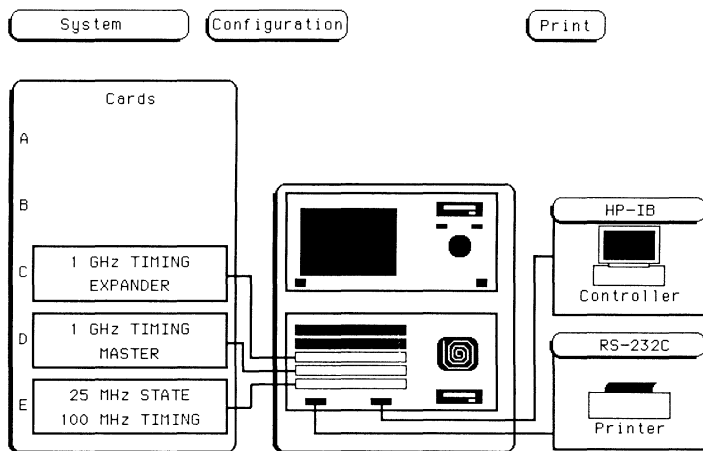
Using the Touch Screen

Any dark-blue field on screen is a "touchable" field. That is, if you touch a dark-blue field, the field will toggle to another value, or a pop-up will appear allowing you to select another function. For example, touch the dark-blue field labeled **System** in the upper-left corner of the screen. A pop-up appears showing all the modules of the mainframe. The actual order and content of this pop-up may vary depending on the modules you have installed and which slots the modules are in.
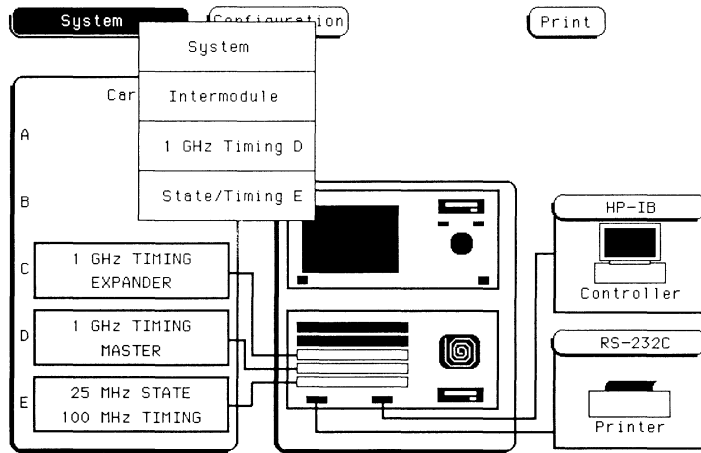
Notice the **System** field in the pop-up is highlighted in light blue. This tells you that you are in a **System** menu. To move to any module in the list, touch that field in the pop-up. The pop-up will close and the module you chose will appear on screen.

If you are in any other module menu, you can return to **System** by touching the module field in the upper-left corner of the screen. When the pop-up appears, notice again that the module you are in is highlighted in light blue. Remember that the dark-blue field in the upper-left corner of the screen allows you to move among the modules.

Module Menus

Each module may have several menus within it. To see these menu selections, touch the dark-blue field second from the left at the top of the screen.

This menu field works the same as the module field to the left of it, except instead of showing all the modules, the menus within each module are displayed. For instance, if you touch this menu field while you are in **System**, you'll get a pop-up that looks like the one shown below.
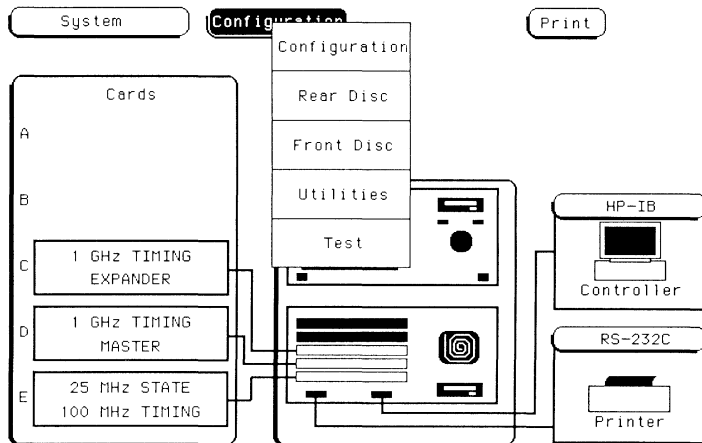
Moving to the 1 GHz Timing Analyzer

Touch the module field in the upper-left corner of the screen. A pop-up will appear similar to the one shown below displaying all the modules in the mainframe. The actual order and content of the pop-up will vary depending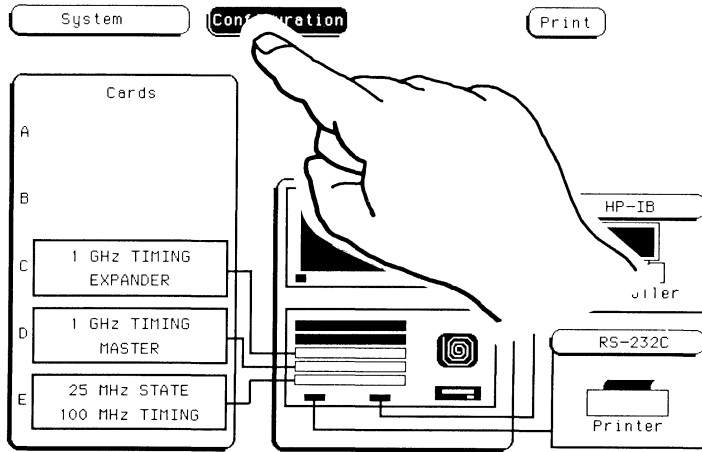 on the modules you have installed and their slot locations. The capitalized letter to the right of the module name refers to the slot in the mainframe where the module is installed.

In this example, to get to the 1 GHz Timing Analyzer menus, you touch the **1 GHz Timing D** field.
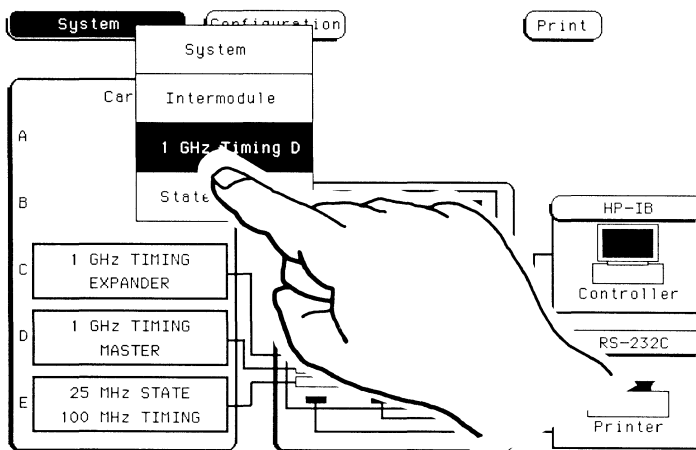
This will bring up the **1 GHz Timing D Format** menu.


```
( 1 GHz Timing D )  ( Format )                    ( Print )  ( Run )

              Pod D2      Pod D1      Pod C2      Pod C1
              ( TTL )     ( TTL )     ( TTL )     ( TTL )
( Label )         --------    --------    --------    --------         ( Symbols )
          Pol  7......0    7......0    7......0    7......0
  A        +   ********    ********    ........    ........
  B        +   ........    ........    ********    ********
 Off
 Off
 Off
 Off
 Off
 Off
 Off
 Off
```
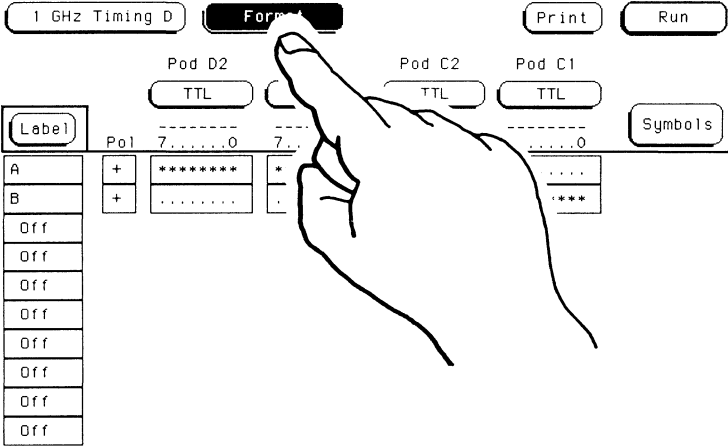
---
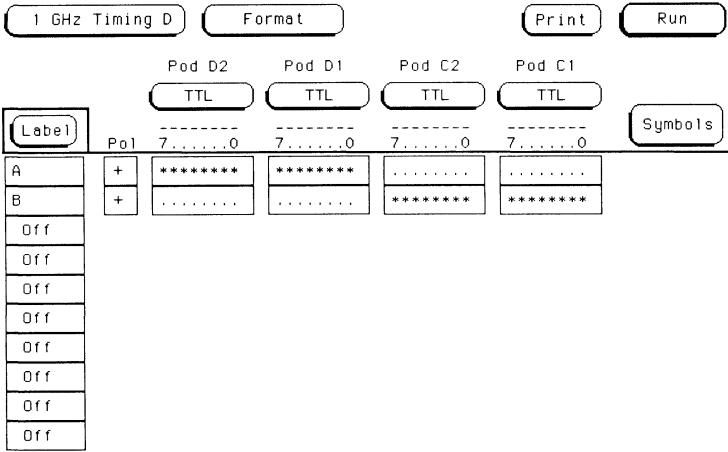
1 GHz Timing Analyzer Menus

The 1 GHz Timing Analyzer has three menus. You can access them by touching the menu field to the right of the **1 GHz Timing** field. Touch the **Format** menu field which is currently being displayed.


```
( 1 GHz Timing D )  [ Format ]                    ( Print )  ( Run )

              Pod D2                  Pod C2      Pod C1
              ( TTL )     (           ( TTL )     ( TTL )
( Label )         --------    ---                    --------         ( Symbols )
          Pol  7......0    7..                    ......0
  A        +   ********    *                          ....
  B        +   ........    .                          (***
 Off
 Off
 Off
 Off
 Off
 Off
 Off
 Off
```

A pop-up appears with all the 1 GHz Timing Analyzer menu
selections.
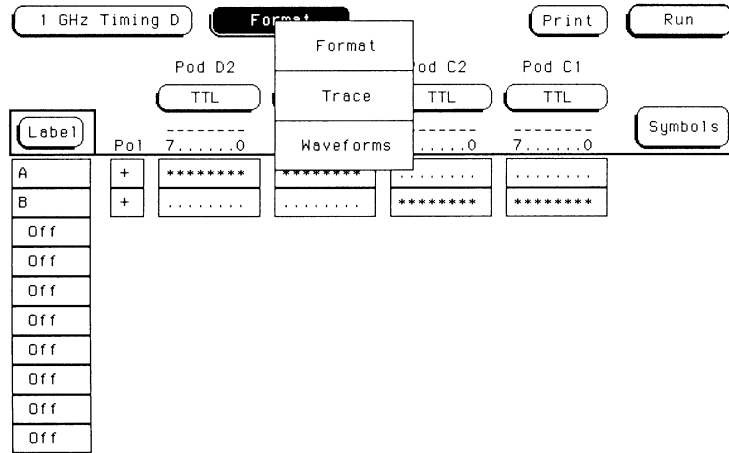
The following chapters will familiarize you with these analyzer
menus. For now, touch the **Format** field in the pop-up menu to
return to the **Format** menu. Just remember that the field next
to **1 GHz Timing** always shows which analyzer menu is displayed.

Data Entry Fields

When you need to enter alphanumeric or numeric data in some fields, a pop-up keypad will appear on screen to allow you to enter the information. In this pop-up there is a field labeled **DONE**. This field lets the instrument know that you are finished entering data. The keypad pop-up will not close until you touch the **DONE** field.
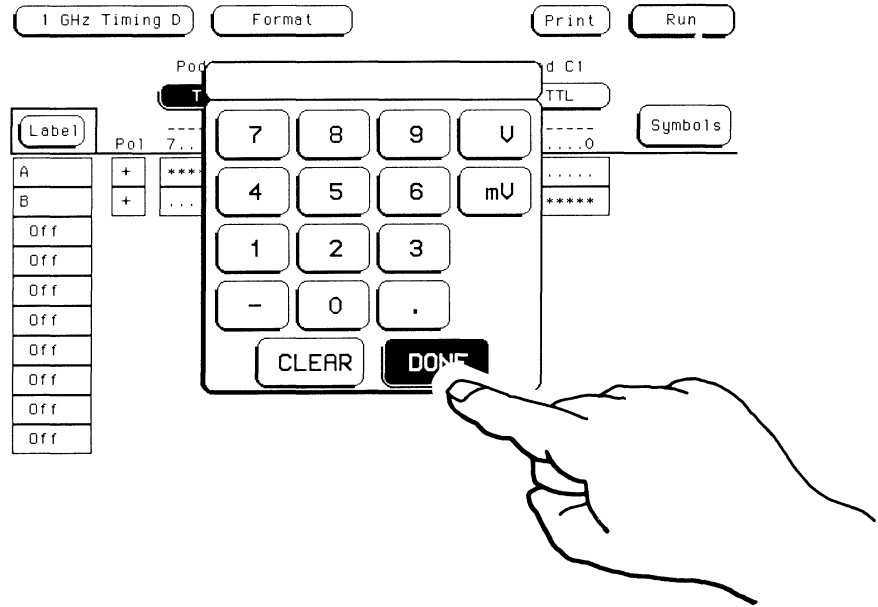
What's the Knob For?

To the right of the screen is a knob. Turning the knob allows you to increment or decrement values in a selected numeric field in the analyzer menus, and to roll the display. "Rolling the display" refers to the instrument's ability to rotate or scroll through information on the screen.

Using the Mouse

Everything that can be done with the touch screen and knob on the HP 16500A can also be done with the optional mouse. The mouse plugs into the connector in the lower right corner of the front panel. As soon as the mouse is plugged in, it is active.

When the mouse is plugged in, a white cursor (cross) appears on screen. Moving the mouse causes the cursor to move. To "touch" a field with the mouse, move the cursor to the field and press the left button on the mouse.

To use the mouse to perform the functions of the front-panel knob, hold down the right button and move the mouse. When you release this button, the function returns to the cursor.

4

The Format Menu

Introduction

In the **Format** menu you describe how the analyzer is connected to the system under test. This includes grouping channels into different labels, renaming labels, and setting the sampling threshold voltages for each pod.

Getting into the Format Menu

If you are not already in the **Format** menu as indicated in the field to the right of **1 GHz Timing**:

1. Touch the field to the right of **1 GHz Timing** in the upper-left corner of the screen.

2. When the pop-up appears, touch the **Format** field. This brings up the **Format** menu.

In the figure shown below, pods C1 and C2 are for the HP 16516A expansion card and pods D1 and D2 are for the HP 16515A master card.

```
( 1 GHz Timing D )  (    Format    )              ( Print )  (   Run   )

                Pod D2      Pod D1      Pod C2      Pod C1
                ( TTL  )    ( TTL  )    ( TTL  )    ( TTL  )
  ( Label )         --------   --------   --------   --------        ( Symbols )
              Pol  7......0   7......0   7......0   7......0
  ┌──────┐   ┌─┐ ┌────────┐ ┌────────┐ ┌────────┐ ┌────────┐
  │ A    │   │+│ │********│ │********│ │........│ │........│
  ├──────┤   ├─┤ │........│ │........│ │********│ │********│
  │ B    │   │+│ └────────┘ └────────┘ └────────┘ └────────┘
  ├──────┤   └─┘
  │ Off  │
  ├──────┤
  │ Off  │
  ├──────┤
  │ Off  │
  ├──────┤
  │ Off  │
  ├──────┤
  │ Off  │
  ├──────┤
  │ Off  │
  ├──────┤
  │ Off  │
  ├──────┤
  │ Off  │
  └──────┘
```

Assigning Labels

For an overview of what you do with the labels, think of the **Format** menu as a switch matrix. The bits of the pods are your columns or inputs and the labels are your rows or outputs. The asterisk (*) connects the input in that column to the output in the corresponding row. The period indicates that no connection exists between that column and the corresponding row.
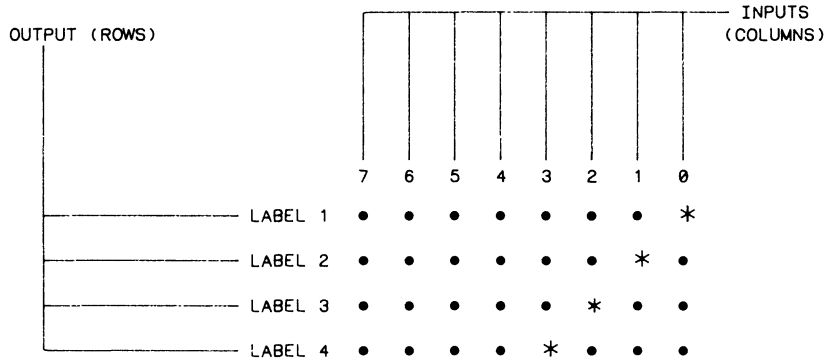

In the figure above, input 0 (bit 0) is connected to output label 1, input 1 (bit 1) is connected to output label 2, and so forth.

The bits represent the channels or inputs of the instrument. The label is a symbolic name in which common channels are grouped for reference. The HP 16515A/16A module offers you 20 different labels in which you can group input lines. The menu will display 10 labels at any given time. To display the additional labels, rotate the knob on the front panel.

Assign each label with a name containing six characters or less that describes the data you are grouping into that label. This helps to avoid confusion when you are configuring the analyzer and interpreting the results.

1. Touch the field for default Label A at the top of the label column.
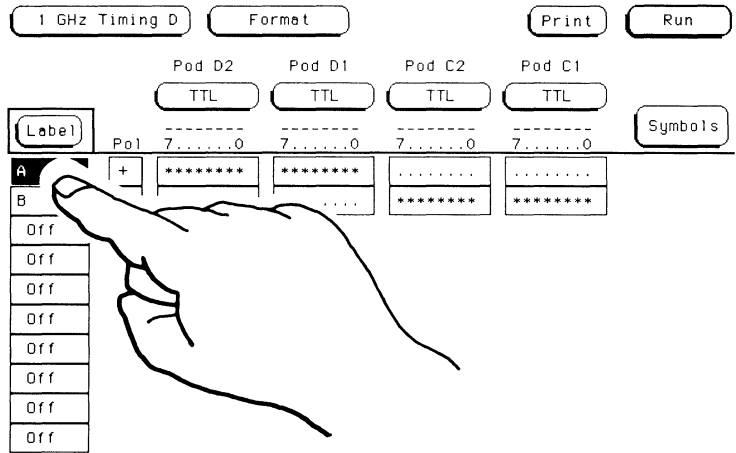
2. When the pop-up appears, touch the **Modify Label** field. A pop-up displaying an alphanumeric keypad will appear.
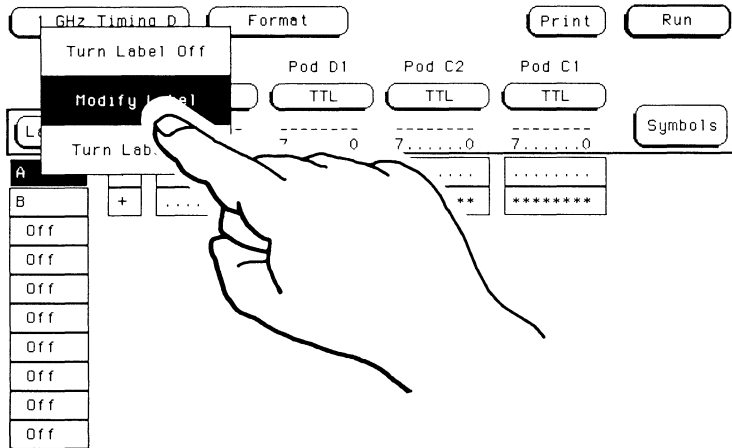
3. For this example, you will rename the label INPUT1 to represent the input of a particular device. Touch the **I** key on the keypad. In the left corner of the box at the top of the pop-up, an "I" appears.

4. Touch the **N** key on the keypad and an "N" appears to the right of the "I."

5. Enter the remaining characters by touching the keys for P, U, T, and 1.

Note

If you make an error, move the cursor with the knob to the incorrect character and use the keypad to insert the correct character.

6. When you are finished, touch the **DONE** field and the pop-up will disappear, putting INPUT1 in the top label position.
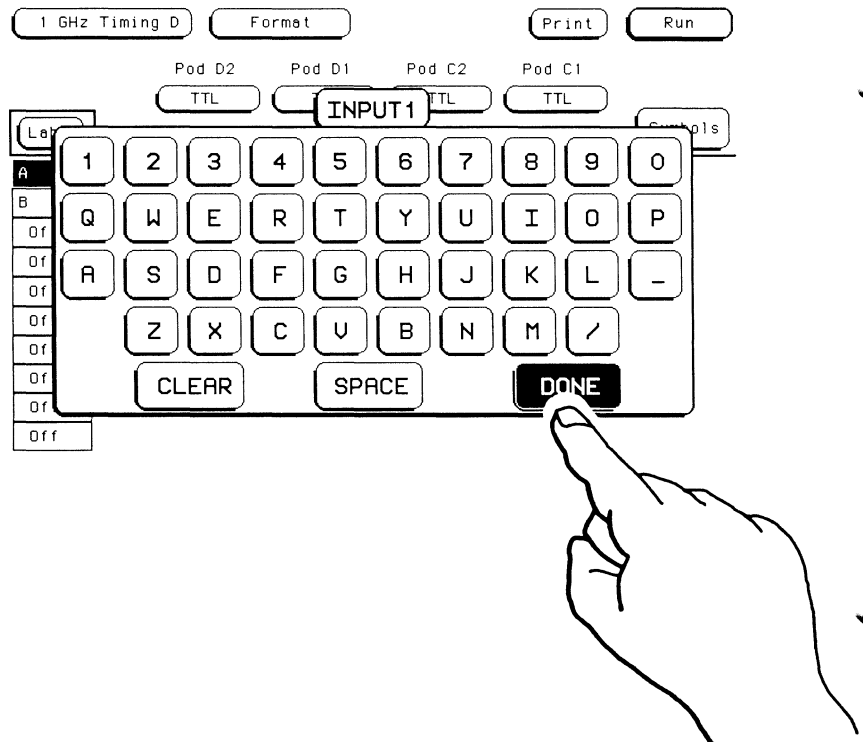
7. Touch the fourth label field down from the top of the label column.

8. When the pop-up appears, touch the **Turn Label On** field. This new label will turn on and the pop-up will disappear. If you have not previously assigned a value, a default value is assigned to this new label. You may change the value (name) of this label the same way you changed the first label to INPUT1.

1 GHz Timing D	Format			Print	Run

|		Pod D2	Pod D1	Pod C2	Pod C1	
		TTL	TTL	TTL	TTL	
Label	Pol	7......0	7......0	7......0	7......0	Symbols
INPUT1	+	********	********	....	....
B	+	....	....	********	********
Off					
D	+	....	....	....	....
Off					
Off					
Off					
Off					
Off					
Off					

Setting Pod Thresholds

The number of pods shown in the **Format** menu depends on how many cards the analyzer is configured with. If configured with just the HP 16515A master, two pods will be shown containing eight input channels or bits each. If configured with both the HP 16515A master and HP 16516A expansion cards, four pods are shown with a total of 32 channels.

To set the pod thresholds:

1. Touch the **TTL** threshold field for any pod displayed.
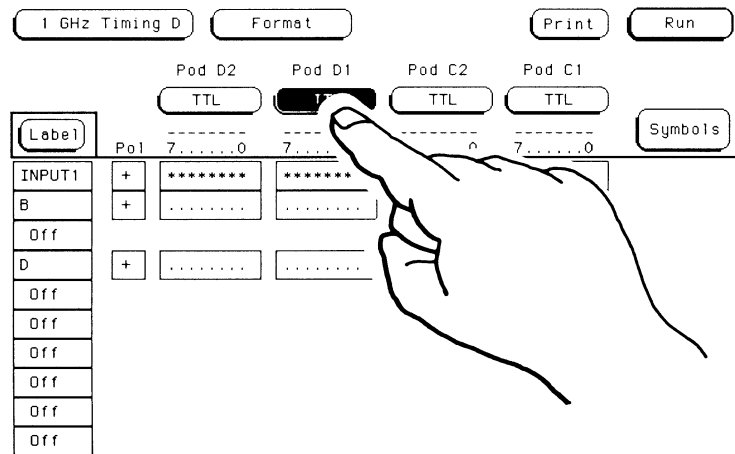
2. When the pop-up appears, you will see your choices displayed. If you touch either **TTL** or **ECL**, the pop-up will disappear, placing your choice in that pod. To see how this works, touch the **ECL** field.
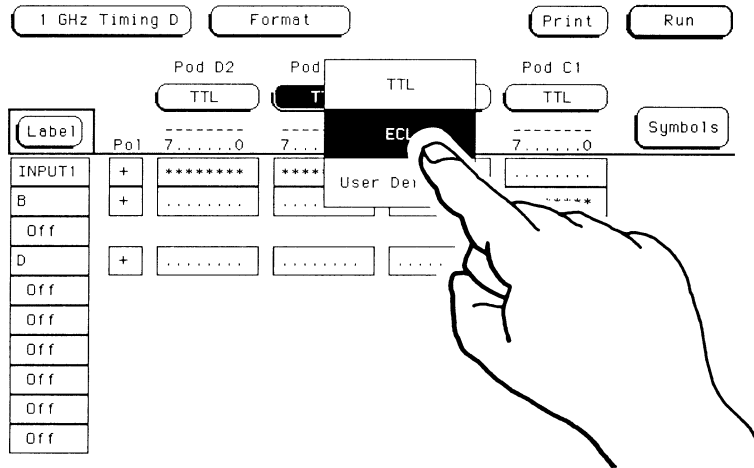
3. Now touch the **TTL** field on another pod.

4. When the pop-up appears, touch **User Defined**. A pop-up
   containing a numeric keypad will then appear.

5. Enter 3.5 from the keypad. This will be displayed in the upper-
   right corner of the pop-up.

6. Touch the **V** key to select the unit of voltage for this example.

7. Touch the negative (-) key to change the threshold from positive
   to negative. If you touch it again, it changes back to positive.

8. Touch **DONE** and the pop-up will disappear, placing your value
   in the appropriate pod.
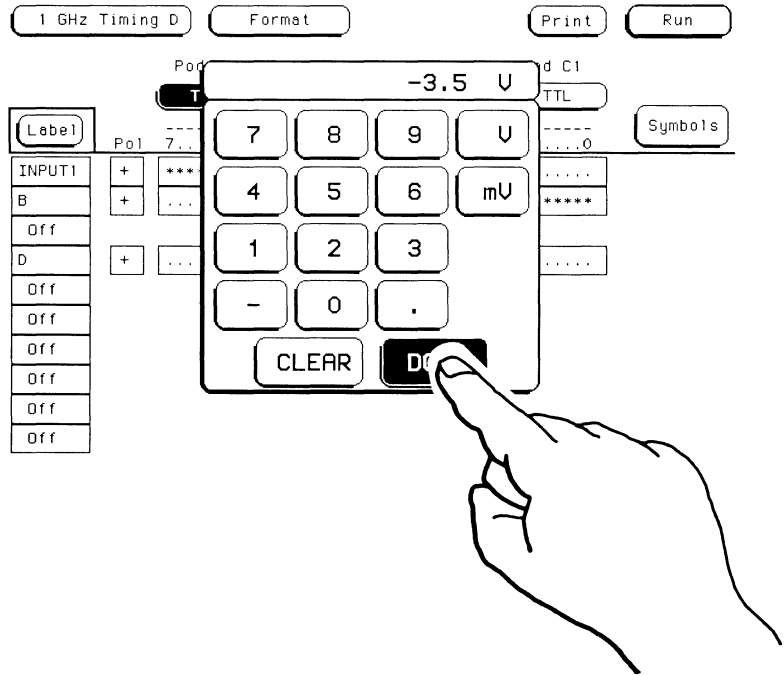
Assigning Bits to Labels

Once you have assigned labels, you need to assign specific pods and bits within the pods to your labels. You will notice that each pod has a box below it and to the right of the label INPUT1. Each box has 7......0 above it. These are the bit numbers that correspond to the input probes for each pod. For this example, assign bits 0 through 3 of pod D2 to the label INPUT1.

1. Touch the bit field to the right of the label INPUT1 and below pod D2.
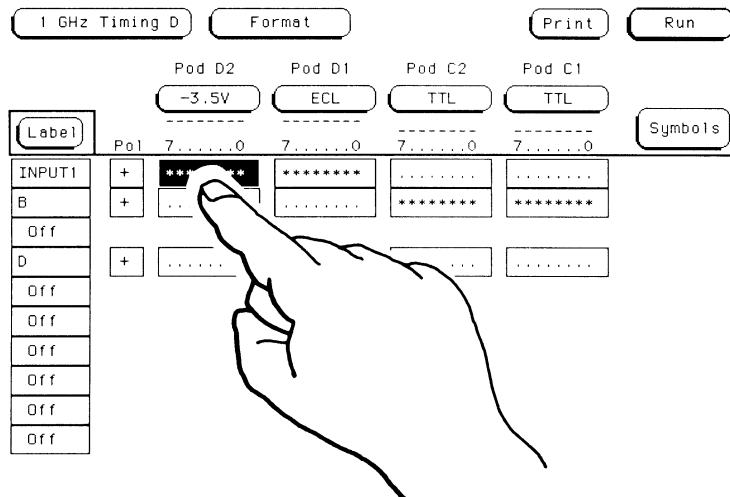
2. When the pop-up appears, touch **CLEAR** to input periods (.) in all of the bit locations. This removes any previous assignment from these bits.

3. Using the knob, move the cursor to the fourth bit location from the right. This is the location for bit 3. Touch the asterisk (*) four times to assign bits 0 through 3 to the label INPUT1.
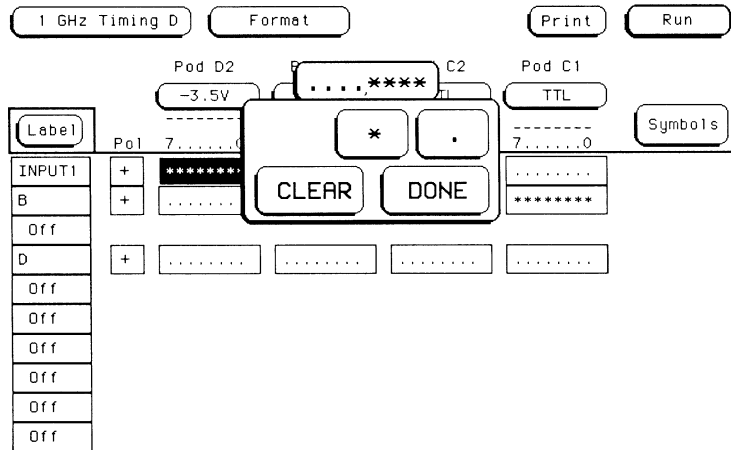
4. Touch **DONE** when you are finished, and the pop-up disappears.

5. Remove any previous assignment from the other bits in the other pods to the right of the label INPUT1 by touching the bit field and when the pop-up appears, touching **CLEAR** and then **DONE**.

Note

*If you select a bit field that is already cleared and touch **CLEAR,** all of the bits in the field will be assigned.*

Now, following the steps in the previous example, assign bit 0 through 3 of pod D1 to the fourth label down.

Assigning Positive or Negative Logic

To set up the analyzer for negative logic, touch the field to the right of the label INPUT1 containing the plus (+) sign. This changes the polarity to minus (-) and sets up the label INPUT1 for circuits using negative logic. This selection does not affect the way waveforms are displayed in the **Waveforms** menu.

To return to positive logic, touch the same field again. This will change the minus sign (-) back to a plus sign (+) for positive logic.
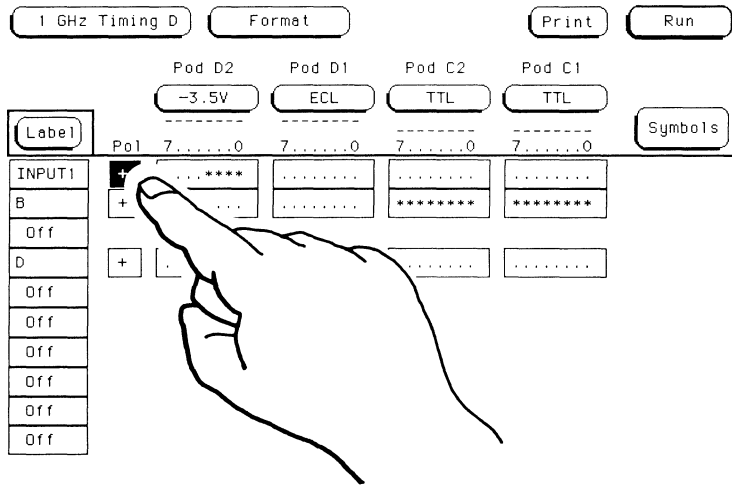
Symbols

Symbols are used to specify the trigger pattern in the **Trace** menu. A symbol can represent a particular pattern, or a range of patterns. It is a name that you enter into the system to represent a set of data. For more information, refer to the *HP 16515A/16A Front-panel Operation Reference* manual.

Summary

Chapter 4 acquainted you with:

- the **Format** menu;

- assigning labels;

- setting pod thresholds;

- assigning bits to labels;

- assigning positive or negative logic; and

- symbols.

5

The Trace Menu

Introduction

In the **Trace** menu you describe when and how the data will be acquired. This is somewhat similiar to setting the trigger level and slope on an oscilloscope.

Getting into the Trace Menu

1. Touch the **Format** field to the right of **1 GHz Timing** in the upper-left corner of the screen.

2. When the pop-up appears, touch **Trace** and the pop-up will disappear, bringing up the **Trace** menu.
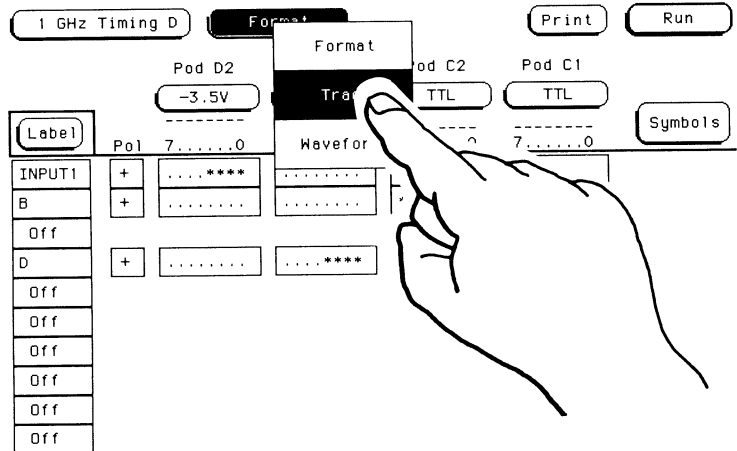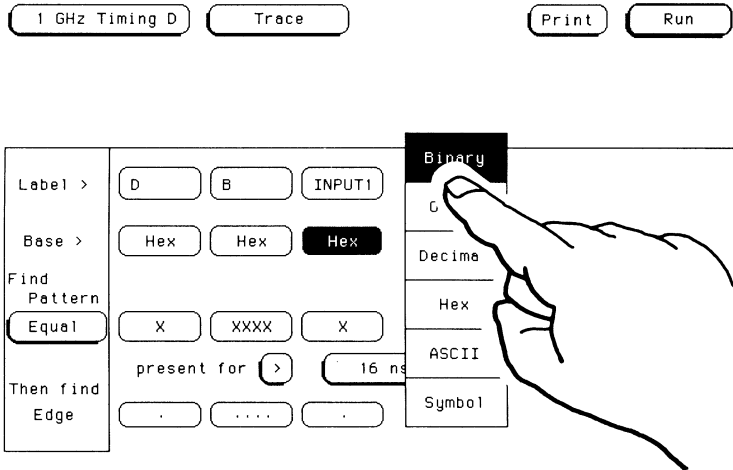
Re-Ordering the Labels

You can change the order in which labels are displayed on the **Trace** menu to arrange them in a better or more usable order. When there are more labels than the analyzer can display at one time, you can arrange the labels to display just the ones that interact with each other.

1. Touch the **INPUT1** field.

2. When the pop-up appears, touch **D** and the label INPUT1 is displayed in the D label location. The D label is now in the original location of the label INPUT1.
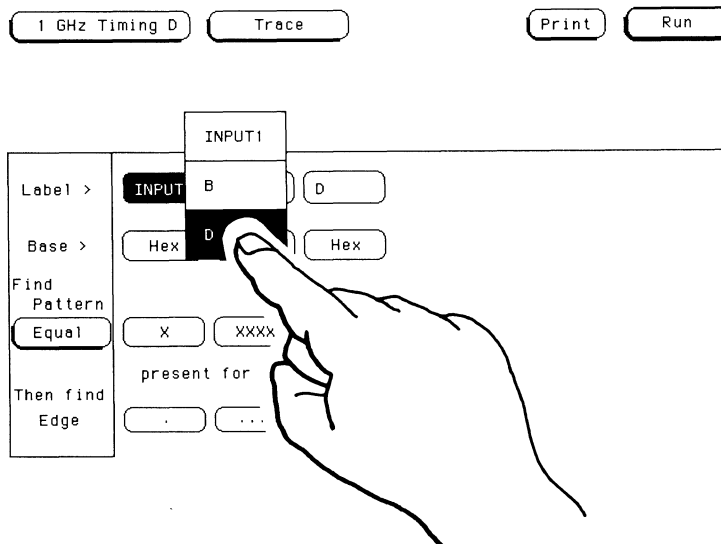
The Base
Field

1. Touch the **Base** field (**Hex**) below the label INPUT1.

2. When the pop-up appears, touch **Binary** to display the pattern and edge fields for this label in a binary base.



```
( 1 GHz Timing D )  (    Trace    )              ( Print )  ( Run )
```

Label >   [D]   [B]   [INPUT1]   Binary

Base >   [Hex] [Hex] [Hex]   Decima
Find
  Pattern   Hex
[Equal] [X]   [XXXX] [X]
                                            ASCII
           present for (>)   (16 n
Then find   Symbol
  Edge   [.] [...] [.]

The Equal
Field

1. Touch the **Equal** field and the field now displays "Not Equal." This sets up the instrument to trigger on any pattern other than the one specified in the **Trace** menu.

2. Touch the **Not Equal** field and "Equal" is again displayed in this field. Now the instrument is going to trigger on the pattern specified in the **Trace** menu.

The Pattern Field

You specify the particular pattern that you are looking for in the pattern field. If you have more than one pattern, then the HP 16515A/16A looks for the logical AND of the patterns specified and triggers when all the patterns are valid.

1. Touch the pattern field displaying the Xs below the label INPUT1.

2. When the pop-up appears, touch the **1** four times to indicate that you are interested in the data when these inputs go high.

   - a "0" indicates a low; and

   - an "X" indicates you don't care whether the input is high or low.

3. Touch **DONE** and the pop-up disappears, placing the pattern you specified in the appropriate field.
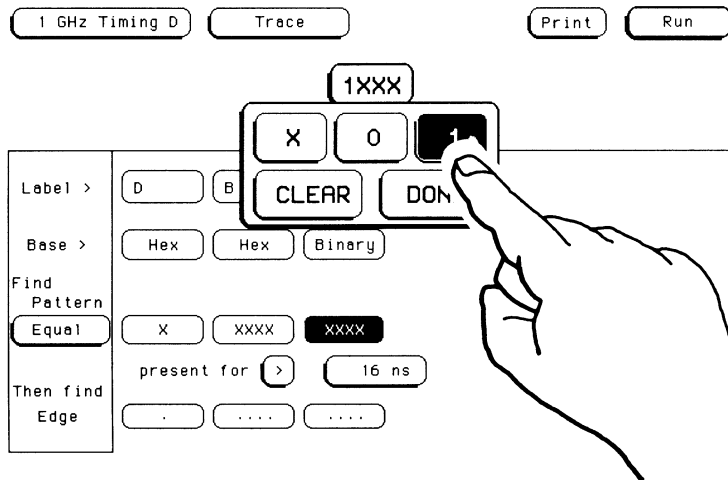
The Greater-Than Field

1. Touch the greater-than field (>) and it changes to less-than (<). This indicates that you are interested in finding the pattern when it is valid for less-than the specified duration.

2. Touch the less-than field (<) and it changes back to greater-than (>). Now the HP 16515A/16A is going to trigger on the pattern when it is valid for greater-than the specified duration.

Setting the Pattern Duration

The field specifying the amount of time or duration that a pattern must be valid has a light blue background. You can change the value of this field, as with any light blue field, by turning the knob. Another way to change the value is:

1. Touch the light blue numeric field.
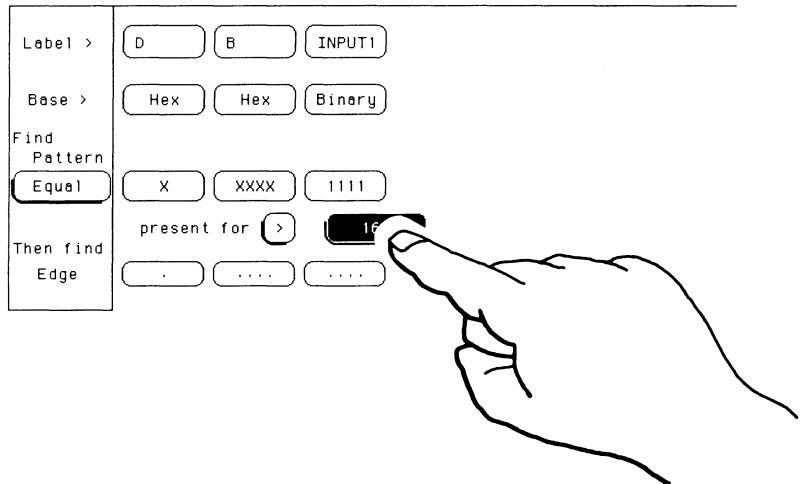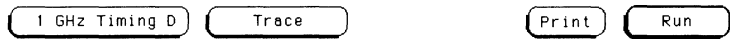
2. When the pop-up containing a numeric keypad appears, enter 32. This value is then displayed in the upper-right corner of the pop-up.

3. Touch the **ns** key to indicate the units of time you want.

4. Touch **DONE** and the pop-up disappears, placing the value 32 ns in the light blue numeric field.
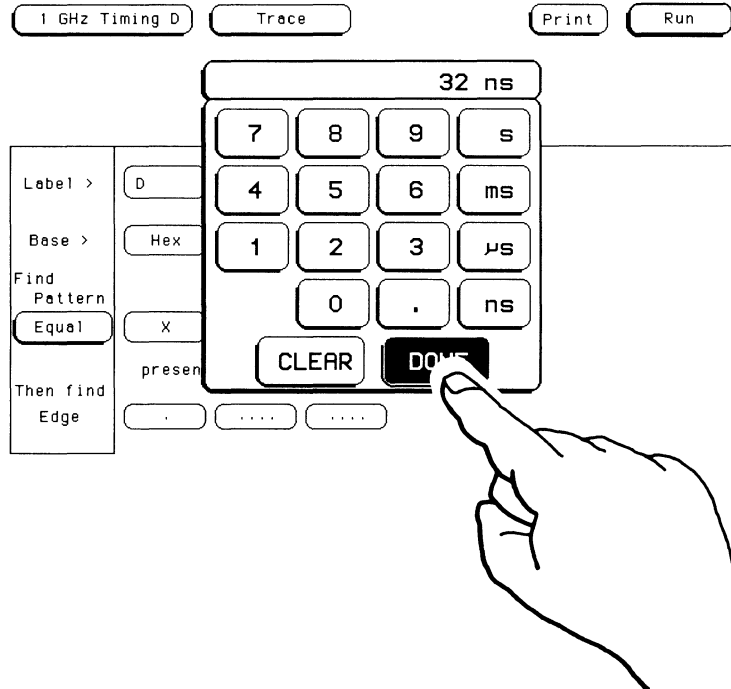
The Edge Field

The **Edge** field allows you to specify edges (transitions) of the data on which to trigger the timing analyzer. Each label has its own edge trigger specification field which allows you to specify either a positive edge or a negative edge on any channel. Since the analyzer looks at the edges to trigger on as ORed edges, it can trigger on any edge shown and without regard to the order shown on the **Trace** menu.

1. Touch the edge field below the label INPUT1.

2. When the pop-up appears, touch the upward arrow key (↑) once to indicate that you want the analyzer to trigger when this bit goes high.

   - the downward arrow (↓) indicates a transition from high to low; and

   - the period (.) indicates that this point is not a trigger condition.

3. Touch **DONE** and the pop-up disappears.
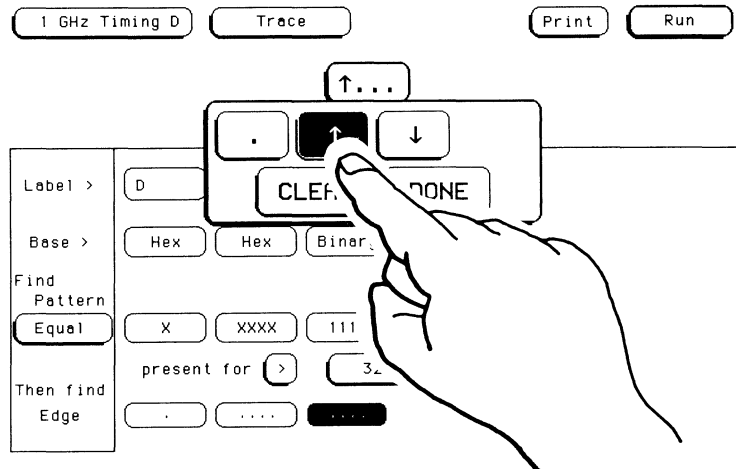
Summary

This chapter acquainted you with:

- getting into the **Trace** menu;

- changing the order in which the labels are presented;

- the base field;

- the equal field;

- the pattern field;

- the greater-than field;

- setting the pattern duration; and

- the edge field.

6

Acquiring Data

Running the Measurement

When the mainframe is first powered up, none of the modules installed in the mainframe are running. This prevents any unwanted interaction between the modules. To start the analyzer running, touch the green **Run** field, then slide your finger down to the **Repetitive** field in the pop-up until this field turns white. Then remove your finger from the screen.
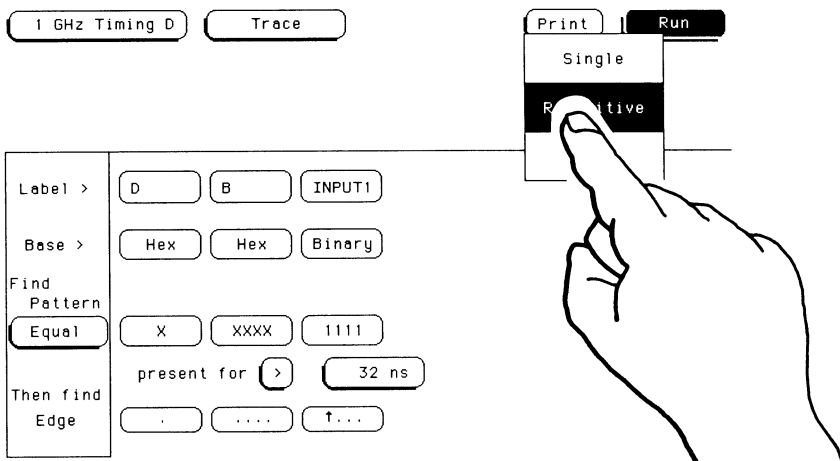
This starts the analyzer running so it can make repetitive real-time acquisitions. In this mode, the display is updated each time a new acquisition is made. If the **Single** field is selected, the analyzer makes a single acquisition and displays the results in the **Waveforms** menu. Then it waits until the **Run** field is touched again before making another acquisition. If the **Cancel** field is selected, the analyzer returns to the state the analyzer was in before the **Run** field was touched.

When the analyzer cannot find the specified trigger condition, the advisory "Waiting for Trigger" is displayed.

Remember that when the field displays **Run**, the analyzer is stopped and touching the **Run** field will start the analyzer running. Likewise, when the field displays **Stop**, the analyzer is running and touching the **Stop** field will stop the measurement.
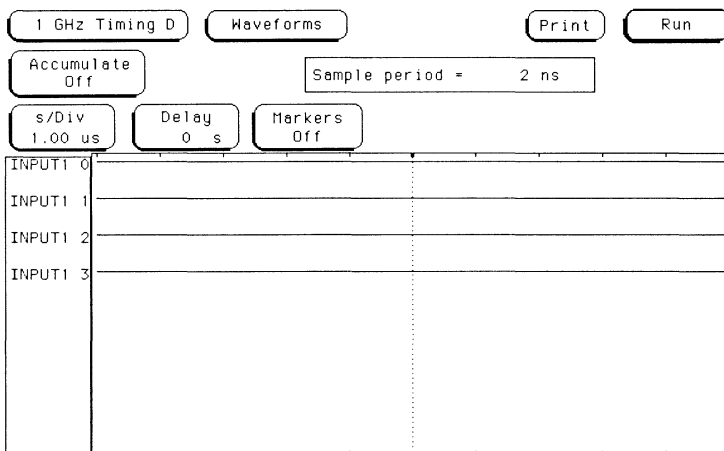
7

The Waveforms Menu

Introduction

When you touch the **Run** field, the analyzer runs the measurement and the data is displayed in the **Waveforms** menu.

Getting into the Waveforms Menu

To get into the **Waveforms** menu without touching **Run**:

1. Touch the field to the right of **1 GHz Timing** in the upper-left corner of the screen.

2. When the pop-up appears, touch **Waveforms** and the pop-up will disappear, bringing up the **Waveforms** menu.

```
( 1 GHz Timing D )  ( Waveforms )              ( Print )  ( Run )
( Accumulate )                    | Sample period =    2 ns |
    Off
( s/Div )   ( Delay )   ( Markers )
  1.00 us     0  s        Off
INPUT1  0
INPUT1  1
INPUT1  2
INPUT1  3
```

The Light Blue Fields

When you touch certain fields in this menu, the fields are displayed with a light blue background. This indicates that you can change the value displayed in them by turning the knob. If you touch these fields when they are already light blue, a pop-up appears containing a numeric keypad. You can then use this keypad to input changes to that field.

The Markers Field

1. Touch the **Markers** field.

2. When the pop-up appears, touch **Time**. This allows you to manually set the X and O markers to measure the time between two points.

   • **Patterns** allows you to preset the markers to specific points for measurements.

   • **Statistics** gives you minimum, maximum, and average (mean) measurement results over a series of runs.

   ### Note

   The sample period is only displayed on screen when markers are turned off.
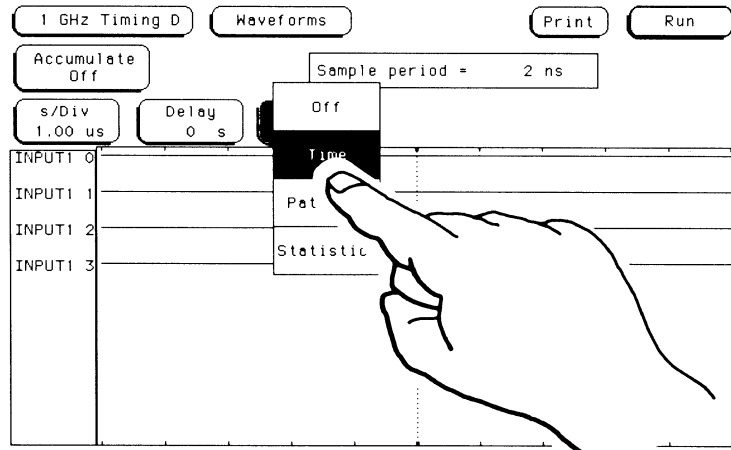
3. Touch the **Trig to X** field and when it turns light blue, use the knob to move the "X" cursor (the green cursor).
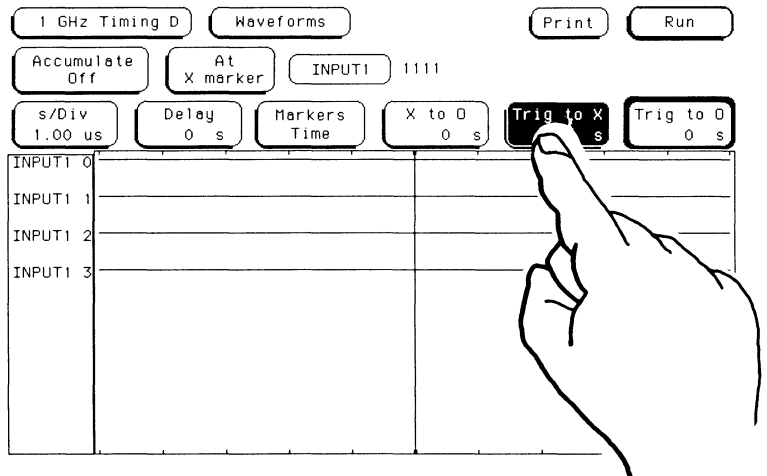

4. Touch the **Trig to O** field and when it turns light blue, use the knob to move the "O" cursor (the yellow cursor). The time from the X to O cursor is displayed in the **X to O** field.

The S/Div Field

1. Touch the **s/Div** field and when it turns light blue, use the knob to change the seconds/division in which your data is displayed.
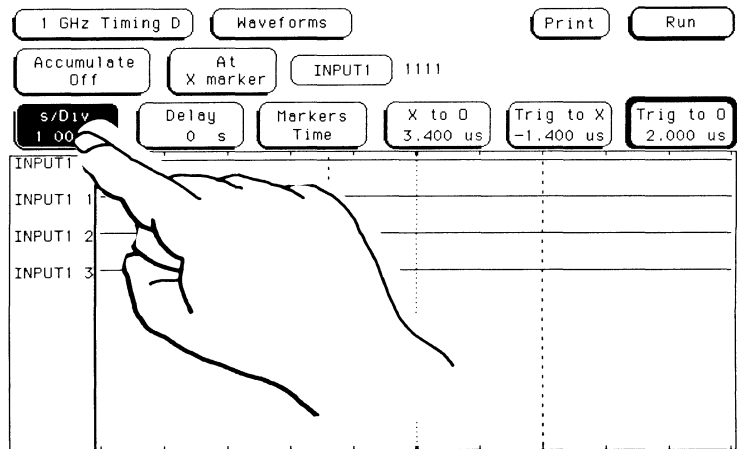
2. Touch the **s/Div** field again and a pop-up keypad appears to input the seconds/division reference you want.

3. Enter 29 μs with the keypad and your value is displayed in the upper- right corner of the pop-up.

4. Touch **DONE** and the pop-up disappears, placing your value in the **s/Div** field.
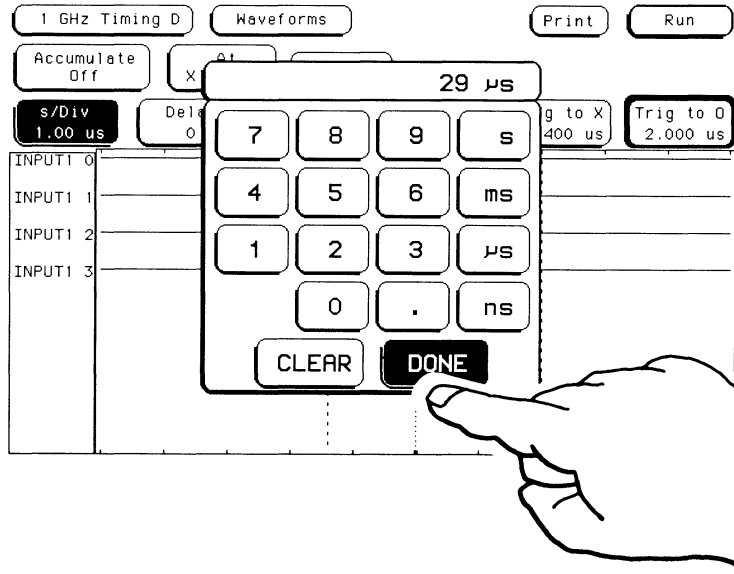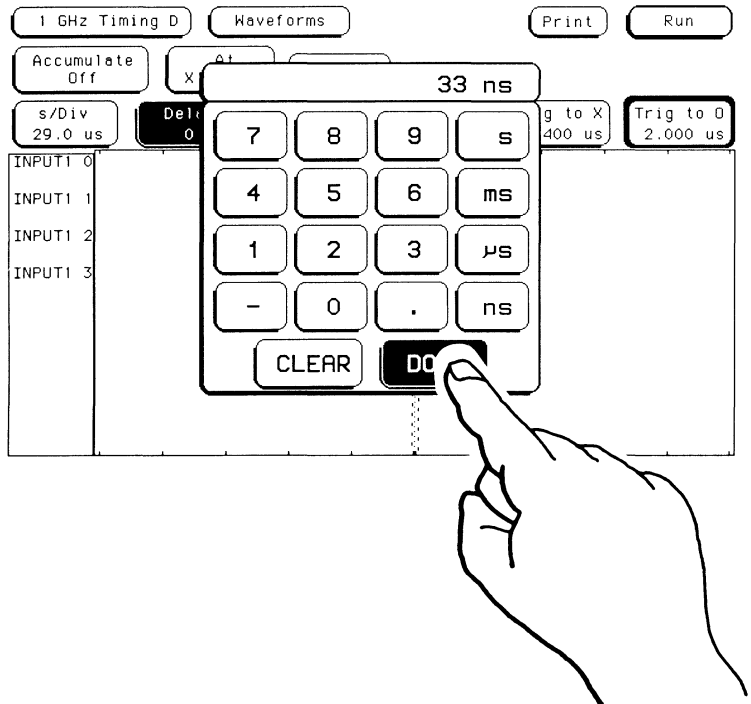

The Delay Field

The **Delay** field allows you to look at the data before or after the trace point (trigger point). The trace point is the point where the analyzer references its data to system activity. This point is referenced at the horizontal center of the waveforms display when the delay = 0.

1. Touch the **Delay** field.

2. When the **Delay** field turns light blue, turn the knob to change its value. A negative value represents data before the trigger point and a positive value represents data after the trigger point.

3. Touch the **Delay** field again.

4. When the pop-up appears containing the keypad, enter 33 ns and touch **DONE**. The pop-up will disappear, putting your new value in the **Delay** field.

Summary

Chapter 7 acquainted you with:

- getting into the **Waveforms** menu;

- the light blue fields;

- the **Markers** field;

- the **s/Div** field; and

- the **Delay** field.

The next two chapters use the functions and menus described in the last four chapters to solve some basic digital system problems.

If you are just learning about digital timing analysis, you should read this entire manual. If you are experienced in digital timing analysis, this is a good place to decide where you want to go next. The next chapter explains how to configure the HP 16515A/16A for a basic measurement. Then the following chapter advances into a more complex measurement. The *HP 16515A/16A Front-Panel Operation Reference* manual describes the functions and features in more detail, but with fewer step-by-step operations.

8

Measurement 1: TTL Inverter

Introduction

This chapter introduces some of the features and capabilities of the HP 16515A/16A 1 GHz Timing Analyzer Module. It is not intended to be a complete guide to every feature, but rather a step-by-step procedure showing you how to solve a basic digital system problem.

Since you may not have the same circuits available for the measurement exercises, assume that the instrument is already connected to the system under test and that you only need to configure the module for the measurement. The actual result for the measurement is shown at the end of each exercise.

Description

An address bit for a memory chip is changing state about 16 ns after the other address inputs. A quick check of the schematic shows an LS series TTL inverter in that same line. You need to measure the propagation delay of the inverter to determine whether it is the cause of your delay problem.

Configure the analyzer assuming that the input of the inverter is connected to line 0 of pod D1 and that the output is connected to line 1 of pod D1.

Returning to the Default Configurations

Start this measurement by turning the power switch off and then back on again. This sets up the default configurations of the analyzer and allows you to become familiar with them.

Format Menu

When the **System** menu comes up (as indicated in the upper-left corner of the menu):

1. Touch the **System** field.

2. When the pop-up appears, touch the **1 GHz Timing D** field. The capitalized letter to the right of the module name refers to the slot in the mainframe where the module is installed. This letter may vary depending on how the modules are arranged in your mainframe.

3. When the **1 GHz Timing** menu appears, notice that the field to the right of **1 GHz Timing** has **Format** in it. This indicates that you are in the **Format** menu of the **1 GHz Timing** module.

In the figure shown below, pods C1 and C2 are for the HP16516A expansion card and pods D1 and D2 are for the HP 16515A master card.

		Pod D2	Pod D1	Pod C2	Pod C1	
(1 GHz Timing D)	(Format)				(Print) (Run)
		(TTL)	(TTL)	(TTL)	(TTL)	
(Label)	Pol	7......0	7......0	7......0	7......0	Symbols
A	+	********	********	....	....	
B	+	....	....	********	********	
Off						
Off						
Off						
Off						
Off						
Off						
Off						
Off						

First Label To measure the propagation delay of the inverter, you need to compare the input of the inverter (line 0 of pod D1) with its output (line 1 of pod D1). Start by renaming the first label "INPUT" for the inverter's input.

1. Touch the first field at the top of the label column (Label A).

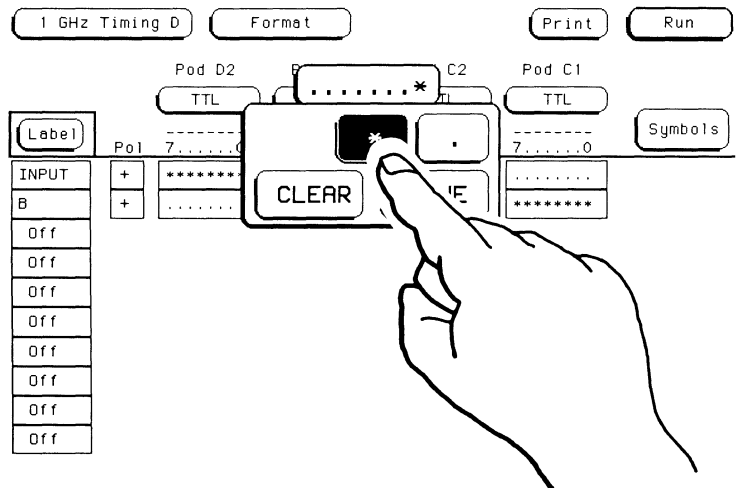2. When the pop-up appears, touch **Modify Label**.
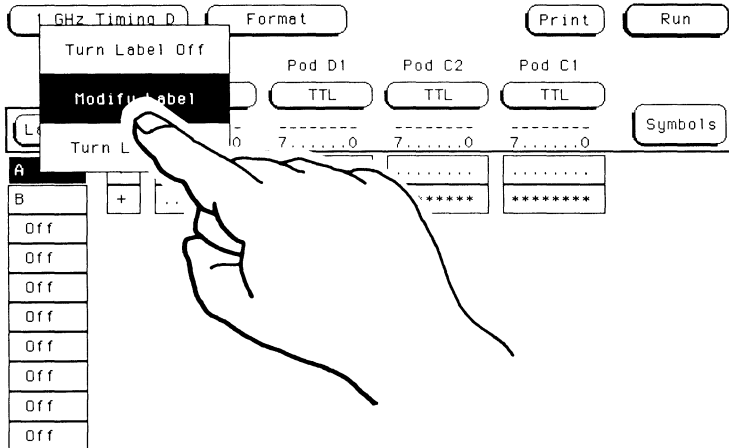
3. When the pop-up for the alphanumeric keypad appears, touch the appropriate keys to rename this label INPUT.
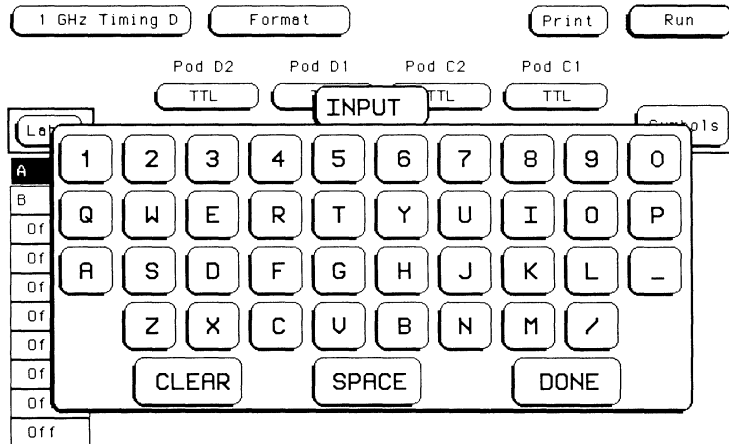
4. Touch **DONE** when you are finished, and the pop-up will disappear.

Assigning Bits Next, assign bit 0 (for input line 0) of pod D1 to the label INPUT.

1. Touch the bit field to the right of the label INPUT and below pod D1.

2. When the pop-up appears, touch **CLEAR** to input periods (.) in all of the bit locations. This removes any previous assignment from these bits.

3. Using the knob, move the cursor to the first bit location from the right. This is the location for bit 0. Touch the asterisk (*) to assign this bit to the label INPUT.

4. Touch **DONE** when you are finished, and the pop-up will disappear.

Now remove any previous assignment from the other bits in the other pods to the right of the label INPUT.

1. Touch the bit field to the right of the label INPUT and below pod D2.

2. When the pop-up appears, touch **CLEAR** to input periods (.) in all of the bit locations. This removes any previous assignment from these bits.

Note

*If you select a bit field that is already cleared and touch **CLEAR**, all of the bits in the field will be assigned.*

3. Touch **DONE**, and the pop-up will disappear.

4. Repeat steps 1 through 3 for any other assigned bit locations to the right of the label INPUT, but not including those in pods D1 and D2.
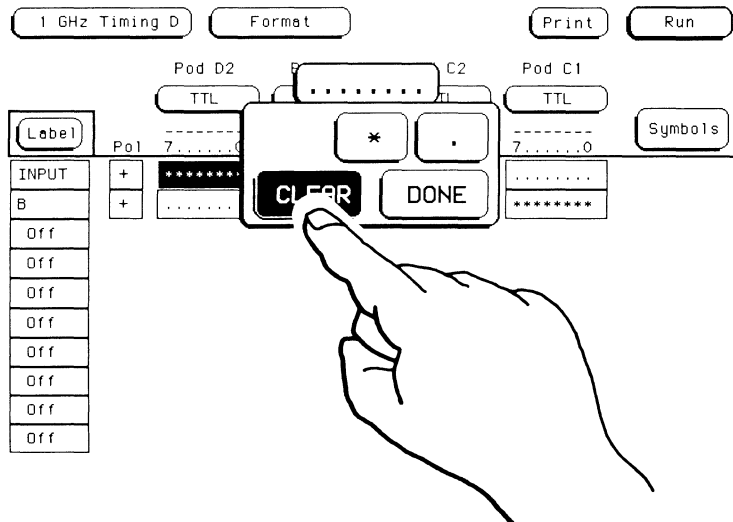
Second Label   Rename the next label "OUTPUT" for the inverter's output.

1. Touch the second field from the top of the label column.

2. When the pop-up appears, touch **Modify Label**.

3. When the pop-up for the alphanumeric keypad appears, touch
   the appropriate keys to rename this label "OUTPUT."

4. Touch **DONE** when you are finished, and the pop-up will
   disappear.
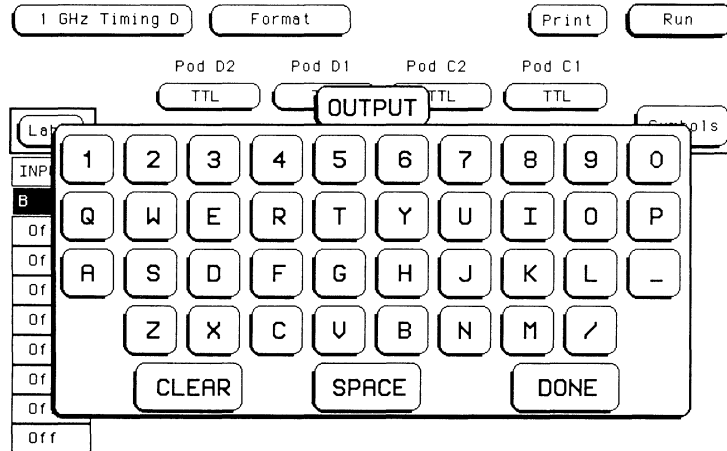
Assigning Bits   Now assign bit 1 (for input line 1) of pod D1 to the label OUTPUT.

1. Touch the bit field to the right of the label OUTPUT and below pod D1.

2. When the pop-up appears, move the cursor with the knob to the second bit location from the right. This is the location for bit 1. Touch the asterisk (*) to assign this bit to the label OUTPUT.
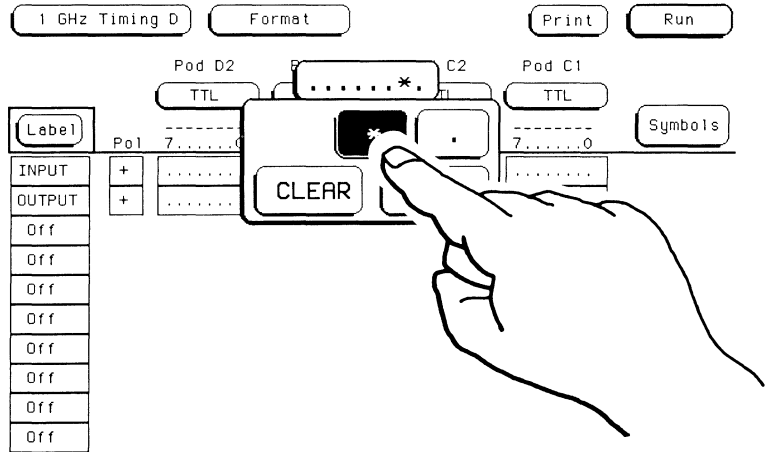

3. Touch **DONE**, and the pop-up will disappear.

4. Remove any previous assignment from the other bits in the other pods to the right of the label OUTPUT by touching the bit field and when the pop-up appears, touching **CLEAR** and then **DONE**.
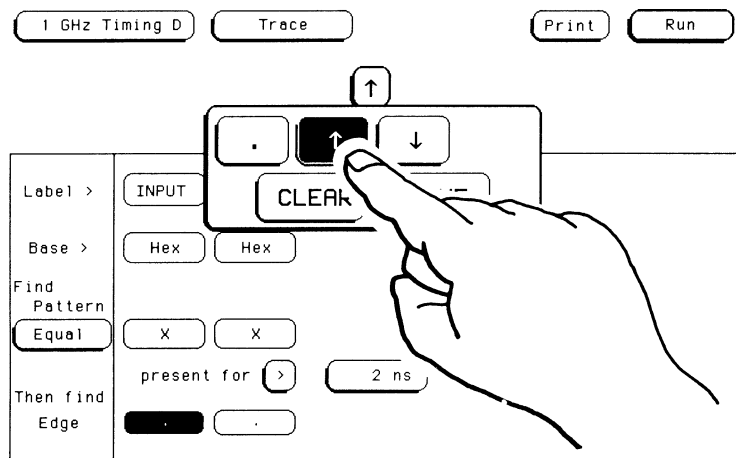
Trace Menu

If you don't specify a trigger condition in the **Trace** menu, you may not get the proper signal displayed in the **Waveforms** menu. Instead, you may get a flat trace. To specify a trigger condition, select the **Trace** menu.

1. Touch **Format** and when the pop-up appears, touch **Trace.**
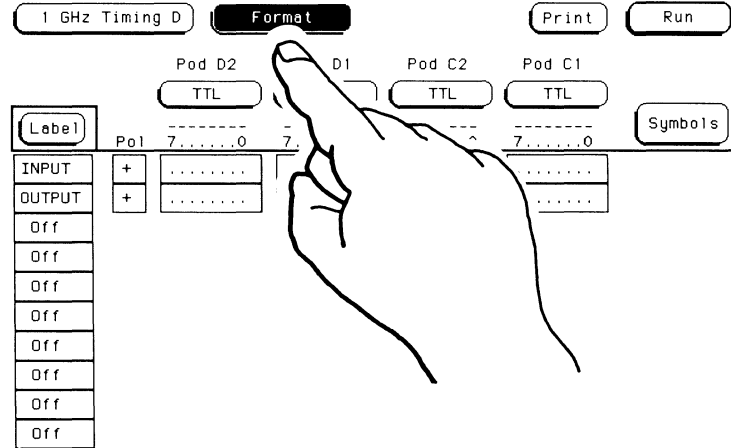
Edge Since you want to measure the propagation delay of the inverter, configure the analyzer to trigger when the input of the inverter goes high.

1. Touch the **Edge** field under label INPUT with the period (.) in it.

2. When the pop-up appears, touch the upward arrow field. This indicates to the analyzer that you want to trigger when this input goes high.

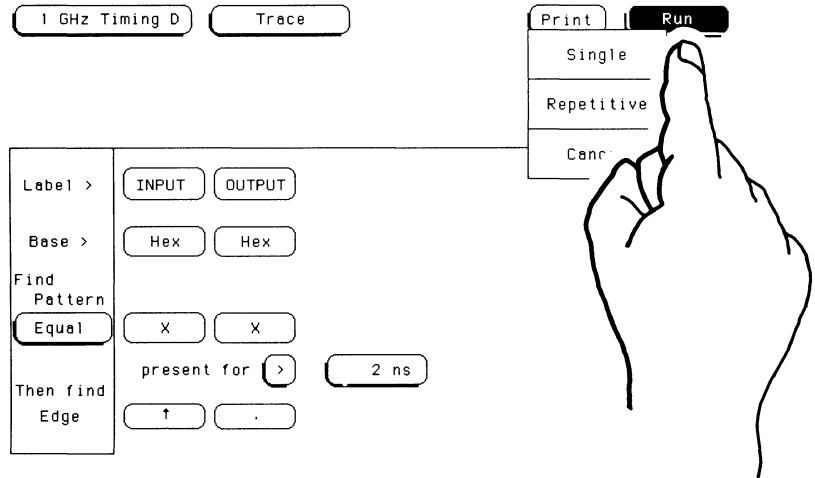3. Touch **DONE** and the pop-up will disappear, putting your choice in the appropriate field

4. Since the analyzer looks at the edges to trigger on as ORed edges, it can trigger on any edge shown, without regard to the order shown on the **Trace** menu. Because of this, make sure the **Edge** field below the label OUTPUT has a period (.) in it to indicate that this edge is not a trigger condition. If this field does not have a period in it, touch this field and when the pop-up appears, touch **CLEAR** and then **DONE.**

Running the Measurement

Now you are ready to make your measurement.

1. Touch and hold the **Run** field located in the upper-right corner of the menu. When the pop-up appears, notice that **Single** is displayed with a light blue background. This is the default mode and indicates that the measurement is only run once.

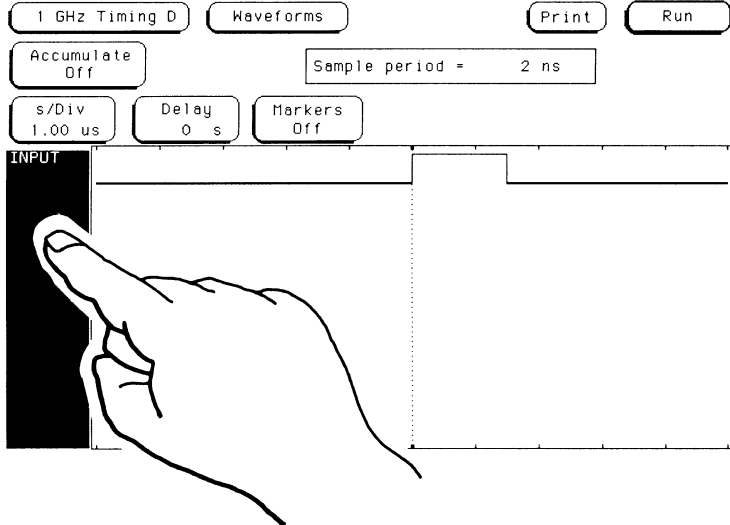2. Now release the **Run** field and the pop-up will disappear.

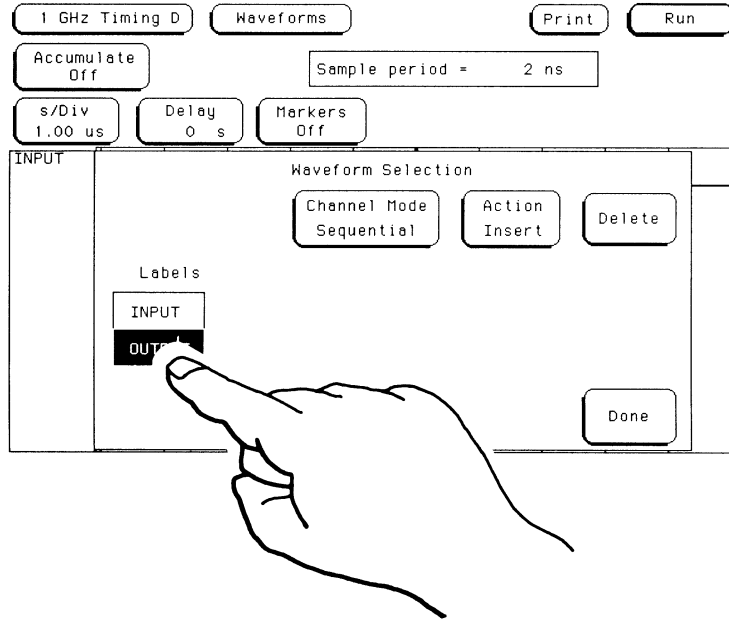This brings up the **Waveforms** menu.

Waveforms Menu

Displaying Both Signals   To display both signals on screen:

1. Touch the label INPUT on the **Waveforms** menu.

2. Touch the **OUTPUT** field and notice that "OUTPUT" appears below "INPUT" on the **Waveforms** menu.

3. Touch **Done** and the pop-up disappears. Both signals are now displayed on the **Waveforms** menu.

Measuring
Propagation Delay

To get a readout of the propagation delay:

1. If the **s/Div** field is not already light blue, touch it.

2. Rotate the knob to change the value in the **s/Div** field to 20 ns.

3. Touch the **Markers: Off** field.

4. When the pop-up appears, touch **Time**. This turns on your X and O markers.
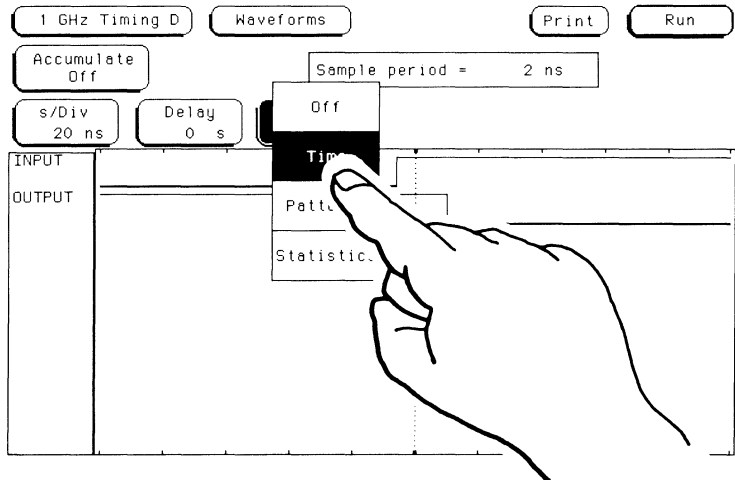
5. Touch the **Trig to X** field. This changes the background of the **Trig to X** field to light blue and allows you to use the knob to position the X marker.

6. Position the X marker on the first positive-going transition of the INPUT line.
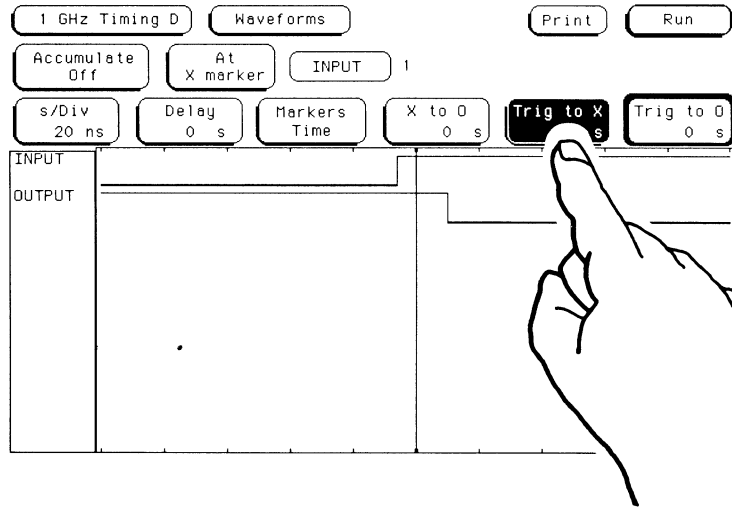
7. Touch the **Trig to O** field.

8. Position the O marker on the first negative-going transition after the X marker on the OUTPUT line.

The amount of propagation delay of the inverter is displayed in the **X to O** field near the center of the menu (16 ns in this example).
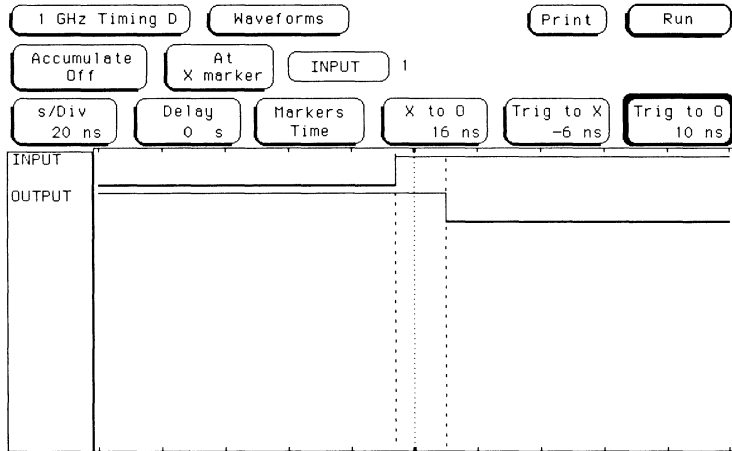
Result

The inverter has the same amount of propagation delay as the address line that is late. Since this inverter is the source of the problem, one solu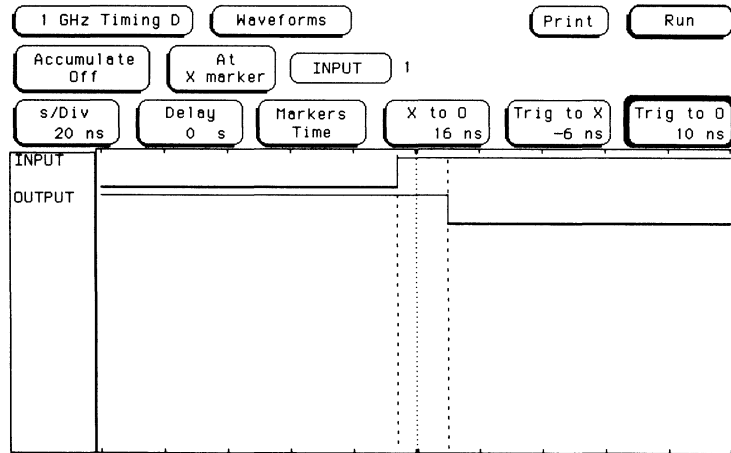tion is to replace the inverter with one that has a shorter propagation delay. Another possibility is to add buffers to the other lines to compensate for the inverter.

```
( 1 GHz Timing D )  ( Waveforms )              ( Print )  ( Run )

( Accumulate )  ( At      )  ( INPUT ) 1
(   Off    )    ( X marker )

( s/Div )  ( Delay )  ( Markers )  ( X to O )  ( Trig to X )  ( Trig to O )
( 20 ns )  (  0  s )  (  Time   )  ( 16 ns  )  (  -6 ns    )  (  10 ns    )

INPUT

OUTPUT
```

Summary

In this measurement you:

- renamed two labels to be more representative of what you were looking at, the input and output of an inverter;

- configured the **Format** menu to indicate which inputs you wanted with each label;

- specified a trigger condition in the **Trace** menu;

- saw the result of your measurement displayed on the **Waveforms** menu; and.

- positioned the X and O markers to measure the propagation delay of the inverter.

9

Measurement 2: TTL Circuit

Introduction

This chapter introduces some additional features and capabilities of the HP 16515A/16A module. Through self-paced exercises, it explains how to configure the HP 16515A/16A module to measure a particular circuit.

Description

For a logic simulation of an LS series TTL circuit containing two NAND gates, an inverter, and a D flip-flop, the maximum propagation delay was estimated to be 70 ns. Due to a possible race condition in the actual circuit, a more exact value for the propagation delay is needed. The main area of concern is the time from when both inputs of the first NAND gate go high to when the Q output of the D flip-flop goes low.

Configure the analyzer assuming that the two inputs of the first NAND gate are connected to line 0 and line 1 of pod D2 and that the Q output of the D flip-flop is connected to line 2 of pod D2.
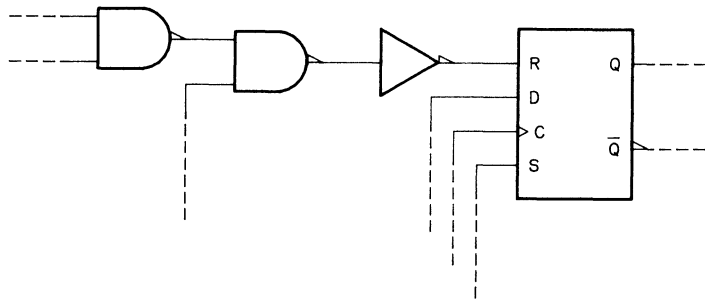
16515/BL02

Format Menu

Select the **1 GHz Timing Format** menu as indicated in the upper-left corner of the screen.

First Label For this measurement you need to compare the two inputs of the first NAND gate (line 0 and line 1 of pod D2) with the Q output of the D flip-flop (line 2 of pod D2). First, group the two inputs of the NAND gate under one label and rename this label "INPUT" for the input of the NAND gate.

1. Touch the first field at the top of the label column and rename this label "INPUT."

2. Assign bit 0 (line 0) and bit 1 (line 1) of pod D2 to the label INPUT.

3. **CLEAR** any assigned bits in the other pods that are to the right of this label.

(1 GHz Timing D)	(Format)			(Print)	(Run)

		Pod D2	Pod D1	Pod C2	Pod C1	
		(TTL)	(TTL)	(TTL)	(TTL)	
(Label)		--------	--------	--------	--------	Symbols
	Pol	7......0	7......0	7......0	7......0	
INPUT	+	......**	....	....	....	
OUTPUT	+	....	.......*	....	....	
Off						
Off						
Off						
Off						
Off						
Off						
Off						
Off						

Second Label   Rename the second label "Q OUT" for the Q output of the D flip-flop.

1. Touch the second field from the top of the label column and rename it "Q OUT."

2. Assign bit 2 (line 2) of pod D2 to the label Q OUT.

3. **CLEAR** any assigned bits in the other pods to the right of this label.

|		Pod D2	Pod D1	Pod C2	Pod C1	
(1 GHz Timing D)	(Format)			(Print)	(Run)	
		(TTL)	(TTL)	(TTL)	(TTL)	
(Label)	Pol	7......0	7......0	7......0	7......0	Symbols
INPUT	+	......**	....	....	....	
Q OUT	+	.....*..	....	....	....	
Off						
Off						
Off						
Off						
Off						
Off						
Off						
Off						

Trace Menu

Now you are ready to go into the **Trace** menu and describe when and how you want the data to be acquired. This is somewhat similiar to setting the trigger level and slope on an oscilloscope.

To get into the **Trace** menu, touch **Format** and when the pop-up appears, touch **Trace**.
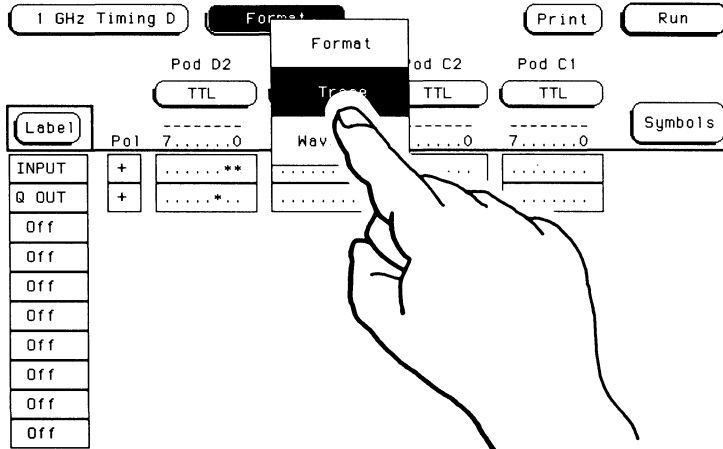
Pattern The pattern you want the analyzer to find is the point at which both inputs of the first NAND gate (INPUT) go high. To configure the **Trace** menu for this pattern:

   1. Touch the **Hex** field below the label INPUT.

   2. When the pop-up appears, touch **Binary.** This will put the label INPUT in the binary base, displaying each binary bit separately.
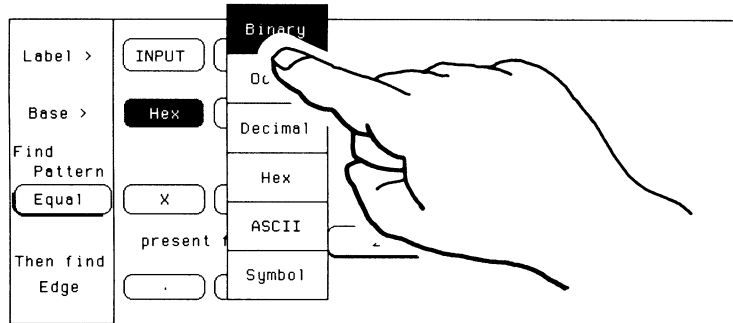
   3. Since you want to find a pattern equal to the one you specify, make sure the field below "Find Pattern" has "Equal" in it. If not, touch this field and its value will change to "Equal."

4. Touch the pattern field below the label INPUT displaying the two Xs.

5. When the pop-up appears, touch **1** twice to show that you are interested in the point at which both of these inputs go high. A "0" indicates a low input, and an "X" indicates you don't care whether this point is high or low.

6. Touch **DONE** and the pop-up will disappear, putting your choice in the appropriate field.
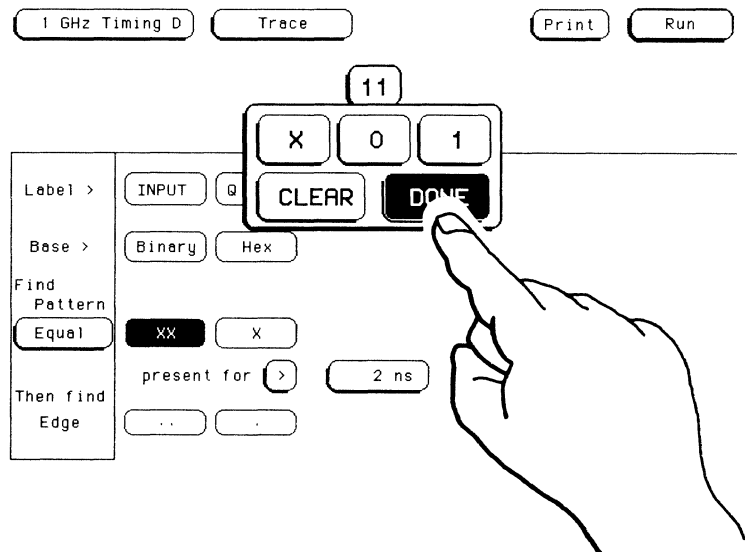
7. Since all of the patterns must be valid to trigger, make sure the pattern field below the label Q OUT has X (don't care) in it. If not, touch this field and when the pop-up appears, touch **CLEAR** and then **DONE** to input an X in it.

Pattern Duration

1. Since you want to find a pattern that is valid for greater than the specified duration, make sure that the field to the right of "present for" displays the greater-than symbol (>). If not, touch this field to change its value to greater-than (>).

2. Since the estimated minimum propagation delay of the circuit is 33 ns, rotate the knob until the light blue pattern duration field displays 33 ns.

```
( 1 GHz Timing D )  (    Trace    )          ( Print )  (   Run   )
```

```
Label >   ( INPUT ) ( Q OUT )

Base >    ( Binary ) (  Hex  )

Find
  Pattern
  ( Equal )   (  11  ) (   X   )

            present for ( > )   ( 33 ns )
Then find
  Edge      (  ..  ) (   .   )
```

Edge   Since you are interested in the time from when the inputs of the
first NAND gate go high to when the Q output of the D flip-flop
goes low, configure the analyzer to trigger on the negative-going
edge of the Q output (Q OUT).

1. Touch the **Edge** field under label Q OUT with the period (.) in
   it.

2. When the pop-up appears, touch the downward arrow field. This
   indicates to the analyzer that you want to trigger when the
   output goes low.

3. Touch **DONE** and the pop-up will disappear, putting your
   choice in the appropriate field.
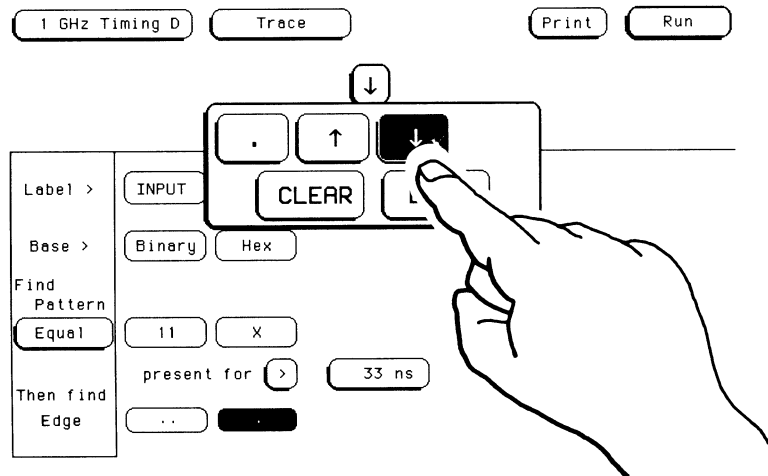
4. Since the analyzer looks at the edges to trigger on as ORed
   edges, it can trigger on any edge shown, without regard to the
   order shown on the **Trace** menu. Because of this, make sure
   the **Edge** field below the label INPUT has a period (.) in it to
   indicate that this edge is not a trigger condition. If this field
   does not have a period in it, touch this field and when the pop-
   up appears, touch **CLEAR** and then **DONE**.

Running the Measurement

Now that you are ready to make your measurement, touch the **Run** field in the upper-right corner of the menu. A pop-up will appear, then disappear and your data will be displayed in the **Waveforms** menu.
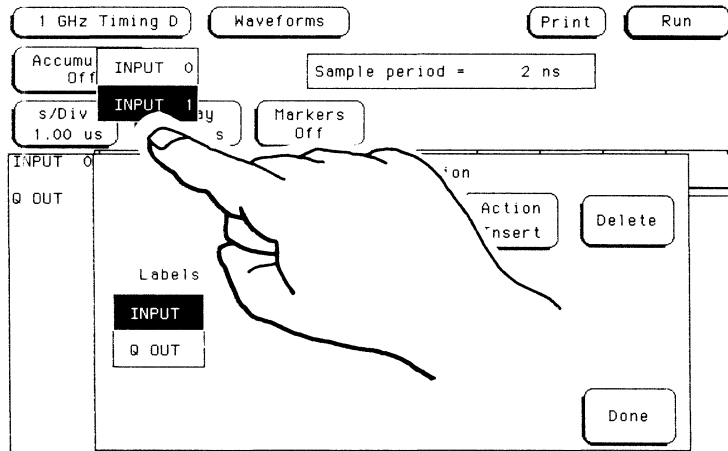
Waveforms Menu

Displaying the Signals

To display all the signals individually:

1. Touch the label INPUT on the **Waveforms** menu.

2. When the pop-up appears, touch the **Channel Mode** field.

3. When the next pop-up appears, touch **Individual** to change the Channel Mode to "Individual."
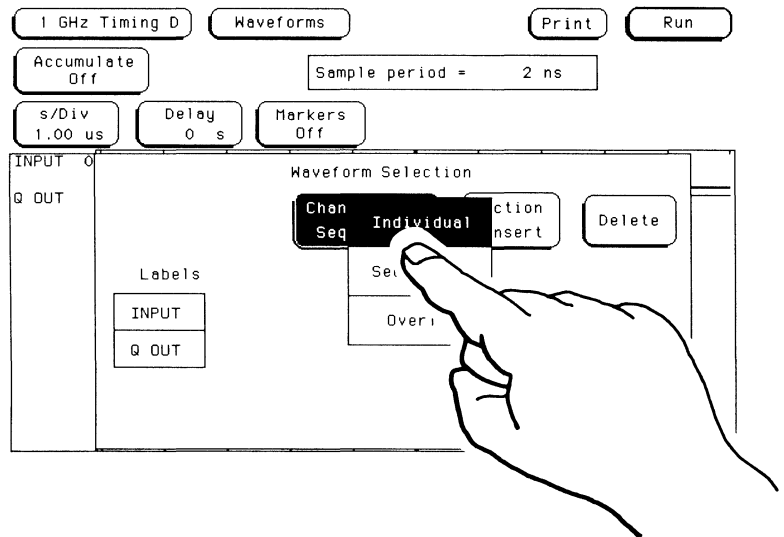
4. To display INPUT 1, touch the **INPUT** field.

5. When the pop-up appears, touch **INPUT 1** to display "INPUT 1" below the other INPUT label.

6. If INPUT 0, INPUT 1, and Q OUT aren't shown on the **Waveforms** menu, touch the field on the pop-up for the missing label and it will appear on the **Waveforms** menu.

7. Touch **Done** and the pop-up disappears. All three labels should now appear on the **Waveforms** menu.

Measuring To measure the propagation delay of the circuit:
Propagation Delay

1. If the **s/Div** field is not already light blue, touch it.

2. Rotate the knob to change the value in the **s/Div** field to 20 ns.

3. Touch the **Markers** field.

4. When the pop-up appears, touch **Time**. This turns on your X and O markers.
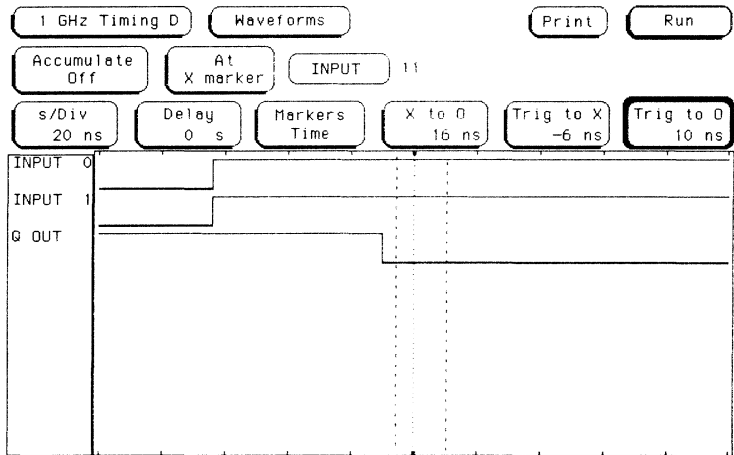
5. Touch the **Trig to X** field. This changes the background of the **Trig to X** field to light blue and allows you to use the knob to position the X marker.

6. Position the X marker to the point where both input lines go high at the same time.
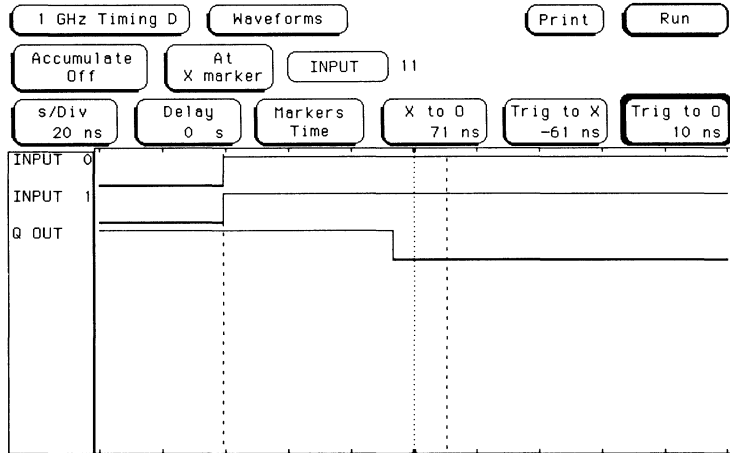
7. Touch the **Trig to 0** field.

8. Position the O marker on the first negative-going transition after the X marker on the Q OUT line.

The amount of propagation delay for the circuit is displayed in the **X to O** field (54 ns in this example).
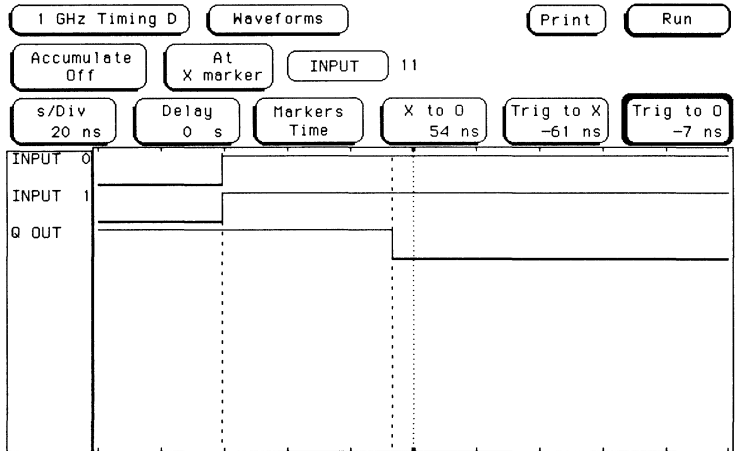
Result

The actual propagation delay you measured is 54 ns. This is within the range you would expect and indicates that your circuit meets your design requirements.
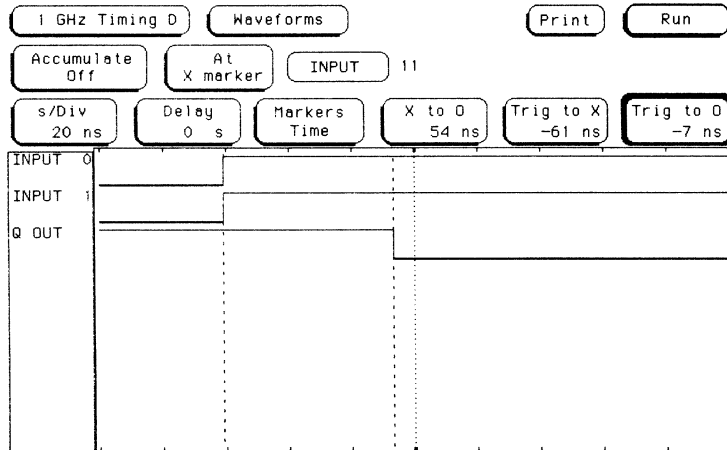
Summary

In this measurement you:

- renamed two labels to be more representative of what you were looking at—the input of a NAND gate and the output of a D flip-flop;

- configured the **Format** menu to indicate which inputs you wanted with each label;

- configured the **Trace** menu to indicate a particular pattern and edge you wanted to capture;

- saw the result of your measurement displayed on the **Waveforms** menu; and

- positioned the X and O markers to measure the propagation delay of the test circuit.

10 What's Next?

Now that you are familiar with the 1 GHz Timing Analyzer, you may want to try some of the basic measurements discussed in this book on your target system.

If you are comfortable with the basic measurements that you can perform with the HP 16515A/16516A 1 GHz Timing Analyzer module, you are ready for the *HP 16515A/16516A Front-Panel Operation Reference* manual. This manual explains all the capabilities of the 1 GHz Timing Analyzer and its operation from the front panel.

HEWLETT PACKARD