Appendix A: Tutorial

This tutorial will get you started making basic signal measurements with the 222PS.

The Screen

Making accurate measurements with an oscilloscope means determining the voltage and timing of your signal from its size on the screen. Therefore, the screen of the 222PS is marked to help you determine exact signal measurements. The vertical axis of an oscilloscope represents voltage. Except in XY mode, the horizontal axis represents time. A waveform trace on the oscilloscope screen, therefore, represents the characteristics of an electrical signal as a function of voltage over time. The exact measurement of a particular trace, however, depends on the scale factor you assign to the vertical and horizontal axes. To determine the exact voltage and timing of a trace, you need to know these facts:

- how many volts each division represents
- how many seconds each division represents
- how many vertical divisions the trace occupies on the screen
- how many horizontal divisions the trace occupies on the screen

The 222PS provides a variety of aids to help you determine the exact size and location of your signal on the screen. You can read the volts-per-division and seconds-per-division scale factors directly from the on-screen readouts. The screen has several markings to help you determine the exact size of your trace.

Along the vertical axis, the screen has eight major divisions. Along the horizontal axis, it has ten major divisions. Major divisions form a grid that covers the entire screen. Each major division has five minor divisions. Minor divisions are marked along the center vertical and horizontal lines.

Two horizontal dotted lines mark the 10% and 90% points of a signal that takes up six vertical divisions. These lines can help you make rise- and fall-time measurements, as explained on page A-7.

Figure A-1 illustrates these markings.

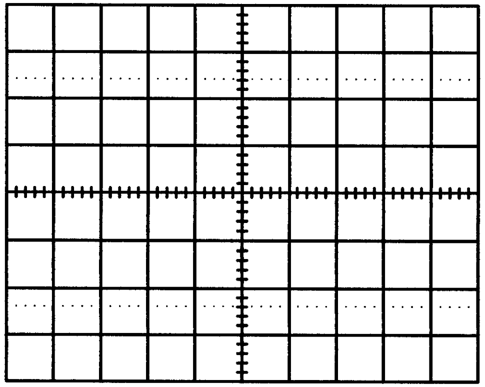


Figure A-1: The Screen Markings

The screen markings are internal, so that no matter what angle you view it from, your measurements are always accurate.

Measuring Voltage

The following two procedures will help you get started making peak-to-peak and ground-reference measurements.

NOTE

When you are measuring a stored waveform, use the vertical and horizontal scale factors that were in effect when you first saved the waveform. The scale factors in effect when you recall the waveform are unrelated to it.

Measuring Peak-to-Peak Voltages

To find the voltage of a waveform peak-to-peak, follow these steps.

☐ **Step 1:** Position the waveform so that either the lowest or the highest point (peak) is at the horizontal center of the screen. In Figure A-2, the high peak is at the center of the screen. Use the vertical center line to help you.

☐ **Step 2:** Count the vertical major and minor divisions occupied by the waveform from its high point (labeled ***A*** in Figure A-2) to its low point (labeled ***B*** in Figure A-2).

☐ **Step 3:** Multiply the number of divisions by the volts per division.

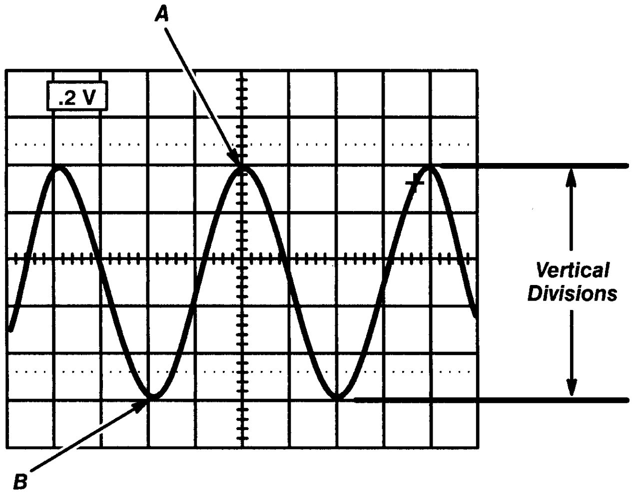


Figure A-2: Measuring Peak-to-Peak Voltages

For example, Figure A-2 shows a sine wave that is five major divisions high. As the readout at the top left indicates, the vertical scale factor is 0.2 volts per division. Therefore, the peak-to-peak voltage of the sine wave is 5 × 0.2, or 1 volt.

NOTE

The volts-per-division scale factor always refers to major divisions. A minor division is one-fifth of a major division.

Using a Ground Reference Point

To find the voltage of a waveform with respect to ground, you must first set a ground reference level. Then you can take the measurement.

To set the ground reference level, follow these steps.

☐ **Step 1:** Press the **MODE** button and select the AUTOBL trigger mode.

☐ **Step 2:** Select ground coupling for the channel you intend to use. Press the button labeled **CH1** (or **CH2**) located in the middle of the front panel, to the right of the display.

If that channel was selected, a menu appears on the display. If the channel was not selected, it now is. Press the button again to invoke the menu.

☐ **Step 3:** Press the menu button next to the item labeled **GND**. The menu disappears and a baseline trace appears on the screen.

☐ **Step 4:** Position the baseline trace to a reference horizontal line on the screen. If the signal is positive with respect to ground, the bottom line on the screen is a good reference to choose.

☐ **Step 5:** Change the channel coupling to DC.

NOTE

To avoid losing your ground reference, do not change the vertical position of the signal after you change to DC coupling.

You can now make your measurement.

☐ **Step 6:** Count the number of vertical divisions from the ground reference to the measurement point of the signal.

☐ **Step 7:** Multiply the number of divisions by the volts per division.

For example, Figure A-3 shows a ground reference at the bottom of the screen. The measurement point is the most negative voltage of the signal. There are 3.5 major divisions between them.

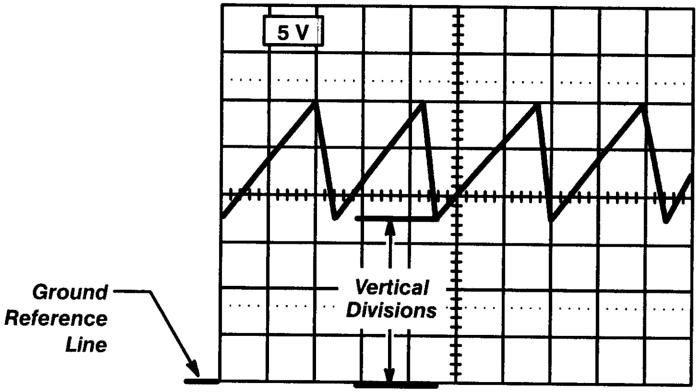


Figure A-3: Measuring With Respect to Ground

The vertical scale factor is 5 volts per division. Performing the multiplication of 5 × 3.5 = 17.5 tells us that the most negative voltage of the signal is 17.5 V above ground.

Measuring Time

The following two procedures will help you get started taking general timing and rise-time measurements.

NOTE

When you are measuring a stored waveform, use the vertical and horizontal scale factors that were in effect when you first saved the waveform. The scale factors in effect when you recall the waveform are unrelated to it.

To measure the time a signal represents, use the following procedure.

☐ **Step 1:** Position the waveform so that its center crosses the vertical center of the screen, as shown in Figure A-4. Use the horizontal center line to help you.

☐ **Step 2:** Count the horizontal major and minor divisions occupied by one complete period of the waveform — from the time it crosses the center line in the positive direction until it again crosses the center line in the positive direction.

☐ **Step 3:** Multiply the number of divisions by the seconds per division.

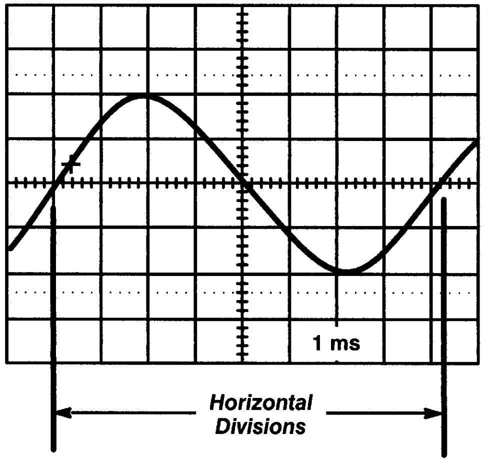


Figure A-4: Measuring Time

For example, one period of the sine wave in Figure A-4 occupies 8 major divisions and 1 minor division. Each minor division is one-fifth, or 0.2 of a major division. Therefore the waveform period is 8.2 major divisions. The horizontal scale factor, as indicated in the bottom right, is 1 ms per division. Therefore, one waveform period is 1 × 8.2 = 8.2 ms.

Measuring Rise- or Fall-time

To measure the rise- or fall-time of a signal, follow these steps.

☐ **Step 1:** Put the instrument in store mode. Press the button labeled **STORE** on the top panel of the instrument.

☐ **Step 2:** Set the trigger position for the display's midpoint. Press the button labeled **TRIG POS** and select the menu item **MID**.

☐ **Step 3:** Select a volts-per-division setting that produces a trace that occupies more than six vertical divisions.

☐ **Step 4:** Use the variable volts per division knob to adjust the trace so that it occupies exactly six vertical divisions.

☐ **Step 5:** Center the trace vertically, as shown in Figure A-5, so that the baseline is at the first vertical division and the peak is at the seventh vertical division.

☐ **Step 6:** Measure the horizontal distance from the place where the trace crosses the 10% dotted line to the place where it crosses the 90% dotted line.

☐ **Step 7:** Multiply that distance, in divisions, by the seconds per division scale factor.

For example, for the signal in Figure A-5, the horizontal distance between the 10% signal crossover point and the 90% crossover point is about nine-tenths of a division. Multiplying 0.9 by a horizontal scale factor of 50 ns gives us a rise time of 45 ns.

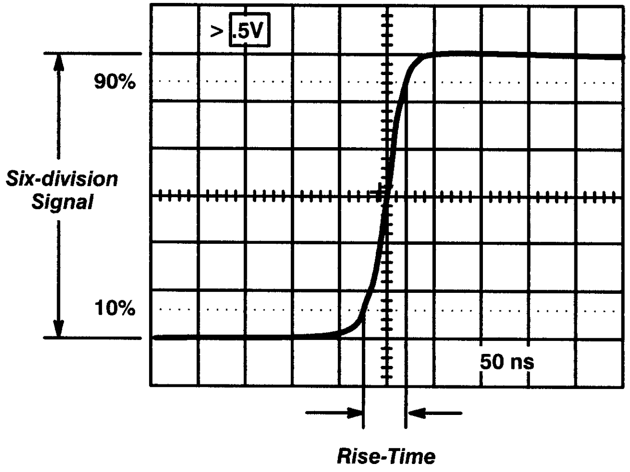


Figure A-5: Measuring Rise-Time

☐ **Step 8:** To change from rise-time to fall-time, press the **SLOPE** button in the trigger controls area of the front panel and repeat the procedure.

Appendix B: Remote Communication

This appendix provides detailed information on remote communication between a 222PS Digital Storage Oscilloscope and an IBM PC/XT®. It contains the following subsections:

- Introductory Information
- Setting the Baud Rate
- Command Formats
- Front Panel Encoding
- Error Codes
- Transfer Options
- Interface Specifications
- Optional Accessories

NOTE

With the exceptions of the "Introductory Information" and "Setting the Baud Rate" subsections, this appendix contains highly technical data and procedures. To use this data to its greatest potential, you must already have a strong background in modern telecommunications.

Introductory Information

You can connect the 222PS to a PC using the RS-232 communications port located on the rear panel, as shown in Figure A-6.

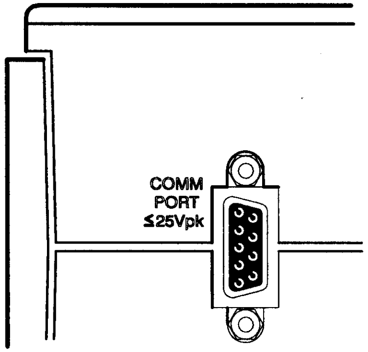


Figure A-6: RS-232 Communications Port

You can connect the 222PS to a PC directly, using the optional accessory cable. (If you connect the 222PS to a different model PC, you may need a different cable.) You can also connect the 222PS to a PC through modems that can communicate over a telephone line. Figure A-7 illustrates both these possible arrangements.

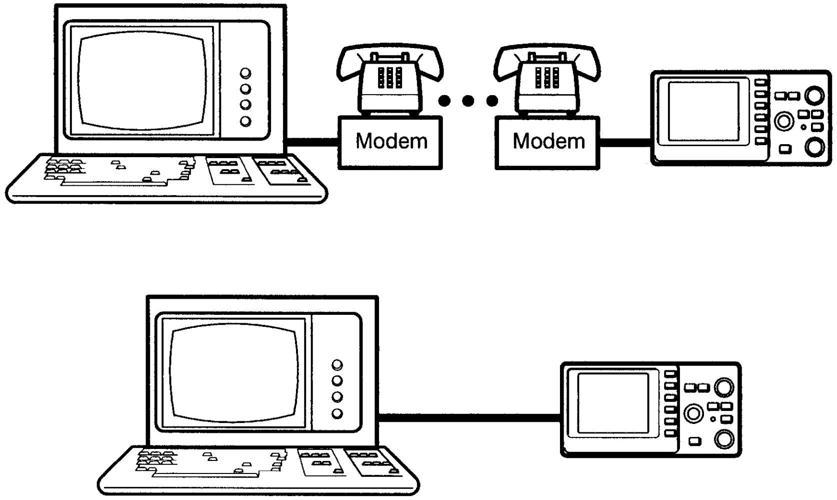


Figure A-7: Communication Between the 222PS and a PC

In either case, the PC must run appropriate terminal emulation and communications software, such as the CAT200 software package available from Tektronix or Procomm®, or a similar application.

If you are using the CAT200 software package from Tektronix and wish to use the same telephone connection for both voice and data communications, you can use the **MODEM ON** menu item on the configuration menu to start sending data. For more information, see the manual that comes with the CAT200 software.

Setting the Baud Rate

Before the 222PS can communicate through modems to a computer, you must set the *baud rate* — the rate at which the two machines send and receive data. The 222PS gives you the choice of four baud rates: 9600, 2400, 1200, or 300.

Determine the appropriate baud rate by checking the baud rate of your modems. Configure your communications software to the same rate.

To set the 222PS baud rate, follow these steps.

☐ **Step 1:** Press the button labeled **AUX FUNCT** on the top panel. This accesses the auxiliary functions menu, as shown in Figure A-8.

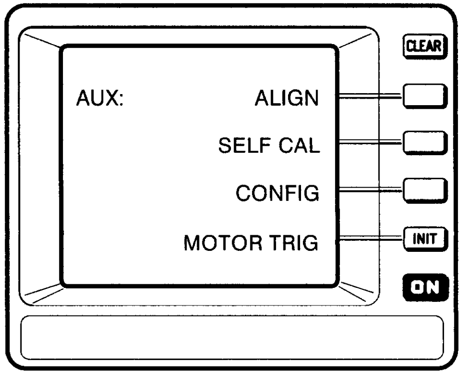


Figure A-8: The Auxiliary Functions Menu

☐ **Step 2:** Press the menu button next to the menu item **CONFIG** to access the configuration menu, as shown in Figure A-9.

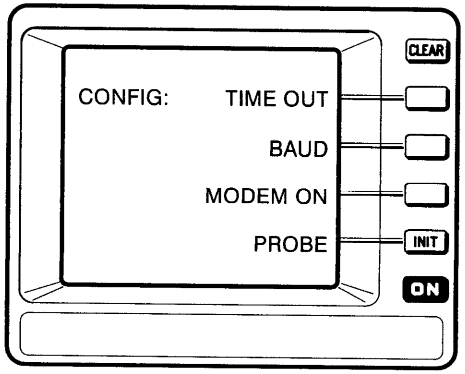


Figure A-9: The Configuration Menu

☐ **Step 3:** Press the menu button next to the menu item **BAUD**. This accesses the baud settings menu, as shown in Figure A-10. The selected baud rate appears boxed.

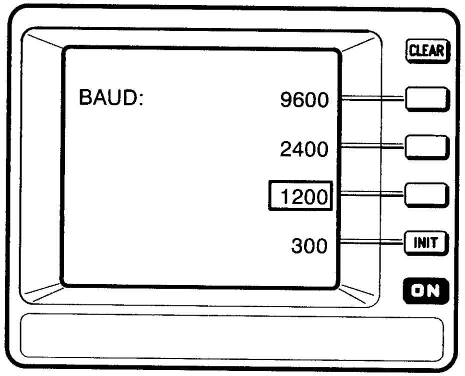


Figure A-10: The Baud Settings Menu

☐ **Step 4:** If the baud rate currently selected is the rate you require, press **CLEAR**. Otherwise, press the menu button next to the baud rate you require. Then press **CLEAR** to remove the menu from the display.

Command Formats

Commands, front panel setups, and waveforms sent over the RS-232 interface are composed of ASCII character strings. The ASCII characters represent hexadecimal numbers, with two characters per number. (See *Front Panel Encoding* for the meanings of the numbers.)

The general RS-232 command format is

cmd arg:data;

where

cmd is the command;

arg is an argument to the command; and

data is any additional data needed for the command.

There must be a single white space (either a space or a tab) between the command and argument. There must be no white space on either side of the colon delimiter between the argument and the data. The semicolon is the command terminator, but a carriage return also terminates the command. Semicolons are necessary only in multiple-command strings.

NOTE

The interface executes a command as soon as it receives the command terminator. If you place multiple commands on one line, the interface executes them in sequence. You can abort a command by sending an escape character.

Commands, Queries, and Responses

Figure A-11 shows the set of commands and queries sent to the instrument and the responses sent by the instrument. Explanation for each is given in the following text.

COMMANDS	QUERIES	RESPONSES
CURV	CURV?	CURV
BUT	ID?	ID
DAC	TRG?	TRG
FP	STA?	READY
	DAC?	DAC
	FP?	FP XXX;

Figure A-11: Commands, Queries, and Responses

Commands — The 222PS Digital Oscilloscope RS-232 interface supports these commands.

- **CURV <frame>: <wfrm data>;**
  This command loads waveform data into the specified 222PS reference memory (REF1–REF4). The waveform data must be sent as hex-encoded ASCII characters.

NOTE

Waveforms may be written back to channel 1 and channel 2, but the next acquisitions into those memories will overwrite any previously saved waveforms.

<frame> is one of the following strings:

CH 1	Channel 1 waveform
CH 2	Channel 2 waveform
REF1	Reference waveform 1
REF2	Reference waveform 2
REF3	Reference waveform 3
REF4	Reference waveform 4

<wfrm data> is composed of <fp data>,<modebyte>,<byte count>,<waveform data>, and <checksum>, which are defined as follows:

<fp data> is composed of ten ASCII characters that represent hexadecimal bytes of the front-panel settings for the waveform data. See *Front Panel Encoding* for the meaning of the characters.

<mode byte> is composed of two characters that indicate the mode the 222PS requires to display a waveform. Normally this byte will be 00. If the waveform is not completely filled (which can happen at very high sweep speeds), this byte will be 02. If it is an XY waveform, the byte will be 03.

<byte count> is composed of four ASCII characters representing the data byte count for the waveform data (in hexadecimal).

<waveform data> can be one of two ASCII character sequences, depending on which display mode the instrument is in. In YT mode, each data point is the hexadecimal value (represented by two ASCII characters) of the Y-coordinate. In XY mode, the X- and Y-coordinates are sent as two hexadecimal values (represented by four ASCII characters) with the X-coordinate value first, followed by the Y-coordinate value.

<checksum> is composed of two ASCII characters that represent the hexadecimal twos complement of the modulo 256 checksum of all data bytes, byte count bytes, and mode byte.

NOTE

Programmers: additional bytes may be added to the data string after the checksum byte. This space is reserved for future expansion.

- **BUT <button>;**
  This command simulates a button press, where <button> is composed of one or two ASCII characters that represent a button code. The button codes are shown in Table A-1.

Table A-1: BUT Button Codes

Code	Simulated Button Press
1	CLEAR
2	Menu Item 0
3	Menu Item 1

Table A-1: BUT Button Codes (Cont.)

Code	Simulated Button Press
4	Menu Item 2
5	Menu Item 3
6	OFF
9	Trigger SOURCE
A	Trigger MODE
B	Trigger SLOPE
C	CH 2 Select
D	Ch1 Select
E	AUTO SETUP
11	Front-Panel Setup Menu
12	Trigger Position Menu
13	Auxiliary Function Menu
14	Display Mode Menu
19	Save Waveform Menu
1A	Recall Waveform Menu
1B	STORE/NONSTORE
1C	Acquisition Mode Menu
20	X10 MAG
21	Variable Gain
22	AUTO LVL: PUSH

- **DAC <DAC code>: <DAC value>;**
  This command sets a DAC value. A DAC is a digital-to-analog converters for digitized potentiometer settings. The digital-to-analog converters determine the variable control settings for the POSITION controls (horizontal and vertical), the trigger LEVEL settings (CH1, CH2, and EXT), and the variable vertical gain (CH1 and CH2). See Table A-2 for the DAC code and DAC value data.

Table A-2: DAC Code and Value Data

DAC	DAC Code	Range	Scale	Reference	
Horiz POSITION	00	0–1FFC	±5 div	Full left	0
CH 1 Trigger LEVEL	01	0–1FFC	±30 div	Center	0FFF
CH 2 Trigger LEVEL	02	0–1FFC	±30 div	Center	0FFF
EXT Trigger LEVEL	03	0–1FFC	±2.33 V	Center	0FFF
CH 2 VAR Gain	04	0–03FF	–2.5:1 to 1:1	Cal'd	03FF
CH 1 VAR Gain	05	0–03FF	–2.5:1 to 1:1	Cal'd	03FF
CH 2 POSITION	06	0–1FFC	±12 div	Center	0FFF
CH 1 POSITION	07	0–1FFC	±12 div	Center	0FFF

- **FP <log fp>:<fp data>;**
  This command sends a front-panel setup to the <log fp> location.

  <log fp> is one of the following:

ACQ	Acquisition system
REF1	Reference waveform 1
REF2	Reference waveform 2
REF3	Reference waveform 3
REF4	Reference waveform 4
STR1	Front panel setup 1
STR2	Front panel setup 2
STR3	Front panel setup 3
STR4	Front panel setup 4

  <fp data> is composed of ten ASCII characters that represent the five, two-character hexadecimal bytes of a logical front-panel setup. See Tables A-3 through A-6 to encode and decode <fpdata>.

NOTE

REF1–REF4 front panel volts can be affected by the selected probe configuration in the 222PS instrument (see Front Panel Encoding section).

Queries — The 222PS Digital Storage Oscilloscope RS-232 interface supports the following queries:

- **CURV? <frame>;**
  This query requests waveform data. The instrument sends waveform data as hex-encoded ASCII characters. **<frame>** is one of six possible sources for curve data (CH1, CH2, REF1, REF2, REF3, or REF4).
- **ID?;**
  This query requests instrument identification and software version.
- **TRG?;**
  This query requests the trigger state.
- **STA?;**
  This query requests the communication task status.
- **DAC? <DAC code>**
  This query requests a DAC value. <DACcode> is one of eight DACs for digitized potentiometer settings. See Table A-2 for DAC identification.
- **FP? <log fp>**
  This query requests a front panel setup. See page A-17 for a listing of <logfp> values.

NOTE

*If you query an empty reference waveform location, you will receive a status error (STA 0005) in response. If you query an empty front-panel location, the response you receive will contain unreliable **<fp data>**. If you query an active channel before it acquires a waveform the response you receive will contain unreliable **<wfrm data>**.*

Responses — The following responses occur as a result of the associated query:

NOTE

If the query or command is terminated by a semicolon, responses will be terminated by a semicolon. If the query or command is terminated by a carriage return, the response will be terminated by a semicolon followed by a carriage return.

- **CURV <frame>:<wfrm data>**
  A frame is one of the six possible sources of waveform data in the instrument (CH1, CH2, REF1, REF2, REF3, or REF4) asked for in the CURV? query. The waveform data includes the front-panel setting and the waveform data point values as hex-encoded ASCII characters, as with the CURV command.
- **ID TEK-222PSVER:X.XX**
  This response is in reply to an ID? query. X.XX is the firmware version installed in the instrument.
- **TRG YES or NO**
  This response indicates if the TRIG'D LED is on (YES: triggered) or off (NO: not triggered) in response to the TRG? query.
- **READY**
  This is the reply to a STA? query when the instrument is ready to communicate. The the instrument sends the same response as the result of a carriage return. If the instrument is not ready, it delays reply until ready.
- **DAC <DAC code>:<DAC value>**
  In response to the DAC? query, the setting of the queried DAC is returned in the same form as the DAC command. See Table A-2 for DAC identification data.
- **FP <log fp>:<fp data>**
  This response is in the same form as the FP command. The byte decoding (by bit) for the front-panel settings is given in Tables A-3 through A-6; each table shows the decoding for one of the hexadecimal bytes.

NOTE

If you send <fp data> originally taken from a location where a setup had not yet been saved, the resulting instrument setup will be unreliable, possibly inducing a lock up condition.

NOTE

REF1 through REF4 front panel volts can be affected by probe configuration in the 222PS (see the Front Panel Encoding section).

Front-Panel Encoding

Tables A-3 through A-6 show how the ten ASCII characters of the logical front-panel hexadecimal bytes are encoded. The tables divide the coded number of the front panel setup into five bytes of two ASCII characters each.

Vertical Settings

From Table A-3 you can decode the ASCII characters for the channel 1 and channel 2 vertical settings. For example, in the setup data string **FP ACQ:24240C2112** the first four characters are 2424. Breaking these numbers into binary bits, a 2 equals 0010, and a 4 equals 0100. Looking at the bit information for the first character tells us that INVERT is OFF, VAR is disabled, and the input coupling is GND. For the second character, its bit values are given, but looking at the Hex Value column tells us that the VOLTS/DIV setting is 0.1 V per division. Exactly the same values are given for characters 3 and 4 as 1 and 2, respectively; therefore the channel 2 settings are the same as the channel 1 settings.

To change the VOLTS/DIV setting for channel 1 to 1 V, change the value of character 2 from 4 to 7 in the front panel setup string when it is sent back to the oscilloscope. The string sent back then is **FP ACQ:27240C2112**.

Table A-3: Channel Settings

CHAR 1			CHAR 2
BYTE 1			
7	6	5 4	3 2 1 0

HEX VALUE	BITS				VOLTS/ DIV
	3	2	1	0	
0	0	0	0	0	5 mV
1	0	0	0	1	10 mV
2	0	0	1	0	20 mV
3	0	0	1	1	50 mV
4	0	1	0	0	0.1 V
5	0	1	0	1	0.2 V
6	0	1	1	0	0.5 V
7	0	1	1	1	1 V
8	1	0	0	0	2 V
9	1	0	0	1	5 V
A	1	0	1	0	10 V
B	1	0	1	1	20 V
C	1	1	0	0	50 V
D*	1	1	0	1	100 V
E*	1	1	1	0	200 V

*Available for recalled waveforms only.

BITS		CLPG
5	4	
0	0	DC
0	1	AC
1	0	GND
1	1	CH OFF

BIT	VAR
6	
0	CAL'd
1	UNCAL'd

BIT	INVERT
7	
0	OFF
1	ON

SEC/DIV Setting

Characters 5 and 6 from the example string are 0 and C. In binary bits, these characters are 0000 and 1100 respectively. You can see from Table A-4 that the bits of character 5 define several settings of the front panel. The example bit values of 0000 decode to show that the READOUT OFF menu choice is OFF (not selected, so the readout is on), XY display mode is OFF, and X10 MAG is OFF.

The fourth bit of character 5 is assigned to the seconds-per-division settings along with all four bits of character 6. A bit value of 0 for this bit defines seconds-per-division settings of 5 ms and faster. A bit value of 1 defines seconds-per-division settings of 10 ms and slower. The four bits of character 6 are all used to define the seconds-per-division setting. In the example the seconds-per-division setting is below 10 ms (0 value of bit 4 of character 5), and the 1100 (hex C) value of character 6 gives a seconds-per-division setting of 0.5 ms per division.

To change the seconds-per-division setting to 0.1 ms, change character 6 from C to A. However to change to 20 ms, the value of character 5 will also have to change from 0 to 1 in the setup example string while character 6 changes to a 1.

Table A-4: Seconds-per-Division and Misc. Settings

CHAR 5				CHAR 6			
BYTE 3							
7	6	5	4	3	2	1	0

BIT 5	X10 MAG
0	OFF
1	ON

BIT 6	XY
0	OFF
1	ON

BIT 7	RO OFF
0	OFF
1	ON

BITS					SEC/DIV	HEX VALUE
4	3	2	1	0		
0	0	0	0	0	50 ns	0
0	0	0	0	1	0.1 μs	1
0	0	0	1	0	0.2 μs	2
0	0	0	1	1	0.5 μs	3
0	0	1	0	0	1 μs	4
0	0	1	0	1	2 μs	5
0	0	1	1	0	5 μs	6
0	0	1	1	1	10 μs	7
0	1	0	0	0	20 μs	8
0	1	0	0	1	50 μs	9
0	1	0	1	0	0.1 ms	A
0	1	0	1	1	0.2 ms	B
0	1	1	0	0	0.5 ms	C
0	1	1	0	1	1 ms	D
0	1	1	1	0	2 ms	E
1	1	1	1	1	5 ms	F
1	0	0	0	0	10 ms	0
1	0	0	0	1	20 ms	1
1	0	0	1	0	50 ms	2
1	0	0	1	1	0.1 s	3
1	0	1	0	0	0.2 s	4
1	0	1	0	1	0.5 s	5
1	0	1	1	0	1 s	6
1	0	1	1	1	2 s	7
1	1	0	0	0	5 s	8
1	1	0	0	1	10 s	9
1	1	0	1	0	20 s	A

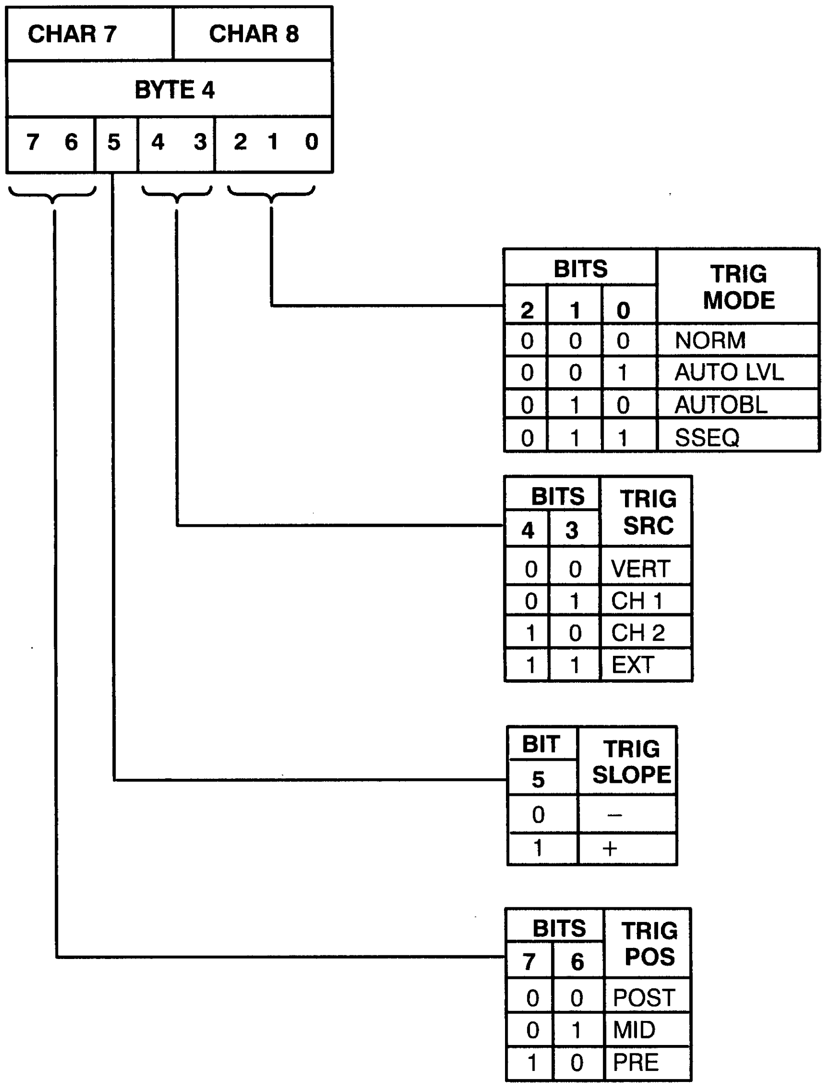
Trigger Positions, Slope, Source, and Mode Settings

Characters 7 and 8 of the front-panel setup string define several of the trigger settings of the instrument. Two bit values of the characters are used to define the Trigger SOURCE setting (bit 4 of character 7 and bit 1 of character 8). Therefore, both characters must be set correctly to control the Trigger SOURCE setting. See Table A-5 for detailed information.

In our example front panel setup string, characters 7 and 8 are 2 and 1 respectively. The binary bits are 0010 and 0001 for these two characters. The first two bits of character 7 define the TRIG POS setting; the bit values of 0 0 in these positions decode to a TRIG POS of POST. The third bit is a 1 and decodes to a + SLOPE setting.

The last bit of character 7 and the first bit of character 8 are 0 and 0 respectively and decode to VERT Trigger SOURCE. The last three bits of character 8 are 001 and decode to AUTO LVL Trigger MODE.

Table A-5: Trigger Position, Slope, Source, and Mode Settings



CHAR 7			CHAR 8	
BYTE 4				
7 6	5	4 3	2 1 0	

BITS			TRIG MODE
2	1	0	
0	0	0	NORM
0	0	1	AUTO LVL
0	1	0	AUTOBL
0	1	1	SSEQ

BITS		TRIG SRC
4	3	
0	0	VERT
0	1	CH 1
1	0	CH 2
1	1	EXT

BIT	TRIG SLOPE
5	
0	–
1	+

BITS		TRIG POS
7	6	
0	0	POST
0	1	MID
1	0	PRE

Acquisition Mode and Miscellaneous Settings

Characters 9 and 10 of the front panel-setup string define the remaining settings not defined by the other 8 characters. Table A-6 shows setup state controlled by each bit. The only two-bit setting is for Acquisition MODE.

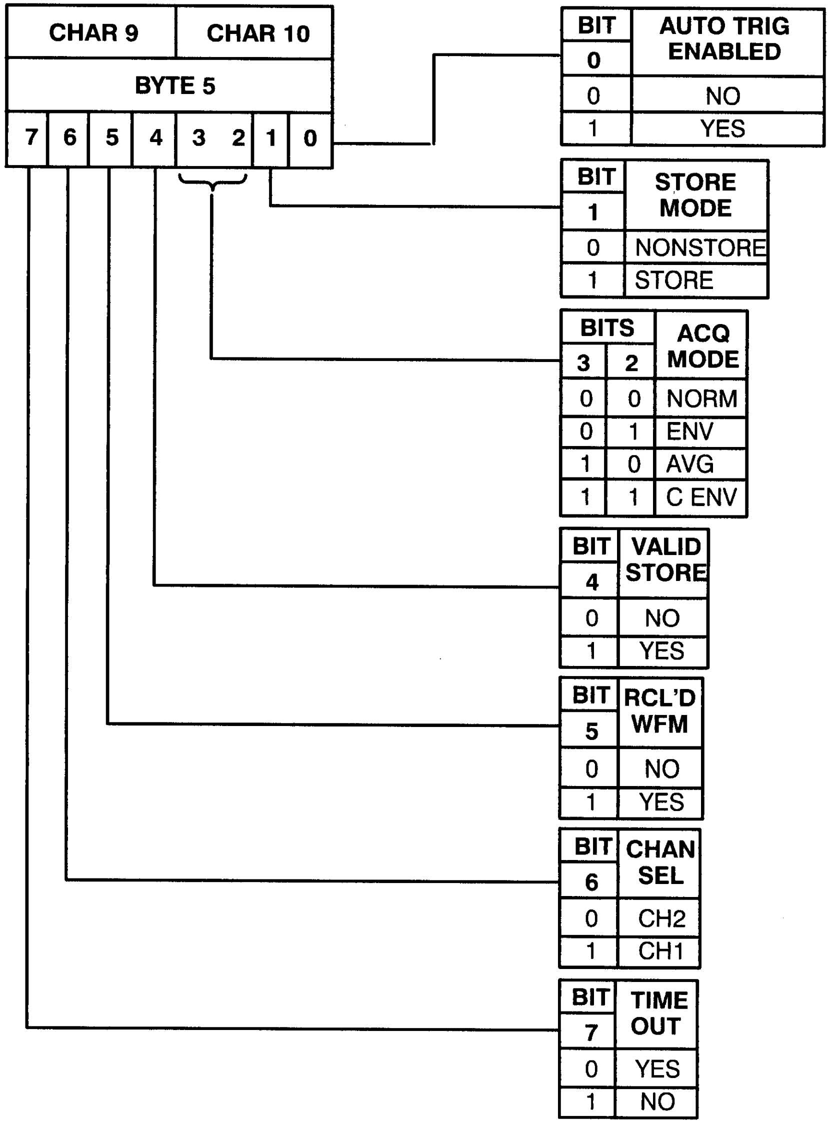
The last two characters of our example setup string are 1 and 2. The bit values for these are 0001 and 0010, respectively. The decoding for the bit values of character 9 is then the following:

- TIME OUT is enabled
- CH2 is selected to respond to the controls settings
- It is not a recalled waveform
- It is a valid store

Character 10 (0010) decodes as follows:

- The Acquisition MODE (2 bits) is NORM
- It is in STORE mode
- AUTO TRIGGER is not enabled

Table A-6: Acquisition Mode and Misc. Settings



CHAR 9				CHAR 10			
BYTE 5							
7	6	5	4	3	2	1	0

BIT 0	AUTO TRIG ENABLED
0	NO
1	YES

BIT 1	STORE MODE
0	NONSTORE
1	STORE

BITS 3	2	ACQ MODE
0	0	NORM
0	1	ENV
1	0	AVG
1	1	C ENV

BIT 4	VALID STORE
0	NO
1	YES

BIT 5	RCL'D WFM
0	NO
1	YES

BIT 6	CHAN SEL
0	CH2
1	CH1

BIT 7	TIME OUT
0	YES
1	NO

RS-232 Error Codes

When you connect the instrument to a terminal or PC, you can read RS-232 error codes. There are two types of error codes. Status messages result from a command error; diagnostic error codes result from errors that occur during normal operation or when running the calibration routine. If there are no errors, the instrument responds with "READY;" when it is ready to respond to commands.

Status Messages

Status messages are returned when an error is detected in a command.

STAtus 0001	Unrecognized command
STAtus 0002	Unrecognized character
STAtus 0003	Command is query only
STAtus 0004	Command has no query
STAtus 0005	Bad command argument
STAtus 0006	Bad data
STAtus 0007	Data is required
STAtus 0008	Argument is required
STAtus 0009	Communication task is busy
STAtus 000A	CURV command had bad checksum
STAtus 000B	Bad task name for message
STAtus FFFF	User pressed escape

Diagnostic Error Codes

If an error is detected in the oscilloscope during normal operation or calibration, an error message is output to an external terminal via the RS-232 serial port. These error codes are formatted as **ERROR wxyy zzzz** where wxyy and zzzz are 16-bit hexadecimal numbers representing the error message.

The code key is as follows:

w = the error type

0 = error during normal calibration
2 = EEPROM programming error
4 = EEPROM calibration constant area error
8 = Calibration error
F = Fatal system error

x = the channel affected by the error

1 = Channel 1
2 = Channel 2
0 = Channel not specified

yy = the error code. The value depends on the type of error (0, 2, 4, 8, or F) at the **w** position in the portion of the first code group (wxyy) as follows:

Error type 0:

Error code 09 = Trigger search error (auto level mode).

Error type 2:

Error code XX = The data that failed to program. The value of the second code group (zzzz) is the address that failed to program.

Error type 4:

Error code 01 = Bad EEPROM checksum detected.

Error code 02 = Calibration needed. The following zzzz codes indicate which calibration routine needs to be done:

0001 = Channel 1 offset/gain calibration
0002 = Channel 2 offset/gain calibration
0004 = Channel 1 offset DAC calibration
0008 = Channel 2 offset DAC calibration
0010 = Channel 1 trigger calibration
0020 = Channel 2 trigger calibration
0040 = External trigger calibration
0080 = Clock delay calibration

If the zzzz error code is FFFF, no calibration routines have been done since all the default values were loaded into the EEPROM (this error code is seen only at the first factory calibration).

Error type 8:

01 = Acquisition timeout error
02 = Mid position search error
03 = Mid position range error
04 = Offset search error
05 = Offset range error
06 = Offset gain error
07 = Gain range error
08 = Gain search error

09 = Trigger search error
10 = Trigger offset range error
11 = Trigger gain error
12 = Trigger hysteresis error
13 = External trigger offset range error
14 = External trigger hysteresis error
15 = Clock delay error
16 = Acquisition delay error

Error type F

00 = COP timeout error
01 = Illegal opcode execution
02 = Interrupt exception
03 = Task exception

NOTE

A COP timeout error most likely indicates that your communications software is not compatible with the 222PS.

zzzz = an additional 16-bit value the meaning of which depends on the first error word. The zzzz values are meaningful only when error type 2 and error type 4 codes are given.

Transfer Options

There are two ways to transfer data between the 222PS Digital Storage Oscilloscope and a PC: local transfer and transfer via modem.

Transfer to a Local PC

With a PC/XT as the host computer, the optional RS-232 interconnection cable provides the required match from the 25-pin connector on the PC to the 9-pin connector on the instrument. The optional cable is also compatible with a PC/AT that has a 25-pin communications port.

Transfer via Modem

Telephone lines may be used to control a remote instrument and to transfer waveforms between the instrument and a PC.

The software utility program you have will determine the operations you need for controlling the modem. If the software does not have a modem control routine, you must first use a terminal communications utility to make the modem connection. You must then exit that utility to permit the instrument control program to function. The CAT200 software provides for modem control. Once the software is installed on the PC and the actions needed at both ends of the link have been decided, the general procedure to capture a waveform follows:

☐ **Step 1:** At the remote site, the instrument operator must hook up the instrument to a modem and acquire the test waveforms to be transferred to the PC. In the operation described here, the modem connected to the instrument at the remote site must be set to auto answer mode (see your modem manual for operating instructions) and told to perform the following actions:

- Answer the phone after a predetermined number of rings
  Hayes: ATS0=2
- Not transfer status information
  Hayes: ATQ1
- Not echo commands back to the 220 series instrument
  Hayes: ATE0
- Enable the CONNECT 1200/2400 code
  Hayes: ATX1

For modems with nonvolatile memory, each Hayes command should be followed by &W to preserve this configuration even if the modem loses power.

☐ **Step 2:** Now the PC operator must call the remote site and establish the modem link. If the instrument control utility does not have modem access capabilities, the PC operator must first use a terminal communications utility (such as Kermit or Procomm) to establish the modem link. When the remote modem answers, the PC operator can exit the communications utility and start the instrument control utility (either by command or by exiting the terminal communications utility without hanging up the modem).

☐ **Step 3:** The PC operator is now in control of the instrument and may request waveforms from it. Waveforms may be transferred from the reference memories and from the two vertical channels. If the PC operator needs more waveforms, the instrument operator must move the probes to new test points or make other adjustments to gather new waveforms. The operator at the PC may store new waveforms into the reference memories or, if wanted, continually ask for new waveforms from channel 1 and channel 2 as they acquire new waveforms. The waveforms received can be filed in the PC for future study.

☐ **Step 4:** The instrument does not support user messages on-screen, so a second voice telephone connection between the two operators may be useful when a series of different waveforms needs to be transferred for use at the PC site. If the modems in use have the capability, VOICE/DATA switching solves the problem. The CAT200 software provides this utility. You may need to consult your modem/communications software manual for operating details.

RS-232 Interface Specifications

RS-232 Communication Parameters

Start bits: 1

Stop bits: 1

Data bits: 8

Parity: None

Flow Control: XON/XOFF

Signals: RX, TX, and SGND are functional. SGND is connected internally to EXT TRIG COMM. DSR and CTS are always high. DTR going active turns the scope on and RTS is ignored.

Baud Rates

300, 1200, 2400, 9600; 0.1% accuracy based on the microprocessor clock.

Levels

Compatible with RS-232-C.

Maximum Applied Voltage

25 V (DC + peak AC) to any pin.

Plotter/Printer Support

There is no plotter/printer support in the instrument.

Messages

User-message displays on the instrument CRT are not supported. The controlling PC cannot send messages to be displayed for the operator of the instrument.

Optional Accessories

CAT200

This is a Tektronix software product. It provides a virtual front panel (a graphical interface with mouse-input facilities) on the PC screen that allows you to fully control 222PS functions from the PC. Waveforms may be transferred either to or from a local instrument connected to the serial communications port of the PC or a remote instrument via a telephone modem. There are no capabilities for further processing of the captured waveform data or for automated control of the front panel under CAT200 programming.

NOTE

*You must use CAT200 **Version 1.2 or above** with the 222PS.*

RS-232 Interconnection Cables

The optional accessory RS-232 interconnection cable supports attachment of the instrument with its DE-9 connector to a PC/XT or compatible with a DB-25 connector (see Figure A-12). For connection to other types of equipment a user must provide the correct cabling (see Table A-7 for typical pin connections).

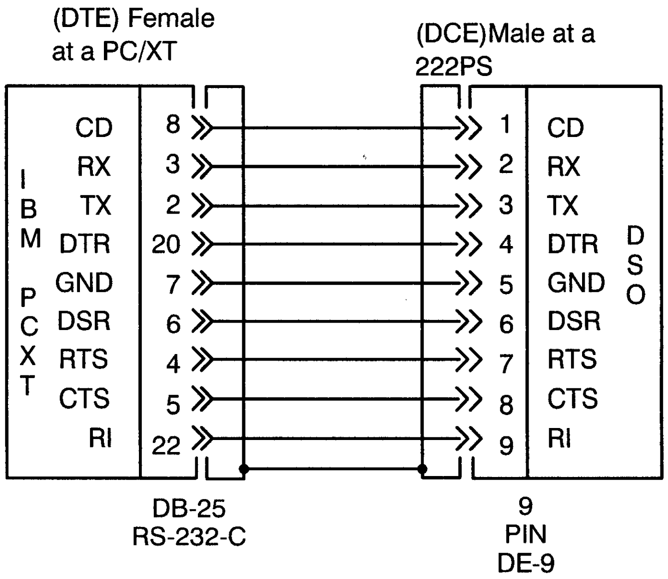


Figure A-12: RS-232 Interconnection Cable Pin Wiring

Table A-7: 222PS Interconnect Pin Assignments

(DCE) Male at the DSO		TO (DCE) Modem		TO (DTE) PC/XT		TO (DTE) PC/AT	
1*	CD	6	DSR	8	CD	1	CD
2	RX	2	TX	3	RX	2	RX
3	TX	3	RX	2	TX	3	TX
4	DTR	8	CD	20	DTR	4	DTR
5*	SGND	7	GND	7	GND	5	SGND
6	DSR	20	DTR	6	DSR	6	DSR
7*	RTS	5	CTS	4	RTS	7	RTS
8	CTS	4	RTS	5	CTS	8	CTS
9*	RI	22	RI	22	RI	9	RI

*Connection optional

Appendix C: Quick Checks

This subsection contains quick-to-perform procedures that you can use to verify that the 222PS functions properly.

The *Self Cal Tests* procedure uses internal routines to confirm that both input channels can be calibrated and that the display is working properly. The only test equipment required is a patch cord.

The *Autoset Tests* procedure uses the automatic setup feature of the 222PS to verify the acquisition system, trigger circuits and waveform display capability. The standard-accessory probes, included with this oscilloscope, are the only equipment needed.

General Instructions

The *Self Cal Tests* and *Autoset Tests* procedures combine with the *Performance Tests* found later in this section to extensively test the 222PS.

You may not need to perform both the *Brief Procedures* and the *Performance Tests*, depending on what you want to accomplish:

- To rapidly confirm that this oscilloscope functions and was adjusted properly, just do the procedure under *Self Cal Tests*, which begins on page A-39.
- To further check functionality, first do the *Self Cal Tests* just mentioned, and then do the procedure under *Autoset Tests* that begins on page A-41.
- If more extensive confirmation of performance is desired, do the *Performance Tests*, beginning on page A-43, after doing the *Self Cal Tests* and *Autoset Tests*. The *Performance Tests* directly check warranted specifications, but they require more time and specific test equipment.

Conventions

Throughout these procedures the following conventions apply:

- Each test procedure uses the following general format:

  Title of Test

  Equipment Required

  Prerequisites

  Procedure

- Each procedure consists of many steps, substeps, and subparts as required to do the test. Steps, substeps, and subparts are sequenced as follows:

1. First Step
   a. First Substep
      - First Subpart
      - Second Subpart
   b. Second Substep
2. Second Step

- Where instructed to use a front-panel button or knob or verify a readout or status message, the name of the button or knob appears in boldface type: "Rotate the **VERT POS** knob to position the waveform at center screen."

STOP

The symbol above is accompanied by information you must read to do the procedure properly.

Initial Setup Procedure

This procedure connects the oscilloscope to external power and installs probes for the tests that follow.

Equipment Required (See Table A-8, page A-44)

P850 probe (standard accessory, Item 11)
External Power AC Adapter (standard accessory, Item 3)

Prerequisites

None

Procedure

1. Plug the External Power AC Adapter into the AC power source.
2. Plug in the cord from the adapter to the **EXT POWER INPUT** connector on the rear panel of the oscilloscope.
3. Open the zipper on the probe pouch and remove the probes. If disconnected, connect the probes through the oval opening at the rear of the pouch to the connectors on the oscilloscope.
4. Press the **ON** button of the oscilloscope to toggle it into the operating mode.

Self Cal Tests

This procedure uses internal routines to verify that this 222PS functions and can properly perform self-calibration of both input channels. This procedure also guarantees the highest accuracy state for the *Performance Tests* that follow.

Equipment Required (See Table A-8, page A-44)

Connector; female-to-dual-banana-plug (Item 7)
External Power AC Adapter (standard accessory, Item 3)

Prerequisites

Initial Setup Procedure

Procedure

1. Press the **AUX FUNCT** button to bring up the AUX menu.
2. Select SELF CAL from the menu.

NOTE

Disconnect both the Channel 1 and Channel 2 probes from any signal source before performing the self-calibration routines.

3. Select CH1 from the SELF CAL submenu to start the Channel 1 self-calibration routine. When the oscilloscope displays a PASS/FAIL message, the first routine is done.
4. Select CH2 from the SELF CAL submenu to start the Channel 2 self-calibration routine. When the oscilloscope displays a PASS/FAIL message, the second routine is done.
5. Select EXT TRIG to display the external trigger self-calibration menu.

NOTE

*For this self-calibration routine, the **EXT TRIG COMM** and **EXT TRIG INPUT** connectors must be connected together. Use a short jumper with banana plug connectors to make the connection.*

6. Select CAL to start the external trigger self-calibration routine after the **EXT TRIG COMM** and **EXT TRIG INPUT** connectors are joined. A PASS/FAIL message is displayed when the routine is done. Remove the jumper.
7. Press the **CLEAR** button at the completion of the self-calibration routines to return to normal oscilloscope operation. You are now ready to make the performance checks.

If a self-calibration step fails, the currently stored calibration constants are not changed. Run the failed routine again. Refer to the *Troubleshooting* in the *Maintenance* section of the 222PS service manual for an explanation of the error codes.

If the failure persists, further information about the nature of the failure may be found by connecting the RS-232 interface port to a terminal or host computer and rerunning the failed self-calibration routine. A coded error message is output when the error occurs.

Refer to the *Remote Communication* section of this manual for explanations of the error codes.

Autoset Tests

The autoset test procedure, while simple and easy to perform, will check 90% of the functionality of your 222PS Digital Storage Oscilloscope.

Equipment Required (See Table A-8)

P850 probe (standard accessory, Item 11)
External Power AC Adapter (standard accessory, Item 3)

Prerequisites

Initial Setup Procedure

Procedure

1. Remove the retractable hook tip from the channel 1 probe.
2. Display the channel 1 signal.
3. Hold the probe tip to the end of your finger. Make good contact, but do not puncture yourself.
4. With one of your *other* fingers, press the **AUTO SETUP** button.
5. When the auto-setup sequence is complete, channel 1 should show a 60 Hz noisy sine waveform.
6. Repeat this procedure for channel 2.

If the auto-setup routine displays a signal for both channels, it indicates that most of the instrument's major systems are operational and will perform correctly.

Appendix D: Performance Tests

This section contains a collection of procedures for checking that the 222PS Digital Storage Oscilloscope performs as warranted.

There are three primary performance verification sequences:

- Vertical Checks
- Horizontal Checks
- Trigger Checks

These performance check procedures verify the performance requirements of the instrument as listed in *Appendix D: Specification*. These checks may be used as an acceptance test or as a preliminary troubleshooting aid to help determine the need for repair or readjustment.

STOP

These procedures extend *the confidence level provided by the basic procedures described in the previous section. Perform the basic procedures first, then continue to these if needed.*

Prerequisites

To ensure the validity of these performance check procedures, the testing environment must meet these qualifications:

- The cabinet must be in place.
- You must perform and pass the self-calibration routines and functional tests found on page A-39.

Related Information

Read *General Instructions* and *Conventions* that start on page A-37.

Equipment Required

Table A-8 lists all the test equipment required to do the performance check procedure. Test equipment specifications described are the minimum necessary to provide accurate results. For test equipment operation information, refer to the appropriate test equipment instruction manual.

When you use equipment other than that recommended, you may have to make some changes to the test setups. If the exact example equipment in Table A-8 is not available, use the Minimum Specification column to determine if any other available test equipment might be adequate to do the check.

Table A-8: Test Equipment

Item Number and Description	Minimum Requirements	Example	Purpose
1 Adapter	Connectors: BNC male-to-dual-banana-jack.	Tektronix part number 103-0035-00	Signal connection
2 Calibration Generator	Standard-amplitude signal levels (DC and square wave): 5 mV to 100 V. Accuracy: 5 mV to 100 V ±0.25%. High-amplitude signal levels: 1 V to 60 V. Repetition rate: 1 kHz. Fast-rise signal level: 1 V. Repetition rate: 1 MHz. Rise time: 1 ns or less. Flatness: ±0.5%	TEKTRONIX PG506A Calibration Generator	Gain and transient response checks
3 AC Power Source	External Power AC Adapter	Standard (U.S.) External Power AC Adapter, Tektronix part number 120-1807-00	Reliable power for oscilloscope and defeats auto-shutdown
4 Adjustment Tool	Small flat blade, narrow tip	General Tool 120-250	Adjust focus before measurements
5 Termination, 50 Ω	Impedance 50 Ω; connectors: female BNC input, male BNC output	Tektronix part number 011-0049-01	Impedance matching between generators and probes
6 Cable, 50 Ω Coaxial	50 Ω, 36 in, male-to-male BNC connectors	Tektronix part number 012-0482-00	Signal connection

Table A-8: Test Equipment (Cont.)

Item Number and Description	Minimum Requirements	Example	Purpose
7 Connector; dual-banana	BNC female-to-dual-banana plug	Tektronix part number 103-0090-00	Signal coupling to External Trigger and Common inputs
8 Connector, BNC-T	Male, BNC-to-dual-female BNC	Tektronix part number 103-0030-00	Checking Trigger Sensitivity
9 Generator, Leveled Sine Wave	50 kHz to 20 MHz; Variable amplitude from 5 mV to 5 V p-p into 50 Ω. Amplitude accuracy: constant within 1.5% of reference frequency to 20 MHz	TEKTRONIX SG 503 Leveled Sine Wave Generator	Checking Vertical Triggering and Bandwidth
10 Generator, Time Mark	Variable marker frequency from 0.55 ms to 5 ns; accuracy within 2 ppm	TEKTRONIX TG501A Time Mark Generator	Checking Sample-Rate and Delay-time Accuracy
11 Probe (2 required)	P850 10X	TEKTRONIX P850	Connect oscilloscope to signal source

Preparation

The performance verification procedure is divided into subsections to let you check individual sections of the instrument when it is not necessary to do the complete performance check. An Equipment Required block at the beginning of each subsection lists the equipment from Table A-8 that is needed to do the checks in that subsection.

The initial control settings at the beginning of each subsection prepare the instrument for the first step of the subsection. Do each of the steps in a subsection completely and in order to ensure the correct control settings for the steps that follow. Let the test equipment warm-up for 20 minutes to obtain a valid performance check to the accuracies stated in *Appendix D: Specifications*.

Preliminaries

This preliminary procedure adjusts the display for greatest clarity prior to making measurements in the Performance Verification checks. You will make only externally available adjustments.

Equipment Required (See Table A-8)

External Power AC Adapter (Item 3)
Adjustment Tool (Item 4)

Prerequisites

Self Tests and Autoset Tests starting on page A-39.

Initial Control Settings

Power and Display

External Power .... External Power AC Adapter connected
Power .... **ON**

Front-Panel Controls

AUTO SETUP .... Press for initial signal display

Procedure

1. Check/Adjust Intensity Control
    a. Adjust the **INTEN** control for a sharp display.
2. Adjust **FOCUS** Control
    a. Press the **AUX FUNCT** button on the top panel.
    b. Select the ALIGN menu choice, then the XY menu choice. These selections display a test pattern on the CRT.
    c. Adjust the **FOCUS** control for the best definition of the pattern.
    d. Press the **CLEAR** button to remove the display pattern and return to normal operation.

Vertical Checks

These procedures check characteristics for the signal acquisition and display systems that are listed as checked under *Warranted Characteristics* in *Appendix D: Specifications*. Set up the test equipment as shown in Figure A-13. The calibration generator and the leveled sine-wave generator will not be used at the same time but they should both remain powered up during the procedure to ensure stable operation.

Equipment Required (See Table A-8)

Leveled Sine Wave Generator (Item 9)
Calibration Generator (Item 2)
50 Ω BNC Termination (Item 5)
BNC-to-banana-jack Adapter (Item 1)
External Power AC Adapter (Item 3)
2 P850 Probes (Item 11)

Prerequisites

Self Tests and Autoset Tests starting on page A-39

Preliminaries on page A-47

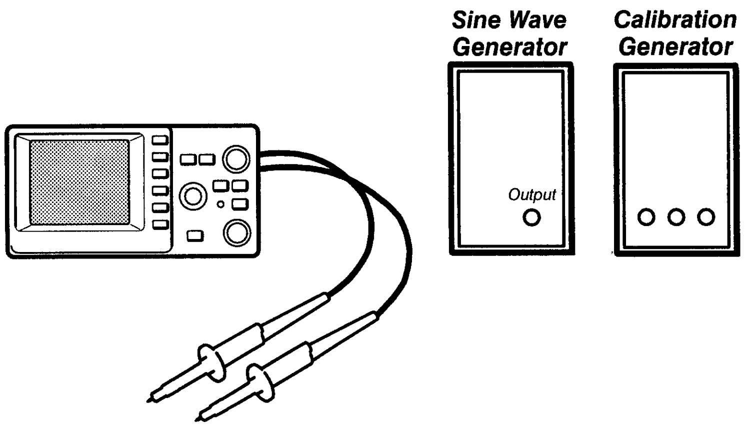


Figure A-13: Initial Setup for Vertical Checks

Initial Control Settings

Power and Display

External Power	External Power AC Adapter connected
Power	**ON**

Vertical Area

CH 2 **VOLTS/DIV**	50 mV
CH 2 Coupling	OFF
CH 2 Variable	CAL
CH 1 **VOLTS/DIV**	50 mV
CH 1 Coupling	GND
CH 1 Variable	CAL

Horizontal Area

SEC/DIV	1 ms
X10 MAG	OFF
POS	center the waveform

Trigger Area

Trigger **MODE** .... AUTOBL
Trigger **SOURCE** .... VERT
Trigger **SLOPE** .... +

Top Panel Controls

TRIG POS .... POST
STORE .... STORE

DISPL
INV1 .... OFF
INV2 .... OFF
XY .... OFF
RO OFF .... OFF (not selected)
ACQ .... NORM

Procedure

1. Check Input Current, DC Balance, and Invert Balance
   a. Connect the channel 1 ground lead to the probe tip.
   b. Press the **CLEAR** button to clear the display.
   c. Vertically position the channel 1 trace to the center horizontal graticule line.
   d. Set the channel 1 coupling to DC.
   e. CHECK for 0.5 division or less shift from the center horizontal graticule line.
   f. Set channel 1 coupling to GND.
   g. Rotate the **VOLTS/DIV** control from 50 mV to 500 V.
   h. CHECK for 0.2 division or less shift from the center horizontal graticule line.
   i. Set the **VOLTS/DIV** control to 50 mV.
   j. Select channel invert by pressing the **DISPL** button and selecting INV1.
   k. CHECK for 0.4 division or less shift from the center horizontal graticule line.
   l. Set channel 1 coupling to CH1 OFF.
   m. Set channel 2 coupling to GND.
   n. Turn off channel invert by pressing the **DISPL** button and selecting INV1.
   o. Repeat steps a through n for channel 2.
2. Check Input Coupling (Set up the test equipment as shown in Figure A-14.)

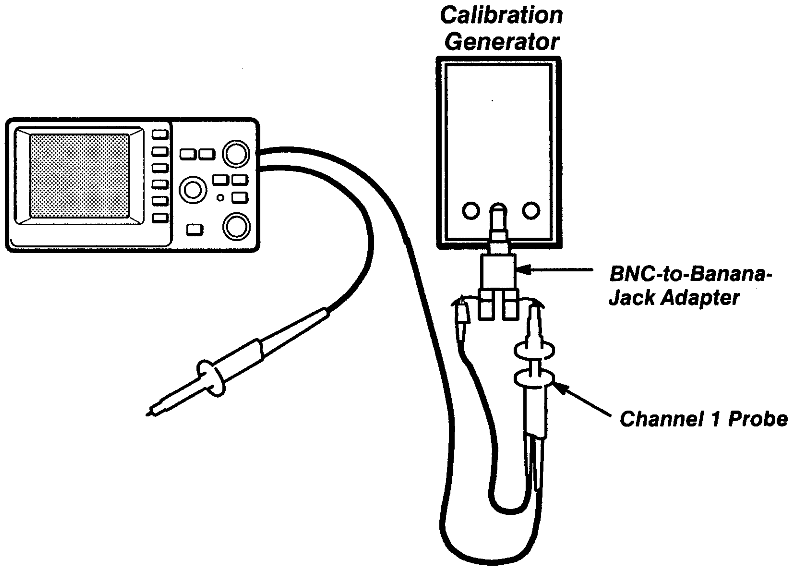


Figure A-14: Setup for Input Coupling Check

a. Set:

CH 2 Coupling	DC
SEC/DIV	0.5 ms
Trigger **MODE**	AUTOLVL
CH 2 **VOLTS/DIV**	0.5 V

b. Set the Calibration Generator to a standard-amplitude mode output signal of 2.0 V.

c. Vertically position the bottom of the signal to the center horizontal graticule line.

d. Set the channel 2 coupling to AC.

e. CHECK that the display moves to approximately vertical center screen.

f. Set:

CH 2 Coupling	CH2 OFF
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	0.5 V

g. Disconnect the channel 2 probe from the test equipment and connect the channel 1 probe.

h. Repeat parts c, d, and e for channel 1.

3. Check the Volts-per-Division Accuracy

a. Set Calibration Generator for a standard-amplitude output signal of 0.2 V.

b. Set the channel 1 **VOLTS/DIV** control to 50 mV.
Set: CH 1 Coupling DC

c. Vertically center the display.

d. CHECK all positions of the volts per division settings for correct signal-to-graticule accuracy using the **VOLTS/DIV** control and Calibration Generator settings and amplitude limits given in Table A-9.

e. Return the Calibration Generator output to 0.2 V.

f. Set:

CH 1 Coupling	CH1 OFF
CH 2 Coupling	DC
CH 2 **VOLTS/DIV**	50 mV

g. Disconnect the channel 1 probe from the test equipment and connect the channel 2 probe.

h. Repeat part c and d for channel 2.

i. Disconnect the test equipment from the oscilloscope.

Table A-9: Volts-per-Division Accuracy Settings

Volts/Div	Calibration Generator	Amplitude Limits
5 mV[1]	20 mV	3.84 div – 4.16 div
10 mV[1]	50 mV	4.80 div – 5.20 div
20 mV[1]	0.1 V	4.80 div – 5.20 div
50 mV	0.2 V	3.84 div – 4.16 div
0.1 V	0.5 V	4.80 div – 5.20 div
0.2 V	1 V	4.80 div – 5.20 div
0.5 V	2 V	3.84 div – 4.16 div

[1] These ranges are available only with a P400 X1 probe.

Table A-9: Volts-per-Division Accuracy Settings (Cont.)

Volts/Div	Calibration Generator	Amplitude Limits
1 V	5 V	4.80 div – 5.20 div
2 V	10 V	4.80 div – 5.20 div
5 V	20 V	3.84 div – 4.16 div
10 V	50 V	4.80 div – 5.20 div
20 V	100 V	4.80 div – 5.20 div
50 V	100 V	1.92 div – 2.08 div
100 V	——	——[2]
200 V	——	——[2]
500 V	——	——[2]

[2] For P850 probe only; not practical to check due to calibration generator limitation. To check attenuator accuracy in these positions, check the 10 and 20 V per division settings.

4. Check Probe Compensation (Low Frequency Pulse Response)

   a. Set up the equipment as shown in Figure A-15.

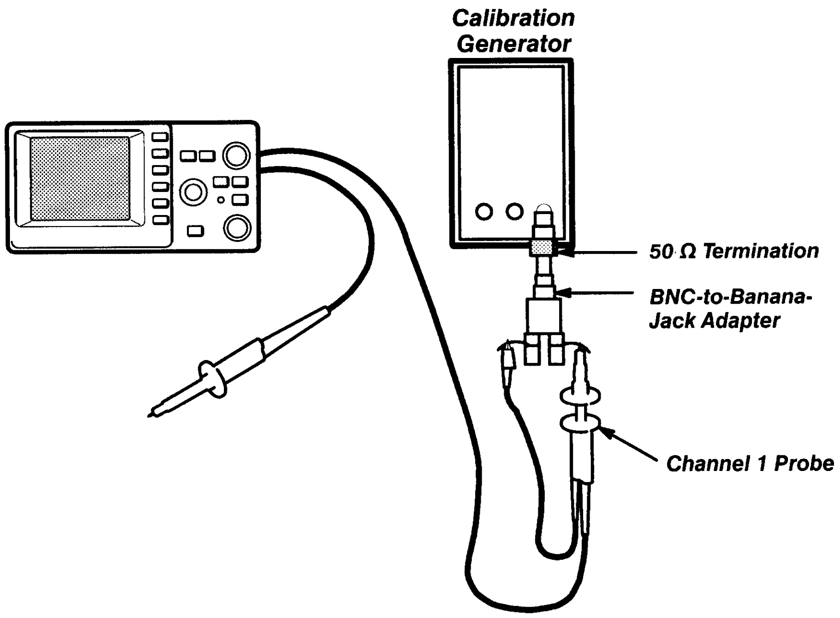


Figure A-15: Setup for Probe Compensation Check

b. Set:

CH 2 Coupling	OFF
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	50 mV
SEC/DIV	0.2 ms
TRIG POS	MID

c. Set the Calibration Generator output for a positive fast-rise signal with a 1 ms period.

d. Adjust the Calibration Generator pulse amplitude for a 5-division display.

e. Vertically position the top of the square wave on the second horizontal graticule line above the center.

f. Position the rising edge at the trigger position to the center vertical graticule line.

g. CHECK for 0.15 division or less of rolloff or overshoot at the front corner.

h. Set:

CH 1 Coupling	CH1 OFF
CH 2 Coupling	DC
CH 2 **VOLTS/DIV**	50 mV

i. Disconnect the channel 1 probe from the BNC-to-banana-jack adapter and connect the channel 2 probe.

j. Repeat parts e – g for channel 2.

k. Disconnect the channel 2 probe from the test equipment.

5. Check Analog Bandwidth (Set up the test equipment as shown in Figure A-16.)

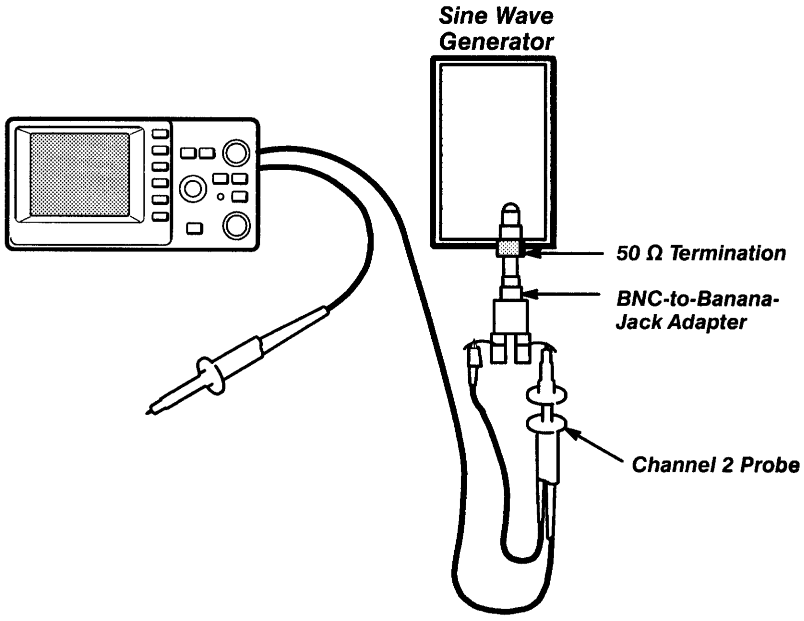


Figure A-16: Setup for Analog Bandwidth Check

a. Set:

CH 2 **VOLTS/DIV**	0.5 V
SEC/DIV	5 µs

b. Set the Leveled Sine Wave Generator for a display amplitude of 6 divisions at 50 kHz.

c. Set the **SEC/DIV** control to 50 ns.

d. Set the Leveled Sine Wave Generator output frequency to 10 MHz.

e. CHECK that the display amplitude is at least 4.2 divisions.

f. Return the Leveled Sine Wave Generator output frequency to 50 kHz.

g. Set:

CH 2 Coupling	CH2 OFF
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	0.5 V
SEC/DIV	5 µs

h. Disconnect the channel 2 probe from the test equipment and connect the channel 1 probe.

i. Vertically center the display.

j. Repeat parts b, c, d, and e for channel 1.

Horizontal Check

This horizontal check procedure verifies characteristics that relate to the time-base system and that are listed as checked under *Warranted Characteristics* in *Appendix D: Specification*. Set up the test equipment as shown in Figure A-17.

Equipment Required (See Table A-8)

Time-Mark Generator (Item 10)
50 Ω BNC Termination (Item 5)
BNC-to-banana-jack Adapter (Item 1)
External Power AC Adapter (Item 3)
2 P850 probes (Item 11)

Prerequisites

Self Tests and Autoset Tests starting on page A-39

Preliminaries on page A-47

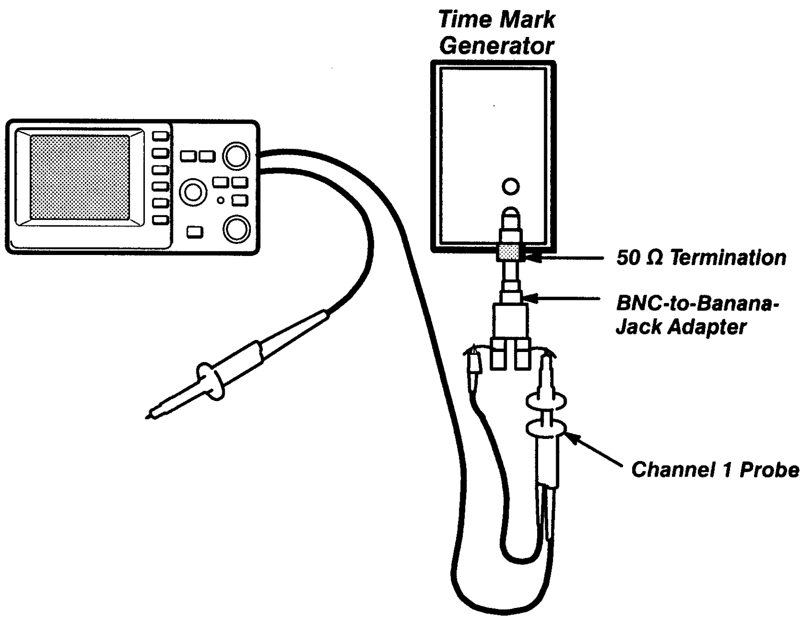


Figure A-17: Setup for Horizontal Test

Initial Control Settings

Power and Display

External Power	External Power AC Adapter connected
Power	**ON**

Vertical Area

CH 2 Coupling	CH2 OFF
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	0.1 V
CH 1 **VAR**	CAL

Horizontal Area

SEC/DIV	1 ms
X10 MAG	OFF

Trigger Area

Trigger **MODE**	AUTOLVL
Trigger **SOURCE**	VERT
Trigger **SLOPE**	+

Top Panel Controls

TRIG POS	POST
STORE	STORE
DISPL	
INV1	OFF
INV2	OFF
XY	OFF
RO OFF	OFF (not selected)
ACQ	NORM

Procedure

1. Check X1 Seconds-per-Division Accuracy

   a. Press the **CLEAR** button to clear the display.

   b. Set the Time Mark Generator to output 1 ms time markers.

   c. Vertically position the baseline of the time-mark signal to the center horizontal graticule line.

   d. Horizontally position the left time marker with the first vertical graticule line.

e. CHECK the accuracy over the center 8 divisions. Accuracy should be ± 0.16 divisions (2%).

f. Disconnect the test equipment from the oscilloscope.

Trigger Checks

The Trigger Checks procedures verify those characteristics that relate to the trigger systems and that are listed as checked under *Warranted Characteristics* in *Appendix D: Specifications*. Set up the test equipment as shown in Figure A-18.

Equipment Required (See Table A-8)

Leveled Sine Wave Generator (Item 9)
BNC-to-dual-banana-plug Adapter (Item 7)
BNC-T connector (Item 8)
BNC-to-banana-jack Adapter (Item 1)
50 Ω BNC Termination (Item 5)
External Power AC Adapter (Item 3)
BNC Coaxial Cable (Item 6)
2 P850 Probes (Item 11)

Prerequisites

Self Tests and Autoset Tests starting on page A-39

Preliminaries on page A-47

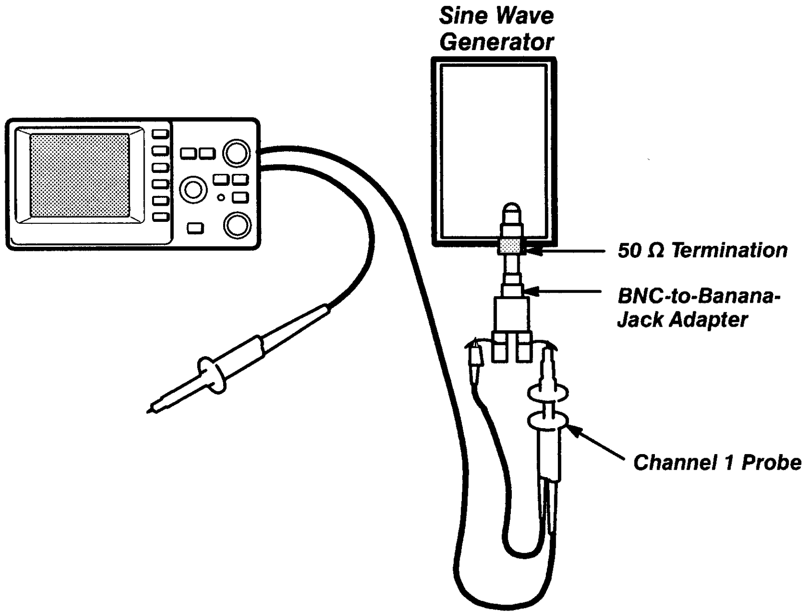


Figure A-18: Setup for Trigger Checks

Initial Control Settings

Power and Display

External Power	External Power AC Adapter connected
Power	**ON**

Vertical Area

CH 2 Coupling	CH2 OFF
CH 2 **VAR**	CAL
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	50 mV
CH 1 **VAR**	CAL

Horizontal Area

X10 MAG	OFF
SEC/DIV	50 ns

Trigger Area

Trigger **MODE**	AUTOLVL
Trigger **SLOPE**	+
Trigger **SOURCE**	VERT

Top Panel Controls

TRIG POS	POST
STORE	STORE

DISPL

INV1	OFF
INV2	OFF
XY	OFF
RO OFF	OFF (not selected)
ACQ	NORM

Procedure

1. Check Trigger Sensitivity
   a. Set the Leveled Sine Wave Generator for a 5 division display amplitude at 10 MHz.
   b. Set the channel 1 **VOLTS/DIV** control to 0.5 V.
   c. Push **AUTOLVL** knob.
   d. CHECK for a stable display with the **TRIG'D** indicator on.
   e. Set the **SEC/DIV** control to 0.2 ms.
   f. Set channel 1 **VOLTS/DIV** control to 50 mV.
   g. Return the Leveled Sine Wave Generator to 50 KHz and adjust for a 5 division display amplitude.
   h. Set the **SEC/DIV** control to 0.2 ms.

   i. Press **INIT** to restart the acquisition.
   j. CHECK that the display fills completely in less than 10 s.

2. Check External Trigger Sensitivity (Set up the test equipment as shown in Figure A-19.)

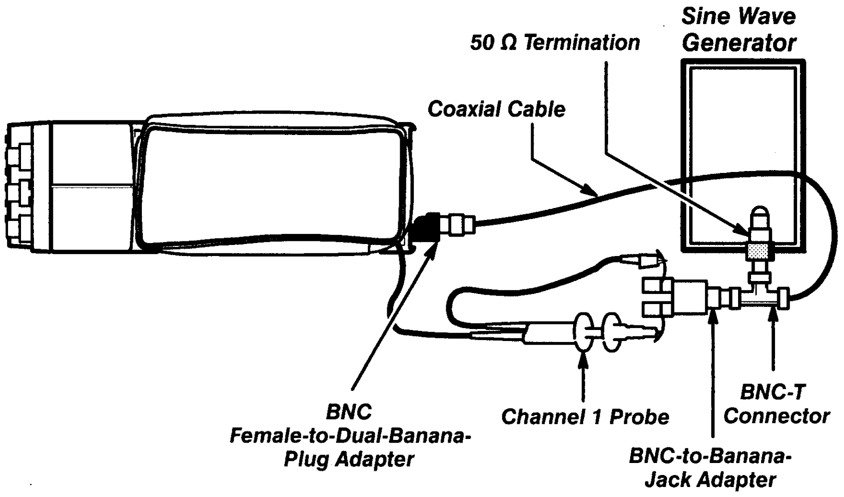


Figure A-19: Setup for External Trigger Sensitivity Check

a. Set:

CH 2 Coupling	GND
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	50 mV
Trigger **SOURCE**	EXT
STORE	OFF (not selected)
SEC/DIV	5 µs

b. Connect the Leveled Sine Wave Generator output via a 50 Ω termination, a BNC-T connector, and a BNC-to-banana-jack adapter to the channel 1 probe.

c. Connect the other side of the BNC-T connector via a 50 Ω coaxial cable and BNC-to-dual-banana-plug connector to the **EXT TRIG INPUT** and **EXT TRIG COMM** input jacks on the rear panel.

   d. Vertically center the display.
   e. Set the **SEC/DIV** control to 50 ns.
   f. Set the Leveled Sine Wave Generator to display 5 divisions of amplitude at 50 kHz.
   g. CHECK for a triggered display (**TRIG'D** indicator light on).
   h. Set the Leveled Sine Wave Generator to display 5 divisions of amplitude at 10 MHz.
   i. CHECK for a triggered display (**TRIG'D** indicator light on).
   j. Disconnect the probe from the test equipment.

3. Check Motor Trigger
   a. Connect the fast rise output of the Calibration Generator through the BNC-to-banana-plug adapter to the CH 1 probe tip.
   b. Set the Calibration Generator frequency to 1 kHz.
   c. Press the **AUTO:LVL PUSH** button to center the trigger level on the waveform.
   d. Adjust the Calibration Generator frequency to the point where the trigger of the waveform is just able to be maintained.
   e. Verify that the negative portion of the displayed square wave is between 2.0 and 3.0 ms.
   f. Disconnect the test equipment from the instrument.

Appendix E: Specifications

This section contains a collection of tables that list the various traits that describe the 222PS PowerScout. This section is divided into three subsections, one for each of three classes of traits: *nominal traits, warranted characteristics,* and *typical characteristics.*

Nominal Traits

This subsection contains a collection of tables that list the various *nominal traits* that describe the 222PS PowerScout. Included are electrical and mechanical traits.

Nominal traits are described using simple statements of fact such as "Two full featured" for the trait "Input Channels, Number of," rather than in terms of limits that are performance requirements.

Table A-10: Nominal Traits—Vertical System

Name	Description
Digitizers, Number of	Two, both identical
Digitized Bits, Number of	8 bits, 25 levels per division, 10.24 divisions of dynamic range
Input Channels, Number of	Two full-featured (CH 1 and CH 2)
Input Coupling	DC, AC, GND or OFF
Maximum Input Voltage, Probe Tip to Common	850 V (DC + peak AC) or 600 VAC rms[1]; Peak Surge Voltage: 6000 V for 250 µs or less (P850 only); derate with increased frequency according to Figure A-20

Table A-10: Nominal Traits—Vertical System (Cont.)

Name	Description
Maximum Input Voltage, Probe Common to Chassis	850 V (DC + peak AC) or 600 VAC rms[1]; Peak Surge Voltage: 6000 V for 250 µs or less (P850 only); derate with increased frequency according to Figure A-21
Maximum Input Voltage, Between Channels	1700 V (DC + peak AC) or 1200 VAC rms[1]
Pulse Width, Minimum Detectable	Envelope and Continuous Envelope Modes: 100 ns
Range, Sensitivity, CH 1 and CH 2	1X probe: 5 mV/div to 50 V/div in a 1-2-5 settings sequence10X probe: 50 mV/div to 500 V/div in a 1-2-5 settings sequence
Single Shot Storage, Useful Bandwidth[2]	Normal Acquisition Mode: $\frac{5}{SEC/DIV\ Setting}$ Hz or 1 MHz, whichever is less Envelope and Continuous Envelope Modes: 1 MHz

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[1] Performance requirement not checked in manual.

[2] Useful storage bandwidth is limited to the frequency where there are 10 Display Sample/Sine Wave Signal periods. At seconds-per-division settings faster than 5 µs/Div, Storage Bandwidths are limited to 1 MHz max sampling rate.

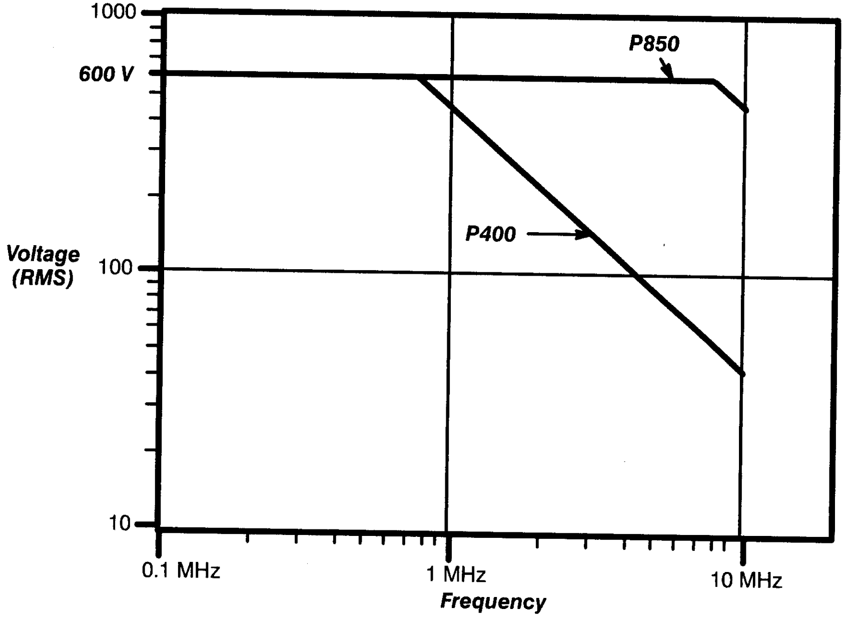

Figure A-20: Maximum Normal-Mode Voltage Versus Frequency Derating Curve

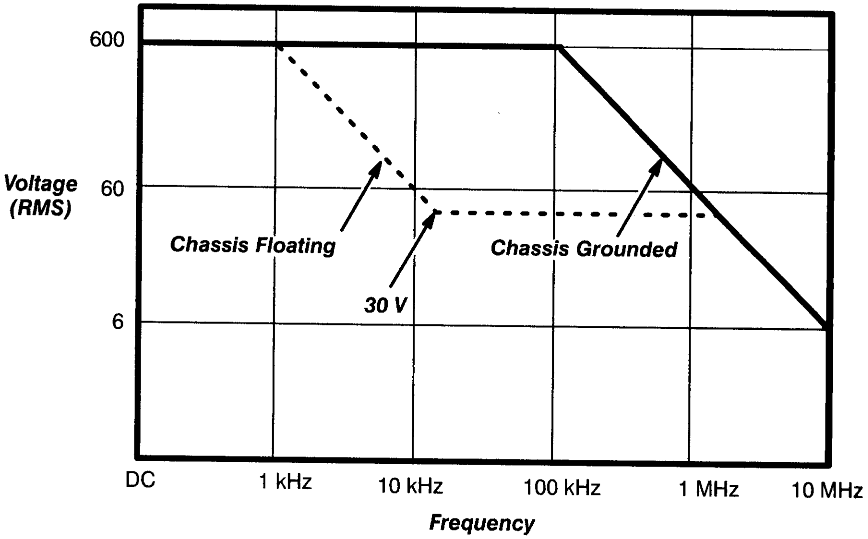

Figure A-21: Maximum Common-Mode Voltage Versus Frequency Derating Curve

Table A-11: Nominal Traits—Horizontal System

Name	Description		
	Time/Div	*Acquisition Mode*	*Sample-Rate Range*
Range, Sample-Rate	5 µs to 20 s/div	Normal	50/(sec/div) Samples/sec
	2 µs/div	Normal	5 MSamples/sec
	50 ns to 1 µs/div	Normal	10 MSamples/sec
	20 µs to 20 s/div	Envelope	10 MSamples/sec
Range, Seconds/Division	50 ns/div to 20 s/div; the X10 MAG control extends the maximum sweep speed to 5 ns/div		
Record Length	512 points; 50 points per division		

Table A-12: Nominal Traits—Triggering System

Name	Description
External Trigger Maximum Input Voltage[1], Input to Common, Input to Earth Ground, Common to Earth Ground	42 V (DC + peak AC)

[1] The external trigger input is not intended for floating measurements beyond 42 V peak.

Table A-13: Nominal Traits—Display System

Name	Description
CRT Display Size	Display area of 6.4 cm (2.5 in) measured diagonally
Waveform Display Graticule	Single graticule: 8 divisions high by 10 divisions wide, where divisions are 0.5 cm by 0.5 cm (0.2 in by 0.2 in)
CRT Reflectivity	CRT filter shield has an anti-reflectance surface to aid viewing in high ambient light conditions

Table A-14: Nominal Traits—Power System

Name	Description
Internal Battery, Type	Sealed lead-acid
External Power, Input Voltage Range Pin to Pin	DC: 12 to 28 VDC AC: 16 to 20 V AC, 47 Hz to 400 Hz
External Power, Input Voltage Range Either Pin to EXT TRIG COM or RS-232 SGND (signal ground)	−0.5 to 28 V (DC + peak AC)

Table A-15: Nominal Traits—Communications Interface

Name	Description
COMM PORT Interface, Type	Complies with RS-232-C specification
COMM PORT Interface, Baud Rates	300, 1200, 2400, and 9600
COMM PORT Interface, Signals	RD, TD and SGND normally used (configured as a DCE device). When the instrument is off, a rising edge on DTR will turn instrument power on
Maximum Input Voltage, Any Pin	25 V (DC + peak AC)

Table A-16: Nominal Traits—Mechanical

Name	Description
Cooling Method	Conduction through cabinet walls; there are no cooling vents
Construction Material	Cabinet/chassis parts constructed of plastic with the internal surface coated with conductive paint for shielding; circuit boards constructed of glass-laminate with predominantly surface mount components
Finish Type	Tektronix Blue cabinet with black synthetic rubber hand grips and black vinyl probe pouch
Weight	Without accessories 2 kg (4.4 lbs) With accessories 2.72 kg (6.0 lbs)
Overall Dimensions	Height: 86.4 mm (3.4 in) Width: 159 mm (6.25 in), with handle. Length: 252 mm (9.9 in)
Probe Length, Detachable	2.0 m (78.7 in), P850

Warranted Characteristics

This subsection lists the various *warranted characteristics* that describe the 222PS PowerScout. Included are electrical and environmental characteristics.

Warranted characteristics are described in terms of quantifiable performance limits that are warranted.

NOTE

In these tables, those warranted characteristics that are checked in the procedure Performance Verification, *found in Appendix C, appear in* **boldface type** *under the column* **Name**.

As stated above, this subsection lists only warranted characteristics. A list of *typical characteristics* starts on page A-76.

Performance Conditions

The electrical characteristics found in these tables of warranted characteristics apply when the scope has been adjusted at an ambient temperature between +15° C and +35° C and is operating at an ambient temperature within ±5° C of the temperature at which self-calibration was performed (unless otherwise noted).

Table A-17: Warranted Characteristics—Vertical System

Name	Description
Accuracy, DC Gain (+15 to +35° C)	±4%, valid when self-cal performed within ±5° C of ambient temperature
Accuracy, DC Gain (Ambient Temperature −15 to +15° C and +35 to +55° C)	±5%, valid when self-cal performed within ±5° C of ambient temperature
Analog Bandwidth, Repetitive Signal[1]	$\frac{5}{SEC/DIV\ Setting}$ Hz or 10 MHz whichever is less
Balance, DC	±0.2 divisions maximum trace shift between VOLTS/DIV settings, valid when self-cal performed within ±5° C of ambient temperature
Balance, Invert	±0.4 divisions maximum trace shift between inverted and non-inverted displays, valid when self cal performed within ±5° C of ambient temperature
Input Current	2.5 nA maximum (0.5 divisions or less when switching between DC and GND input coupling with VOLTS/DIV set at 50 mV/div)
Pulse Response Aberrations, Low Frequency	±3% maximum (0.15 divisions with a 5 division signal displayed)

Table A-17: Warranted Characteristics—Vertical System (Cont.)

Name	Description
Rise Time, Useful for Repetitive Signals	$\frac{(SEC/DIV\ Setting) * 1.6}{50}$ or 35 ns, whichever is greater

[1] Useful repetitive bandwidth is limited to the frequency at which 10 display samples are acquired for each sine wave period. For example at 10 µs per division the useful repetitive bandwidth is 500 kHz. At seconds-per-division settings faster than 0.5 µs/div, repetitive bandwidth is limited to 10 MHz by the input amplifier.

Table A-18: Warranted Characteristics—Horizontal System

Name	Description
Accuracy, Displayed (X1)	±2% with X1 magnification
Accuracy, Displayed (X10)	±5% with X10 magnification

Table A-19: Warranted Characteristics—Triggering System

Name	Description
Jitter, Trigger	2 μs/div to 50 ns/div: 1/50 division ±2 ns in X1 magnification 1/5 division ±2 ns in X10 magnification
Sensitivity, CH 1 and CH 2[1]	0.5 division p-p at 10 MHz
Sensitivity, External Trigger	250 mV p-p at 10 MHz

[1] **The minimum sensitivity for obtaining a stable trigger. A stable trigger results in a uniform, regular display triggered on the selected slope. The trigger point must not switch between opposite slopes on the waveform and the display must not "roll" across the screen on successive acquisitions. The TRIG'D LED stays constantly lit when the seconds-per-division setting is 2 ms or faster but may flash when the setting is 10 ms or slower.**

Table A-20: Warranted Characteristics—Environmental, Safety, and Reliability

Name	Description
Atmospherics	Temperature: −15 to +55° C, operating; −30 to +70° C, non-operating Relative humidity: 0 to 95% (−5%, +0%), operating to +55° C; non-operating to 60° C Altitude: Operating: to 4572 m (15,000 ft); Nonoperating: to 15240 m (50,000 ft); Maximum Operating Temperature decreases 1° C/300 m (1000 ft) above 15240 m (50,000 ft)
Dynamics	Vibration, Sinusoidal (Operating and Nonoperating): Meets or exceeds MIL-T-28800D, Class III Shock, 50 G, half-sine, 11 ms duration: Meets or exceeds MIL-T-28800D, Class III
Emissions, Electromagnetic	Meets or exceeds the requirements of the following standards: VDE 0871, Class B[1] FCC Rules and Regulations, Part 15, Subpart B, Class A
User-Misuse Simulation	Electrostatic Discharge Susceptibility: Conforms to IEC 801-2 Bench Use (Operating and Nonoperating): One 10.6 cm (4 in) or balance point drop per corner

[1] **To ensure compliance use the specified shielded cable and connector housing for the RS-232 connections and detach the probes or store them in the probe pouch.**

Typical Characteristics

This subsection contains tables that lists the various *typical characteristics* that describe the 222PS PowerScout.

Typical characteristics are described in terms of typical or average performance. Typical characteristics are not warranted.

This subsection lists only typical characteristics. A list of warranted characteristics starts on page A-72.

Table A-21: Typical Characteristics—Vertical System

Name	Description
Common Mode Rejection Ratio, DC – 100 kHz	60 dB minimum (P850 probe), 1000:1 80 dB minimum (P400 probe), 10,000:1
Input Capacitance, Common to Chassis	150 pF
Input Capacitance Probe Tip to Common	X1 probe (P400): 30 pF X10 probe (P850): 4.5 pF
Input Resistance, Probe Tip to Common	X1 probe: 1 MΩ X10 probe: 10 MΩ
Isolation, Common Mode, DC – 100 kHz	80 dB minimum
Isolation, Normal Mode, DC – 10 MHz	80 dB minimum, 10000:1 (P400)
Slew Rate, Maximum Common Mode	10,000 V/μs
Range, Position, CH 1 and CH 2	±12 divisions minimum
Range, Variable VOLTS/DIV	Increases deflection factor by ≥250%

Table A-22: Typical Characteristics—Horizontal System

Name	Description
Accuracy, Sample Rate	±0.01%
Position Control Range	Either end of waveform can be positioned past the center vertical graticule line
Display Sweep Length	10.24 divisions

Table A-23: Typical Characteristics—Triggering System

Name	Description
Input Capacitance, External Input	18 pF
Input Resistance, External Input	1 MΩ
Trigger Level Range, External Input	±2.0 V
Trigger Level Range, Internal	±20 divisions

Table A-24: Typical Characteristics—Power System

Name	Description
Battery, Charge Time	Three hours for full charge with instrument turned off
Battery, Excessive Discharge Protection	Instrument operation automatically interrupted when battery voltage drops to 7.32 VDC
Battery, Minimum Operating Time	Three hours at 25° C
Battery, Capacity Over Operating Temperature	−15° C: 80% 25° C: 100% 55° C: 110%

Table A-24: Typical Characteristics—Power System (Cont.)

Name	Description
Current, Demand	1 A Max (when charging battery)
Consumption, Maximum	15 watts or 16 VA (maximum power demand occurs when charging the battery)

Appendix F: Accessories

This appendix provides a list of standard and optional accessories for the 222PS, with Tektronix part numbers. To order an accessory, determine its part number and contact your local Tektronix field office or representative. In the United States, you can also call the Tektronix National Marketing Center toll-free at 1-800-426-2200.

For more information about Tektronix products and accessories, see the current Tektronix Product Catalog.

Standard Accessories

The following accessories come with the instrument.

Table A-25: Standard Accessories

Accessory	Part Number
222PS PowerScout Operator Manual	070-8097-XX
222PS, 222A, and 224 Reference	070-8965-XX
External power AC adapter (110 VAC)	120-1807-00
Instrument carrying case	016-1024-01
Cabinet feet accessory kit	020-1752-00
10X probe with accessories (two each)	P850
Industrial Lead Set (2)	012-1392-00

Optional Accessories

You can order the following accessories.

Table A-26: Optional Accessories

Accessory	Part Number
222PS PowerScout Service Manual	070-8098-XX
Spare battery	146-0075-00
Accessory pouch (for spare battery or external power AC adapter)	016-0993-01
RS-232 cable	174-1453-00
BNC-female-to-dual-banana-plug adapter	103-0090-00
BNC-male-to-dual-banana-jack adapter	103-0035-00
Version 2.1 utility software	063-1585-00
1X probe with accessories	P400
Automotive lead set	020-2080-00
Automotive self-study training package	650-3076-00
External trigger probe with accessories (requires BNC-female-to-dual-banana-plug adapter)	P6122
Virtual instrument software package	CAT200
Intelligent printer interface	WP200
1X BNC-to-Probe Adaptor	206-0451-00
External battery charger with field accessories: External battery charger External battery charger data sheet Accessory pouch Viewing hood Spare battery Cigarette lighter adapter power cable Accessory kit data sheet	BAT200

Instrument Options

You can order the following options for the 222PS PowerScout.

Table A-27: Instrument Options

Description	Part Number
Option 05 — instrument supplied with CAT200 Virtual Instrument Software	CAT200
Option 04 — instrument supplied with WP200 Intelligent Printer Interface	WP200

External Power AC Adapter Options

You can order the following options for the external power AC adapter.

Table A-28: External Power AC Adapter Options

Description	Part Number
Option 02 — instrument supplied without external power AC adapter	————————
Option A1 — European 220 V	120-1826-00
Option A2 — UK 240 V	120-1827-00