



# **PART ONE**

# **ABOUT**

# **REMOTE CONTROL**

**Part One of the manual explains how Waverunner operates under remote control. It covers GPIB and RS-232-C interfaces, the transfer and formatting of waveforms, and the use of status bytes in reporting errors.**

## **CHAPTER ONE: *Overview***

**In this chapter, see how**

*To construct program messages*

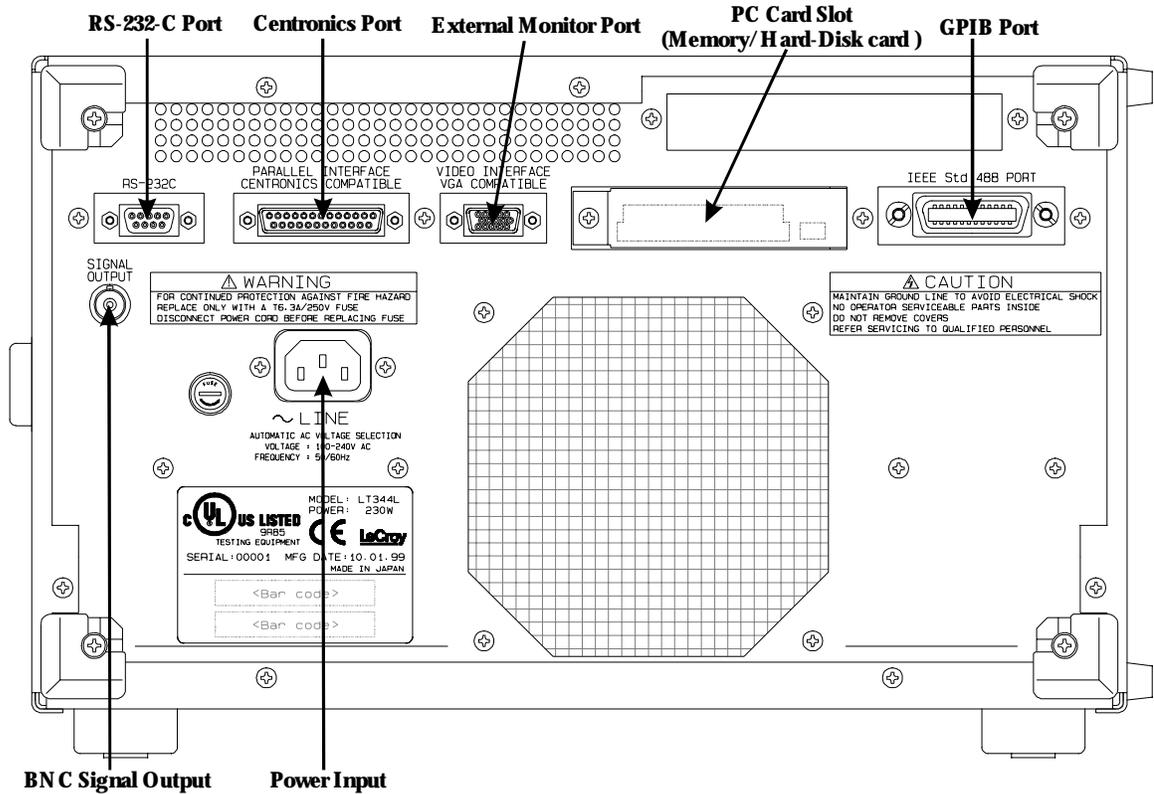
*To use commands and queries*

*To include data, and make data strings*

*To use ScopeExplorer® for remote control*

## Operate Waverunner by Remote Control

You can fully control your Waverunner oscilloscope remotely by using either the GPIB (General Purpose Interface Bus) port or the RS-232-C communication port on the scope rear panel, shown below. The only actions for which you must use the front panel controls are the powering up of the scope and the setting of remote addresses. Use LeCroy's ScopeExplorer software as the ideal interface between scope and PC (see page 11).



Waverunner back panel, including the GPIB and RS-232-C ports used in remote control.

**TIP:** Use Waverunner Remote Control Assistant to monitor all your remote control operations. See the `COMM_HELP` command in Part Two of this manual, and Chapter 12 of the Operator's Manual, "Use Waverunner with PC".

## STANDARDS

LeCroy remote control commands conform to the GPIB IEEE 488.2\* standard. This may be considered an extension of the IEEE 488.1 standard, which deals mainly with electrical and mechanical issues. The IEEE 488.2 recommendations have also been adopted for RS-232-C communications wherever appropriate.

## PROGRAM MESSAGES

You control the oscilloscope remotely using program messages that consist of one or several commands or queries. The program messages you send from the external controller to the Waverunner oscilloscope must conform to precise format structures. The oscilloscope will execute all program messages sent in the correct form, but will ignore those with errors.

You can use upper- or lower-case characters, or both, in program messages.

Warning or error messages are normally not reported unless the controller explicitly examines the relevant status register, or if the status-enable registers have been set so that the controller can be interrupted when an error occurs. If you connect an external monitor to the Waverunner's RS-232-C port, however, you will be able to observe all your remote control transactions, including error messages, as they happen. See the command `COMM_HELP` in Part Two, "Commands."

Program messages are separated by semicolons ; and end in a terminator:  
<command/ query>;.....;<command/ query> <terminator>.

The oscilloscope will not decode an incoming program message before receiving its terminator. The exception is when the program message is longer than the 256 byte input buffer; then the oscilloscope will start analyzing the message when the buffer is full. Commands and queries are executed in the order in which they are transmitted.

In GPIB mode, the following are valid terminators:

- <NL> New-line character (i.e. the ASCII new-line character, whose decimal value is 10).
- <NL><EOI> New-line character with a simultaneous <EOI> signal.
- <EOI><EOI> Signal together with the last character of the program message.

The <NL> <EOI> terminator is always used in response messages sent by the oscilloscope to the controller.

In RS-232-C communications, you can define the terminator with the command `COMM_RS232`. The default value is <CR>, which is the ASCII carriage return character, whose decimal value is 13.

***NOTE: The <EOI> signal is a dedicated GPIB interface line, which can be set with a special call to the GPIB interface driver. Refer to the GPIB interface manufacturer's manual and support programs.***

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\*ANSI/IEEE Std. 488.2-1987, IEEE Standard Codes, Formats, Protocols, and Common Commands. The Institute of Electrical and Electronics Engineers Inc., 345 East 47th Street, New York, NY 10017 USA.

## COMMANDS AND QUERIES

Program messages are made up of one or more commands or queries. While the command directs the oscilloscope to change its state (for example, its timebase or vertical sensitivity) the query asks the oscilloscope about that state. Very often, you will use the same mnemonic for a command and a query, the query being identified by a ? after the last character.

For example, to change the timebase to 2 ms/div, send this command to the oscilloscope:

```
TIME_DIV 2 M
```

Or, to ask the oscilloscope about its timebase, send this query:

```
TIME_DIV?
```

A query causes the oscilloscope to send a response message. The control program should read this message with a 'read' instruction to the GPIB or RS-232-C interface of the controller.

The response message to the above query might be:

```
TIME_DIV 10 NS
```

The portion of the query preceding the question mark is repeated as part of the response message. If desired, this text can be suppressed with the command `COMM_HEADER`.

Depending on the state of the oscilloscope and the computation to be done, several seconds may pass before a response is received. Command interpretation does not have priority over other oscilloscope activities.

The general form of a command or a query consists of a command header, <header>, optionally followed by one or several parameters, <data>, separated by commas:

```
<header> [?] <data> , ... , <data>
```

The notation [?] shows that the question mark is optional (turning the command into a query).

There is a space between the header and the first parameter.

There are commas between parameters.

The following are examples of how program messages are made up of commands and queries..

`GRID DUAL`: This program message consists of a single command that instructs the oscilloscope to display a dual grid.

***TIP: Set the controller I/O timeout conditions to three or more seconds to give the scope time to respond. An incorrect query will not get a response; and, if Remote Control Assistant is enabled, a beep will sound.***



The terminator is not shown, as it is usually automatically added by the interface driver routine writing to GPIB or RS232.

`DZOM ON; DISPLAY OFF; DATE?`: This program message consists of two commands, followed by a query. They instruct the oscilloscope to turn on the multi-zoom mode, turn off the display, and then ask for the current date. Again, the terminator is not shown.

`DATE 15 , JAN , 1993 , 13 , 21 , 16`: This command instructs the oscilloscope to set its date and time to 15 JAN 1993, 13:21:16. The command header `DATE` indicates the action, the 6 data values specify it in detail.

## HEADERS

The header is the mnemonic form of the operation to be performed by the oscilloscope. Most command and query headers have a long form, which allows them to be read more easily, and a short form for better transfer and decoding speed. The two are fully equivalent and you can use them interchangeably. For example, TRIG\_MODE AUTO and TRMD AUTO are two separate but equivalent commands for switching to the automatic trigger mode.

Some command or query mnemonics are imposed by the IEEE 488.2 standard. They are standardized so that different oscilloscopes will present the same programming interface for similar functions. All these mnemonics begin with an asterisk \*. For example, the command \*RST is the IEEE 488.2 imposed mnemonic for resetting the oscilloscope, whereas \*TST? instructs the oscilloscope to perform an internal self-test and report the outcome.

## HEADER PATHS

Certain commands or queries apply to a sub-section of the oscilloscope; for example, a single input channel or a trace on the display. In such cases, you must prefix the header by a path name that indicates the channel or trace to which the command applies. The header path normally consists of a two-letter path name followed by a colon : immediately preceding the command header. One of the waveform traces can usually be specified in the header path:

HEADER PATH NAME	WAVEFORM TRACE
C1, C2	Channels 1 and 2
C3, C4	Channels 3 and 4 (on four-channel models)
M1, M2, M3, M4	Memories 1, 2, and 3 and 4
TA, TB, TC, TD	Traces A, B, C and D
EX, EX10, EX5	External trigger
LINE	LINE source for trigger

Example: C1:OFST -300 MV                      Command to set the offset of Channel 1 to -300 mV.

You need only specify a header path once. Subsequent commands with header destinations not indicated are assumed to refer to the last defined path. For example, the queries C2:VDIV? ; C2:OFST? ask: What is the vertical sensitivity and the offset of channel 2? While the queries C2:VDIV? ; OFST? ask exactly the same question without repeating the path.

**DATA**

Whenever a command or query uses additional data values, the values are expressed as ASCII characters. There is a single exception: the transfer of waveforms with the command/query `WAVEFORM`, where the waveform can be expressed as a sequence of binary data values. See Chapter 4, “Waveform Structure.” ASCII data can have the form of character, numeric, string, or block data.

**CHARACTER DATA**

These are simple words or abbreviations to indicate a specific action.

Example: `DUAL_ZOOM ON`

In this example, the data value `ON` commands the dual zoom mode to be turned on (the data value `OFF` will have the opposite effect).

However, this can become more complex. In some commands, where you can specify as many as a dozen different parameters, or where not all the parameters are applicable at the same time, the format requires pairs of data values. The first value names the parameter to be modified, while the second gives its value. Only those parameter pairs changed need to be indicated.

Example: `HARDCOPY_SETUP DEV, EPSON, PORT, GPIB`

In this example, two pairs of parameters have been used. The first specifies the device as an `EPSON` (or compatible) printer, while the second indicates the `GPIB` port. While the command `HARDCOPY_SETUP` allows many more parameters, either they are not relevant for printers or they are left unchanged.

**NUMERIC DATA**

The numeric data type is used to enter quantitative information. Numbers can be entered as integers or fractions, or in exponential representation:

<code>TA:VPOS -5</code>	Move the displayed trace of Trace A downwards by five divisions.
<code>C2:OFST 3.56</code>	Set the DC offset of Channel 2 to 3.56 V.
<code>TDIV 5.0E-6</code>	Adjust the timebase to 5 $\mu$ sec/div.

Example: There are many ways of setting the timebase of the oscilloscope to 5  $\mu$ sec/div:

<code>TDIV 5E-6</code>	Exponential notation, without any suffix.
<code>TDIV 5 US</code>	Suffix multiplier <code>U</code> for $1E-6$ , with the (optional) suffix <code>S</code> for seconds.
or	
<code>TDIV 5000 NS</code>	
<code>TDIV 5000E-3 US</code>	

You can follow numeric values with multipliers and units, to modify the value of the numerical expression. The following mnemonics are recognized:

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MULTIPLIER	EXP. NOTE.	SUFFIX	MULTIPLIER	EXP. NOTE.	SUFFIX
EX	1E18	Exa-	PE	1E15	Peta-
T	1E12	Tera-	G	1E9	Giga-
MA	1E6	Mega-	K	1E3	kilo-
M	1E-3	milli-	U	1E-6	micro-
N	1E-9	nano-	PI	1E-12	pico-
F	1E-15	femto-	A	1E-18	atto-

### STRING DATA

This data type enables you to transfer a (long) string of characters as a single parameter. Simply enclose any sequence of ASCII characters between single or double quotation marks:

```
MESSAGE 'Connect probe to point J3'
```

The oscilloscope displays this message in the Message field above the grid.

### BLOCK DATA

These are binary data values coded in hexadecimal ASCII: four-bit nibbles translated into the digits 0 through 9 or A through F, and transmitted as ASCII characters. They are used only for the transfer of waveforms from Waverunner to controller (WAVEFORM) and for Waverunner panel setups (PANEL\_SETUP)

### RESPONSE MESSAGES

The oscilloscope sends a response message to the controller in answer to a query. The format of such messages is the same as that of program messages: individual responses in the format of commands, separated by semicolons ; and ending in terminators. These messages can be sent back to the oscilloscope in the form in which they were received, to be accepted as valid commands. In GPIB response messages, the <NL> <EOI> terminator is always used.

Example: The controller sends the program message:

```
TIME_DIV?;TRIG_MODE NORM;C1:COUPLING? (terminator not shown).
```

The oscilloscope might respond to this with:

```
TIME_DIV 50 NS;C1:COUPLING D50 (terminator not shown).
```

The response message refers only to the queries: TRIG\_MODE is left out. If this response is sent back to the oscilloscope, it is a valid program message for setting its timebase to 50 ns/div and the input coupling of Channel 1 to 50  $\Omega$ .

Whenever you expect a response from the oscilloscope, you must have the control program instruct the GPIB or RS-232-C interface to read from the oscilloscope. If the controller sends another program message without reading the response to the previous one, the response message in the output buffer of the oscilloscope will be

discarded. The oscilloscope keeps to stricter rules for response messages than for acceptance of program messages. While you can send program messages from the controller in upper- or lower-case characters, response messages are always returned in upper-case. Program messages may contain extraneous spaces or tabs (white space), but response messages will not. And while program messages may contain a mixture of short and long command or query headers, response messages always use short headers by default.

However, you can use the command `COMM_HEADER` to force the oscilloscope to use long headers, or none at all. If the response header is omitted, the response transfer time will be minimized. But the response will not be able to be sent back to the oscilloscope. Suffix units are also suppressed in the response.

If you were to set the trigger slope of Channel 1 to negative, the query `C1:TRSL?` might yield the following responses:

```
C1:TRIG_SLOPE NEG      header format: long
C1:TRSL NEG           header format: short
NEG                   header format: off
```

***TIP: Waveforms you obtain from the oscilloscope using the query `WAVEFORM?` are a special kind of response message. Control their exact format by using the `COMM_FORMAT` and `COMM_ORDER` commands.***



**USE SCOPEEXPLORER**

ScopeExplorer is an easy-to-use and practical software tool for interfacing your Waverunner oscilloscope with a PC running Windows:

1. Connect the scope to a PC using either the GPIB (you'll need a PC with GPIB card installed) or PC-standard RS-232-C port on the scope's rear panel.
2. Download ScopeExplorer free of charge at <http://www.lecroy.com/scopeexplorer>. Or inquire at your LeCroy customer service center.
3. Having installed ScopeExplorer, open it as you would any Windows program. Use its on-line help to do the following:

Use the teletype-like terminal to send standard remote control commands from computer to oscilloscope, and to display the Waverunner response on the PC.

Control the scope by means of an interactive, virtual scope front panel.

Pipe sequences of commands from a file to the scope, then send the scope's responses to another file.

Transfer pixel-for-pixel copies of your Waverunner display to PC, then view them, print them, or both from the computer. With a single press of a button or key, you can copy bitmap waveform images to the Windows Clipboard, ready to paste into any Windows application.

Capture Waverunner front panel setups and, using a long filename, store them on the computer. You can then transfer them back into the scope to reproduce an identical setup.

Transfer your waveforms to PC, and store them in either the compact LeCroy Binary format, or an ASCII version compatible with PC-based analysis products.

