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Operation Manual

Shutter Controller

SR470

Stanford Research Systems

Revision 1.0 • April 7, 2009

Certification

Stanford Research Systems certifies that this product met its published specifications at the time of shipment.

Warranty

This Stanford Research Systems product is warranted against defects in materials and workmanship for a period of one (1) year from the date of shipment.

Service

For warranty service or repair, this product must be returned to a Stanford Research Systems authorized service facility. Contact Stanford Research Systems or an authorized representative before returning this product for repair.

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General Information

The SR470 Shutter Controller is a flexible instrument capable of powering, controlling, and providing I/O interfaces for an external SR470 Series Laser Shutter head.

Shutter control modes include manual control from the front panel, control by an external TTL signal, and control by internal timing, including triggerable bursts.

Remote operation is supported with GPIB, RS-232 and Ethernet computer interfaces. All instrument functions can be controlled and read over any of the interfaces. Shutter faults are automatically detected and result in audible, visible and electronic alarms.

Safety and Preparation for Use

WARNING **Dangerous voltages, capable of causing injury or death, are present in this instrument. Use caution whenever the instrument covers are removed. Do not remove the covers while the unit is plugged into a live outlet.**

CAUTION Never connect any of the shutter output ports to anything besides an SR470 Series Laser Shutter head.

Line Voltage

The universal input power supply of the SR470 accommodates any voltage in the range 90 VAC to 260 VAC, with a frequency in the range 47 Hz to 63 Hz.

Line Cord

The SR470 has a detachable, three-wire power cord for connection to the power source and to a protective ground. The exposed metal parts of the instrument are connected to the outlet ground to protect against electrical shock. Always use an outlet which has a properly connected protective ground.

The shields of the six rear-panel BNC ports, the rear-panel Chassis Ground binding post, and the metal chassis of the instrument are all connected to Earth through the power-line-outlet ground.

Line Fuse

There are two line fuses internal to the SR470 that may not be serviced by the user.

If no front panel LEDs are lit when line power is applied and the power switch is in the “on” position, contact Stanford Research Systems.

Service

Do not attempt to service or adjust this instrument unless another person, capable of providing first aid or resuscitation, is present.

Do not install substitute parts or perform any unauthorized modifications to this instrument. Contact the factory for instructions on how to return the instrument for authorized service and adjustment.

Environment

This product is intended for use only in a clean and dry laboratory environment. Operation in other environments may cause damage to the product. To reduce the risk of fire or electrocution do not expose this product to rain or excessive moisture. Be careful not to spill liquid of any kind onto or into the product.

Laser Safety

⚠ WARNING

Certain hazards are always present when working with laser radiation. Visible and invisible beams of light have the potential to cause serious bodily injury including blindness or death and to cause significant damage to property. While the SR470 is designed for use with laser systems, **it is fully the users responsibility to ensure that safe operating conditions are maintained and to provide for fail-safe operation whenever an equipment failure could lead to a hazardous situation**.

Symbols you may Find on SRS Products

Symbol	Description
	Alternating current
	Caution - risk of electric shock
	Frame or chassis terminal
	Caution - refer to accompanying documents
	Earth (ground) terminal
	Battery
	Fuse
	On (supply)
	Off (supply)

Notation

The following notation will be used throughout this manual.

WARNING A warning means that injury or death is possible if the instructions are not obeyed.

CAUTION A caution means that damage to the instrument or other equipment is possible.

Typesetting conventions used in this manual are:

- Front-panel buttons are set as [Button].
- Front-panel indicators are set as *Remote*.
- Remote command names are set as *IDN?.
- Literal text other than command names is set as `OFF`.

Remote command examples will all be set in monospaced font. In these examples, data sent by the host computer to the SR470 are set as `straight teletype font`, while responses received by the host computer from the SR470 are set as *`slanted teletype font`*.

Specifications

Operation

Shutter Type	SR470 Series Laser Shutters.
Shutter Output	Drives one shutter.
Shutter State	Open or closed, controlled either manually from front-panel inputs or from external TTL input.
Shutter Polarity	User selectable for “normally open” or “normally closed” operation.
Control Modes	Internally or externally triggered with timing generation, direct external level control, or manual.
Manual Control	Front-panel [OPEN] and [CLOSED] buttons command shutter to the corresponding state. [RESET] button commands shutter to its *Normal* state.
Timing Sequence	Pre-delay, exposure time, post-delay. Each time interval may be set independently with 0.1 ms resolution, up to 9,999.9999 seconds.
Bursts	Timing sequence may be repeated after a trigger, from 1 to 99,999,999 times, or continuously.
Sync Output	The rear-panel SYNC OUT TTL signal mirrors whether the shutter is presently commanded to the open or closed state.
Alignment Mode	Front-panel [Align] button (active when in manual mode) opens and closes shutter at 1 Hz chopping rate to assist with mechanical alignment.
Gate/Inhibit	The rear panel AUX I/O 1 port can be configured to allow or disallow TTL control depending on the value of the input TTL level.
Fault Detection and Reporting	Automatic detection of shutter disconnect or fault, with front-panel indicator LED, Rear panel TTL $\overline{Alarm}$ output plus audible alarm, which can be muted from the front panel.
Display Blanking	Front panel LEDs can be disabled.
Remote Operation	All instrument functions are controllable over GPIB, RS-232, and Ethernet interfaces.

Electrical and Mechanical

Shutter Outputs	Voltages	+12 VDC, +4.5 VDC
	Current limits	1.50 A max (12 VDC)
		0.5 A max (4.5 VDC)
	Signal lines	Serial TX, Serial RX, logic-level control
	Connector type	Mechanically compatible with 6-pin IEEE 1394 cables.
	Cable length	10 ft (3 m) max
	Cable shield	Grounded or floating (internal jumper)
I/O ports	Control input	TTL compatible rear panel input BNC connector, internally pulled up to +3.3 VDC through 100 kΩ.
	Auxiliary I/O	Two rear-panel BNC connectors; TTL level, multi-purpose.
	Alarm output	One rear-panel TTL output BNC connector
Interfaces	Shutter output	One rear-panel shutter connector
	Host interface	RS-232; DB–9 (female) DCE
		GPIB
		Ethernet; 10/100 Base-T
Operating	Temperature	0 °C to 40 °C, non-condensing
	Power	90 VAC to 260 VAC, 47 Hz to 63 Hz
		85 W max
Physical	Weight	6 lbs
	Dimensions	8.25″ W × 4″ H × 11″ D

1 Getting Started

This chapter gives you the necessary information to get started quickly with the SR470 Shutter Controller.

In This Chapter

1.1 Introduction to the Instrument

The SR470 Shutter Controller is a full-featured timing generator and driver for SR470 Series Laser Shutters. It features multiple control modes and is ideally suited for laser shutter applications where flexible and precise timing generation is needed. It can be operated independently as a stand-alone instrument or integrated with existing automated test and measurement equipment.

1.1.1 Overview

The basic function of the SR470 Shutter Controller is to provide power, control signals, and I/O interfaces to an SR470 Series Laser Shutter. The shutter connects to an output on the rear panel of the instrument, and can be controlled by rear-panel TTL level inputs or manually from either the front panel or remote interfaces.

1.1.2 Power-on state

The SR470 stores its operation state in non-volatile memory, including the configuration of the remote interfaces and the position state of a connected shutter.

At power-on, the SR470 will return to its previous configuration after a brief system check and initialization.

1.2 Front-Panel Operation

The front panel of the SR470 (Figure 1.1) provides controls for the operator and displays the operational state of the shutter at a glance. The upper half of the panel has a multifunction numeric LED display as well as a timing diagram. The lower half of the panel has controls that are divided into five sections: "Master," "Timing," "Mode," "Utility," and "Modify."

1.2.1 Data Entry

Many of the SR470's operating parameters are simple commands or mode selections—for example to open the shutter or select internally triggered mode—for which there is no numeric entry.

Setting the SR470's numeric operating parameters is done by first pressing the key with the desired parameter's name on it ([Burst], for example, to set the burst count). Some parameters and functions are labeled above the keys in light gray. To display these values first press the [Shift] key and then the labeled key. [Shift][Sleep] for example, powers down an attached shutter head, putting it into *standby* mode.

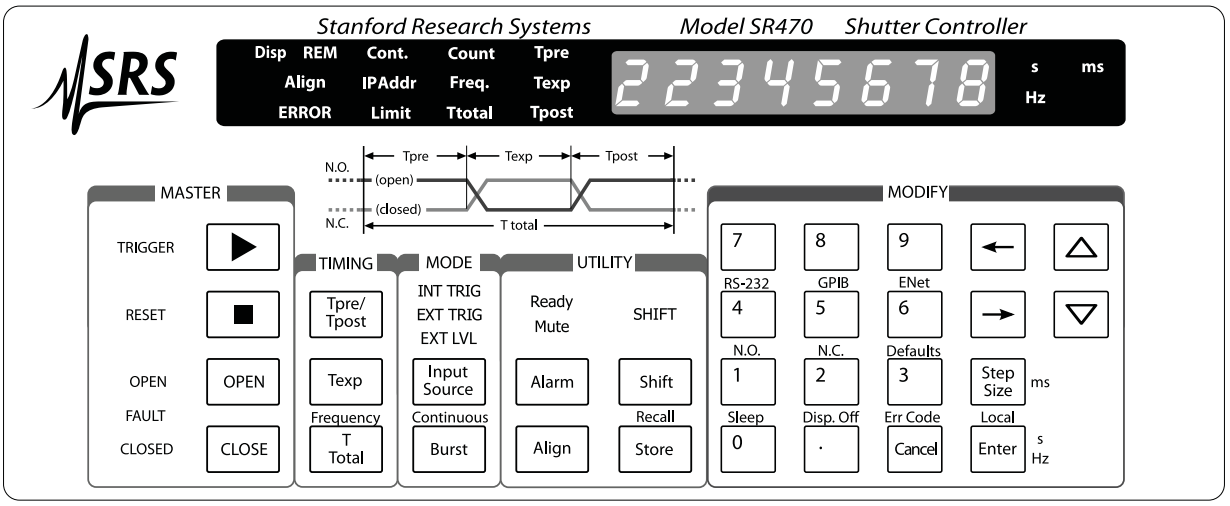

Figure 1.1: The SR470 front panel.

Numeric values are changed through the numeric keypad or the arrow keys in the "Modify" section of the front panel. To enter a value simply type the new value using the keypad and complete the entry by hitting one of the two *units* keys: [ms], [s], or [Hz], depending on context. These unit names are labeled on the right hand sides of their respective keys. If a quantity is unitless (like burst count), the [Enter] key should be pressed to enter the value.

If an entry error is made, pressing the [Cancel] key returns the previous value.

Numeric parameters may also be increased or decreased with the arrow keys. Pressing the [△] (up arrow) key will increase the value by the current step size, while pressing while the [▽] (down arrow) key will decrease the value by the current step size. If the entered value is outside of the allowable limits for the parameter the instrument will beep and display an error message.

1.2.1.1 Step Size

Each numeric parameter has an associated step size which may be an exact power of 10 (1 ms, 10 ms or 100 ms for example), or may be an arbitrary value. If the step size is an exact power of 10, that digit of the display will flash. (If it is not an exact power of 10, the flashing digit is of the same magnitude as the leading digit of the step size.) A flashing underscore may be used to represent the flashing digit, if that digit is a hidden leading zero.

Pressing the [Step Size] key displays the step size for the current parameter, which may be changed by typing and entering a new value. Pressing [Step Size] again returns the display to the previously displayed parameter. Pressing the [△] (up arrow) or [←] (left arrow) while the step size is displayed increases the step size to the next larger decade, while pressing the [▽] (down arrow) or [→] (right arrow) key will decrease the step size to the next smaller decade.

1.2.2 Master control and basic shutter operation

The "Master" section of the front panel, located on the left hand side, contains some of the most important and frequently used controls on the SR470 . There are four keys in this section: [►] (trigger), [■] (reset), [OPEN] and [CLOSE]. Each of these keys has an associated indicator LED, and there is also a *FAULT* indicator located between the *OPEN* and *CLOSED* indicators. In introducing these features we will discuss many aspects of manual shutter control.

1.2.2.1 Keys and normal operation

When the SR470 has an attached shutter head that is powered on and functioning properly, the four keys in the "Master" section have the following functions:

- The [►] (trigger) key instructs the SR470 to initiate a predefined timed sequence of operation, which may be a single opening/closing cycle, a finite burst, or continuous operation. Note: This key is ignored if the instrument is in the *EXT LVL* mode (§1.2.3.3).
- The [■] (reset) key cancels any timing sequence (trigger) in progress and resets the shutter to the unasserted, or *normal*, state (§1.2.2.2).
- The [OPEN] key commands an attached and operational shutter head to go to the open state.
- The [CLOSE] key commands an attached and operational shutter head to go to the closed state.

These buttons can affect the operational mode (§1.2.3) of the SR470 . Pressing either [■] (reset), [OPEN], or [CLOSE] are requests for manual control that will force the instrument to the *INT TRIG* mode.

Pressing the [►] (trigger) key while the instrument is in the *EXT TRIG* mode will not change the mode, but will force a trigger even though it remains in the externally triggered mode.

1.2.2.2 Shutter polarity

An SR470 Series Laser Shutter head may be operated either as a *normally open* (N.O.) or *normally closed* (N.C.) shutter. The *normal* state refers to the *unasserted state* of the shutter, which is (for example) the state in which the shutter idles when a trigger has not yet come.

The polarity may be selected by pressing [Shift] [N.O.] or [Shift] [N.C.]. These alternate ("shifted") functions are located above the [1] and [2] keys in the "Modify" section of the front panel.

The currently selected shutter polarity is indicated on the timing diagram near the center of the SR470 front panel. On the left hand side of the diagram, one of the two indicators *N.O.* or *N.C.* will be lit to indicate the polarity.

1.2.2.3 Shutter status

The shutter operational status may be determined by looking at the *OPEN*, *FAULT*, and *CLOSED* indicators in the lower left hand corner.

When an SR470 Series Laser Shutter head is plugged in, powered, and operating properly, either the *OPEN* or *CLOSED* will be lit, showing the position of the shutter blade. (Note: It is possible to disable the front panel LEDs; see §1.2.5.6.)

The *FAULT* indicator on the SR470 may be lit either if the shutter head reports a fault or if the shutter head is unexpectedly unplugged. The fault indicator may be cleared by pressing the [■] (reset) key. Pressing [■] when a fault condition is present will power down the shutter head (if attached), and turn off the *OPEN*, *FAULT*, and *CLOSED* indicators. See also §1.2.2.5 for more information about faults and alarms.

When all three of the *OPEN*, *FAULT*, and *CLOSED* indicators are off, that indicates that there is not presently a shutter head that is both plugged in and powered. If there is not a shutter head present, the words "no HEAd" will usually be displayed on the numeric display. If a shutter head is present but powered off, the word "SLEEP" may be appear on the seven segment display.

1.2.2.4 Turning on the shutter head

It is possible to manually power down the shutter head by pressing [Shift][Sleep].

When a shutter head is plugged in but not powered on, it is said to be in *standby*, also known as *sleep* mode. From this state, pressing

[■], *OPEN*, or *CLOSED* will cause the SR470 to attempt to enable the shutter head and move it to the open or closed position as requested.

If the head powers on successfully, the SR470 will display its state with either the *OPEN* or *CLOSED* indicator. If the shutter head instead encounters a fault, the SR470 will remove power to the shutter head and illuminate the *FAULT* indicator. Again, this fault condition can be cleared by pressing the [■] (reset) key.

The shutter "logic" power supply (at +4.5 VDC) is always provided to a connected shutter when the SR470 is powered on, regardless of the operational state of the shutter head. This provides power for diagnostics and serial communications. It is separate from the +12 VDC power supply that drives the motor (coil) in an attached shutter head. When the shutter is said to be powered down (e.g., in *sleep* mode), it is the +12 VDC power supply that is disconnected from the shutter head. Because power is not available to change the position of the shutter blade, the blade position is therefore indeterminate.

1.2.2.5 Shutter faults and alarms

The SR470 is equipped with audible and electronic alarms that are asserted whenever the front-panel *FAULT* indicator is lit.

The audible alarm is a continuously emitted, loud siren-like noise. It can be enabled or muted by pressing the [Alarm] in the "Utility" section of the front panel; see §1.2.5.1.

The electronic alarm is a rear-panel $\overline{Alarm}$ output (§1.3.7) that is also asserted (pulled low) whenever the *FAULT* indicator is lit. This is a fixed output and cannot be disabled.

The alarm functions are intended to help draw attention to fault conditions that might otherwise be difficult to detect. For example, if an enabled shutter head is disconnected, that event will generate a fault. The expected configuration of the SR470 is saved in non-volatile memory such that if a shutter head is accidentally disconnected during a power outage, a fault will be declared in that channel when power is restored, and cannot be cleared by merely cycling the power. Operator action is required to clear a fault condition.

As discussed in §1.2.2.3, a shutter fault can be cleared by pressing the [■] (reset) key. *Before* the fault is cleared, it is possible to display the error word for the shutter by pressing [Shift] [Err Code]. This alternate function is located is above the [Cancel] key in the "Modify" section of the front panel. Please see the manual for your shutter head for the meanings of possible error codes. See also §2.6 for more about the error codes on the SR470 .

1.2.3 Operating modes

The SR470 has several distinct operating modes. The most basic mode distinction is between *direct state control*– where the shutter is explicitly commanded to open or close –versus *triggered control*, where a timed sequence is executed. In either of these modes, the control signals can be derived from internal or external sources.

Pressing the front panel [Input Source] key, in the "Mode" section, will cycle between the different operating modes.

1.2.3.1 Internal triggered mode

The SR470 is in the *internal triggered mode* when the front panel indicator *INT TRIG* in the "Mode" section is illuminated.

This mode should be selected to control the shutter state independently of the rear-panel TTL control input (§1.3.3); internal triggered mode ignores that input.

While in this mode, timed sequences may be initiated by pressing the front panel [►] (trigger) button. Direct state control of the shutter is also allowed in this mode: the state can be changed by pressing the [OPEN] or [CLOSE] keys.

Please see §1.2.4 for more about timed sequences.

1.2.3.2 External triggered mode

The SR470 is in the *external triggered mode* when the front panel indicator *EXT TRIG* in the "Mode" section is illuminated.

In this mode, timed sequences may be initiated on the falling edge of a signal connected to the rear-panel TTL control input. Pressing the [►] (trigger) key while in *external triggered mode* will *force* an immediate trigger and "Forc trg" will appear on the numeric display.

Pressing either [■] (reset), [OPEN], or [CLOSE] are requests for manual control that will force the instrument out of *EXT TRIG* mode and back to the *INT TRIG* mode.

1.2.3.3 External level mode

The SR470 is in the *external level mode* when the front panel indicator *EXT LVL* in the "Mode" section is illuminated.

In this mode, the state of the shutter is controlled only by the *level* of the rear-panel TTL control input. When the input is high (unasserted), the shutter is commanded to be in the *Normal* state.

When the TTL input is low (asserted), the shutter is commanded to be in the $\overline{Normal}$ state.

Pressing either [■] (reset), [OPEN], or [CLOSE] are requests for manual control that will force the instrument out of *EXT LVL* mode and back to the *INT TRIG* mode.

The [►] (trigger) key has no effect while in *external level mode*.

1.2.4 Timing and sequences

The SR470 is capable of controlling an attached shutter head through timed sequences of operation, including triggered bursts.

Sequences are allowed when the shutter is powered on and the SR470 is in the *INT TRIG* or *EXT TRIG* operating mode (§1.2.3). The sequence does not begin until a trigger is received; the trigger source may be the front panel [►] (trigger) key, the rear-panel TTL control input (if in *EXT TRIG* mode), or a trigger command from one of the remote interfaces.

The front panel *TRIGGER* indicator, located next to the [►] key, remains illuminated for the duration that any timed sequence is in progress.

1.2.4.1 Timing diagram

The timing diagram for the instrument appears on the front panel and is reproduced here:

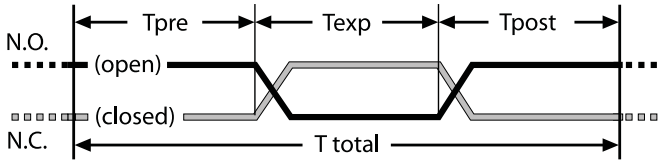

Figure 1.2: Timing diagram.

The sequence represents a single exposure cycle, with a *predelay* T_{pre}, *exposure* of length T_{exp}, and *postdelay* T_{post}. The length of these intervals combined is T_{total}, the total duration of the sequence.

There are two curves drawn on the timing diagram, one for *normally open* operation (§1.2.2.2) and one for a *normally closed* operation; the curves are labeled by designations *N.O.* and *N.C.*.

Suppose that the shutter is idle in its *normal* state, (and in the *INT TRIG* or *EXT TRIG* mode) when a new trigger signal is received. The timed sequence begins when the trigger is received. During the first part of the sequence, the *predelay*, the shutter remains in its *normal*

state. At the end of the *predelay*, the *exposure* time begins. As illustrated on the timing diagram, the *exposure* is defined to begin at the moment that the shutter begins moving from the *normal* to the $\overline{Normal}$ (*asserted*) state. The shutter remains commanded to the asserted state until the end of the *exposure* time. The *postdelay* follows the *exposure*, and is defined to begin at the moment that the shutter head begins to return to the *normal* state. The SR470 is able to accept new triggers after the end of the postdelay.

As a concrete example, consider the case with a shutter that has a fixed opening/closing time of 10 ms, configured in *normally closed* mode, with pre-delay of 500 ms, exposure of 50 ms, and postdelay of 10 s. Further suppose that the shutter is in the closed state when a trigger is received. 500 ms after the trigger is received, the shutter begins to open, and is fully opened 510 ms after the trigger. Since the exposure time is 50 ms, the shutter begins to close at 550 ms after the trigger, and is fully closed 10 ms later. The *postdelay* of 10 s begins at the moment that the shutter begins to close, and finishes at a time 10.550 s after the trigger was received.

The actual opening/closing time of a shutter is hardware and possibly mode dependent; please consult the user manual for your shutter head.

1.2.4.2 Entering timing parameters

Timing parameters on the SR470 can be configured and viewed by using the three keys in the "Timing" section of the front panel in conjunction with numeric controls in the "Modify" section of the front panel.

The [Tpre/Tpost] key allows the operator to view and edit the *predelay* and *postdelay*. Pressing this key alternates between selecting those two delays, and indicator lights to the left of the numeric display indicate which of the two delays is shown.

The [Texp] key and the [T Total] key allow the operator to view and edit the *exposure* time and total duration of the sequence. The "frequency" f of the full cycle is defined as $f = 1/T_{total}$, and may be accessed by selecting [Shift][Frequency]. For each of these selections, the appropriate indicator "Texp," "Ttotal," or "Freq." is illuminated to the left of the numeric display when that parameter is displayed.

If the sequence timing has been entered as a set of delays (measured in seconds), then it is important to note that the frequency shown in hertz on the numeric display may be truncated, since the true frequency is equal to $1/T_{total}$ and may have trailing digits that do not fit on the display. As an example, if a timed sequence were set up with

T_{total} = 3 s, then the true frequency would be $f = \frac{1}{3\ s} = 0.3333\ldots$ Hz, but [Shift][Frequency] would only display 0.333 Hz. This does not mean that the timing is degraded to match the displayed frequency, only that there are additional digits not shown. Similarly, if the operator should set up a sequence timing with a frequency as the controlling parameter, for example by entering 3 Hz, then the full precision of the SR470 would be dedicated to producing true 3 Hz cycles, while the *delay times* would be the parameters that may be truncated for display.

Because the *exposure* and *postdelay* portions of the timing sequence each contain a transition between the open and closed states, the minimum *practical* value for those two delays is given by the actual opening/closing time of the shutter head. The SR470 queries the shutter head to determine this interval, and if either T_{exp} or T_{post} is shorter than the opening/closing time, the *Limit* enunciator to the left of the numeric display will be illuminated. Delay times can be selected to be as low as 1 ms for both of these parameters, even if that is less than the opening/closing time. The maximum rate, which is related to the opening/closing time, can be queried over the remote interface; please see §2.5.5.

There are two possible frameworks, *delay priority* and *frequency priority*, for entering timing parameters, which depend upon whether the individual delay times are the most important parameters, or on whether the complete sequence duration is the most important parameter. We will discuss these separately in the next two sections.

1.2.4.3 Delay priority mode

The default framework for entering timing information is called *delay priority*. In *delay priority* mode, the user may directly enter the three timing delay parameters T_{pre}, T_{exp}, and T_{post}. If these values are changed, the total sequence duration T_{total} will change as an *elastic parameter*, remaining equal to the sum of T_{pre}, T_{exp}, and T_{post}. The frequency f also changes, since $f = 1/T_{total}$.

In this framework, T_{total} and f might best be regarded as *read-only* values, since it is not obvious which of the three component delays should be altered when the the total is changed.

1.2.4.4 Frequency priority mode

A second timing framework is called *frequency priority*. In *frequency priority* mode, the total sequence duration T_{total}, or equivalently $f = 1/T_{total}$, is considered to be the most important timing parameter, while T_{post} is considered to be the *elastic parameter*. The SR470 enters into *frequency priority* mode when the operator enters

a value for either f or T_{total}. This can be performed with the [△] or [▽] arrow keys, or by typing a valid value and entering it. (It is not necessary that the entered value be different from the existing value, but note that a new T_{total} must be greater than or equal to $T_{pre} + T_{exp}$, and that a corresponding rule applies to a new value of f.)

Once in *frequency priority* mode, changes to T_{pre} or T_{exp} will *not* change T_{total} (which remains constant) but will instead only change the value of the *elastic parameter* T_{post}. Entering a new value for T_{total} (or f) will similarly affect the value of T_{post}, but leave T_{pre} or T_{exp} unchanged. An error message will be displayed if a timing value is requested that is not possible by changing only T_{post}, for example, if $T_{pre} = T_{exp} = T_{post} = 1$ s, and T_{total} were requested to be changed from 3 s to 1 s.

To exit *frequency priority* mode and restore *delay priority* mode, enter a value for T_{post}. As with entering a value for T_{total} to enter the mode, this can be performed with the [△] or [▽] arrow keys, or by typing a valid value—changed or not—and entering it.

1.2.4.5 Bursts and continuous mode

The timing diagram discussed in §1.2.4.1 represents a single exposure cycle, with an *exposure* bracketed by a *predelay* and *postdelay*.

A *burst* consists of a set of single exposure cycles that are triggered continuously, one after the other. The *burst count*, the number of cycles that will execute after a trigger is received, can be accessed by pressing the [Burst] located in the "Mode" section of the front panel. When selected, the enunciator "Count" will be illuminated to the left of the numeric display and the value will be displayed. Using the keypad and arrow keys, any value between 1 (the default value; a single cycle) and 99 999 999 can be entered.

As a special case of using bursts, it is also possible to configure the SR470 to cycle forever after a trigger is received. This is called *infinite burst* or *continuous* mode, and can be selected by pressing [Shift][Continuous]. When this mode is selected, the word "inF initE" will appear on the numeric display, and the enunciator "Cont." on the left of the numeric display will light up and remain lit so long as *continuous* mode is selected. It is also possible to enter *continuous* mode using the [△] and [▽] arrow keys, by adjusting to a value less than 1 or greater than 99 999 999. Exit *continuous* mode by entering a nonzero, finite value for the burst count.

1.2.4.6 Indicators on the timing diagram

The timing diagram on the front panel of the SR470 serves not only as an illustration of the different time intervals but also as an indicator. As mentioned earlier, the *N.O.* or *N.C.* label on the diagram will be lit to indicate the configured polarity of the shutter. Additionally, the labels T_{pre}, T_{exp}, and T_{post} on the diagram will each illuminate in sequence to indicate which phase of a sequence is currently being executed.

(Note: it is possible to disable the front panel LEDs; see §1.2.5.6.)

1.2.5 Utility functions

Several useful features of the SR470 are located in or near the "Utility" section of the front panel.

1.2.5.1 Alarm key

The [Alarm] key toggles the configuration of the SR470 audible alarm between the states of *Ready* and *Mute*.

As discussed in §1.2.2.4 and §1.2.2.5, the audible alarm is active whenever the front-panel *FAULT* indicator is lit, unless the alarm is muted. The fault condition causing the alarm can usually be cleared by pressing the [■] (reset) key.

1.2.5.2 Align key

The [Align] key enables a special *alignment* mode, where the shutter is commanded to chop (open and close) at a rate of approximately 1 Hz. This mode is intended to help facilitate mechanical alignment and identification of shutter heads. This function is only available when connected shutter head is enabled and in one of the triggered modes, either *INT TRIG* or *EXT TRIG* (§1.2.3).

The enunciator "Align" to the left of the numeric display will light up and remain lit so long as *alignment* mode is selected.

Alignment mode is "transient," and only lasts until another feature of the SR470 is accessed that affects the shutter state.

1.2.5.3 Shift key

Operation of the [Shift] key, which is used to select the functions printed in gray above the keys, is described in §1.2.1.

1.2.5.4 Store and Recall

Press the [Store] key, followed by a number *i* and the [Enter] key to store the current configuration in memory location *i*. The parameter *i* may range from 1 to 9. Location 0 is reserved for current instrument settings and is overwritten after each key press.

The following settings are saved:

1. Whether the shutter is in *sleep* mode
2. Shutter polarity
3. Trigger mode
4. All trigger delay settings and step sizes
5. Alarm Mute/Audible selection
6. Display on/off state

Press the [Shift][Recall] key, followed by a number *i* and the [Enter] key to recall and restore configuration *i*. The parameter *i* may range from 0 to 9.

1.2.5.5 Alternate shutter modes

SR470 Series Laser Shutters may have alternate operation modes available, for example alternate speed modes. The possible modes are numbered 0 through 3, and their function is hardware dependent; please see the shutter head operation manual for details.

To configure the shutter to operate in an alternate mode, press [Shift][Align]. The numeric display will display (for example) "ALt 0" to indicate that alternative mode 0 is currently selected. The arrow keys or numeric keypad can then be used to change the value.

Important note: Alternate mode settings are stored in the volatile memory of the shutter head, not in the SR470; the mode setting is lost whenever the SR470 or the shutter head is unplugged, powered down, or otherwise reset.

1.2.5.6 Display Blanking

Press [Shift][Disp. Off] to temporarily blank the front panel indicators. (This function is not actually in the "Utility" section, but is instead in the numeric keypad area.)

When blanking is turned on, all front panel LEDs will go dark except for the *Disp Off* enunciator located to the left of the numeric display. To turn the display back on, press any key.

Turning off the display may be helpful because it prevents front panel indicators (such as *OPEN* and *CLOSED*) from blinking synchronously with shutter operation—a potential nuisance in certain laboratory environments.

1.2.5.7 Error code display

As discussed in §1.2.2.5, it is possible to display the error code in the event of a shutter fault by pressing [Shift] [Err Code]. SR470 errors, for example communications errors, are indicated by the lighted word "ERROR" to the left of the numeric display. If this enunciator is lit, [Shift] [Err Code] will display the SR470 error. If the message is too long to fit on the display, the [←] and [→] keys can be used to reveal the whole message.

If there are multiple errors, use the [△] and [▽] keys to view the additional messages. The "ERROR" enunciator will remain lit while there are still unviewed error messages.

The list of SR470 error codes is in §2.6.

1.2.6 Remote interface configuration

The remote interfaces of the SR470, RS-232, GPIB, and Ethernet, can be configured from the front panel. The user interface for these three configurations is different from data entry elsewhere on the SR470 in that it is menu driven. Within each configuration, use the [△] and [▽] keys to navigate between menu items (parameters), and the [←] and [→] keys to choose between different values or to scroll through long IP address parameters.

1.2.6.1 RS-232

The SR470 comes standard with an RS-232 communications port located on the rear panel of the SR470 . For more information about this port, please see §1.3.8.3.

The RS-232 menu can be accessed by pressing [Shift][RS-232]. Use [△] and [▽] to navigate between menu items. The menu items are:

- RS-232 on or off. Press the [←] and [→] keys to switch between

  r232 on

  and

  r232 oFF,

which indicate, respectively, that the RS-232 interface is enabled or disabled. A change in this parameter will not take effect until the SR470 is power cycled or the interface is reset.

- Interface reset. When an interface is reset, all connections on that interface are reset to the power-on state.

  To reset the RS-232 interface, use the [←] and [→] keys to switch from

  rSt no

  to

  rSt YES,

  and then press the [Enter] key. The message "rESEt r2" will briefly display on the screen as confirmation that the interface has been reset.

- Baud rate. Two RS-232 baud rate choices are available on the SR470 . Press the [←] and [→] keys to switch between

  bd 9600

  and

  bd 57600

  which indicate, respectively, that the RS-232 interface is at baud rate 9,600 baud or 57,600 baud. A change in this parameter will not take effect until the SR470 is power cycled or the interface is reset.

1.2.6.2 GPIB

The GPIB menu can be accessed by pressing [Shift][GPIB]. Use [△] and [▽] to navigate between menu items. The menu items are:

- GPIB on or off. Press the [←] and [→] keys to switch between

  GPib on

  and

  GPib oFF,

  which indicate, respectively, that the GPIB interface is enabled or disabled. A change in this parameter will not take effect until the SR470 is power cycled or the interface is reset.

- Interface reset. When an interface is reset, all connections on that interface are reset to the power-on state. To reset the GPIB interface, use the [←] and [→] keys to switch from

  rSt no

  to

  rSt YES,

  and then press the [Enter] key. The message "rESEt 9b" will briefly display on the screen as confirmation that the interface has been reset.

- GPIB Address. The SR470 GPIB address may be set to any value from 0 to 30. The current value will be displayed as (for example)

  Addr 8

  when the GPIB address is 8. Press the [←] and [→] keys to adjust the address number.

  A change in this parameter will not take effect until the SR470 is power cycled or the interface is reset.

1.2.6.3 Ethernet

The SR470 comes standard with an RJ-45 network communications port located on the rear panel. The port may be used to communicate with the SR470 over a 10/100 Base-T ethernet connected network or LAN. Any changes to the interface configuration will not take effect until the SR470 is power cycled or the interface is reset.

The ethernet menu can be accessed by pressing [Shift][ENet]. Use [△] and [▽] to navigate between menu items. The menu items are:

- Ethernet interface on or off. Press the [←] and [→] keys to switch between

  tc on

  and

  tc oFF,

  which indicate, respectively, that the ethernet (TCP/IP) interface is enabled or disabled.

- Interface reset. When an interface is reset, all connections on that interface are reset to the power-on state. To reset the ethernet interface, use the [←] and [→] keys to switch from

rSt no

to

rSt YES,

and then press the [Enter] key. The message "rESEt tc" will briefly display on the screen as confirmation that the interface has been reset.

- Interface speed. The SR470 link speed may be selected to 10 Base-T, 100 Base-T, or to auto-negotiate between these speeds.

  Use the [←] and [→] keys to choose between

  SPd 10,

  for speed 10 Base-T,

  SPd 100,

  for speed 100 Base-T, and

  SPd Auto

  for auto-negotiation.

  Under certain circumstances Auto-negotiation of link speed may fail. To avoid this, the SR470 defaults to manually configured 100 Base-T link speed.

- Default router configuration. When this menu item is selected, the numeric display of the SR470 will show

  routEr. . .,

  indicating that the router address is displayed on that line. (The *IPAddr* enunciator to the left of the numeric display is also lit while displaying IP addresses.)

  Use the [←] key to scroll over and display the full router address, which might be (for example) 127.0.0.1. A valid router address consists of four sets of numbers in the range 0 to 255, separated by dots (decimal points). To enter a new router, type the new value with the keypad, including the dots, and press the [Enter] key. If the entry is invalid, the instrument will beep and the error message

  iP Err

  will appear briefly on the numeric display.

- Subnet address/network mask. When this menu item is selected, the numeric display of the SR470 will show

SubnEt. . .,

indicating that the subnet mask is displayed on that line.

As with the router configuration, use the [←] to display the mask value, and use the keypad to enter a new value.

- Static IP address When this menu item is selected, the numeric display of the SR470 will show

  iPAddr. . .,

  indicating that the IP address is displayed on that line.

  As with the router and subnet configurations, use the [←] to display the address, and use the keypad to enter a new value.

1.2.7 Remote lockout and front-panel operation

When a host computer accesses the SR470 over one of the remote interfaces, it normally places the unit in the *Remote* state, where most manual input is not allowed. This is indicated by the *REM* enunciator, located to the left of the numeric display.

To return to front panel operation from *Remote* mode, press the [Local] key (this is the same key as [Enter]).

The SR470 can also be placed into *complete lockout* mode by using the LOCK? query over a remote interface. In this mode the *REM* indicator is lit, but the instrument will not respond to any front panel input, including the [Local] key. This mode can only be disabled using the UNLK? query over a remote interface as described in §2.5.6 or by cycling the power to the instrument.

1.2.8 Restoring factory default configuration

The SR470 can be reset to its factory-default settings by pressing [Shift][Defaults] or by power cycling the unit with the [Reset] key depressed. This is equivalent to sending the *RST command over one of the remote interfaces. It recalls the following setup:

1. Shutter enabled (not in *sleep* mode)
2. Trigger mode: *INT TRIG*
3. Polarity: N.C.
4. T_{pre} = 0
5. T_{exp} = 1 s
6. T_{post} = 1 s
7. Burst count = 1.
8. All delay step sizes: 0.1 s
9. Frequency step size: 0.1 Hz

10. Count step size: 1
11. Aux I/O configuration: Manual, high
12. Alarm: Audible
13. Display: On

Recalling factory default settings this way does not affect the interface configuration. The interface configuration can be restored to factory defaults by power cycling the unit with the [ENet] ([6]) key pressed. In this case, the following interface setup is recalled:

1. RS-232: Enabled
2. RS=232 baud rate: 9600
3. GPIB: Enabled
4. GPIB address: 8
5. TCP/IP interface: Enabled
6. IP Address: 0.0.0.0
7. Subnet: 0.0.0.0
8. Router: 0.0.0.0
9. Link speed: 100 Base-T
10. VXI-11, Telnet, and Raw socket interfaces enabled.

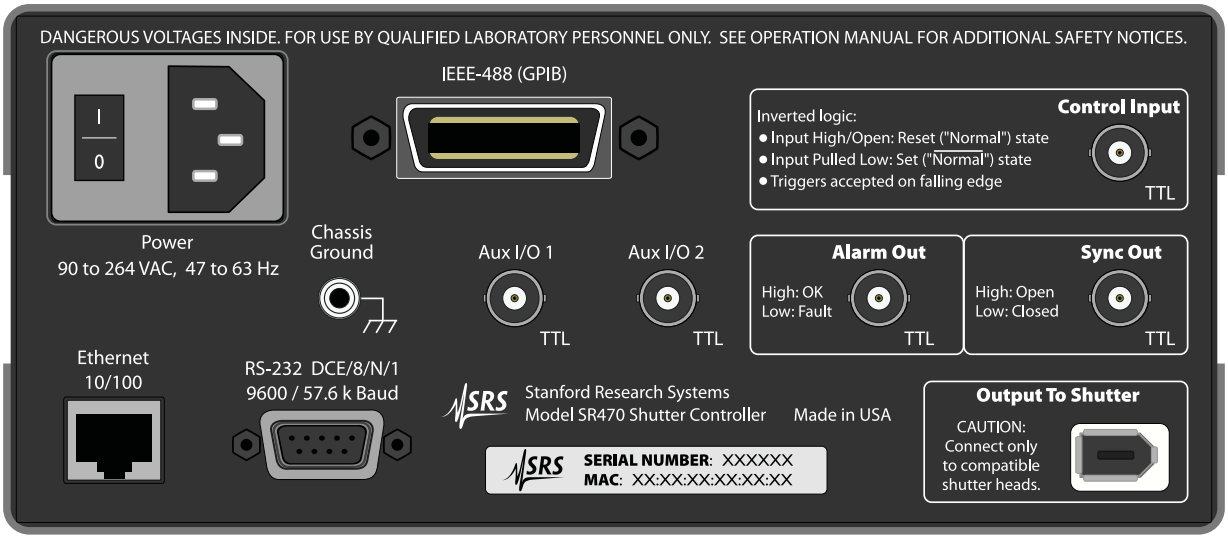

Figure 1.3: The SR470 rear panel.

1.3 The SR470 Rear Panel

The rear panel of the SR470 (see Figure 1.3) provides input and output connectors for controlling the shutter, a TTL sync output, an alarm output, two auxiliary I/O ports, a chassis-grounded binding post, three remote interfaces, and the power entry module.

The SR470 serial number and ethernet MAC address are printed on a label located on the back side.

1.3.1 Power entry

The power entry module is located on the upper left side of the rear panel and contains an integrated power switch.

The universal input power supply of the SR470 accommodates any voltage in the range 90 VAC to 260 VAC, with a frequency in the range 47 Hz to 63 Hz.

The SR470 has a detachable, three-wire power cord for connection to the power source and to a protective ground. The exposed metal parts of the instrument are connected to the outlet ground to protect against electrical shock. Always use an outlet which has a properly connected protective ground.

1.3.2 Chassis ground

This binding post is connected to the SR470 chassis and to earth ground.

1.3.3 TTL input

The primary input for the SR470 Shutter Controller is the rear-panel BNC input labeled "Control Input." This connector accepts an externally generated logic-level input signals. It is internally pulled up to +3.3 VDC through 100 kΩ and is compatible with +5 VDC (TTL) input signals.

The input is *active low*, and the response to the input signal is mode dependent. When the SR470 Shutter Controller is in the *INT TRIG* mode (§1.2.3), the control input is ignored. In *EXT TRIG* mode, a trigger is generated when a low-going edge is detected on the input. In the *EXT LVL* mode, a signal that is unasserted, i.e., logically high or open (disconnected), commands the shutter to its *Normal* state, and an input signal that is asserted, i.e., pulled low, commands the shutter to its $\overline{\textit{normal}}$ state.

Note: The shield of the input BNC is connected to earth ground.

1.3.4 Shutter connector

The SR470 has one shutter connector, which provides power and interface connections for an external SR470 Series Laser Shutter head.

⚠ CAUTION Never connect the shutter output port to anything other than an SR470 Series Laser Shutter head.

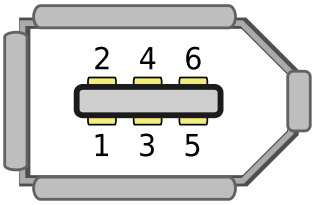

Figure 1.4: Shutter connector pinout, as seen looking into the connector on the rear panel.

Connector Pin	Description
1	+12 V to shutter head (Coil power supply)
2	Ground
3	TX (Serial to shutter head)
4	RX (Serial from shutter head)
5	+4.5 V to shutter head (Logic power supply)
6	Control signal to shutter head (logic level)

Table 1.1: Shutter connector pinouts

The pinout for the connector is shown in Fig. 1.4 and the signal names are shown in Table 1.1.

The shield of the shutter connector is connected to earth ground as it ships from the factory. Please see §1.3.9 about grounding considerations for more information.

1.3.5 Aux I/O ports

The two rear-panel Auxiliary I/O BNC connector (labeled "Aux I/O 1" and "Aux I/O 2") are multifunction I/O ports that can be configured over any remote interface. Each has specific capabilities; please see §2.5.3 in the remote programming section for more information.

Both ports can be used for manual TTL-level input or output, and there are additional capabilities that include inhibiting triggers, forcing a shutter to the normal state, or outputting a pulse when a trigger is issued. The factory default setting for each is to be configured for manual control, with high output.

The Aux I/O ports are each internally pulled up to +5 VDC through a 10 kΩ resistor.

Note: The shields of these BNC connectors are connected to earth ground.

1.3.6 Sync out

This rear-panel TTL output provides a logic signal that mirrors the commanded state of the shutter. A high output is provided when the shutter is commanded to the *open* state, and a low output is given when the shutter is commanded to the *closed* state.

Note: The shield of this BNC connector is connected to earth ground.

1.3.7 Alarm output

The $\overline{Alarm}$ *Out* rear-panel BNC connector is a TTL output that is normally held high at +5 VDC. This signal is asserted (driven low) whenever the front panel *FAULT* indicator is lit.

The $\overline{Alarm}$ output port is always active. The polarity of the signal is such that the SR470 will no longer hold the $\overline{Alarm}$ signal at +5 VDC in the event that it loses line power.

Note: The shield of this BNC connector is connected to earth ground.

1.3.8 Remote interfaces

Remote operation of the SR470 is supported with GPIB, RS-232 and Ethernet computer interfaces. All configuration options are settable from the front panel (§1.2.6) or over the remote interface.

For additional information about the remote interface configuration, please see §1.2.6.

1.3.8.1 IEEE-488 GPIB

The SR470 comes with an IEEE-488 port for communicating over GPIB. The port is located on the rear panel of the SR470 The GPIB address is configured from the front panel; please see §1.2.6.2 for more information.

1.3.8.2 Ethernet

The SR470 comes standard with an RJ-45 network communications port located on the rear panel. The port may be used to communicate with the SR470 over a 10/100 Base-T ethernet connected network or LAN. The SR470 supports static network configuration as configured from the front panel; please see §1.2.6.3 for more information.

The ethernet hardware (MAC) address is printed on the serial number sticker on the rear panel.

1.3.8.3 RS-232

The RS-232 interface connector is a standard 9 pin, type D, female connector configured as a DCE (transmit on pin 3, receive on pin 2). The factory default communication parameters are set to: 8 Data bits, 1 Stop bit, No Parity, No Hardware Flow Control. All of these parameters are fixed. The interface is enabled or disabled, and the baud rate is set from the front panel. Please see §1.2.6.1 for more information.

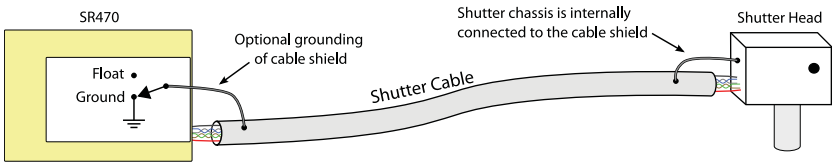

Figure 1.5: Grounding the shield of the shutter cable.

1.3.9 Shutter grounding considerations

For reliable operation of a shutter head connected to the SR470 it is essential that the shield of the cable to the shutter is properly grounded.

The grounding scheme for the shutter cable is shown in Fig. 1.5. The cable connects a rear-panel output to an external shutter head. Inside the shutter head, there is an electrical connection between its chassis (case) and the shield of the cable. If the chassis of the shutter head is electrically connected to earth ground, for example by way of attachment to a grounded optical table, then the shield will be grounded as well. The SR470 can internally connect the cable shield to ground or leave it floating, as selected by an internal jumper for each channel. The factory default setting is to ground the shield for each of the four shutter channels.

If a shutter head is properly grounded and thereby providing a suitable ground to the cable shield, it may be desirable to remove the shield-ground connection for the shutter cable inside the SR470 .

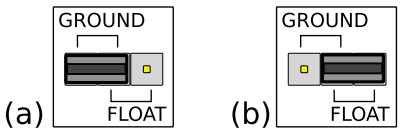

Figure 1.6: Shutter cable ground selection header. Part (a) shows the cable shield grounded at the SR470 with the jumper over the two pins marked “GROUND” and part (b) shows the cable ground floating, where the jumper sits over the two pins marked “FLOAT.”

The procedure for removing shield-ground connection inside the SR470 is as follows: First, turn off and unplug the unit. Wait one minute after removing power to reduce the risk due to residual voltages inside the instrument. To remove the top cover, first remove the four large screws from the top cover of the instrument. The cover can now be removed by carefully sliding it back towards the rear of the instrument while tilting it up (from the rear). The ground connection for the cable shield is in the form of a three-pin header, which is located adjacent to the shutter output connector. A two-pin jumper on the header selects whether the cable shield is in the grounded or floating configuration, as illustrated in Fig. 1.6. Replace the cover of the instrument and re-install the four cover screws before once again attaching it to power.

⚠ WARNING

Dangerous voltages, capable of causing injury or death, are present in this instrument. Use extreme caution whenever the instrument covers are removed. Do not remove the covers while the unit is plugged into a live outlet.

2 Remote Operation

This chapter describes operating the SR470 over its remote interfaces.

In This Chapter

2.1 Index of Common Commands

symbol	definition
i,j	Integers
t,f	Floating point numbers
s	Single ASCII character
b	Hexadecimal formatted byte(s)
(*?*)	Required for queries; illegal for set commands
var	Parameter always required
{*var*}	Required parameter for set commands; illegal for queries
[*var*]	Optional parameter for both set and query forms

IEEE-488 Commands

Status Reporting Commands

Instrument Control Commands

Exposure Cycle Control Commands

Shutter Specific Commands

Interface Commands

2.2 Alphabetic List of Commands

T

U

X

2.3 Introduction

The SR470 may be remotely programmed via the GPIB interface, the RS-232 serial interface, or the LAN ethernet interface using a simple command language documented in this chapter. Any host computer interfaced to the SR470 can easily control and monitor the operation of the SR470 .

The SR470 interface configuration is determined by configuration parameters stored in nonvolatile memory. At power-on the instrument returns to the state it was last in when power was removed. Exceptions are noted in the command descriptions. These parameters can be changed from the front panel as detailed in §1.2.6, or via the IFCF command over a remote interface.

2.4 Commands

This section provides syntax and operational descriptions for remote commands.

2.4.1 Command syntax

Communications with the SR470 uses ASCII characters. All commands are 4-characters long and are case-insensitive. Standard IEEE-488.2 defined commands begin with the "*" character followed by 3 letters. SR470 specific commands are composed of 4 letters.

The four letter mnemonic (shown in CAPS) in each command sequence specifies the command. The rest of the sequence consists of parameters.

Commands may take either *set* or *query* form, depending on whether the "?" character follows the mnemonic. *Set only* commands are listed without the "?", *query only* commands show the "?" after the mnemonic, and *optionally query* commands are marked with a "(?)".

Parameters shown in { } and [ ] are not always required. Parameters in { } are required to set a value, and are omitted for queries. Parameters in [ ] are optional in both set and query commands. Parameters listed without any surrounding characters are always required. A parameter *i* denotes an integer value. Restrictions limiting the range of valid values will be noted in the command description.

Do NOT send ( ) or { } or [ ] as part of the command.

The command buffer is limited to 255 bytes, with 25 byte buffers allocated to each of up to 3 parameters per command. If the command buffer overflows, both the input and output buffers will be flushed

and reset. If a parameter buffer overflows, a command error will be generated and the offending command discarded.

Commands are terminated by either a semicolon, a ⟨CR⟩ (ASCII 13), or a ⟨LF⟩ (ASCII 10). If the communications interface is GPIB, then the terminating character may optionally be accompanied by an EOI signal. If the EOI accompanies a character other than a ⟨LF⟩, a ⟨LF⟩ will be appended to the command to terminate it. Execution of the command does not begin until a command terminator is received. White space is ignored.

Aside from communication errors, commands may fail due to either syntax or execution errors. Syntax errors can be detected by looking at bit 5 (CME) of the event status register (*ESR?). Execution errors can be detected by looking at bit 4 (EXE) of the event status register. In both cases, an error code, indicating the specific cause of the error, is appended to the error queue. The error queue may be queried with the LERR? command. Descriptions of all error codes can be found in the section Error Codes, starting on page 2 – 25 .

2.4.1.1 Examples

Commands may be given with a simple example illustrating their usage. In these examples, all data sent by the host computer to the SR470 are set as `straight teletype font`, while responses received the host computer from the SR470 are set as *`slanted teletype font`*.

The usage examples vary with respect to set/query, and optional parameters. These examples are not exhaustive, but are intended to provide a starting point for user programming.

2.5 Command List

2.5.1 Common IEEE-488.2 Commands

*CLS — Clear Status

*CLS Clear Status immediately clears the ESR register as well as the LERR error buffer.

Example: *CLS

*ESE(?) {*i*} — Standard Event Status Enable

Set (query) the Standard Event Status Enable register {to *i*}. Bits set in this register cause ESB (in STB) to be set when the corresponding bit is set in the ESR register.

*ESR? — Standard Event Status Register

Query the Standard Event Status Register. Upon executing a *ESR? query, the returned bits of the *ESR register are cleared. The bits in the ESR register have the following meaning:

Bit	Meaning
0	OPC operation complete
1	Reserved
2	QYE query error
3	DDE device dependent error
4	EXE execution error
5	CME command error
6	Reserved
7	PON power-on

Example: *ESR?⟨CR⟩
176

The returned value of 176 (= $2^7 + 2^5 + 2^4$) indicates that PON, CME, and EXE are set.

*IDN? Identify

Read the device identification string; returns a string similar to the following:

Example: `*IDN?⟨CR⟩`
Stanford_Research_Systems,SR470,s/n004025,ver1.00

*OPC(?) Operation Complete

The set form sets the OPC flag in the ESR register when all prior commands have completed. The query form returns '1' when all prior commands have completed, but does not affect the ESR register.

*PSC(?) {*i*} Power-on Status Clear

Set (query) the Power-on Status Clear flag {to *i*}. The Power-on Status Clear flag is stored in nonvolatile memory in the SR470, and thus, maintains its value through power-cycle events. If the value of the flag is 0, then the Service Request Enable and Standard Event Status Enable Registers (*SRE, *ESE) are stored in non-volatile memory, and retain their values through power-cycle events. If the value of the flag is 1, then these two registers are cleared upon power-cycle.

Example: `*PSC 1⟨CR⟩`
Set the Power-on Status Clear to 1

Example: `*PSC?⟨CR⟩`
1
Returns the current value of Power-on Status Clear.

*RCL *i* Recall Instrument Settings

Recall instrument settings from location *i*. The parameter *i* may range from 0 to 9. Locations 1 to 9 are for arbitrary use. Location 0 is used for current instrument settings. It is continually updated after each key press instrument settings, and restored upon power-on. See *SAV for a list of settings that are restored.

Example: `*RCL 3⟨CR⟩`
Recall instruments settings from location 3.

---

*RST — Reset the Instrument

Reset the SR470 to default configuration. This is equivalent to pressing [Shift][Defaults] from the front panel or power cycling the unit with the [Reset] key depressed. See §1.2.8 for a list of the factory default settings.

Example: `*RST⟨CR⟩`

---

*SAV *i* — Recall Instrument Settings

Save instrument settings to location *i*. The parameter *i* may range from 0 to 9. Locations 1 to 9 are for arbitrary use. Location 0 is reserved for current instrument settings. This location is overwritten after each key press, and restored upon power-on. See §1.2.5.4 for a list of the settings that are saved.

Example: `*SAV 3⟨CR⟩`
Save current instruments settings to location 3.

---

*SRE(?) {*i*} — Service Request Enable

Set (query) the Service Request Enable register {to *i*}. Bits set in this register cause the SR470 to generate a service request when the corresponding bit is set in the STB register.

---

*STB? — Status Byte

Query the standard IEEE 488.2 serial poll status byte. The bits in the STB register have the following meaning:

Bit	Meaning
0	Shutter disconnected
1	Shutter fault
2	INSR_BIT: Unmasked Instrument Status Bit
3	Reserved
4	MAV - message available
5	ESB-ESR summary bit
6	MSS - master summary bit
7	Reserved

Example: `*STB?⟨CR⟩`
114

A return of '114' indicates that Shutter fault, MAV, ESB, and MSS are set. MAV indicates that a message is available in the output queue. ESB indicates that an enabled bit in ESR is set. MSS reflects the fact that at least one of the enabled summary bits is set.

*TRG — Trigger

Trigger the controller to start an exposure cycle. This command fails if the shutter is under external level control. Otherwise it attempts to trigger the shutter. A rate error may occur if a cycle is already in progress.

*WAI — Wait for Command Execution

The instrument will not process further commands until all prior commands including this one have completed.

Example: `*WAI⟨CR⟩`
Wait for all prior commands to execute before continuing.

2.5.2 Status Reporting Commands

CNTR? — Counts Remaining

Query the counts remaining in the burst of cycles. If no trigger is in progress or the last cycle is in progress, the command will return 0. If the count is infinite, it will return -1.

INSE(?) {*i*} — Instrument Status Enable

Set (query) the instrument status enable register {to *i*}. The instrument status enable register determines which bits of the instrument status register get ORd together to set INSR_BIT in the serial poll status byte. (see *STB).

Example: `INSE 3⟨CR⟩`

When a trigger or an end of cycle occurs the INSR_BIT of the serial poll status byte will be set.

INSR? Instrument Status Register

Query the instrument status of the controller. The bits are sticky: once set, they remain set until queried by this command, at which point they are cleared. The status bits have the following definitions:

Bit	Meaning
0	Trigger: set when shutter is triggered
1	End of cycle: set after post delay completes
2	End of burst: set after post delay completes and no more cycles remain
3	OPEN: set when the shutter transitions from closed to open
4	CLOSE: set when the shutter transitions from open to closed.
5	RATE: set when the controller receives a trigger while a cycle is still in progress

FLTS? Fault Status

Query the current fault status of the shutter. This command may return the following fault responses:

Code	Meaning
0	No fault
1	Disconnect fault
2	Fault reported by shutter
3	12 V power fault

If the shutter reported a fault, use the SERR command to identify the cause.

Example: FLTS?⟨CR⟩
1

A return of 1 indicates that the shutter head is disconnected.

LERR? Last Error

Query the last error in the error buffer. Errors are returned on a first-in-first-out basis.

Upon executing a LERR? query, the returned error is removed from the error buffer. See the section Error Codes later in this chapter for a description of the possible error codes returned by LERR?. The error buffer has space to store up to 20 errors. If more than 19 errors occur without being queried, the 20th error will be 254 (Too Many Errors), indicating that errors were dropped.

TRGS? Trigger Status

Query the triggered status of the controller. The bits have the following meanings:

	Code	Meaning
Bits 0-1:	0	Idle
	1	PreDelay
	2	Exposure
	3	PostDelay

	Code	Meaning
Bits 2-3:	0	Open
	1	Closed
	2	Indeterminate
	3	Indeterminate

2.5.3 Instrument Control Commands

ABRT Abort Trigger in Progress

Abort any trigger in progress and return the shutter to the unasserted state. Any trigger received subsequent to this command will trigger a new cycle.

ASRT(?) {*i*} Assertion State

Set (query) the assertion state of the shutter {to *i*}.

The set version forces the shutter to the given state by canceling any trigger in progress and changing the trigger source to internal trigger mode. If the parameter *i* is 0 the shutter is unasserted (i.e., commanded to the *normal* state). If it is 1, the shutter is asserted.

Example: `ASRT 0⟨CR⟩`
Place the shutter in the unasserted state.

Example: `ASRT?⟨CR⟩`
1
A return of 1 indicates that the shutter is asserted, i.e., commanded to the *normal* state.

AUXC(?)1{,*i*} Auxiliary I/O BNC 1 Configuration

Set (query) the auxiliary configuration of the AUX I/O 1 rear-panel BNC connector {to *i*}. The parameter *i* controls the configuration according to the following table:

i	Configuration
0	Manual Configuration. State controlled by AUXI command.
1	Master Inhibit. Shutter forced to normal unasserted state when AUX I/O 1 input is asserted low.
2	Trigger Inhibit. Shutter ignores all trigger sources when the AUX I/O 1 input is asserted low.

Example: `AUXC 1,2⟨CR⟩`
Configure Aux I/O 1 as Trigger Inhibit input.

AUXC(?)2{,*i*} Auxiliary I/O BNC 2 Configuration

Set (query) the auxiliary configuration of the AUX I/O 2 rear-panel BNC connector {to *i*}. The parameter *i* controls the configuration according to the following table:

i	Configuration
0	Manual Configuration. State controlled by AUXI command.
1	Reset. Shutter aborts any trigger in progress, on the falling edge of the AUX I/O 2 input. Pulse width must be at least 200 μs
2	Trigger Out. AUX I/O 2 output is asserted low for 100 μs at the beginning of each trigger cycle within a burst.
3	Trigger Busy. AUX I/O 2 output is asserted low at time of first trigger, and stays low until all cycles are complete.

Example: `AUXC 1,2⟨CR⟩`
Configure Aux I/O 1 as Trigger Inhibit input.

AUXI(?) i {,*j*} Auxiliary I/O State

Set (query) the Aux I/O *i* BNC port state {to *j*}, where *i* is either 1 or 2.

The set form sets the value applied to the BNC when it is configured for manual I/O. The query form always reads the current value of the BNC. A value of 0 indicates the BNC is logic low. A 1 indicates the BNC is logic high.

Note that the input hardware has a positive pull-up resistor; the port should be configured to the high state for use as a manual input.

CHOP(?) {*i*}

Alignment Mode

Set (query) alignment mode– i.e., continuous chopping– of shutter {to *i*}. If parameter *i* is 0, alignment mode is turned off. If it is 1, alignment mode is turned on. This command will fail if the instrument is in *external level* mode. See §1.2.5.2 for more about alignment mode.

DISP(?) {*i*}

Display On/Off

Set (query) the display state {to *i*}. If parameter *i* is 0 the display is turned off. If it is 1 the display is turned on. See §1.2.5.6 for more about display blanking.

ENAB(?) {*i*}

Enable Shutter

Set (query) the enable state of the shutter *c* {to *i*}. If parameter *i* is 0 the shutter is in sleep mode. If it is 1 then shutter is powered on. The query form will return 2 if a fault has been detected for the shutter. The fault is cleared when the shutter is turned off. Changing the state of a shutter from disabled to enabled takes 500 ms to complete.

See §1.2.2.4 for more about shutter head operation and standby modes.

MUTE(?) {*i*}

Mute Alarm

Set (query) the mute status on the audible alarm. If *i* is 0 alarms are audible. If 1, alarms are muted. See §1.2.2.5 and §1.2.5.1 for more about faults and alarms on the SR470 .

POLR(?) {*i*}

Shutter Polarity

Set (query) the polarity of the shutter to *i*. A value of 0 indicates the shutter is normally open. A value of 1 indicates the shutter is normally closed.

See §1.2.2.2 for more about shutter polarity.

SHOW(?) {*i*} Show Main Display

Set (query) the main front panel display to *i*. The parameter i has the following interpretation:

i	Display
0	Pre-delay
1	Post-delay
2	Exposure
3	Total delay
4	Frequency
5	Burst count

SRCE(?) {*i*} Source of Control

Set (query) the shutter control source/mode {to *i*}. The parameter i has the following interpretation:

i	Source
0	Internal level (*INT TRIG*)
1	External triggered (*EXT TRIG*)
2	External level (*EXT LVL*)

See §1.2.3 for details about these modes.

Example: `SRCE 2⟨CR⟩`
Place shutter under external level control.

STAT(?) {*i*} Open/Closed State

Set (query) the open/closed state of the shutter {to *i*}. The set version forces the shutter to the given state by canceling any trigger in progress and changing the trigger source to internal triggered mode. If the parameter *i* is equal to 0, the shutter is closed, if it is 1 it is opened. The query form returns the number 2 if the shutter state is indeterminate.

Example: `STAT 0⟨CR⟩`
Close the shutter.

Example: `STAT?⟨CR⟩`
2
A return of 2 indicates that the shutter 2 is in an indeterminate state.

2.5.4 Exposure Cycle Control Commands

SPCN *i*	Step Burst Count Step the burst count by the current step size in the direction given by *i*. If*i* is 1, step up, if *i* is 0, step down.
SPPR *i*	Step Predelay Step the *predelay* T_{pre} by the current step size in the direction given by *i*. If *i* is 1, step up, if *i* is 0, step down.
SPEX *i*	Step Exposure Step the *exposure* T_{exp} by the current step size in the direction given by *i*. If *i* is 1, step up, if *i* is 0, step down.
SPPS *i*	Step Postdelay Step the *postdelay* T_{post} by the current step size in the direction given by *i*. If *i* is 1, step up, if *i* is 0, step down.
SPTL *i*	Step Total Delay Step the total sequence length T_{total} by the current step size in the direction given by *i*. If *i* is 1, step up, if *i* is 0, step down.
SPFR *i*	Step Frequency Step the frequency *f* by the current step size in the direction given by *i*. If *i* is 1, step up, if *i* is 0, step down.
SSCN(?) {*i*}	Step Size Burst Count Set (query) the burst count step size {to *i*}.
SSPR(?) {*t*}	Step Size Predelay Set (query) the *predelay* step size {to *t*} in seconds.
SSEX(?) {*t*}	Step Size Exposure Set (query) the *exposure* step size {to *t*} in seconds.
SSPS(?) {*t*}	Step Size Postdelay Set (query) the *postdelay* step size {to *t*} in seconds.

SSTL(?) {*t*}	Step Size Total Delay Set (query) the total sequence length step size {to *t*} in seconds.
SSFR(?) {*f*}	Step Size Frequency Set (query) the frequency step size {to *f*} in hertz.
COUN(?) {*i*}	Burst Count Set (query) the burst count {to *i*}. If the burst count is -1, the burst count will be infinite. Otherwise, valid burst counts range between 1 (a single cycle) and 99 999 999. See §1.2.4.5 for more information about bursts.
FREQ(?) {*f*}	Frequency Set (query) the frequency {to *f*}. If valid, adjust the *postdelay* T_{post} to provide the requested frequency.
TPRE(?) {*t*}	Predelay Time Set (query) the *predelay* {to *t*} in seconds.
TEXP(?) {*t*}	Exposure Time Set (query) the *exposure* {to *t*} in seconds.
TPST(?) {*t*}	Postdelay Time Set (query) the *postdelay*{to *t*} in seconds.
TOTL(?) {*t*}	Total Delay Time Set (query) the total sequence length {to *t*} in seconds.

2.5.5 Shutter Specific Commands

MODE(?) {*i*}	Shutter Mode Set (query) the alternate mode for the shutter{to *i*}. Valid modes range from 0 to 3 with zero being the default mode. The set form sends the byte '0', '1', '2' or '3' to the shutter. The effect of different modes is hardware dependent; please see the shutter head manual for descriptions of the available modes. The query form returns bits 12 and 13 of the shutter status byte (see SSTB).

Since the mode setting is stored in the volatile memory of the shutter head, not in the SR470 , the mode setting is lost whenever the SR470 or the shutter head is reset or re-enabled.

MODL? — Shutter Model

Query the model number for the shutter. This should return something like 'SR475' if the shutter is an SR475 shutter. This command sends 'X' to the shutter and returns the response.

RATE? — Maximum Rate

Query the maximum rate at which the shutter can operate. A return of 100 would indicate that it can operate at 100 Hz. This command sends 'R' to the shutter and returns the response.

SCMD(?) *s*(,*b*) — Shutter Command

Send ascii bytes *s* followed optionally by hex bytes *b* to the shutter. Send back the shutter response if the query form is used.

Example:
```
SCMD?T⟨CR⟩
35
```
Send the ASCII byte 'T' to shutter 1 and return the response. This returns the shutter temperature.

SERR? — Shutter Error Word

Query the shutter error word. This command sends 'W' to the shutter and returns the response.

SPOS? — Shutter Position

Query the shutter position. A value of 1 indicates the shutter is open. A value of 0 indicates the shutter is closed. A value of 1 indicates the shutter position is indeterminate. This command sends 'S' to the shutter and returns the response.

SSER? — Shutter Serial Number

Query the shutter serial number. This command sends 'Y' to the shutter and returns the response.

SSTB? — Shutter Status Byte

Query the shutter status byte. This command sends 'Z' to the shutter and returns the response.

TEMP? Shutter Temperature

Query the current board temperature in °C. This command sends 'T' to the shutter and returns the response.

2.5.6 Interface Configuration Commands

EMAC? Ethernet MAC Address

Query the SR470's ethernet MAC address.

EPHY(?) *i*{,*j*} Ethernet Physical Layer Configuration

Set (query) the physical configuration item *i* {to *j*}. The parameter *i* may be one of the following:

i	Configuration
0	Enable/disable Auto-negotiation of link speed
1	Set link speed to 10 Base-T or 100 Base-T

When auto-negotiation is enabled, the manual link speed selection is ignored. When auto-negotiation is disabled, the manual speed selection is used to configure the link. Under certain circumstances the auto-negotiation of link speed may fail. To avoid this, the SR470 defaults to manually configured 100 Base-T link speed. When setting the link speed, a value of *j* equal to 0 selects 10 Base-T, and a value of 1 selects 100 Base-T.

Example: `EPHYS0,0⟨CR⟩`
Disable auto-negotiation of link speed

Example: `EPHYS1,1⟨CR⟩`
Manually configure link for 100 Base-T operation

IFCF(?) *i*{,*j*} Interface Configuration

Set (query) interface configuration parameter *i* {to *j*}. The parameter *i* may be one of the following:

i	Configuration parameter
0	RS-232 Baud Rate disable/enable
1	RS-232 Baud Rate: 9600 or 57600
2	GPIB disable/enable
3	GPIB address
4	Disable/Enable TCPIP interface
5	Disable/Enable Raw Socket access on port 5025
6	Disable/Enable Telnet access on port 5024
7	Disable/Enable VXI-11 access
8	Set/Query Static IP Address
9	Set/Query Subnet Address/Network Mask
10	Set/Query Default Gateway

Set *j* to 0 to disable a setting and 1 to enable it. Parameters 8–10 require an IP address in the form 'a.b.c.d' where each letter is a decimal integer in the range 0–255. Parameters 47 indicate the active IP configuration.

Example: `IFCF 6,0⟨CR⟩`
Disable Telnet Access

Example: `IFCF 8,192.168.10.5⟨CR⟩`
Set IP address to `192.168.10.5`

Example: `IFCF?10⟨CR⟩`
`192.168.10.1`

The returned value indicates the active default gateway.

IFRS *i* Interface Reset

Reset one of the communications interfaces. The parameter *i* identifies the interface to reset:

i	Configuration parameter
0	RS-232
1	GPIB
2	TCP/IP

When an interface is reset, it is changed to its power-on state.

LCAL	Go to Local Revert to local control of the instrument. This enables the front panel key pad for instrument control. This command is only active on telnet, raw-socket, and RS-232 connections. The other interfaces have built in functionality for implementing this functionality.
LOCK?	Request Lock Request the instrument lock. The SR470 returns 1 if the lock is granted and 0 otherwise. When the lock is granted, no other instrument interface may alter instrument settings until the lock is released via the UNLK command or the power is cycled. It also forces a complete lockout of the front panel.
UNLK?	Release Lock Release a previously acquired instrument lock. Returns 1 if the lock was released, otherwise 0. If UNLK? returns 0 and it is necessary to verify that the instrument is not presently locked from any other interface, acquire the lock with LOCK? before executing the UNLK? query.
REMT	Go to Remote Enable remote control of the instrument. In this mode, the front panel key pad is disabled, so that control of the instrument can only occur via the remote interface. This command is only active on telnet, raw socket, and RS-232 connections. The other interfaces have built in functionality for implementing this functionality.
XTRM *i*[,*j*][,*k*]	Set Interface Terminator Set the interface terminator that is appended to each response to *i* *j* *k*. The default terminator is '⟨CR⟩⟨LF⟩', i.e., ASCII character 13, followed by ASCII character 10. The interface terminator may be set to a different sequence of up to three characters in length by executing XTRM with parameters that consist of the decimal equivalent of the ASCII characters desired, separated by commas. *Example:* `XTRM 65,66,13` Set the interface terminator to 'AB⟨CR⟩'

2.6 Error Codes

The SR470 contains an error buffer that stores up to 20 error codes associated with errors encountered during power-on self tests, command parsing, or command execution. The ERR LED will be highlighted when a remote command fails for any reason. The errors in the buffer may be read one by one by executing successive LERR? commands. The meaning of each of the error codes is described below.

2.6.1 Execution Errors

Error Code	Meaning
0	**No Error** No more errors left in the queue.
10	**Illegal Value** A parameter was out of range.
11	**Illegal Mode** The action is illegal in the current mode. This might happen, for instance, if alignment mode is enabled when a shutter is under external level control.
12	**No Shutter Response** A query was made to a shutter but it didnt respond.
13	**Bad Shutter Response** A query was made to a shutter but the response was not in the expected format.
15	**Not Allowed** The requested action is not allowed because the instrument is locked by another interface.

2.6.2 Query Errors

Error Code	Meaning
30	**Lost Data** Data in the output buffer was lost. This occurs if the output buffer overflows, or if a communications error occurs and data in output buffer is discarded.
32	**No Listener** This is a communications error that occurs if the SR470 is addressed to talk on the GPIB bus, but there are no listeners. The SR470 discards any pending output.

2.6.3 Device Dependent Errors

Error Code	Meaning
40	**Failed ROM Check** The ROM checksum failed. The firmware code is likely corrupted.

2.6.4 Parsing Errors

Error Code	Meaning
110	**Illegal Command** The command syntax used was illegal. A command is normally a sequence of four letters, or a '*' followed by three letters.
111	**Undefined Command** The specified command does not exist.
112	**Illegal Query** The specified command does not permit queries
113	**Illegal Set** The specified command can only be queried.

(Continues)

Parsing errors, continued:

Error Code	Meaning
114	**Null Parameter** The parser detected an empty parameter.
115	**Extra Parameters** The parser detected more parameters than allowed by the command.
116	**Missing Parameters** The parser detected missing parameters required by the command.
117	**Parameter Overflow** The buffer for storing parameter values overflowed. This probably indicates a syntax error.
118	**Invalid Floating Point Number** The parser expected a floating point number, but was unable to parse it.
120	**Invalid Integer** The parser expected an integer, but was unable to parse it.
121	**Integer Overflow** A parsed integer was too large to store correctly.
122	**Invalid Hexadecimal** The parser expected hexadecimal characters but was unable to parse them.
126	**Syntax Error** The parser detected a syntax error in the command.

2.6.5 Communication Errors

Error Code	Meaning
170	**Communication Error** A communication error was detected. This is reported if the hardware detects a framing, or parity error in the data stream.
171	**Over Run** The input buffer of the remote interface overflowed. All data in both the input and output buffers will be flushed.

2.6.6 Other Errors

Error Code	Meaning
254	**Too many errors** The error buffer is full. Subsequent errors have been dropped.