MODEL 1471

HIGH VOLTAGE MODULE

LeCroy

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CE CONFORMITY

**CONDITIONS FOR
CE CONFORMITY**

Since this product is a subassembly, it is the responsibility of the end user, acting as the system integrator, to ensure that the overall system is CE compliant. This product was demonstrated to meet CE conformity using a CE compliant crate housed in an EMI/RFI shielded enclosure. It is strongly recommended that the system integrator establish these same conditions.

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GENERAL INFORMATION

PURPOSE

This manual is intended to provide instruction regarding the setup and operation of the covered instruments. In addition, it describes the theory of operation and presents other information regarding its functioning and application.

UNPACKING AND INSPECTION

It is recommended that the shipment be thoroughly inspected immediately upon delivery. All material in the container should be checked against the enclosed Packing List and shortages reported promptly. If the shipment is damaged in any way, please notify the Customer Service Department or the local field service office. If the damage is due to mishandling during shipment, you may be requested to assist in contacting the carrier in filing a damage claim.

WARRANTY

LeCroy warrants its instrument products to operate within specifications under normal use and service for a period of one year from the date of shipment. Component products, replacement parts, and repairs are warranted for 90 days. This warranty extends only to the original purchaser. Software is thoroughly tested, but is supplied "as is" with no warranty of any kind covering detailed performance. Accessory products not manufactured by LeCroy are covered by the original equipment manufacturers' warranty only.

In exercising this warranty, LeCroy will repair or, at its option, replace any product returned to the Customer Service Department or an authorized service facility within the warranty period, provided that the warrantor's examination discloses that the product is defective due to workmanship or materials and has not been caused by misuse, neglect, accident or abnormal conditions or operations.

The purchaser is responsible for the transportation and insurance charges arising from the return of products to the servicing facility. LeCroy will return all in-warranty products with transportation prepaid.

This warranty is in lieu of all other warranties, express or implied, including but not limited to any implied warranty of merchantability, fitness, or adequacy for any particular purpose or use. LeCroy shall not be liable for any special, incidental, or consequential damages, whether in contract, or otherwise.

PRODUCT ASSISTANCE

Answers to questions concerning installation, calibration, and use of LeCroy equipment are available from the Customer Service Department, 700 Chestnut Ridge Road, Chestnut Ridge, New York, 10977-6499, (914) 578-6030.

MAINTENANCE AGREEMENTS

LeCroy offers a selection of customer support services. For example, Maintenance Agreements provide extended warranty that allows the customer to budget maintenance costs after the initial warranty has expired. Other services such as installation, training, on-site repair, and addition of engineering improvements are available through specific Supplemental Support Agreements. Please contact the Customer Service Department for more information.

**DOCUMENTATION
DISCREPANCIES**

LeCroy is committed to providing state-of-the-art instrumentation and is continually refining and improving the performance of its products. While physical modifications can be implemented quite rapidly, the corrected documentation frequently requires more time to produce. Consequently, this manual may not agree in every detail with the accompanying product and the schematics in the Service Documentation. There may be small discrepancies in the values of components for the purposes of pulse shape, timing, offset, etc., and, occasionally, minor logic changes. Where any such inconsistencies exist, please be assured that the unit is correct and incorporates the most up-to-date circuitry.

**SOFTWARE LICENSING
AGREEMENT**

Software products are licensed for a single machine. Under this license you may:

■ Copy the software for backup or modification purposes in support of your use of the software on a single machine.

■ Modify the software and/or merge it into another program for your use on a single machine.

■ Transfer the software and the license to another party if the other party accepts the terms of this agreement and you relinquish all copies, whether in printed or machine readable form, including all modified or merged versions.

SERVICE PROCEDURE

Products requiring maintenance should be returned to the Customer Service Department or authorized service facility. If under warranty, LeCroy will repair or replace the product at no charge. The purchaser is only responsible for the transportation charges arising from return of the goods to the service facility. For all LeCroy products in need of repair after the warranty period, the customer must provide a Purchase Order Number before any inoperative equipment can be repaired or replaced. The customer will be billed for the parts and labor for the repair as well as for shipping. All products returned for repair should be identified by the model and serial numbers and include a description of the defect or failure, name and phone number of the user. In the case of products returned, a Return Authorization Number is required and may be obtained by contacting the Customer Service Department at (914) 578-6030.

PRODUCT DESCRIPTION

INTRODUCTION

The 1471 is an 8-channel, high voltage generation module in the 1450 system. The 1471 supplies up to 6 kV for 200 µA. Each channel is fully independent.

This manual is divided into two sections. The first part describes the operation of the 1471 when used in a 1450 mainframe. The second part includes additional information required to use the 1471 independent of a 1450 mainframe. Independent operation is not recommended because the user is required to supply several power supply voltages, clock frequencies and safety features for correct operation.

SPECIFICATIONS

Channels: 8, fully independent.
Output Voltage: Programmable, 0 to 6 kV.
Voltage Polarity: Model 1471N for negative voltage, Model 1471P for positive voltage.
Voltage Set Resolution: < 1 V (500 mV nominal).
Voltage Output Accuracy: ±(0.10% of setting + 3 V) at 25°C, from 5% to 100% of full scale. (Below 5% of full scale, a minimum load may be necessary).
Temperature Stability: < 100 ppm/°C.
Voltage Repeatability: < ±1 V at constant load, line and temperature.
Voltage Output Ripple: < 50 mV p-p, (< 10 mV p-p for f > 1 kHz).
Voltage Measurement Resolution: < 1 V (500 mV nominal).
Voltage Measurement Accuracy: ±(0.1% of reading + 3 V) at 25°C.
Voltage Ramp Rate: Programmable per channel, separate ramp up and ramp down rates (nominally 1 to 500 V per second in 1 V steps). Enable for over current trip is programmable.
Current: 200 µA per channel.
Charging Current: 200 µA per channel if ramp trip enabled, ~2 mA otherwise.
Current Trip: Programmable per channel from 1 µA to 200 µA, < 15 nA resolution.
Current Measurement Resolution: < 15 nA.
Current Measurement Accuracy: ± (1% of reading + 50 nA).
Current Trip Detect Time: < 10 msec (normally 2 msec).
24 V Power Requirements: 56 mA + 330 µA/µA.
Hardware Voltage Limit: One potentiometer on panel and 1000:1 test point.
HV ON LED: One; steady on for all channels stable HV, flash for any channel changing output.
Dimensions: 6 U (10.3" high x 14.6" deep x 1" wide; Eurocard C size).
Connector Type: 8 SHV.

DESCRIPTION

Versions

The 1471 is available in both polarities (model numbers 1471N and 1471P). The polarity of the module cannot be changed by the user.

Hardware HV Limit

The 1471 HV module supports a hardware based high voltage limit. A single potentiometer and test point are located on the front panel of the 1471 HV module. The voltage at the test point measures the high voltage limit with a 1000 to 1 reduction. The potentiometer sets the limit, clockwise increases the limit. The test point voltage is always positive regardless of the module's polarity.

The test point voltage is actually measured by the 1471's ADC and the firmware blocks any voltage settings above the limit. The voltage limit is not 'live' and cannot be used to control the output. If the voltage limit is adjusted to a value below an existing output, the channel is tripped, even if the high voltage is off. The target voltage must be set below the limit and the channel re-enabled to clear the trip condition.

The HV limit has a resolution of 0.5 volts. The maximum value is above 6 kV. Settings above 6 kV disable the front panel HV limit since the module's inherent 6 kV limit applies.

Hardware Current Limit

The maximum output channel current capacity is 200 μA. It is always enforced during periods of non-ramping. The firmware in the 1471 enforces this limit by tripping channels in violation. This limit can be disabled for any current during ramping if ramp trip enable is cleared. By default ramp tripping is enabled (fixed at 200 μA). **Note:** this allows the 1471 to power a resistive load of 30.0 MΩ to 6000 V.
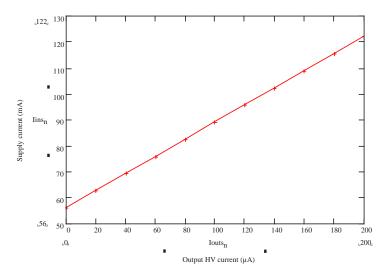
Front Panel LED

The LED on the front panel of the 1471 is a visual indication of the state of high voltage generation. When the LED is flashing, the outputs of the 1471 are ramping to a new voltage. When the LED is on, steady high voltage is being generated. When the LED is off, no power is being delivered to the output but there could still be substantial voltage at the output, depending on the type of load.

Power Requirements

The standard mainframe supplies an average of about 3.75 amperes per slot. The 1471 HV card can sink as much as 980 mA. Most applications do not require this power level (6 kV, 200 μA on all channels). The following graph shows the supply current required as a function of the output current. With this it is possible to compute the supply current required for any particular application. If the supply current requirements exceed the specifications of the selected mainframe, it will be necessary to use modified mainframes or to redistribute the required channels over more mainframes.

Supply Current (mA) requirement vs. Output Current (μA) per Channel

The points shown are measurements. The lines are fit to the corresponding data. The nominal slope is 330 μA Supply Current per μA Output Current. This data is the result of measurements and may change with revisions of the 1471

INSTALLATION

To install the Model 1471 HV module in a 1450 series mainframe:

1. Turn mainframe power off.

2. Insert 1471 into a numbered slot of the 1450 mainframe.

3. Tighten both captive screws at the top an bottom of the 1471 front panel. Do not use the captive screws to force the module into the slot.

4. Turn On AC power.

5. Check HV limit at the test point on the front panel. Factory defaults should place the HV limit at maximum.

6. Check that the 1471 generates high voltage correctly without loads.

7. Turn off high voltage and wait until the LED on the 1471 front panel is off and stops flashing. Make HV connections to equipment or detectors.

Usually, the 1471 is operated with a 1450 mainframe. In this case, the properties supported by the 1471 simply appear in the database of the mainframe. To operate this way, only the Properties section is required reading.

To operate the 1471, independent of the mainframes, significant support is required. The Hardware section describes the connectors, signals and power supplies required.

PROPERTIES

Properties describe the state of each channel in the 1450 system. All the channels in a module have the same properties. The properties usually have different values. For example, the demand voltage (DV) is a property of a 1471 channel. The value of this property (for example - 6000.0) is the desired output voltage for that channel.

Each channel of the 1471 has 15 properties. The chart below lists all these properties and a little information about each.

Property	**Type**	**Mnemonic**
Measured Current	Read Only	MC
Measured Peak Current	Read Only	MCpk
Measured Voltage	Read Only	MV
Demand Voltage	Read/Write	DV
Ramp Rate Up	Read/Write	RUP
Ramp Rate Down	Read/Write	RDN
Trip Peak Current	Read/Write	TCpk
Trip Current	Read/Write	TC
Channel Enable	Read/Write	CE
Ramp Trip Enable	Read/Write	RTE
Channel Status	Read Only	ST
Measured Voltage Dead Zone	Read/Write	MVDZ
Measured Current Dead Zone	Read/Write	MCDZ
High Voltage Limit	Read Only	HVL

The Measured Current (MC) and the Measured Voltage (MV) properties are self-explanatory. When the value of this property is required, the 1471 return the most recent measurements. These properties are naturally read-only.

The Demand Voltage (DV), Ramp Rate (RUP), Trip Current (TC) and Trip Peak Current (TCpk) properties are also straight forward. The values given to these properties control the functioning of the channel. The 1471 firmware imposes limits on the value of these properties. When a property is set, the 1471 firmware computes its best attempt at the value and uses it. When the property value is read, the changes required by the hardware limitations are shown.

The 1471 supports independent Ramp Up (RUP) and Ramp down (RDN) rates.

The Channel Enable (CE) simply permits a channel to generate output. If a channel is not enabled, no power is delivered to the output. When a channel is changed from enabled to disabled, the output voltage ramps at the programmed ramp rate to zero. Tripped channels are cleared with an enable command.

The Channel Ramp Trip Enable (RTE) permits the channel to trip during ramping conditions where the maximum allowable current during ramping is fixed at 200 μA. The default value is "Enabled".

The Channel Status (ST) property gives information on why a channel is tripped, if it is enabled, if ramp tripping is enabled, and if it is ramping up or down.

The Measured Voltage Dead Zone (MVDZ) and Measured Current Dead Zone (MCDZ) properties are part of a system controlling updates. Whenever a property changes, the update system increments a control word. The MVDZ and MCDZ properties define how much change in the measured value (MV ,MC and MCpk respectively) is considered significant. If these properties are zero, virtually every measurement is identified by the update system as a change since, the LSB of the measurement is likely to change with each measurement. If these properties are set to 2 V and 2 μA, respectively, then the measurement must change by this much to be noticed by the update system. Regardless of the value of MVDZ and MCDZ, reading of MV,MC and MCpk return the most recent measurements.

The update system is used by the 1454 mainframe for the display updates. Increasing the Dead Zones, reduces the amount of time spend on screen updates.

The High Voltage Limit (HVL) is voltage limit imposed by the front panel potentiometer. This value is the same for all channels but for convenience is shown individually for each channel.

HARDWARE

Backplane Signal Descriptions

GA 0-7	Geographic address bits.	
CONFIG 0-7	Configuration for HV Modules. Pull-up on backplane, selected bits are driven low by 1450-1 interface card.	
100 kHz	Clock for HV switching power supplies, sync to 800 kHz.	
800 kHz	Clock for HV switching power supplies	
8 MHz	Clock for microprocessors	
20 MHz	Clock for ARCNET network	
ARCNET	ARCNET data path. bussed, open collector, 5 V	
+15 V	Power supply, two pins	
-15 V	Power supply, two pins	
+24 V	Power supply, three pins	
MOSI, MISO	Master Out Slave In and Master In Slave Out; 5 V, open collector, bussed serial data line	
ATTN*	Attention from HV card to HV mainframe; 5 V, open collected, bussed.	
HVENB*	Drive by mainframe to enable High Voltage generation	
UCLK	Uncommitted Clock	

Backplane Connector Pinout

Pin No	Row A	Row B	Row C
1	GA0	GND	ATTN*
2	GA1	GND	GND
3	GA2	GND	HVENB*
4	GA3	GND	GND
5	GA4	GND	100 kHz
6	GA5	GND	GND
7	GA6	GND	800 kHz
8	GA7	GND	GND
9	+24 V	GND	+15 V
10	8 MHz	GND	GND
11	+24 V	GND	GND
12	MISO	GND	SYSRESET*
13	GND	GND	GND
14	MOSI	GND	20 MHz
15	+24 V	GND	GND
16	GND	GND	ARCNET
17	+12 V	GND	GND
18	GND	GND	UCLK
19	-15 V	GND	GND
20	GND	GND	GND
21	CONFIG 0	GND	CONFIG 4
22	GND	GND	GND
23	CONFIG 1	GND	CONFIG 5
24	GND	GND	GND
25	CONFIG 2	GND	CONFIG 6
26	GND	GND	GND
27	CONFIG 3	GND	CONFIG 7
28	GND	GND	GND
29	GND	GND	GND
20	GND	GND	GND
31	-15V	VCC	+15V
32	VCC	VCC	VCC

Configuration Register

The configuration register controls 1471 module during power-up. This register is static and read only during the power-up sequence. The 1471 interprets the bits as follows:

Bit	Description for 1	Description for 0
0	Normal Bootstrap	Special Bootstrap
1	EEPROM Write Inhibit	EEPROM Write Enable
2	Normal Operation	Stand-Alone Operation
3	Cold Reboot	Hot Reboot
4:5	Baud Rate Select: 115.2 k, 38.4 k, 19.2 k, 9600 = 3,2,1,0 resp.	
6		Maintenance
7	(reserved)	(reserved)

Some bits are interpreted by the hardware and some by the software. When all of these bits are driven high (1), the 'normal user' mode results. This allows a user's mainframe to be constructed without the ability to drive these bits low.

Special Bootstrap mode is only used by manufacturing for the initial in-circuit programming of the system. In this mode the microprocessor executes ROM code inside the HC11 device. Programming data is then accepted over the serial (SCI) port. This module will not operate with this bit low and blocks the use of the serial interface by other modules in the same backplane.

The EEPROM Write Inhibit simply prevents the programming from being changed. This is enforced by hardware so even program failures cannot alter the programming. The system must be write enabled during calibration to allow calibration constants to be copied to the EEPROM. It must also be enabled for initial programming of the EEPROM.

Normal versus Stand-Alone operation differ only in that the Normal operation demands regular serial messages in order to continue the generation of high voltage. No particular message is required, only continued contact with the host. A failure to communicate with the mainframe on a regular basis terminates the high voltage generation. Stand-Alone operation simply omits this requirement.

Hot reboot causes the module to use previously saved start-up data for the output voltage and initiates high voltage generation. Before this is allowed to happen, 1) the output voltage settings must have been saved in the EEPROM previously, 2) Stand-Alone Operation configuration bit must be asserted in addition to Hot Reboot configuration bit.

The baud rate select controls the default speed for the serial connection over the backplane. Some implementations require the serial data be relayed to other systems. The lower baud rate selection (9600) eases the system hardware requirements. The highest baud rate, 115.2 k, is the maximum possible rate with the current hardware.

The maintenance-off bit turns-off several properties used during testing and calibration.

THEORY OF OPERATION

CALIBRATION THEORY

The 1471 design does not include any hardware adjustments for calibrating the output voltage, measured voltage or measured current. All corrections are done by the microprocessor with its software. During the calibration procedure, measurements are made with external, calibrated instruments (high voltage divider and precision voltmeter) and a computer. These measurements are converted into coefficients to be used by the module for all reported measurements and settings. Thus the high voltage generation hardware requires only an adequate range and stability to produce accurate output and measurements.

This system requires three transfer functions:

1. convert ADC codes to measured voltage
2. convert ADC codes to measured current
3. convert voltage request to DAC codes

The first two transfer functions are straight forward since there is simply a 14-bit ADC. The first transfer function requires a quadratic polynomial (3 constants). This is primarily because high voltage resistors have significant voltage coefficients. This effect is completely compensated for with a quadratic polynomial. The measured current does not have this effect and a linear transfer function is completely adequate.

The third transfer function requires a quadratic polynomial (3 constants). The DAC is composed of one 14-bit DAC per channel.

The transfer function from target voltage to output voltage appears to be a quadratic approximated by *256* line segments.

VOLTAGE RAMP PROCEDURES

Ramping of the output voltage is done by successively programming the output voltage to values closer to the target. Because of the 14-bit resolution and fixed ramp timer interval, not all ramp rates are possible.

The HV module begins a ramp by computing the data value for the DAC which will generate the correct target voltage. If the ramp is to a voltage of higher magnitude, the DAC is changed several times a second, with a step size computed from the ramp rate. If during ramping the RTE is enabled, then the output will be disabled if the current exceeds 200 μA. The ramping trips are controlled by the Ramp Trip Enable (RTE) property.

HARDWARE TRIP LIMITS

The hardware limit controlled via a Field Programmable Gate Array is responsible for protecting the hardware by detecting and correcting overcurrent situations. The hardware is capable of tripping off the voltage within 10 m seconds to protect the hardware from over heating. (Fixed at 200 μA during non-ramping conditions.) The ramping trips are controlled by the Ramp Trip Enable (RTE) property.

This appendix describes communication protocols used by the 1471. Any number of HV modules are connected together on a single pair of serial line. The protocol includes arbitrating access to these lines and addressing messages to their destinations.

The content of messages consists of command to examine or modify properties. The section on commands describes the syntax and meaning of all the commands recognized by the 1471. Other HV modules may have larger or smaller command sets but the same command always performs the same function.

Finally, the properties of 1471 channels are described.

MESSAGE ROUTING PROTOCOL

Two serial connections are used to transfer data to and from the HV module (slave) and the host system (master). Both lines are unidirectional and named MasterOut-SlaveIn (MOSI) and MasterIn-SlaveOut (MISO). All HV modules receive data on the MOSI line and transmit on the MISO line. The host system is in control of all arbitration and must avoid contention by the slaves..

To begin a message the host transmits (on MOSI) an address byte followed by additional bytes ending with a terminator byte. All slaves receive the address byte and compare it to their geographic address. The slave with a match is said to have received the token. The slave must promptly send one response, possibly empty, on MISO to return the token. In this way the host sends the token to each slave in turn, searching for responses to previously sent messages.

In every message is a status byte regarding receipt of the last message. The slaves are required to re-transmit the previous response message whenever a negative host-receive-status is received. The host can re-transmit or send a new message.

If the message is not empty it contains an optional sub-module-address, a ticket-number and a command string. The ticket-number for each command is included in the response. This allows the host to route responses back to the originator of the command. This allows multiple sources to send commands to the HV module and have the responses correctly returned.

The following describes the syntax for messages on the serial line in detail. No separators or terminators are implied. All bytes appearing on the back plane are described. The construction [xx] indicates a single byte with the hex value 'xx'. Curly brackets '{}' enclose optional items

host-message:
   address host-receive-status {sub-module-address space} {ticket-number space command} terminator

slave-message:
   slave-receive-status {ticket-number space response} terminator

address:
   [80 + geographic address]

sub-module-address:
    ASCII-digit {ASCII-digit} space

ticket-number:
    ASCII-digit {ASCII-digit {ASCII-digit}} space

host-receive-status:
    ack
    nak

slave-receive -status:
    ack
    nak

ack:
    [06]

nak:
    [15]

space:
      [20]

terminator:
    [0D]

COMMAND SYNTAX

The following describes the syntax for commands. Literal text is shown in bold. Alternative formats are shown on consecutive lines or separated by a vertical bar (|). Syntax elements are shown in italics. All items are separated by one or more spaces.

command:
    ATTR *property-name*
    DMP *channel-number*
    HVON
    HVOFF
    HVSTATUS
    ID
    LD *property-name channel-number property-value-list*
    PROP
    PSUM
    RC *property-name*
    SAVE *channel-number*
    SM
    SN *serial-number*

property-value-list:
    property-value {property-value-list}

property-name:
    MV
    DV
    MC
    MCpk
    RUP
    RDN
    TCpk
    TC
    CE
    RTE
    ST
    MVDZ
    MCDZ

channel-number:
    0 | 1 | 2 | 3 | 4 | 5 | 6 | 7

Commands and Responses

This section describes each command an the HV module's responses. Each response is returned with the ticket number of the command. All successful responses consist of the original command followed the requested data or the original parameters corrected to the constraints of the HV module.

Error messages are also returned on the same ticket number but begin with the text "US", for unsolicited. Some errors return the part of the part of the command string that was successfully parsed. The ticket number is not checked in any way.

ATTR Command

This command returns all the attributes for the named property. This response consists of exactly six space separated tokens which describe the property. If any of the six attributes requires spaces these are re-placed with the underscore. See the section on property attributes for details of the possible attributes

Examples:

Command: ATTR DV
Returns: ATTR DV Demand V P N -6000.0_0.0_0.5 %5.1f

Command: ATTR MC
Returns: ATTR MC Current µA M N 7 %7.2f

Command: ATTR TCpk
Returns: ATTR TCpk Current µA M N 7 %7.2f

DMP Command

HVON/HVOFF Commands

These two commands switch the high voltage on and off. When HV is off, all clocks to the HV generation hardware are blocked. The response to this command is exactly the same as the command. In other words, the command "HVON" responds with the string "HVON".

Both commands causes the outputs to be ramped, at the appropriate ramp rate. HVOFF ramps outputs to zero at the ramp down (RDN) rate and then disables the HV generation circuits. HVON ramps the output from zero to the target voltage (DV) at the ramp up rate (RUP).

HVSTATUS Command

This command returns the current status of the HV. The string "HVSTATUS HVON" or the string "HVSTATUS HVOFF" is returned.

ID Command

This command returns a fixed descriptor for the module. The fields in the descriptor are module number, sub module number, number of sub modules, number of channels, serial number, revision number, ECO number, and firmware version.

Example:

Command: ID
Response: ID 1471N 0 0 6 20 A123456 -1 1000 0.04

LD Command

The load command modified the values of a single property. The property specified must be writable. The channel number is the first channel to be modified. The list must be compatible with the property specified. The first value is assigned to the channel specified. The number of items in the list must not exceed the number of channels in the module. The response to this command is exactly the values listed possibly adjusted to conform to the limitations of the module

Example:

Command: LD DV 3 -5000 -5000 -4000
Response: LD DV 3 -1000.5 -1000.7 -1999.7

PROP Command

This command returns a list of the user properties supported by the module. Property names are separated by spaces and are used as arguments to command which accept property-names. The number of property names to expect can be determined with the ID command.

Example:

Command: PROP
Response: PROP MC MCpk MV DV RUP RDN TCpk TC CE RTE
                     ST MVDZ MCDZ HVL

PSUM Command

This command (Property Summary) returns a change control number for each user property. This number is computed by incrementing a 16 bit number whenever a significant change to the property value occurs. This command identifies a properties whose values have changed. The host reads the change control numbers first and then the data. The next time, the host reads the control numbers and compares them to the older control numbers read previously. If the control number for a particular property has not changed, then the values of the corresponding property need not be re-read. This one command checks all the data in the module.

In the case of measured properties (e.g. Measured Voltage, Measured Current), a dead zone concept is used. If the value of the measured

property has moved more than a dead zone amount from a previous reading, the new reading is saved and the change control number is incremented. The most recent measurements are always returned with the recall command, they are just not considered different in the change control system.

The maximum rate at which the change control can be incremented is about 10 Hz. This means that change control numbers do not reoccur for about 1.8 hours.

RC Command

The recall command returns all the values for one property. The values are returned in channel order.

Example:

Command: RC MV
Response: RC MV -1000.5 -1000.8 -2380.5 ...

SAVE command

This command causes the previously loaded calibration constants to be copied to the EEPROM. If EEPROM writes are blocked an error message is returned. If the command is successful, significant delays are created during the EEPROM writes. After the token is returned to the host, communication must be suspended for about 1 second to avoid communication failures. During the EEPROM write, processor interrupts are disabled. Arriving data will cause an immediate overrun error.

The target voltage, ramp rate, enable status and trip current are also copied to initial value arrays in the EEPROM. This data is used when power is restored. If the configuration bits indicate, high voltage generation is started and outputs ramp to the previously saved values.

SM Command

This command returns the number of sub modules present in the physical module. The 1471 has only one submodule.

SN Command

The command sets the module serial number. This is the same number which appears on the HV modules' front panel.

The default serial number is "000000" Only the default serial number can be overwritten. The only way to change the serial number of board is to download a new copy of the firmware.

PROPERTIES

The following properties are considered "golden" and will probably appear in all HV modules. The attributes listed are examples only.

MV   **Measured Voltage**

Label: Meas_V
Units: V
Protection: Measured (M)
Type: Numeric (N)
Range: 7 (maximum string length)
Format: %7.1f

This is the measured output voltage.

DV	**Demand Voltage**
Label:	Target_V
Units:	V
Protection:	None(N)
Type:	Numeric (N)
Range:	-6000 0 0.5
Format:	%7.2f

This is the desired output voltage

MCpk	**Measured Current**
Label:	MeasPk_uA
Units:	µA
Protection:	Measured(M)
Type:	Numeric (N)
Range:	7 (maximum string length)
Format:	%7.2f

This is the current measured on the channel.

MC	**Measured Current**
Label:	Meas_µA
Units:	µA
Protection:	Measured(M)
Type:	Numeric (N)
Range:	7 (maximum string length)
Format:	%7.2f

This is the current measured on the channel.

RUP	**Ramp Up Rate**
Label:	RUp_V/s
Units:	V/s
Protection:	Password(P)
Type:	Numeric (N)
Range:	10 500 10
Format:	%7.1f

This property is loaded with the desired ramp up rate. This rate is used when the HV is turned on or the output voltage is set to a higher (in magnitude) value.

RDN	**Ramp Down Rate**
Label:	RDn_V/s
Units:	V/s
Protection:	Password(P)
Type:	Numeric (N)
Range:	10 500 10
Format:	%7.1f

This property is loaded with the desired ramp down rate. This rate is used when the HV is turned on or the output voltage is set to a higher (in magnitude) value.

TCpk   **Peak Trip Current**

Label: TripPk_μA
Units: μA
Protection: Password(P)
Type: Numeric (N)
Range: 200 5 .015
Format: %7.2f

This property is loaded with the maximum allowed Peak sense current. If this current is exceeded the channel is tripped. HV generation is discontinued.

TC   **Trip Current Slow**

Label: Trip_μA
Units: μA
Protection: Password(P)
Type: Numeric (N)
Range: 200 5 .015
Format: %7.2f

This property is loaded with the maximum allowed SLOW sense current. If this current is exceeded the channel is tripped. HV generation is discontinued.

CE   **Channel Enable**

Label: Ch_En
Units:
Protection: Password(P)
Type: Numeric (N)
Range: En Ds
Format: %2s

This property is used to enable and disable HV channels. While this property can be examined it is more informative to examine the ST (status) property.

RTE   **Ramp Enable Trip**

Label: RT_En
Units:
Protection: Password(P)
Type: Numeric (N)
Range: 0 1
Format: %1s

This property is used to enable and disable tripping during ramp up and ramp down caused by both the current trip measurement (fixed in software to 200 μA).

ST   Channel Status

Label: Status
Units:
Protection: Measured(M)
Type: Numeric (N)
Range: 4 (maximum string length)
Format: %4x

Bit   Description

0   Channel is enabled
1   Output is ramping to a higher absolute value.
2   Output is ramping to a lower absolute value or zero
5   Trip for violation of supply limits
6   Trip for violation user's current limit
7   Trip for voltage error
8   Trip for violation of voltage limit
9   Thermal Overload
10   Trip for violation user's Peak current limit
11   Trip for ARC
12   reserved
13   reserved
14   reserved

This property is a measured value and cannot be loaded. The return value is a number which describes the state of the HV channel. The returned data is a bit wise-status word. The following table describes the meaning of each bit.

Tripped is defined as a state where the firmware as shut the channel down because it has exceeded some user limit e.g. current limit. This state is cleared by cycling the Enable/Disable status.

MVDZ Measured Voltage Dead Zone

Label: MV_Zone
Units: V
Protection: None (N)
Type: Numeric (N)
Range: 0_6000
Format: %7.1f

MCDZ Measured Current Dead Zone

Label: MC_Zone
Units: μA
Protection: None (N)
Type: Numeric (N)
Range: 0_200
Format: %7.1f

PROPERTY ATTRIBUTES   Properties are used to describe the state of each channel. Each property has exactly one value for each channel. Some properties can be set by the user and others can only be examined.

Each property has six attributes which describe how to manipulate the value of each property.

Label Attribute   The label is simply a short text string suitable for the top of a column containing the values of this property.

Units Attribute   The units is a short string which assigns the correct units to the property value.

Protection Attribute   The protections attribute describes the accessibility of the property. "N" indicates no protection. Any user can alter this attribute. "P" indicates password protection. The password must have been previously enabled and presented to the unit before the property can be altered. The 1471 does not use passwords. "M" indicates the value is measured and cannot be altered by user commands.

Type Attribute   This attribute describes what kind of value the property accepts or delivers. "N" indicates a numeric value, "S" is a general string value. and "L" indicates logical values.

Range Attribute   This attribute describes the allowed values for properties which can be written and the maximum size of properties which are measurements.

For numeric, not measured, values this attribute is a string of three numbers which are the minimum, maximum and resolution. For example the target voltage property has a minimum of 0.0 volts, a maximum of 6000.0 volts and a resolution of 0.5 volt.

For measured value and strings, the range is a single number indicating the maximum length of the string returned. This is use for set up of displays containing the measured data.

For logical values, the range is list of all the allowed values of the property separated by spaces. For example "ON OFF".

Format Attribute   The format attribute is a 'C' format string which can be used to reprint the value of the property.