Model 523

GPIB Remote Controlled
Precision DC Source/Calibrator

KROHN-HITE CORPORATION

Operating and Maintenance Manual

Service and Warranty

Krohn-Hite Instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If your instrument fails to provide satisfactory service and you are unable to locate the source of trouble, contact our Service Department at (508) 580-1660, giving all the information available concerning the failure.

DO NOT return the instrument without our written or verbal authorization to do so. After contacting us, we will issue a Return Authorization Number which should be referenced on the packing slip and purchase order. In most cases, we will be able to supply you with the information necessary to repair the instrument, avoiding any transportation problems and costs. When it becomes necessary to return the instrument to the factory, kindly pack it carefully and ship it to us prepaid.

All Krohn-Hite products are warranted against defective materials and workmanship. This warranty applies for a period of one year from the date of delivery to the Original Purchaser. Any instrument that is found within the one year warranty period not to meet these standards, will be repaired or replaced. This warranty does not apply to electron tubes, fuses or batteries. No other warranty is expressed or implied.

Krohn-Hite Corporation reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

Modifications to this instrument must not be made without the written consent of an authorized employee of Krohn-Hite Corporation.

Model 523

Precision DC Source/Calibrator

Operating Manual

TABLE OF CONTENTS

SECTION 3 - REMOTE (GPIB) PROGRAMMING

SECTION 4 - INCOMING ACCEPTANCE

Warranty, Service and Safety

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CLAIMS

Immediately upon arrival, purchaser shall check the packing container against the enclosed packing list and shall, within thirty days of arrival, give Krohn-Hite notice of shortages or any non-conformity with the terms of the order.

The purchaser assumes all risk of loss or damage to instrument upon delivery by Krohn-Hite to the carrier. If an instrument is damaged in transit, *purchaser must file all claims for damage with the carrier* to obtain compensation. Upon request by purchaser, Krohn-Hite will submit an estimate of cost to repair shipment damage.

SAFETY ISSUES

WARNING

HIGH VOLTAGE is used in the operation of this instrument. LETHAL voltages may be present on the output terminals. Please observe all safety precautions when operating this instrument.

POWER SOURCE

The Model 523 is intended to operate from a 105V to 240V ac rms source. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

PROPER FUSE

To avoid damage to the Model 523 or to prevent a fire hazard, use the correct fuse for the line voltage selected. Proper fuse requirement is screened on the rear panel of the instrument above the power connector.

The Model 523 has been designed, tested and supplied in a safe condition. The following general safety precautions must be observed during all phases of operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture and intended use of this instrument. Krohn-Hite assumes no liability for the customer's failure to comply with these requirements.

This manual contains information and warnings that must be observed to keep the instrument in a safe condition and ensure safe operation. Operation or service in conditions or in a manner other than specified could compromise safety. For the correct and safe use of this instrument, operating and service personnel must follow generally accepted safety procedures.

To avoid injury or fire hazard, do not switch on the instrument if it is damaged or suspected to be faulty. Do not use the instrument in damp, wet, condensing, dusty or explosive gas environments.

Whenever it is likely that safety protection has been impaired, make the instrument inoperative and secure against any unintended operation, and then inform qualified personnel. Safety protection is likely to be impaired if, for example, the instrument shows visible damage, or fails to operate normally.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. Any interruption of the protective ground conductor inside or outside the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

PROTECTIVE EARTH GROUND

Protective earth symbols located on the inside rear chassis near the AC line filter module designate the point at which the safety earth system is attached tot the chassis. These symbols must not be altered or removed. The safety earth wires (green/yellow) must never be disconnected. The safety earth ground wires (green/yellow) connecting the module must make direct contact with the chassis.

The following are symbols used on the chassis of the 523:

---- Chassis Protective Ground

---- AC (Alternating Current)

---- Conforms to European Union Directives

---- Important Information, Refer to the Manual

---- Caution, Risk of Electric Shock

DO NOT OPERATE IN AN EXPLOSIVE AREA

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Qualified maintenance personnel must make component replacement and internal adjustments. Under certain conditions, dangerous voltages may exist. To avoid injuries, always disconnect input voltages before removing the covers.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modifications. Return the unit to the Krohn-Hite Service Department to modify or repair the instrument to ensure that safety features are maintained.

DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE the POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to the Krohn-Hite Service Department for service and repair to ensure that the safety features are maintained.

DO NOT REMOVE COVER

To avoid personal injury, do not remove the covers of the Model 523. There are no user-serviceable parts inside the instrument, so there is no reason for any user to remove the covers of this instrument.

UNPACKING AND INSPECTION

The Model 523 has been shipped in a container designed to prevent any damage from occurring during shipping. Inspect the 523 carefully for damage, and immediately report any damage to the shipper.

If you need to return the 523 for any reason, use the original container if possible. If not, you can order a new container from Krohn-Hite Corporation at (508) 580-1660 indicating the model and serial number.

Notes

Figure 1 *Model 523 Precision Source/Calibrator*

SECTION 1

General Description and Specifications

1.1   INTRODUCTION

The NEW Krohn-Hite Model 523 Precision DC Source is a highly stable and repeatable dc voltage and current source providing N.I.S.T. traceable voltages and currents for use in production, calibration labs, QA and QC departments, design labs, or any place where an accurate voltage or current source is needed.

Using Krohn-Hite's state-of-the-art reference, the 523 provides accurate and stable voltages to ±110.99999Vdc to within ±4ppm for 90 days (±8ppm for 1 year), and precise currents to ±110.99999mA to within ±8ppm for 90 days (±16ppm for 1 year). It is an extremely quiet source with <7µVrms of noise measured over a 10Hz to 100kHz bandwidth (<2µVrms 0.1Hz to 10Hz).

The 523 features a user friendly 7½ digit display and a membrane keyboard entry for all settings. Output settings can be modified using a plus/minus delta function, multiply/divide function and curser control keys that allow placing a curser on any digit to increment or decrement its value. Output 2-wire, 4-wire and chassis grounding are accomplished with one keystroke. A crowbar function places the output in a safe mode when desired. The 523 output can be set to 0 volts, allowing the output sense to maintain true 4-wire low impedance zero output.

1.2   AUTO ZERO OFFSET

An AUTO ZERO OFFSET CALIBRATION (AZOC) corrects any thermally generated offsets to within specified limits and is accessible via the front panel or over the GPIB interface bus. The unit is designed for a "Covers-On Calibration" using the optional KH523CAL Calibration Software Program (License needed). With the KH523CAL software program and a Model HP3458 Digital Voltmeter, unattended calibrations can be made in approximately 15 minutes.

1.3   STORING OUTPUT SETTINGS

The 523 provides for the storage of up to 31 output settings that can be recalled at any time. Internal operating temperature, serial number, last calibration date and firmware version can all be called to the display for quick access when needed. Error messages are displayed when incorrect or out-of-range entries are made.

1.4   APPLICATIONS

The Model 523 is well suited for many applications where an extremely accurate and stable dc voltage or dc current is needed. At a cost much less than most sources in its class, the 523 can be a valuable asset to any company's production line, calibration lab, QA and QC department and design lab.

1.5   CALIBRATION PROCESS

Calibration of the Model 523 requires the HP3458A or Fluke 8508A Digital Multimeter and a precision 100 ohm resistor (optional Krohn-Hite Model PCR100). Calibration constants that define the calibration points for controlling the output are stored in memory. Traceable calibration to the specified performance is accomplished in a semi-automated process that updates this table during calibration using the KH523CAL Automatic Testing and Calibration Program.

1.6   SUPPORT EQUIPMENT NEEDED

The only support equipment needed for the Model 523 is the HP3458A Digital Multimeter and a precision 100 ohm resistor for current adjustment checks.

1.7   ESTABLISHING TRACEABILITY

Traceability to national standards is accomplished as follows:

An HP3458A that is traceable to N.I.S.T and is periodically checked against an in-house Fluke 732A 10V Reference. All verifications of calibration are performed to better than actual manufacturers specifications.

1.8   CALIBRATION REPORTS

In the future the KHCAL523 Automatic Testing and CalibrationProgram, provided with each unit, will have the ability to display and print N.I.S.T. traceable reports.

1.9   CALIBRATION CHECK

Checking the calibration of the Model 523 can be simply accomplished using the optional KHCAL523 Software Calibration Program. The program allows for two calibration tests, a voltage only and current only test. The voltage test checks 90 points while the current test checks 46.

1.10   CALIBRATION INTERVALS

The traditional practice of returning a calibrator to a standards laboratory at regular intervals for a full calibration is disruptive, costly and time consuming. It can leave a gap in confidence. You then rely on manufacturer's specifications to determine if a calibrator will perform the same outside the lab. So you then must assume that drift is predictable enough so that the performance is within limits between re-calibrations.

However, the Model 523 can be completely calibrated to it's original specifications by using a HP3485A Multimeter, a 100 ohm standard precision resistor and the Krohn-Hite optional KHCAL523 Calibration Program, and by not removing its covers or making an adjustment.

1.11   TEMPERATURE CONTROL

To maximize performance in the Model 523, the internal temperatures must be controlled. The 523 has internal temperature control by the use of a temperature sensor. The 523 can maintain 40ºC ±0.1º if operated in a favorable environment. A favorable environment is one that is maintained between 20ºC to 28ºC (68ºF to 82.4ºF) with average temperature changes not occurring faster than 1ºC per hour (approximately 2ºF per hour).

The top cover of the 523 should not be directly exposed to airflow from a heat or air conditioning register, or air circulating fan. For peak performance when the 523 is moved to a new location, allow the 523 to acclimate to its environment for 4 to 8 hours. If a room temperature transient should occur, allow 1 to 4 hours for the 523 to correct out the effect. If the 523 has been off for an extended period of time, allow 8 hours for the internal temperatures to stabilize and achieve maximum performance. For short periods, allow 1 to 4 hours. When first making connection to the 523 and other devices, allow temperatures generated thermals at the terminals to stabilize for a minute or two. This is important for µV level effects.

Following these recommendations will maximize the 523 capabilities and are good practices for any ultra-precision instrument.

1.12   SPECIFICATIONS

The following specifications are with a constant internal operating temperature equal to Calibration Temperature (Cal Temp) ±1ºC. The HP3458A NPLC is set for 100 and AUTO CAL cycle (ACAL) run. The Model 523's calibration is normally done at a room temperature of 23ºC ±1ºC. The internal Cal Temp is saved at the time of calibration and is displayed with the present internal temperature using the [TEMP] key.

The 90 day and 1 year specifications are valid within 24 hours of a zero CAL (AZOC) cycle, and a constant internal operating temperature equal to the Calibration Temperature (Cal Temp) ±1ºC. The zero CAL (AZOC) cycle takes out the effect of internal DC offset drift.

1.12.1 Output Specifications

(Specifications apply at CAL TEMP ±1ºC, <70% relative humidity.)

Range	Res.	Relative [1] Uncertainty ±1ºC		Absolute Uncertainty[2] ±1ºC from calibration temperature			Stability * ±1ºC
		90 days	1yr	24 hrs	90 days	1yr	24 hrs
		±(ppm output + µV or nA)					
DC Voltage							
111.11119mV	10nV	4 + 2	8 + 2	3 + 2	6 + 2	10 + 2	1 + 1
1.1111119V	100nV	4 + 3	8 + 3	3 + 2	6 + 3	10 + 3	1 + 1
11.111119V	1µV	4 + 10	8 + 20	3 + 10	6 + 20	10 + 20	1 + 10
110.99999V	10µV	6 + 200	10 +200	5 +100	8 + 200	12 + 200	1 + 100
DC Current [3]							
11.111119mA	1nA	8 + 40	16 + 40	4 + 20	10 + 40	18 + 40	2 + 20
110.99999mA**	10nA	8 + 200	16 + 200	+44 to -4, ±400	+50 to -10, ±400	+58 to -18, ±400	2 + 100
* Non-Additive \n** For values between 12mA and 110mA use graph provided with PCR100 Precision Resistor.							

- **Note 1:** *The RELATIVE ACCURACY specifications are to the HP3458A Digital Voltmeter used for calibration.*

- **Note 2:** *The absolute accuracies and traceability to N.I.S.T. include the traceability accuracies of the calibration standard and the maintained RELATIVE accuracies of the HP3458A or Fluke 8508A added to the 523 RELATIVE specifications.*

- **Note 3:** *Current calibration uses an external precision 100-ohm resistor (Krohn-Hite Model PCR100) and measures the voltage using a 4-wire Kelvin connection to the resistor.*

Range	Temperature Coefficient		Linearity * ±1ºC	Noise		Equivalent Output Z_o Ω
	18ºC to 28ºC	0ºC - 18ºC 28ºC - 40ºC		0.1Hz to 10Hz	10Hz to 100kHz	
	±(ppm output + µV or nA)/ºC			p-p	rms	
DC Voltage						
111.1119mV	1 + 0.2	2 + 0.2	1 + 1	2µV	7µV	0.1µ
1.1111119mV	1 + 0.5	2 + 0.5	1 + 1	2µV	7µV	1µ
11.111119mV	1 + 1	2 + 1	1 + 10	4µV	15µV	10µ
110.99999V	2 + 10	4 + 10	1 + 100	40µV	100µV	100µ
DC Current						
11.111119mA	2 + 5	4 + 5	1 + 20	20nA	150nA	10GΩ
110.99999mA	2 + 10	4 + 10	1 + 100	200nA	300nA	1GΩ
Temperature coefficient is best straight line fit method. * Non-Additive						

Line Regulation: <±0.1ppm change for a 10% change from normal line voltage, typically no measurable change.

Load Regulation 4-Wire Operation: <±0.1ppm change from no load to 100mA full load, typically no measurable change. Measurements must be made at sense lead connection point to the load.

Compliance Voltage Effect on Current Output: <10nA change for a 100V change in compliance voltage for output currents <11.11112mA, equivalent to >10 Gig-ohm output impedance; <100nA change for a 100V change in compliance voltage for output currents ≥11.11112mA, equivalent to >1 Gig-ohm output impedance.

Compliance Voltage Limit: Settable in 1V steps from 1V to 110V. Compliance limits approximately 15% +0.25V above the setting.

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Maximum Output Current: ±110mA. Output protected from damage with a current limiter. Output may be shorted to ground indefinitely.

Warm-Up Time from a Cold Start: 1 Hour to within 5ppm of final value. 4 Hours to rated accuracy and final value.

Calibration: The Model 523 is specified with a 1-year calibration cycle. An AUTO ZERO OFFSET CALIBRATION (AZOC) is provided that returns any thermally generated offset to within specified limits, and can be accessed via front panel controls or over the GPIB interface bus. The Model 523 is designed for a "Covers On" calibration using the KH523CAL Test and Calibration Software Program (license required). The KH523CAL software, together with an HP3458A or Fluke 8508A Digital Voltmeter, allows virtually unattended calibration to be performed in approximately 15 minutes. The calibration date and internal temperature is stored in memory and can be called to the display or over the GPIB interface bus.

Calibration Temperature Limits ("Covers-On Calibration"): Internal temperature (T Cal), 40ºC ±1ºC; Ambient temperature (T Amb), 0ºC to 30ºC.

Isolation: Power transformer-to-analog output, control logic-to-analog output, optically isolated.

1.12.2   GPIB Programming

Subsets: SH1, AH1, T6, SR1, RL1, PP1, DC1, DC1, DT1, CO, E1.

Line Termination: The GPIB EOI signal is always sent with the last character on a line.

Talker Function: Allows interrogation of the Model 523 by a controller.

1.12.3 Terminals

Output Terminals: Gold plated mounted on both the front and rear panels. Only one set of terminals may be used at a time.

Both terminal sets are configured for remote sensing of the output as follows:

High Output and High Sense
Low Output and Low Sense
Case Ground.

1.12.4 General

Display: 2 line, 40 character, backlit, LCD, 7.5 digits. Displays output settings and other pertinent information.

Keyboard: Membrane. Mechanical

Power Requirements: Selectable 105-130 or 210-240 volts $\sim$ ac, single phase, 50Hz to 60Hz, 60 watts.

Dimensions and Weights: 3.5" (9cm) high, 14" (36cm) wide, 12.5" (32.13cm) deep; 12 lbs (5.4kg) net, 14 lbs (6.3kg) shipping.

Operating Temperature Range: 0ºC to 50ºC.

1.12.5 Safety

The Model 523 is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control and laboratory use: IEC61010-1, EN61010-1

1.12.6 Electromagnetic Compatability

Emissions and Immunity: EN61326-1, EMC, 61000-4-2; ESD, 61000-4-3; Radiated Immunity, 61000-4-4; EFT, 61000-4-5; Surge, 61000-4-6; Conducted Immunity, 61000-4-8; Magnetic Immunity, 61000-4-11; Voltage Interuption EN61010-1.

CE Compliant for Class B Equipment.

1.12.7 Options

RK-314: Rack Mount Kit permits the installation of the Model 523 into a 19" rack spacing.

KH523CAL: Calibration and Test License - License to unlock the 523 for calibration with KH523CAL Calibration Software.

CAB005: Cable, 2 conductor shielded balanced line.

CAB018: Cable: multi-stacking double banana plug.

CAB023: The CAB023 is a low thermal EMF retractable sheath banana plug patch cord set. These low thermal cables minimize thermal errors so accurate low voltage measurements can be made. Each set includes 2 test leads (one black and one red).

CAB024: The CAB024   is a low thermal EMF spade lug patch cord set for low voltage measurements. These low thermal cables minimize thermal errors so accurate low voltage measurements can be made. Each set includes 2 test leads (one black and one red).

PCR100: 100Ω Precision Current Resistor used for calibrating the Model 523 in the Current Mode.

1.12.8   Accessories
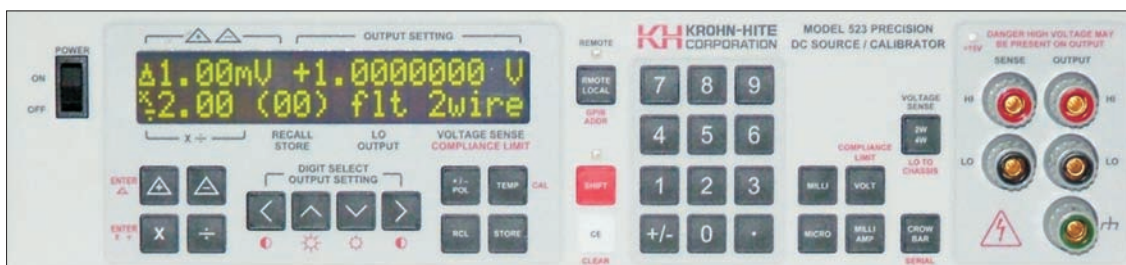
3 terminal line cord.
Operating manual.

SECTION 2

OPERATION

2.1   FRONT PANEL CONTROLS

2.1.1   Basics Entry Characteristics

Front Panel features explained on the following pages include all controls, indicators, terminals and display.

2.1.2   Tone Annunciator

The 523 uses tone enunciation to enhance the tactile feedback to the operator. This includes key tones to indicate the key was taken. Other tones are used to indicate a message is presently in the display or to indicate the end of a calibration operation.

2.1.3   Leading and Trailing Zeros

Leading or trailing zeros are not required to fill out a value. When entering a value that starts with a decimal point, the 523 will place the leading zero for you. If a leading zero is entered the 523 will only allow a decimal to follow it. If a second zero is entered it is ignored, if a number is entered instead of the decimal it will replace the zero with the number. Decimal point entry is not required if the value does not require it. Entering 1 Volt only requires the entry of the [1] digit then the [VOLT] key. The 523 will insert the decimal after the 1 and fill the remaining digits with zeros. 1mV is the same. Depress [1] [MILLI] [VOLT]. The 523 will enter the decimal and fill zeros after the [MILLI] key is depressed.

2.1.4   >15 Volt Indicator

>15V	If the 523 detects a voltage >15V on the output a >15V LED will light. This LED is located near the output terminals on the front panel. The detector is independent of all other circuits including the micro processor.

2.1.5   Shift Key

SHIFT	Keys with Second Functions are labeled in RED next to the key. To activate the secondary function of a key, the [SHIFT] key must be depressed. The Second Function mode will activate and the SHIFT LED will illuminate. The next key depressed will now activate the secondary function of that key. It will also clear the SHIFT SECOND FUNCTION mode and turn the SHIFT LED off. Depressing the shift key a second time without using any other key will turn the SHIFT mode off. Depressing a key that has no second function will also clear the SHIFT mode.

There is one exception to clearing the SHIFT mode. It is the second function associated with Display Brightness and Contrast using the DIGIT SELECT keys. This allows the controls to function as a display control while the [SHIFT] is engaged. To turn this mode off the [SHIFT] key must be depressed again when finished adjusting the display.

Key functions that bring special information to the display, such at [TEMP], GPIB ADDR or SERIAL NO., will be brought to the display for approximately 5 seconds, then automatically returns to display the previous information.

If the entered value for a function is greater than the 523 capabilities, the 523 operation will not change and an Error Message will appear in the display for approximately 5 seconds along with the maximum allowed value for that function, then automatically returns to display the previous information. |

2.1.6 Remote/Local Key

In Remote mode, the 523 will have a partial local lockout. Only the [REMOTE/LOCAL] key will be active. No other key will function. The REMOTE LED will illuminate indicating it is in Remote mode. To control the 523 from the front panel it must be in Local mode, with the REMOTE LED not illuminated. When in the Remote mode, depressing the [REMOTE/LOCAL] key will switch the 523 to Local mode. The [REMOTE/LOCAL] key functions as a toggle and can force the 523 into Remote mode thereby disabling Local key control.

When the 523 is in Local mode and the instrument is addressed over the GPIB interface bus, the unit will switch to the Remote mode and the REMOTE LED will illuminate.

2.1.7 Clear Entry Key
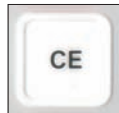
The [CE], Clear Entry key, has two modes of operation. When entering a value, depressing [CE] will erase the last digit entered. Depressing [CE] multiple times will erase each digit one at a time beginning with the last digit entered to the first digit entered. Depressing it one more time will return the 523 display to the previous setting. If a value modifier such as [MILLI] or [MICRO] has been depressed, [CE] will clear and remove any decimal and filled zeros.

With voltage and current entries, [CE] can also return a completed entry to its previous entry. In this mode it functions as a toggle, switching between the last two values entered. This can include switching between a voltage entry and a current entry.

2.1.8 Setting the GPIB Address

The default GPIB address from the factory is set to 25. The address can be set from the front panel when in the Local Mode. When the REMOTE LED is illuminated, the 523 can be returned to Local mode by depressing the [REMOTE/LOCAL] key.

To set the GPIB address, enter the address number desired, followed by the [SHIFT] key followed by the [REMOTE/LOCAL] key. The new address entry will be brought to the display for approximately 5 seconds, then automatically returns to display the previous information. One or two digits can be entered from 0 to 30. Only the first two digits entered are used, any additional digits are ignored. If the first two digits are greater than 30, the 523 will flash the entry limits into the display and not change the address setting. Although address 0 is allowed, it is usually reserved for the controller in charge and not recommended for use.

To display the GPIB set address without changing it, depress the [SHIFT] key followed by the [REMOTE/LOCAL] key. The address will be flashed in the display for a brief time.

2.1.9 Crowbar Key

CROWBAR sets the internal voltage setting to 0V, disconnects the output amplifier, and connects the HI and LO output terminals together through relay contacts. It is a way to set the 523 to a NO OUTPUT state. If zero volts out is desired, setting the output voltage for 0V is preferred. This allows the output amplifier to maintain a true 4-Wire output, maintaining minimum thermal voltage effects.

To turn the CROWBAR function on or off, use the [CROWBAR] key.

The [CROWBAR] key functions as a toggle, when on, depressing it will turn it off. When off, depressing it will turn the CROWBAR on.

2.1.10   Voltage Key

Voltage is entered into the 523 in the following manner:

Polarity [+/– POL] key first, followed by a number, a decimal point, and finally a modifier, such as [MICRO] or [VOLT].

If no modifier is needed, then depress [VOLT]. If the polarity sign is not entered first, the 523 assumes the previous polarity. (Special Note: This differs from entries on the GPIB where the 523 will assume + polarity if polarity is not entered.)

Up to 7 digits may be entered for numbers from 1111112 to 9999999, 8 digits for numbers from 10000000 to 11111119. If more digits are entered, they will be truncated to these limits.

The smallest 7 digit voltage that may be entered is 10.00000mV. The smallest voltage entry possible is 0.00001mV or 0.01uV. The maximum voltage entry is 110.11119 V.

Leading or trailing zeros are not required to fill out a value. When entering a value that starts with a decimal point, the 523 will place the leading zero for you. If a leading zero is entered the 523 will only allow a decimal to follow it. If a second zero is entered it is ignored, if a number is entered instead of the decimal it will replace the zero with the number. A decimal point entry is not required if the value does not require it.

Entering 1 Volt only requires the entry of the [1] digit then the [VOLT] key. The 523 will insert the decimal after the 1 and fill the remaining digits with zeros.

1mV is the same. Only [1] digit, the [MILLI] key and the [VOLT] key are needed. The 523 will enter the decimal and fill zeros after the [MILLI] key is depressed.

Entries may be made in micro volts, millivolts or volts. Entering 1000000µV is allowed and will be reformatted to 1.0000000 V.

Example	Entry	Display and Output
1	1.005 [Volt]	+/–1.0050000 V
2	25 [Volt]	+/– 25.00000 V
3	– 10 [MILLI [Volt]	– 10.00000mV
4	+. 25 [Volt]	+0.2500000 V
5	+0.001 [Volt]	+ 1.00000mV
6	– 2250 [MILLI [Volt]	– 2.250000 V
7	100 [MICRO] [Volt]	+/– 0.10000mV
8	12345678 [MICRO] [Volt]	+/– 12.34567 V
9	+ 0 [Volt]	+ 0.00000mV
Note: For the entries without sign, the polarity will be the previous polarity.		

2.1.11 Current Key

Current entries can not be made in amps or micro-amps. The 523 assumes all current entries are in milliamps regardless of any modifiers that are used with the entry. Modifiers will be ignored and the numerical entry will be assumed the mA value of the entry.

Entered with the [+/– POL] first followed by numbers and any decimal point followed by [MILLI AMP]. If the sign is not entered first the 523 assumes the previous polarity. (Special Note: This differs from entries on the GPIB where the 523 will assume + polarity if polarity is not entered.)

The maximum current entry is 111.11119mA, the smallest 7 digit current entry is 1.000000mA, the smallest current entry is 0.000001mA. Except for modifiers, all the basic entry information for voltage applies to current entries.

Example	Entry	Display and Output
1	1.005 [MILLI AMP]	+/– 1.005000mA
2	– 10 [MILLI AMP]	–10.000000mA
3	+0.05 [MILLI AMP]	+/– 0.050000mA
4	100 [MICRO] [MILLI AMP]	+/–100.00000mA

2.1.12 Compliance Limits

Compliance Limits is a second function of the [VOLT] key. The limits are from 1 to 110V with 1 Volt resolution. Decimal entries will be ignored. Compliance Voltage applies to both polarities so polarity entries are ignored.

Entered with the numbers first followed by [SHIFT] [VOLT] (compliance limits key).

When in current output mode the compliance setting is displayed in the same location as the 2-WIRE/4-WIRE is located for Volts Output mode. The compliance can be set while in Voltage Output mode. The entered value will briefly flash into the display. It also can be displayed while in Volts Output mode using the [SHIFT] key, then the [VOLT] key. This will briefly flash the setting into the display.

Example	Entry	Display and Output
1	0.25 [SHIFT] [VOLTS]	1V
2	−25 [SHIFT] [VOLTS]	25V
3	10.5 [SHIFT] [VOLTS]	10V
4	100m [SHIFT] [VOLTS]	1V

2.1.13 2-Wire/4-Wire Key (Output Termination)

The [2W/4W] key functions as a toggle when set for 2W operation, depressing it will switch to 4W. When in 4W operation, depressing it will switch to 2W. 4-Wire output only applies to Voltage Output mode. Current Output is always a 2-Wire operation independent of this setting.

When in Voltage Output mode, the output termination setting is displayed in the same location. The Compliance Voltage setting is located in the same location as Current Output mode. The output termination for Voltage Output can be set while in Current Output mode. The entered value will briefly flash into the display.

2.1.14 Lo To Chassis Key (flt/chs)

The LO TO CHASSIS is a second function of the [2W/4W] key and functions as a toggle. When set for float, flt will be present in the display. Depressing [SHIFT] [2W/4W] (LO TO CHASSIS) will switch to Chassis, chs will be present in the display. When in chs, depressing [SHIFT] [2W/4W] will switch it to flt.

2.1.15 Delta Key (ENTER Δ)

The ENTER Δ is a second function of the [Delta Δ] keys. Voltage and current output have independent Delta values. In Volts Output, it will be a voltage delta value. In Current Output, it will be a current delta value.

To set the current delta, the output must be set to Current Output mode. To set the voltage delta the output must be set to Voltage Output mode. Range of entry is 0.01uV to 110V and 0.01uA to 110mA respectively.

To enter a value for Delta, enter the numbers and any decimal point followed by [MICRO] or [MILLI] modifier then the [SHIFT] key then [+Δ] (ENTER Δ) or [-Δ] (ENTER Δ). If no modifier is used then just [+Δ] or [-Δ]. The maximum resolution is 3 digits. Any additional digits after the decimal point will be ignored. Any polarity entry will be ignored. The delta value is numerical only, so when the output is negative and [+Δ] is used it increases the numerical value by the Delta value making it more negative. Decrementing through zero volts to the opposite polarity is prevented.

To use Delta to modify the output, simply use the [+Δ] or [–Δ] key. If the Δ value is within the output displayed resolution, it will add or subtract its value amount to the set value.

Example	Output Mode	Entry	Display Indicates
1	Voltage	0.25 SHIFT Δ	Sets Delta to Δ0.25V in the display.
2		25 MILLI SHIFT Δ	Sets Delta to Δ25.0mV in the display
3		10.5 SHIFT Δ	Sets Delta to Δ10.5 V in the display.
4		100 [MICRO][SHIFT][Δ]	Sets Delta to D100 u V in the display.
5	Current	1.2345 [MICRO][SHIFT][Δ]	Sets Delta to Δ1.23μA in the display.

2.1.16 Multiply/Divide Key (ENTER × ÷)

Entry of the $^\times/_\div$ value is a second function of the [×] or [÷] keys.

To enter a value for $^\times/_\div$, enter the numbers and any decimal point followed by the [SHIFT] key then [×] ENTER × ÷ or [÷] ENTER × ÷ key. Maximum resolution is 3 digits with a maximum value of 999 and a minimum value of 0.01. Any additional digits after the first 3 will be ignored. Any polarity entry will be ignored. Zero can be entered as a valid value, but multiply and divide by 0 will both give 0 for a result.

If the multiply or divide operation yields a result with more digits then the 523 can use, display and process the result will be truncated to the limits of the 523. This can result in divide down and then multiply back up not returning to the exact same values due to the loss of accuracy.

To use the [×] or [÷] key to modify the output, simply use the [×] key for multiplying or [÷] key for dividing without any numerical entry first.

Example	Entry	Display Indicates
1	0.25 SHIFT ×	Sets Mult/Div to $^\times/_\div$ 0.25 in the display
2	25 SHIFT ÷	Sets Mult/Div to $^\times/_\div$ 25.0 in the display
3	10.5 SHIFT ×	Sets Mult/Div to $^\times/_\div$ 10.5 in the display

Example	Key	Comment
1	×	Will multiply the numerical value of the output by the $^\times/_\div$ value.

2.1.17   Multiply/Divide Key (cont.)

	If Mult/Div value is set to [1][0][.][0], it becomes a convenient decade multiplier. If Mult/Div value is set to [2][.][0][0], it becomes a convenient binary step multiplier.

2.1.18   +/– Polarity Key

	The [+/- POL] key allows changing the polarity of the output without reentering the set value. The [+/– POL] key functions as a toggle. When set for (+) plus, depressing it will switch it to (–) minus. When (–) minus, depressing it will switch it to (+) plus.

2.1.19 Store/Recall Key

There are 31 storage locations, 0 through 30. Location 0 holds the settings used when device clear or device reset is used over the GPIB bus.

The data stored is voltage or current setting, compliance setting and crowbar on or off setting. All but location 0 can be cleared of data, see CLEAR MEM. Location 0 can only be over written..

To store or recall from a particular number storage location, enter that number first followed by [STORE] key for store or the [RCL] key for recall. The Store/Recall pointer in the display will jump to that location and the 523 will store or recall the settings for that location.

To sequentially store or recall, use the [STORE] key or [RCL] key without the numerical entry first. The 523 will sequentially store or recall the settings in the next location and advance the pointer in the display.

Example	Entry	Comment
1	[1][2] [RCL]	Will recall the settings stored in location 12.
2	[0] [STORE]	Will store the setting in location 0 which are the settings used when GPIB bus device clear or device reset is used.
3	[RCL]	Will sequentially recall the settings in the next location.

2.1.20 Temp Key

TEMP CAL	Used to display the present internal temperature, and the temperature recorded at the time of the last **FULL** calibration. The top line in the display will indicate the current internal temperature of the 523. The bottom line is the internal temperature of the 523 during the time of the last calibration. The actual temperatures will be those measured.

2.1.21 CAL Key

TEMP CAL **SHIFT**	CAL is a second function of the [TEMP] key. Entering [SHIFT] then [TEMP] (CAL), will place the 523 into its Zero Cal DC offset calibration to minimize any DC offsets. This will bring any change in DC offset to within specified limits. During this CAL (calibration) operation, the display will show Zero Cal and tone enunciation will keep track of the progress. OUTPUT SETTING △100.mV Zero Cal %0.25 (00) chs 2wire x÷ RECALL LO VOLTAGE SENSE STORE OUTPUT COMPLIANCE LIMIT

2.1.22 Clear Mem Key

CLEAR MEM is a second function of the [CE] key. Entering [SHIFT] then [CE] (CLEAR MEM), will clear the stored settings in store/recall locations 1 through 30. Location 0, the reset settings does not clear. It can only be over written.

When a memory location is cleared, the 523 will beep indicating the memory has been cleared.

2.1.23 Serial No.

SERIAL NO. is a second function of the [CROWBAR] key. Depressing [SHIFT] then [CROWBAR] (SERIAL NO.) will briefly flash the serial number of the unit in the display. The software version number and the last Cal date of the 523 will be in the display.

The actual calibration date will be the last date entered at the time of calibration.

2.1.24 Digit Select and Controls

Cursor Left **Increment** **Decrement** **Cursor Right**	The [<][^][v][>] keys under the display allow the selection of a specific digit and modify that digit up or down in value. Incrementing [^] any digit through 9 will increase the value of the next digit to the left of that digit.
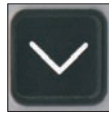
Likewise, decrementing [v] any digit through 0 will decrease the value of the next digit to the left of that digit.

Note: Decrementing [v] through zero volts to the opposite polarity is prevented.

If the most significant digit of a setting is decremented to zero, two things will happen:

1. The 523 will reformat the value for optimum resolution. When the digit resolution that is selected is no longer valid for the displayed value, that digit, along with the digit select cursor, will be dropped preventing further decrementing.

2. When the resolution is valid for the displayed value, the digit will go to zero, the digit select cursor will remain in place, but further decrementing will stop. This will also happen when incrementing the least significant digit of an 8 digit resolution value and the incremented value crosses over to a 7 digit resolution value, the digit along with the digit select cursor will be dropped. Up to 7 digits may be entered for numbers from 1111112 to 9999999, 8 digits for numbers from 10000000 to 11111119.

The [<] (cursor left) [>] (cursor right) are used to select a digit. A cursor underline will move in from the left or right side of the display indicating which digit is selected. The [^] [v] are used to increment [^] or decrement [v] the selected digit value. |

2.1.25 Display Brightness and Contrast Control

The display controls ● ☼ ☼ ● are second functions of the Digit select Controls ⟨ ⟩ . Depressing the [SHIFT] key will activate this mode. The [SHIFT] key will not clear when used with these keys. To disable this mode the [SHIFT] key must be depressed when finished with the adjustments.

The ∧ increases the brightness of the back light.

The ∨ decreases the brightness of the back light.

The ⟨ increases the contrast of the display.

The ⟩ decreases the contrast of the display.

2.2 CONDITIONS THAT WILL PRODUCE AN ERROR MASSAGE

An error message along with a tone is displayed when an error has occurred.

2.2.1 Too High Entry of a Voltage or Current Level

When a Voltage or Current is entered that exceeds the limits of the 523, an error massage will be displayed as indicated below.

2.2.2 Too High Entry of a Compliance Voltage Level

When a Compliance Voltage is entered that exceeds the limits of the 523, an error massage will be displayed as indicated below.

2.2.3 Too High Entry of a Delta Voltage Level

When a Delta Voltage is entered that exceeds the limits of the 523, an error massage will be displayed as indicated below.

2.2.4 Output Limit Condition

The Error Massage OUTPUT LIMIT will flash on and off in the display. During the on time the keys are disabled. During the off time, the keys are active allowing a setting to be change to correct a set condition that may have resulted in the OUTPUT LIMIT. Once the entry of a new setting is started, the OUTPUT LIMIT flashing is inhibited, allowing the entry to be completed.

2.2.5   Storing or Recalling Beyond the Maximum Location of 30.

If an entry has been made to Store or Recall a location above 30, an error massage will be displayed as indicated below.

2.2.6   Recalling from a Location That Has No Stored Setup in It.

When trying to Recall a setup from a location that has nothing stored in it, an error massage will be displayed as indicated below.
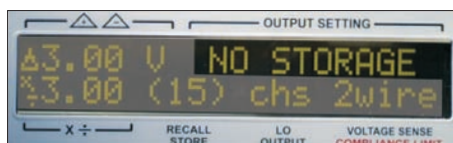
2.2.7   Illegal GPIB Address Entry

If a GPIB address has been made that is over 30, an error massage will be displayed as indicated below.

2.3   OUTPUT CONNECTIONS

2.3.1   Front and Rear Panel Terminals

CAUTIONS
Both front and rear panel terminals are active at all times. However, only one set of terminals can be used in order to maintain the 4-wire voltage accuracy specifications.

All the output terminals on the front and rear panel are 5-way binding posts. Spacing is the standard ¾" centers. Connections are located as follows:

The load and sense refers to 4-wire remote sensing capability.

Note: The Load-Sense circuit must be complete in either one of two configurations.

For the current mode or for driving high impedances in the voltage mode, only two wires may be connected to the load. However, if an appreciable current is to flow in the circuit, in the voltage mode (0.1mA), then the sense lines should be connected at the load.

This 4-wire system eliminates the IR drop and thus maintains the voltage accuracy at the load.
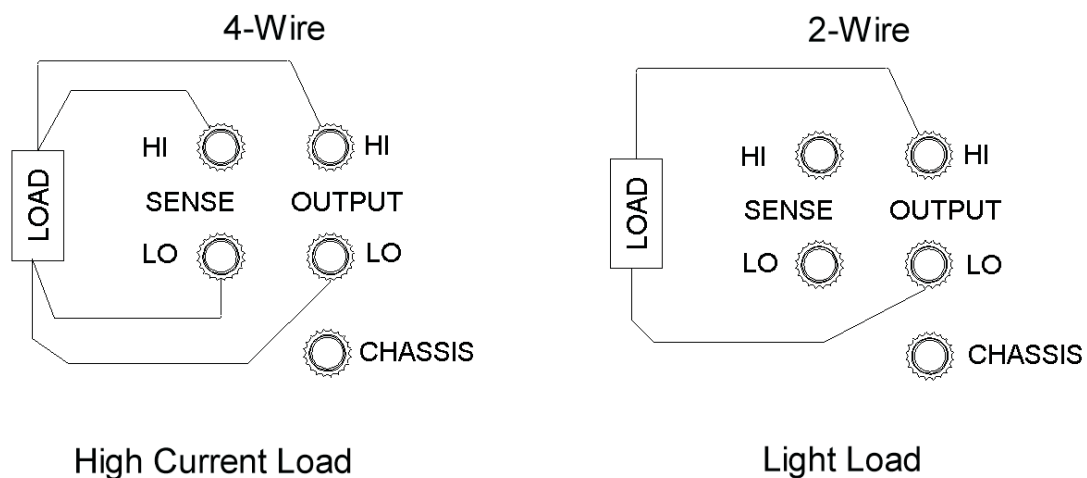
Figure 2.1 4-Wire and 2-Wire Connections

2.3.2 Wire and Cable Connections

When making connections to the Model 523, it is desirable to make them in a way that minimizes the thermally generated voltages (thermal EMF) produced at the junction of two metals. All connections will produce thermal voltages. They are inescapable. To minimize the effect use good quality wires, patch cords or cables that are designed for low thermal EMF. Have as few interconnections as possible and an equal number of interconnections in the HI and LO sides.

When using the 4-wire operation, the HI and LO SENSE are the critical connections and require attention. The thermal EMF generated on the HI side connections will have the opposite polarity to those on the LO side, if the same type of wire and connection method is used on both HI and LO terminal, and all internal interconnections. This will result in the thermal EMF canceling to the extent that the two match. This also requires that all the connections are at or close to the same temperature.

Krohn-Hite makes the following suggestions for connecting the 523 to achieve optimum results.

The simplest connection method is with twisted pair wire stripped and placed under HI and LO binding posts, tightening them down for good solid connection. The connection is directly from wire to binding post with no other connections in the middle such as a banana plug or spade lug. This follows the minimum number of interconnections rule, but may be inconvenient or too fragile.

Pomona Electronics, and perhaps others, have several cable and patch cords that are LOW THERMAL EMF.

2.3.3 Temperature Control

To maximize the performance of the Model 523, the internal temperatures must be controlled. This is accomplished by the use of an internal temperature control sensor. This controls the internal operating temperature to 40ºC ±0.1ºC as long as the unit is operated in a favorable environment. A favorable environment is one that is maintained between 20ºC to 28ºC (68ºF to 82.4ºC) with average temperature changes not occurring faster than 1ºC per hour (approximately 2ºF perhour).

Note: *The top cover of the Model 523 should not be directly exposed to airflow from a heat or air conditioning register, or an air circulating fan.*

For a peak performance when the unit is moved to a new location, allow 4 to 8 hours to become acclimated with the new environment. If a room transient should occur, allow 1 to 4 hours for the unit to correct out the effect. If off for an extended period of time, allow 8 hours for the temperatures to stabilize and achieve maximum performance. For short periods, allow 1 to 4 hours. When first making connection, allow termperature generated thermals at the terminals to stabilize for a minute or two. This is important for µV effects.

Following these recommendations will maximize the Model 523 capabilities and are good practices for any ultr-precision instrument.

SECTION 3

GPIB Programming

3.1   Introduction

When the Model 523 is in Local Mode and the GPIB addresses the unit, the 523 will switch to Remote operation. The REMOTE LED will light indicating it is in Remote Mode.

In Remote Mode, the 523 will have a partial local lockout. Only the [REMOTE/LOCAL] key will be active, allowing the unit to be returned to Local Mode from the front panel. No other keys will function.

Multiple settings of the instrument may be sent in a single string up to 30 characters long. The 523 will buffer the string then interpret and process the instructions. The EOI line must be asserted with the last character to indicate an end of line to the 523. When the 523 is in Talker Mode, it will assert the EOI line with the last character sent.

Individual instructions may follow one another without a delimiter. If a delimiter is preferred, a comma, semicolon or spaces may be used. The delimiters must be counted as string characters. Instructions should not have spaces or commas between the required numbers and letters and will result in an unrecognized instruction.

Letter entries are not case sensitive, upper or lower case means the same thing.

The 523 will not recognize the entry of scientific notation numbers. Letter designators are used as follows:

M or m for milli.   25mV enters 25×10^{-3} Volts.

U or u for micro   300uV enters 300×10^{-6} Volts.

K or k for kilo is not used or recognized.

Unrecognized characters or instructions will stop the 523 from processing a string at the point of occurrence and initiate an "UNRECOGNIZED" service request.

Leading or trailing zeros are not required to fill out a value.

A value with more digits than the 523 can use, display and output, will be truncated to the limits of the 523. Limits depend on the type of entry made. Volts out and volts compliance have different limits. Refer to the instruction syntax for the individual limits.

Example	String	Result
1	1.23456789V	1.234567 V on the display and output.
2	11111111111111uV	11.111111 V on the display and output This is equivalent to an entry of 11111111uV; the additional 1's were ignored.

Note: All examples shown, are characters sent as ASCII string characters entered into a program or interface routine that handles outputting to a GPIB interface board.

3.1.1 Setting the GPIB Address

The default GPIB address from the factory is 25. It can be set from the front panel with the 523 in Local Mode. If the REMOTE LED is lit, the 523 can be returned to Local Mode by depressing the [REMOTE/LOCAL] key.

To set the GPIB address, enter the address number desired followed by the [SHIFT] key followed by the [REMOTE/LOCAL] key. The new address entry will be flashed in the display for a brief time. One or two digits can be entered from 0 to 30. Only the first two digits entered are used. Any additional numbers are ignored. If the first two digits are greater than 30, the 523 will flash the entry limits into the display and not change the address setting. Although address 0 is allowed, it is usually reserved for the controller in charge and not recommended for use.

To display the GPIB set address without changing it, depress the [SHIFT] key followed by the [REMOTE/LOCAL] key. The address will be flashed in the display for a brief time.

3.1.2 GPIB Instruction Syntax

Note: If an unrecognized character or instruction is sent, the 523 will stop processing the string at the point of occurrence, and initiate an "UNRECOGNIZED" service request.

3.1.3 Crowbar

To turn the Crowbar function on, use the letter Z or z.

To turn the Crowbar function off, use the letter V or v without any numbers preceding it.

V is also used to enter a voltage value when preceded with a number entry; see the next item.

Example	Comment
1	"Z 12V V" The first Z will set the crowbar on, the 12V will set the 523 for 12 Volts output, the last V will turn the crowbar function off.
2	"z; 22ma; v" The first z will set the crowbar on, the 22ma will set the 523 for 22milliamp output, the last V will turn the crowbar function off.
3	"Z, D, D, V" The first Z will set the crowbar on, the D, D, will add the delta value twice to the output, the last V will turn the crowbar function off.
Note: Delimiters are optional but make it easier to read and follow.	

3.1.4   Voltage

Entered with the sign +/– first, followed by numbers and any decimal point followed by letter modifier u or m then V. If no modifier is used then just V. Upper and lower case letters work the same. If the sign is not entered first the 523 assumes + polarity. Up to 7 digits may be entered for numbers from 1111112 to 9999999, 8 digits for numbers from 10000000 to 11111119. If more digits are entered, they will be truncated to these limits. The smallest 7 digit voltage that may be entered is 10.00000mV. The smallest voltage entry possible is 0.00001mV or 0.01uV. The maximum voltage entry is 110.11119 V.

Example	String	Result
1	"1.005V"	+1.0050000 V in the display and output.
2	"25v"	+ 25.00000 V in the display and output.
3	"– 10mV"	– 10.00000mV in the display and output.
4	"+. 25V"	+0.2500000 V in the display and output.
5	"+0.001V"	+ 1.00000mV in the display and output.
6	"– 2250mv"	– 2.250000 V in the display and output.
7	"100uV"	+ 0.10000mV in the display and output.
8	"25.123456789V"	+ 25.12345 V in the display and output.
9	"0v"	+ 0.00000mV in the display and output.
10	" – 0v"	– 0.00000mV in the display and output.

3.1.5   Current

Current entries can not be made in amps or micro-amps. The 523 assumes all current entries are in milliamps regardless of any modifiers that are used with the entry. Modifiers will be ignored and the numerical entry will be assumed the mA value of the entry.

Entered with the sign +/– first, followed by numbers and any decimal point followed by a or A. Upper and lower case letters work the same. If the sign is not entered first, the 523 assumes + polarity.

The maximum current entry is 111.11119mA, the smallest 7 digit current entry is 1.000000mA, the smallest current entry is 0.000001mA.

Example	String	Result
1	"1.005mA"	+ 1.005000mA in the display and output.
2	"25a"	+ 25.00000mA in the display and output.
3	"– 10mA"	–10.000000mA in the display and output.
4	"+0.05a"	+ 0.050000mA in the display and output.
5	"100uA"	+100.00000mA in the display and output.

3.1.6   Compliance

The compliance entry is limited to 1 to 110V with 1 Volt resolution. Decimal entries will be ignored. Compliance Voltage applies to both polarities so polarity entries are ignored.

Entered with the numbers first, and any decimal point followed by c or C. Upper and lower case letters work the same.

Example	String	Result
1	"0.25c"	1V compliance in the display and output.
2	"–25C"	25V compliance in the display and output.
3	"10.5C"	10V compliance in the display and output.
4	"100mC"	1V compliance in the display and output.
5	"100uc"	1V compliance in the display and output.

3.1.7   2 Wire/4 Wire Output Termination

Entered with the number 2 or 4 first, then w or W, any other number entry or no number will be an unrecognized instruction and the 523 will stop processing the string at that point initiating an "UNRECOGNIZED" service request.

Example	String	Result
1	"2w"	2wire output termination in the display and output.
2	"4W"	4wire output termination in the display and output.

3.1.8   Lo Float/ Chassis (flt/chs)

The letter f or F is used to designate Lo floating, g or G to designate Lo tied to chassis.

Example	String	Result
1	"f"	flt in the display and output.
2	"G"	chs in the display and output.

3.1.9   Delta ∆

Entry of Value

Voltage and current output have independent Delta values. In volts output, it will be a voltage delta value. In current output, it will be a current delta value. To set the current delta the output must be set to current out. To set the voltage delta the output must be set to voltage. Range of entry is 0.01uV to 110V and 0.01uA to 110mA.

To enter a value for Delta, enter the numbers and any decimal point followed by letter modifier u or m then d or D. If no modifier is used then just D. The maximum resolution is 3

digits. Any additional digits after the decimal point will be ignored. Any polarity entry will be ignored. The delta value is numerical only so when the output is negative and +Delta is used it increases the numerical value by the Delta value making it more negative.

Using Delta to Modify the Output

To use Delta to modify the output, simply use the + or – sign to indicate increase or decrease in value and the letter d or D. If D is used without a leading sign the 523 will assume increase Delta (+D).

Example	String	Result
Voltage		
1	"0.25d"	Sets Delta to Δ0.25 V in the display.
2	"25mD"	Sets Delta to Δ25.0mV in the display.
3	"10.5d"	Sets Delta to Δ10.5 V in the display.
4	"100ud"	Sets Delta to Δ100 u V in the display
5	"1.2345mD"	Sets Delta to Δ1.23mV in the display.
Current		
6	"10d"	Sets Delta to Δ10.0mA in the display.
7	"0.05d"	Sets Delta to Δ0.05mA in the display.
8	"25uD"	Sets Delta to Δ25.0 uA in the display.
9	"15mD"	Sets Delta to Δ15.0mA in the display.
10	"0.005D"	Sets Delta to Δ0.00mA in the display.
Note: Leading 0 before decimal shown for clarity, not necessary as part of entry.		

Example	String	Result
1	"D"	Will increase the numerical value of the output by the delta value.
2	"– d"	Will decrease the numerical value of the output by the delta value.

3.1.10 Multiply/Divide $^{\times}/_{\div}$

Entry of Value

To enter a value for Mult/Div, enter the numbers and any decimal point followed by x or X or /. Maximum resolution is 3 digits with a max value of 999 and a min value of 0.01. Any additional digits after the first 3 will be ignored. Any polarity entry will be ignored. Zero can be entered as a valid value but multiply and divide by 0 will both give 0 for a result.

If the multiply or divide operation yields a result with more digits then the 523 can use, display and process the result will be truncated to the limits of the 523. This can result in divide down and then multiply back up not returning to the exact same values due to the loss of accuracy.

Using Mult/Div to Modify the Output

To use Mult/Div to modify the output, simply use the x or X for multiply or / for divide without any numerical entry first.

Example	String	Result
1	"0.25x"	Sets Mult/Div to ×/÷0.25 in the display.
2	"25/"	Sets Mult/Div to ×/÷25.0 in the display.
3	"10.5X"	Sets Mult/Div to ×/÷10.5 in the display.
4	".05/"	Sets Mult/Div to ×/÷0.05 in the display.
5	".001x"	Sets Mult/Div to ×/÷0.00 in the display.
Note again that divide by 0 in the 523 will give 0 for a result, the same as multiply by 0.		

Example	String	Result
1	"x"	Will multiply the numerical value of the output by the Mult/Div value.
2	"/"	Will divide the numerical value of the output by the Mult/Div value.
If Mult/Div value is set to 10.0, it becomes a convenient decade multiplier.		
If Mult/Div value is set to 2.00, it becomes a convenient binary step multiplier.		

3.1.11 +/– Polarity

This allows changing the polarity of the output without reentering the set value. Enter the desired polarity sign first, + or –, then p or P. If the sign is left out it becomes an unrecognized instruction and the 523 will stop processing the string at that point initiating an "UNRECOGNIZED" service request.

Example	String	Result
1	"+p"	Will force the output polarity to be positive.
2	"–P"	Will force the output polarity to be negative.

3.1.12 Store/Recall

There are 31 storage locations, 0 through 30. Location 0 holds the settings used when device clear or device reset is used. Data stored is Voltage or Current setting, Compliance setting and Crowbar on or off. All but location 0 can be cleared of data, see special command *CLM. Location 0 can only be written over.

To store or recall from a particular number storage location, enter that number first followed by s or S for store and r or R for recall. The Store/Recall pointer in the display will jump to that location and the 523 will store or recall the settings.

To sequentially store or recall, use the S or R without the numerical entry first and the 523 will sequentially store or recall the settings in the next location and advance the pointer in the display.

Example	String	Result
1	"12r"	Will recall the settings stored in location 12.
2	"0S"	Will store the settings into location 0 which are the settings used when device clear or device reset is used.
3	"0r, r, r, r, r, r"	Will recall the settings in location 0 and then sequentially recall the next 5 locations stopping at location 5.
4	"1V; 10S; 2V; S; 3V; S; 4V; S"	Will first set the 523 for 1volt then save it to location 10 then set to 2 volts, save, set to 3 volts, save, set to 4 volts, save, sequentially saving each setting stopping at location 13.

3.1.13 Toggle

Toggle is similar to the CE key on the panel. On voltage or current entries, it will toggle the 523 back to the previous setting. The toggling can be repeatedly done toggling between the last two entries. The letter t or T is entered for the operation.

Example	String	Result
1	"4V, 5V, T, T, T, T, T"	Will set the 523 for 4 volts then 5 volts then toggle form 5V to 4V to 5V to 4V to 5V to 4V then stop.

3.2 SPECIAL COMMANDS

Special commands are used to perform special functions such as Zero Calibration or clearing store/recall memory or retrieving information from the 523.

These commands all start with the asterisk " * " followed by three letters. They will end with a " ? ", if a response from the unit is expected.

Upper and lower case letters mean the same thing.

They should be used alone, without other instructions following them, or used at the end of a string of instruction, being the very last instruction in the string.

3.2.1 *RST or *rst

Resets the 523 to the settings stored in location 0 of store/recall memory. Essentially the 523 executes a 0 recall, "0R".

This is a standard 488.2 recognized command.

Example	String	Result
1	"*RST"	Will set the 523 to storage location 0 settings.

3.2.2 *CAL or *cal

Will place the 523 into its Auto Zero Offset Calibration mode to minimize any DC offsets.

Example	String	Results
1	"*CAL"	Will place the 523 into the Auto Zero Offset Calibration (AZOC) mode, DC offset minimizing self-calibration.

3.2.3   523 *CAL or 523*cal

Will place the 523 into its full calibration mode. This cal is not a self-cal and requires external equipment to complete. See calibration instructions for full details.

Example	String	Result
1	"523*CAL"	Will place the 523 into its full calibration mode.
Note: If you enter this mode by accident, you can exit without changing any of the cal data simply by sending another setting to the 523 after it runs the zero cal operation.		

3.2.4   *CLM or *clm

Used to clear the store/recall stored settings. The 523 will remove any settings except for location 0, the reset settings.

Example	String	Result
1	"*CLM"	Will clear stored settings in all but location 0.

3.2.5   *IDN? Or *idn?

Used to request the 523 to identify its self on the GPIB. Followed by a request to talk, it will return, **Krohn-Hite, Model 523, BB53000, Ver.123** . The number after the model number will be the serial number; the Ver. number will be the firmware version number.

Identify is the default response when asked to talk without a specific request for information. This makes the command optional, just asking it to talk yields the same result.

This is a standard 488.2 recognized command.

Example	String	Result
1	"*IDN?"	Request for identification on the GPIB; follow it by a talk request.

3.2.6   *STG? or *stg?

In addition to this string the ? used alone will also work.

Used to request the 523 to return the present displayed settings over the GPIB. When followed by a request to talk, it will return the following:

Output=volts or current setting, Delta=setting, Mult/Div=setting, Store/Recall=setting, LO= setting, Output Termination or Compliance=setting .

Example	String	Result
1	"*STG?"	Request for present displayed settings; follow it by a talk request.
Example of the string returned from a 523		
2		Output= 2.000000 V Delta=1.00mV,Mult/Div=2.00,Store/Recall=05, LO=flt,Output Termination or Compliance =2W

3.2.7   *CLD? or *cld?

Used to request the 523 to return the last full calibration date over the GPIB. Followed by a request to talk, it will return, **Cal. 01/01/01** . The actual date will be the last calibration date as entered at the time of calibration.

Example	String	Result
1	"*CLD?"	Request for calibration date; follow it by a talk request.

3.2.8   *TMP? or *tmp?

Used to request the 523 to return the present internal temperature, and the temperature recorded at the time of the last full calibration, over the GPIB. Followed by a request to talk, it will return, **Temp 31.7c Cal Temp 31.2c** . The actual temperatures will be those measured.

Example	String	Result
1	"*TMP?"	Request for present internal temperature and calibration temperature; follow it by a talk request.

3.2.9   *MSG? or *msg?

Used to request the 523 to return a message after the 523 requested service on the GPIB. Followed by a request to talk, it will return the reason for the service request.

Example	String	Result
1	"*MSG?"	Returns service request message; follow it by a talk request.

3.3 Conditions That Will Produce a Service Request on the GPIB

Service requests indicate that a setting is out of range, or an unrecognized instruction or command was sent, or the 523 output is clipping. The 523 may be serial polled or remotely configured for parallel polling. After determining that the 523 is the requesting instrument, sending the special command *MSG?, followed by a request to talk will produce a brief description of the offending condition. In addition, the serial poll initial response byte indicates what type of condition caused the request.

If the *MSG? special command is used when no error message is present, the response will be **No Message**.

Error messages are cleared after the query. They are also cleared if any settings or another special command is sent to the 523 before the *MSG? is used. The service request will also be cleared.

In the following, the initial response bytes are in hex format with the ASCII character of that value shown in quotes.

3.3.1 Entry of a Voltage or Current Level
Greater Than the Capabilities of the 523

The message returned will be **MaxEntry 110.99999V** or **MaxEntry 110.99999mA**.

The initial response byte would be 41h "A" for volts and 42h "B" for current.

3.3.2 Entry of a Compliance Voltage Level
Greater than the Capabilities of the 523.

The message returned will be **MaxEntry 110.V**

The initial response byte would be 43h "C"

3.3.3 Entry of to Large a Delta Voltage or Current Value.

The message returned will be **MaxEntry 110.V** or **MaxEntry 110.mA**

The initial response byte would be 44h "D" for current, 45h "E" for volts.

3.3.4 Entry of an Unrecognized Instruction or Command.

The message returned will be **UNRECOGNIZED**.

The initial response byte would be 46h "F"

3.3.5 Output Limit Condition

The message returned will be **OUTPUT LIMIT**.

The initial response byte would be 47h "G"

3.3.6 Storing or Recalling Beyond the Maximum Location of 30.

The message returned will be **Max Store 30** or **Max Recall 30**.

The initial response byte would be 48h "H" for store 49h "I" for recall.

3.3.7 Recalling from a Location That Has No Stored Setup

The message returned will be **No Storage**.

The initial response byte would be 4Ah "J".

3.3.8 Serial Poll Initial Response Byte Chart

SERIAL POLL RESPONSE BYTES				
ERROR	**BYTE**	**HEX**	**DEC**	**ASCII**
Voltage Entry to High	01000001	41	65	A
Current Entry to High	01000010	42	66	B
Compliance Entry to High	01000011	43	67	C
Delta mA Entry to High	01000100	44	68	D
Delta Voltage Entry to High	01000101	45	69	E
Unrecognized Command	01000110	46	70	F
Output Limit	01000111	47	71	G
Store Entry to High	01001000	48	72	H
Recall Entry to High	01001001	49	73	I
No Stored Data	01001010	4A	74	J

Notes

SECTION 4

Incoming Acceptance

4.1   INTRODUCTION

This section contains operational a verification test which provide a method of testing the operation and accuracy of the Model 523.

4.2   TEMPERATURE CONTROL

To maximize performance in the Model 523, the internal temperatures must be controlled. The 523 has internal temperature control by the use of a temperature sensor. The 523 can maintain 40ºC ±0.1º if operated in a favorable environment. A favorable environment is one that is maintained between 20ºC to 28ºC (68ºF to 82.4ºF) with average temperature changes not occurring faster than 1ºC per hour (approximately 2ºF per hour).

The top cover of the 523 should not be directly exposed to airflow from a heat or air conditioning register, or air circulating fan. For peak performance when the 523 is moved to a new location, allow the 523 to acclimate to its environment for 4 to 8 hours. If a room temperature transient should occur, allow 1 to 4 hours for the 523 to correct out the effect. If the 523 has been off for an extended period of time, allow 8 hours for the internal temperatures to stabilize and achieve maximum performance. For short periods, allow 1 to 4 hours. When first making connection to the 523 and other devices, allow temperatures generated thermals at the terminals to stabilize for a minute or two. This is important for µV level effects.

Following these recommendations will maximize the 523 capabilities and are good practices for any ultra-precision instrument.

4.3   REQUIRED EQUIPMENT

The following equipment is needed to perform the incoming acceptance of the Model 523.

1. HP3458A Multimeter or equivalent.

2. 100 ohm Precision Resistor, ±1ppm accuracy, ±6ppm 12 month stability.

4.4   PRELIMINARY SET-UP

1. Verify that the Model 523 and the HP3458A have properly warmed-up.

   The HP3458A requires a 4 hour warm-up period. If this has not occurred, turn the unit on and allow the proper time to warm-up.

3. The internal temperature of the HP3458A must be within 5ºC of its temperature when last calibrated. Press the [TEMP?] key to obtain the current internal temperature of the HP3458A and compare it to the calibration temperature obtained by pressing the [CAL? 59] key for DCV. Pressing the [<] and [>] keys to scroll and view the entire message in the display.

4. If the HP3485A self test has not been run, disconnect all input connections and press the [TEST] key. When completed, the display should indicate "SELF TEST PASSED".

4.5   INSPECTION PROCEDURE

4.5.1   Zero Cal

Zero Cal DC Offset minimizes any dc offsets in the Model 523. This will bring any dc offset at the output to within specified limits.

1. Press [SHIFT] [TEMP].

    When activated, the display will indicate "ZERO CAL". A beep and a double beep

    will occur, alternately, approximately every 10 seconds to indicate the 523 is calibrating itself..When complete, the 523 will sound off a series of 4 beeps.

    Note: The Zero Cal procedure, once started, can not be aborted. If there is a power failure, it is recommended that the Zero Cal be run again for best results.

4.5.2   Output Voltage Checks

1. Connect the 523 Output to the HP3485A using low thermal cables.

2. Configure the HP3458A for highly accurate measurements by pressing [RESET], powered-on state; [NPLC 200], integration time of 200power line cycles; [NDIG8], 8.5 digits.

   *Note: The longer integration time reduces measurement noise and increases resolution.*

3. Enter the voltage settings in the chart below and record reading.

Positive Setting	Spec (µV)	Negative Setting
0V	2.00	-0V
100mV	2.60	-100mV
1V	9.00	-1V
2V	32.00	-2V
3V	38.00	-3V
4V	44.00	-4V
5V	50.00	-5V
6V	56.00	-6V
7V	62.00	-7V
8V	68.00	-8V
9V	74.00	-9V
10V	80.00	-10V
11V	86.00	-11V
12V	296.00	-12V
100V	1000.00	-100V
110.99999V	1088.00	-110.99999V

4.5.3   Output Current Checks

Note: Figure 4.1 below shows the proper connections that need to be made between the Multimeter, Model 523 and the Precision 100 Resistor. in order to limit thermal errors. Cable sets CAB023 and CAB024 are recommended.
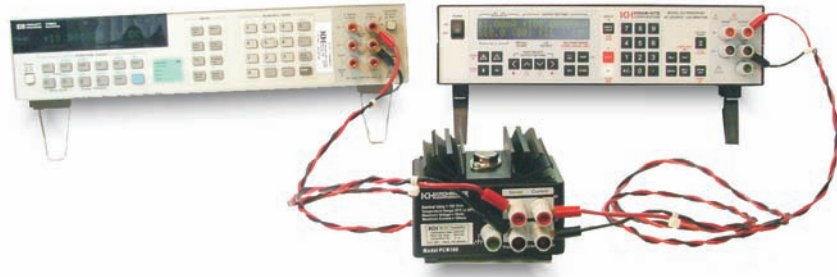
1. Connect the 523 Output terminals, using low thermal cables, to the PCR100 (100 ohm current resistor) CURRENT terminals.

2. Connect the PCR100 SENSE terminals, using low thermal cables, to the input of the Multimeter.

3. Enter the voltages in the following chart and record the readings.

Positive Setting	Spec (nA)	Negative Setting
0mA	±40.00	-0mA
1mA	±50.00	-1mA
2mA	±60.00	-2mA
3mA	±70.00	-3mA
4mA	±80.00	-4mA
5mA	±90.00	-5mA
6mA	±100.00	-6mA
7mA	±110.00	-7mA
8mA	±120.00	-8mA
9mA	±130.00	-9mA
10mA	±140.00	-10mA
11mA	±150.00	-11mA
12mA	-1000.00 to +520.00	-12mA
100mA	-5400.00 to +1400.00	-100mA
110mA	-5900.00 to +1500.00	-110mA

Notes