5200A Calibrator Enhancement Manual

Models 5200A-90x
Characterization Services

Model 5200A-800
Operation and Calibration Software

P/N 758904

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Section 1
Introduction and Specifications

INTRODUCTION

The established excellent stability of the Model 5200A Calibrator and the Models 5205A and 5215A Amplifiers offers an opportunity to further enhance accuracy performance by using traditional metrology techniques in an innovative way. This manual describes a package of performance options that integrate characterization with automation. Characterization gives significantly better accuracy. Automation removes tedium and specialized skill requirements, making this enhanced performance productive and easy to use.

The 5200A Alternating Voltage Calibrator is a precision high-performance alternating voltage source with exceptional stability and accuracy over a broad frequency range. The 5205A and 5215A Power Amplifiers are precision fixed-gain amplifiers that extend 5200A output levels to 1100V and 200 mA, with the capacitive and inductive drive capabilities to accomplish calibration in a system installation without isolating the meter. Model 5205A is a general purpose dc-coupled amplifier. Model 5215A is an ac-coupled amplifier designed specifically for use with the Model 5200A Calibrator. In use, either amplifier is completely controlled by the 5200A front panel or by an instrument controller through a 5200A-05 IEEE-488 Interface. Each unit is specified over a wide 0°C to 50°C operating range for use in both laboratory and manufacturing environments.

HOW TO USE THIS MANUAL

You do not need to read this entire manual unless you plan to develop a compatible table of correction factors in your standards laboratory.

If you are unfamiliar with the use of characterization tables in calibration, a discussion of characterization fundamentals follows in this Section 1. Section 1 also includes 5200A and 5205A/5215A specifications, with and without these enhancements.

Section 2 guides you though your initial use of 5200A-800 software to operate a 5200A calibrator. You will find the display screens easy to understand.

Section 3 describes, with worked-out examples, how to manually use a 5200A-90x characterization table to achieve enhanced 5200A specifications without the need for an instrument controller.

Section 4 is the procedure for developing a table of 5200A-90x compatible correction factors in your standards laboratory. While requiring additional equipment and skill, this procedure is structured and easy to follow. Provisions are included for calibrating any or all of the points in the standard 5200A-90x correction table, as well as up to 50 special points customized to meet the needs of the meters you are responsible for calibrating.

WHAT IS CHARACTERIZATION?

Characterization is a process of measuring a particular calibrator's errors at selected points, using traceable transfer standards, and recording these errors in a table. When the calibrator is later used at one of these points, this known error can be compensated for. Also, if the characteristics of the calibrator are known, mathematical interpolation can be used for points other than those in the characterization table.

It is practical to use specific characterization points since meters are commonly calibrated at specified voltage and frequency points.

FLUKE 5200A/5205A/5215A ENHANCEMENTS

Options 5200A-90x are characterization services for 5200A calibrators and 5205A or 5215A amplifiers. A standard set of correction points compatible with 5200A-800 and 7411A software is included. You can also request additional correction points appropriate for the meters that you will be calibrating. A certified traceable table of correction factors is supplied in both written and compatible disk form.

Option 5200A-800 is a software package that uses the touch-sense display of a Fluke 1722A or 1720A Instrument Controller to operate a 5200A calibrator in a simplified manner similar to a Fluke 5440B Direct Voltage Calibrator. It uses a 5200A-90x characterization table for accuracy corrections, and automatically interpolates for voltages and frequencies not on the table. When a table of correction factors is not provided, it operates the calibrator to standard specifications.

This software controls all calibrator functions through the touch sense display of the 1722A or 1720A to simplify operation. You can select and edit output frequency and voltage, and select operate/standby modes, phase lock, and external sense. In operation, the controller displays calibrator output and UUT (Unit Under Test) uncertainty in your choice of percentage, volts, or ppm.

Model 7411A software, scheduled for release in Fall 1985, is general-purpose system software for automated calibration workstations. It executes stored procedures that were generated by its Procedure Generator/Editor. When operating a 5200A Calibrator, it automatically generates corrections from a 5200A-90x compatible characterization table when one is available to it.

GETTING YOUR 5200A CHARACTERIZED

5200A-800 and 7411A software will operate the calibrator and amplifier to standard specificatons without a table of correction factors. However to enhance accuracy for your 5200A and 5205A or 5215A, a 5200A-90x characterization table is required. There are two ways to accomplish this:

1. Order 5200A-90x characterization service from Fluke.

Whether you are purchasing a new 5200A (and optional 5205A or 5215A Precision Amplifier) or already own a 5200A, characterization service is available from Fluke. Order one of the following services:

MODEL	FOR...
5200A-900	New-purchase 5200A/5215A
5200A-901	Customer-owned 5200A and 5205A or 5215A
5200A-902	New-purchase 5200A
5200A-903	Customer-owned 5200A

5200A-900 and 5200A-902 services are available from Fluke when included on a purchase order for a 5200A calibrator or 5200A/5215A cluster. 5200A-901 and 5200A-903 are available only through Fluke Technical Service Centers.

A table of correction factors is supplied in written form and on a disk compatible with 5200A-800 software.

2. Generate the table of correction factors in your own Standards Laboratory.

   5200A-800 software includes programs designed to make this easy. Equipment requirements and procedures are described in Section 4.

SPECIFICATIONS

Table 1-1 gives **Characterized-Point specifications.** These are absolute uncertainties at the points in a 5200A-90x table. Similar uncertainties can be expected for any special points you select for the meters in your calibration workload.

Table 1-2 gives uncertainty specifications for the Calibrator and a 5205A or 5215A Amplifier under its control. As you can see, characterization enhances 5200A performance dramatically.

Basic Instrument specifications are for a standard 5200A. **Characterized Instrument specifications** give the uncertainty obtained by interpolating between the points of a 5200A-90x table using 5200A-800 or 7411A software, or the manual techniques described in Section 3.

Absolute uncertainties include the error contributions of standards and of transfer techniques used here at Fluke. When calibrated by Fluke, these specifications are valid for 180 days, and are certified traceable to the U.S. National Bureau of Standards. Certified traceability to other national standards is also available at many Fluke Technical Service Centers throughout the world.

If you prepare a 5200A-90x compatible table of correction factors using professional metrology techniques and the procedures described in Section 4 of this manual, you can use these uncertainty specifications with confidence.

Voltage	Characterized-Point Absolute Uncertainty[1,2], ±ppm								
	Frequency, Hz								
	50	100	200	1k	2k	10k	20k	50k	100k
0.5	125	125	-	125	-	125	-	210	450
1	120	120	120	120	120	120	120	200	450
3	130	130	-	130	130	130	-	220	450
10	120	120	120	120	120	120	120	200	450
30	130	130	-	130	-	130	-	220	450
100	120	120	120	120	120	120	120	200	450
300[3]	190	190	-	190	-	190	-	630	-
1000[3]	180	180	180	180	180	180	200	610	-

Notes:

1. Includes transfer standards, DC reference source, and allowances for calibration technique.
2. Requires 5200A-900, -901, -902, or -903.
3. Output is through 5205A or 5215A amplifier.

Table 1-1. 5200A/5205A/5215A Characterized-Point Absolute Uncertainty

Voltage Ranges	Absolute Uncertainty			
	Basic Instrument		Characterized Instrument[2]	
	Frequency Hz	±(ppm setting + uV)	Frequency Hz	±(ppm setting + uV)
1 mV[3] 10 mV	10 - 30 30 - 20k 20k - 100k 100k - 1M	1000 + 10 200 + 10 500 + 20 3300 + 30		
100 mV	10 - 30 30 - 20k 20k - 100k 100k - 1M	1000 + 10 200 + 10 500 + 20 3300 + 30	50 - 100 100 - 20k 20k - 50k 50k - 100k	150 + 10 145 + 10 250 + 20 470 + 20
		±(ppm setting + ppm range)		±(ppm setting + ppm range)
1 V 10 V 100 V	10 - 30 30 - 20k 20k - 100k 100k - 1M	1000 + 50 200 + 20 500 + 50 3300 + 300	50 - 100 100 - 20k 20k - 50k 50k - 100k	150 + 20 145 + 15 250 + 20 470 + 30
1000 V[4]	10 - 30 30 - 20k 20k - 50k 50k - 100k	1200 + 50 400 + 40 800 + 50 1000 + 100	50 - 100 100 - 10k 10k - 20k 20k - 50k	210 + 20 200 + 20 220 + 20 630 + 30

Notes:

1. Includes transfer standards, DC reference source, and allowances for calibration technique.
2. Requires 5200A-900, -901, -902, or -903.
3. Applies for measuring instruments with less than 2 MHz bandwidth.
4. Output is through 5205A or 5215A amplifier.

Table 1-2. 5200A/5205A/5215A Absolute Uncertainty

Section 2
Automated 5200A-800 Operation

INTRODUCTION

This section tells you how to use **5200A-800 Software** to operate a 5200A Calibrator with the touch-sensitive display of a Fluke instrument controller. The calibrator can operate a 5205A or 5215A Amplifier. Either a 1722A or 1720A instrument controller may be used. And when a 5200A-90x correction table is available on its disk, the software enhances calibrator accuracy automatically.

The 5200A calibrator is connected through its optional 5200A-05 IEEE-488 interface to the controller. In operation, the controller touch-display becomes the user interface for the calibrator. All 5200A operating controls except **POWER**, **CONTROL**, and **VOLTAGE ERROR -%** are accessible on the controller display. POWER is activated manually, and CONTROL is set to **REM** (remote). The **VOLTAGE ERROR - &** editing function is accomplished to full 1,199,999 count resolution on the controller touch-display.

The table of 5200A and 5205A or 5215A corrections may also be used by 7411A Computer-Aided Calibration Software. This is described in a separate manual.

SAFETY FEATURES

WARNING

HIGH VOLTAGE
is used in the operation of this equipment.

DEATH ON CONTACT
may result if you do not understand and follow safety procedures.

WHEN OPERATED BY 5200A-800 SOFTWARE, CALIBRATOR STATUS AND OUTPUT VOLTAGE ARE NOT AS SELECTED ON THE CALIBRATOR FRONT PANEL.

In Operate Mode, Calibrator output is energized whenever **OPERATE** is backlit on the OPERATE/STANDBY touch-switch on the controller Data-Entry or Edit display screens. When OPERATE mode is touch-selected, the backlit voltage level display, top-center on the controller screen, is changed from **Selected:** to **Output:**, and calibrator or amplifier output is energized.

Calibrator and amplifier output may be de-energized at any time by:

- switching 5200A POWER **OFF**, or
- selecting **STANDBY** on the OPERATE/STANDBY touch-switch on the controller display screen.

Calibrator output is not energized by the controller during start-up sequence or when **Demo mode** is selected.

While nothing can take the place of professional safety procedures, the 5200A Calibrator, the 5205A and 5215A Amplifiers, and 5200A-800 software include safety features that help you ensure safe operation:

- When power is turned on, the calibrator starts up in **STDBY** (standby) mode regardless of the condition it was last in. 5200A-800 software initializes in **STANDBY** mode with 0.1 mV selected.

- If the calibrator sense leads are accidentally disconnected in **External-Sense** mode, output is prevented from rising more than 2V above the selected setting.

- The calibrator switches to **STDBY** (standby) whenever the 1000V range is manually selected. 5200A-800 software switches to **STANDBY** mode whenever you increase the selected voltage past 20V, and again past 120V.

SOFTWARE FAMILIARIZATION

As a first step, we suggest you use 5200A-800 software in **Demo Mode** to familiarize yourself with its operation without the need for additional equipment. The only difference in Demo Mode is that IEEE-488 Bus commands are not generated. This allows the software to run on a controller with no other equipment connected.

What follows is a description of each software display, and each functional selection that you can make. Select Demo Mode, and you will be able to try each function.

Getting started is as simple as placing the 5200A-800 disk in your 1722A or 1720A instrument controller and either turning it **ON** or pressing **RESTART**. After software loading, the start-up display shown in Figure 2-1 will appear.

The Start-Up Display gives information and presents some choices. Figure 2-1 shows the display when there is no correction data table available on the disk. When a valid correction data table is available, an expiration date is displayed in place of **Not Meaningful**, and either one or two serial numbers are displayed in place of **NO CORRECTION DATA**. When only a 5200A serial number is displayed, the table does not include corrections for a 5205A or 5215A amplifier.

The software will operate the calibrator and amplifier regardless of correction factors or expiration date. Correction data is used if it is available.

> **Verify that displayed serial number(s) are for calibrator (and amplifier) that you are using, and that the expiration date has not passed.**

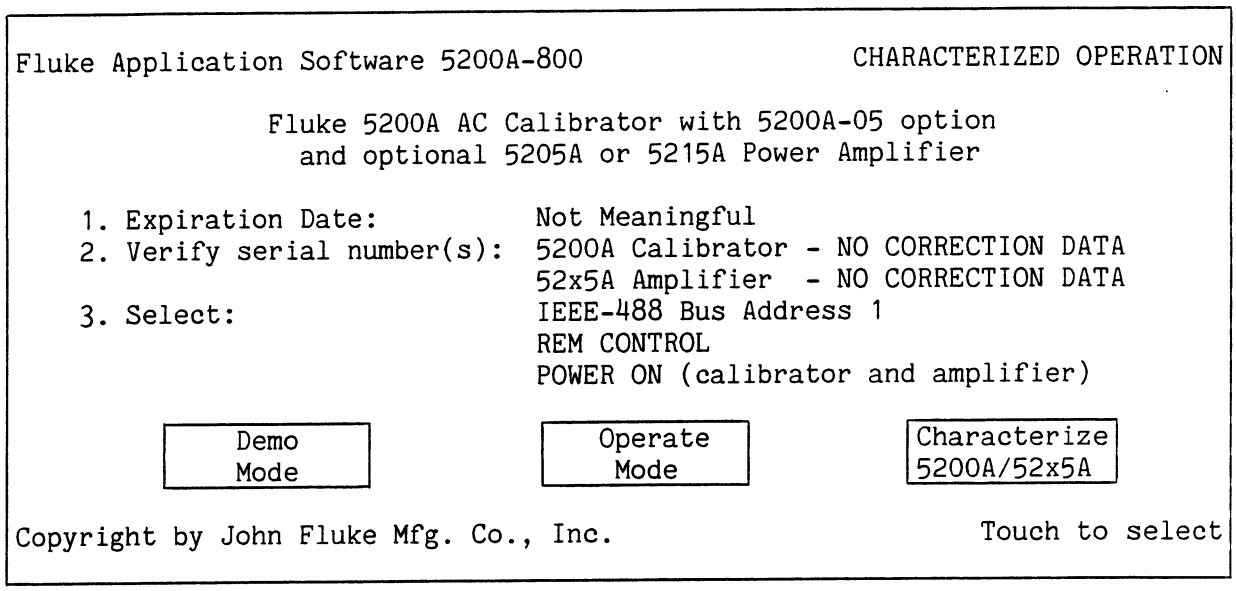


Figure 2-1. Start-Up Display

Three choices are presented:

Demo Mode

Touch-select **Demo Mode** to get the display of Figure 2-2. Demo Mode is identical to operate mode, except that it allows the software to operate without the calibrator connected. No IEEE-488 Bus commands are sent. Demo Mode is provided to help you become familiar with the software without generating calibrator voltages.

Operate Mode

Touch-select **Operate Mode** to get the display of Figure 2-2. Operate Mode is the normal mode of operation. IEEE-488 Bus commands are sent to the 5200A Calibrator as it is operated through the touch-sensitive display of the controller. If a 5205A or 5215A amplifier is connected, it is in turn operated by the 5200A calibrator.

Characterize 5200A/52x5A

Touch-select **Characterize 5200A/52x5A** to start up a program that generates a table of correction factors for a 5200A and a 5205A or 5215A amplifier. Refer to Section 4 for further information.

Summary of Controls and Indicators - DATA ENTRY MODE

Data Entry Mode is reached from the Start-Up display by touch-selecting **Demo Mode** or **Operate Mode.** It may also be reached from Edit Mode by touch-selecting **Select Data Entry.**

The Data Entry Control Display is shown in Figure 2-2. Following is a summary describing each of its controls and indicators.

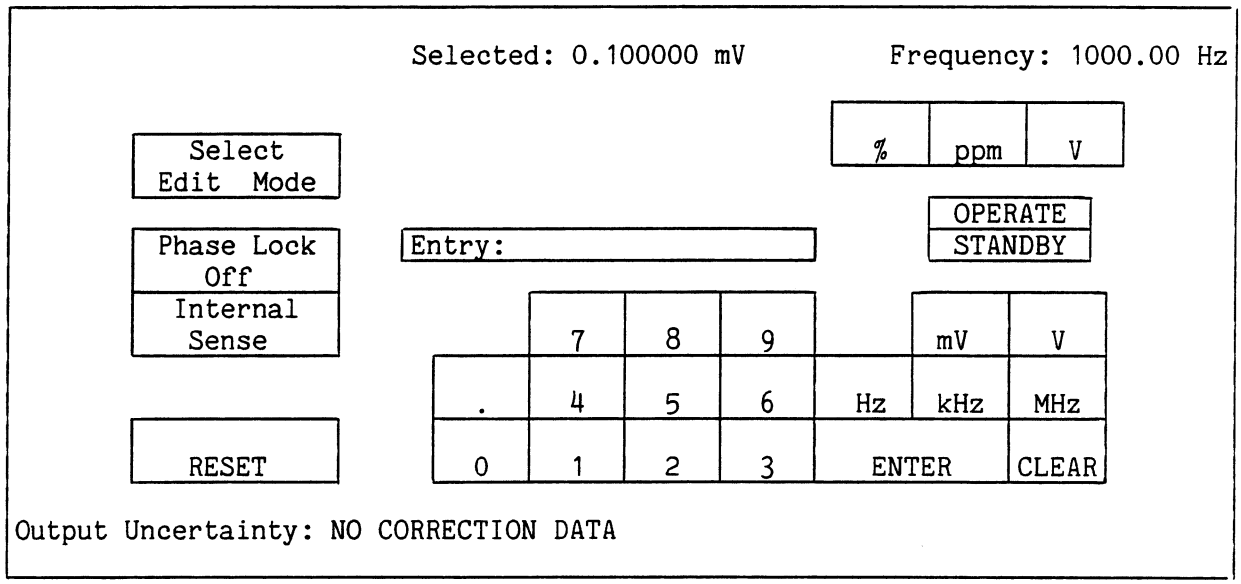


Figure 2-2. Data Entry Control Display

RESET

Touch-select **RESET** to reset the software and the calibrator to start-up condition. The Start-Up screen (Figure 2-1) is displayed, and the calibrator is reset to STANDBY, 0.100000 mV, and 1000.00 Hz. This allows you to leave Demo Mode and select Operate Mode.

Selected: 0.100000 mV
Output: 0.100000 mV

Indicates the current selected output voltage level. Reads **Selected:** in STANDBY mode. Reads **Output:** in OPERATE mode, with the calibrator energized to the indicated level.

Frequency: 1000.00 Hz

Indicates the current selected output frequency.

Select Edit Mode

Touch-select **Select Edit Mode** to re-draw the keypad with edit keys as shown in Figure 2-3. See the description of Edit Mode below.

Phase Lock Off

This is an alternating switch. Touch-select **Phase Lock Off** to send a phase-lock command to the 5200A. **Off** is replaced by **On**. This instructs the calibrator to lock phase with an external signal supplied to it through its rear **PHASE LOCK INP** connector.

When selected again, phase lock is turned off and the switch again displays **Off**.

Internal Sense

This is an alternating switch. Touch-select **Internal Sense** to request external voltage level sensing. If it is available for the current voltage level, the touch-switch display will change to **External Sense**. The calibrator **SENSE HI** and **SENSE LO** lines must be connected to the meter being calibrated at its input terminals.

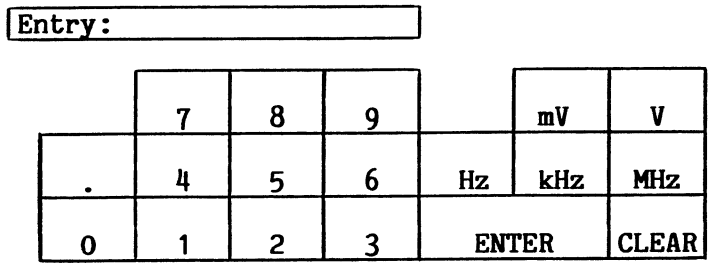
The message **Not available at this output...** is displayed along the lower right of the screen when external sense is requested for voltage settings below 120 mV and at or above 120V. Press either **CLEAR** or **Internal Sense** to clear this message and re-enable the keypad.

OPERATE STANDBY

This is an alternating switch. Touch-select **OPERATE/STANDBY** to select operate or standby mode. The active mode is backlit on the display switch. Start-up condition is STANDBY. When **OPERATE** is selected, the **Selected:** display changes to **Output:** and the calibrator is energized with the voltage and frequency displayed on the top of the controller screen.

WARNING

The controller display is the only indication of calibrator output voltage. 5200A front panel settings will NOT indicate true output.



The entry keypad is used for entering voltage and frequency. Entries accumulate in the entry window until you touch **ENTER** or **CLEAR**. The proper sequence is to enter a numeric value, and then to identify it with a label: **mV**, **V**, **Hz**, **kHz**, or **MHz**. Then, either touch **ENTER** if the entry is correct, or **CLEAR** if you would like to re-enter it. When **ENTER** is touched, the entry is checked against performance limits, and transferred to the **Selected:** or **Output:** and **Frequency:** windows.

For OPERATE mode, two voltage safety thresholds are established: 20V and 120V. When a voltage entry exceeds one of these thresholds, and the previous level was less, calibrator status is automatically switched to STANDBY. You must then touch **OPERATE/STANDBY** to re-energize calibrator output.

When an entry is attempted without an identifying label, the message **Select voltage or frequency units...** is displayed on the right half of the bottom line. Touch a voltage or frequency label, or touch **CLEAR** to proceed.

When an entry is attempted that is beyond the performance limits of the calibrator, it is not accepted and the message **Entry is beyond amplitude limits...** is displayed. Press **CLEAR** to delete the entry and re-enable the keypad.

This is a dual-purpose key. Touch-select **CLEAR** once to clear information from the **Entry:** window. Touch-select **CLEAR** twice to reset calibrator status to STANDBY, and output display to **Selected: 0.100000 mV**. Frequency is not affected.

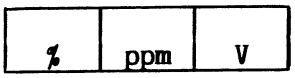
Output Uncertainty: NO CORRECTION DATA

Displays the absolute uncertainty of the selected output level, including a floor calculation. Displays **NO CORRECTION DATA** when a 5200A-90x table of correction factors is not available on the disk.

This uncertainty is only valid for the serial-numbered calibrator (and amplifier) for which the correction table was created, and prior to its expiration date. When the table was created by Fluke, it is

certified by Fluke to be true and traceable to the national standards bureau cited on the written certification that was supplied with it.

The displayed uncertainty will automatically drop when a point on the table of corrections is selected, allowing it to be used directly. Try, for example, 1V at 10kHz, and you will see 120 ppm. However, if you select a custom point that you added to the table, the displayed uncertainty will be the interpolated value even though the more accurate correction is being used.



These switches control the format in which **Output Undertainty:** is displayed. They also control the format of the Edit Mode **UUT Error:** display.

The designations **%** and **ppm** are relative to the current output voltage (ppm = parts per million, 100 ppm = 0.01%). **V** is the absolute magnitude of voltage uncertainty for the current output voltage.

Since display resolution is limited to three digits, you can often get more information from the **ppm** display than from **%**.

Summary of Controls and Indicators - EDIT MODE

Edit Mode is reached from Data Entry Mode by touching **Select Edit Mode.** The Edit Control Display is shown in Figure 2-3. Some controls and indicators remain unchanged. Following is a summary of each added control and indicator.

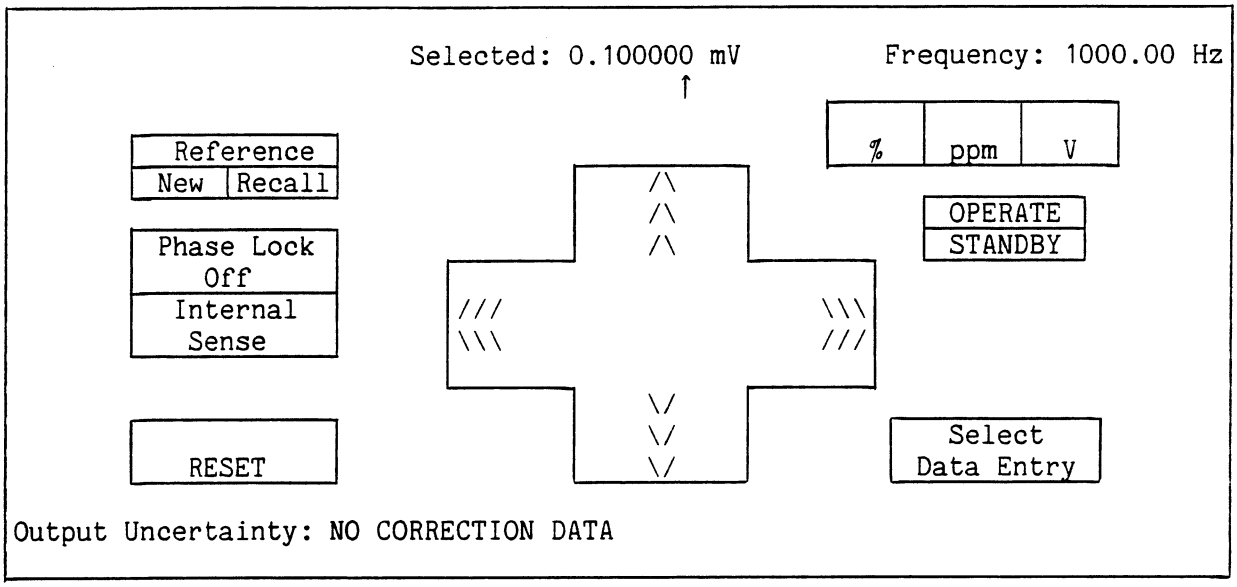


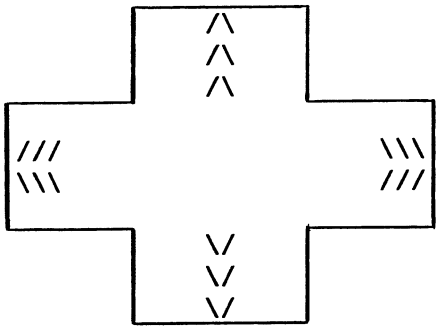
Figure 2-3. Edit Control Display

Select Data Entry

Touch-select **Select Data Entry** to re-draw the edit keys with the data-entry keypad, and return to Data Entry mode as shown in Figure 2-2.

↑

Indicates the digit that will be changed by touching the edit control.



This is the edit control area. Touch left or right to move the ^ digit indicator and select a digit for editing. Then touch up or down to increase or decrease that digit. Hold it down, and it will repeat at a slow rate that is easily managed while you are looking at the meter being calibrated.

Normal technique is to set voltage and frequency initially to the nominal setting called for in the meter calibration procedure. Then use Edit Mode to make adjustments as required to get a correct meter reading. The error can then be read directly from the display indicator described next.

UUT Error: -10.0 ppm

Indicates the difference between the reference voltage (usually the originally selected output voltage) and the edited value. **UUT Error:** does not appear until an editing change is done.

The format of the **UUT Error:** display can be changed by touching the **%**, **ppm**, or **V** keys.

Reference	
New	**Recall**

This is a dual switch. The reference voltage is normally the value that was initially entered, prior to editing changes. Touch-select **Recall** to re-establish output to that initial level. Touch-select **New** to define the voltage currently in the **Selected:** or **Output:** window as a new reference voltage.

Note that **UUT Error:** is simply the difference between the reference voltage and the current output voltage. Since it is only displayed when there is a difference, it disappears when you touch-select **New Reference.**

Make a Working Copy

Your 5200A-800 disk should be protected in a safe place. We suggest that you leave the write-protect tab in place and make a working copy. Use the same FUP whole-copy **/W** procedure that you would to duplicate any other disk.

With E-Disk...

If your controller has expansion memory (or 1720A E-Disk), 5200A-800 software will automatically configure and format it for you on start-up. Use this procedure:

1722A	1720A	Comments
(Insert 5200A-800 disk)		
<RESTART>	<RESTART>	Start up the software
<CTRL>C	<CTRL>C	Stop operating software
---	EXIT	Exit BASIC (1720A only)
FUP	FUP	File Utility Program
EDO:=MFO:/W	EDO:=MFO:/W	Copy disk onto E-Disk
(file name list)	(file name list)	
(Insert blank disk)		
MFO:/F@	MFO:/F	Format the blank disk
MFO:=EDO:/W	MFO:=EDO:/W	Copy E-Disk onto disk

If you are using a 1720A, and would like to limit the copy to 1720A files, watch for the message **Copying CALC.BAL ...** and type **<CTRL>C.** FUP will complete copying that file and then stop. If you do not do this, the 1720A will stop and indicate an error when one of the 1722A files overruns its capacity. This causes no problem except that the disk is needlessly full.

Without E-Disk...

If your controller does not have expansion memory (or 1720A E-Disk), you can still make a working copy. You will have to swap disks a few times to complete the copy. The procedure is similar, except that you must tell the FUP whole-copy **/W** procedure where in the directory to continue copying after each swap:

1722A	1720A	Comments
(Insert 5200A-800 disk)		
<RESTART>	<RESTART>	Start up the software
<CTRL>C	<CTRL>C	Stop operating software
---	EXIT	Exit BASIC (1720A only)
FUP	FUP	File Utility Program
(Insert blank disk)		
MFO:/F@	MFO:/F	Format the blank disk
EDO:/C-1	---	Configure main memory
(Insert 5200A-800 disk)		
EDO:=MFO:/W	MMO:=MFO:/W	Copy from disk
(file name list)	(file name list)	

```
?No room on device      ?No room on device
```

At this point, the controller memory does not have room for the next file. The 1722A helps you out by telling you the name of the file that would not fit, so you know where to start next time. Write down that file name. If you are using a 1720A, write down the last file that was copied.

Continuing the procedure:

```
        (Insert blank disk)
MF0:=ED0:/W             MF0:=MM0:/W             Copy onto disk
(file name list)        (file name list)
        (Insert 5200A-800 disk)
 ---                    <PAGE MODE>
 ---                    MF0:/L
 ---                    <NEXT PAGE>             Display directory
```

If you are using a 1720A, look on the directory for the next file to be copied, and write it down. Then, if for example the next file is **FUP.CIL**, continue the procedure as follows:

```
 ---                    <PAGE MODE>             Make sure it's off
ED0:/Z                  MM0:/Z                  Clear memory
ED0:=MF0:FUP.CIL/W      MM0:=MF0:FUP.CIL/W      Continue copying
```

Continue this procedure until there are no more files to copy. If you using a 1720A, you do not need file **OPER/.BAL** or any of the files that follow it in the directory.

Use a 1722A if you need the copy to work on either controller. A copy made by a 1720A will not work on a 1722A.

Copying the 5200.DAT File

When you have your 5200A Calibrator (and 5205A or 5215A Amplifier) characterized with a Fluke 5200A-90x service, you get a table of corrected voltage settings in both printed and compatible disk-file form. To use this disk file with 5200A-800 software, you will need to copy it onto the working-copy disk you just made.

Use the same FUP **/B** procedure that you would to copy any other binary format file. Use this procedure, except that you can skip the **ED0:/C-1** command if your 1722A has expansion memory installed:

```
1722A                   1720A                   Comments

        (Insert 5200A-800 disk)
<RESTART>               <RESTART>               Start up the software
<CTRL>C                 <CTRL>C                 Stop the software
 ---                    EXIT                    Exit BASIC (1720A only)
FUP                     FUP                     File Utility Program
ED0:/C-1                 ---                    Configure main memory
ED0:=MF0:5200.DAT/B     MM0:=MF0:5200.DAT/B     Copy file from disk
        (Insert working disk)
```

```
MF0:=ED0:5200.DAT/B     MF0:=MM0:5200.DAT/B     Copy file onto disk
```

Changing IEEE-488 Bus Address

As supplied, 5200A-800 operating software expects the 5200A calibrator to be set for Bus Address 1. Bus addressing for calibrator operating software uses the variable **IA%** (Instrument Address) to identify the 5200A Bus Address. This variable is assigned early in the **OPER** program, and can be easily changed.

Following are step-by-step instructions to change the 5200A Bus Address. Where they are different, 1720A instructions are shown in [brackets].

1. Insert the 5200A-800 disk and press **RESTART.**
2. When the Start-Up screen appears, type **<CTRL>C**
3. Type **BASIC** [skip this step for 1720A].
4. Type **OLD "MF0:OPER_.BAL"** [skip this step for 1720A].
5. Type **EDIT**
6. Look about 8 lines down from the top for the line

   IA%=1%

   Use the arrow keys to move the cursor to the **1.** Press **DEL CHAR** and replace the number with the Bus Address that you would like to use.
7. Type **<CTRL>C**
8. Remove the write-protect tab from the side of the disk cover and replace the disk in the disk drive. Then type **SAVEL "OPER_".** [For 1720A, type **SAVEL "OPER"**]. Replace the write-protect tab on the disk.

If you will be using 5200A-800 software to generate compatible tables of correction factors, refer also to the instructions in Section 4 for changing Bus addressing of calibration software.

SOFTWARE STRUCTURE

5200A-800 software is supplied in a form that allows it to run on either a 1722A or 1720A Instrument Controller, even though a 1720A can access only one side of the disk. This is accomplished in the following way:

- The disk is formatted across both sides in a continuous format. (Normal 1722A disk format alternates sides to reduce head movement during file access.)
- All 1720A software is placed on the disk first. This allows the 1720A to have access to it.

Program files are in lexical form. This allows faster operation, since some operations chain to other programs. However this requires separate 1722A and 1720A program files.

1722A and 1720A system software use different file names. This allows each controller to recognize its own system software. Here is a list of the files on your 5200A-800 disk:

File Name	Description
COMMND.SYS	1720A start-up command file
STRTUP.CMD	1722A start-up command file
STRT1 .CMD	1722A start-up command file (E-Disk allocation)
STRT2 .CMD	1722A start-up command file
5200 .DAT	Table of correction factors
FDOS .SYS	1720A system software
CONMON.SYS	1720A console monitor
BASIC .CIL	1720A BASIC interpreter
FUP .CIL	1720A File Utility Program
TIME .CIL	1720A Time-set utility
OPER .BAL	5200A-800 operating program, 1720A version
CALA .BAL	5200A-800 calibration program A, 1720A version
CALB .BAL	5200A-800 calibration program B, 1720A version
OPER_ .BAL	5200A-800 operating program, 1722A version
CALA_ .BAL	5200A-800 calibration program A, 1722A version
CALB_ .BAL	5200A-800 calibration program B, 1722A version
FDOS2 .SYS	1722A system software
MACRO .SYS	1722A system software
BASIC .FD2	1722A BASIC interpreter
FUP .FD2	1722A File Utility Program
TIME .FD2	1722A Time-set utility

Notice that 1722A versions of 5200A-800 programs are identified by a "_" after the file name. This is not a legitimate file name character for a 1720A. If you look at this directory with a 1720A, you will see "/" instead (eg: OPER/.BAL).

The program files on your 5200A-800 disk have had comments stripped and are in lexical form. This allows them to load faster and to fit onto the disk. In some cases they are the result of merging two files.

INSTRUMENT SETUP

Controller Display Alignment

1722A and 1720A instrument controllers use a touch-sensitive display overlay that is independent of the location of displayed characters. Adjustments within the controller video section affect character location. If the controller display is not properly aligned, operation of an application program such as the 5200A-800 can be difficult. This is particularly true for the data-entry keypad screen which allocates one sense location for each number.

You can use the data-entry keypad to do a quick check of alignment. Select **Demo Mode** from the Start-Up screen to get the keypad. If you look

closely at the display overlay, you will see horizontal and vertical lines. These are isolation lines between conductive bands. (You can see them easier in low light with a flashlight held at an angle.) The horizontal lines should line up with the horizontal display lines of the keypad. The vertical lines should be about a half-character width to the left of the horizontal display lines of the keypad.

If you decide that your controller display alignment requires adjustment, refer to your controller service manual or call your nearest Fluke Technical Service Center for advice.

Instrument Setup

For normal operation, connect the equipment as follows:

1. Make sure each instrument is turned off.

2. Connect an IEEE-488 cable from Port 0 on the controller to the IEEE-488 connector on the 5200A.

3. Set the IEEE-488 Address Switch on the 5200A (located just below the IEEE-488 connector) to 1. Do this by setting the top switch segment (A1) to 1 (left) and setting the remaining switch segments to 0 (right).

4. If a 5205A or 5215A Amplifier is included, connect it to J32 on the bottom rear panel of the 5200A using the cable supplied with the amplifier (Fluke Part Number 341560). Consult the amplifier manual first before making this connection if you are unfamiliar with the amplifier.

Section 3
Manual Corrections

INTRODUCTION

When a 5200A Calibrator and 5205A or 5215A Amplifier is characterized by Fluke with a 5200A-90x option, a table of corrected voltages is supplied in both printed and 5200A-800 compatible disk-file form.

This section tells you how to manually use a printed **5200A-90x** table of corrected voltages to enhance the accuracy of a 5200A AC Calibrator and 5205A or 5215A Amplifier. For the points on the table, you simply substitute the table value. For other points, you must interpolate between points. Worked-out examples are included.

SAMPLE TABLE OF CORRECTED VOLTAGES

Table 3-1 is a sample table of corrected voltages developed for a calibrator at Fluke. These values will be used for example calculations.

FREQ (Hz)	V O L T A G E				
	50 mV	100 mV	0.5 V	1.0 V	3.0 V
50	49.9998*	99.9976*	0.499998	0.999976	2.99989
100	50.0000*	100.0013*	0.500000	1.000013	3.00002
200	50.0002*	100.0015*	0.500002*	1.000015	3.00003
1k	50.0022*	100.0023*	0.500022	1.000023	3.00013
2k	50.0023*	100.0030*	0.500023*	1.000030	3.00024
10k	50.0026*	100.0057*	0.500026	1.000057	3.00026
20k	50.0033*	100.0060*	0.500030*	1.000060	3.00023*
50k	50.0040*	100.0112*	0.500040	1.000112	3.00016
100k	50.0020*	100.0263*	0.500121	1.000263	2.99991
	10 V	30 V	100 V	300 V	1000 V
50	9.99970	29.9997	99.9992	299.995	999.980
100	10.00007	30.0009	100.0031	300.010	1000.020
200	10.00010	30.0010*	100.0044	300.011*	1000.023
1k	10.00025	30.0018	100.0053	300.022	1000.047
2k	10.00073	30.0017*	100.0045	300.023*	1000.050
10k	10.00068	30.0016	100.0032	300.029	1000.067
20k	10.00063	30.0008*	100.0014	300.029*	1000.138
50k	10.00010	29.9984	99.9980	300.030	1000.330
100k	9.99907	29.9946	99.9865		

Table 3-1. Sample 5200A-90x Table of Corrected Voltages

Values identified with an asterick are not directly characterized. For millivolt levels, these values are derived from 0.5V and 1.0V corrections respectively by multiplying by 0.1. Other indirect values are derived by interpolation from the frequencies above and below.

DIRECT CORRECTION

For the points listed in the table of corrected voltages, these corrections may be used directly. The calibrator is simply set to the value in the table.

For example, the calibrator that generated Table 3-1 can be set to 1V at 1kHz within the uncertainty given in the specifications in Section 1 by setting it to 1.000023 V.

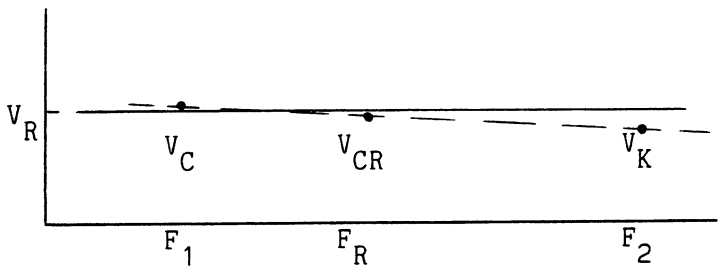
INTERPOLATED CORRECTION

Linear interpolation is used. The choice of linear interpolation was based on the design of the 5200A as well as its performance history. This method of interpolation has been demonstrated valid by verification of measured data from a cross section of new and existing 5200A calibrators.

Three examples are worked out in this section. The first interpolates between two characterized frequencies at a characterized voltage. A second example interpolates between two characterized voltages at a characterized frequency. The third example interpolates both voltage and frequency for a point that is between both voltage and frequency points on the table.

Example 1: Interpolation Between Frequency Points

Figure 3-1 illustrates interpolation between frequency points. The voltage errors at frequencies F_1 and F_2 are known because they are in the table of corrected voltages. In this example we want to use the calibrator at voltage V_R which is a characterized voltage, and at frequency F_R, which is not a characterized frequency and is between F_1 and F_2



F_1 = Next lower characterized frequency

F_2 = Next higher characterized frequency

F_R = Requested frequency

V_R = Requested voltage

V_C = Corrected voltage at F_1 (from Table 3-1)

V_K = Corrected voltage at F_2 (from Table 3-1)

V_{CR} = Corrected voltage for V_R,F_R (unknown)

Figure 3-1. Example 1

To calculate the voltage correction at F_R, this equation is used:

$$V_{CR} = V_C + (V_K - V_C) \left(\frac{F_R - F_1}{F_2 - F_1}\right)$$

In this example we will calculate a corrected voltage setting for **10V** at **80 kHz**, using the calibrator that generated Table 3-1.

For our selected values, the known variables are:

F_1 = 50k Hz

F_2 = 100k Hz

F_R = 80k Hz

V_C = 10.00010V

V_K = 9.99907V

The calculation of V_{CR} proceeds like this:

$$V_{CR} = 10.00010V + (9.99907V - 10.00010V)\left(\frac{80\ kHz - 50\ kHz}{100\ kHz - 50\ kHz}\right)$$

$$= 10.00010V + (-0.00103V)\left(\frac{30}{50}\right)$$

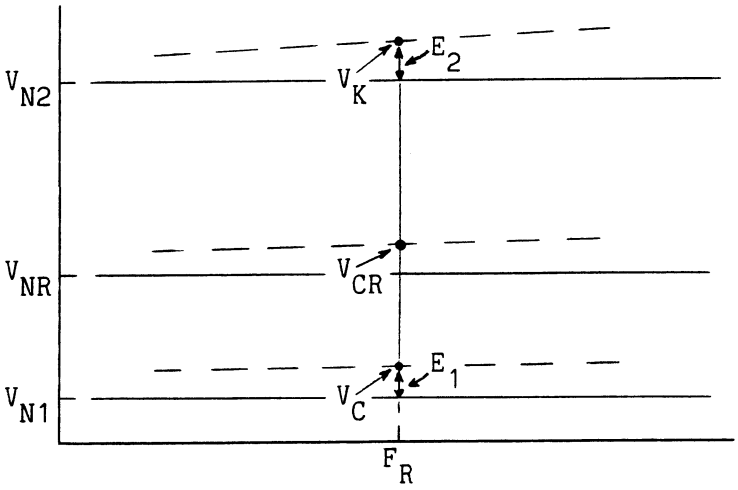
$$= 10.00010V - 0.00062V$$

$$= 9.99948V$$

Therefore, to more closely approach 10V at 80 kHz, we need to set this 5200A to 9.99948V.

Example 2: Interpolation Between Voltage Points

Figure 3-2 illustrates interpolation between voltage points. The voltage errors at voltages V_{N1} and V_{N2} are known from the 5200A-90x table. In this example we want to use the calibrator at voltage V_{NR}, which is between V_{N1} and V_{N2}. All these voltages are at a frequency which is on the 5200A-90x table.



V_{N1} = Nominal value of next lower characterized voltage

V_{N2} = Nominal value of next higher characterized voltage

V_{NR} = Nominal requested voltage

F_R = Requested frequency

V_C = Corrected value of next lower characterized voltage

V_K = Corrected value of next higher characterized voltage

E_1 = Error correction at V_{N1} $(= V_C - V_{N1})$

E_2 = Error correction at V_{N2} $(= V_K - V_{N2})$

V_{CR} = Corrected voltage for V_{NR} (unknown)

Figure 3-2. Example 2

This calculation of V_{CR} proceeds as follows:

To calculate the voltage correction at V_{NR}, F_R, this equation is used:

$$V_{CR} = V_{NR} + E_1 + (E_2 - E_1)\left(\frac{V_{NR} - V_{N1}}{V_{N2} - V_{N1}}\right)$$

In this example we will calculate a corrected voltage setting for **5V** at **1 kHz**, using the calibrator that generated Table 3-1.

For our selected values, the known variables are:

$$V_{N1} = 3V$$

$$V_{N2} = 10V$$

$$V_{NR} = 5V$$

$$V_C = 3.00013V$$

$$V_K = 10.00025V$$

$$E_1 = V_C - V_{N1} = 3.00013V - 3V = 0.00013V$$

$$E_2 = V_K - V_{N2} = 10.00025V - 10V = 0.00025V$$

This calculation of V_{CR} proceeds as follows:

$$V_{CR} = 5V + 0.00013V + (0.00025V - 0.00013V)\left(\frac{5V - 3V}{10V - 3V}\right)$$

$$= 5.00013V + 0.00012V\left(\frac{2}{7}\right)$$

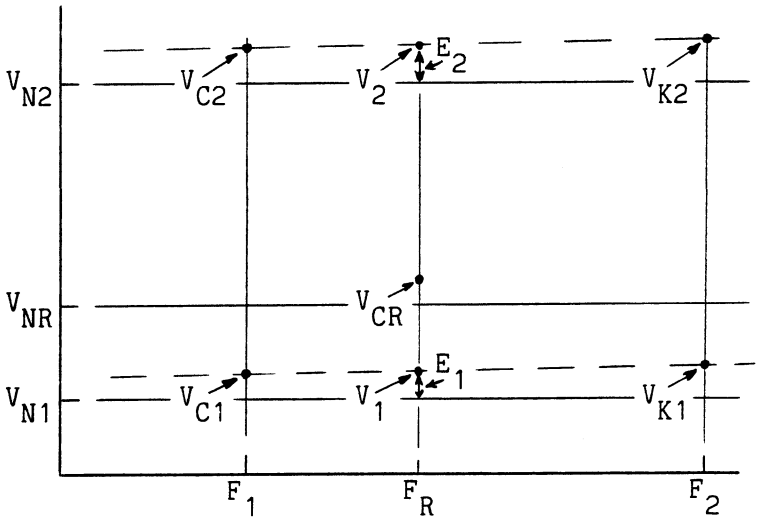
$$= 5.00013V + 0.00003V$$

$$= 5.00016V$$

Therefore, to more closely approach 5V at 1 kHz, we need to set this 5200A to 5.00016V.

Example 3: Interpolation Between Voltage and Frequency Points

Figure 3-3 illustrates interpolation between voltage and frequency points. In this example we want to use the calibrator at frequency F_R (requested frequency), which is somewhere between F_1 and F_2, and voltage V_{NR} (nominal requested voltage), which is between V_{N1} and V_{N2}. Neither F_R nor V_{NR} are on the 5200A-90x table.



F_1 = Next lower characterized frequency

F_2 = Next higher characterized frequency

F_R = Requested frequency

V_{N1} = Nominal value of next lower characterized voltage

V_{N2} = Nominal value of next higher characterized voltage

V_{NR} = Nominal requested voltage

V_{C1} = Lower corrected voltage at F_1

V_{C2} = Higher corrected voltage at F_1

V_{K1} = Lower corrected voltage at F_2

V_{K2} = Higher corrected voltage at F_2

V_1 = Lower corrected voltage at F_R

V_2 = Higher corrected voltage at F_R

E_1 = Error correction at V_{N1}, F_R (= $V_1 - V_{N1}$)

E_2 = Error correction at V_{N2}, F_R (= $V_2 - V_{N2}$)

V_{CR} = Corrected voltage at V_{NR}, F_R (unknown)

Figure 3-3. Example 3

To calculate the corrected voltage V_{CR}:

$$V_1 = V_{C1} + (V_{K1} - V_{C1}) \left(\frac{F_R - F_1}{F_2 - F_1}\right)$$

(Similar to Example 1)

$$V_2 = V_{C2} + (V_{K2} - V_{C2}) \left(\frac{F_R - F_1}{F_2 - F_1}\right)$$

(Similar to Example 1)

$$V_{CR} = V_{NR} + E_1 + (E_2 - E_1) \left(\frac{V_{NR} - V_{N1}}{V_{N2} - V_{N1}}\right)$$

(Similar to Example 2)

For this example we will calculate a corrected voltage for **5V** at **5 kHz**, using the calibrator that generated Table 3-1.

For our selected values, the known variables are:

F_1 = 2k Hz

F_2 = 10k Hz

F_R = 5k Hz

V_{C1} = 3.00024V

V_{C2} = 10.00073V

V_{K1} = 3.00026V

V_{K2} = 10.00068V

V_{NR} = 5V

The calculation to solve for V_{CR} proceeds like this:

$$V_1 = 3.00024V + (3.00026V - 3.00024V) \left(\frac{5k\ Hz - 2k\ Hz}{10k\ Hz - 2k\ Hz}\right)$$

$$= 3.00024V + 0.00002V \left(\frac{3}{8}\right)$$

$$= 3.00024V + 0.00001V$$

$$= 3.00025V$$

$$V_2 = 10.00073V + (10.00068V - 10.00073V) \left(\frac{5k\ Hz - 2k\ Hz}{10k\ Hz - 2k\ Hz}\right)$$

$$= 10.00073V + (-0.00005)V \left(\frac{3}{8}\right)$$

$$= 10.00073V - 0.00002V$$

$$= 10.00071V$$

$$E_1 = V_1 - V_{N1}$$
$$= 3.00025V - 3V$$
$$= 0.00025V$$

$$E_2 = V_2 - V_{N2}$$
$$= 10.00071V - 10V$$
$$= 0.00071V$$

$$V_{CR} = 5V + 0.00025V + (0.00071V - 0.00025V) \left(\frac{5V - 3V}{10V - 3V}\right)$$

$$= 5V + 0.00025V + 0.00046 \left(\frac{2}{7}\right)$$

$$= 5.00025V + .00013V$$

$$= 5.00038V$$

Therefore, to more closely approach 5V at 5 kHz, we need to set this 5200A to 5.00038V.

Section 4
Characterization Procedure

INTRODUCTION

Model 5200A-800 Operation and Calibration Software includes programs that allow you to develop your own table of corrected voltages for a 5200A AC Calibrator and a 5205A or 5215A Precision Amplifier. This section describes procedures that use those programs. If you will be using Fluke characterization services (see Section 1), you will not need the information in this section.

WARNING

HIGH VOLTAGE
is used in the operation of this equipment.

DEATH ON CONTACT
may result if you do not understand and follow safety procedures.

Note

While this procedure is identical to that used by Fluke to achieve the performance specifications given in Section 1, that performance relies on established metrology laboratory conditions, and on skills that are beyond the scope of this manual. This procedure does not ensure characterization integrity, nor does it provide checks for valid characterized values. You are responsible for deriving valid constants and ensuring correct data entry.

The characterization procedure precisely measures the output of the 5200A calibrator at 46 voltage/frequency points, and produces a list of corrected voltage settings. An additional 13 points are measured when a 5205A or 5215A amplifier is included.

REQUIRED EQUIPMENT

The procedure relies on the equipment listed in Table 4-1. The calibration program (on the 5200A-800 disk) runs on a Fluke 1722A or 1720A Instrument Controller. It provides procedure-step prompts for interconnections and 540B settings, control of the 5440B or 5440A, and recording and printing of the characterization table.

Instrument Controller:	Fluke 1722A or 1720A
Thermal Transfer Standard:	Fluke 540B, characterized
DC Source:	Fluke 5440B or 5440A
Cables:	Belden 9271 low capacitance 4 each 30 cm lengths, with spade lugs
Connector:	Pomona #1699 or #1698 Binding post to UHF

Table 4-1. Required Equipment

The 540B must be accompanied by a valid Report of Calibration from the Fluke Primary Standards Laboratory, or otherwise characterized at the points and the uncertainties listed in Table 4-2.

Voltage	Uncertainty (± Percent)		
	20 kHz	50 kHz	100 kHz
0.5	.005	.01	.02
1	.005	.01	.02
3	.005	.01	.02
10	.005	.01	.02
30	.005	.01	.02
100	.005	.01	.02
300	.005	.05	*
1000	.005	.05	*

Table 4-2. Required 540B Characterization Points and Uncertainties
(* beyond volt-hertz limit)

GETTING FAMILIAR

The characterization program is menu-driven to guide you through the process. Most commands are entered through the touch-sensitive display of the controller.

This familiarization exercise uses **Demo Mode.** You do not need to have instruments connected to the 1722A or 1720A controller.

To enter the characterization program, start up the 5200A-800 disk as described in Section 2, and touch-select

Characterize 5200A/52x5A

on the start-up display.

The response will be:

VERIFY 5200A SERIAL NUMBER

S/N :0000000

YES	NO

To change the stored serial number, touch-select: **NO**, and it will respond with

ENTER 5200A SERIAL NUMBER

?

Use the keyboard to enter a 7-digit number, and it will return to the **VERIFY 5200A SERIAL NUMBER** screen, with the new serial number displayed.

If the serial number is correct, touch-select **YES**, and it will respond with:

DO YOU HAVE A 5205A OR 5215A
VOLTAGE AMP CONNECTED?

YES	NO

If you select **NO**, it will respond with the Main Menu below.

If you select **YES**, it will again ask you to verify or enter a serial number. After verifying or entering the serial number, it responds with the Main Menu:

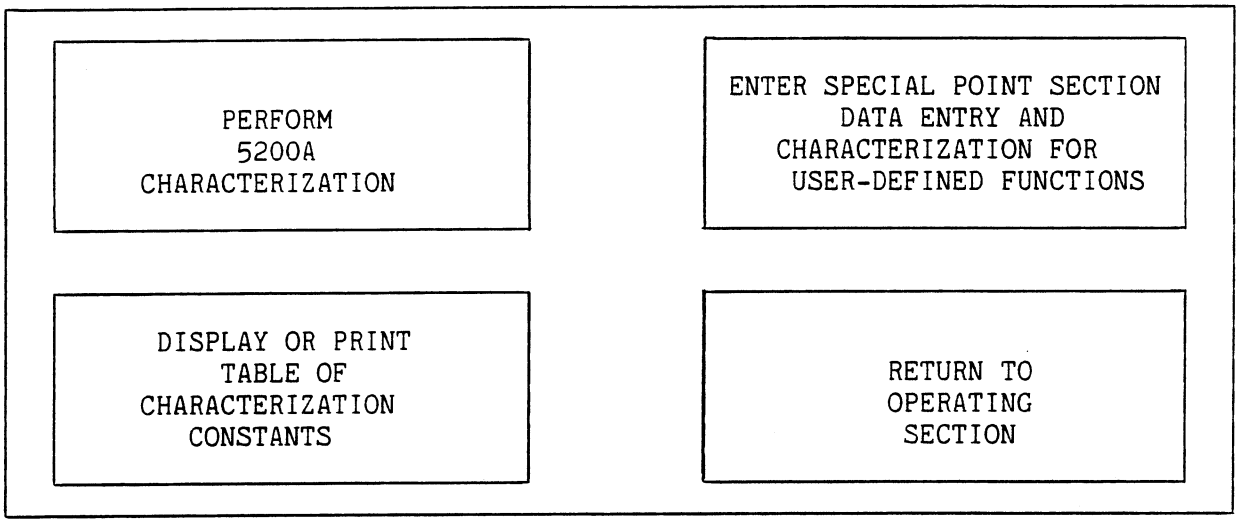


Figure 4-1. Main Calibration Menu

From the Main Menu you can:

- Proceed to standard-point characterization.
- Enter the special-point characterization program.
- Display the characterization table as it currently exists.
- Leave the characterization program (return to operation).

Touch-select **RETURN TO OPERATING SECTION**. The response allows you touch-select **(1)** to return to the start-up display of Figure 2-1, or to touch-select **(2)** to change your decision and return to the **Main Menu** display of Figure 4-1. Touch-select **(2)**.

From the Main Menu, touch-select **PERFORM 5200A CHARACTERIZATION**. The software responds with a message to refer to this manual for set-up instructions, and to make sure the calibrators have warmed up. Ignore this for now, and touch the screen.

The next message instruct you to set IEEE-488 Bus addresses, set up the 5200A front panel, and connect an IEEE-488 Bus cable to the controller.

Note

> If you would like to change the IEEE-488 Bus addressing in the calibrating portion of the software, refer to the end of this section for instructions.

Touch-select the lower-right of this diplay in the touch-sense area labelled **DEMO MODE**. In Demo Mode, IEEE-488 Bus commands are suppressed. This allows you to try out the software without instruments connected to the controller.

You now have a menu with three choices:

(1) ENTER OR CHANGE AC/DC
DIFFERENCE CONSTANTS FOR 540B

(2) DISPLAY TABLE OF AC/DC
DIFFERENCE CONSTANTS

(3) CONSTANTS CORRECT
CONTINUE CHARACTERIZATION

You are asked at this point to verify or correctly enter a table of AC/DC difference constants for the 540B Thermal Transfer Standard that you will be using. These correction factors are used in the final calculations of 5200A corrected voltages.

Touch-select **(2)** to display the table of 540B AC/DC difference constants currently stored on the disk. The 10 kHz constants are a function of the 20 kHz constants, calculated by software. Touch the screen again.

This time touch-select **(3)**.

You now have a menu with two choices:

(1) PROCEED WITH COMPLETE 5200A
CHARACTERIZATION IN SEQUENCE
(0.5 TO 100V, 50 HZ TO 100 HZ)

(2) SELECT SPECIFIC VOLTAGE AND
FREQUENCY POINT (MUST BE
CHARACTERIZATION POINT)

At this point you can choose to develop a complete 5200A-90x compatible characterization table in sequence, or to simply re-characterize one of the points on that standard table.

Touch-select **(1)**.

The controller next produces the Characterization Point Display shown in Figure 4-5. You can choose to characterize this point, go to the next point in the sequence, display the table of 5200A characterization constants, or terminate.

Touch-select **CHARACTERIZE.**

The first time through this sequence, the software interrupts at this point with instructions for 540B settings. **Do not change any 540B settings at this time.** Touch the display to continue.

The controller display responds with a message to allow 30 minutes for 540B stabilization. Time remaining is displayed for convenience. You can touch the screen at any time to continue.

The next display instructs you to wait 10 seconds, and null the 540B galvanometer. **Do not change any 540B settings at this time.** Touch the display to continue.

The controller momentarily displays **SET "GALV" SWITCH TO "OPEN".**

The controller then shows the AC/DC Transfer Control Display, with these five options:

DC NULL

AC NULL

CHANGE DC POLARITY

ENTER CHAR. POINT

TERMINATE

Touch-select **TERMINATE**. This returns you to the Characterization Point Display.

Figure 4-2 is a flowchart of the characterization program. You will find it useful for finding your way through the characterization procedure.

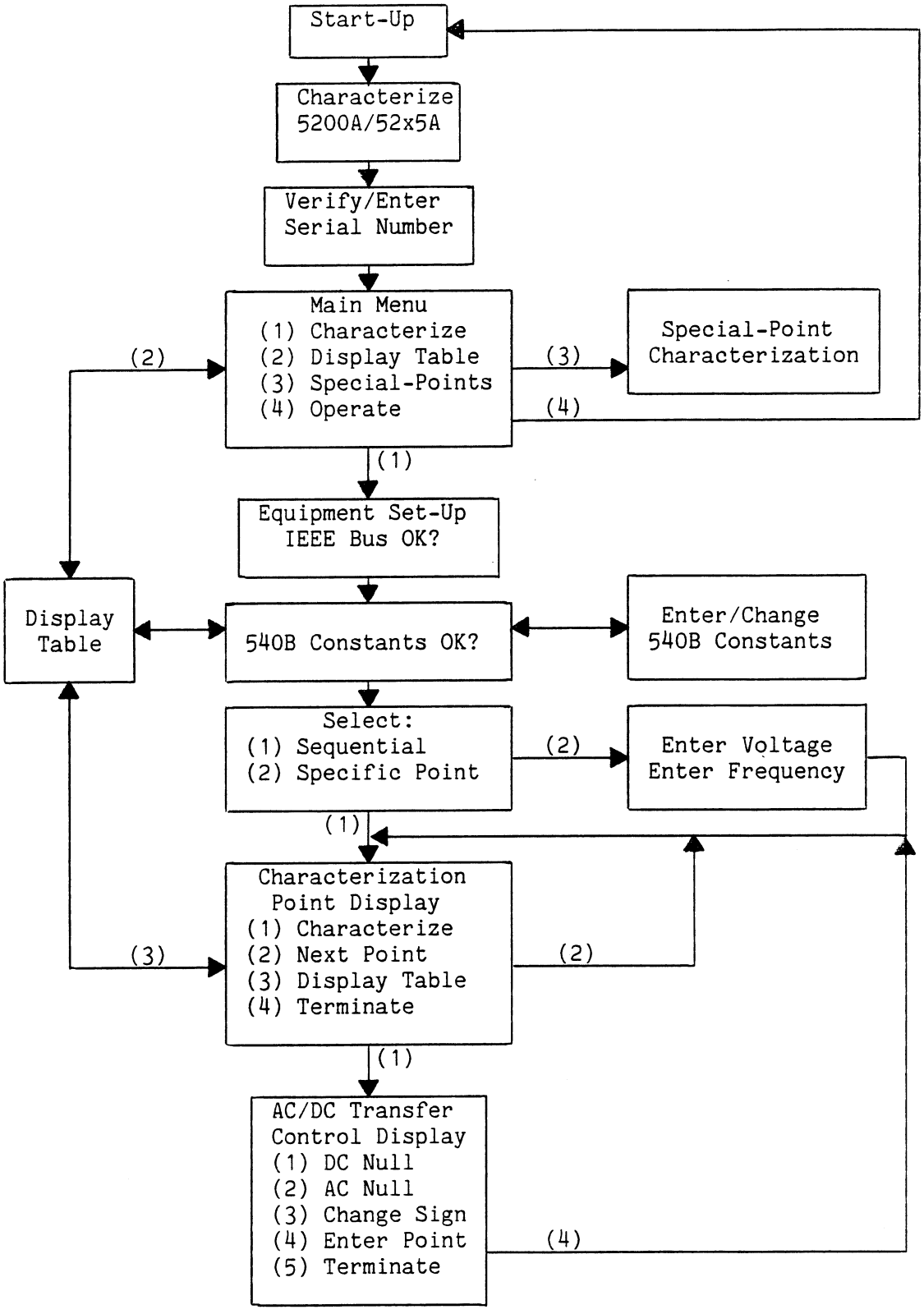


Figure 4-2. Characterization Program Flowchart

INITIAL PREPARATION

This characterization must be performed in a thermally stable environment, within the temperature range of 23°C ± 1°C. The 5200A (and 52x5A) must be allowed to thermally stabilize at least two hours, power ON, in the controlled environment.

Before connecting your instruments, verify each of the following:

1. The 5200A to be characterized has Option 5200A-05 (IEEE-488 interface) installed.

2. The 5200A has passed the following verification tests in the 5200A Instruction Manual:

4-30	Output Accuracy Test - Voltage Ranges
4-40	Frequency Output Test
4-43	Distortion Tests
4-50	Line Regulation Test

3. The 540B Thermal Transfer Standard has a valid Certification Document that includes a table of AC/DC difference constants for all the points and within the uncertainties listed in Table 4-2.

4. The 5440B or 5440A is within its calibration cycle, and has performed its analog self-tests and its internal calibration within the last 24 hours. (Refer to the 5440B or 5440A Service Manual for instructions.)

5. The 540B Thermal Transfer Standard has passed the operating checks that follow.

540B OPERATING CHECKS

The 540B Thermal Transfer Standard must be functionally tested immediately prior to beginning this characterization procedure. Failure to verify 540B operation can lead to errors in characterization accuracy. Also, be sure to verify valid calibration dates on the 540B and its accompanying Report of Calibration.

Battery Check

Set the **POWER** switch to **REFERENCE, GALV** and to **SEARCH**. The **PERCENT INPUT** meter must read above the lower limit of the **BAT** band on the meter scale in all three battery check positions.

Range Check

Set 540B **RANGE** to 10 Volts and **MODE to OFF**. Apply 10 V DC from 5440B or 5440A calibrator to the 540B **DC INPUT** terminals. Set 540B **MODE** to **DC SEARCH**. Verify approximately 100% indication on the 540B **PERCENT INPUT** meter.

Switch Contact Check

Set the 5440B or 5440A calibrator to **STANDBY**. Rotate all 540B switches and **REFERENCE ADJUST** controls vigorously at least 15 times, through all ranges and against the stops.

Null Check

Re-apply 10 V DC from the 5440B or 5440A calibrator. Set 540B **MODE** to **DC TRANSFER**. Obtain a null on the galvanometer.

Galvanometer Control Checks

Verify good contact on the galvanometer **SENSITIVITY** switch and **REFERENCE ADJUST** controls by lightly tapping on them.

After giving the 540B Thermal Element several minutes to stabilize, verify that the **FINE** REFERENCE ADJUST control gives a stable and linear response on the galvanometer.

Depress **SENSITIVITY TEST** to the 0.01% position and note a positive galvanometer deflection of approximately 7 small divisions.

Set **SENSITIVITY** to **MED** and verify that the **MEDIUM** REFERENCE ADJUST control gives a stable and linear response on the galvanometer.

Depress **SENSITIVITY TEST** to the 0.1% position and verify positive galvanometer deflection. Set **SENSITIVITY** to **HIGH**. Adjust for a null on the galvanometer.

Set the **GALV** switch to **OPEN**. Rotate the **MODE** switch several times rapidly between **DC TRANSFER** and **AC TRANSFER**.

Set the **GALV** switch to **MOMENTARY** and verify that the null repeats to within one small division. (It is very important that the 540B pass this test.)

With a good null on the galvanometer, set the **GALV** switch to **OPEN** and press **CHNG SIGN** on the 5440B or 5440A calibrator. Set the **GALV** switch to **MOMENTARY** and verify a total galvanometer deflection of less than 0.01%.

Set the **GALV** switch to **OPEN** and press **CHNG SIGN** on the 5440B or 5440A calibrator. Check that galvanometer deflection is within one small division from the original DC polarity. (Do not change the REFERENCE ADJUST controls. The null must repeat from the previous settings.)

Set the 5440B or 5540A to **STANDBY**, 540B **MODE** and **POWER** to **OFF**.

Notes

If the 540B fails any of these functional tests, appropriate servicing must be performed. Disturbing A54 components can affect calibration corrections. Any servicing of the A54 range switch contacts must be performed immediately prior to 540B calibration.

If you will be servicing your own 540B, ask your local Fluke Technical Service Center for a copy of Fluke Service

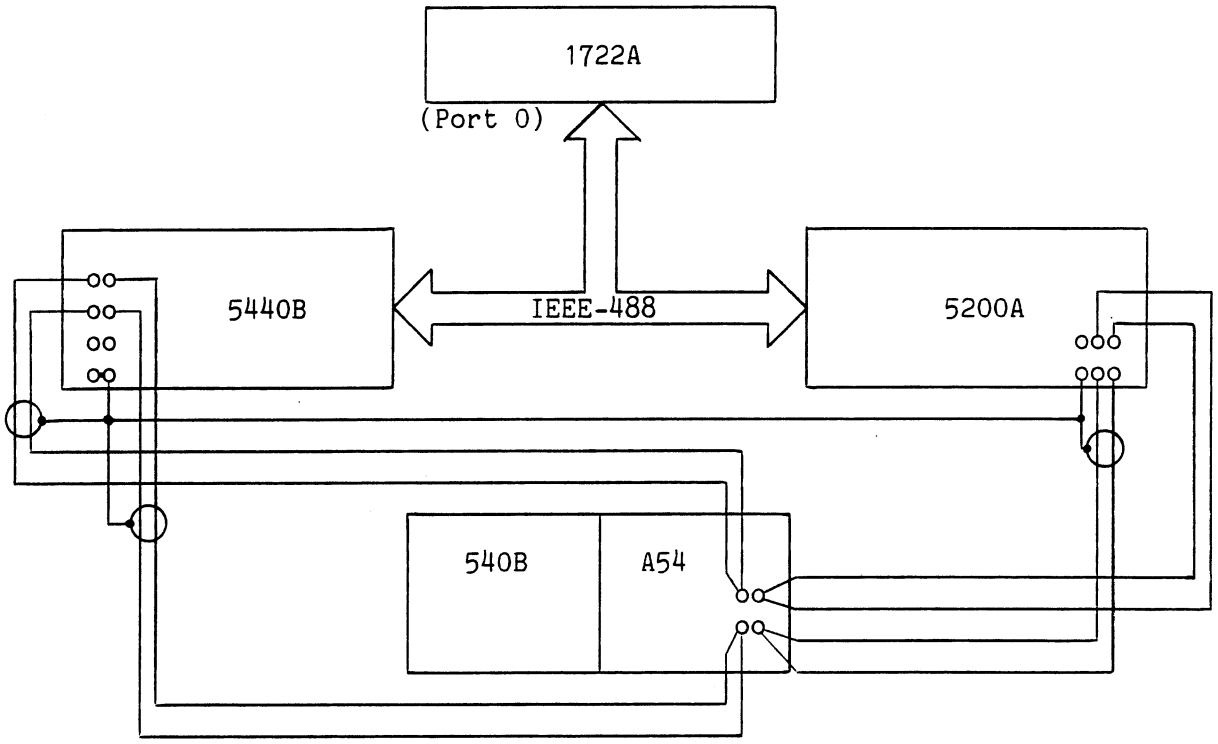
Bulletin C0064 **Fluke Instrument Switches.** It provides recommended cleaning and lubricating procedures for switches used in Fluke instruments.

EQUIPMENT SETUP

WARNING

THIS PROCEDURE INVOLVES CONNECTION AND OPERATION OF EQUIPMENT GENERATING LETHAL VOLTAGES. DO NOT ATTEMPT ANY OF THESE PROCEDURES UNLESS YOU THOROUGHLY UNDERSTAND THEM AND HAVE BEEN TRAINED IN AND ARE FOLLOWING ADEQUATE SAFETY PROCEDURES.

Connect the equipment as shown in Figure 4-3. If you are characterizing a 5205A or 5215A amplifier, refer to Figure 4-4 when the program prompts for amplifier connections.



Belden 9271
124 Twinax
w/ spade lugs

Banana Plug to
UHF Connector
Pomona #1698

Figure 4-3. Equipment Setup, 5200A

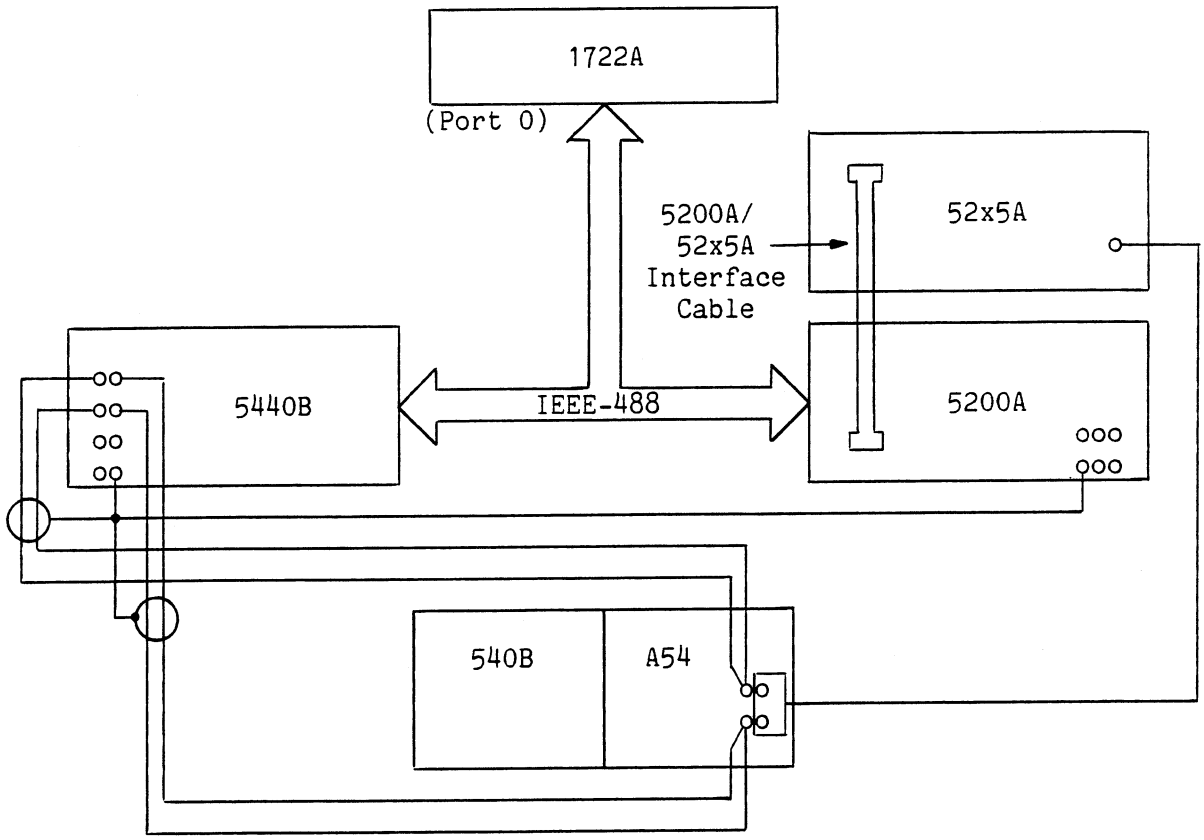


Figure 4-4. Equipment Setup, 5205A or 5215A

Set the equipment controls as follows:

1. Set the 5200A to **POWER-ON, CONTROL-REM.**

2. Set the 540B **POWER** switch **ON.** Select **MODE OFF.**

Start up the controller as follows:

1. With the controller ON, insert the 5200A-800 floppy disk, and press RESTART.

2. When the display illustrated in Figure 2-1 appears, touch-select **Characterize 5200A/52x5A.**

3. Verify or enter the serial number of the 5200A. Touch-select **YES** or **NO** to the prompt, **DO YOU HAVE A 5205A OR 5215A VOLTAGE AMP CONNECTED?** and enter the amplifier's serial number if used.

4. The Main Menu, shown in Figure 4-1, appears. Select **PERFORM 5200A CHARACTERIZATION.** This calls up a message referring you to this manual for setup instructions. Touch the display.

5. The display next instructs you to set bus addresses on the 5200A and 5440B. Set these bus addresses. Refer to the instruction manuals of each instrument for address switch locations if necessary. If you

would like to modify the program for a different address, refer to the the instruction at the end of this Section.

6. Verify correct equipment setup, and correct IEEE Bus addresses. The program will not operate (except in Demo Mode) unless the 5440B and 5200A addresses are correct and the 5200A is set to REM.

7. Touch the display. The menu shown below will appear:

   (1) ENTER OR CHANGE AC/DC
   DIFFERENCE CONSTANTS FOR 540B

   (2) DISPLAY TABLE OF AC/DC
   DIFFERENCE CONSTANTS

   (3) CONSTANTS CORRECT
   CONTINUE CHARACTERIZATION

8. Leave the equipment on and allow it to warm up for two hours before characterizing. Leave the controller running. The next instructions begin with the program at the menu shown in the last step.

ENTERING 540B CHARACTERIZATION CONSTANTS

AC/DC Difference Constants for the 540B Thermal Transfer Standard must be entered into the program before 5200A characterization can begin. These constants are listed on the 540B/A54 Certification Document from the Fluke Primary Standards Lab. Once entered, these constants are stored on disk. They need not be re-entered unless they change. Use this procedure to enter the constants:

1. Start from this menu, from the end of the equipment setup procedure:

   (1) ENTER OR CHANGE AC/DC
   DIFFERENCE CONSTANTS FOR 540B

   (2) DISPLAY TABLE OF AC/DC
   DIFFERENCE CONSTANTS

   (3) CONSTANTS CORRECT
   CONTINUE CHARACTERIZATION

   Touch select **(1)**.

2. Now sequentially enter the AC/DC difference constants from the 540B/A54 Certification Document, beginning with 0.5V at 20 kHz. These will replace whatever is already recorded on the disk. Enter all the values listed in Table 4-2 following the instructions from the prompts on the controller display.

   When an AC/DC constant is entered or changed, the display is updated to allow the entry to be verified. Press the RETURN key to store the entry and sequence to the next voltage. After you have entered the

100V constant (or 1000V when using a 5205A or 5215A), the display sequences to next frequency. The levels 300V and 1000V at 100 kHz are beyond the volt-hertz limit of a characterized 540B, so they are omitted. After you enter the 100V/100 Hz constant, program control is returned to the display, and the menu from step 1 is displayed.

Note

The AC/DC constants for 10 kHz are a function of the 20 kHz constants. They are calculated by the program after all other constants are entered. Be sure to enter all the AC/DC constants the program requests, even if the values are zero.

3. To see the table of 540B constants as stored in the program, select **(2) DISPLAY TABLE OF AC/DC DIFFERENCE CONSTANTS** from the menu. This table is automatically displayed after the last data entry. Check the table to verify all constants and polarities before continuing.

Note

The program does not check 540B status or the validity of characterization values entered. Carefully review the table of 540B AC/DC constants at the end of the sequence. Verify any values that deviate from adjacent values or are not within specifications.

4. From the menu, select **(3) CONSTANTS CORRECT CONTINUE CHARACTERIZATION.** This calls up the following menu:

(1) PROCEED WITH COMPLETE 5200A CHARACTERIZATION IN SEQUENCE (0.5 TO 100V, 50 HZ TO 100 HZ)

(2) SELECT SPECIFIC VOLTAGE AND FREQUENCY POINT (MUST BE CHARACTERIZATION POINT)

5. From this point you can choose **(1)** for sequential characterization of all standard characterization points, or **(2)** for specific-point characterization. This is useful for leaving the rest of the points the way they are currently, while characterized only a certain point. Later in the instructions, at **Sequential Characterization**, and **Specific-Point Characterization**, you will begin from this branching point.

THE CHARACTERIZATION PROCEDURE

This section includes step-by-step explanations of the instructions and choices presented by the characterization program display. To best understand the characterization procedure, we suggest you use Demo Mode to make a dry run through the program before attempting to characterize your 5200A. (See **Getting Familiar With the Characterization Program** earlier in this section.) Also, review the 540B Operating Instructions in the 540B

Instruction Manual before operating the 540B. **The 540B galvanometer indicator can easily be damaged by improper use.**

The instructions here begin with Sequential Characterization, then explain how to do Specific-Point Characterization (characterization of standard points, but selected out of sequence, individually). Finally, there are instructions for setting up your own custom points. This is called Special-Point Characterization.

You should have have all equipment running now, have all 540B constants entered into the program, and be at the menu that reads:

(1) PROCEED WITH COMPLETE 5200A CHARACTERIZATION IN SEQUENCE (0.5 TO 100V, 50 HZ TO 100 HZ)

(2) SELECT SPECIFIC VOLTAGE AND FREQUENCY POINT (MUST BE CHARACTERIZATION POINT)

Sequential Characterization

1. From the menu, select:

   (1) PROCEED WITH COMPLETE 5200A CHARACTERIZATION IN SEQUENCE (0.5 TO 100V, 50 HZ TO 100 HZ)

2. The program is now at the Characterization-Point Display, shown in Figure 4-6. The voltage and frequency of the characterization point are shown on the display. From here you can skip to the next point, display the whole table and return to this point, terminate the procedure, or characterize this point. To characterize this point, touch select **CHARACTERIZE.**

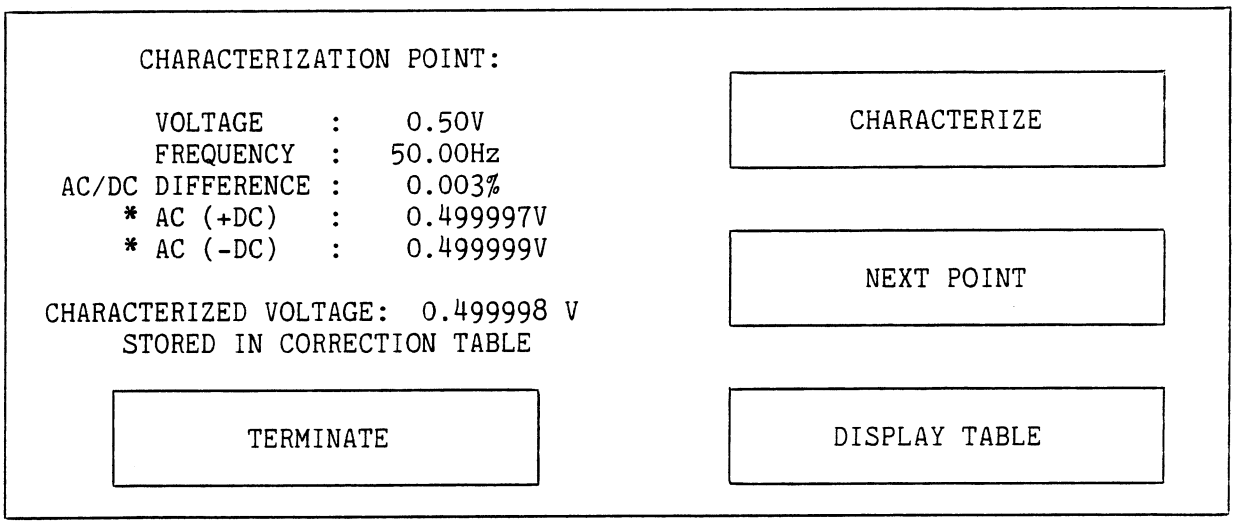


Figure 4-5. Characterization Point Display
* Displayed only after derived

3. Touching **CHARACTERIZE** calls up instructions for setting controls on the 540B. Set these 540B controls as shown:

MODE:	DC TRANSFER
RANGE:	.5
SENSITIVITY:	LOW
GALV:	OPEN

Note

For the first reading, leave the 540B **MODE set to SEARCH.** Verify that the **PERCENT INPUT** meter reading is approximately 100% before setting it to transfer.

4. Touch the display. A 30-minute countdown timer is enabled for 540B Thermal Element stabilization. The **PERCENT INPUT** indicator on the 540B should be at 100% as soon as the timer is enabled. If the indicator is not at 100%, make sure 540B power is on and that the 5200A and 5440B are supplying the correct voltages.

5. After the 30-minute timer expires (or is interrupted by touching the display), the following instructions appear on the display:

WAIT 10 SECONDS THEN ENGAGE "GALV" SWTCH
NULL GALVANOMETER USING "REFERENCE
ADJUST" CONTROLS (COURSE, MEDIUM, FINE)
AND "SENSITIVITY" CONTROL
(LOW, MED, AND HIGH) ON 540B

To accomplish this, first make sure the **SENSITIVITY** switch is set to **LOW.** Set the **GALV** switch to **MOMENTARY** while quickly adjusting the **COARSE**, and then **MEDIUM** controls to null the **GALVANOMETER** needle. Set

the **GALV** switch to **LOCK**. Set **SENSITIVITY** to **MED**. Adjust the **MEDIUM** control and then the **FINE** control to again null the **GALVANOMETER** indicator. Set **SENSITIVITY** to **HIGH**, and again null the **GALVANOMETER** as before with the **FINE** control (and the **MEDIUM** control if necessary).

You do not have to use this exact process for nulling the GALVANOMETER. How you do it is up to you. Just be aware that the GALVANOMETER needle is a delicate mechanism, so be careful to keep the needle within range. Be sure you are familiar with 540B operating instructions in Section II of the 540B Instruction Manual.

After nulling the GALVANOMETER, touch the display. You have just completed **DC NULL**, mentioned in the next steps.

6. New instructions appear briefly that say:

   SET "GALV" SWITCH TO "OPEN"

   Do this. The AC/DC Transfer Control Display as shown in Figure 4-6 is then called up.

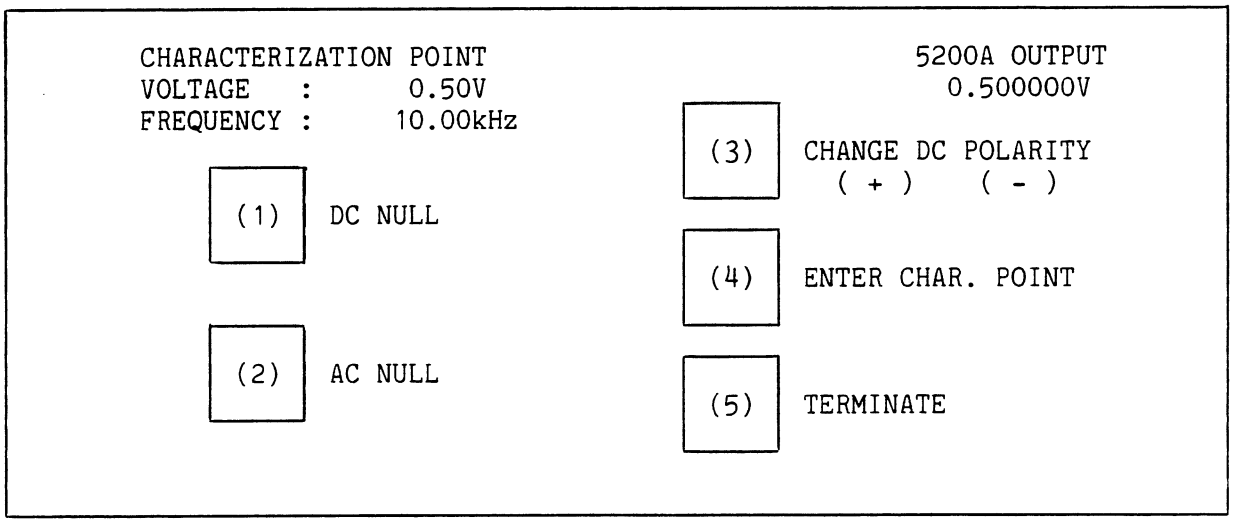


Figure 4-6. AC/DC Transfer Control Display

7. The AC/DC Transfer Control Display provides the main control for the AC and DC nulling of the 540B galvanometer. There are five options on this display. The object at this point is to do option **(2) AC NULL** for both +DC and -DC polarities. AC NULL is similar to DC NULL done in step 4, above, except that the touch sense controls on the controller display are used to null the galvanometer instead of the reference adjust controls on the 540B.

   After each **AC NULL** operation, repeat the **DC NULL** process. When both polarities are done for **AC NULL**, store the characterization constant in the program by touch selecting **(4) ENTER CHAR. POINT.**

   Each of the five menu choices is described briefly below:

(1) **DC NULL**

Re-energizes the 5440B DC source and prompts you to set the 540B MODE to **DC TRANSFER** and to the appropriate range. The process described in Steps 4 and 5 is DC NULL. Repeat it after each **AC NULL**.

(2) **AC NULL**

Prompts you to set the 540B MODE to **AC TRANSFER** and to the appropriate range. You are then prompted close the **GALV** switch. (Set it to **LOCK**).

The next touch results in the AC Null Control Display of Figure 4-7. This display provides touch-sense 5200A amplitude control. **HIGH**, **MED**ium, and **LOW** amplitude editing keys control the three least significant digits of 5200A output. Characterization-point nominal voltage and frequency is displayed, and actual 5200A output is displayed in high-intensity.

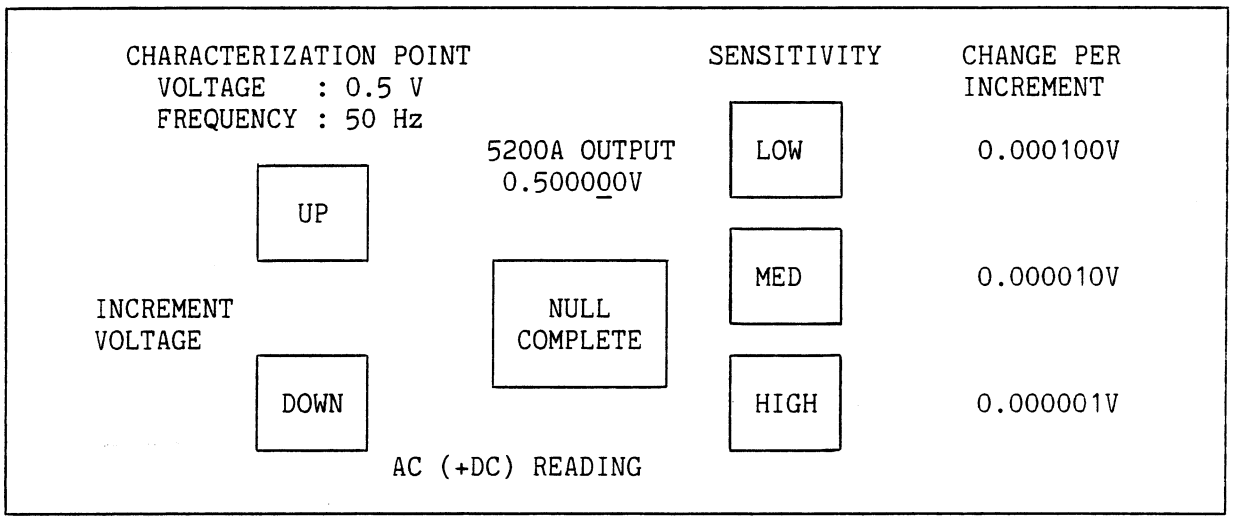


Figure 4-7. AC Null Control Display

Use these controls to null the **GALVANOMETER** needle in a similar manner as Steps 4 and 5 above.

Once **AC NULL** is complete, touch-select **NULL COMPLETE** to return control to the AC/DC Transfer Control Display of Figure 4-6, after a momentary prompt to open the **GALV** switch. **NULL COMPLETE** also stores the 5200A output voltage as a characterization constant. If **AC NULL** is repeated for the same point, this constant is updated.

(3) **CHANGE DC POLARITY**

Sends a change-sign command to the 5440B DC source. High-intensity identifies the current polarity. After doing **AC NULL**, touch select **(3) CHANGE DC POLARITY** and repeat **AC NULL**. If you do not do **AC NULL** for both DC polarities, you will be prompted to do so when you

touch select **(4) ENTER CHAR. POINT.**

(4) ENTER CHAR. POINT

Enters AC characterized voltage into memory. This selection prompts you if either the AC(+DC) voltage or the AC(-DC) voltage was not derived, or if the characterized voltage as entered is not within 5200A Basic Instrument Uncertainty Specifications.

This selection returns control to the updated Characterization-Point Display (Figure 4-5), which offers you a choice of repeating the last point or proceeding to the next point.

Note

If the last frequency was 100 kHz, then the next characterization point will require a change in voltage range on the 540B. Change the 540B range at the same time as you touch select to go to the next voltage, to minimize voltage interruption of the thermal element.

(5) TERMINATE

Returns control to Characterization Point Display. A second **TERMINATE** is required to reset the instruments and to exit the program.

Notes

1. Any characterized point null can repeated as many times as necessary, until **ENTER CHAR. POINT** is pressed. If a constant is inadvertently stored, it can be corrected by selecting the specific voltage / frequency point and repeating characterization.

2. Characterized values are the average of the positive AC(+DC) and negative AC(-DC) DC null constants, as well as a function of the AC/DC difference constants. A characterized point will not be accepted for entry until both positive and negative null constants are recorded.

3. When **TERMINATE** is touch selected from the AC/DC Transfer Control Display (Figure 4-6), control returns to the Characterization-Point Display (Figure 4-5). When **TERMINATE** is then touch selected from this display, an instrument reset occurs over the IEEE-488 Bus, and control is returned to the Main Menu. Be sure the 540B **GALVO** switch is open before touch selecting **TERMINATE** and resetting the instruments.

Specific-Point Characterization

Select this option to characterize a subset of the characterization points or to verify a specific point. Also if a non-recoverable error occurs during sequential characterization, you can resume the characterization sequence by entering the last point measured. Using this option, the program automatically resumes sequencing when told to do so. Remember to always observe a 30-minute stabilization period for the 540B Thermal Element whenever power is interrupted.

Specific-Point Characterization can be entered after pressing **TERMINATE** or when restarting the program. To enter this mode, do the following:

1. Select **PERFORM 5200A CHARACTERIZATION** from the Main Menu.

2. After equipment setup and IEEE-488 Address prompts, select **(2) SPECIFIC VOLTAGE AND FREQUENCY POINT.**

3. Enter a voltage and frequency from the points on Table 3-1 when prompted to do so by the display. This calls up the Characterization Point Display (Figure 4-5).

   If either the voltage or frequency entered is not one of the points on Table 3-1, a prompt occurs and both must be re-entered.

4. Characterize the point exactly as in steps 2 through 7 of **Sequential Characterization.**

   After the first point has been characterized and **NEXT POINT** has been selected, you have three options:

   (1) SELECT ANOTHER SPECIFIC VOLTAGE AND FREQUENCY POINT

   (2) PROCEED WITH SEQUENTIAL CHAR. STARTING FROM LAST SELECTED SPECIFIC VOLTAGE/FREQ. POINT

   (3) RETURN TO MENU

   If **(2)** is chosen, the characterization sequence is entered, and there is no further chance to enter a specific point. Choose **(1)** to verify or characterize additional specific points.

Characterization Table Notes

The Table of Characterization Constants, as displayed in the program, is shown in Table 4-3. The table is presented when requested from the Characterization Point Display (Figure 4-5), or from the Main Calibration Menu (Figure 4-1). Before you begin characterization, the table will contain all nominal

values. Then, as each characterization point is derived, its value is automatically entered in the data file. If the point is re-derived, the characterization table constant is updated.

TABLE OF CHARACTERIZATION CONSTANTS STORED IN 5200.DAT

FREQ (Hz)	V O L T A G E 0.5 V	1.0 V	3.0 V	10 V	30 V	100 V	300 V	1000 V
50	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
100	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
200	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
1 k	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
2 k	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
10 k	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
20 k	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
50 k	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000	300.000	1000.000
100k	0.500000	1.000000	3.00000	10.00000	30.0000	100.0000		

TOUCH SCREEN TO CONTINUE

Table 4-3. Display Table of Characterization Constants

Ten points are not actually measured. Their values are interpolated from adjacent points at the end of the characterization sequence. These values remain nominal until the characterization sequence is completed. The program then interpolates adjacent values and fills them in. Table 3-1 identifies these values with an asterisk (*).

The completed table will contain all non-nominal values, except in the unlikely event that a characterization constant as derived exactly equals the nominal value.

Note

The program does not check 540B status or the validity of characterization values entered. Carefully review the table of characterization data at the end of the sequence. Verify any values that deviate from adjacent values or are not within specifications.

For example, if the corrected value of 1V at 1 kHz is 1.000023V and the corrected value of 1V at 10 kHz is 1.000077V, then a value of 1.000109V for the 1V at 2 kHz range deviates from the range linearity specification and should be verified. A more reasonable value would be 1.000035V. All voltage ranges should exhibit linearity across all frequency ranges except for a non-linear change in amplitude when changing from the 1-kHz range to the 10-kHz range in the 10V-range.

Printing Out the Table

To make a printed copy of the 5200A table of corrected voltages, connect a serial character printer through an RS-232 printer cable to Serial Port 1 (KB1:) of the controller. If you need to configure the controller serial port for data rate, parity, etc., consult the controller manual.

From the Main Calibration Menu (Figure 4-1), touch select:

DISPLAY OR PRINT
TABLE OF CHARACTERIZATION
CONSTANTS

The display will respond with these choices:

(1) DISPLAY TABLE OF
CHARACTERIZATION CONSTANTS

(2) PRINT CHARACTERIZATION
TABLE AT OUTPUT PORT KB1

Touch select **(1)** to get the display in Figure 4-3 above. Touch select **(2)** to get a printed copy similar to Figure 3-1.

If your printer is not producing results, you probably have a mis-match of serial port configuration. Consult your controller manual, of call Fluke Customer Service for assistance.

SPECIAL-POINT CHARACTERIZATION

This option is selected from the Main Menu and actually calls a separate program. Up to fifty non-standard special voltage / frequency points can be entered, changed, edited, or characterized using this option. The data stored can be displayed in a table, and the whole table can be cleared all at once, if desired.

Notes

System limits:

Voltage:	.1 mV to 1199.999V
Frequency:	10 Hz to 1.1999 MHz
Uncertainty:	1.0%.
Characterized Voltage:	10% of Voltage;

For example, minimum/maximum limits at 10V are 9.0V to 11.0V.

540B accuracy degrades rapidly below 0.5V. To characterize voltages below 0.3V, use another method (such as a ratio transformer).

Set up and characterize a special point as follows:

1. Enter the special-point characterization program from the Main Menu

(Figure 4-1) by touch selecting:

ENTER SPECIAL POINT SECTION DATA ENTRY AND CHARACTERIZATION FOR USER-DEFINED POINTS

2. The same setup prompts occur as in sequential characterization, so use the same setup procedure. After setup, the following menu is displayed:

   (1) ENTER OR EDIT SPECIAL CHARACTERIZATION POINTS

   (2) ZERO ALL SPECIAL POINTS

   (3) DISPLAY TABLE OF SPECIAL POINTS

3. Touch select **(3)** to look at the table of special points already stored. To clear the table completely, touch select **(2)**.

   Touch select **(1)** to set up and characterize a special point.

4. The Special-Point Characterization Menu shown in Figure 4-8 is now displayed with the voltage and frequency for Special Point #1. These values are zero if you have not already programmed Special Point #1.

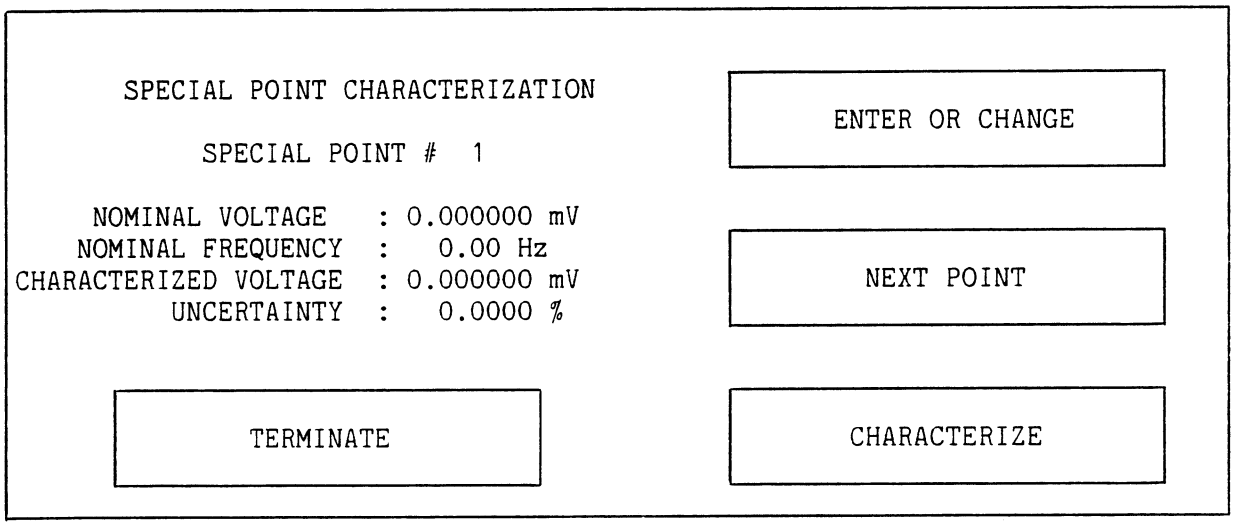


Figure 4-8. Special-Point Characterization Menu

If there are special points programmed, you can step to the one you want to recharacterize or change the value of by touch selecting **NEXT POINT**. Selecting **TERMINATE** brings you to this menu:

(1) DISPLAY TABLE OF
SPECIAL POINTS

(2) RETURN TO SEQUENTIAL
CHARACTERIZATION SECTION

(3) RETURN TO SPECIAL
POINT MENU

Touch select (3) to return to the menu in Step 2 above. Then select (1) again to return to the Special-Point Characterization Menu of Figure 4-8.

Touch select **CHARACTERIZE**. Then touch select **RETURN** to again return to the Special-Point Characterization Menu of Figure 4-8.

Touch select **ENTER OR CHANGE**.

5. The display prompts you with:

NEW VOLTAGE (in Volts).....?_

Use the keyboard to enter it and press the **RETURN** key.

You are then prompted with:

NEW FREQUENCY (in Hertz).....?_

Use the keyboard to enter it and press the **RETURN** key.

6. Now you are prompted with:

NEW CHAR. VOLTAGE (in Volts)..?_

This option allows you to directly enter characterization constants developed by a separate procedure into 5200A-800 software. To continue with this procedure, simply enter the nominal value again.

7. Next you are prompted with:

NEW UNCERTAINTY (in Percent)..?_

This also is for characterization constants you have developed with a separate procedure. The only purpose of this uncertainty value is for display during automated 5200A-800 operation. If you are going to characterize the point with this procedure, enter an arbitrary uncertainty such as .001%.

Notes

UNCERTAINTY as entered above is used to display the uncertainty of a special point while 5200-800 software is in the Operate Mode. It is not used in the calculation of the characterized voltage. If you are relying on a characterized 540B for accuracy

enhancement, the AC/DC Difference correction factors must be taken into account, and the characterized voltage must be calculated and entered manually. This software does not automatically compensate characterized voltages even though a 540B AC/DC difference table was entered.

The characterized accuracy of the 540B, as provided in the test report accompanying a Fluke-characterized 540B, is valid only at the points listed in the table. Generally, the AC/DC Difference at 10 kHz is 25% of the difference at 20 kHz, and the difference below 10 kHz is assumed zero. These assumptions are valid, and the errors associated with them have been taken into account for the enhanced accuracy specifications. However, for special-point characterization, it is your responsibility to determine the correct AC/DC Difference for the point in question.

If special points are above 10 kHz and are not in the set of standard 540B characterized points, then a special 540B characterization should be performed at the point in question. Special 540B Characterization Points are available from the Fluke Standards Lab through any Fluke Technical Service Center.

8. This returns you to the Special-Point Characterization Menu (Figure 4-8). Now however your special-point value is displayed. Touch select **CHARACTERIZE** to call up the Special-Point Characterization Display shown in Figure 4-9.

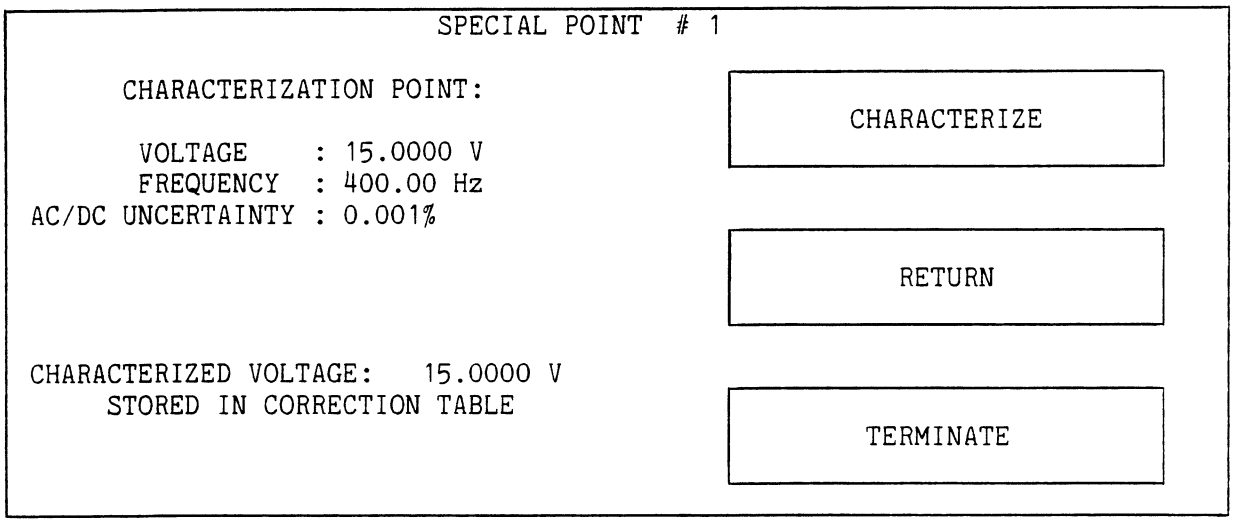


Figure 4-9. Special-Point Characterization Display

Touch select **CHARACTERIZE** again.

9. The controller responds with instructions for setting up the 540B, as in step 3 of **Sequential Characterization** above. The procedure is now

identical to steps 3 through 7 of **Sequential Characterization** except for one difference. Since you must set the 540B to a range that is equal to or greater than the value of the characterization-point voltage, the **PERCENT INPUT** indicator on the 540B may not be at 100%. This is normal in the case of a characterization point voltage that is not equal to a 540B range setting.

10. When you have characterized and entered all the special points, touch select **TERMINATE**. This records any new or changed values and displays this menu:

    (1) DISPLAY TABLE OF SPECIAL POINTS

    (2) RETURN TO SEQUENTIAL CHARACTERIZATION SECTION

    (3) RETURN TO SPECIAL POINT MENU

11. From this menu you can branch to other menus in the characterization program.

CHANGING SOFTWARE IEEE-488 BUS ADDRESSING

You can easily modify this calibration software to use different IEEE-488 Bus addressing for the 5440B or 5440A DC Calibrator and the 5200A AC Calibrator being characterized. Addressing is taken from variables set early in the **CALA** program.

For a 1722A, you need to modify the file **CALA_.BAL**. For a 1720A, you need to modify the file **CALA.BAL**. The address for the 5440B or 5440A is stored in variable **A1**. The address for the 5200A is stored in variable **A2**. These are part of a variable definition list located in line 2200 of each file. Be sure that you save the modifications onto disk and restart the software.

Following are step-by-step instructions to change the bus addressing. Where they are different, 1720A instructions are shown in [brackets].

1. Insert the 5200A-800 disk and press **RESTART**.

2. When the Start-Up screen appears, type **<CTRL>C**

3. Type **BASIC** [skip this step for 1720A].

4. Type **OLD "MF0:CALA_.BAL"** [**OLD "MF0:CALA.BAL"**]

5. Type **EDIT 2200**

6. Look for the variables **A1** and **A2**.

   Use the arrow keys to move the cursor to the numbers following = for A1 and A2. Press **DEL CHAR** and replace the number with the Bus

Address that you would like to use. A1 is the 5440B or 5440A address. A2 is the 5200A address.

7. Type **<CTRL>C**

8. Remove the write-protect tab from the side of the disk cover and replace the disk in the disk drive. Then type **SAVEL "CALA_"**. [For 1720A, type **SAVEL "CALA"**]. Replace the write-protect tab on the disk.