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# Model 2182 and 2182A Nanovoltmeter

## Service Manual

2182A-902-01 Rev. B July 2022

2182A-902-01B

KEITHLEY
A Tektronix Company

# Model 2182 and 2182A

# Nanovoltmeter

# Service Manual

Cleveland, Ohio, U.S.A.



These are the original instructions in English.



Document number: 2182A-902-01 Rev. B July 2022

KEITHLEY
A Tektronix Company

# Safety precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

**Responsible body** is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

**Operators** use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

**Maintenance personnel** perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

**Service personnel** are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories. Maximum signal levels are defined in the specifications and operating information and shown on the instrument panels, test fixture panels, and switching cards.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as protective earth (safety ground) connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a  screw is present, connect it to protective earth (safety ground) using the wire recommended in the user documentation.

The  symbol on an instrument means caution, risk of hazard. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means warning, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains hazards that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

The **CAUTION** heading with the  symbol in the user documentation explains hazards that could result in moderate or minor injury or damage the instrument. Always read the associated information very carefully before performing the indicated procedure. Damage to the instrument may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits — including the power transformer, test leads, and input jacks — must be purchased from Keithley. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F); and pollution degree 1 or 2.

To clean an instrument, use a cloth dampened with deionized water or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Safety precaution revision as of June 2018.

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Section 1

# Introduction

## In this section:

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# Welcome

The two-channel Model 2182A Nanovoltmeter is optimized for making stable, low-noise voltage measurements and for characterizing low resistance materials and devices reliably and repeatably.

Features of the 2182A Nanovoltmeter include:

- 1 nV sensitivity to provide accurate ultra-low voltage measurements.
- Typically just 15 nV peak-to-peak noise at 1 s response time, with 40 nV to 50 nV peak-to-peak noise at 60 ms, which ensures low noise levels over a wide range of useful response times.
- Dual channels support measuring voltage, temperature, or the ratio of an unknown resistance to a reference resistor.
- Measurement cycle is synchronized to the power line ac cycle to minimize variations due to readings that begin at different phases of the line cycle. The result is exceptionally high immunity to line interference with little or no shielding and filtering required.
- Built-in thermocouple linearization and cold junction compensation to simplify making accurate temperature measurements.
- Internal polarity reversal measurement technique to eliminate thermal error sources.
- Optimized for use with the Keithley Model 6220 and 6221 current sources, which allows both instruments to be operated like a single instrument when making differential conductance, pulsed, and resistance measurements.
- Delta mode current reversal measurement technique when combined with the 6220 or 6221 to enable resistance measurements down to 10 nΩ.

# Introduction to this manual

The Model 2182 and 2182A Nanovoltmeter Service Manual provides verification information and maintenance information.

This service manual supports the Models 2182 and Models 2182A. References to the 2182A also apply to the Model 2182 unless otherwise indicated.

# Extended warranty

Additional years of warranty coverage are available on many products. These valuable contracts protect you from unbudgeted service expenses and provide additional years of protection at a fraction of the price of a repair. Extended warranties are available on new and existing products. Contact your local Keithley Instruments office, sales partner, or distributor for details.

# Contact information

If you have any questions after you review the information in this documentation, please contact your local Keithley Instruments office, sales partner, or distributor. You can also call the Tektronix corporate headquarters (toll-free inside the U.S. and Canada only) at 1-800-833-9200. For worldwide contact numbers, visit tek.com/en/contact-tek.

# General ratings

The general ratings of the 2182A are listed in the following table.

| **Category** | **Specification** |
|---|---|
| Supply voltage range | 100 V setting: 90 V to 110 V<br>120 V setting: 108 V to 132 V<br>220 V setting: 198 V to 242 V<br>240 V setting: 216 V to 264 V |
| Supply voltage frequency | 50 Hz, 60 Hz, or 400 Hz (automatically sensed at power on) |
| Input and output connections | See Rear-panel overview. |
| Environmental conditions | For indoor use only<br>**Altitude:** Maximum 2000 meters (6562 feet) above sea level<br>**Operating:** 0 °C to 50 °C, ≤80 percent relative humidity at 35 °C<br>**Storage:** −40 °C to 70 °C<br>**Pollution degree:** 2 |

Section 2

# Performance verification

## In this section:


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# Introduction

Use the procedures in this section to verify that 2182A accuracy is within the limits stated in the instrument's one-year accuracy specifications. You can perform these verification procedures:

- When you first receive the instrument to make sure that it was not damaged during shipment.
- To verify that the instrument meets factory specifications.
- To determine if calibration is required.
- Following calibration to make sure it was performed properly.

**WARNING**

**The information in this section is intended for qualified service personnel only, as described by the types of product users in the Safety precautions pages, provided at the beginning of this document. Do not attempt these procedures unless you are qualified to do so.**

**Some of these procedures may expose you to hazardous voltages, that if contacted, could cause personal injury or death. Use appropriate safety precautions when working with hazardous voltages.**

NOTE

If the instrument is still under warranty and its performance is outside specified limits, contact your Keithley representative or the factory to determine the correct course of action.

# Verification test requirements

Be sure that you perform the verification tests:

- Under the proper environmental conditions.
- After the specified warmup period.
- Using the correct line voltage.
- Using the proper test equipment.
- Using the specified output signals and reading limits.

# Environmental conditions

Conduct your performance verification procedures in a test environment with:

- An ambient temperature of 18°C to 28°C (65°F to 82°F).
- A relative humidity of less than 70% unless otherwise noted.

# Warmup period

Allow the 2182A to warm up for at least 2½ hours before conducting the verification procedures. If the instrument has been subjected to temperature extremes (those outside the ranges stated in Environmental conditions (on page 2-2)), allow additional time for the instrument's internal temperature to stabilize. Typically, allow one extra hour to stabilize an instrument that is 10°C (18°F) outside the specified temperature range.

Also allow the test equipment to warm up for the minimum time specified by the manufacturer.

# Line power

The 2182A requires a nominal line voltage of 100 V, 120 V, 220 V, or 240 V and a line frequency of 50 Hz to 60 Hz or 400 Hz. Verification tests must be performed with the correct line voltage. If necessary, change the line voltage setting, as described in Line voltage selection (on page 4-3).

# Recommended verification equipment

The following table summarizes recommended verification equipment. You can use alternate equipment if that equipment has specifications at least four times better than corresponding 2182A specifications. Test equipment accuracy adds to the uncertainty of each measurement.

**Recommended verification equipment**

| Description | Manufacturer/Model | Specifications* |
|---|---|---|
| DC Calibrator | Fluke 5700A | 100 mV: ±14 ppm<br>1 V: ±7 ppm<br>10 V: ±5 ppm<br>100 V: ±7 ppm |
| Low Thermal Divider | | 100:1 division: ±5 ppm |
| Thermocouple Calibrator | Omega CL523 | Type J: −200°C to 700°C<br>Type K, N : −200°C to 1300°C<br>Type N: −200°C to 400°C<br>Type E: −200°C to 1000°C<br>Type R, S: 0°C to 1700°C<br>Type B: 400°C to 1700°C |
| Digital Multimeter | Keithley 2000 | 1 V: ±32 ppm |
| Low Thermal Cable | Keithley 2107 | |
| Low Thermal Cable | Keithley 1506 | |
| BNC-to-dual banana jack cable | | |

*DC calibrator specifications shown include total 90-day 23°C ±5°C uncertainty at specified output. Model 262 error includes a short-term transfer error of ±5ppm at 23°C ±1°C. Digital multimeter specification is 90-day, 23°C ±5°C full-range value.

# Verification reading limits

The verification limits stated in this section have been calculated using only the 2182A one-year accuracy specifications. **They do not include test equipment uncertainty.** If a particular measurement falls outside the allowable range, recalculate new limits based on 2182A specifications and corresponding test equipment specifications.

## Example limits calculation

As an example of how verification limits are calculated, assume you are testing the 10 V dc voltage range using a 10 V input value. Using the 2182A 10 V range one-year accuracy specification of ±(25 ppm of reading + 2 ppm of range), the calculated reading limits are:

Reading limits = 10 V ± [(10 V × 25 ppm) + (10 V × 2 ppm)

Reading limits = 10 V ± (250 µV + 20 µV)

Reading limits = 10 V ± 270 µV

Reading limits = 9.99973 V to 10.00027 V

# Restoring factory defaults

Before performing the verification procedures, restore the instrument to its factory front panel default conditions.

***To restore the default conditions:***

1. Press **SETUP RESTR**. The instrument displays the following prompt:

   RESTORE: FACT
2. Using either RANGE key, select **FACT**.
3. Restore the factory default conditions by pressing the **ENTER** key.

NOTE

You can use either RANGE key to toggle between FACT and USER setups. Be sure you use factory defaults for the verification procedures.

# Autocalibration (ACAL)

Before verifying accuracy, perform an autocalibration to ensure the instrument meets its specifications.

Autocalibration takes several minutes to complete.

## CAUTION

**Do not perform full autocalibration with a test voltage connected to the input jack. Test voltage connected to the input jack may cause instrument damage.**

***To perform autocalibration:***

1. Disconnect the test cable from the input jack.
2. Turn on instrument power.
3. Allow the instrument to warm up for at least 2½ hours.
4. Press the **ACAL** key. The instrument displays the following prompt:

   ACAL: LOW-LVL
5. Use either RANGE key to select **FULL**, then press the **ENTER** key. The instrument prompts you to disconnect the input cable:

   REMOVE INPUT
6. Make sure the input cable is disconnected, then press the **ENTER** key. The instrument runs autocalibration. While autocalibration is running, the instrument displays the following message:

   ACAL

## NOTE

LOW-LVL ACAL performs a new gain calibration for the 10 mV range only based on 10 V calibration. FULL ACAL performs both a 100 V and 10 mV gain calibration based on the last 10 V calibration.

# Performing the verification test procedures

The verification test procedures include:

- DC voltage measurement accuracy
- Temperature measurement accuracy
- Analog output accuracy

If the 2182A is not within specifications and is not under warranty, see Calibration (on page 3-1) for information on calibrating the instrument.

## Test considerations

When performing the verification procedures:

- Be sure to restore factory front panel defaults, and perform a full auto-calibration (ACAL), as outlined above.
- Make sure that the 2182A and test equipment are properly warmed up, and that the test equipment is connected to the appropriate 2182A jacks.
- Be sure the test equipment is set up for the proper function and range.
- Allow the test signal to settle before making a measurement.
- Use only copper-to-copper connections to minimize thermal EMFs.
- Make sure that all connections are clean and free of oxidation to avoid thermal EMFs that could affect measurement accuracy. Clean oxidation from connector terminals with DeoxIT cleaning solution.
- Keep test connections and all equipment away from drafts to avoid thermal drift.
- Do not connect test equipment to the 2182A through a scanner, multiplexer, or other switching equipment.
- Do not use autoranging. Autorange hysteresis may cause the 2182A to be on an incorrect range.

**WARNING**

**The maximum voltage between any terminals to chassis ground is 350 $V_{PEAK}$. Exceeding this value may cause a breakdown in insulation, creating a shock hazard that could result in personal injury or death.**

**CAUTION**

**The maximum voltage between CHANNEL 1 HI and LO is 120 V. The maximum voltage between CHANNEL 2 HI and LO is 12 V. Exceeding these voltage values may result in instrument damage.**

## Voltage measurement accuracy

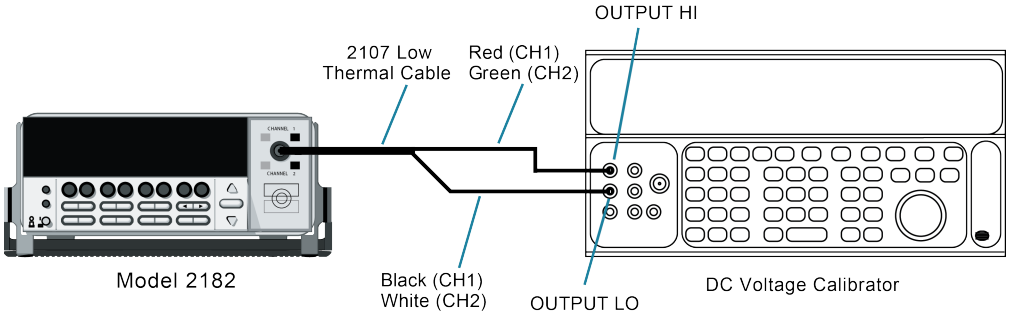
Follow the steps below to verify that 2182A voltage measurement accuracy is within specified limits. The test involves applying precise dc voltages and then verifying that the 2182A voltage readings are within required limits.

## 100 mV to 100 V range accuracy

***To verify the voltage measurement accuracy for the 100 mV to 100 V ranges:***

1. With the power off, connect the DC calibrator to CHANNEL 1 of the 2182A input jack, as shown in the following figure.

**Figure 1: Connections for 100 mV to 100 V range accuracy**




Connections for the Model 2107 Low Thermal Input Cable are summarized in the following table.

| **Input cable color codes** | |
|---|---|
| **Input connection** | **Wire color** |
| Channel 1 HI | Red |
| Channel 1 LO | Black |
| Channel 2 HI | Green |
| Channel 2 LO | White |

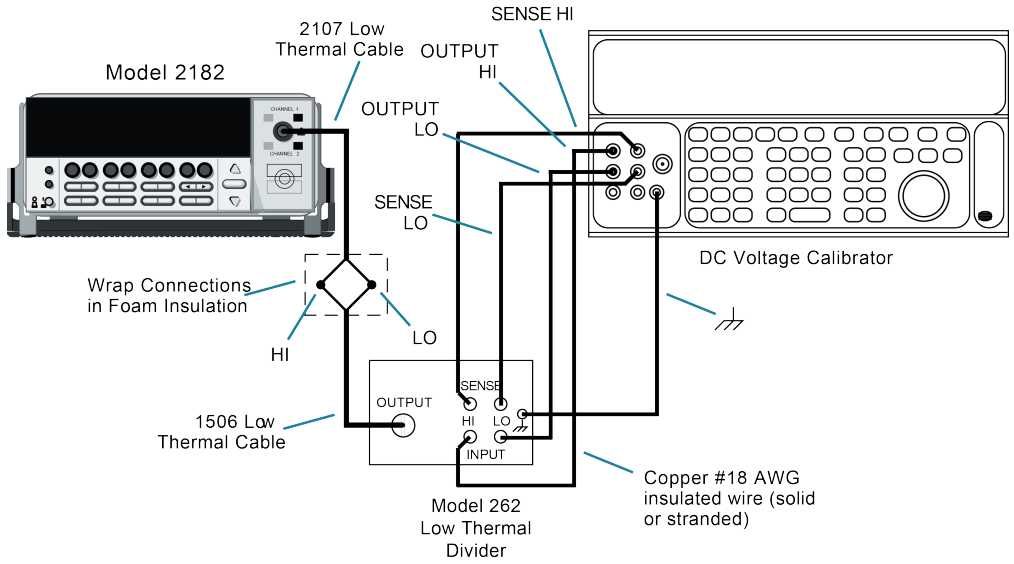
2. Turn on the power and allow a 2½ hour warmup period.
3. Restore factory defaults, and do a full auto-calibration as described in Autocalibration (ACAL) (on page 2-5).
4. Select the 2182A DCV1 measurement function and select the 100 mV range.
5. Set the calibrator output to 0.00000 mV and allow the reading to settle.
6. Enable REL, and leave it enabled for the remainder of the tests.
7. Verify reading accuracy for each of the voltages listed in the "DC voltage measurement accuracy limits" table in 10 mV range accuracy (on page 2-8). For each test point:
   - Select the correct 2182A measurement range.
   - Set the DC calibrator output voltage to the indicated value.
   - Verify that the 2182A voltage reading is within the limits given in the table.
8. Repeat step 7 for negative source voltages with the same magnitudes as those listed in the "DC voltage measurement accuracy limits" table.
9. Repeat steps 4 through 8 for the 100 mV to 10 V ranges of the CHANNEL 2 input. Be sure to connect the calibrator to the appropriate input jack terminals by changing input cable wire connections and select the DCV2 measurement function.

## 10 mV range accuracy

***To verify the voltage measurement accuracy for the 10 mV range:***

1. With the power off, connect the DC calibrator and low-thermal divider to the 2182A CHANNEL 1 terminals of the input jack, as shown in the following figure.

**Figure 2: Connections for 10 mV range accuracy**




2. Turn on the power and allow a 2½ hour warmup period.
3. Select the 2182A DCV1 measurement function and choose the 10 mV range.
4. Select the 100:1 divider ratio.
5. Set the calibrator output to 0.00000 V and allow the reading to settle.
6. Enable REL.
7. Set the DC calibrator output voltage to 1.000000 V.
8. Verify voltage reading accuracy for the 10 mV range listed in following table.
9. Repeat steps 7 and 8 for a negative 10 mV source voltage by setting the calibrator voltage to −1.00000 V.

| **DC voltage measurement accuracy limits** | | |
|---|---|---|
| **2182A range** | **Calibrator voltage setting** | **Reading limits (1 Year, 18°C to 28°C)** |
| 10 mV*<br>100 mV<br>1 V<br>10 V<br>100 V* | 10.00000 mV**<br>100.0000 mV<br>1.000000 V<br>10.00000 V<br>100.0000 V | 9.99460 mV to 10.00054 mV<br>99.9966 mV to 100.0034 mV***<br>0.999973 V to 1.000027 V<br>9.99973 V to 10.00027 V<br>99.9961 V to 100.0039 V |

*Channel 1 only.
**Use 100:1 divider ratio and 1.000000 V calibrator voltage.
***99.9963 mV to 100.0037 mV for channel 2.

# Temperature measurement accuracy

This procedure involves applying thermocouple voltages from a temperature calibrator and then verifying that 2182A temperature measurements are within required limits.

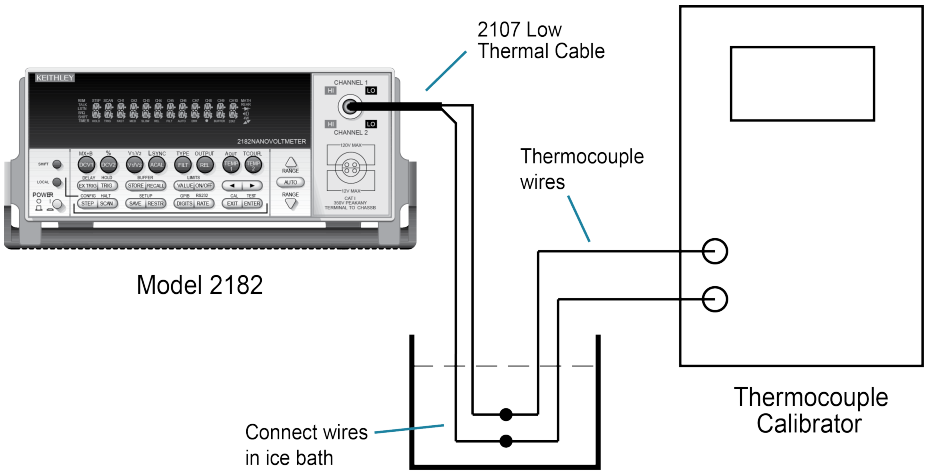
## NOTE

If the 2182A meets its dc volts accuracy specifications, temperature accuracy is automatically guaranteed, and it is not necessary to verify temperature measurement accuracy. However, the following procedure is provided for those who wish to independently measure temperature measurement accuracy.

***To verify that 2182A temperature measurement accuracy is within specified limits:***

1. With the power off, connect the temperature calibrator to the 2182A CHANNEL 1 input jack, as shown in the following figure. Connect the free ends of the thermocouple wire securely to the Model 2107 cable lugs and observe proper polarity (thermocouple + to HI; thermocouple – to LO). Place the connections in a 0°C ice bath as shown.

**Figure 3: Connections for temperature accuracy verification**




2. Turn on the power, and allow a 2½ hour warmup period.
3. Press **SHIFT** then **TCOUPL**, then use the RANGE and left and right arrow keys to select the following:
   - **UNITS:** C
   - **JUNC:** SIM, set to 0°C
   - **TYPE:** J
   - **SENS:** TCOUPLE
4. Select the 2182A TEMP 1 function.

5. Verify temperature measurement accuracy for each of the temperature settings listed in the following table. For each measurement:
   - Set the 2182A for the appropriate thermocouple type.
   - Set the temperature calibrator to the correct thermocouple type and temperature setting.
   - Verify that the 2182A temperature reading is within the limits given in the table.

| **Temperature measurement accuracy limits** | | |
|---|---|---|
| **Thermocouple type** | **Temperature calibrator setting (°C)** | **2182A temperature reading limits (1 Year, 18°C to 28°C)** |
| J, K, N, T | −200 | −200.2°C to –199.8°C |
| J, K, N, T | 0 | −0.2°C to 0.2°C |
| J, K, N, T | 400 | 399.8°C to 400.2°C |
| J, K, N | 700 | 699.8°C to 700.2°C |
| K, N | 1300 | 1299.8°C to 1300.2°C |
| | | |
| E | −200 | −200.2°C to −199.8°C |
| E | 0 | −0.2°C to 0.2°C |
| E | 1000 | 999.8°C to 1000.2°C |
| | | |
| R, S | 0 | −0.2°C to 0.2°C |
| R, S, B | 400 | 399.8°C to 400.2°C |
| R, S, B | 1700 | 1699.8°C to 1700.2°C |

## Analog output accuracy

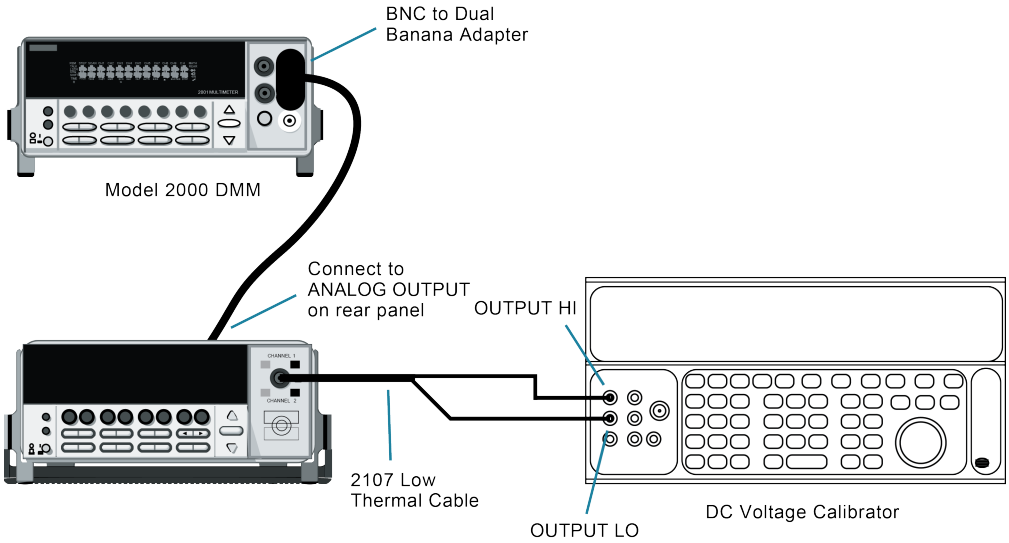
### NOTE

Be sure that dc voltage measurement accuracy is within required limits before attempting this procedure.

***To verify accuracy of the analog output:***

1. With the power off, connect the 2182A CHANNEL 1 input jack to the DC voltage calibrator and connect the rear panel ANALOG output jack to the digital multimeter, as shown in the following figure.

**Figure 4: Connections for analog output accuracy**




2. Select the 2182A DCV1 measurement function and choose the 10 V range.
3. Press **SHIFT** then **AOUT**, then use the RANGE and left and right arrow keys to set the following:
   - **STATE:** ON
   - **M:** +1.0000000
   - **B:** +00.000000
4. Set the calibrator voltage to 0.00000 V, then enable the 2182A REL mode. Also enable REL on the digital multimeter.
5. Verify analog output accuracy for each of the voltages listed in the following table. For each test point:
   - Set the DC calibrator voltage to the indicated value.
   - Verify that the digital multimeter voltage reading is within the limits given in the table.

| **Analog output accuracy limits** | | |
|---|---|---|
| **Calibrator voltage** | **Nominal analog output value** | **Analog output voltage limits** |
| 2.500000 V | 0.25 V | 0.24875 V to 0.25125 V |
| 5.000000 V | 0.5 V | 0.4985 V to 0.5015 V |
| 7.500000 V | 0.75 V | 0.74825 V to 0.75175 V |
| 10.00000 V | 1 V | 0.998 V to 1.002 V |

Section 3

# Calibration

## In this section: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# Introduction

Use the procedures in this section to calibrate the 2182A. These procedures require accurate test equipment to supply precise dc voltages. Calibration can be performed either from the front panel, or by sending SCPI calibration commands over the IEEE-488 bus or RS-232 port with the aid of a computer.

There are two general types of calibration covered in this section:

- **Normal calibration:** Usually the only type of calibration required in the field.
- **Factory calibration:** Required only if the 2182A has been repaired, or if a +516, "Linearity Precal Lost" error occurs.

## ⚠ WARNING

**The information in this section is intended for qualified service personnel only, as described by the types of product users in the Safety precautions pages, provided at the beginning of this document. Do not attempt these procedures unless you are qualified to do so.**

**Some of these procedures may expose you to hazardous voltages, that if contacted, could cause personal injury or death. Use appropriate safety precautions when working with hazardous voltages.**

# Environmental conditions

Conduct the calibration procedures at an ambient temperature of 18°C to 28°C (65°F to 82°F) with relative humidity of less than 70% unless otherwise noted.

# Warmup period

Allow the 2182A to warm up for at least 2½ hours before performing calibration.

If the instrument has been subjected to temperature extremes (those outside the ranges stated in Environmental conditions (on page 3-2)), allow additional time for the instrument's internal temperature to stabilize. Typically, allow one extra hour to stabilize an instrument that is 10°C (18°F) outside the specified temperature range.

Also allow the test equipment to warm up for the minimum time specified by the manufacturer.

# Line power

The 2182A requires a nominal line voltage of 100 V, 120 V, 220 V, or 240 V and a line frequency of 50 Hz to 60 Hz or 400 Hz. Calibration must be performed with the correct line voltage. If necessary, change the line voltage setting, as described in Line voltage selection (on page 4-3).

# Calibration considerations

When performing the calibration procedures:

- Make sure that the test equipment is properly warmed up and connected to the appropriate 2182A jack.
- Always allow the source signal to settle before calibrating each point.
- Use only copper-to-copper connections to minimize thermal EMFs.
- Make sure that all connections are clean and free of oxidation to avoid thermal EMFs that could affect calibration accuracy. Clean oxidation from connector terminals with DeoxIT cleaning solution.
- Keep test connections and all equipment away from drafts to avoid thermal drift.
- Do not connect test equipment to the 2182A through a scanner or other switching equipment.
- If an error occurs during calibration, the 2182A generates an appropriate error message. See Error summary (on page 7-12) for more information.

**WARNING**

**The maximum voltage between any terminals to chassis ground is 350 $V_{PEAK}$. Exceeding this value may cause a breakdown in insulation, creating a shock hazard that could result in personal injury or death.**

**CAUTION**

**The maximum voltage between CHANNEL 1 HI and LO is 120 V. The maximum voltage between CHANNEL 2 HI and LO is 12 V. Exceeding these voltage values may result in instrument damage.**

# Calibration cycle

Perform calibration every two years to ensure the instrument meets or exceeds its specifications.

# Calibration menu

The calibration menu allows you to access the calibration items summarized in the following table. To access the calibration menu, press SHIFT then CAL. Use the RANGE and left and right arrow keys to scroll through selections. Use the ENTER key to choose menu items. Use the EXIT key to cancel menu items.

| Calibration menu item | Description |
|---|---|
| CAL: DATES | Display calibration and calibration due dates. |
| CAL: COUNT | Display number of times instrument was calibrated. |
| CAL: RUN | Run calibration procedure. |
| CAL: TEMP | Display internal calibration temperature. |

## Calibration dates

Choose the DATES selection in the calibration menu to display the date the 2182A was calibrated and the date calibration is due. The instrument displays these dates as in the examples below:

DATE:12/07/97

NDUE:12/08/98

## Calibration count

Choose the COUNT selection in the calibration menu to display the number of times the instrument was calibrated. The instrument displays the calibration count as in this example:

COUNT: 1

## Calibration temperature

Select TEMP to display the internal temperature of the instrument at the time it was calibrated; for example:

TEMP: 27.61

## Calibration code

Before performing calibration, you must first unlock calibration by entering or sending the calibration code, as discussed in the following topics.

## Front-panel code

1. Access the calibration menu by pressing **SHIFT CAL**, and note that the instrument displays the following:

   CAL: DATES
2. Use the up or down **RANGE** key to scroll through the available calibration menu items until the instrument displays RUN, then press **ENTER**.
3. The 2182A prompts you to enter a code. The factory default code is 002182.

   CODE? 000000

   Use the left and right arrow keys to move among the digits. Use the up **RANGE** key to increment numbers, and press the down RANGE key to specify alphabetic letters. Confirm the code by pressing **ENTER**.
4. The 2182A allows you to define a new calibration code.

   NEW CODE? N
5. Use the up and down **RANGE** keys to toggle between Y (yes) and N (no). Choose N if you do not want to change the code. Choose Y if you want to change the code. The instrument then prompts you to enter a new code. Enter the code and press **ENTER**.

## Remote calibration unlock

To unlock calibration using remote communications, send the following command:

```
:CAL:PROT:CODE '<code>'
```

For example, the following command uses the default code:

```
:CAL:PROT:CODE 'KI002182'
```

NOTE

To change the calibration code, first send the present code, then send the new code. If you change the first two characters of the password to something other than "KI", you will not be able to unlock calibration from the front panel.

## Resetting the calibration code

If you lose the calibration code, you can unlock calibration by shorting together the CAL pads, which are located on the display board. Doing so will also reset the password to the factory default (KI002182).

See Disassembly (on page 6-1) for details on disassembling the instrument to access the CAL pads. Refer to the display board component layout drawing at the end of Disassembly for the location of the CAL pads.

# Calibration errors

The 2182A checks for errors after each calibration step, minimizing the possibility that improper calibration may occur due to operator error.

## Front-panel error reporting

If an error is detected during comprehensive calibration, the instrument displays an appropriate error message. The instrument then prompts you to repeat the calibration step that caused the error. If a calibration step fails, error +500 (calibration data invalid) occurs. The calibration step must be repeated.

Refer to Error summary (on page 7-12) for a list of error messages.

### Remote error reporting

You can detect errors while in remote by testing the state of EAV (Error Available) bit (bit 2) in the status byte. Use the *STB? query to request the status byte.

Query the instrument for the type of error by using the :SYST:ERR? query. The 2182A responds with the error number and a text message describing the nature of the error. Refer to Calibration reference (on page 7-1) for details.

## Aborting calibration

You can abort the front panel calibration process at any time by pressing EXIT. The instrument asks you to confirm your decision to abort with the following message:

ABORT CAL?

Press EXIT to abort calibration at this point, or press any other key to return to the calibration process.

NOTE

The 2182A will not respond to any remote programming commands while the ABORT CAL? message is displayed.

## Normal calibration

The calibration procedures described below are generally the only instrument calibration required in the field. If, however, the 2182A has been repaired, the factory calibration procedures described in Factory calibration (on page 3-14) should be performed instead.

## Recommended calibration equipment

The following table lists the recommended equipment for the normal calibration procedures. You can use alternate equipment if that equipment has specifications at least four times better than equivalent 2182A specifications.

| **Recommended normal calibration equipment** | | |
|---|---|---|
| **Description** | **Manufacturer/model** | **Specifications*** |
| DC Calibrator | Fluke 5700A | 10 V: ±5 ppm |
| Low Thermal Shorting Plug | Keithley 2188 | |
| Low Thermal Input Cable | Keithley 2107 | |
| * 90-day total uncertainty at specified output. | | |

# Front panel calibration

The procedures for front panel calibration include:

- Preparing the 2182A for calibration
- Front panel short and open calibration
- DC volts calibration
- Setting calibration dates and saving calibration
- Locking out calibration

## Preparing the 2182A for calibration

***To prepare the 2182A for calibration:***

1. Turn on the2182A.
2. Allow it to warm up for at least 2½ hours before performing the calibration procedure.

***To start the calibration process:***

1. Access the calibration menu by pressing SHIFT then CAL.
2. Use the up and down RANGE keys to scroll through the available calibration menu items until the instrument displays RUN, then press ENTER.
3. At the prompt, enter the calibration code. (The default code is 002182.) Use the left and right arrow keys to move among the digits. Use the up RANGE key to increment numbers, and press the down RANGE key to specify alphabetic letters. Confirm the code by pressing ENTER.
4. Choose N at the prompt to proceed without changing the code, then press ENTER.

## Front panel short and open calibration

NOTE

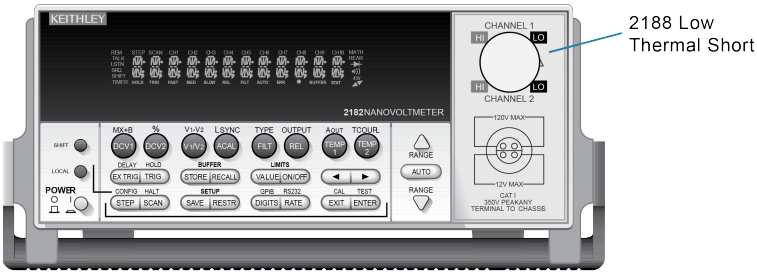
Keep drafts away from low-thermal connections to avoid thermal drift, which could affect calibration accuracy.

***To perform short and open calibration:***

1. At the start of calibration, the instrument prompts for a front panel short:

   FRONT SHORT
2. Connect the Model 2188 low-thermal shorting plug to the instrument front-panel input jack, as shown in the following figure. Wait at least three minutes before proceeding to allow for thermal equilibrium.

**Figure 5: Low-thermal short connections**

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3. Press ENTER to start short-circuit calibration. While the instrument is calibrating, it will display:

   CALIBRATING

4. When the instrument is done calibrating, it displays the following prompt:

   REMOVE INPUT

5. Remove the low-thermal short, and press ENTER. During this phase, the CALIBRATING message is displayed.

# DC volts calibration

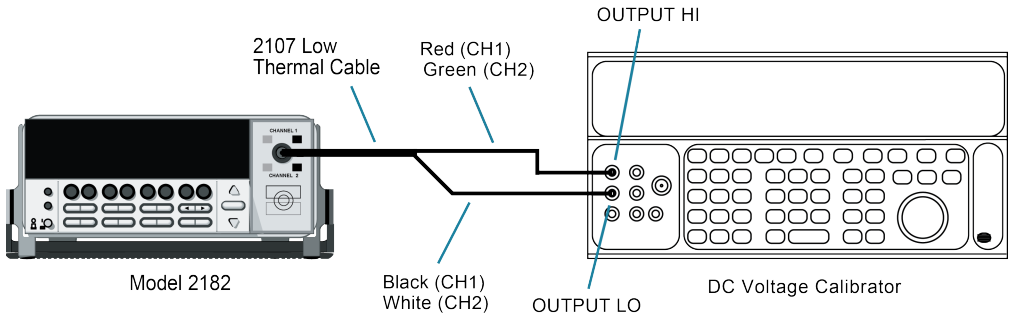
***To calibrate DC volts:***

1. After the front panel short and open procedure, the instrument prompts you for the first DC voltage:

   10.000000 V

2. Connect the calibrator to the CHANNEL 1 input of the 2182A using the low-thermal cable, as shown in the following figure.

**Figure 6: Connections for DC volts calibration**



The Model 2107 cable connections are summarized in the following table.

| Input cable color codes | |
|---|---|
| **Input connection** | **Wire color** |
| Channel 1 HI | Red |
| Channel 1 LO | Black |
| Channel 2 HI | Green |
| Channel 2 LO | White |

3. Wait two minutes to allow for thermal equilibrium before proceeding.
4. Set the calibrator to output DC volts and turn external sense off.
5. Perform the steps in the following table to complete DC volts calibration.

| DC volts front panel calibration summary | | |
|---|---|---|
| **Calibration step** | **Calibrator voltage*** | **Allowable range** |
| 10.000000 V | +10.000000 V | +9 V to +11 V |
| −10.000000 V | −10.000000 V | −9 V to −11 V |

* Use indicated values when possible.

For each calibration step:

- Set the calibrator to the indicated value and make sure it is in operate.
- Wait for the signal voltage to settle.
- Press the ENTER key to calibrate that step.
- Wait until the 2182A finishes each step. The instrument displays the CALIBRATING message while calibrating.

## NOTE

Lock the calibrator to the 11 V range. If your calibrator cannot output the values recommended in the calibration summary table, use the left and right arrow keys and the up and down RANGE keys to set the 2182A display value to match the calibrator output voltage.

## Setting dates and saving calibration

At the end of the calibration procedure, the instrument displays the CALIBRATION COMPLETE message. Press ENTER to continue. The 2182A prompts you to enter the calibration date and the calibration due date.

***Set the calibration dates as follows:***

1. At the CAL DATE: mm/dd/yy prompt, use the left and right arrow keys and the RANGE keys to set the calibration date, then press ENTER.
2. The instrument prompts you to enter the next calibration due date with this prompt: CAL NDUE: mm/dd/yy. Use the left and right arrow keys and the RANGE keys to set the calibration due date, then press ENTER.
3. The instrument prompts you to save new calibration constants with this message: SAVE CAL? YES. To save the new constants, press ENTER. If you do not want to save the new constants, press the down range key to toggle to NO, then press ENTER.

### NOTE

Calibration constants calculated during the current calibration procedure are not saved unless you choose the YES option. Previous calibration constants are retained if you select NO.

# Remote calibration

The following topics provide instructions to perform calibration using remote connections. See Calibration reference (on page 7-1) for a detailed list and description of SCPI calibration commands.

When sending calibration commands, be sure that the 2182A completes each step before sending the next command. You can do so either by observing the front panel CALIBRATING message, or by detecting the completion of each step over the bus. Be sure to include a space character between each command and parameter.

The procedures for calibrating the 2182A using SCPI commands include:

- Preparing the 2182A for calibration
- Front panel short and open calibration
- DC volts calibration
- Programming calibration dates
- Saving calibration constants
- Locking out calibration

# Preparing the 2182A for calibration

***To prepare the 2182A for remote calibration:***

1. Connect the 2182A to the IEEE-488 bus of the computer using a shielded IEEE-488 cable, such as the Keithley Model 7007, or connect the instrument to a computer through the RS-232 port using a straight-through 9-pin to 9-pin cable (use a 9 to 25-pin adapter if necessary).
2. Turn on the 2182A and allow it to warm up for 2½ hours before performing calibration.
3. Select the DCV1 function.
4. Make sure the primary address of the 2182A is the same as the address specified in the program that you will be using to send commands. (Use the GPIB key.)
5. Unlock the calibration function by sending this command:

   ```
   :CAL:PROT:CODE 'KI002182'
   ```

   The above command shows the default code, `KI002182`. Substitute the correct code if changed.
6. Send the following command to initiate calibration:

   ```
   :CAL:PROT:INIT
   ```

# Short and open calibration

## NOTE

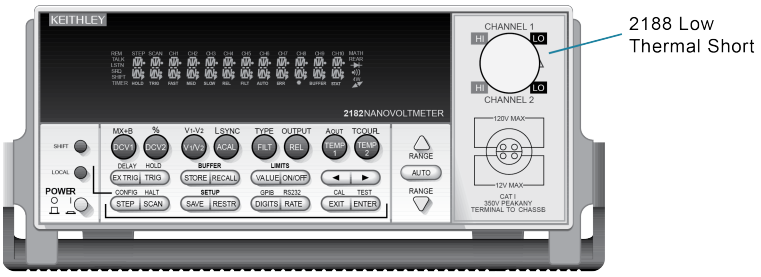
Keep drafts away from low-thermal connections to avoid thermal drift, which could affect calibration accuracy.

***To perform short and open calibration:***

1. At the start of calibration, the instrument prompts for a front panel short:

   FRONT SHORT
2. Connect the Model 2188 low-thermal shorting plug to the instrument front-panel input jack, as shown in the following figure. Wait at least three minutes before proceeding to allow for thermal equilibrium.

**Figure 7: Low-thermal short connections**

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3. Send the following command:

   ```
   :CAL:PROT:DC:STEP1
   ```

4. After the 2182A completes this step, remove the low-thermal short.
5. Send this command:

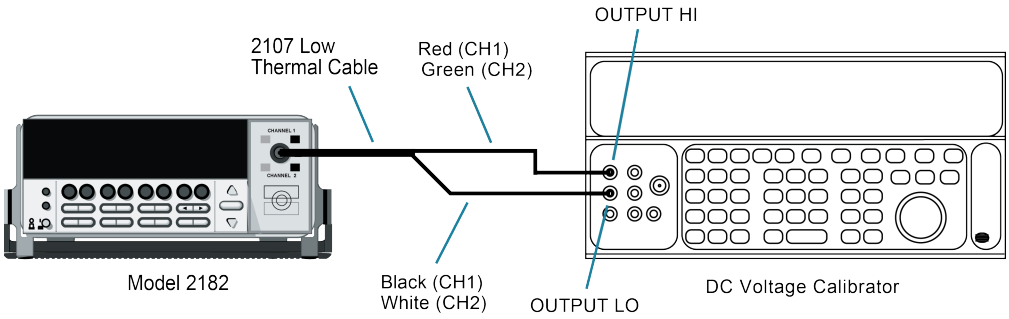
   ```
   :CAL:PROT:DC:STEP2
   ```

# DC volts calibration

***To perform the dc volts calibration:***

1. Connect the calibrator to the CHANNEL 1 input of the 2182A using the low-thermal cable, as shown in the following figure.

**Figure 8: Connections for DC volts calibration**




The Model 2107 cable connections are summarized in the following table.

| **Input cable color codes** | |
|---|---|
| **Input connection** | **Wire color** |
| Channel 1 HI | Red |
| Channel 1 LO | Black |
| Channel 2 HI | Green |
| Channel 2 LO | White |

2. Wait two minutes to allow for thermal equilibrium before proceeding.
3. Perform the calibration steps summarized in the following table.

| **Calibration step** | **Calibrator voltage** | **Calibration command*** | **Parameter range** |
|---|---|---|---|
| +10 V | +10.000000 V | `:CAL:PROT:DC:STEP3 10` | 9 to 11 |
| −10 V | −10.000000 V | `:CAL:PROT:DC:STEP4 −10` | −9 to −11 |

* Use indicated values whenever possible. Change parameter accordingly if using a different calibrator voltage.

For each step:

- Set the calibrator to the indicated voltage and make sure the instrument is in operate. (Use the recommended voltage whenever possible.)
- Allow the signal voltage to settle.
- Send the indicated programming command. (Change the voltage parameter if you are using a different calibration voltage.)
- Wait until the 2182A completes each step before continuing.

## Programming calibration dates

***Program the present calibration date and calibration due date by sending the following commands:***

```
:CAL:PROT:DATE <year>, <month>, <day>
:CAL:PROT:NDUE <year>, <month>, <day>
```

For example, the following commands assume calibration dates of 12/15/2021 and 12/15/2020 respectively:

```
:CAL:PROT:DATE 2021, 12, 15
:CAL:PROT:NDUE 2020, 12, 15
```

## Saving calibration constants

After completing the calibration procedure, you must save the new calibration constants.

### NOTE

Calibration constants are not saved unless the :SAVE command is sent.

***To save the new calibration constants, send the following command:***

```
:CAL:PROT:SAVE
```

Calibration constants can be returned using the :CAL:PROT:DATA? command. For details, see :CALibration:PROTected:DATA? (on page 7-8).

Default calibration constants and tolerances are listed in Default calibration constants and tolerances (on page 7-2).

## Locking out calibration

***After saving calibration, send the following command to lock out calibration:***

```
:CAL:PROT:LOCK
```

# Factory calibration

The following calibration procedures are normally performed only at the factory, but the necessary steps are included here in case the instrument is repaired (such as changing internal components) and the instrument requires these calibration procedures. The instrument also requires factory calibration if a +516, "Linearity Precal Lost" error occurs.

# Recommended test equipment

The following table summarizes the test equipment recommended for the manufacturing calibration steps.

| Description | Manufacturer/model | Specifications* |
|---|---|---|
| DC Calibrator | Fluke 5700A | 1 V: ±7 ppm<br>10 V: ±5 ppm |
| Low Thermal Input Cable | Keithley 2107 | |
| Low Thermal Short | Keithley 2188 | |
| BNC-to-Clip Leads | | |

* 90-day total uncertainty at specified output.

# Remote factory calibration

Follow the steps in this section to perform factory calibration using a remote connection. See Calibration reference (on page 7-1) for a detailed list and descriptions of SCPI calibration commands.

When sending calibration commands, be sure that the 2182A completes each step before sending the next command. You can do so either by observing the front panel PRECAL or CALIBRATING message, or by detecting the completion of each step over the bus. Be sure to include a space character between each command and parameter.

The procedures for factory calibrating the 2182A using SCPI commands include:

- Preparing the 2182A for factory calibration
- Precalibration
- Front panel short and open calibration
- DC volts calibration
- Analog output calibration
- Programming calibration dates
- Saving calibration constants
- Locking out calibration

# Preparing the 2182A for factory calibration

***To prepare the 2182A for remote calibration:***

1. Connect the 2182A to the IEEE-488 bus of the computer using a shielded IEEE-488 cable, such as the Keithley Model 7007, or connect the instrument to a computer through the RS-232 port using a straight-through 9-pin to 9-pin cable (use a 9 to 25-pin adapter if necessary).
2. Press in and hold the STEP key, then turn on the 2182A and allow it to warm up for 2½ hours before performing calibration.
3. Select the DCV1 function.
4. Make sure the primary address of the 2182A is the same as the address specified in the program that you will be using to send commands. (Use the GPIB key.)
5. Unlock the calibration function by sending these commands:

   ```
   :DIAG:KEIT:CAL:UNLOCK
   :CAL:PROT:CODE 'KI002182'
   ```

   The above command shows the default code, `KI002182`. Substitute the correct code if changed.
6. Send the following command to initiate calibration:

   ```
   :CAL:PROT:INIT
   ```

# Precalibration

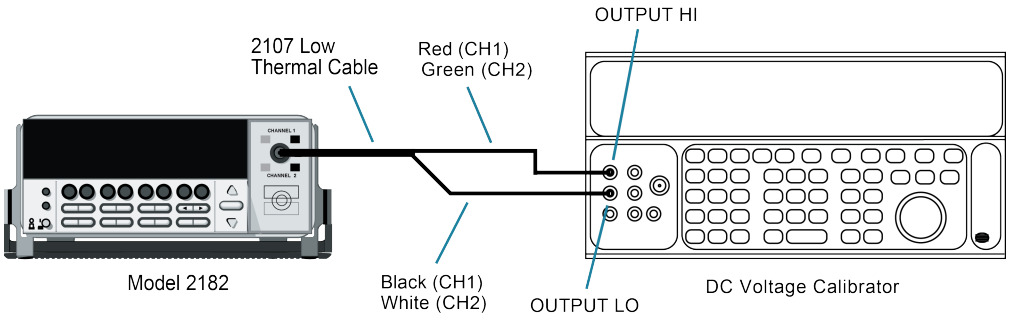
## NOTE

Keep drafts away from low-thermal connections to avoid thermal drift, which could affect calibration accuracy.

***To prepare for calibration:***

1. Connect the calibrator to the CHANNEL 1 input of the 2182A using the low-thermal cable, as shown in the following figure.

**Figure 9: Connections for DC volts calibration**



The Model 2107 cable connections are summarized in the following table.

| Input cable color codes | |
|---|---|
| **Input connection** | **Wire color** |
| Channel 1 HI | Red |
| Channel 1 LO | Black |
| Channel 2 HI | Green |
| Channel 2 LO | White |

2. Wait two minutes to allow for thermal equilibrium before proceeding.
3. Set the calibrator to output DC volts and turn external sense off.
4. Perform the precalibration steps summarized in the following table. For each step:
   a. Set the calibrator to the indicated voltage and make sure the instrument is in operate.
   b. Allow the signal voltage to settle.
   c. Send the indicated programming command.
   d. Wait until the 2182A completes each step before continuing.

| Precalibration step | Calibrator voltage | Calibration command |
|---|---|---|
| 10 V | 10.000000 V | `:CAL:PROT:PCAL:STEP0 10` |
| 0 V | 0.0000000 V | `:CAL:PROT:PCAL:STEP1 0` |
| 1 V | 1.0000000 V | `:CAL:PROT:PCAL:STEP2 1` |

## NOTE

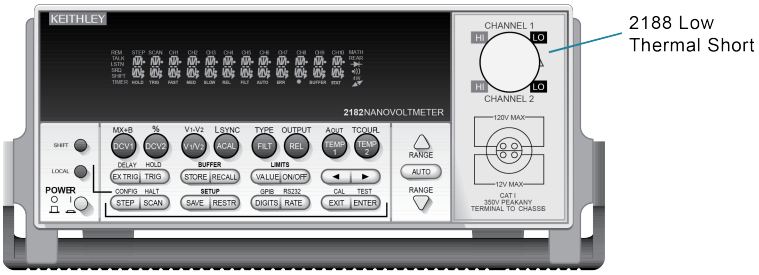
Keep the calibrator locked to the 11 V range.

# Short and open calibration

***To perform short and open calibration:***

1. Connect the Model 2188 low-thermal shorting plug to the instrument front-panel input jack, as shown in the following figure. Wait at least three minutes before proceeding to allow for thermal equilibrium.

**Figure 10: Low-thermal short connections**

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2. Send the following command:

   `:CAL:PROT:DC:STEP1`

3. After the 2182A completes this step, remove the low-thermal short, and send this command:

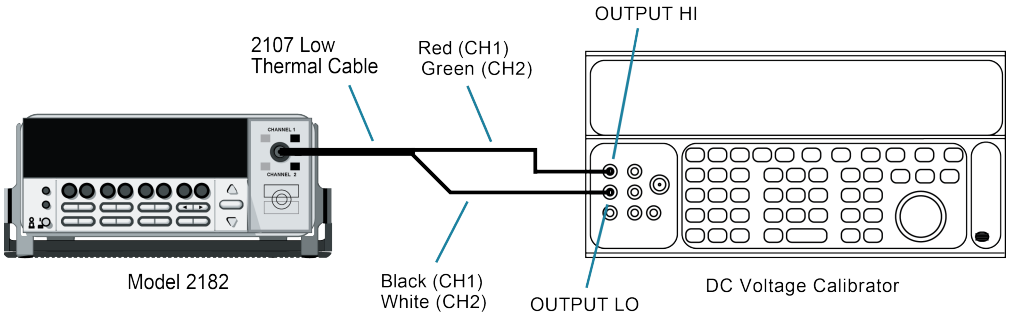
   `:CAL:PROT:DC:STEP2`

# DC volts calibration

***After front panel short and open steps, do the following:***

1. Connect the calibrator to the 2182A using the low-thermal cable, as shown in the following figure.

**Figure 11: Connections for DC volts calibration**




2. Allow two minutes for thermal equilibrium.
3. Perform the calibration steps summarized in the following table.

| Calibration step | Calibrator voltage | Calibration command* | Parameter range |
|---|---|---|---|
| +10 V<br>−10 V | +10.000000 V<br>−10.000000 V | `:CAL:PROT:DC:STEP3 10`<br>`:CAL:PROT:DC:STEP4 -10` | 9 to 11<br>−9 to −11 |

* Change parameter accordingly if using a different calibrator voltage.

For each step:

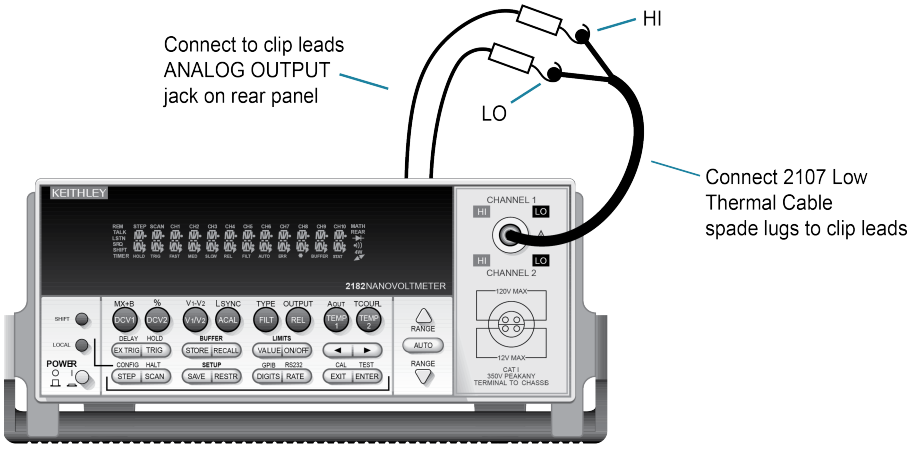
1. Set the calibrator to the indicated voltage and make sure the instrument is in operate. (Use the recommended voltage if possible.)
2. Allow the signal voltage to settle.
3. Send the indicated programming command. (Change the voltage parameter if you are using a different calibration voltage.)
4. Wait until the 2182A completes each step before continuing.

# Analog output calibration

***To perform analog output calibration:***

1. Connect the 2182A analog output to CHANNEL 1 of the front-panel input jack, as shown in the following figure.

**Figure 12: Connections for analog output calibration**

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2. Send the following command to calibrate the analog output:

```
:CAL:PROT:DC:STEP5
```

# Programming calibration dates

***Program the present calibration date and calibration due date by sending the following commands:***

```
:CAL:PROT:DATE <year>, <month>, <day>
:CAL:PROT:NDUE <year>, <month>, <day>
```

For example, the following commands assume calibration dates of 12/15/2021 and 12/15/2020 respectively:

```
:CAL:PROT:DATE 2021, 12, 15
:CAL:PROT:NDUE 2020, 12, 15
```

## Saving calibration constants

After completing the calibration procedure, you must save the new calibration constants.

NOTE

Calibration constants are not saved unless the :SAVE command is sent.

***To save the new calibration constants, send the following command:***

```
:CAL:PROT:SAVE
```

Calibration constants can be returned using the :CAL:PROT:DATA? command. For details, see :CALibration:PROTected:DATA? (on page 7-8).

Default calibration constants and tolerances are listed in Default calibration constants and tolerances (on page 7-2).

## Locking out calibration

***After saving calibration, send the following command to lock out calibration:***

```
:CAL:PROT:LOCK
```

Section 4

# Maintenance

## In this section:

Introduction .....4-1
Line fuse replacement.....4-1
Line voltage selection .....4-3

# Introduction

This section includes information about routine type maintenance that can be performed by the operator.

# Line fuse replacement

A fuse on the 2182A rear panel protects the power line input of the instrument. See the following instructions to replace the fuse. You do not need to return your instrument for service if the fuse is damaged.

**⚠ WARNING**

**Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before replacing a line fuse. Failure to do so could expose the operator to hazardous voltages that could result in personal injury or death.**

**Use only the correct fuse type. Failure to do so could result in injury, death, or instrument damage. If the instrument repeatedly blows fuses, locate and correct the cause of the problem before replacing the fuse. See Troubleshooting (on page 5-1) for troubleshooting information. If the fuse continues to become damaged, return the instrument to Keithley Instruments for repair.**

The powerline fuses for the 2182A are listed in the following table.

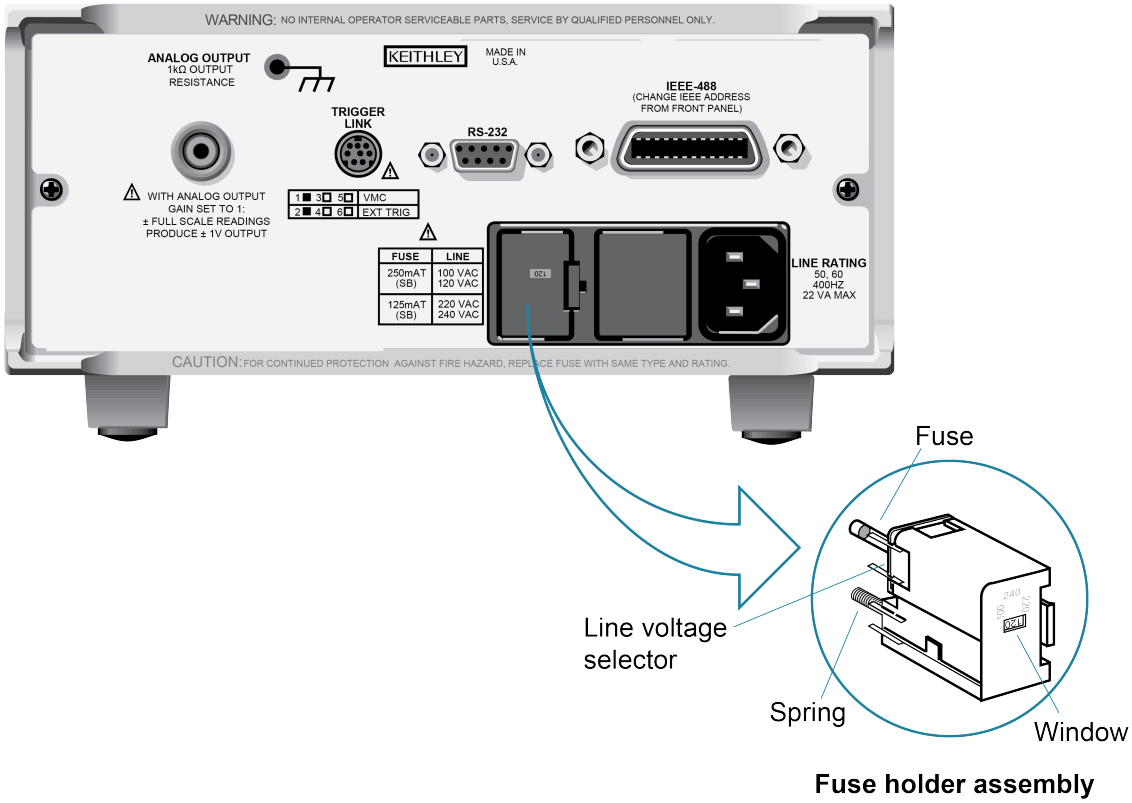
**Fuse ratings**

| Line voltage | Fuse rating | Part number |
|---|---|---|
| 100 V or 120 V | 0.25 A, slow blow, 5 mm × 20 mm | Littelfuse 239.250 |
| 220 V or 240 V | 0.125 A, slow blow, 5 mm × 20 mm | Schurter 0034.3108 |

***To replace the line fuse:***

1. Power off the instrument.
2. Remove all test leads connected to the instrument.
3. Remove the line cord.
4. Make note of the voltage displayed in the fuse holder assembly window.
5. Place the tip of a flat-blade screwdriver into the power module by the fuse holder assembly.
6. Gently push in and move to the left. Release pressure on the assembly. Its internal spring pushes it out of the power module, as shown in the following figure.

**Figure 13: Fuse and line voltage selector**




**Fuse holder assembly**

7. Remove the blown fuse.
8. Replace the fuse.
9. Install the fuse holder assembly into the power module by pushing it in until it locks in place.

# Line voltage selection

**WARNING**

**Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before changing the line voltage. Failure to do so could expose the operator to hazardous voltages that could result in personal injury or death.**

The 2182A can be set to operate on either 100 V, 120 V, 220 V, or 240 V nominal line voltages.

***To change the line voltage:***

1. Carefully pry the locking tab that secures the fuse carrier to the power module.
2. Pull the fuse holder from the carrier.
3. If you are changing the line voltage that requires a different fuse, replace it with the correct type. Refer to Line fuse replacement (on page 4-1).
4. Rotate the fuse holder so that the correct line voltage setting is displayed in the small window in the carrier.
5. Install the holder in the carrier.
6. Install the fuse carrier in the power module. Make sure the locking tab secures it properly.

Section 5

# Troubleshooting

## In this section:


Introduction ..... 5-1
Repair considerations ..... 5-2
Power-on self-test ..... 5-2
Principles of operation ..... 5-4
Power supply ..... 5-4
Display board ..... 5-5
Digital circuitry ..... 5-6
Analog circuitry ..... 5-8
Troubleshooting ..... 5-10
Factory service ..... 5-14


# Introduction

This section of the manual will assist you in troubleshooting and repairing the 2182A. Included are self-tests, test procedures, troubleshooting tables, and circuit descriptions.

NOTE

Disassembly instructions are in Disassembly (on page 6-1).

⚠ WARNING

**The information in this section is intended for qualified service personnel only, as described by the types of product users in the Safety precautions pages, provided at the beginning of this document. Do not attempt these procedures unless you are qualified to do so.**

**Some of these procedures may expose you to hazardous voltages, that if contacted, could cause personal injury or death. Use appropriate safety precautions when working with hazardous voltages.**

# Repair considerations

CAUTION

**The printed circuit (PC) boards are built using surface mount techniques and require specialized equipment and skills for repair. If you are not equipped or qualified, it is strongly recommended that you send the instrument back to the factory for repairs or limit repairs to PC board replacement. Without proper equipment and training, you could damage a PC board beyond repair.**

Before making any repairs to the 2182A, be sure to read the following considerations.

- Repairs will require various degrees of disassembly. However, it is recommended that the Front Panel Tests be performed before any disassembly. The disassembly instructions for the 2182A are provided in Disassembly (on page 6-1).
- Do not make repairs to surface mount PC boards unless equipped and qualified to do so.
- When working inside the instrument and replacing parts, be sure to adhere to the handling precautions and cleaning procedures explained in Disassembly (on page 6-1).
- Many CMOS devices are installed in the 2182A. These static-sensitive devices require special handling as explained in Disassembly (on page 6-1).
- Whenever a circuit board is removed or a component is replaced, the 2182A must be recalibrated. See Calibration (on page 3-1) for details on calibrating the instrument.

# Power-on self-test

During the power-on sequence, the 2182A performs a checksum test on its EPROM and tests its RAM. If one of these tests fails, the instrument will lock up.

## Front-panel tests

The front-panel tests check the functionality of the front-panel keys and the display. In the event of a test failure, refer to Display board checks (on page 5-10) for details on troubleshooting the display board.

# KEY test

The KEY test allows you to check the functionality of each front-panel key.

***To run the KEY test:***

1. Press **SHIFT** and then **TEST** to access the self-test options.
2. Use the up or down RANGE key to display `TEST: KEY`.
3. Press **ENTER** to start the test. When a key is pressed, the label name for that key is displayed to indicate that it is functioning properly. When the key is released, the message `NO KEY PRESS` is displayed.
4. Pressing EXIT tests the EXIT key. However, the second consecutive press of EXIT aborts the test and returns the instrument to normal operation.

# DISP test

The display test allows you to verify that each segment and annunciator in the vacuum fluorescent display is working properly.

***To run the display test:***

1. Press **SHIFT** and then **TEST** to access the self-test options.
2. Use the up or down **RANGE** key to display `TEST: DISP`.
3. Press **ENTER** to start the test. There are four parts to the display test. Each time **ENTER** is pressed, the next part of the test sequence is selected. The four parts of the test sequence are as follows:
   - All annunciators are displayed.
   - The segments of each digit are sequentially displayed.
   - The 12 digits (and annunciators) are sequentially displayed.
   - The annunciators at either end of the display are sequentially displayed.
4. When finished, abort the display test by pressing **EXIT**. The instrument returns to normal operation.

# Principles of operation

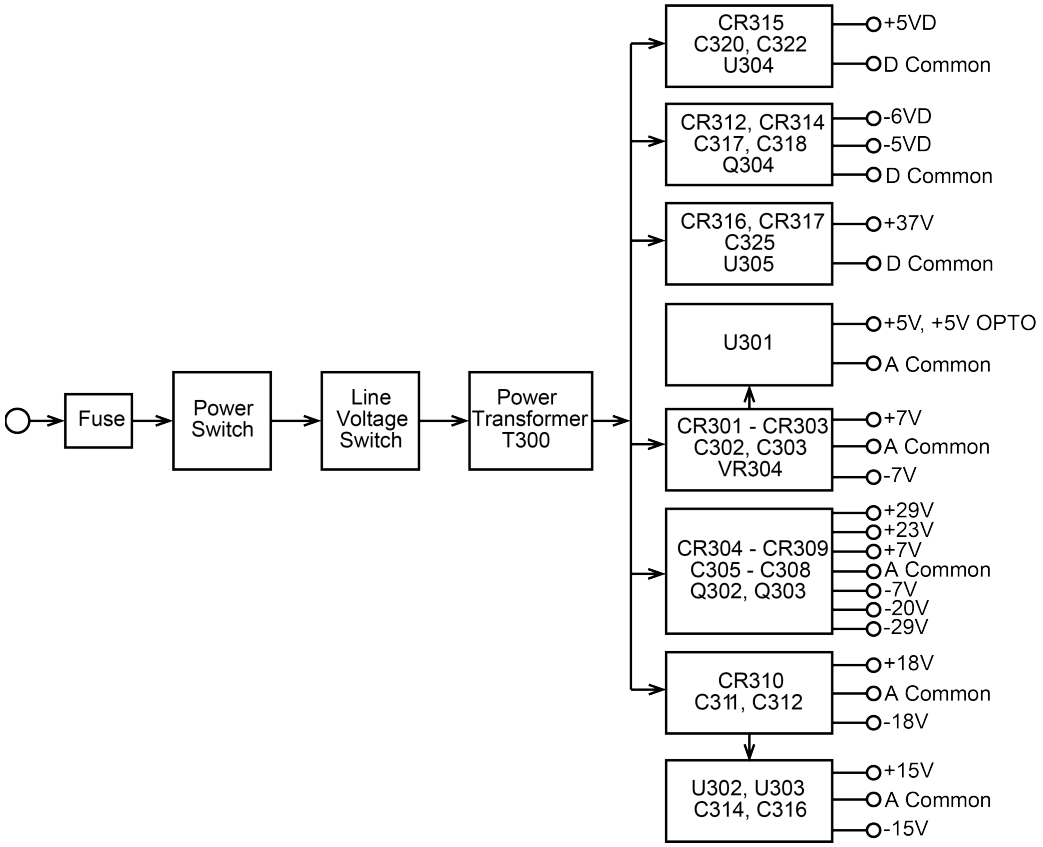
The following information is provided to support the troubleshooting tests and procedures covered in this section of the manual. Refer to the following block and schematic diagrams:


- Power supply (on page 5-4)
- Display board (on page 5-5)
- Digital circuitry (on page 5-6)
- Analog circuitry (on page 5-8)


# Power supply

The following information provides some basic circuit theory that can be used as an aid to troubleshoot the power supply. A block diagram of the power supply is shown in the following figure.

**Figure 14: Power supply block diagram**



AC power is applied to the ac power module receptacle. Power is routed through the line fuse and line voltage selection switch of the power module to the power transformer. The power transformer has several secondary windings for the various supplies.

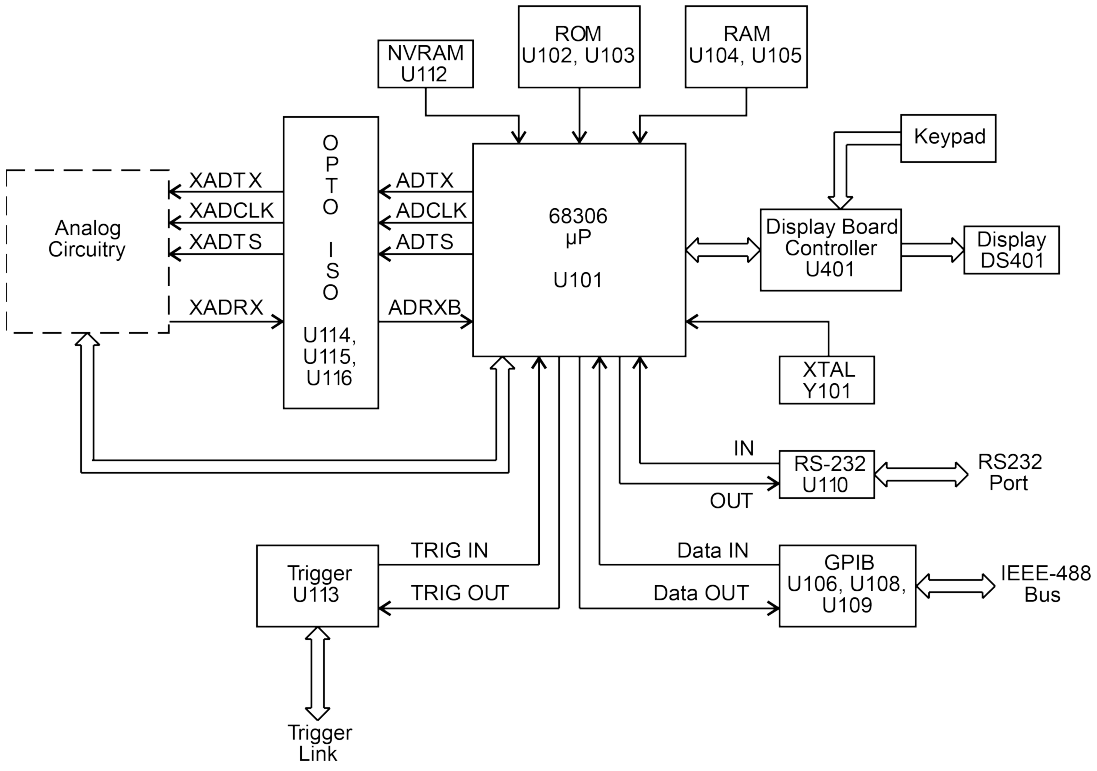
AC voltage for the display filaments is taken from a power transformer secondary at F1 and F2, and then routed to the display board.

Each DC supply uses a rectifier and a capacitive filter, and many supplies use an IC regulator or transistors, as shown in the block diagram.

# Display board

Display board components are shown in the following figure.

**Figure 15: Digital circuitry block diagram**



## Microcontroller

U401 is the display board microcontroller that controls the display and interprets key data. The microcontroller uses three internal peripheral I/O ports for the various control and read functions.

Display data is serially transmitted to the microcontroller from the digital section via the TXB line to the microcontroller RDI terminal. In a similar manner, key data is serially sent back to the digital section through the RXB line via TDO. The 4MHz clock for the microcontroller is generated by crystal Y401.

## Display

DS401 is the display module, which can display up to 12 alphanumeric characters and includes the annunciators.

The display uses a common multiplexing scheme with each character refreshed in sequence. U402 and U403 are the drivers for the display characters and annunciators. Data for the drivers are serially transmitted from the microcontroller (MOSI and PC1).

Filament voltage for the display is derived from the power supply transformer (F1 and F2). The display drivers require +37 V dc and +5 V dc, which are supplied by U304 (+5 VD) and U305 (+37 V).

## Key matrix

The front-panel keys (S401 to S430) are organized into a row-column matrix to minimize the number of microcontroller peripheral lines required to read the keyboard. A key is read by strobing the columns and reading all rows for each strobed column. Key-down data is interpreted by the display microcontroller and sent back to the main microprocessor using proprietary encoding schemes.

# Digital circuitry

Refer to the figure in Display board (on page 5-5) the following discussion on digital circuitry.

## Microprocessor

U101 is a 68306 microprocessor that oversees all operating aspects of the instrument. The MPU has a 16-bit data bus and provides an 18-bit address bus. It also has parallel and serial ports for controlling various circuits. For example, the RXDA, TXDA, RXDB and TXDB lines are used for the RS-232 interface.

The MPU clock frequency of 14.7456 MHz is controlled by crystal Y101. MPU RESET is performed momentarily (through C133) on power-up by the +5 VD1 power supply.

## Memory circuits

ROMs U102 and U103 store the firmware code for instrument operation. U102 stores the D0 to D7 bits of each data word. U103 stores the D8 to D15 bits.

RAMs U104 and U105 provide temporary operating storage. U104 stores the D0 to D7 bits of each data word. U105 stores the D8 to D15 bits.

Semi-permanent storage facilities include NVRAM U112. This integrated circuit stores information such as instrument setup and calibration constants. Data transmission from this device is done in a serial fashion.

## RS-232 interface

Serial data transmission and reception is performed by the TXDB and RXDB lines of the MPU. U110 provides the necessary voltage level conversion for the RS-232 interface port.

## IEEE-488 interface

U106, U108, and U109 make up the IEEE-488 interface. U106, a 9914A GPIA, handles routine bus overhead such as handshaking. U108 and U109 provide the buffering and drive capabilities for the data, control, and handshake lines.

## Trigger circuits

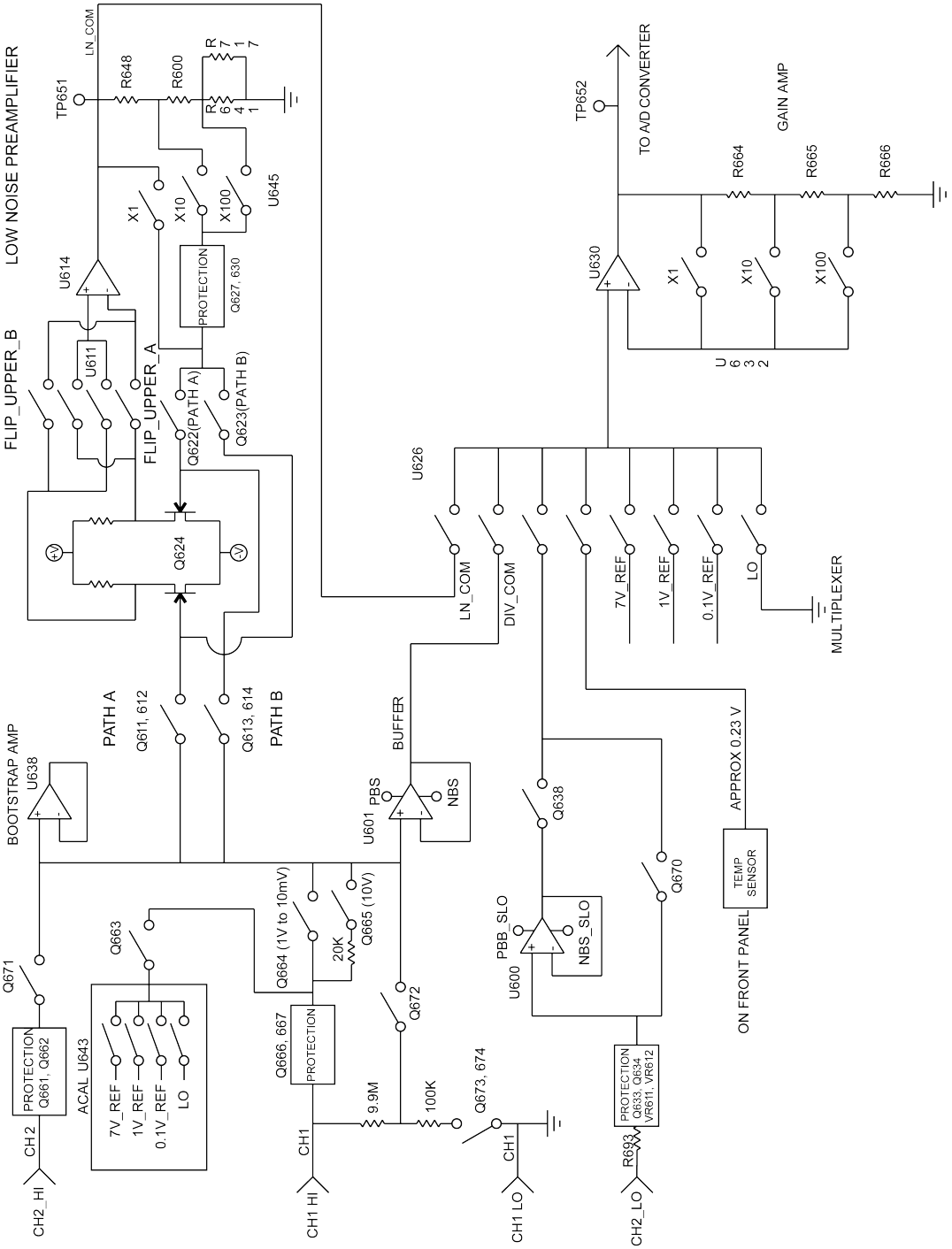
Buffering for the Trigger Link input and output is performed by U113. Trigger input and output is controlled by the IRQ4 and PB3 lines of the MPU.

At the factory, trigger output is connected to line 1 of the Trigger Link connector (resistor R145 installed). Trigger input is connected to line 2 of the Trigger Link connector (resistor R142 installed).

# Analog circuitry

Refer to the following figure for the discussion of analog circuitry.

**Figure 16: Simplified schematic of analog circuitry**



# Input signal conditioning

## Protection circuits

The CH1 HI, CH2 HI, and CH2 LO inputs have protection circuits designed to prevent circuit damage from overvoltage signal conditions. Q666 and Q667 provide protection for CH1 HI. Q661 and Q662 provide similar protection for CH2 HI.

## Signal paths

There are two basic signal paths: DIV_COM (divider common) and LN_COM (low noise common). The divider common path has an attenuation factor of 100:1 and is used for the 100 V range. The low-noise preamplifier is used for the 10 mV to 10 V ranges.

## Buffering

U601 is a unity-gain amplifier that provides signal buffering for the divider common signal path. A 100:1 resistive divider is switched in to attenuate the signal for the 100 V range.

## Low-noise preamplifier

The low-noise preamplifier is made up of Q624, U614, and associated components. Q624 and U614 form a composite op-amp with switchable gain depending on the selected measurement function. Q624 forms the differential amplifier input. U614 provides the required high open-loop gain. Circuit gain is controlled through feedback elements and signal paths by switches Q611 to Q614, Q622, Q623, and U645.

# Multiplexer and gain amplifier

## Multiplexer

U626 is the multiplexer that switches among a number of signals during the phases of the measurement cycle. In addition to the two main signal paths, DIV_COM and LN_COM, the multiplexer also switches input LO, CH2 LO, the front-panel temperature sensor, and the 7 V, 1 V, and 0.1 V reference signals. The two LO signals are measured to null offsets, the temperature sensor is measured for temperature measurements and TCAL, and the reference voltages provide stable comparison voltages for accurate measurements.

## Gain amplifier

U630, Q651, and associated components are gain amplifiers that provide X1, X10, or X100 gain factors, depending on the selected range. Gain is controlled by switching resistors into the feedback loop. Note that the output of U630 is the signal that is applied to the A/D converter for conversion into digital data that can be read by the microprocessor.

### Circuit gain

The following table summarizes the circuit gain factors for the ranges.

| Circuit gain factors | | | |
|---|---|---|---|
| **Range** | **Divider attenuation** | **Preamp gain** | **Multiplexer gain** |
| 100 V | 100:1 | N/A | X10 |
| 10 V | N/A | X1 | X1 |
| 1 V | N/A | X1 | X10 |
| 100 mV | N/A | X1 | X100 |
| 10 mV | NA | X100 | X10 |

# Troubleshooting

Troubleshooting information for the various circuits is summarized below. Use the Principles of operation (on page 5-4) as aids in troubleshooting.

## Display board checks

If the front panel DISP test indicates that there is a problem on the display board, refer to the following table.

| Display board checks | | | |
|---|---|---|---|
| **Step** | **Item/component** | **Required condition** | **Remarks** |
| 1 | Front panel DISP test. | Verify that all segments operate. | Use front-panel display test. |
| 2 | P1005, pin 5 | +5 V ±5% | Digital +5 V supply. |
| 3 | P1005, pin 9 | +37 V ±5% | Display +37 V supply. |
| 4 | U401, pin 1 | Goes low briefly on power up, then goes high. | Microcontroller RESET. |
| 5 | U401, pin 43 | 4 MHz square wave. | Controller 4 MHz clock. |
| 6 | U401, pin 32 | Pulse train every 1 ms. | Control from main processor. |
| 7 | U401, pin 33 | Brief pulse train when front-panel key is pressed. | Key down data sent to main processor. |

# Power supply checks

Power supply problems can be checked out using the following table.

| Power supply checks | | | |
|---|---|---|---|
| **Step** | **Item/component** | **Required condition** | **Remarks** |
| 1 | Line fuse | Check continuity. | Remove to check. |
| 2 | Line voltage | 120 V or 240 V as required. | Check power module position. |
| 3 | Line power | Plugged into live receptacle, power on. | Check for correct power-up sequence. |
| 4 | U304, pin 2 | +5 V ±5% | +5 VD, referenced to TP301. |
| 5 | U305, pin 2 | +37 V ±5% | +37 V, referenced to TP301. |
| 6 | CR313 anode | −6 V ±20% | −6 VD, referenced to TP301. |
| 7 | Q304, pin 2 | −5 V, ±5% | −5 VD, referenced to TP301. |
| 8 | U302, pin 3 | +15 V ±5% | +15 V, referenced to TP303. |
| 9 | U303, pin 3 | −15 V ±5% | −15 V, referenced to TP303. |
| 10 | U301, pin 3 | +5 V ±5% | +5 V, referenced to TP303. |
| 11 | CR305 cathode | +29 V ±20% | +29 V, referenced to TP303. |
| 12 | CR309 anode | −29 V ±20% | −29 V, referenced to TP303. |
| 13 | CR310 V+, pin 1 | +18 V ±20% | +18 V, referenced to TP303. |
| 14 | CR310 V-, pin 2 | −18 V ±20% | −18 V, referenced to TP303. |
| 15 | CR306 anode | −7 V ±20% | −7 V, reference to TP303. |
| 16 | CR308 cathode | +7 V ±5% | +7 V, referenced to TP303. |

# Digital circuit checks

Digital circuit problems can be checked out using the options in the following table.

| Digital circuit checks | | | |
|---|---|---|---|
| **Step** | **Item/component** | **Required condition** | **Remarks** |
| 1 | Power-on test | RAM OK, ROM OK. | Verify that RAM and ROM are functional. |
| 2 | TP301 | Digital common. | All signals referenced to digital common. |
| 3 | U103 pin 32 | +5 V | Digital logic supply. |
| 4 | U101 pin 48 | Low on power-up, then goes high. | MPU RESET line. |
| 5 | U101, lines A1 to A18 | Check for stuck bits. | MPU address bus. |
| 6 | U101, lines D0 to D1 | Check for stuck bits. | MPU data bus. |
| 7 | U101 pin 44 | 14.7456 MHz | MPU clock. |
| 8 | U110 pin 13 | Pulse train during RS-232 I/O. | RS-232 RX line. |
| 9 | U110 pin 14 | Pulse train during RS-232 I/O. | RS-232 TX line. |
| 10 | U106 pins 34 to 42 | Pulse train during IEEE-488 I/O. | IEEE-488 data bus. |
| 11 | U106 pins 26 to 31 | Pulses during IEEE-488 I/O. | IEEE-488 command lines. |
| 12 | U106 pin 24 | Low with remote enabled. | IEEE-488 REN line. |
| 13 | U106 pin 25 | Low during interface clear. | IEEE-488 IFC line. |
| 14 | U101 pin 84 | Pulse train. | ADRXB |
| 15 | U101 pin 91 | Pulse train. | ADTX |
| 16 | U101 pin 90 | Pulse train. | ADCLK |
| 17 | U101 pin 89 | Pulse train. | ADTS |

# Analog circuit checks

The following table summarizes checks for the analog circuits. These tests involve applying specific test voltages to the channel 1 input terminals and measuring voltages at the indicated test points.

Refer to Voltage measurement accuracy (on page 2-6) for the dc voltage input test connections.

Before testing, disable autozero by sending the following command over the remote interface:

```
:SYST:AZER0:STAT OFF
```

All voltage measurements are referenced to TP303.

| **Analog circuit checks** | | | |
|---|---|---|---|
| **Step** | **Item/component** | **Required condition** | **Remarks** |
| 1 | Function | DCV1 | Use DCV1 for measurements. |
| 2 | Input connections | CH1 HI and LO | Connect voltage source to CH1. |
| 3 | Measurement range | 100 V | Select 100 V range. |
| 4 | Input voltage | 100 V | Apply 100 V to CH1 input. |
| 5 | U601 pin 6 | +1 V | Buffer output. |
| 6 | TP652 | +10 V | Multiplexer output to A/D. |
| 7 | Measurement range | 10 V | Select 10 V range. |
| 8 | Input voltage | +10 V | Apply 10 V to CH1 input. |
| 9 | TP651 | +10 V | Preamplifier output. |
| 10 | TP652 | +10 V | Multiplexer output to A/D. |
| 11 | Measurement range | 1 V | Select 1 V range. |
| 12 | Input voltage | +1 V | Apply 1 V to CH1 input. |
| 13 | TP651 | +1 V | Preamplifier output. |
| 14 | TP652 | +10 V | Multiplexer output to A/D. |
| 15 | Measurement range | 100 mV | Select 100 mV range. |
| 16 | Input voltage | +100 mV | Apply 100 mV to CH1 input. |
| 17 | TP651 | +100 mV | Preamplifier output. |
| 18 | TP652 | +10 V | Multiplexer output to A/D. |
| 19 | Measurement range | 10 mV | Select 10 mV range. |
| 20 | Input voltage | +10 mV | Apply 10 mV to CH1 input. |
| 21 | TP651 | +1 V | Preamplifier output. |
| 22 | TP652 | +10 V | Multiplexer output to A/D. |

# Analog signal switching states

The following tables provide the switching states of the various integrated circuits and transistors for the basic measurement functions and ranges. You can use these tables to assist in tracing an analog signal from the channel 1 and channel 2 inputs to the A/D multiplexer.

| **Signal multiplexing gain switching** | | | | | |
|---|---|---|---|---|---|
| **Function and range** | **U626 (Signal)** | **U632 Pin 1** | **U632 Pin 8** | **U632 Pin 9** | **Gain** |
| **DCV1:** | | | | | |
| 10 mV | S4 | Off | Off | On | X10 |
| 100 mV | S4 | Off | On | Off | X100 |
| 1 V | S4 | Off | Off | On | X10 |
| 10 V | S4 | On | Off | Off | X1 |
| 100 V | S3 | Off | Off | On | X10 |
| **DCV2:** | | | | | |
| 100 mV | S4, S7 | Off | On | Off | X100 |
| 1 V | S4, S7 | Off | Off | On | X10 |
| 10 V | S4, S7 | On | Off | Off | X1 |
| **DCV2 (LQ MODE ON)*** | | | | | |
| 100 mV | S3, S7 | Off | On | Off | X100 |
| 1 V | S3, S7 | Off | Off | On | X10 |
| 10 V | S3, S7 | On | Off | Off | X1 |

*Send the following remote command to enable:
`:SENS:VOLT:CHAN2:LQM ON`

| **Input protection and low-noise preamplifier analog switching states** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Function and range** | **Q666** | **Q667** | **Q664** | **Q665** | **Q672** | **Q673** | **Q674** | **U645 Pin 1, 16** | **U645 Pin 8** | **U645 Pin 9** |
| **DCV1:** | | | | | | | | | | |
| 10 mV | On | On | On | On | Off | Off | Off | On | Off | Off |
| 100 mV | On | On | On | On | Off | Off | Off | Off | Off | On |
| 1 V | On | On | On | On | Off | Off | Off | Off | Off | On |
| 10 V | On | On | Off | On | Off | Off | Off | Off | Off | On |
| 100 V | Off | Off | Off | Off | On | On | On | Off | Off | On |
| **DCV2:** | **Q661** | **Q662** | **Q671** | | | | | | | |
| 100 mV | On | On | On | | | | | Off | Off | On |
| 1 V | On | On | On | | | | | Off | Off | On |
| 10 V | On | On | On | | | | | Off | Off | On |

## No comm link error

A "No Comm Link" error indicates that the front panel processor has stopped communicating with the main processor, which is on the motherboard. This error indicates that one of the main processor ROMs may require re-seating in its socket.

***To reset the ROMs:***

1. Turn off the power.
2. Disconnect the line cord and all other test leads and cables from the instrument.
3. Remove the case cover as described in Disassembly (on page 6-1).
4. Locate the two firmware ROMs, U102 and U103, on the motherboard. These are the only integrated circuits (ICs) installed in sockets.
5. Carefully push down on each ROM IC to make sure it is properly seated in its socket.

CAUTION

**Be careful not to push down excessively to prevent cracking the motherboard.**

6. Connect the line cord.
7. Turn on the power. If the problem persists, additional troubleshooting will be required.

# Factory service

If you need to return the 2182A for repair or calibration, call 1-800-408-8165 or complete the form at https://www.tek.com/en/services/repair/rma-request (tek.com/en/services/repair/rma-request).

When you request service, you need the serial number and firmware or software version of the instrument.

Section 6

# Disassembly

## In this section:


Introduction ..... 6-1
Handling and cleaning ..... 6-1
Assembly drawings ..... 6-3
Disassembly ..... 6-3
Main CPU firmware replacement ..... 6-5
Changing trigger link lines ..... 6-6
Removing power components ..... 6-7
Instrument reassembly ..... 6-8


# Introduction

This section explains how to handle, clean, and disassemble the 2182A. Disassembly drawings are provided at the end of this section.

# Handling and cleaning

To avoid contaminating PC board traces with body oil or other foreign matter, avoid touching the PC board traces while you are repairing the instrument. Some board areas have high-impedance devices or sensitive circuitry where contamination could cause degraded performance.

## Handling PC boards

Observe the following precautions when handling PC boards:

- Wear cotton gloves.
- Handle PC boards only by the edges and shields.
- Do not touch any board traces or components not associated with repair.
- Do not touch areas adjacent to electrical contacts.
- Use dry nitrogen gas to clean dust off PC boards.

## Solder repairs

Observe the following precautions when soldering a circuit board:

- Use an OA-based (organic activated) flux. Take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work area when you have finished the repair by using pure water with clean, foam-tipped swabs or a soft clean brush.
- Once you have removed the flux, swab only the repair area with methanol, then blow dry the board with dry nitrogen gas.
- After cleaning, allow the board to dry in a 50 °C low-humidity environment for several hours.

## Static-sensitive devices

CAUTION

**Many CMOS devices are installed in the 2182A. Handle all semiconductor devices as being static sensitive.**

CMOS devices operate at very high impedance levels. Therefore, any static that builds up on you or your clothing may be sufficient to destroy these devices if they are not handled properly. Use the following precautions to avoid damaging them:

- Transport and handle integrated circuits only in containers specially designed to prevent static build-up. Typically, you will receive these parts in antistatic containers made of plastic or foam. Keep these devices in their original containers until ready for installation.
- Remove the devices from their protective containers only at a properly grounded workstation. Also, ground yourself with a suitable wrist strap.
- Handle the devices only by the body; do not touch the pins.
- Ground any printed circuit board into which a semiconductor device is to be inserted to the bench or table.
- Use only antistatic type desoldering tools.
- Use only grounded-tip solder irons.
- Once the device is installed in the PC board, it is normally adequately protected, and you can handle the boards normally.

# Assembly drawings

Use the following assembly drawings to assist you as you disassemble and reassemble the 2182A. The drawings are provided at the end of this section.

- Front Panel Assembly: 2182-040
- Chassis/Transformer Power Supply Assembly: 2182-050
- Front Panel/Chassis Assembly: 2182-051
- Chassis Assembly: 2182-052
- Final Inspection: 2182-080

# Disassembly

## Case cover removal

**WARNING**

**Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before removing the case cover. Failure to do so could expose the operator to hazardous voltages that could result in personal injury or death.**

***To remove the case cover to gain access to internal parts:***

1. **Remove handle:** The handle serves as an adjustable tilt-bail. Adjust its position by gently pulling it away from the sides of the instrument case and swinging it up or down. To remove the handle, swing the handle below the bottom surface of the case and back until the orientation arrows on the handles line up with the orientation arrows on the mounting ears. With the arrows lined up, pull the ends of the handle away from the case.
2. **Remove mounting ears:** Remove the screw that secures each mounting ear. Pull down and out on each mounting ear.

NOTE

When reinstalling the mounting ears, make sure to mount the right ear to the right side of the chassis, and the left ear to the left side of the chassis. Each ear is marked "RIGHT" or "LEFT" on its inside surface.

3. **Remove rear bezel:** To remove the rear bezel, loosen the two captive screws that secure the rear bezel to the chassis. Pull the bezel away from the case.
4. **Remove grounding screws:** Remove the two grounding screws that secure the case to the chassis. They are on the bottom of the case at the back.
5. **Remove cover:** To remove the case, grasp the front bezel of the instrument and carefully slide the chassis forward. Slide the chassis out of the metal case.

## Motherboard removal

### NOTE

This procedure assumes that the case cover is already removed as described in Case cover removal (on page 6-3).

***To remove the motherboard.***

1. Remove the IEEE-488, RS-232, and BNC jack fasteners.
2. The IEEE-488 and the RS-232 connectors each have two nuts that secure the connectors to the rear panel, while the BNC jack has a single nut. Remove these nuts.
3. Remove the input jack.
4. Remove the four screws that secure the input jack PC board to the front panel. Remove the ground wire from the chassis bolt, then remove the assembly.
5. Remove the following cables:
   - Unplug the display board ribbon cable from connector J1003.
   - Unplug the transformer cables from connectors J1015 and J1016.
   - Unplug the cable from J1014.
   - Remove the cables from the cable clips at each side of the chassis and remove the cable ties.
6. Remove screw.
7. Remove the screw that secures the motherboard to the chassis. This screw also secures U304.
8. Remove the motherboard, which is held in place by edge guides on each side, by sliding it forward until the board edges clear the guides. Carefully pull the motherboard from the chassis.

## Front-panel disassembly

***To disassemble the front panel:***

1. Remove the power pushrod.
2. Carefully pry the end of the power pushrod free of the power switch.
3. Remove the front-panel assembly.

   This assembly has four retaining clips that snap onto the chassis over four PEM nut studs. Two retaining clips are on each side of the front panel. Pull the retaining clips outward and, at the same time, pull the front-panel assembly forward until it separates from the chassis.
4. Use a thin-bladed screwdriver to pry the plastic PC board stop (at the bottom of the display board) until the bar separates from the casing. Pull the display board from the front panel.
5. Remove the switch pad by pulling it from the front panel.

# Main CPU firmware replacement

The firmware revision levels for the main and front panel CPUs are displayed during the power-on sequence. (The main firmware revision level is displayed on the left; the front panel firmware revision level is displayed on the right.) For example: REV: A01 A02 indicates a main firmware revision level of A01 and a front panel firmware revision level of A02.

## NOTE

To update the firmware on a 2182A, refer to the instructions in the release notes for the 2182A firmware, available at tek.com/keithley.

On the 2182 only, changing the firmware may be necessary as upgrades become available. The 2182 firmware for the main CPU is located in the EPROMs U102 (EVEN) and U103 (ODD), leadless ICs that reside in chip carriers on the PC board.

## ⚠ WARNING

**Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before replacing the CPU. Failure to do so could expose the operator to hazardous voltages that could result in personal injury or death.**

***To replace the main CPU on a 2182:***

1. Remove the case cover as described in Case cover removal (on page 6-3).
2. Locate U102 EVEN and U103 ODD (EPROMs) on the motherboard. They are the only devices installed in chip carriers (sockets).

## CAUTION

**EPROMs U102 and U103 are static-sensitive devices. Be sure to follow the handling precautions explained in Static-sensitive devices (on page 6-2).**

3. Using an appropriate chip extractor, remove U102 from its chip carrier.
4. Position the new U102 EPROM on the appropriate chip carrier. Make sure the notched corner of the chip is aligned with the notch in the chip carrier.

## NOTE

Be sure to install the correct EPROMs at the ODD and EVEN locations. The instrument will not function if the EPROMs are installed in the wrong sockets.

5. With the EPROM properly positioned, push down on the chip until it completely seats into the chip carrier.
6. Repeat steps 3 through 5 for EPROM U103.
7. After installation, make sure the instrument powers up normally before replacing the cover.

# Changing trigger link lines

The 2182A uses two lines of the TRIGGER LINK rear-panel connector as External Trigger (EXT TRIG) input and Voltmeter Complete (VMC) output. At the factory, line 1 is configured as VMC and line 2 as EXT TRIG. Line 1, 3 or 5 of the Trigger Link can be configured as VMC, while line 2, 4 or 6 can be configured as EXT TRIG. You can change trigger link line configurations by changing the resistor connections, as summarized in the following table.

| Trigger Link connection | Resistor |
|---|---|
| VMC to line 1* | R145 |
| VMC to line 3 | R146 |
| VMC to line 5 | R147 |
| EXT TRIG to line 2* | R142 |
| EXT TRIG to line 4 | R143 |
| EXT TRIG to line 5 | R144 |

* Factory default

## WARNING

**Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before changing the Trigger Link lines. Failure to do so could expose the operator to hazardous voltages that could result in personal injury or death.**

***To change Trigger Link lines:***

1. Remove the case cover as described in Case cover removal (on page 6-3).
2. The resistors used to select the trigger link lines are next to the Trigger Link connector. The "resistors" are actually solder beads that bridge PC board pads. If the factory default lines are selected, the solder beads are located at R145 (line 2, EXT TRIG) and R142 (line 1, VMC).
3. To change a trigger link line:
   - Use a soldering iron and solder sucker to remove the appropriate solder bead.
   - Using a solder with OA-based flux, apply a solder bead to the appropriate resistor location.
   - Replace the cover on the instrument.

## CAUTION

**Use care when removing and installing resisters. Excessive heat may damage PC board pads or traces.**

# Removing power components

The following procedures to remove the power transformer and power module require that the case cover and motherboard be removed, as described in Case cover removal (on page 6-3) and Motherboard removal (on page 6-4).

**WARNING**

**Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before removing the case cover. Failure to do so could expose the operator to hazardous voltages that could result in personal injury or death.**

## Power transformer removal

***To remove the power transformer:***

1. Remove the motherboard.
2. Unplug the transformer wires that are connected to the power module at the rear panel.
3. Remove the cable tie.
4. Remove the two nuts that secure the transformer to the bottom of the chassis.
5. Remove the transformer shield.
6. Pull the black ground wire off the threaded stud, and remove the power transformer from the chassis along with the shielded wires.

## Power module removal

***To remove the power module:***

1. Remove the motherboard.
2. Unplug the transformer wires that attach to the power module at the rear panel.
3. Disconnect the power module's ground wire. This green and yellow wire connects to a threaded stud on the chassis with a nut.
4. Squeeze the latches on either side of the power module while pushing the module from the access hole.

# Instrument reassembly

Reassemble the instrument by reversing the previous disassembly procedures. Make sure that all parts are properly seated and secured, and that all connections are properly made.

**WARNING**

**To ensure continued protection against electrical shock, verify that power line ground (green and yellow wire attached to the power module), the power transformer ground (black wire), and input jack ground (green wire) are securely connected to the chassis. Also make sure that the case grounding screws at the bottom rear are securely installed.**

## Power module connections

During reassembly, connect power module wires as summarized in the following table.

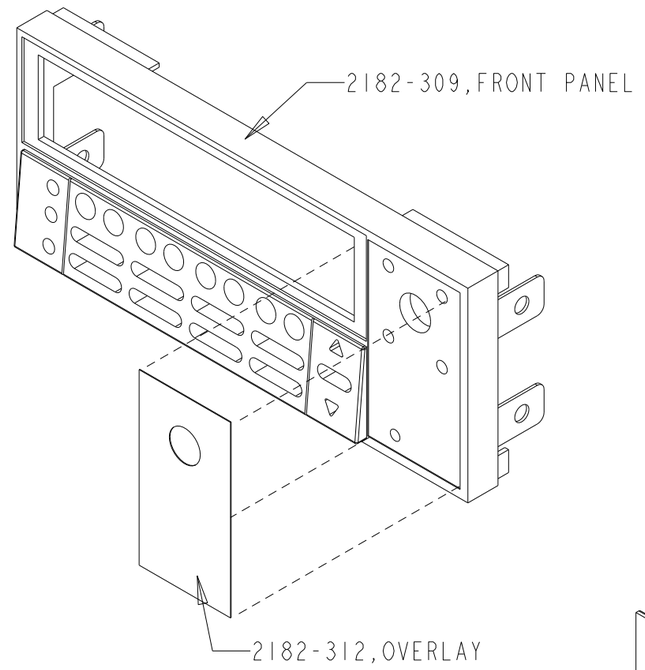
| Power module connections | |
|---|---|
| **Wire** | **Color** |
| Top | Gray |
| Right top | Violet |
| Right bottom | White |
| Left top | Red |
| Left bottom | Blue |

## Board installation

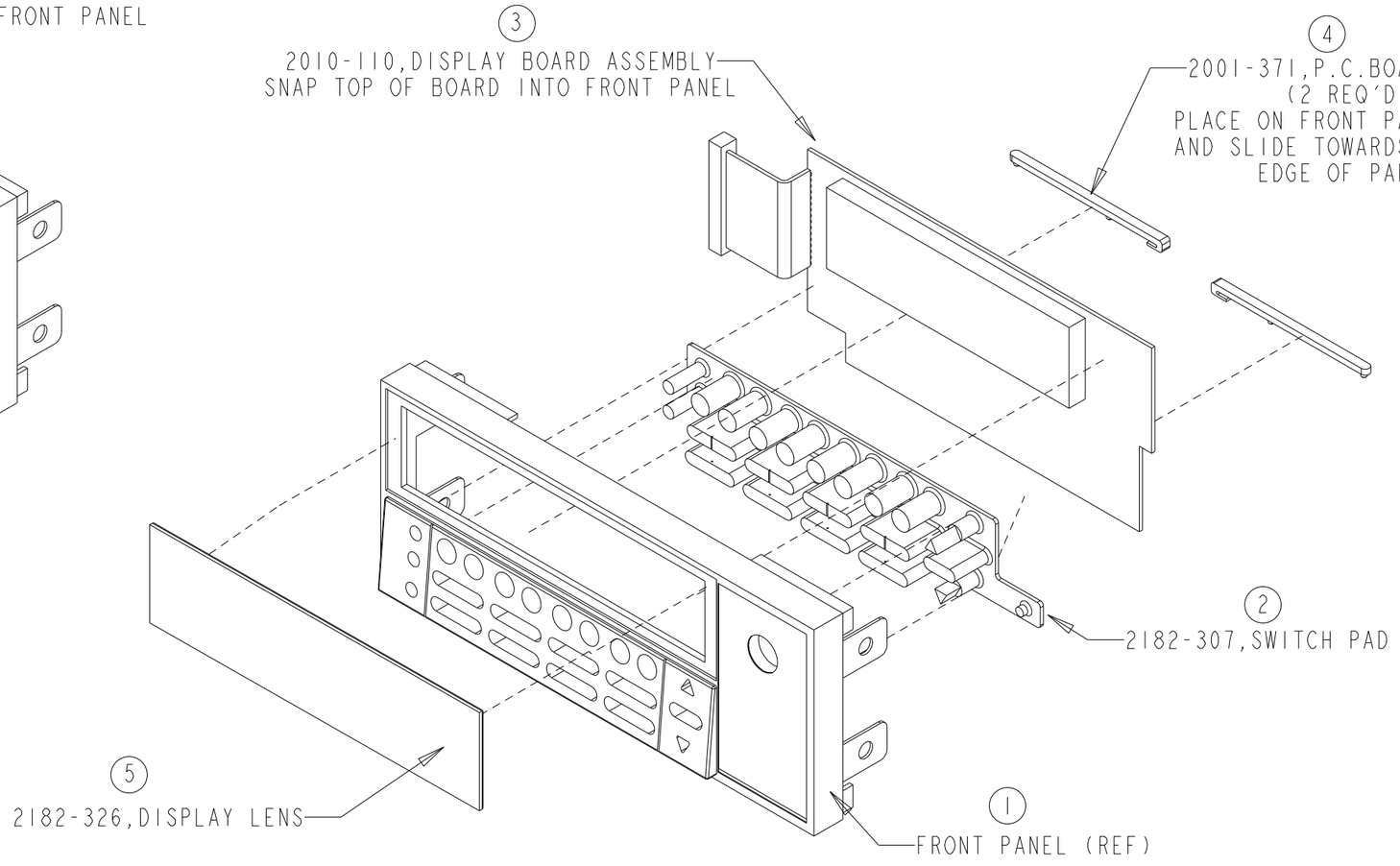
During reassembly, replace the motherboard, and start the IEEE-488, RS-232, and BNC jack connector nuts and the mounting screw. Tighten all the fasteners once they are all in place and the board is correctly aligned.

| LTR | | REVISION | | DATE |
|---|---|---|---|---|
| B | | 2182-326A Was 2182-314B;<br>Update Used On Block | | 2/24/04 |
| B1 | | Del Rev's & Rev Symbols | | 1/31/05 |
| | | | | |

**STEP 1**



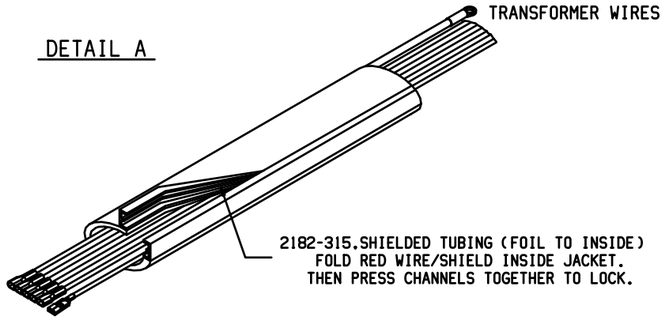

**STEP 2**



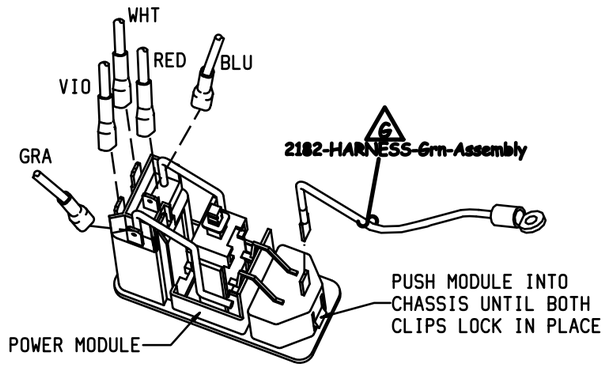

| DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED | DATE 5/20/97 | SCALE ----- | TITLE Front Panel Assembly OP6 |
|---|---|---|---|
| XX = ±.015 ANG. = ±1° | | | |
| XXX = ±.005 FRAC. = ±1/64 | MATERIAL | | NO. 2182-040 |
| SURFACE MAX. 63 | FINISH | | |

| LTR | | REVISION | | DATE |
|---|---|---|---|---|
| G | | See ECA For Change Information | | 11/30/11 |
| | | | | |
| | | | | |

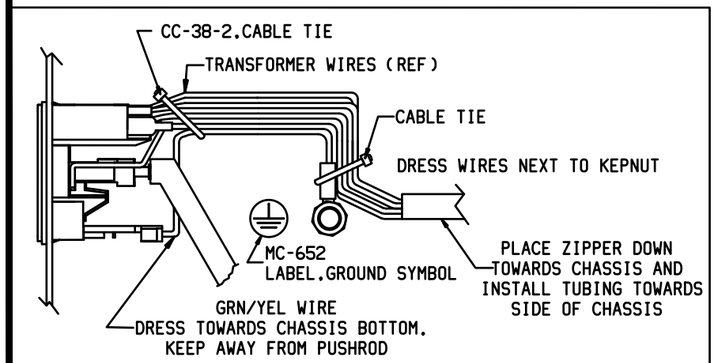
DETAIL A




DETAIL B TRANSFORMER WIRING




USE T-7892







Part Images May Differ From Actual Part Appearance

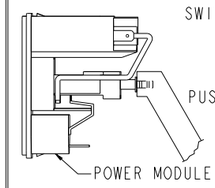
| DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED | DATE 5/13/97 | SCALE | TITLE Chassis/Transformer Power Supply Assembly |
|---|---|---|---|
| XX - ±.015 ANG - ±1° | | | |
| XXX - ±.005 FRAC - ±1/64 | MATERIAL | B | NO. 2182-050 |
| SURFACE MAX 63 | FINISH | | |

2182
MODEL

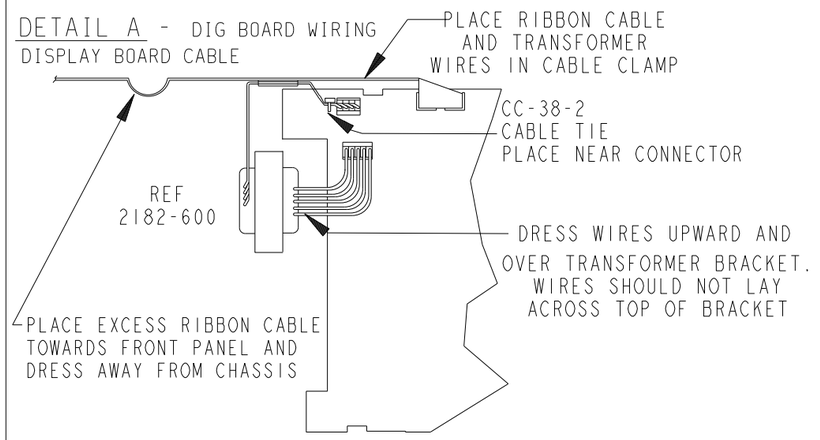
NO. 2182-051

| LTR | | REVISION | | DATE |
|---|---|---|---|---|
| E | | Del Rev's & Symbols<br>Add Detail B, 2001-320 | | 8/2/04 |

DETAIL B PROPERLY INSTALLED PUSH ROD
TOP VIEW

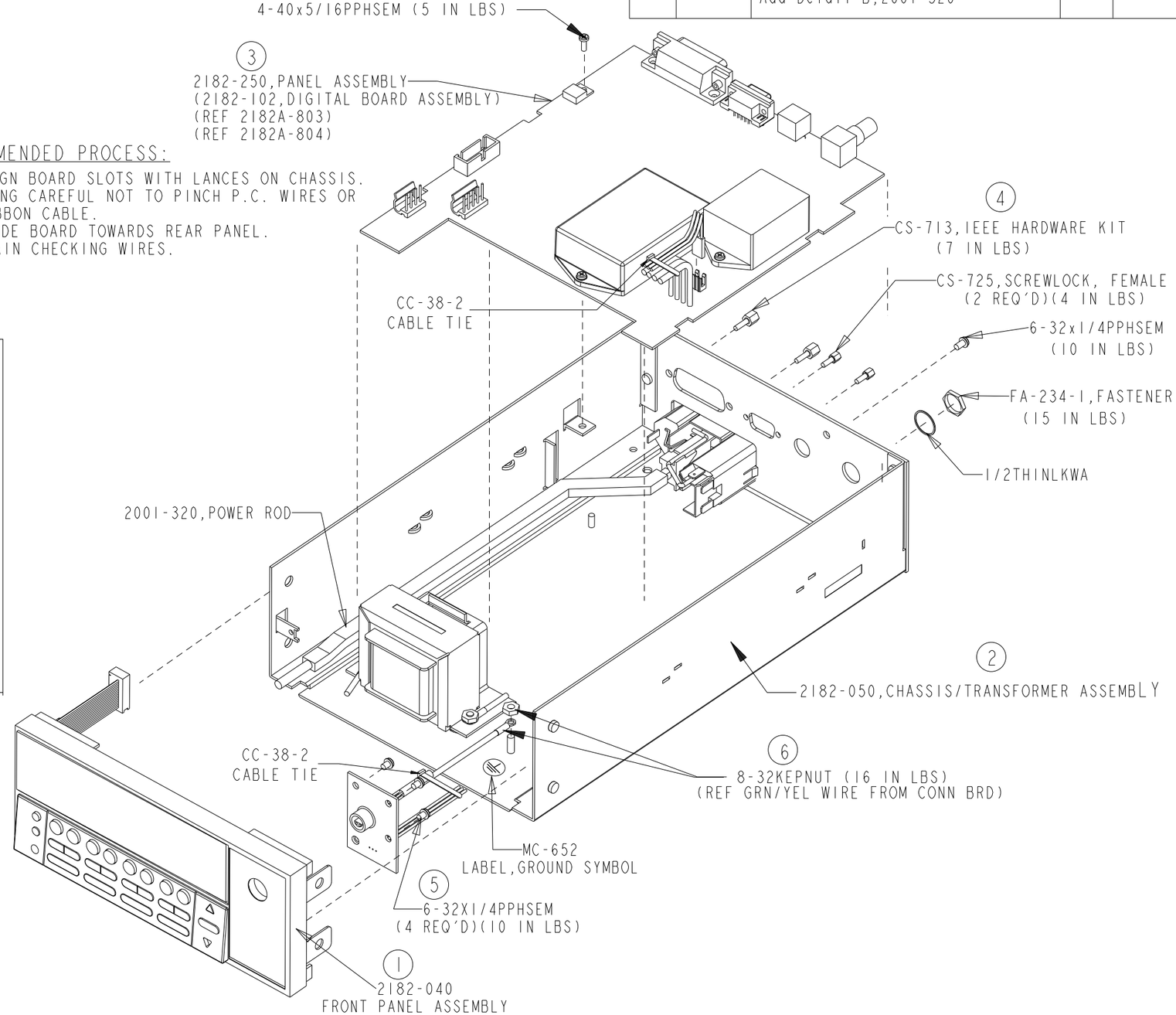



DETAIL A - DIG BOARD WIRING




RECOMMENDED PROCESS:

ALIGN BOARD SLOTS WITH LANCES ON CHASSIS.
BEING CAREFUL NOT TO PINCH P.C. WIRES OR
RIBBON CABLE.
SLIDE BOARD TOWARDS REAR PANEL.
AGAIN CHECKING WIRES.



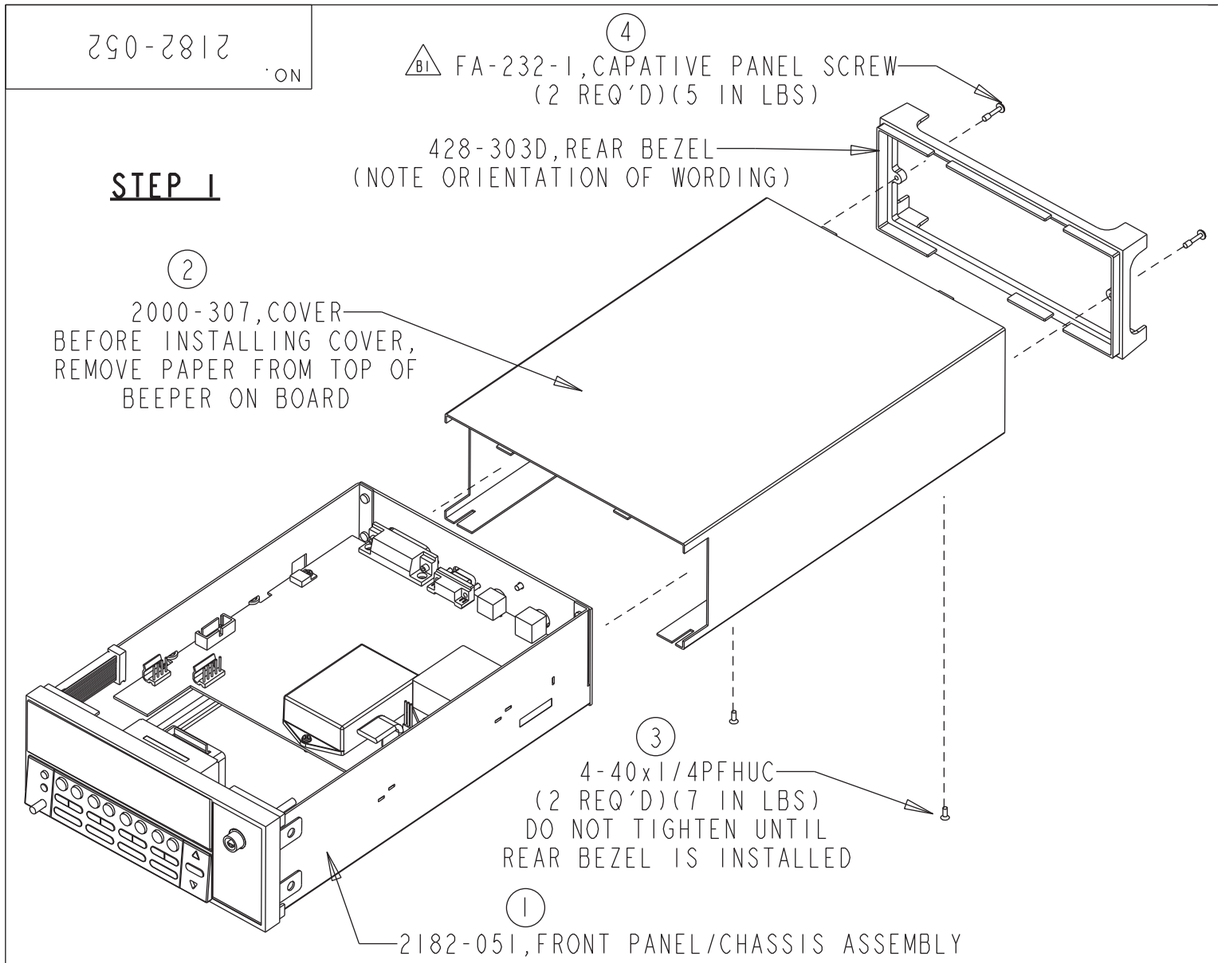

| PART NUMBER | QTY | DESCRIPTION |
|---|---|---|
| 2182-050 | 1 | CHASSIS/TRANSFORMER ASSEMBLY |
| 2182-040 | 1 | FRONT PANEL ASSEMBLY |
| 2182-250 | 1 | DIGITAL BOARD & CONNECTOR BOARD |
| | | (REF 2182A-803 |
| | | (REF 2182A-804 |
| CS-713 | 1 | IEEE HARDWARE KIT |
| CS-725 | 2 | SCREWLOCK, FEMALE |
| 4-40X5/16PPHSEM | 1 | PHIL PAN HEAD SEMS SCREW |
| 6-32X1/4PPHSEM | 5 | PHIL PAN HEAD SEMS SCREW |
| 2001-320 | 1 | POWER ROD |
| 8-32KEPNUT | 1 | KEPNUT |
| FA-234-1 | 1 | FASTENER |
| 1/2THINLKWA | 1 | THIN LOCKWASHER |
| CC-38-2 | 3 | CABLE TIE |
| MC-652 | 1 | LABEL, GROUND SYMBOL |

| | | | | |
|---|---|---|---|---|
| DO NOT SCALE THIS DRAWING | DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED | DATE 6/6/97 | SCALE ----- | TITLE Front Panel/Chassis Assembly |
| | XX = ±.015 ANG. = ±1° | | | |
| | XXX = ±.005 FRAC. = ±1/64 | MATERIAL | B | NO. 2182-051 |
| | SURFACE MAX. 63 | FINISH | | |

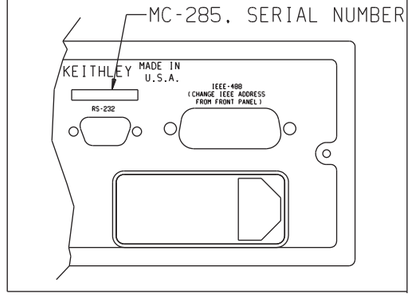
2182-052
ON

| LTR | | REVISION | | DATE |
|---|---|---|---|---|
| B | | Add 428-329F Handle | | 3/27/03 |
| B1 | | See ECA For Change Information | | 1/28/09 |
| | | | | |

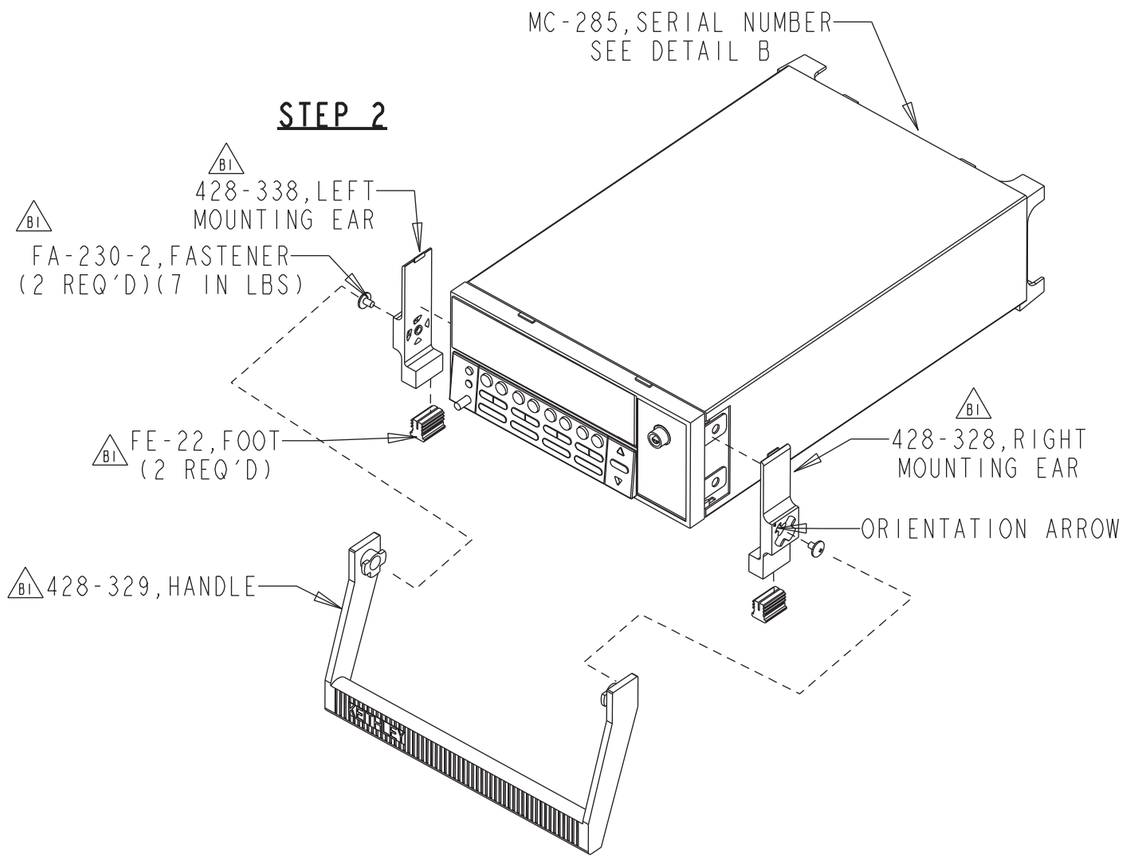
## STEP 1



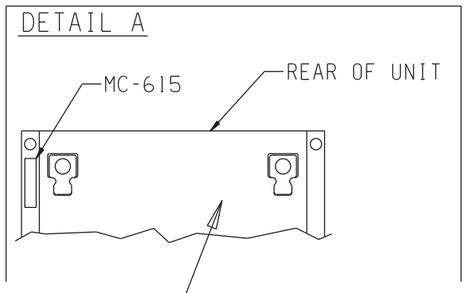

DETAIL B




## STEP 2



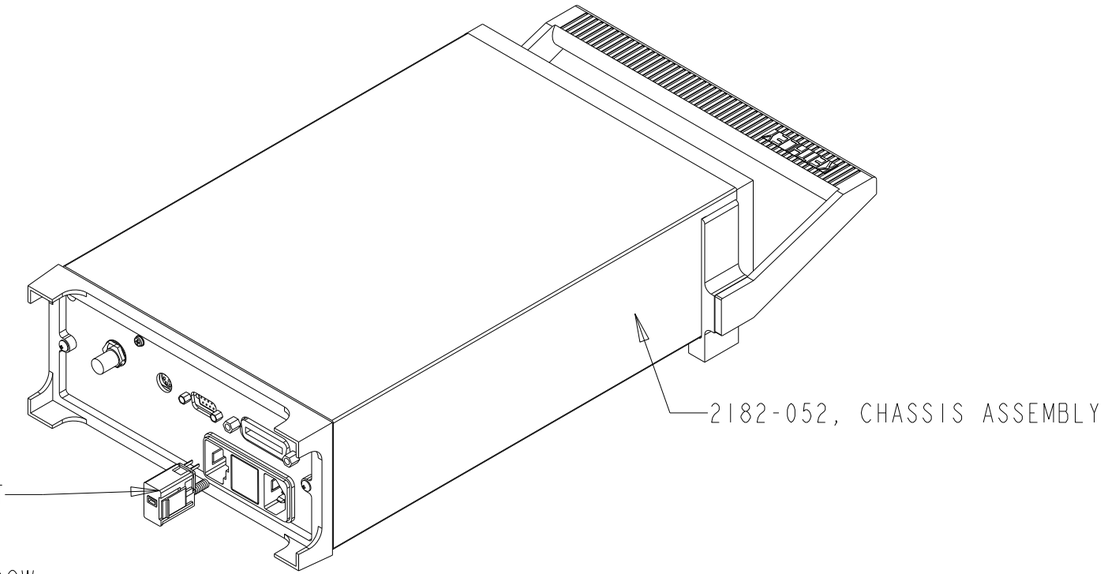

DETAIL A




| | | | | |
|---|---|---|---|---|
| DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED | DATE 6/4/97 | SCALE ----- | TITLE Chassis Assembly -- OP6 | |
| XX = ±.015 ANG. = ±1° | | | | |
| XXX = ±.005 FRAC. = ±1/64 | MATERIAL | | B | NO. 2182-052 |
| SURFACE MAX. 63 | FINISH | | | |

NO. 2182-080

| LTR | | REVISION | | DATE |
|---|---|---|---|---|
| G | | Del PO-14-4,C0-26,C0-35<br>Various Updates | | 3/27/03 |
| | | | | |
| | | | | |




| VOLTAGE | FUSE |
|---|---|
| JAPAN 100V<br>DOMESTIC 120V | FU-96-4 .25A<br>EXISTING FUSE |
| EUROPE 220V<br>-------- 240V | FU-91 |

| PART NUMBER | QTY | DESCRIPTION |
|---|---|---|
| 2182-052 | 1 | CHASSIS ASSEMBLY |
| | | |
| | | |
| | | |
| | | |
| | | |
| FOR EUROPE | | |
| FU-91 | 1 | FUSE 1/8 AMP |

| | | | | |
|---|---|---|---|---|
| DO NOT SCALE THIS DRAWING | DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED | DATE 08-Mar-00 | SCALE --- | TITLE FINAL INSPECTION |
| | XX = ±.015 ANG. = ±1° | | | |
| | XXX = ±.005 FRAC. = ±1/64 | MATERIAL | B | NO. 2182-080 |
| | SURFACE MAX. 63 | FINISH | | |

Section 7

# Calibration reference

## In this section:


Introduction ..... 7-1
Command summary ..... 7-2
Default calibration constants and tolerances ..... 7-2
General calibration commands ..... 7-4
Calibration step commands ..... 7-9
Precalibration commands ..... 7-10
Detecting calibration errors ..... 7-11
Detecting calibration step completion ..... 7-13


# Introduction

This section contains detailed information on the 2182A remote calibration commands, calibration error messages, and methods to detect the end of each calibration step.

For the calibration procedures, refer to Calibration (on page 3-1).

# Command summary

The 2182A calibration commands are summarized in the following table. These commands are covered in detail in the following paragraphs.

**Remote calibration command summary**

| Command | Description |
|---|---|
| :CALibration | |
| :PROTected | |
| :CODE <name> | Send the code to unlock calibration. Default: 'KI002182'. |
| :INITiate | Required before starting any other cal steps. |
| :PCAL | Precal commands.* |
| :STEP0 <nrf> | Precal 10 V input. |
| :STEP1 <nrf> | Precal 0 V input. |
| :STEP2 <nrf> | Precal 1 V front input. |
| :DC | Normal calibration commands. |
| :STEP1 | Normal calibration short-circuit input. |
| :STEP2 | Normal calibration open-circuit. |
| :STEP3 <nrf> | Normal calibration +10 V input. |
| :STEP4 <nrf> | Normal calibration –10 V input. |
| :STEP5 | Analog output calibration.* |
| :DATE <string> | Set the cal date. |
| :DATE? | Query cal date. |
| :NDUE <string> | Set the due date for the next cal. |
| :NDUE? | Query cal due date. |
| :SAVE | Save cal constants.** |
| :LOCK | Lock out calibration. |
| :LOCK? | Query lock status. |
| :DATA? | Query cal constants (unlocking not required). |
| :COUNt? | Query cal count. |

*Factory cal only. Send :DIAG:KEIT:CAL:UNLOCK to enable.

**Calibration data is not saved if an error occurred.

# Default calibration constants and tolerances

Default calibration constants and tolerances for the 2182A are listed in the following table. The tolerances for user-entered values are expressed as a percentage (10%). For example, for the +10 V calibration, the calibration signal can be +9 V to +11 V. The rest of the tolerances are expressed as full-scale values. Most are 10% of the default value.

The tolerance for the autocalibration (ACAL) temperature constant (ACalTemp) is ±30 °C of the default (which is 30 °C). Therefore, valid ACAL can be performed for temperatures from 0 °C to 60 °C.

| Default calibration constants and tolerances | | | | |
|---|---|---|---|---|
| **Cal constant name** | **Default cal constant** | **Cal constant tolerance** | **Typical constants** | **Description** |
| usr_10vfs | +10e+0 | 10% | 1.0000000E+01 | +10 V value entered by user. |
| usr_m10vfs | −10e+0 | 10% | −1.0000000E+01 | −10 V value entered by user. |
| usr_100vfs | +100e+0 | 10% | 1.0000000E+02 | +100 V value entered by user (not used). |
| aper_corr_1plc | +1.44e−1 | 1.44e−2 | 1.4449467E−01 | Gain-aperture correction, 1 PLC. |
| aper_corr_5plc | +1.44e−1 | 1.44e−2 | 1.4449382E−01 | Gain-aperture correction, 5 PLC. |
| c10mvz | −6e−6 | 2e−2 | 5.3548538E−06 | Zero, 10 mV range. |
| c1vz | −6e−6 | 8e−5 | 8.5682575E−08 | Zero, +1 V. |
| c10vz | −4e−7 | 1e−4 | −2.9889257E−07 | Zero, +10 V. |
| c100vz | −6e−6 | 8e−5 | −2.6752717E−07 | Zero, +100 V. |
| c10vratz_ch2hi | −6.00e−6 | 6.00e−5 | 3.4445513E−08 | Zero, +10 V, channel 2 high. |
| c10vratz | −4e−6 | 8e−5 | 6.9316616E−07 | Zero, +10 V, channel 2 low. |
| c10vratz_LOW_Q | −4e−6 | 8e−5 | −3.5030445E−07 | Zero, +10 V, channel 2 low-pumpout mode. |
| c10vfs | +1.4231e+0 | 1.44e−1 | 1.4294341E+00 | Full scale, +10 V. |
| cm10vfs | −1.44e+0 | 1.44e−1 | −1.4294396E+00 | Full scale, −10 V. |
| cFE_B_0_DIV100 | −6.00e−6 | 6.00e−5 | −2.3740633E−07 | Background zero x1/100 gain. |
| c100vfs | −6.00e−6 | 1.00e−3 | −4.7622696E−04 | Check for voltage applied at start of full ACAL. |
| cm100vfs | −1.44e−1 | 1.44e−2 | −1.4400000E−01 | Full scale, −100 V (not used; no 100 V cal step). |
| cFE_B_7_DIV100 | +1.00e−2 | 1.00e−3 | 9.9931261E−03 | ACAL 7 V reference, x1/100 gain. For 100 V range. |
| cFE_B_7_1 | +1.00e+0 | 1.00e−1 | 9.9988576E−01 | ACAL 7 V reference, x1 gain. For 100 V range. |
| cFE_B_0_1_100V | −6.00e−6 | 6.00e−5 | −6.0000000E−06 | ACAL, 100 V divider gain. Not used. |
| cFE_B_1_1 | +1.44e−1 | 1.44e−2 | 1.4449498E−01 | ACAL 1 V reference, x1 gain. For 10 mV range. |
| cFE_B_1_10 | +1.44e+0 | 8.64e−1 | 1.4436776E+00 | ACAL 1 V reference, x10 gain. For 10 mV range. |
| cFE_B_0_10 | +1.44e−1 | 1.44e−2 | 1.4294286E−01 | c1V_Icorr_off @ 1PLC |
| cFE_B_P1_10 | +1.44e−1 | 8.64e−2 | 1.5625974E−01 | ACAL 0.1 V reference, x10 gain. For 10 mV range. |
| cFE_B_P1_100 | +1.44e+0 | 2.88e−1 | 1.5614776E+00 | ACAL 0.1 V reference, x100 gain. For 10 mV range. |
| cFE_B_0_100 | +1.44e−1 | 1.44e−2 | 1.4294303E−01 | c1v_Icorr_on @ 1 PLC |
| ACalTemp | 30.0 | ±30 | 3.2249547E+01 | Temperature (in °C) of instrument during ACAL. |
| caoutvz | 0.00025 | 0.025 | 2.8907327E−04 | Analog output, DAC at 0. |
| caoutv32000 | −1.667e−1 | 3.2e−2 | −1.7226908E−01 | Analog output, DAC at +32000. |
| caoutvm32000 | 1.667e−1 | 3.2e−2 | | Analog output, DAC at −32000. |

# General calibration commands

The general calibration commands perform functions such as saving calibration constants, locking out calibration, and programming date parameters.

## :CALibration:PROTected:CODE

This command unlocks calibration so that you can perform the calibration procedures.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Command only | Not applicable | Not applicable | Not applicable |

### Usage

```
:cal:prot:code '<code>'
```

| | |
|---|---|
| `<code>` | Up to an 8-character string including letters and numbers. |

### Details

The `:CODE` command sends the code and enables calibration when performing these procedures using remote communications. The correct code must be sent to the instrument before sending any other calibration command. The default remote code is `KI002182`.

The `:CODE` command should be sent only once before performing calibration. Do not send `:CODE` before each calibration step.

To change the code, first send the present code, then send the new code.

The code parameter must be enclosed in single quotes.

If you change the first two characters of the code to something other than "KI", you will not be able to unlock calibration from the front panel.

### Example

| | |
|---|---|
| `:CAL:PROT:CODE 'KI002182'` | Send default code of `KI002182`. |

### Also see

None

# :CALibration:PROTected:COUNT?

To request the number of times the 2182A has been calibrated.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Query only | Not applicable | Not applicable | Not applicable |

### Usage

```
:cal:prot:count?
```

### Details

Returns the number of times the instrument has been calibrated.

The `:COUNT?` query may be used to determine the total number of times the 2182A has been calibrated.

### Example

| | |
|---|---|
| `:CAL:PROT:COUNT?` | Request calibration count. |

### Also see

None

# :CALibration:PROTected:LOCK

Locks out calibration.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Command and query | Not applicable | Not applicable | Not applicable |

### Usage

```
:cal:prot:lock
:cal:prot:lock?
```

### Details

Query response:

- 0: Calibration unlocked
- 1: Calibration locked

The `:LOCK` command allows you to lock out calibration after completing those procedures. Thus, `:LOCK` performs the opposite of sending the code with the `:CODE` command. The `:LOCK?` query returns calibration lock status.

## NOTE

To unlock calibration, send the :CODE command with the appropriate password.

### Example

| | |
|---|---|
| :CAL:PROT:LOCK | Lock out calibration. |

### Also see

:CALibration:PROTected:CODE (on page 7-4)

# :CALibration:PROTected:SAVE

Saves calibration constants in EEROM after the calibration procedure.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Command only | Not applicable | Not applicable | Not applicable |

### Usage

```
cal:prot:save
```

| | |
|---|---|
| <n> | |

### Details

The :SAVE command stores internally calculated calibration constants derived during calibration in EEROM. EEROM is nonvolatile memory, and calibration constants are retained indefinitely once saved. Generally, :SAVE is sent after all other calibration steps (except for :LOCK).

## NOTE

Calibration is temporary unless the :SAVE command is sent to permanently store calibration constants. Calibration data is not saved if any errors occurred.

### Example

| | |
|---|---|
| :CAL:PROT:SAVE | Save calibration constants. |

### Also see

None

# :CALibration:PROTected:DATE

Programs the calibration date.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Command and query | Not applicable | Not applicable | Not applicable |

## Usage

```
:cal:prot:date <year>, <month>, <day>
:cal:prot:date?
```

| | |
|---|---|
| <year> | 1997 to 2096 |
| <month> | 1 to 12 |
| <day> | 1 to 31 |

## Details

Query response: <year>, <month>, <day>

The :DATE command allows you to store the calibration date in instrument EEROM for future reference. You can read back the date from the instrument by using the :DATE? query.

The year, month, and day parameters must be delimited by commas.

## Example

| | |
|---|---|
| `:CAL:PROT:DATE 2020,11,20` | Send cal date (11/20/20). |

## Also see

None

# :CALibration:PROTected:NDUE

Sends the next calibration due date to the instrument.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Command and query | Not applicable | Not applicable | Not applicable |

### Usage

```
:cal:prot:ndue <year>, <month>, <day>
:cal:prot:ndue?
```

| | |
|---|---|
| <year> | 1997 to 2096 |
| <month> | 1 to 12 |
| <day> | 1 to 31 |

### Details

Query response: <year>, <month>, <day>

The :NDUE command allows you to store the date when calibration is next due in instrument memory. You can read back the next due date by using the :NDUE? query.

The next due date parameters must be delimited by commas.

### Example

| | |
|---|---|
| :CAL:PROT:NDUE 2023,11,20 | Send due date (11/20/2023). |

### Also see

None

# :CALibration:PROTected:DATA?

Requests the calibration constants for the active range.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Query only | Not applicable | Not applicable | Not applicable |

### Usage

```
:cal:prot:data?
```

### Details

The :CAL:PROT:DATA? query requests the calibration constants for the active range. The returned constants are in ASCII floating-point format delimited by commas.

## NOTE

To request the appropriate constants, choose the range, and send the :DATA? query.

### Example

| | |
|---|---|
| `:CAL:PROT:DATA?` | Request calibration constants. |

### Also see

None

# Calibration step commands

## :CALibrate:PROTected:DC:STEP<n>

Performs calibration steps.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Command only | Not applicable | Not applicable | Not applicable |

### Usage

```
:cal:prot:dc:step<n>
```

| | |
|---|---|
| `<n>` | See **Details** |

### Details

The `:DC` commands perform the calibration steps summarized in the following table. All commands except `:STEP5` are part of the normal calibration procedure. See Calibration (on page 3-1) for details on performing the calibration steps.

NOTE

The appropriate calibration signal must be connected to the input jack before sending the corresponding `:STEP` command.

| Calibration step command | Description |
|---|---|
| `:CAL:PROT:DC:STEP1` | Low thermal short. |
| `:CAL:PROT:DC:STEP2` | Open-circuit input. |
| `:CAL:PROT:DC:STEP3 10` | +10 V calibration |
| `:CAL:PROT:DC:STEP4 -10` | −10 V calibration |
| `:CAL:PROT:DC:STEP5` | Analog output* |

* Factory calibration only. Send `:DIAG:KEIT:CAL:UNLOCK` to enable.

### Example

| | |
|---|---|
| `:CAL:PROT:DC:STEP3 10` | Perform normal calibration 10 V step. |

### Also see

None

# Precalibration commands

## :CALibrate:PROTected:PCAL:STEP<n>

Performs precalibration steps.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Command only | Not applicable | Not applicable | Not applicable |

### Usage

```
:cal:prot:pcal:step<n>
```

| | |
|---|---|
| <n> | See **Details** |

### Details

NOTE

Precalibration :STEP commands are intended to be one-time manufacturing calibration steps. They are only allowed if the STEP key was held in at power-up.

The :PCAL commands perform the precalibration steps summarized in the following table. All these steps are part of factory calibration and are not normally performed in the field.

NOTE

The appropriate calibration signal must be connected to the input jack before sending the corresponding :STEP command.

Factory calibration is enabled by sending :DIAG:KEIT:CAL:UNLOCK.

| Precalibration step command | Description |
|---|---|
| :CAL:PROT:PCAL:STEP0 10 | 10 V precalibration |
| :CAL:PROT:PCAL:STEP1 0 | 0 V precalibration |
| :CAL:PROT:PCAL:STEP2 1 | 1 V precalibration |

### Example

| | |
|---|---|
| :CAL:PROT:PCAL:STEP2 1 | Perform precalibration 1 V step. |

### Also see

Calibration (on page 3-1)

## :CALibrate:PROTected:PCAL:DATA?

Query precalibration constants.

| Type | Affected by | Where saved | Default value |
|---|---|---|---|
| Query only | Not applicable | Not applicable | Not applicable |

### Usage

```
:CALibrate:PROTected:PCAL:DATA?
```

### Details

The :CAL:PROT:PCAL:DATA? query requests the precalibration constants. Two values are returned; the Linearity Correction Flag (1 or 0), and the offset DAC value. Note that unlocking with the STEP key is not required for this query command.

### Example

| | |
|---|---|
| :CAL:PROT:PCAL:DATA? | Request precalibration constants. |

### Also see

None

# Detecting calibration errors

If an error occurs during any calibration step, the 2182A generates an appropriate error message. Several methods to detect calibration errors are discussed below.

## Reading the error queue

As with other 2182A errors, any calibration errors are reported in the error queue. You can read the error queue by using the :SYST:ERR? query.

## Error summary

The following table summarizes calibration errors.

| Calibration errors | |
|---|---|
| **Error number** | **Error message** |
| +400 | "10m vdc zero error" |
| +401 | "1 vdc zero error" |
| +402 | "10 vdc zero error" |
| +403 | "100 vdc zero error" |
| +404 | "10 vdc full scale error" |
| +405 | "-10 vdc full scale error" |
| +406 | "100 vdc full scale error" |
| +408 | "10 vdc ch2 high zero error" |
| +409 | "10 vdc ch2 low zero error" |
| +410 | "B_7_div100 ACAL error" |
| +411 | "B_0_div100 ACAL error" |
| +412 | "B_7_1 ACAL error" |
| +413 | "B_0_1 ACAL error" |
| +414 | "B_1_1 ACAL error" |
| +415 | "B_1_10 ACAL error" |
| +416 | "ACAL not open-circuit" |
| +417 | "B_P1_10 ACAL error" |
| +418 | "B_P1_100 ACAL error" |
| +419 | "B_0_10 ACAL error" |
| +420 | "Analog output zero error" |
| +421 | "Analog positive gain error" |
| +422 | "Analog negative gain error" |
| +423 | "B_0_100 ACAL error" |
| +430 | "Precal selection error" |
| +431 | "Precal offset DAC zero error" |
| +432 | "ACAL Temperature error" |
| +438 | "Date of calibration not set" |
| +439 | "Next date of calibration not set" |
| +440 | "Gain-aperture correction error" |
| +449 | "10 vdc ch2 Low-Q zero error" |
| +500 | "Calibration data invalid" |

## Status byte EAV (Error Available) bit

Whenever an error is available in the error queue, the EAV (Error Available) bit (bit 2) of the status byte will be set. Use the *STB? query to obtain the status byte, then test bit 2 to see if it is set. If the EAV bit is set, an error has occurred, and you can use the appropriate error query to read the error and at the same time clear the EAV bit in the status byte.

### Generating an SRQ on error

To program the instrument to generate an IEEE-488 bus SRQ (Service Request) when an error occurs, send the following command: `*SRE 4`. This command enables SRQ when the EAV bit is set. You can then read the status byte and error queue as outlined above to check for errors and to determine the exact nature of the error.

## Detecting calibration step completion

When sending remote calibration commands, you must wait until the instrument completes the present operation before sending another command. You can use either `*OPC?` or `*OPC` to help determine when each calibration step is completed.

### Using the *OPC command

You can use the `*OPC` (operation complete) command to detect the completion of a calibration step. The following command sequence shows how to use *OPC with a calibration step:

```
*CLS      ' Clears all event registers and error queue.
*ESE 1    ' Enables OPC bit in standard event register.
*SRE 32   ' Enables ESB bit in status byte register.
:CAL:PROT:STEP1;*OPC    ' Perform calibration step and send *OPC.
```

After sending `*OPC`, use the serial poll (SPE, SPD) sequence to monitor the RQS bit of the serial poll (status) byte of the 2182A. When the calibration step is completed, a service request is generated and set the RQS bit, indicating that the next calibration step can now be performed.

#### NOTE

After a service request is generated, it must be cleared by reading the event status register by sending the following command:

`*ESR?`

Section 8

# Calibration program

## In this section:

Introduction ..... 8-1
Computer hardware requirements ..... 8-1
Software requirements ..... 8-1
Calibration equipment ..... 8-2
General program instructions ..... 8-2
Calibration program ..... 8-3

# Introduction

This section provides a calibration program written in BASIC to help you to field calibrate the 2182A. Refer to Calibration (on page 3-1) for details on calibration procedures, equipment, and connections. Refer to Calibration reference (on page 7-1) for descriptions of the calibration commands.

# Computer hardware requirements

The following computer hardware is required to run the calibration programs:

- IBM PC compatible computer.
- Keithley KPC-488.2, KPS-488.2, or KPC-488.2AT, or CEC PC-488 IEEE-488 interface for the computer.
- Two shielded IEEE-488 connecting cables (Keithley Model 7007).

# Software requirements

To use the calibration programs, you need the following computer software:

- Microsoft QBasic (supplied with MS-DOS 5.0 or later).
- MS-DOS version 5.0 or later.
- HP-style Universal Language Driver, CECHP.EXE (supplied with Keithley and CEC interface cards listed above).

# Calibration equipment

The following calibration equipment is required:

- Fluke 5700A calibrator
- Low thermal input cable
- Low thermal shorting plug

See Recommended verification equipment (on page 2-3) and Recommended calibration equipment (on page 3-6) for detailed equipment specifications.

# General program instructions

***To set up the instrument for the program:***

1. With the power off, connect the 2182A and the calibrator to the IEEE-488 interface of the computer. Be sure to use shielded IEEE-488 cables for bus connections.
2. Turn on the computer, the 2182A, and the calibrator. Allow the 2182A and the multimeter to warm up for at least 2½ hours before performing calibration.
3. Make sure the 2182A is set for its default primary address of 7.
4. Make sure the calibrator primary address is set at 4.
5. Make sure that the computer bus driver software (CECHP.EXE) is properly initialized.
6. Enter the QBasic editor, and type in the program below.
7. Check thoroughly for errors, then save it using a convenient filename.
8. Run the program, and follow the prompts on the screen to perform calibration. For test connections, refer to the following figures in Calibration (on page 3-1):
   - Low-thermal short connections: Front panel short and open calibration (on page 3-7)
   - Calibrator connections: DC volts calibration (on page 3-8)

# Calibration program

```
' 2182A calibration program for use with the Fluke 5700A calibrator.
' Rev. 1.0, 8/20/97
OPEN "IEEE" FOR OUTPUT AS #1  ' Open IEEE-488 output path.
OPEN "IEEE" FOR INPUT AS #2         ' Open IEEE-488 input path.
PRINT #1, "INTERM CRLF"       ' Set input terminator.
PRINT #1, "OUTTERM LF"        ' Set output terminator.
PRINT #1, "REMOTE 4 7"        ' Put 2182, 5700A in remote.
PRINT #1, "CLEAR"             ' Send DCL.
PRINT #1, "OUTPUT 7;:SYST:PRES;*CLS"       ' Initialize 2182.
PRINT #1, "OUTPUT 7;*ESE 1;*SRE 32"        ' Enable OPC and SRQ
PRINT #1, "OUTPUT 4;*RST;*CLS;STBY"        ' Reset 5700A calibrator.
C$ = ":CAL:PROT:DC:"          ' 2182 partial command header.
'
CLS       ' Clear CRT.
PRINT "Model 2182A Calibration Program"
PRINT #1, "OUTPUT 7;:CAL:PROT:CODE 'KI002182'"           ' Send KI002182 cal code.
PRINT #1, "OUTPUT 7;:CAL:PROT:INIT"        ' Initiate calibration.
GOSUB ErrCheck
RESTORE CmdList
'
FOR I = 1 TO 4         ' Loop for all cal points.
READ Msg$, Cmd$        ' Read message, cal strings.
SELECT CASE I          ' Select cal sequence.
        CASE 1, 2
                PRINT Msg$
                GOSUB KeyCheck
        CASE 3
                PRINT "Connect calibrator to CHANNEL 1 input."
                PRINT "Wait 2 minutes."
                GOSUB KeyCheck
                PRINT #1, "OUTPUT 4;EXTSENSE OFF"
                PRINT #1, "OUTPUT 4;"; Msg$
                PRINT #1, "OUTPUT 4;OPER"
        CASE 4, 5
                PRINT #1, "OUTPUT 4;"; Msg$
                PRINT #1, "OUTPUT 4;OPER"
END SELECT
IF I > 2 THEN GOSUB Settle
PRINT #1, "OUTPUT 7;"; C$; Cmd$; ";*OPC" ' Send cal command to 2182.
GOSUB CalEnd           ' Wait until cal step ends.
GOSUB ErrCheck         ' Check for cal error.
NEXT I
'
PRINT #1, "OUTPUT 4;STBY"
LINE INPUT "Enter calibration date (yyyy,mm,dd): "; D$
PRINT #1, "OUTPUT 7;:CAL:PROT:DATE "; D$
LINE INPUT "Enter calibration due date (yyyy,mm,dd): "; D$
PRINT #1, "OUTPUT 7;:CAL:PROT:NDUE "; D$
PRINT #1, "OUTPUT 7;:CAL:PROT:SAVE"        ' Save calibration constants.
GOSUB ErrCheck
PRINT #1, "OUTPUT 7;:CAL:PROT:LOCK"        ' Lock out calibration.
```

```
PRINT "Calibration completed."
PRINT #1, "OUTPUT 7;:SYST:PRES"
END
'
KeyCheck:       ' Check for key press routine.
WHILE INKEY$ <> "": WEND            ' Flush keyboard buffer.
PRINT : PRINT "Press any key to continue (ESC to abort program)."
DO: I$ = INKEY$: LOOP WHILE I$ = ""
IF I$ = CHR$(27) THEN GOTO EndProg         ' Abort if ESC is pressed.
RETURN
'
CalEnd:         ' Check for cal step completion.
PRINT "Performing calibration step #"; I
DO: PRINT #1, "SRQ?"          ' Request SRQ status.
INPUT #2, S            ' Input SRQ status byte.
LOOP UNTIL S           ' Wait for operation complete.
PRINT #1, "OUTPUT 7;*ESR?"          ' Clear OPC.
PRINT #1, "ENTER 7"
INPUT #2, S
PRINT #1, "SPOLL 7"          ' Clear SRQ.
INPUT #2, S
RETURN
'
ErrCheck:       ' Error check routine.
PRINT #1, "OUTPUT 7;:SYST:ERR?"            ' Query error queue.
PRINT #1, "ENTER 7"
INPUT #2, E, Err$
IF E <> 0 THEN BEEP: PRINT Err$: GOTO ErrCheck    ' Display error.
RETURN
'
Settle:         ' Calibrator settling routine.
DO: PRINT #1, "OUTPUT 4;ISR?"       ' Query status register.
PRINT #1, "ENTER 4"
INPUT #2, S
LOOP UNTIL (S AND &H1000)           ' Test settle bit.
RETURN
'
EndProg:        ' Close files, end program.
BEEP: PRINT "Calibration aborted."
PRINT #1, "OUTPUT 4;STBY"
PRINT #1, "OUTPUT 7;:SYST:PRES"
PRINT #1, "LOCAL 4 7"
CLOSE
END
'
CmdList:
DATA "Connect low-thermal short to input jack, wait 3 minutes.","STEP1"
DATA "Disconnect low-thermal short from input jack.","STEP2"
DATA "OUT 10 V,0 HZ","STEP3 10"
DATA "OUT -10 V","STEP4 -10"
```

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