KEITHLEY

Model 2800 RF Power Analyzer

User's Manual

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE EVEN IF KEITHLEY INSTRUMENTS, INC., HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.

KEITHLEY

A GREATER MEASURE OF CONFIDENCE

Keithley Instruments, Inc.

Model 2800 RF Power Analyzer
User's Manual

Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number 2800-900-01) .... January 2003
Revision B (Document Number 2800-900-01) .... January 2004

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 non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified 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 manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product 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 manual. 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, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

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 30V RMS, 42.4V peak, or 60VDC 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 volts, **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, make sure 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 ca-

bles 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.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

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

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

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth 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 $\textcircled{\underline{\underline{=}}}$ screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The $\triangle$ symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The $\triangle$ symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The $\downarrow$ symbol indicates a connection terminal to the equipment frame.

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

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage 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 Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. 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 Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth 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., 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.

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1
Getting Started

Section topics

General information

Warranty information

Warranty information is located at the front of this manual. Should your Model 2800 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the instrument for repair, be sure to fill out and include the service form at the back of this manual to provide the repair facility with the necessary information.

NOTE   *The service form requires the serial number of the Model 2800. The serial number label is located on the rear panel.*

NOTE   *The serial number can also be read from the front panel by selecting the* **SERIAL#** *item from the* **GENERAL** *menu. Press the Menu key to access the* **GENERAL** *menu. For remote operation, the serial number can be read using the *IDN? command (see "Common commands" in Section 2 of the Reference Manual for details).*

Contact information

Worldwide phone numbers are listed at the front of this manual. If you have any questions, please contact your local Keithley sales representative or call a Keithley Application Engineer at 1-800-348-3735 (U.S. and Canada only).

Safety symbols and terms

The following symbols and terms may be found on the instrument or used in this manual:

If a $\textcircled{\underline{=}}$ screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The $\triangle$ symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The $\triangle$ symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The $\underset{rh}{\perp}$ symbol indicates a connection terminal to the equipment frame.

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

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

Inspection

Your Model 2800 was carefully inspected electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit (there may be a protective film over the display lens, which can be removed). Report any damage to the shipping agent immediately. Save the original packing carton for possible future shipment.

NOTE   *The Model 2800 is shipped with rear panel protection brackets installed. These brackets must remain installed when shipping the unit or when carrying it to a different location. To remove the brackets, see "Rear panel protection brackets" on page 1-9.*

The following items are included with every Model 2800 order:

- Model 2800 with line cord.
- Hard copy of the Model 2800 User's Manual (P/N 2800-900-00).
- RF Product Information CD-ROM that contains PDFs of the Model 2800 User's and Reference Manuals.
- Rack mount kit.
- Bench assembly kit.
- Accessories as ordered.
- Certificate of calibration.

NOTE   *A software driver to control the Model 2800 is available as a free download on the Keithley website (www.keithley.com). This driver is suitable for use with LabView, LabWindows CVI, Visual Basic, C++, and TestPoint. The driver is available in the download section of the 2800 product page on the website.*

GPIB cables

The following GPIB cables are available from Keithley:

Models 7007-1 and 7007-2 shielded GPIB cables — Connect Model 2800 to the GPIB bus using shielded cables and connectors to reduce electromagnetic interference (EMI). Model 7007-1 is one meter long. Model 7007-2 is two meters long.

NOTE   *At the factory, the GPIB address of the Model 2800 is set to 28 and the SCPI protocol is selected. To check and/or change the address or protocol, see"GPIB address and protocol" on page 1-25.*

Front & rear panel familiarization

Front panel summary

The front panel of Model 2800 is shown in Figure 1-1.

Figure 1-1
Model 2800 front panel

Note: Right-hand side of front panel not shown.

NOTE   *Some keys provide a dual function or operation. The nomenclature on a key indicates its unshifted function/operation that is selected by pressing the key. Nomenclature above a key indicates its shifted function. A shifted function is selected by pressing the SHIFT key and then the function/operation key.*

1 Special keys:

SHIFT   Use to select a shifted function or operation.
LOCAL   Cancels GPIB remote mode.

2 Function and operation keys:

Top Row
Unshifted

PRIMARY   Selects display format for primary channel readings. Multiple formats are displayed by repeated presses of the **PRIMARY** key.

ADJ/ALT   Selects display format for primary, adjacent, and alternate readings. Multiple formats are displayed by repeated presses of the **ADJ/ALT** key.

PEAK	Displays power level and frequency of the highest peak in the power spectrum.
ΔF	Displays the frequency difference between the center frequency and the highest peak in the power spectrum. If no significant peaks are found, the "UndrFlw" message will be displayed (CW and CDMA).

Shifted

PEAK	Displays power level and frequency of the 2nd, 3rd, 4th, and 5th highest peak in the power spectrum.

Middle Row

Unshifted

Attenuator	Sets the input attenuation.
dBm/dBc	Toggles displayed Adjacent/Alternate power readings between dBm and dBc, provided Adjacent and/or Alternate readings are visible on the display.
MHz | Ch#	Two ways to set center frequency: Use **MHz** key to set frequency, or use **Ch#** key to select channel number.
Avg	Sets the number of readings to average and the averaging type (moving average or repeat average).
Menu	Accesses various menus: SETUP, CALIBRATION, GPIB, TEMP, INPUT, TEST, CABLE, and GENERAL.

Shifted

Meas BW	Displays measurement BW for primary, adjacent, and alternate channels. Primary BW can be changed for GSM, NADC, and PHS.
Freq Offset	Displays/changes frequency offset for adjacent channel. Displays frequency offset for alternate channel.

Bottom Row

Unshifted

Standard	Selects mobile standard and band.
Acq Time	Sets the acquisition time for measurements.
Trigger	Use to force a bus trigger. Details on "Triggering" are provided in Section 3 of the Reference Manual.
Exit	Cancels selection and exits the menu structure.
Enter	Accepts selection, then moves to next choice or exits menu structure.

Shifted

Store	Selects number of readings to store, and enables buffer.
Recall	Recalls readings stored in buffer.
Setup	Configures triggering: Select trigger source, trigger delay, and trigger count.
Exit	Use to restore front panel key control, if operation locks up while

waiting for a Level trigger. See "Triggering" in Section 3 of the Reference manual for details on the Level trigger control source.

3 Edit keys:

keypad   Used to enter numeric values (e.g., center frequency and channel number)

PREV NEXT   While displaying readings, use to change display format. While in a menu, these keys are used to change between various menu selections. While entering numerical values, these keys are used to change the position of the cursor in the entry.

4 Display annunciators:

* (asterisk)	Readings being stored in buffer.
ARM	Measurement being performed.
ERR	External reference unlocked.
FILT	Readings being averaged.
LSTN	Instrument addressed to listen over GPIB.
REM	Instrument in GPIB remote mode.
SRQ	Service request over GPIB.
TALK	Instrument addressed to talk over GPIB bus.
TRIG	External triggering selected (EXTERNAL, Level, or BUS).

Rear panel summary

The rear panel of Model 2800 is shown in Figure 1-2.

Figure 1-2
Model 2800 rear panel

KEITHLEY 2800 rear panel
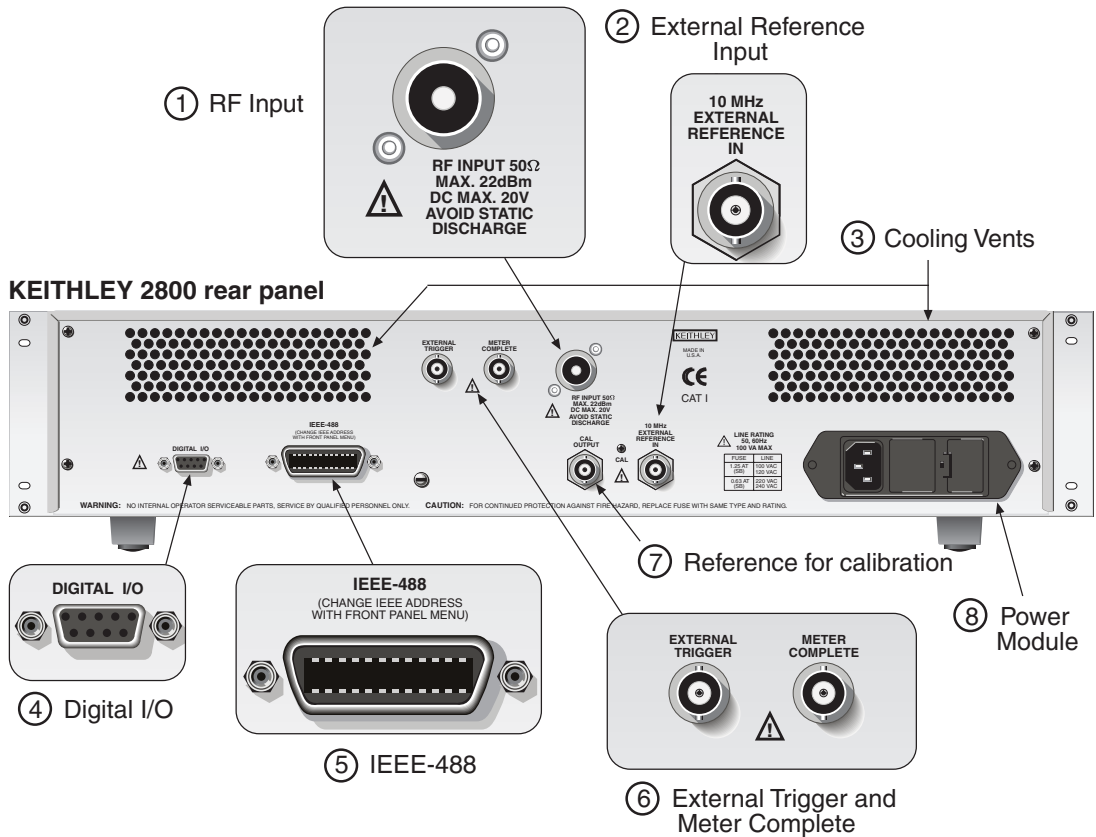
① **RF Input**

 Type N Female connector for RF input.

② **External Reference Input**

 Female BNC connector for external 10MHz reference.

③ **Cooling vents**

 The Model 2800 has two internal cooling fans. To avoid overheating, keep the cooling vents clean and open.

④ Digital I/O

Male DB-9 connector for digital outputs and the digital input. The "Digital I/O" is covered in Section 3 of the Reference Manual.

⑤ IEEE-488

Connector for IEEE-488 (GPIB) operation. Use a shielded cable, such as Models 7007-1 and 7007-2.

⑥ External Trigger and Meter Complete

Female BNC connectors for external triggering. Use External Trigger for input triggers and Meter Complete for output triggers.

⑦ Reference for calibration

Female BNC connector for calibration output. The Model 2800 must be returned to Keithley for calibration. Contact your Keithley sales representative for instructions.

⑧ Power module

Contains the AC line receptacle, power line fuses, and line voltage selector. The instrument can be configured for line voltages of 100V/120V/220V/240VAC at line frequencies of 50 or 60Hz. See "Power-up" on page 1-13 for details.

Bench-top use & rack mounting

Hardware is provided with the Model 2800 so that it can be installed in a standard 19-inch rack or used on a bench top. Before installing the unit in a rack or setting it up for bench use, the supplied handles should be installed and the rear panel protection brackets should be removed.

NOTE   *Store the Model 2800 in a Chiploc bag with desiccant if the unit is expected to be in an un-powered state for extended periods of time.*

Initial unit preparation

Handles

Two carrying handles are provided that attach to the ends of the front panel. These handles should be installed for either the bench or rack-mount configuration.

The handles should be installed with the handles curved inward towards each other. Figure 1-1 shows how the left handle is to be installed. The right handle is to be installed in a similar manner.

Rear panel protection brackets

The Model 2800 is shipped with two L-shaped brackets installed to protect the rear panel connectors. These brackets are to be removed at the location where the unit will be rack mounted or set up for bench-top use.

The protection brackets are shown in Figure 1-3. Each bracket is secured to a side panel with four screws. Remove the eight screws and retain the hardware for future use.

CAUTION   **NEVER stand the Model 2800 up on its rear panel. This will cause damage to the RF input connector.**

Input connector damage caused by negligence is not covered by the warranty. Even slight damage to RF input connector will result in poor measurement performance.

NOTE   *If the unit is to be shipped or carried to a different location, the rear panel protection brackets must first be installed to protect the rear panel connectors.*

Figure 1-3
Rear panel protection brackets

Rear Panel
Protection Brackets

Phillips Truss
Head Screw
8-32 × 5/8 (4)
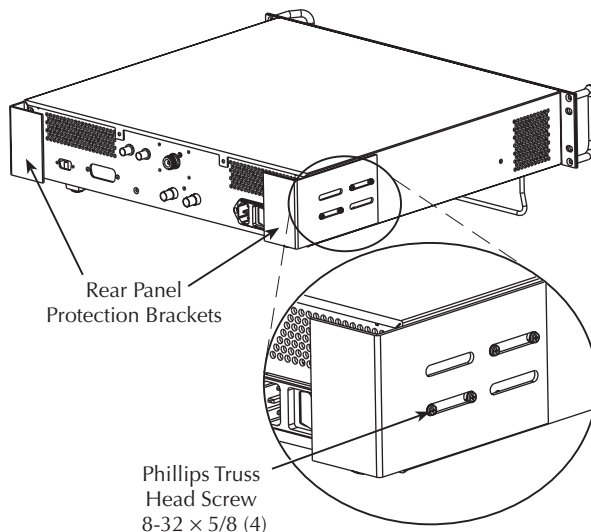
Bench-top use

For bench-top use, four feet and a tilt bail are to be installed on the bottom cover of the unit as shown in Figure 1-4. The feet and tilt bail are supplied with the unit. To gain access to the bottom cover, gently and carefully turn the unit upside down. Please read the following *NOTE* and **CAUTION** before proceeding.

NOTE   *If the rear panel protection brackets are installed, leave them on until you finish installing the feet and tilt bail. Instructions to remove the "Rear panel protection brackets" are provided on page 1-9.*

CAUTION   **NEVER stand up the Model 2800 on its rear panel. This will cause damage to the RF input connector.**

                  Input connector damage caused by negligence is not covered by the warranty. Even slight damage to RF input connector will result in poor measurement performance.

Each foot has a mounting screw and a rubber plug. After installing a foot, cap the screw hole with the rubber plug. Figure 1-4 shows the bottom cover of the Model 2800 and how to position the feet and tilt bail for proper installation.

Figure 1-4
Bottom feet and tilt bail
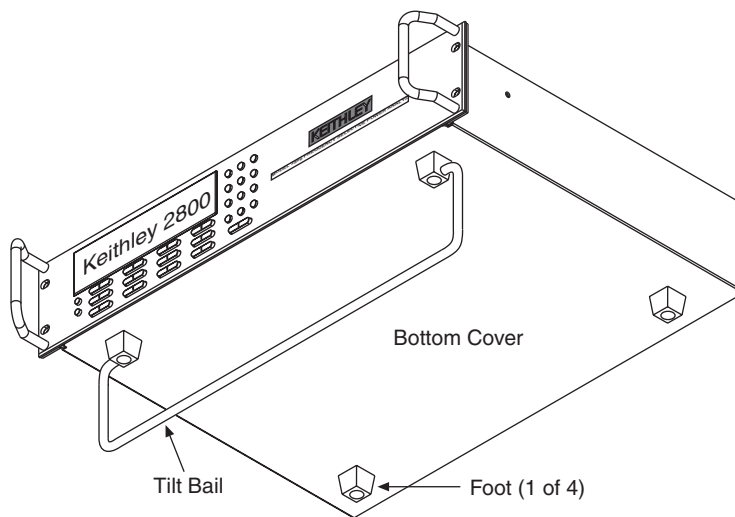
Rack mounting

The Model 2800 mainframe can be mounted in a standard 19-inch equipment rack. The hardware necessary to secure the unit in the rack is supplied with the Model 2800.

CAUTION   **The Model 2800 uses two cooling fans and associated cooling vents to prevent overheating. Two air intake vents are located on the sides of the unit and two exhaust vents are located on the rear panel. When rack mounting, make sure there is adequate airflow at the vent locations.**

WARNING   **To prevent injury, at least two extra people should assist when installing the Model 2800 in the rack. Two people are needed to hold the Model 2800 up in the rack, while the third one installs the mounting screws.**

Hardware supplied for front support

Qty	Description	Keithley P/N
4	Retaining clip (with captive screw)	FA-148
4	10-32 × 5/8" Phillips dress screw	—

Hardware supplied for rear support

Qty	Description	Keithley P/N
4	Retaining clip (with captive screw)	FA-148
4	10-32 × 5/8" Phillips truss head screw	—
2	Rear support bracket	2750-330
8	8-32 × 5/8" Phillips truss head screw	—

NOTE   *The rear panel protection brackets must be removed in order to install the unit in a rack. Instructions to remove "Rear panel protection brackets" are provided on page 1-9.*

CAUTION   **NEVER stand the Model 2800 up on its rear panel. This will cause damage to the RF input connector.**

                     Input connector damage caused by negligence is not covered by the warranty. Even slight damage to RF input connector will result in poor measurement performance.

Perform the following steps to rack mount the Model 2800:

**WARNING   Make sure the Model 2800 is turned off, the line cord is discon-
nected, and the Model 2800 is not connected to any external
circuitry.**

1. Select a location in the rack. With the feet and tilt bale removed, the main-
frame will take up 3.5-inches of vertical space.
2. Using Figure 1-5 as a guide, install the eight retaining clips on the front and
rear rack rails. Slide each retaining clip over a mounting hole such that the
captive nut is positioned on the inside of the rack cabinet.
3. If installed, remove the four foot assemblies from the bottom of the Model
2800. The retaining screw for an assembly is located under the rubber foot.
Pull off the rubber feet to gain access to the screws. Retain these foot
assemblies for future use.
4. Attach the two rear support brackets securely to the Model 2800 as shown
in Figure 1-5.
5. Position the Model 2800 in the rack and loosely attach the front panel to the
front rack rails using the four 10-32 dress screws supplied with the Model
2800.
6. Loosely attach the two rear support brackets to rear rack rails using the four
10-32 screws supplied with the rack kit.
7. Tighten the front and rear support screws to secure the mainframe to the rack.

Figure 1-5
Rack preparation
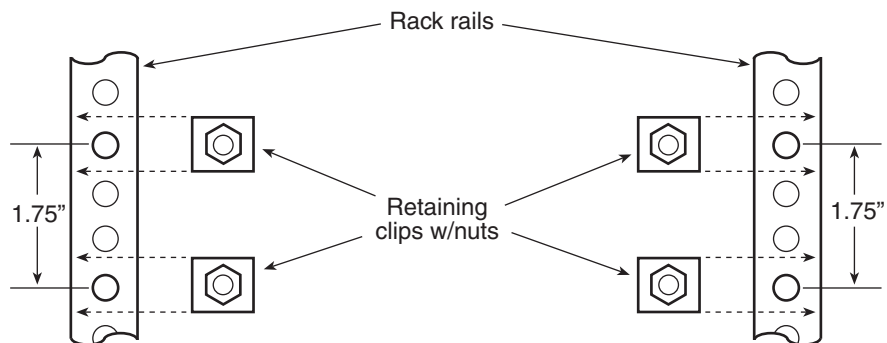
**CAUTION   To prevent damage to the Model 2800, the rack, and the other
equipment, DO NOT rack mount the unit using the front rack
rails only. Front rack rail mounting alone will not support the
weight of the unit. You must also use the rear brackets for
proper support.**

Figure 1-6
Rear support brackets

Rear Support
Bracket (2)

Phillips Truss
Head Screw
8-32 × 5/8 (4)
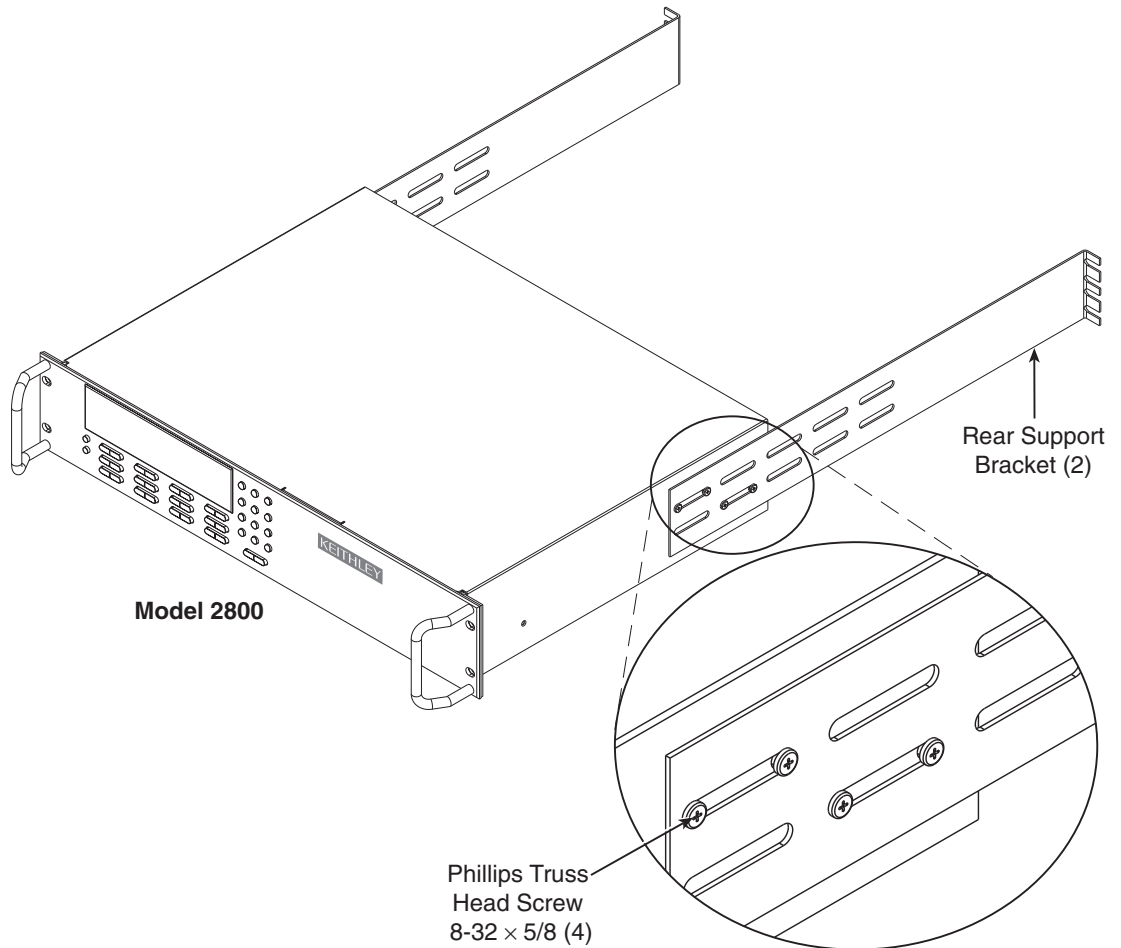
Model 2800

Power-up

Ventilation

Before turning on the Model 2800, note that two cooling fans and associated cooling vents are used to prevent overheating. Two air intake vents are located on the sides of the unit and two exhaust vents are located on the rear panel. To maintain adequate ventilation, do not block these vents and keep them free of dirt and dust.

Line power connection

Follow the procedure below to connect the Model 2800 to line power and turn on the instrument.

1. Check to see that the line voltage indicated in the window of the fuse holder assembly (Figure 1-7) is correct for the operating voltage in your area. If not, refer to "Line voltage and fuses" on page 1-15.

CAUTION **Operating the instrument on an incorrect line voltage may cause damage to the instrument, possibly voiding the warranty.**

2. The power switch is located on the rear panel power module. Before plugging in the power cord, make sure that the power switch is in the OFF (O) position.
3. Connect the female end of the supplied power cord to the AC receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

NOTE *If the power switch on the Model 2800 will not be easily accessible after it is set up for bench-top use or rack mounted, use a power strip that has a power switch. This will allow you to turn the instrument on or off from the power strip.*

WARNING **The power cord supplied with the Model** 2800 **contains a separate ground wire for use with grounded outlets. When proper connections are made, the instrument chassis is connected to power line ground through the ground wire in the power cord. Failure to use a grounded outlet may result in personal injury or death due to electric shock.**

4. Turn on the instrument by placing the front panel power rocker switch to the ON (1) position.

Line frequency

The Model 2800 will operate at line frequencies from 45 to 55Hz and 54 to 66Hz. There are no user-settings for line frequency.

Line voltage and fuses

Two fuses protect the power line input of the instrument. The present voltage setting is displayed through a window in the fuse holder assembly. The fuse holder assembly is shown in Figure 1-7. If the line voltage setting needs to be changed or a line fuse needs to be replaced, perform the following steps:

WARNING   Make sure the instrument is disconnected from the AC line and other equipment before changing the line voltage setting or replacing the line fuse.

1. Using a small flat-blade screwdriver, push the retaining clip to the right to release the fuse holder assembly.
2. Pull the fuse holder out of the power module.
3. Remove blown fuses and replace with the type listed in Table 1-1.

CAUTION   For continued protection against fire or instrument damage, only replace fuses with the type and rating listed. If the instrument repeatedly blows fuses, return the unit back to Keithley (see "Contact information" on page 1-2).

4. If configuring the instrument for a different line voltage, pull out the line voltage selector from the assembly and rotate it to the proper position. When the selector is installed into the fuse holder assembly, the correct line voltage appears in the window.
5. Install the line voltage selector and fuse holder into the power module by pushing them in until they lock in place.

Table 1-1
Fuse ratings

Region	Line voltage	Fuse type and rating	Keithley P/N
USA and Japan	100/120V	Littlefuse 218 — 1.25A, slow-blow, 5×20mm	FU-58
Europe, Asia (China, Korea)	220/240V	Littlefuse 218 — 0.63A, slow-blow, 5×20mm	FU-106-.630

Figure 1-7
Fuse holder assembly

Fuse Holder Assembly
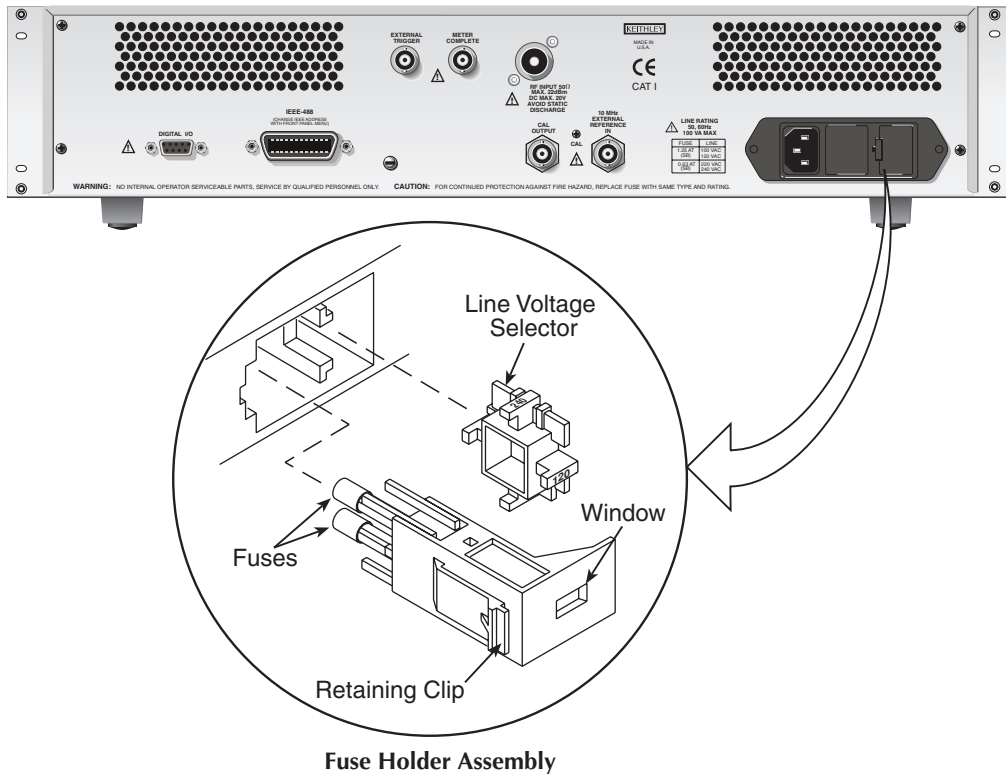
Power-up sequence

On power-up, the Model 2800 performs self-tests on its memory elements and momentarily lights all segments and annunciators. If a failure is detected, the instrument momentarily displays an error message and the ERR annunciator turns on (error messages are listed in Appendix B of the Reference Manual).

NOTE   *If a problem develops while the instrument is under warranty, return*
            it to Keithley Instruments, Inc., for repair.

If the instrument passes the self-tests, the firmware revision levels and IEEE address are displayed. An example of this display is:

Model 2800

REV B01 A07   SCPI Addr = 28

where: B01 is the main board ROM revision.
A07 is the DSP board ROM revision.
SCPI is GPIB protocol.*
28 is the GPIB address.*

* For more information, see "GPIB address and protocol" on page 1-25
of this manual.

After the power-up sequence, the instrument displays primary power readings.

NOTES   *If the instrument fails to communicate with the DSP (Digital Signal
Processor), the message "Communication Error!!! DSP not
responding" is displayed. Contact Keithley for instructions.*

*The serial number and revision levels for the Model 2800 can be
displayed by selecting the **SERIAL#** item of the GENERAL menu.
The GENERAL menu is accessed by pressing the **Menu** key.*

*For remote operation, the serial number can be read using the
*IDN? command (see "Common Commands" in Section 2 of the
Reference Manual for details).*

Display tests

The functionality of front panel keys and display digits can be checked from the
front panel MAIN MENU.

To access the display test menu, press **Menu,** select **TEST,** and then select
DISPLAY TESTS. There are three menu items to choose from:

- **KEYS** menu item – Use to test front panel keys. Use the **NEXT** or **PREV**
  key to place the blinking cursor on **KEYS** and press **Enter** to start the test.

  When a key is pressed, the label name for that key will be displayed to indi-
  cate that it is functioning properly. When the key is released, the message
  "NO KEY PRESS" is displayed. When finished, press the **EXIT** key twice to
  terminate the test.

- **DISPLAY PATTERNS** menu item – Use to test display pixels and
  annunciators. Use the **NEXT** or **PREV** key to place the blinking cursor on
  DISPLAY PATTERNS and press **Enter** to start the test.

  There are five parts to this test. Each time a key (except **EXIT**) is pressed,
  the next part of the test sequence is selected. The five parts of the test are
  as follows:

  - Checkerboard pattern (alternate pixels on) and all annunciators.
  - Checkerboard pattern and the annunciators that are on during normal
    operation.
  - Horizontal lines (pixels) of the first digit are sequenced.
  - Vertical lines (pixels) of the first digit are sequenced.

- Each digit (and adjacent annunciator) is sequenced. All pixels of the selected digit are on.

  When finished, press the **Exit** key to terminate the test.

- **CHAR SET** menu item – Use to test special display pixels. Use the **NEXT** or **PREV** key to place the blinking cursor on **CHAR SET** and press **Enter** to start the test.

  Press any key (except **Exit**) to cycle through all used characters. When finished, press the **Exit** key to terminate the test.

When finished with the display tests, use the **Exit** key to back out of the menu structure.

Display formats (readings)

Display formats for power readings are controlled by front panel keys:

- **PRIMARY** key – This key displays primary channel power readings.
- **ADJ/ALT** key:
- For CDMA, this key displays primary, adjacent, and alternate channel power readings.
- For NADC, GSM, and PHS, this key displays primary and adjacent channel power readings.
- For AMPS, this key displays primary, carrier, and upper sideband power readings.
- **PEAK** key – This key displays the power level and frequency of the highest peak in the power spectrum.
- **NEXT PEAK** key – This shifted key cycles through the power level and frequency of the next four highest peaks in the power spectrum.
- Δ**F** key – This key displays the difference between the center frequency and frequency of the highest peak in the power spectrum. If a significant peak is not found, the message "UndrFlw" will instead be displayed (CW and CDMA).

NOTE   *The **PREV** and **NEXT** keys can also be used to select a display format for the displayed reading type. For example, if displaying **PRIMARY** readings, the **PREV** and **NEXT** keys can be used to scroll through the various formats.*

PRIMARY key

When using the **PRIMARY** key, three display formats are available for primary channel power readings. The three display formats for CDMAOne cell are shown and explained in Figure 1-8. The display formats for the other mobile standards and bands are similar except the center frequency and bandwidth will be different for each.

On power-up, the primary channel power reading is displayed along with the center frequency and bandwidth. This is the first display shown in Figure 1-8. Each press of the **PRIMARY** key selects the next display format.

Figure 1-8
Display formats for PRIMARY key (CDMAOne cell shown)
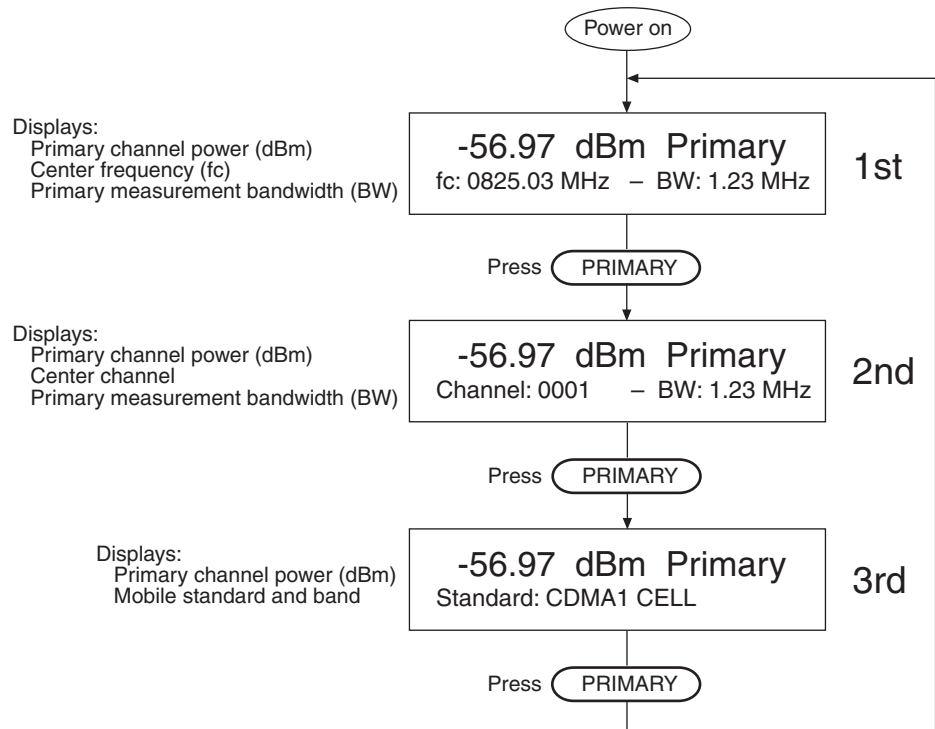
ADJ/ALT key

CDMA standards – The **ADJ/ALT** key toggles the display between six display formats for primary, adjacent and alternate channel power readings.The six display formats for CDMAOne cell are shown and explained in Figure 1-9. As shown, a different display format is displayed each time the ADJ/ALT key is pressed. The display formats for the other CDMA standards and bands are similar except the center frequency, offsets, and bandwidths may be different for each.

Figure 1-9 shows dBm readings for primary, adjacent, and alternate channel power. The adjacent and alternate channel readings can instead be displayed in dBc by pressing the **dBm/dBc** key. This key toggles between dBm and dBc.

NADC, GSM, and PHS – The **ADJ/ALT** key toggles the display between three display formats for primary and adjacent channel power readings.The three display formats for NADC are shown and explained in Figure 1-10. As shown, a different display format is displayed each time the ADJ/ALT key is pressed. The display formats for GSM and PHS are similar except the center frequency, offset, and bandwidth may be different for each.

Figure 1-10 shows dBm readings for primary and adjacent channel power. The adjacent readings can instead be displayed in dBc by pressing the **dBm/dBc** key. This key toggles between dBm and dBc.

AMPS – The **ADJ/ALT** key toggles the display between three display formats for primary, carrier, and upper sideband channel power readings.The three display formats for AMPS are shown and explained in Figure 1-11. As shown, a different display format is displayed each time the ADJ/ALT key is pressed.

Figure 1-11 shows dBm readings for primary, carrier, and upper sideband channel power. The sideband reading can instead be displayed in dBc by pressing the **dBm/dBc** key. This key toggles between dBm and dBc.

Figure 1-9
CDMA display formats for ADJ/ALT key (CDMAOne cell shown)

Press (ADJ/ALT)

Displays:
  Primary channel power in dBm.
  Adjacent channel power in dBm or dBc:
    Lower channel (ADJL).
    Upper channel (ADJU).

| -56.97 dBm Primary |
| -73.59 dBm ADJL, -73.44 dBm ADJU |

1st

Press (ADJ/ALT)

Displays:
  Primary channel power in dBm.
  Alternate channel power (dBm or dBc):
    Lower channel (ALTL).
    Upper channel (ALTU).

| -56.97 dBm Primary |
| -72.66 dBm ALTL, -72.46 dBm ALTU |

2nd

Press (ADJ/ALT)

Displays:
  Adjacent lower channel power in dBm or dBc.
  Adjacent channel frequency offset.
  Adjacent channel measurement bandwidth (BW).

| -73.59 dBm ADJLower |
| Offset: 885 kHz   – BW: 30.0 kHz |

3rd

Press (ADJ/ALT)

Displays:
  Adjacent upper channel power in dBm or dBc.
  Adjacent channel frequency offset
  Adjacent channel measurement bandwidth (BW).

| -73.44 dBm ADJUpper |
| Offset: 885 kHz   – BW: 30.0 kHz |

4th

Press (ADJ/ALT)

Displays:
  Alternate lower channel power in dBm or dBc.
  Alternate channel frequency offset.
  Alternate channel measurement bandwidth (BW).

| -72.66 dBm ALTLower |
| Offset: 1.98 MHz   – BW: 30.0 kHz |

5th

Press (ADJ/ALT)

Displays:
  Alternate upper channel power in dBm or dBc.
  Alternate channel frequency offset.
  Adjacent channel measurement bandwidth (BW).

| -72.66 dBm ALTUpper |
| Offset: 1.98 MHz   – BW: 30.0 kHz |

6th

*Note: Use the **dBm/dBc** key to toggle
adjacent and alternate channel
power readings between dBm
and dBc.*

Press (ADJ/ALT)

Figure 1-10
NADC, GSM, and PHS display formats for ADJ/ALT key (NADC shown)

Press (ADJ/ALT)

Displays:
 Primary channel power in dBm.
 Adjacent channel power in dBm or dBc:
  Lower channel (ADJL).
  Upper channel (ADJU).

| -95.39 dBm Primary |
| -95.27 dBm ADJL, -95.01 dBm ADJU |

1st

Press (ADJ/ALT)

Displays:
 Adjacent lower channel power in dBm or dBc
 Adjacent channel frequency offset.
 Adjacent channel measurement bandwidth (BW).

| -95.27 dBm ADJLower |
| Offset: 30.0 kHz   – BW: 25.0 kHz |

2nd

Press (ADJ/ALT)

Displays:
 Adjacent upper channel power in dBm or dBc
 Adjacent channel frequency offset.
 Adjacent channel measurement bandwidth (BW).

| -95.01 dBm ADJUpper |
| Offset: 30.0 kHz   – BW: 25.0 kHz |

3rd

Press (ADJ/ALT)

*Note: Use the **dBm/dBc** key to toggle
        upper side-band power readings
        between dBm and dBc.*

Figure 1-11
AMPS display formats for ADJ/ALT key

Press (ADJ/ALT)

Displays:
  Primary channel power in dBm.
  Carrier power (Pcar) in dBm.
  Upper sideband power (Psb) in dBm or dBc.

| -93.01 dBm Primary |
| -106.62 dBm Pcar, -105.64 dBm Psb |

1st

Press (ADJ/ALT)

Displays:
  Carrier power in dBm.
  Upper sideband frequency offset.
  Upper sideband measurement bandwidth (BW).

| -106.62 dBm Pcarrier |
| Offset: 10.0 kHz   –   BW: 1.00 kHz |

2nd

Press (ADJ/ALT)

Displays:
  Upper sideband power in dBm or dBc.
  Upper sideband frequency offset.
  Upper sideband measurement bandwidth (BW).

| -105.64 dBm Psidebnd |
| Offset: 10.0 kHz   –   BW: 1.00 kHz |

3rd

*Note: Use the **dBm/dBc** key to toggle upper sideband power readings between dBm and dBc.*

Press (ADJ/ALT)

PEAK key

The power level and frequency of the highest peak in the power spectrum (over a ±1.82MHz range relative to the channel center frequency) is displayed in response to the **PEAK** key. The frequency resolution for peak power measurements is 5kHz. Details for "Peak power measurements" are provided on page 3-18.

As shown in Figure 1-12, the amplitude and frequency for the highest peak is displayed by pressing the **PEAK** key. The shifted **PEAK** key is used to display the power level and frequency of each of the next four highest peaks in the power spectrum. As shown in Figure 1-12, each key-press sequence (**Shift** > **PEAK**) displays the next highest peak.

Figure 1-12
Displays for PEAK key

PEAK key: Press **PEAK**

Displays:
  Highest peak power
  and frequency

Peak: -55.33 dBm
PEAK Frequency: 825.030 MHz

NEXT PEAK key: Press **Shift**

Press **NEXT PEAK**

Displays:
  2nd highest peak power
  and frequency

Next Pk: -71.77 dBm [2]
Next Pk Frequency: 825.040 MHz

Press **Shift**

Press **NEXT PEAK**

Displays:
  3rd highest peak power
  and frequency

Next Pk: -80.13 dBm [3]
Next Pk Frequency: 825.020 MHz

Press **Shift**

Press **NEXT PEAK**

Displays:
  4th highest peak power
  and frequency

Next Pk: -82.36 dBm [4]
Next Pk Frequency: 825.050 MHz

Press **Shift**

Press **NEXT PEAK**

Displays:
  5th highest peak power
  and frequency

Next Pk: -95.47 dBm [5]
Next Pk Frequency: 825.010 MHz

∆**F key**

This key displays the difference between the frequency of the channel center frequency and the frequency at which the highest level of the power spectrum occurs. This high resolution measurement allows you to accurately calculate the frequency for the highest peak. The procedure is provided on page 3-20.

For the example shown in Figure 1-13, the frequency of the highest peak is calculated as follows:

Freq (highest peak) = $f_C + \Delta F$

$\qquad = 825.03\text{MHz} + 0.05\text{kHz}$

$\qquad = 825.03005\text{MHz}$

Figure 1-13
Display for ∆*F* measurement

Press (∆F)

Displays:
   Delta frequency
   Center frequency

△FREQ: +00.005 kHz
Center Frequency: 0825.03 MHz

GPIB address and protocol

GPIB address

In order avoid communication conflicts over the bus, each device in the GPIB system must have a unique primary address. The Model 2800 is shipped from the factory with the primary address set to 28.

The set address is displayed on power-up. It can also be viewed and changed from the GPIB option of the Main Menu (see "Address and protocol selection").

GPIB protocols

GPIB operation can use one of two protocols: SCPI or 488.1. The Model 2800 is shipped from the factory with the SCPI protocol selected. The 488.1 protocol is typically used when increased measurement speed is required.

The selected protocol is displayed on power-up. It can also be viewed and changed from the GPIB option of the Main Menu (see "Address and protocol selection").

NOTE   *Details on "GPIB Protocols" are provided in Appendix C of the Reference Manual.*

Address and protocol selection

You can set the address to a value from 0 to 30, but do not assign the same address to another device or to a controller that is on the same GPIB bus (controller addresses are usually 0 or 21).

Perform the following steps to check/change the GPIB address and protocol:

1. Press **Menu** to display the main menu.
2. Use the **NEXT** or **PREV** key to place the blinking cursor on **GPIB,** and press **Enter** to display the present address
3. To change the address, enter the address value (0 to 30) and press **Enter**.
4. Place the cursor on the desired protocol (SCPI or 488.1) and press **Enter**.
5. Use the **Exit** key to back out of the menu structure.

Readings over the bus

NOTE   *The following information summarizes the fundamental process of triggering a measurement and sending the readings to the computer, where they are displayed. It shows how to select a measurement function (power, peak, and delta frequency) and perform a measurement.*

This measurement introduction does not go into details on instrument configuration. Not covered here are the commands to select a mobile standard, select a band, set adjacent offset, or make other settings to optimize measurement performance. Details on instrument configuration are provided in Section 3 of this manual.

"Reference" links for details on the following information are provided on page 1-30.

Summary of read commands

:FETCh?

This query command requests the latest post-processed readings stored in the sample buffer. After sending this command and addressing the Model 2800 to talk, the readings are sent to the computer. This command does not affect the instrument setup.

This command does not trigger a measurement; it simply requests the last available readings. Until there are new readings, this command continues to return old readings.

NOTE   *The :FETCh? command is automatically asserted when the :READ? or :MEASure? command is sent.*

:READ? or :MEASure?

Both of these commands work the same way and can be used to trigger and acquire readings. The number of readings depends on how the trigger model is configured. For example, if the trigger model is configured for 20 measurements (trigger count 20), then 20 sets of readings will be acquired after the Model 2800 returns to the idle state.

When :READ? or :MEASure? is sent, the following commands execute in the order that they are presented:

- :INITiate
- :FETCh?

The :INITiate command starts operation by taking the instrument out of idle.

After all measurements are completed, the Model 2800 goes back into idle at which time the :FETCh? command is executed. The readings are sent to the computer and displayed when the Model 2800 is addressed to talk.

NOTES   *Sending :READ? or MEASure? with BUS trigger source selected will cause a -215, "Arm deadlock" error. Under this condition, use :FETCh? after a trigger has been initiated (:INIT followed by *TRG).*

Power readings

When a typical power measurement, such as CDMAOne, is performed, the primary channel (PRIM), lower adjacent channel (ADJL), upper adjacent channel, lower alternate channel, and upper alternate channel are measured.

Programming example:

```
*RST
SENS:FUNC POW        ' Select power function.
UNIT:POW DBM         ' Select dBm units for adjacent and alternate channels.
READ?                ' Trigger measurement and request readings.
```

After addressing the Model 2800 to talk, the returned reading string will include the five power readings, a timestamp (TIME), and a status byte (STATUS).The returned power readings for the above command sequence are in dBm units.

Primary channel readings are always returned using dBm units. Adjacent and alternate channel readings can be returned in dBm or dBc units. To instead return the adjacent and alternate channel readings in dBc units, change the third command in the above sequence to UNIT:POWer DBC.

The seven data elements (separated by commas) are sent in the following order in the returned string:

PRIM, ADJL, ADJU, ALTL, ALTU, TIME, STATUS

Concurrent measurements

By default, the Model 2800 measures the primary, adjacent, and alternate channels concurrently. To increase measurement speed, concurrent measurements can be disabled. When disabled, the adjacent and alternate channels are not measured. Concurrent measurements can be enabled or disabled using the following commands:

```
SENS:POW:CONC OFF        ' Disable concurrent measurements.
SENS:POW:CONC ON         ' Enable concurrent measurements.
```

NOTE   *With concurrent measurements disabled, the GSM primary channel bandwidth cannot be set to 30kHz. If the GSM primary bandwidth was previously set to 30kHz, it will reset to 400kHz when concurrent measurements are disabled. With concurrent measurements enabled, the PHS primary channel bandwidth cannot be set to 1MHz. If the PHS primary bandwidth was previously set to 1MHz, it will reset to 192kHz when concurrent measurements are enabled.*

Peak readings

When the peak measurement function is selected, the power and frequency of the five highest peaks of the power spectrum are measured (the bandwidth is ±1.82MHz of the set center frequency).

Programming example:

```
*RST
SENS:FUNC PEAK            ' Select peak function.
SENS:FREQ:CENT 825.03e6  ' Set center frequency to 825.03MHz.
READ?                    ' Trigger measurement and request readings.
```

The peak measurement process for the above example will find the five highest power levels in the 823.18 to 826.88MHz frequency range. The returned reading string will include five power (POW) readings and five frequency (FREQ) readings. The readings are returned in the following order:

POW1, POW2, POW3, POW4, POW5, FREQ1, FREQ2, FREQ3, FREQ4, FREQ5

POW1 and FREQ1 are the power and frequency of the highest peak.
POW2 and FREQ2 are the power and frequency of the 2nd highest peak.
POW3 and FREQ3 are the power and frequency of the 3rd highest peak.
POW4 and FREQ4 are the power and frequency of the 4th highest peak.
POW5 and FREQ5 are the power and frequency of the 5th highest peak.

Not shown in the above reading string are the timestamp and status byte. For the command sequence in the above programming example, those data elements will be appended to the string after the frequency readings.

ΔF readings

When a ΔF measurement is performed, the frequency difference between the set center frequency and frequency of the highest peak is measured. This measurement can be used to determine the actual frequency of the highest peak, to within ±1Hz.

The bandwidth for the ΔF measurement is ±700kHz of the set center frequency. For example, if the center frequency is 825.030MHz, the frequency range tested is 824.33 to 825.73MHz.

Programming example:

```
*RST
SENS:FUNC DFR                ' Select ΔF function.
SENS:FREQ:CENT 825.03e6 ' Set center frequency to 825.03MHz.
READ?                       ' Trigger measurement and request readings.
```

The returned reading string for the above example will include the delta frequency (ΔF) along with the timestamp (TIME) and status byte (STATUS). The data elements are returned in the following order:

ΔF, TIME, STATUS

Reference

- **Measure commands** – For details on measure commands, see "Signal-oriented commands" in Section 2 of the Reference Manual.
- Data format (elements) – For details on data format, see "FORMat subsystem commands" in Section 2 of the Reference Manual. Included are details on the timestamp and status byte.
- **Measurement procedures** – Detailed power measurement procedures for the CDMAOne and NADC mobile standards are provided in Section 3 of this manual (see "Making power measurements" on page 3-6). Also covered in that section are procedures for peak power and ΔF measurements.
- **Additional standards** – Measurement procedures for all mobile standards are summarized in Section 4 of this manual.

Defaults & user setups

Factory defaults

The Model 2800 can be restored to the default FACTORY setup, or one of three user-saved setups (denoted as LOC0, LOC1, or LOC2). As shipped from the factory, the Model 2800 defaults to the CDMAOne standard. The factory default settings for CDMAOne Cell are listed in Table 1-2.

NOTE   *The Model 2800 stores (remembers) the most recently used frequency for each standard. When a mobile standard is selected, the stored frequency setting will be restored.*

Table 1-2
Factory default settings (CDMAOne Cell)

Setting	Factory default
Mobile standard	CDMAOne Cell
Center frequency:	
Channel	1
Frequency	825.03MHz
Adjacent channel offset	885kHz
Note: The following settings are fixed and cannot be changed: Primary channel BW = 1.23MHz Adjacent channel BW = 30kHz Alternate channel BW = 30kHz Alternate channel offset = ±1.98MHz	

Table 1-3 lists the global factory defaults. When factory defaults are restored, these settings will be selected regardless of which mobile standard was selected.

Restoring factory defaults from the front panel places the instrument in a continuous triggering (measurement) mode. Restoring factory defaults using remote programming places the instrument in the one-shot trigger mode. With one-shot triggering, a measurement cycle is performed whenever the instrument is triggered.

NOTE   *The initial settings for the three user setups (LOC0, LOC1, and LOC2) are all set to the factory default.*

Table 1-3
Factory default settings (global)

Setting	Factory default
Acquisition Time	10.0msec
Attenuator	26dB
Averaging filter:	
State	Off
Count	6
Type	Moving
Cable correction:	
Control	Disabled
Low-band (Cell)	0.0dB
High-band (PCS)	0.0dB
Data store:	
Points	100
Control	Disabled
Digital I/O [1]	
Digital input state	HI
Digital output pattern	15
Input protection	Disabled
Root Raised Cosine (RRC) filter [2]	Enabled
Temperature compensation	Enabled
Trigger setup:	
Source	Immediate
Delay	0.01msec
Count	Finite, 1
Units	dBm

1. The "Digital I/O" is covered in Section 3 of the Reference Manual.
2. The RRC filter applies only to WCDMA.

Saving and restoring setups

Setups are saved and restored from the SETUP item of the main menu. Perform the following steps to access the SETUP menu:

1. Press **Menu** to display the main menu items.
2. Use the **PREV** and/or **NEXT** key to place the blinking cursor on **SETUP.**
3. Press **Enter** to display the setup menu items (**SAVE**, **RECALL**, **POWER-ON** and **RESET**).

Once in the **SETUP** menu, use the following procedures to save and restore setups:

Saving a user setup

1. Configure the Model 2800 for the desired measurement application.
2. From the **SETUP** option of the **Main** menu, use the **PREV** and/or **NEXT** key to place the blinking cursor on **SAVE** and press **Enter**.
3. Place the cursor on the desired setup (**LOC0**, **LOC1,** or **LOC2)** and press **Enter**.
4. Press **Exit** to return to the measurement state.

Remote programming:

```
*SAV <NRf>          ' Save present setup as a user setup: <NRf> = 0, 1 or 2.
```

Selecting a power-on setup

1. From the **SETUP** option of the **Main** menu, use the **PREV** and/or **NEXT** key to place the blinking cursor on **POWER-ON** and press **Enter**.
2. Place the cursor on **FACTORY** (for factory defaults), ***RST** (for GPIB defaults), or **USER-SETUP**, and press **Enter**.
3. If you selected **USER-SETUP**, place the cursor on **LOC0**, **LOC1,** or **LOC2** and press **Enter**.
4. Press **Exit** to return to the measurement state.

Remote programming:

```
SYSTem:POSetup <name>   ' Select power-on setup: <name> = RST,
                        ' PRESet, SAV0, SAV1, or SAV2.
```

Restoring a user setup

1. From the **SETUP** option of the **Main** menu, use the **PREV** and/or **NEXT** key to place the blinking cursor on **RECALL** and press **Enter**.
2. Use the **PREV** or **NEXT** key to display the desired setup (**LOC0**, **LOC1,** or **LOC2**) and press **Enter**.

Remote programming:

```
*RCL <NRf>          ' Restore a user setup: <NRf> = 0, 1 or 2.
```

Restoring factory defaults

From the **SETUP** option of the **Main** menu, use the **PREV** and/or **NEXT** key to place the blinking cursor on **RESET** and press **Enter**.

Remote programming:

```
*RST                 ' Restore factory defaults.
SYSTem:PRESet        ' Restore factory defaults.
```

NOTE   *The only difference between *RST defaults and SYSTem:PRESet defaults is byte order for sending non-ASCII readings over the bus. For details on data format, see "FORMat subsystem commands" in Section 2 of the Reference Manual.*

Section topics

Section topics

Section topics

2

Measurement Techniques

Section topics

Signal processing architecture in Model 2800

Block diagram

The Model 2800 consists of a number of subsystems but can be divided conceptually into an RF section and a digital section. The RF section performs functions similar to those implemented in a traditional spectrum analyzer.

Given an input signal in the 824 to 915MHz or 1710 to 1980MHz range with a power level between +20dBm and -70dBm, the RF section down converts the signal to a nominal 70MHz IF that is band limited to approximately 10MHz (66.5MHz to 76.5MHz).

The IF signal is digitized by a 14-bit analog-to-digital (A/D) converter running at a 40.96 MSPS sample rate. The digital data follows one or two different processing paths depending on the standard selected by the user. The block diagram below summarizes these processing paths.

Figure 2-1
Model 2800 block diagram – digital side
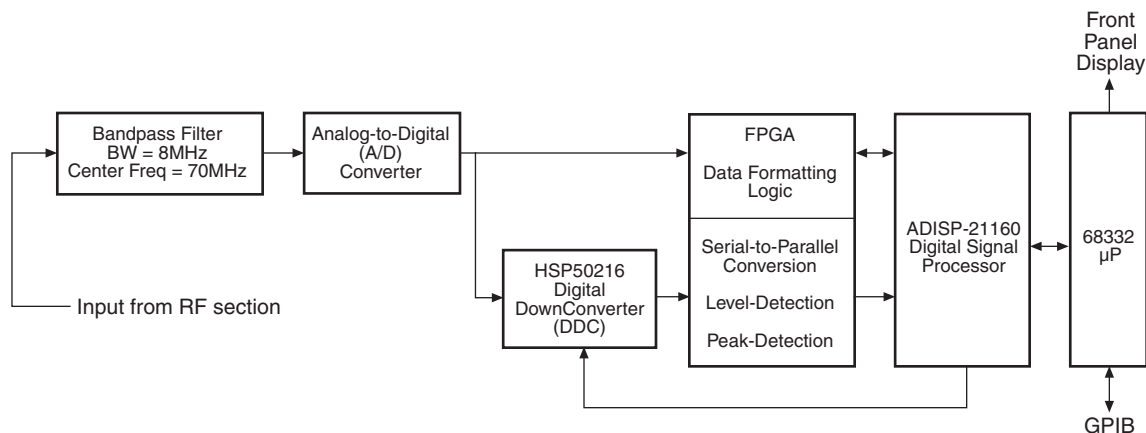
Low-resolution FFT-based measurements

Low-resolution FFT-based measurements are used primarily for wideband (1MHz or greater) measurements. The resolution in this case refers to the bin-width of the FFT which, for an 8k FFT and a 40.96 MSPS sample rate, is 5kHz. In response to a trigger command (from the front panel, GPIB bus, or external input), 8192 samples are obtained from the A/D converter. Formatting circuitry in the FPGA makes the A/D output compatible with the DSP data bus. The DSP then performs an 8k FFT on these samples.

The signal power in a bandwidth centered at the RF center frequency is calculated by summing the squared magnitude of the FFT over the bandwidth of interest. This approach is used for the CDMAOne and CDMA2000 primary channels and for the primary, adjacent, and alternate channels for WCDMA. The approach is also used for the low-resolution peak search function.

Narrow-band DDC-based measurements

The DDC is used for narrowband measurements and currently supports measurement bandwidths of 30kHz and 400kHz (with several different filter types), depending on the standard. A DDC-based power measurement is obtained by downconverting the channel of interest to a complex (I and Q) baseband signal with a power spectrum centered at 0Hz, and a bandwidth determined by Finite-Impulse Response (FIR) and decimation filters.

The DDC calculates the (possibly time-varying) magnitude of this complex signal. The DSP calculates a running sum-of-squared magnitude samples that are proportional to the average power in the signal over a bandwidth determined by the decimation and/or FIR filters in the DDC. The time over which this average is performed is controlled by the user. This approach is used for all NADC and GSM measurements and for CDMAOne and CDMA2000 adjacent and alternate channel measurements.

High-resolution FFT-based measurements

High-resolution FFT-based measurements are used whenever a frequency-resolved measurement with resolution better than 5kHz is required. A single DDC channel is used to decimate the signal from the A/D by a factor of 100. This results in a 409.6kHz sample rate. The DSP then calculates an 8k FFT on the I and Q outputs of the DDC.

The bin width in this case is 50Hz. The narrower bin width provides better resolution in the frequency domain and facilitates measurements over narrower bandwidths than would otherwise be possible. This approach is used for AMPS measurements.

Reading repeatability

Each power measurement made by the Model 2800 will exhibit a signal-dependent variability from one measurement to the next. This variability is due to two factors. The first is the signal-to-noise ratio of the signal being measured. As the power level of a given signal approaches the noise floor of the Model 2800 or of the signal source, the noise power becomes larger relative to the total signal power. Since the noise is random, an average power measurement over a finite interval will exhibit variations from one interval to the next.

A second factor is the inherent variability of the signal due to the modulation scheme itself. This is especially true in CDMA-type modulation schemes, which involve the deliberate introduction of randomness to the transmitted signal. In this case, the randomness is an inherent part of the signal and therefore does not change with signal power level.

The repeatability of measurements made by the Model 2800 can be improved upon through a proper selection of acquisition time and by averaging successive measurements. The appropriate choice for these parameters will depend on the modulation scheme of the signal being measured.

Acquisition time

FFT-based power measurements involve acquisition of a fixed record length of data. This record length is a function of the sampling rate and the number of points in the FFT and is not user-selectable. For CDMAOne or CDMA2000 primary channel measurement, the default acquisition time is 10ms. For WCDMA measurements, the acquisition time is fixed at 200µs. For AMPS measurements, the acquisition time is fixed at 20ms, while the default acquisition time for PHS and GSM is 542µs. Finally, the default NADC acquisition time is 6.46ms. Repeatability for these measurements can be improved only by "Averaging" (see the following paragraphs).

For CDMAOne or CDMA2000 adjacent and alternate channel measurements, the acquisition time directly affects the repeatability of the measurements. The default value for these measurements is 10ms. The repeatability of NADC PHS and GSM measurements can be improved by an increase in acquisition time to the extent that this time does not exceed the useful duration of the signal. The useful duration of the signal is the portion of time over which the signal is "on" and is approximately 600µs for PHS, 6.42ms for NADC, and 577µs for GSM.

Note that, in general, measurement speed is inversely proportional to acquisition time. For a complete explanation of how these measurements are performed and how they are affected by acquisition time, see "Mobile Transmitter Measurements" in Section 4 of this manual.

Averaging

The Model 2800 is capable of storing successive measurements and averaging them in order to improve repeatability. Block or moving averages can be performed, and the number of measurements averaged is user-selectable from 1 to 100.

Repeat (block) Averaging — The specified number of measurements are performed, and the displayed result is the average of those measurements. There is no overlap between successive blocks of measurements.

For external triggering, the instrument must receive N number of triggers to yield a single averaged reading (where N is the averaging count). For example, assume the Model 2800 is configured to measure the primary channel only, and the averaging count (N) is set to 10. Each received trigger will cause a measurement to occur and temporarily store it in an averaging stack (buffer). After the stack fills (10 readings stored), they are averaged to yield a single displayed averaged reading.

Modify the above example so the primary channel, upper adjacent channel, lower adjacent channel, upper alternate channel, and lower alternate channel are measured. The process is the same except that an averaged reading is yielded for every channel.

Moving (boxcar) Averaging — Let *N* be the number of measurements to average. Each time a new measurement is obtained, an average is performed over the *N* most recent measurements.

Measurements for mobile standards

The Model 2800 uses a combination of time-domain and frequency-domain methods for performing power measurements on mobile communication signals. The actual method used depends on the standard to which the signal belongs and on the bandwidth over which the measurement is made.

All wideband measurements (1MHz or greater) are FFT-based. An estimate of the power spectrum of the signal is obtained by sampling and performing an 8k FFT on the data. The power is a sum-of-squares of the magnitude of the FFT data over the bins corresponding to the bandwidth of the measurement. The CDMAOne and CDMA2000 1x primary channel measurements are made over a 1.23MHz bandwidth. The CDMA2000 3x primary channel measurement is made over a 3.69MHz bandwidth. The WCDMA primary, adjacent, and alternate channel measurements are made over a 3.84MHz bandwidth for each measurement.

All narrowband measurements (400kHz or less) are performed using the Digital DownConverter (DDC).

Oscillators

Local oscillator

The Model 2800 uses an internal local oscillator to set the frequency for power measurements. When a frequency setting change occurs (i.e., channel changed), the local oscillator automatically locks in to the new frequency to allow measurements.

Measurement event register — Bit B3 of the Measurement Event register sets when the local oscillator locks in and status message +118 is placed in the status queue. Details on "Status structure" are provided in Section 3 of the Reference Manual.

Reference oscillator

The Model 2800 also uses a 10MHz reference for power measurements.

Internal reference – The Model 2800 has its own internal 10MHz reference oscillator. However, better frequency accuracy is achieved by using an external master reference.

External reference – When an external reference is connected, the Model 2800 will automatically detect it and lock it in. When an external reference is NOT connected, the internal reference will be used.

The signal for the external reference can be a square wave or a sine wave and must be 10MHz ±50Hz. The power level of the external reference must be ≥2dBm. If the external reference is connected to the Model 2800 and it is not within specification, the front panel display **ERR** annunciator will turn on.

Measurement event register – The following bits of the measurement event register pertain to the reference oscillator:

- Bit B0 sets when an external reference is detected. Status message +115 is placed in the status queue.
- Bit B1 sets when the external reference has been locked in by the Model 2800. Places status message +116 in the status queue.
- Bit B2 sets when an external reference is NOT connected, and the internal reference is being used (active). Places status message +117 in the status queue.

Details on "Status structure" are provided in Section 3 of the Reference Manual.

Input protection

The Model 2800 has input protection that can be enabled or disabled by the user. When enabled, input protection serves two purposes:

- Input protection reduces average power to the mixer of the Model 2800 for some measurement modes. Power is only provided to the mixer during data acquisition where measurements are being performed.
- Input Protection reduces local oscillator emission from the Model 2800 when it is NOT performing a measurement. See page 3-39 to enable or disable "Input protection".

NOTE   *Enabling input protection slows down measurement speed by adding 500µs to the measure time for each reading. Input protection should be disabled for the NADC and GSM standards since they measure high speed pulses.*

Cable compensation

Power loss in the signal path to the input (RF cables, couplers, and splitters) could adversely affect a power measurement by the Model 2800. Power loss in the input signal path could be large enough to affect the integrity of your measurements. By using cable compensation, the power loss is factored into the calculation for the power measurement. This cancels the effect of the power loss in cables, splitters, and couplers.

The cable compensation process consists of determining the power loss, entering the dB power value into the Model 2800, and then enabling cable compensation. The procedure to enter correction values for "Cable compensation" is provided on page 3-5 of this manual.

Temperature compensation

Temperature compensation is used to cancel the effects of ambient temperature drift which could cause measured readings to drift. With temperature compensation enabled, the Model 2800 measures temperature as part of its measurement process. These temperature measurements are then factored into the algorithm to calculate a measured reading.

With temperature compensation disabled, temperature is not routinely measured. Therefore, if the ambient temperature drifts, the measured readings will also drift.

Temperature compensation adds 2ms to the measurement time. When optimum speed is required, disable temperature compensation for short periods of time. Temperature compensation should be enabled periodically to obtain a current temperate measurement. The Model 2800 remembers and uses the last temperature measurement in the algorithm to calculate a measured reading. The procedure to enable or disable "Temperature compensation" is provided on .

For remote programming, an action command is included to force (acquire) a temperature measurement while temperature compensation is disabled. The latest temperature reading is then used in the algorithm to calculate subsequent readings.

The following command acquires temperature and uses it to calculate subsequent readings.

SENS:TEMP:OCOM:ACQ

NOTE   *If using an instrument setup (user or power-on) that has temperature compensation disabled, you can use the above command to update the temperature for the algorithm to calculate measured readings.*

Attenuation

In order to perform accurate power measurements, the input signal needs to be properly attenuated by the Model 2800.

Nominal attenuator settings for measuring power levels can be defined by the following formulas:

For the Cellular Bands (824 – 849MHz, 880 – 915MHz):
Attenuator Value (dB) = Expected Input Power + 14

DCS,PCS Bands (1710 – 1785MHz, 1850 – 1980MHz)

Attenuator Value (dB) = Expected Input Power + 24

When measuring primary power measurements only, one attenuator setting can be used over a maximum of a 30dB range.

The range over which power measurements can be made for a given attenuator setting is as follows:

For the Cellular Bands (824 – 849MHz, 880 – 915MHz):

(Attenuation setting – 70) <Expected Input Power (dBm) <(Attenuation – 14) [dBm]

DCS,PCS Bands (1710 – 1785MHz, 1850 – 1980MHz):
(Attenuation setting – 70) <Expected Input Power (dBm) <(Attenuation –24) [dBm]

The following paragraphs give information on setting attenuation levels to maximize the accuracy of adjacent channel and alternate channel measurements

Interpreting response graphs

Response graphs show how a 0dBm input signal is affected by the different attenuator settings of the Model 2800. The following discussion explains how to interpret response graphs. The example graphs (Figure 2-2 and Figure 2-3) used for this discussion apply specifically to the cell band (839.01MHz).

Primary channel measurements

When measuring the primary channel, an under-attenuated input signal will drive the Model 2800 into compression. Figure 2-2 shows an example of a primary channel power response curve for a 0dBm input. As shown, the 0dBm signal cannot be properly measured unless the Model 2800 attenuator is set to >16dB.

The dashed-line portion of the curve shows its response to under-attenuation. This is where compression occurs. The solid-line portion of the curve shows attenuator settings that allow proper measurement of the 0dBm input.

It is good practice to drive the operating point away from the "knee" of curve where compression begins by increasing attenuation by 6 to 8dB. For the response curve in Figure 2-2, a valid dynamic range for attenutator settings is 14 to 50dB.

Figure 2-2
Example graph – attenuation for primary channel (0dBm input)

Attenuation (dB)
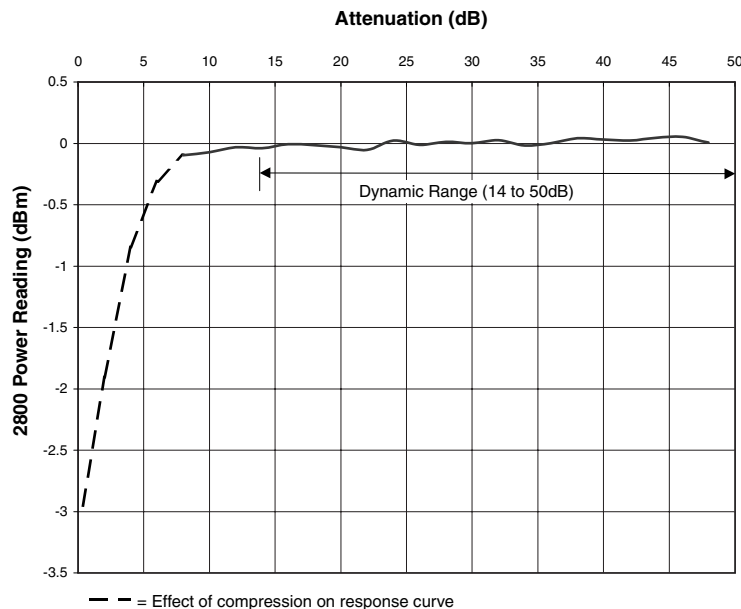
Adjacent and alternate channels

When measuring the adjacent and/or alternate channel power, an under attenuated input signal will be driven into a non-linear response due to 3rd-order and 5th-order products. An over-attenuated input signal will be adversely affected by thermal noise. Figure 2-3 shows examples of adjacent and alternate channel power measurement response curves for a 0dBm input.

Adjacent channel – For the adjacent channel, the large dashed-line portion of the curve shows the attenuator settings where non-linearity occurs due to 3rd-order products. The solid-line portion of the curve shows where thermal noise affects the measurement. The nominal dynamic range for attenuator settings is the region on the curve where 3rd order products and thermal noise intersect.

In Figure 2-3, the nominal dynamic range for the adjacent channel is around 22 to 28dB (labeled "Adj"). As attenuation increases from this region, the measurement is adversely affected by thermal noise. As attenuation decreases from this region, the measurement is adversely affected by 3rd order products.

Alternate channel – For the alternate channel, the small dashed-line portion of the curve shows the attenuator settings where non-linearity occurs due to 5rd-order products. The solid-line portion of the curve shows where thermal noise affects the measurement. The nominal dynamic range for attenuator settings is the region on the curve where 5th order products and thermal noise intersect.

In Figure 2-3, the nominal dynamic range for the alternate channel is around 16 to 26dB (labeled "Alt"). As attenuation increases from this region, the measurement is adversely affected by thermal noise. As attenuation decreases from this region, the measurement is adversely affected by 5th order products.

Figure 2-3
Example graph – attenuation for adjacent and alternate channels (0dBm input)

= Effect of 3rd order products on response curve

= Effect of 5th order products on response curve

= Effect of thermal noise on response curves

Adj / Alt = Dynamic range for attenuation (adjacent / alternate channel)
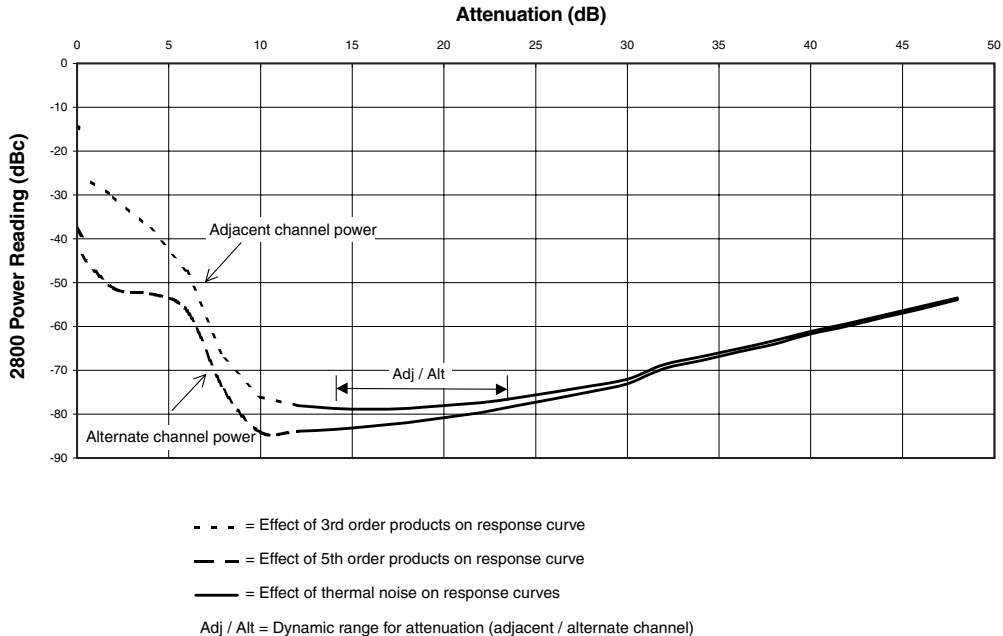
Concurrent measurements

An attenuator setting that is appropriate for the primary channel may not be suitable for the adjacent and alternate channels. When concurrently measuring primary, adjacent, and/or alternate channels, you must select an attenuator setting that is suitable for all the measurements.

In Figures 2-2 and 2-3, the dynamic ranges for the primary, adjacent, and alternate channels overlap. Select an attenuator setting that is within the dynamic range of all three measurements, such as 14dB.

Attenuator settings for cell and PCS bands

There are two methods to determine a valid attenuator setting:

- The equations presented at the beginning of this discussion can be used (repeated here):

  For the Cellular Bands (824 - 849MHz, 880 - 915MHz):
  Attenuator Value (dB) = Expected Input Power +14

  DCS, PCS Bands (1710 - 1785MHz, 1850 - 1980MHz):
  Attenuator Value (dB) = Expected Input Power + 24

- Cellular and PCS Response graphs can be used to determine the attenuation setting for a 0dBm input. Attenuator settings for other power levels can then be calculated.

Using response graphs to determine attenuator setting

The graphs in Figures 2-4 through 2-7 plot power versus attenuator settings. They show how a 0dBm input power level is affected by the various attenuator settings of the Model 2800.

Figure 2-4 and Figure 2-5 show the graphs for 848.01MHz, which is in the cell band. The graphs for other cell band frequencies are similar. Figure 2-6 and Figure 2-7 show the graphs for 1850.05MHz, which is in the PCS band. The graphs for other PCS band frequencies are similar.

Cell band (848.01MHz)

The typical response curves for measurements in the cell band (<1GHz) are shown in Figure 2-4 and Figure 2-5. As explained in "Interpreting response graphs", select an attenuation point that is suitable for your measurements. Keep in mind that graphs shown in Figures 2-2 and 2-3 are of the same form as the graphs in Figure 2-4 and Figure 2-5.

Keep in mind that the selected attenuation point is for a 0dBm input signal. For a non-0dBm input, add the dBm input value to the selected attenuation point. For example, assume a -10dBm input level and that the selected attenuation point is 16dB. The Model 2800 attenuator setting is calculated as follows:

2800 Attenuator Setting = Selected attenuation point on graph + -10
$$= 16 - 10$$
$$= 6$$

PCS band (1850.05MHz)

The typical response curves for measurements in the PCS band (>1GHz) are shown in Figure 2-6 and Figure 2-7. As explained in "Interpreting response graphs", select an attenuation point that is suitable for your measurements.

Keep in mind that the selected attenuation point is for a 0dBm input signal. For a non-0dBm input, add the dBm input value to the selected attenuation point. For example, assume a -10dBm input level and that the selected attenuation point is 26dB. The Model 2800 attenuator setting is calculated as follows:

2800 Attenuator Setting = Selected attenuation point on graph + -10
$$= 26 - 10$$
$$= 16$$

Figure 2-4
Primary channel power attenuation for 0dBm input – cell band (848.01MHz)

Attenuator Setting (dB)
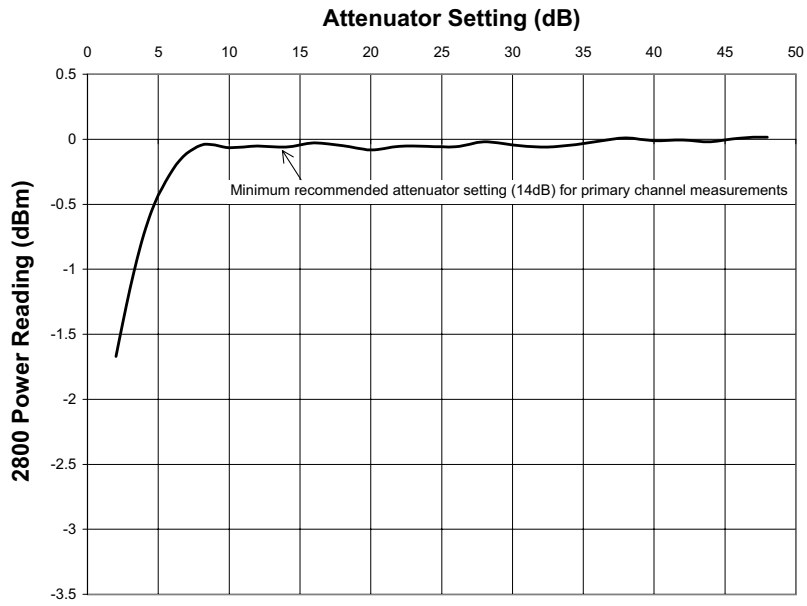
Figure 2-5
Adjacent and alternate channel power attenuation for 0dBm input – cell band (848.01MHz)
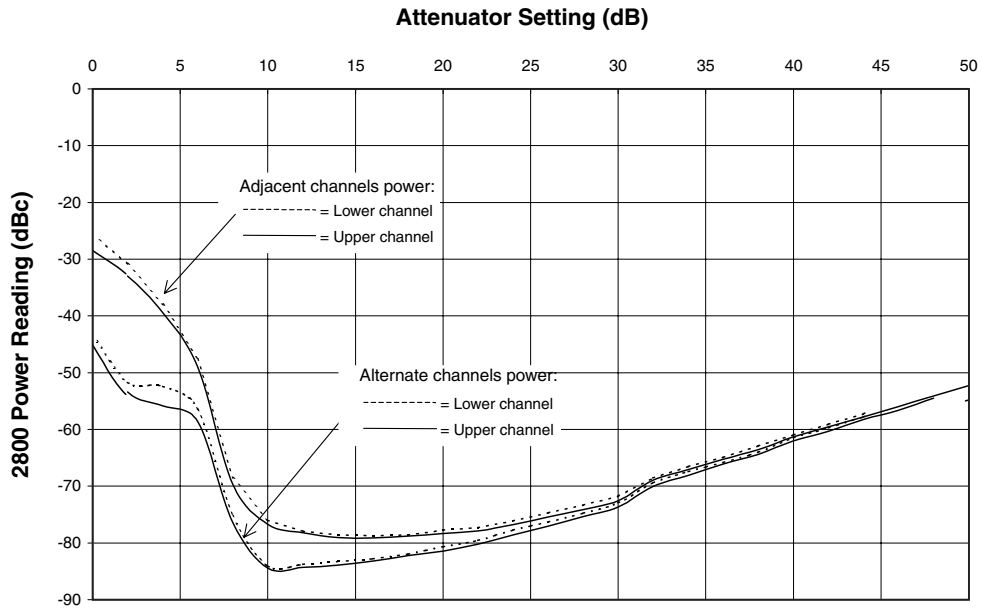
Figure 2-6
Primary channel power attenuation for 0dBm input – PCS band (1850.05MHz)
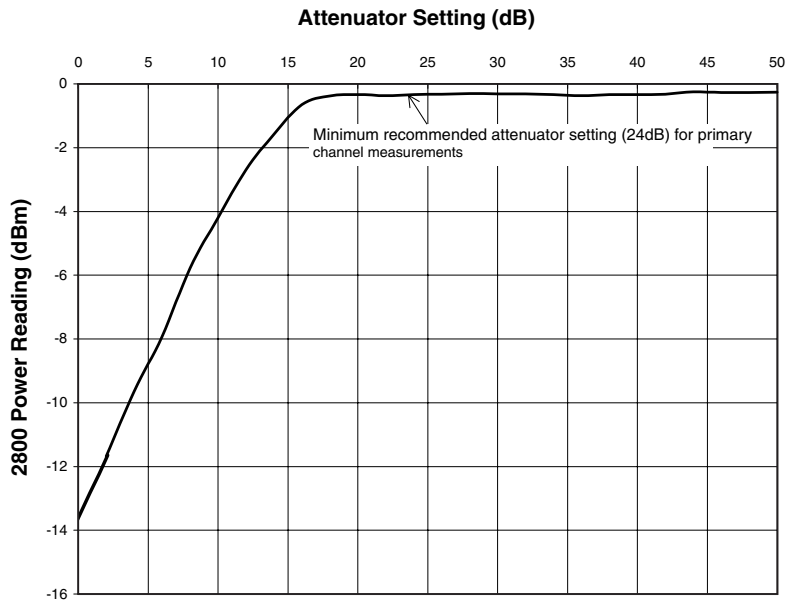
Figure 2-7
Adjacent and alternate channel power attenuation for 0dBm input – PCS band (1850.05MHz)
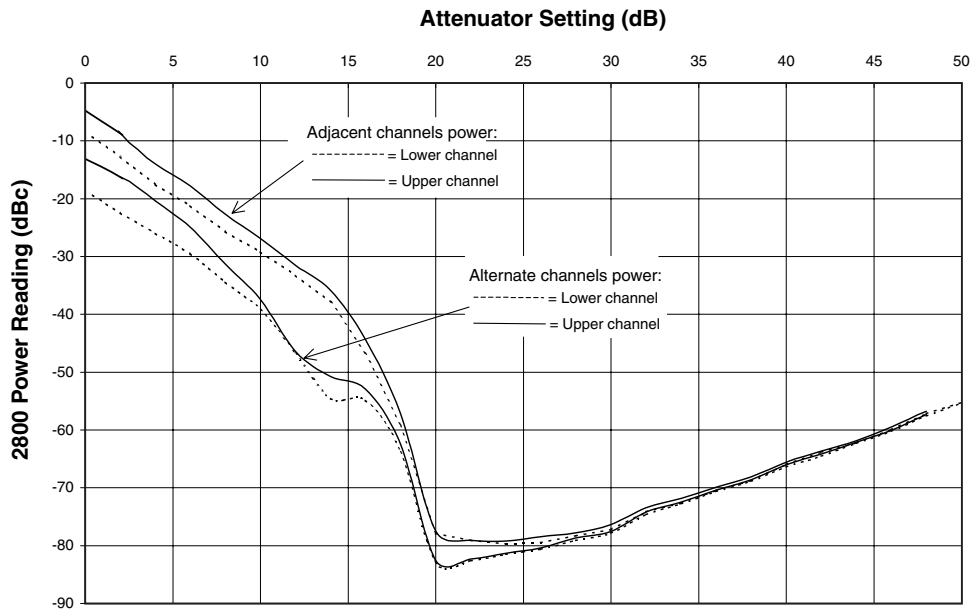
Alternate channel only measurement

The previous procedures used to determine the attenuator setting are, in most cases, suitable for the alternate channel. However, if optimum attenuation is required for the alternate channel, decrease the attenuator setting by 4dB over the nominal values for both the cell and PCS bands (from 14dB down to 10dB for cell; from 24dB down to 20dB for PCS).

Primary channel only measurement

When measuring the primary channel power only, the attenuator setting is not as critical as the setting used when the maximum possible adjacent and/or alternate dynamic range is needed. The dynamic range for the primary channel can be expressed as follows (see Figure 2-4 and Figure 2-6):

For the Cellular Bands (824 - 849MHz, 880 - 915MHz):
Input Power + 70 >= 2800 Attenuator Setting >= Input Power Value + 14

DCS, PCS Bands (1710 - 1785MHz, 1850 - 1980MHz):
Input Power +70 >= 2800 Attenuator Setting >= Input Power Value + 24

From the above expressions, the minimum and maximum attenuator settings can be calculated as follows:

For the Cellular Bands,
Minimum 2800 Attenuator Setting = Input Power + 14
Maximum 2800 Attenuator Setting = Input Power + 70

For the PCS Bands,
Minimum 2800 Attenuator Setting = Input Power + 24
Maximum 2800 Attenuator Setting = Input Power + 70

Example — For measurement of the primary channel only at 1850.05MHz, assume the following:

Input Power = -20dBm
The recommended range of attenuation values is calculated as follows:

Minimum 2800 Attenuator Setting = Input Power Value + 24 (14 for cell bands)
                                                  = 4dB

Maximum 2800 Attenuator Setting = Input Power Value + 70
                                                  = 50dB

For a -20dBm input signal at 1850.05MHz, the recommended range of attenuator settings for primary channel measurements only is 4dB to 50dB.

NOTE   *The maximum attenuator setting for the Model 2800 is 50dB. If the result of the calculation for the maximum setting is >50dB, use the 50dB setting.*

Auto attenuation (CDMA only)

For CDMAOne, CDMA2000, and WCDMA measurements, auto attenuation can be used. However, a high quality source with very low inter modulation must be used.

NOTE   *For auto attenuation, a high quality CDMA source with very low inter modulation products must be used. If such a source is not being used, DO NOT use auto attenuation.*

When using auto attenuation, the Model 2800 automatically selects the optimum attenuator setting for the adjacent channel. Refer to Figure 2-3 for the following discussion to explain how auto attenuation operates.

When auto attenuation is selected, the Model 2800 sets attenuation to 50dB and measures the adjacent channel power. The unit then steps the attenuator setting down to 48dB and again measures the adjacent channel power. If that power reading is LESS than the previous power reading, the unit steps down attenuation to 46dB and performs another measurement.

As long as the latest reading is LESS than the previous one, this process of stepping down 2dB and comparing readings continues. When the latest reading is GREATER than the previous one, the process stops and the Model 2800 uses the previous auto attenuator setting for CDMA measurements.

For the graph for the adjacent channel in Figure 2-3, the Model 2800 steps down until the transition from thermal noise (solid line) to 3rd order products (dashed line) occurs. This occurs at 24dB, which becomes the auto attenuator setting for the Model 2800.

Root-raised cosine (RRC) filter

The RRC filter is available for the WCDMA standard to cancel the effects of Inter Symbol Interference (ISI). ISI is the spreading and smearing of symbols. Energy from one symbol leaks over into the next symbol to possibly distort the received signal enough to be interpreted incorrectly. An example of a transmitted digital sequence is shown in Figure 2-8A. Symbol smearing caused by ISI is shown in Figure 2-8B.

The solution to ISI is pulse shaping of the received signal. A signal is measured using timing pulse slices. Power is measured at each slice. The goal is to reshape

the pulse such that the amplitude for each slicing instant is the same as the ampli-
tude of the original transmitted signal. It does not matter what the signal looks like
before or after each slicing instant.

Figure 2-8
ISI spreading

Amplidude

1   3   Symbol
(1of 4)

2   4   Time

→| |← Symbol Time (Ts)

A) Sequence 1010 to be sent

1   3

2   4   Time

B) Symbol spreading caused by ISO
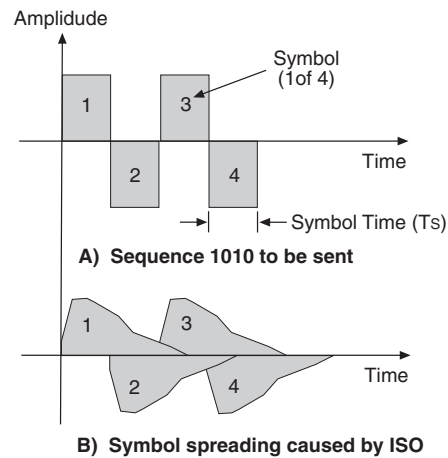
As shown in Figure 2-8A, the time period of a symbol is called the Symbol Time.
In the frequency domain, the symbol rate is used. Symbol Rate (R_S) is the inverse
of Symbol Time (T_S) and is calculated as follows:

$R_S = 1 / T_S$

For example, if the Symbol Time = 0.5 seconds, then Symbol Rate is 2:

$R_S \qquad = 1 / 0.5$

$\qquad = 2$

The Root Raised Cosine (RRC) filter uses a weighting function to re-shape the
symbol pulses. The result of an RRC filtering process is shown in Figure 2-9 for a
symbol rate of 2. At the frequency for the symbol rate (in this case 2Hz), the ampli-
tude of the pulse is at its half power (-3dB) and falling. This sharp amplitude drop-
off of the pulse significantly reduces its effect on the next symbol.

Figure 2-9
Frequency response of RRC filter

3
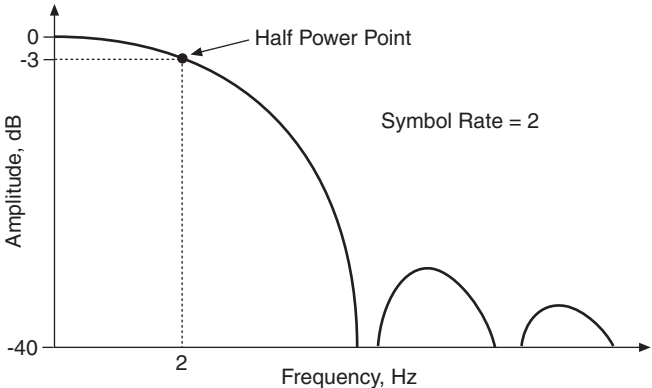
Basic Power Analyzer Operation

Section topics

Readings & power levels

Power readings

All Model 2800 power readings are given in dBm (or, alternatively, dBc for adjacent and alternate channel power measurements). 0dBm corresponds to a power of 1mW into a 50Ω load. You can convert power in dBm to power in milliwatts as follows:

$$P(mW) = 10^{\,(PdBm/10)}$$

For example, a power reading of +15dBm corresponds to a power level of 31.62mW.

Alternate or adjacent channel power measurements can be displayed in either dBm or dBc. A dBc reading indicates the number of dB's the adjacent or alternate power is down from the primary power:

Adj/Alt power (dBc) = Adj/Alt power (dBm) - Primary power (dBm)

For example, if the primary channel power measures -5dBm and the adjacent channel power measures -50dBm, the adjacent channel dBc equivalent is -45dBc.

Display formats for readings

The following keys are used to display measured readings:

PRIMARY	Use to display primary channel power readings.
ADJ/ALT	Use to display adjacent and alternate channel readings.
PEAK	Use to display the power level and frequency of the highest peak in the power spectrum.
Shift, PEAK	Use to display the power levels and frequencies of the next four highest peaks in the power spectrum.
ΔF	Use to display the frequency difference between the highest peak and the center frequency in the power spectrum. If no significant peaks are found, the message "UndrFlw" will be displayed.

Reference   *Details on using these keys to view the various "Display formats (readings)" are covered on page 1-18 of this manual.*

Bus readings

The following commands are used to trigger and return a reading string for power readings:

READ?   ' Trigger measurement and request reading string.

The above read command is used for most measurements. However, the MEAS? command can instead be used since it functions the same as the READ? command.

When using the LIST mode with LEVel or EXTernal triggering selected, the following command sequence is used to read and request measured readings:

INIT   ' Triggers a measurement.
FETCh?   ' Returns readings after 2800 is addressed to talk.

A returned reading can include measurements, a timestamp, and a status byte. Measurements that are returned depend on the selected function for data elements: Power, peak, or ΔF.

NOTE   *Details on "Readings over the bus" are provided on page 1-26 of this manual.*

Concurrent measurements

By default, the Model 2800 measures the primary, adjacent, and alternate channels concurrently. To increase measurement speed, concurrent measurements can be disabled over the bus. When disabled, the adjacent and alternate channels are not measured. The commands to disable and enable "Concurrent measurements" are explained on page 3-40 of this manual.

Reference   *More information on "Readings over the bus" is provided on page 1-26 of this manual.*

Maximum power levels

The maximum power that can be measured by the Model 2800 is +20dBm (100mW). For higher power levels, you must use an external attenuator.

CAUTION   **The maximum safe input power for the Model 2800 is +22dBm, 20V DC. Exceeding this value may cause damage to the instrument, voiding the warranty.**

Input connections

RF input and 10MHz reference

Input connections for a typical system to test cell phones are shown in Figure 3-1. As shown, a standard RF cable terminated with a Type N connector is used for the RF signal connections between the cell phone (DUT) and Model 2800.

Figure 3-1 shows an external 10MHz reference connected to the Model 2800. However, this connection is optional since the Model 2800 has its own internal 10MHz reference oscillator. To use the internal reference, disconnect the BNC cable. The internal reference oscillator will activate automatically.

NOTE   *Details on "Oscillators" are provided on page 2-6 of this manual.*

CAUTION **NEVER stand the Model 2800 up on its rear panel. This will cause damage to the RF input connector.**

Input connector damage caused by negligence is not covered by the warranty. Even slight damage to RF input connector will result in poor measurement performance.

Figure 3-1
Model 2800 input connections

Model 2800 rear panel
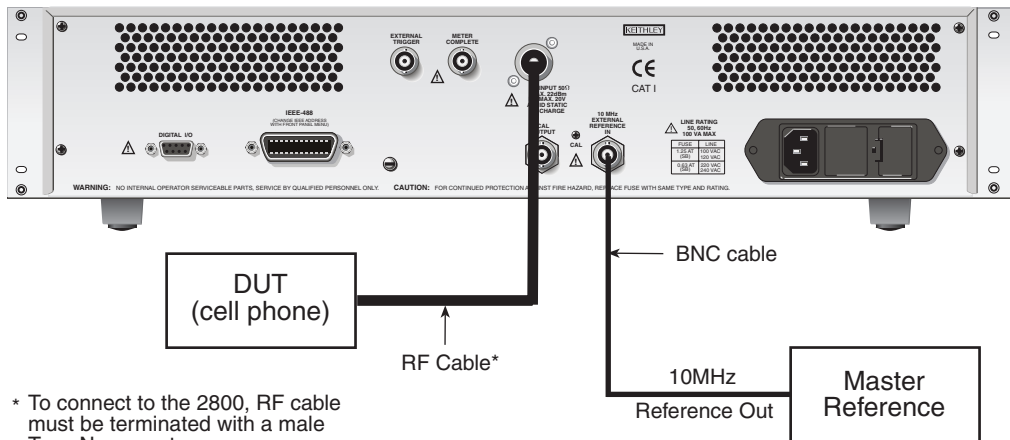
To connect to the 2800, RF cable must be terminated with a male Type N connector.

DUT (cell phone)

RF Cable*

BNC cable

10MHz Reference Out

Master Reference

NOTE *The use of an external 10MHz reference is optional.*

Cable compensation

Power loss in RF cables, couplers, and splitters can adversely affect a power measurement by the Model 2800. In Figure 3-1, an RF cable connects the cell phone to the input of the Model 2800.

NOTE *When using the level trigger source and cable correction is enabled, the level trigger level will be detected on the cable corrected measured value.*

For optimum performance, cable compensation can be used to cancel the effects of power loss in the cables, couplers, and splitters. In general, you must first determine the insertion loss in the signal path between the cell phone and the Model 2800, and then enter the insertion loss value into the Model 2800. When

measuring, the Model 2800 factors the insertion loss value into the calculation for the reading.

NOTE   *Use a Vector Network Analyzer (VNA) to characterize the cable.*

After determining the required power loss correction value (00.00 to 99.99dB), enter it into the Model 2800 as follows:

1. Press **Menu** to display the main menu.
2. Use the **PREV** and/or **NEXT** key to place the blinking cursor on **CABLE** and press **Enter.**
3. Place the cursor on **LOW-BAND** (for cell band) or **HIGH-BAND** (for PCS band), and press **Enter**.
4. Key in the correction value (00.00 to 99.99 dB) and press **Enter**.
5. Place the cursor on **CONTROL** and press **Enter**.
6. Place the cursor on **ENABLE** to activate cable correction and press **Enter**.
7. Press **Exit** to exit the menu structure.

Remote programming:

```
SENS:CORR:CELL <NRf>     ' Enter correction value for cell (in dB):
                         ' <NRf> = 0 to 99.99.
SENS:CORR:PCS <NRf>      ' Enter correction value for PCS (in dB):
                         ' <NRf> = 0 to 99.99.
SENS:CORR:STAT <b>       ' Enable (1) or disable (0) cable compensation.
```

Making power measurements

NOTES   *A software driver to control the Model 2800 is available as a free download on the Keithley website (www.keithley.com). This driver is suitable for use with LabView, LabWindows CVI, Visual Basic, and C++. The driver is available in the download section of the 2800 product page on the website.*

For remote operation, the Model 2800 can be configured for optimum measurement speed. The "Commands to optimize measurement speed" are listed on page 5-10.

Detailed step-by-step procedures are provided here for two mobile standards. Also included are the detailed procedures to measure the power level and frequency of the five highest peaks in the power spectrum, and delta frequency (ΔF).

Mobile standards – Measurement procedures are provided for the CDMAOne standard and NADC standard. These procedures demonstrate the basic steps to

make frequency selective power measurements. For CDMAOne, the primary channel, adjacent channel, and alternate channel are measured. For NADC, burst and average power will be measured for a frame of the pulse train.

> *Reference   More information on the mobile standards is provided in Section 4 of this manual. Also included is an abbreviated measurement procedure for each mobile standard.*

Peak and ΔF – A procedure is included to measure the power level and frequency of the five highest peaks within a power spectrum (see Figure 3-2), and a procedure to accurately determine the frequency of the highest peak (ΔF) (see Figure 3-3).

Restoring factory defaults

Before performing any of the following measurement procedures, it is recommended that the Model 2800 be restored to its factory defaults.

Front panel operation – Use the following key-press sequence to restore factory defaults:

1. Press **Menu**.
2. Select the **SETUP** option from the Main Menu.
3. Place the blinking cursor on **RESET** and press **Enter**.

Remote programming – Send one of the following commands to restore factory defaults and place the Model 2800 in the one-shot measurement mode.

*RST   or   SYSTem:PRESet

NOTE   *The only difference between *RST and SYST:PRES is the parameter for the FORM:BORD command. *RST selects the normal byte order for returned readings, while SYST:PRES selects the swapped byte order. Details on "Byte order" are provided on page 2-12 of the Reference Manual.*

CDMAOne measurements

NOTE   *Remote programming locks out front panel operation. To restore front panel operation, press the **LOCAL** key.*

Primary channel

1. **Mobile standard** – Press **Standard** and select the **CDMA1** standard, then select the **CELL** or **PCS** band.

    Remote programming example:

    ```
    INST:SEL CDMA1              ' Select CDMAOne standard.
    INST:SEL?                   ' Query mobile standard.
    SENS:CDMA1:TYPE <name>      ' Select band: <name> = CELL, PCS, or
                                  KPCS.
    SENS:CDMA1:TYPE?            ' Query band.
    ```

    Reference   For details on "Selecting mobile standard", go to page 3-35.

2. **Primary BW** – The primary channel bandwidth (BW) for CDMAOne is 1.23MHz. This fixed setting can be viewed by pressing **SHIFT** and then **Meas BW**.

    Remote programming example:

    ```
    SENS:PRIM:BAND?            ' Query primary channel BW.
    ```

    Reference   For details on viewing "Bandwidths", go to page 3-36.

3. **Averaging** – Averaging improves reading repeatability. The default number of readings to average is six. Use the **Avg** key to set the instrument to average 1 to 100 readings, and select the averaging mode (**MOVING** or **REPEAT)**. Details on "*Averaging*" are provided on *page 2-5* of this manual.

    Remote programming example:

    ```
    SENS:AVER:COUN 10          ' Set to average 10 readings.
    SENS:AVER:TCON REP         ' Select Repeat averaging mode.
    SENS:AVER:STAT ON          ' Enable averaging.
    ```

Reference   For details to configure "Averaging", go to page 3-40.

4. **Attenuator** – In order to perform accurate power measurements, the input signal needs to be properly attenuated by the Model 2800. The attenuator setting depends on the set center frequency and the input power level.

   Use the **Attenuator** key to set the appropriate attenuator value (0 to 50dB in 2dB steps).

   NOTE   Auto attenuation can be used if using a high quality CDMA source with very low inter modulation products. If such a source is not being used, DO NOT use auto attenuation. Details on "Auto attenuation (CDMA only)" are provided on page 2-17 of this manual.

   Remote programming example:

   ```
   SENS:POW:ATT 24        ' Set attenuator to 24dB (proper setting for
                          ' input signal power of 0dBm for cell band).
   ```

   Reference   Details to determine and set the "Attenuator" are provided on page 3-41.

5. **Center frequency** – The default center frequency is channel 1 (or 825.03MHz). To change the center frequency, use the **Ch#** key to select a channel number, or use the **MHz** key to specify the center frequency.

   Remote programming example:

   ```
   SENS:FREQ:CHAN 1          ' Select channel 1.
   SENS:FREQ:CHAN?           ' Query channel number.
   or
   SENS:FREQ:CENT 825.03e6   ' Set center frequency to 825.03MHz.
   SENS:FREQ:CENT?           ' Query center frequency.
   ```

   Reference   For details to set the "Center frequency", go to page 3-38.

6. **Display primary power** – The measured primary channel power is displayed using the **PRIMARY** key.

   Remote programming example:

   ```
   SENS:FUNC POW     ' Select the power function.
   READ?             ' Trigger and request power reading.
   ```

   Reference   For details on using the "PRIMARY key" go to page 1-19.

   For other options to acquire "Readings over the bus", go to page 1-26.

Adjacent and alternate channels

1. **Mobile standard** – Press **Standard** and select the **CDMA1** standard, then select the **CELL** or **PCS** band.

   Remote programming:

   ```
   INST:SEL CDMA1              ' Select CDMAOne standard.
   INST:SEL?                   ' Query mobile standard.
   SENS:CDMA1:TYPE <name>      ' Select band: <name> = CELL or PCS.
   SENS:CDMA1:TYPE?            ' Query band.
   ```

   Reference   For details on "Selecting mobile standard", go to page 3-35.

2. **Adjacent BW or alternate BW** – The adjacent and alternate channel BW for CDMAOne is 30kHz. To view these fixed BW settings, press **SHIFT** and then **Meas BW**. Select **ADJACENT** or **ALTERNATE** to view the bandwidth.

   Remote programming:

   ```
   SENS:ADJ:BAND?      ' Query adjacent channel BW.
   SENS:ALT:BAND?      ' Query alternate channel BW.
   ```

   Reference   For details on viewing "Bandwidths", go to page 3-36.

3. **Channel offset** – The default adjacent channel offset for CDMAOne cell is ±885kHz. For CDMAOne PCS, the default adjacent offset is ±1250kHz. The alternate channel offset for CDMAOne (cell and PCS) is 1.98MHz. Alternate channel offset is fixed and cannot be changed by the user.

   To view an offset, press **SHIFT**, press **Freq Offset,** and then select **ADJACENT** or **ALTERNATE**. To change the adjacent offset, select **ADJACENT** and set the desired offset frequency.

   Remote programming examples:

   ```
   SENS:ADJ:OFFS 885e3        ' Set adjacent offset to 885kHz.
   SENS:ADJ:OFFS?             ' Query adjacent offset.
   SENS:ALT:OFFS?             ' Query alternate offset.
   ```

   Reference   For details to view or set "Offset frequencies", go to page 3-38.

4. **Acquisition time** – A measurement acquisition time is used for CDMAOne adjacent and alternate channels. The default acquisition time is 10msec. Acquisition time is typically set to a value that provides a compromise between repeatability and speed. For details to improve "Reading repeatability", go to page 2-4. Use the **Acq Time** key to set the acquisition time (up to 999.999 ms).

   Remote programming example:

   ```
   SENS:ACQ:TIME 10e-3        ' Set acquisition time to 10ms.
   ```

   Reference   For details to set "Acquisition time", go to page 3-41.

5. **Attenuator** – In order to perform accurate power measurements, the input signal needs to be properly attenuated by the Model 2800. The attenuator setting depends on the set center frequency and the input power level.

    Use the **Attenuator** key to set the appropriate attenuator value (0 to 50dB in 2dB steps).

NOTE   *Auto attenuation can be used if using a high quality CDMA source with very low inter modulation products. If such a source is not being used, DO NOT use auto attenuation. Details on "Auto attenuation (CDMA only)" are provided on page 2-17 of this manual.*

Remote programming example:

```
SENS:POW:ATT 24          ' Set attenuator to 24dB (proper setting for
                         ' input signal power of 0dBm for cell band).
```

Reference   Details to determine and set the "Attenuator" are provided on page 3-41.

6. **Center frequency** – The default center frequency is channel 1 (or 825.03MHz). To change the center frequency, use the **Ch#** key to select a different channel number, or use the **MHz** key to specify the center frequency.

    Remote programming example:

```
SENS:FREQ:CHAN 1         ' Select channel 1.
SENS:FREQ:CHAN?          ' Query channel number.
or
SENS:FREQ:CENT 825.03e6  ' Set center frequency to 825.03MHz.
SENS:FREQ:CENT?          ' Query center frequency.
```

Reference   For details to set the "Center frequency", go to page 3-38.

7. **Display adjacent or alternate power** – The measured adjacent and alternate channel power is displayed using the **ADJ/ALT** key. Adjacent and alternate power can be displayed in dBm or dBc. Use the **dBm/dBc** key to toggle the between dBm and dBc.

    Remote programming example:

```
UNIT:POW DBC         ' Set power units to dBc.
SENS:FUNC POW        ' Select the power function.
READ?                ' Trigger and request power reading.
```

Reference   For details on using the "ADJ/ALT key" go to page 1-20.

For other options to acquire "Readings over the bus", go to page 1-26.

NADC measurements

NOTE   *Remote programming locks out front panel operation. To restore front panel operation, press the LOCAL key.*

Burst average power

NOTE   *Burst power measurements require that input protection be disabled. To disable input protection, press **Menu**, select **INPUT,** and select **DISABLE**. Details on enabling/disabling "Input protection" are provided on page 3-39 of this manual.*

1. **Mobile standard** – Press **Standard** and select the **NADC** standard, then select the **CELL** or **PCS** band.

    Remote programming:

    ```
    INST:SEL NADC             ' Select NADC cell standard.
    INST:SEL?                 ' Query mobile standard.
    SENS:NADC:TYPE <name>     ' Select band: <name> = CELL or PCS
    SENS:NADC:TYPE?           ' Query band.
    ```

    Reference   For details on "Selecting mobile standard", go to page 3-35.

2. **Primary and adjacent BW** – The primary channel BW for NADC is 30kHz while the adjacent BW is 25kHz. To view these BW settings, press **SHIFT** and then **Meas BW**. Use the **PRIMARY** menu item to view primary bandwidth and use the **ADJACENT** menu item to view adjacent BW.

    Remote programming:

    ```
    SENS:PRIM:BAND?           ' Query primary channel BW.
    SENS:ADJ:BAND?            ' Query adjacent channel BW.
    ```

    Reference   For details on viewing "Bandwidths", go to page 3-36.

3. **Adjacent channel offset** – The default adjacent channel offset for NADC cell is 30kHz. To view and/or change the offset, press **SHIFT** and then **Freq Offset**. Select **ADJACENT** and then, if desired, change the offset frequency.

    Remote programming example:

    ```
    SENS:ADJ:OFFS 30e3            ' Set adjacent offset to 30kHz.
    SENS:ADJ:OFFS?               ' Query adjacent offset.
    ```

    Reference   For details to view or set "Offset frequencies", go to page 3-38.

4. **Trigger setup** – The level trigger control source is used for these measure-
    ments. When the set power level is detected, a measurement will be trig-
    gered. Details on "Triggering" are provided in Section 3 of the Reference
    Manual.

    Press **SHIFT** and then **Trigger** to access the trigger setup menu.
    - After selecting **SOURCE**, select **LEVEL** and set the input signal level
      that will trigger a measurement.
    - Select **DELAY** and set the appropriate period to delay the start of the
      measurement process. A typical delay is 125µs.
    - Select **COUNT**, select **FINITE** and set the count to the desired number
      of measurements to perform (1 to 2500).

    Remote programming example:

    ```
    TRIG:SOUR LEV        ' Select the input signal level trigger source.
    TRIG:LEV -50         ' Set trigger level to -50dBm.
    TRIG:DEL 125e-6      ' Set trigger delay to 125µs.
    ```

    Reference   For details to configure "Triggering" go to page 3-42.

5. **Acquisition time** – Acquisition time for this measurement must not exceed
    6.67ms, which is the usable portion of the pulse. A typical acquisition time
    is 6ms. Details on "NADC measurements" are provided on page 4-11 of
    this manual.

    Use the **Acq Time** key to set the acquisition time.

    Remote programming example:

    ```
    SENS:ACQ:TIME 6e-3          ' Set acquisition time to 6ms.
    ```

    Reference   For details to set "Acquisition time", go to page 3-41.

6. **Attenuator** – In order to perform accurate power measurements, the input
    signal needs to be properly attenuated by the Model 2800. The attenuator
    setting depends on the set center frequency and the input power level.
    Use the **Attenuator** key to set the appropriate attenuator value (0 to 50dB
    in 2dB steps).

    Remote programming example:

    ```
    SENS:POW:ATT 24        ' Set attenuator to 24dB (proper setting for
                           ' input signal power of 0dBm for cell band).
    ```

    *Reference   Details to determine and set the "Attenuator" are provided on
    page 3-41.*

7. **Center frequency** – The default center frequency is channel 1 (or 825.03MHz for the cell band or 1850.01MHz for the PCS band). To change the center frequency, use the **Ch#** key to select a channel number, or use the **MHz** key to specify the center frequency.

    Remote programming examples:

    ```
    SENS:FREQ:CHAN 1              ' Selects channel 1.
    SENS:FREQ:CHAN?              ' Query channel number.
    or
    SENS:FREQ:CENT 825.03e6     ' Set center frequency to 825.03MHz.
    SENS:FREQ:CENT?             ' Query center frequency.
    ```

    Reference   For details to set the "Center frequency", go to page 3-38.

8. **Display primary burst power** – The measured primary channel power is displayed using the **PRIMARY** key.

    Remote programming example:

    ```
    SENS:FUNC POW        ' Select power function.
    READ?                ' Trigger and request power reading.
    ```

    Reference   For details on using the "PRIMARY key" go to page 1-19.

    For other options to acquire "Readings over the bus", go to page 1-26.

NOTE   To measure adjacent and/or alternate channel power, continue on to step 9.

9. **Display adjacent burst power** – The measured adjacent channel power is displayed using the **ADJ/ALT** key. Adjacent power can be displayed as dBm or dBc. Use the **dBm/dBc** key to toggle the between dBm and dBc.

    Remote programming example:

    ```
    UNIT:POW DBC         ' Set power units to dBc.
    SENS:FUNC POW        ' Select the power function.
    READ?                ' Trigger and request power reading.
    ```

    Reference   For details on using the "ADJ/ALT key" go to page 1-20.

    For other options to acquire "Readings over the bus", go to page 1-26.

NOTE   *Perform the following steps to measure alternate burst power.*

There is no selection for alternate channel power. Alternate channel power is measured by changing the adjacent channel offset such that the measurement occurs in the frequency range of the alternate channel.

10.   **Alternate channel offset** – Alternate channel offset is set from the **ADJACENT** item of the frequency offset menu. Press **SHIFT** and then **Freq Offset**. Select **ADJACENT** and then increase the offset appropriately to measure the alternate channel.

Remote programming example:

```
SENS:ADJ:OFFS 60e3      ' Set adjacent offset to 60kHz.
SENS:ADJ:OFFS?          ' Query adjacent offset.
```

Reference   *For details to set "Offset frequencies", go to page 3-38.*

11.   **Measure alternate burst power** – The measured alternate channel power is displayed using the **ADJ/ALT** key. However, keep in mind that alternate power will be displayed as ADJ power. Alternate power can be displayed as dBm or dBc. Use the **dBm/dBc** key to toggle the between dBm and dBc.

Remote programming example:

```
UNIT:POW DBC      ' Set power units to dBc.
SENS:FUNC POW     ' Select the power function.
READ?             ' Trigger and request power reading.
```

Reference   *For details on using the "ADJ/ALT key" go to page 1-20.*

For other options to acquire "Readings over the bus", go to page 1-26.

Average power

1.   **Mobile standard** – Press **Standard** and select the **NADC** standard, then select the **CELL** or **PCS** band.

Remote programming:

```
INST:SEL NADC            ' Select NADC cell standard.
INST:SEL?                ' Query mobile standard.
SENS:NADC:TYPE <name>    ' Select band: <name> = CELL or PCS.
SENS:NADC:TYPE?          ' Query band.
```

Reference   *For details on "Selecting mobile standard", go to page 3-35.*

2. **Primary and adjacent BW** – The primary channel BW for NADC is 30kHz while the adjacent channel BW is 25Hz. To view the fixed BWs, press **SHIFT** and then **Meas BW**. Use the **PRIMARY** menu item to view primary bandwidth and use the **ADJACENT** menu item to view adjacent BW.

Remote programming:

```
SENS:PRIM:BAND?          ' Query primary channel BW.
SENS:ADJ:BAND?           ' Query adjacent channel BW.
```

Reference   For details on viewing "Bandwidths", go to page 3-36.

3. **Adjacent channel offset** – The default adjacent channel offset for NADC cell is 30kHz. To view and/or change the offset, press **SHIFT** and then **Freq Offset**. Select **ADJACENT** and then, if desired, change the offset frequency.

Remote programming example:

```
SENS:ADJ:OFFS 30e3       ' Set adjacent offset to 30kHz.
```

Reference   For details to view or set "Offset frequencies", go to page 3-38.

4. **Trigger setup** – Press **SHIFT** and then **Trigger** to access the trigger setup menu. After selecting **SOURCE**, select the **IMMEDIATE** trigger source for continuous measurements.

Remote programming example:

```
TRIG:SOUR IMM            ' Select immediate triggering.
```

Reference   For more information on "Triggering", go to page 3-42.

5. **Acquisition time** – Using the **Acq Time** key, set the acquisition time to 20ms (for full rate) or 40ms (for half rate).

Remote programming example:

```
SENS:ACQ:TIME 20e-3      ' Set 20ms acquisition time.
```

Reference   For details to set "Acquisition time", go to page 3-41.

6. **Attenuator** – In order to perform accurate power measurements, the input signal needs to be properly attenuated by the Model 2800. The attenuator setting depends on the set center frequency and the input power level.

Use the **Attenuator** key to set the appropriate attenuator value (0 to 50dB in 2dB steps).

Remote programming example:

```
SENS:POW:ATT 26          ' Set attenuator to 26dB (proper setting for
                         ' input signal power of 0dBm for cell band).
```

Reference   Details to determine and set the "Attenuator" are provided on page 3-41.

7. **Center frequency** – The default center frequency is channel 1 (or 825.03MHz for the cell band or 1850.01MHz for the PCS band). To change the center frequency, use the **Ch#** key to select a channel number, or use the **MHz** key to specify the center frequency.

    Remote programming example:

    ```
    SENS:FREQ:CHAN 1            ' Select channel 1.
    SENS:FREQ:CHAN?            ' Query channel number.
    or
    SENS:FREQ:CENT 825.03e6    ' Set center frequency to 825.03MHz.
    SENS:FREQ:CENT?            ' Query center frequency.
    ```

    Reference   For details to set the "Center frequency", go to page 3-38.

8. **Display primary average power** – The measured primary channel power is displayed using the **PRIMARY** key.

    Remote programming example:

    ```
    SENS:FUNC POW             ' Select the power function.
    FORM:ELEM:POW PRIM        ' Select the primary channel element.
    READ?                     ' Trigger and request power reading.
    ```

    Reference   For details on using the "PRIMARY key" go to page 1-19.
    For other options to acquire "Readings over the bus", go to page 1-26.

NOTE   To measure adjacent and/or alternate power, continue on to step 9.

9. **Display adjacent average power** – The measured adjacent channel power is displayed using the **ADJ/ALT** key. Adjacent power can be displayed as dBm or dBc. Use the **dBm/dBc** key to toggle the between dBm and dBc.

    Remote programming example:

    ```
    SENS:FUNC POW             ' Select the power function.
    FORM:ELEM:POW ALL         ' Include all data elements.
    UNIT:POW DBC              ' Set power units to dBc.
    READ?                     ' Trigger and request power reading.
    ```

.

    Reference   For details on using the "ADJ/ALT key" go to page 1-20.
    For other options to acquire "Readings over the bus", go to page 1-26.

> *NOTE*   *Perform the following steps to measure alternate burst power. Alter-*
>   *nate power measurement is configured by changing the adjacent*
>   *channel offset to the offset of the alternate channel.*

10. **Alternate channel offset** – Alternate channel offset is set from the
    ADJACENT item of the frequency offset menu. Press **SHIFT** and then **Freq
    Offset**. Select **ADJACENT** and then change the offset appropriately to
    measure the alternate channel. A typical alternate channel offset for this
    measurement is 60kHz.

    Remote programming example:

    ```
    SENS:ADJ:OFFS 60e3          ' Sets alternate offset to 60kHz.
    ```

    Reference   For details to set "Offset frequencies", go to page 3-38.

11. **Measure alternate average power** – The measured alternate channel
    power is displayed using the **ADJ/ALT** key. However, keep in mind that
    alternate power will be displayed as ADJ power. Alternate power can be
    displayed as dBm or dBc. Use the **dBm/dBc** key to toggle between dBm
    and dBc.

    Remote programming example:

    ```
    UNIT:POW DBC          ' Sets power units to dBc.
    SENS:FUNC POW         ' Select the power function.
    READ?                 ' Trigger and request power reading.
    ```

    Reference   For details on using the "ADJ/ALT key" go to page 1-20.
    *For other options to acquire "Readings over the bus", go to
    page 1-26.*

Peak power measurements

> *NOTE*   *Remote programming locks out front panel operation. To restore*
>   *front panel operation, press the **LOCAL** key.*

The peak power function measures the power levels of the five highest peaks
within a frequency power spectrum (see Figure 3-2). Measurement resolution is
5kHz. The frequency of each peak is also measured.

1. **Mobile standard** – Press **Standard** and select the desired mobile standard.

   Remote programming example:

   ```
   INST:SEL CDMA1               ' Selects CDMAOne standard.
   INST:SEL?                    ' Query mobile standard.
   ```

   Reference   For details on "Selecting mobile standard", go to page 3-35.

2. **Center frequency** – Use the **MHz** key to specify the center frequency.

    Remote programming example:

    `SENS:FREQ:CENT 825.03e6`   ' Sets center frequency to 825.03MHz.

    Reference   *For details to set the "Center frequency", go to page 3-38.*

3. Press the **PEAK** key to display the power level of the highest peak and frequency.
4. Use the **Shift** and **PEAK** keys to display the power level for the 2nd, 3rd, 4th and 5th highest peaks and their frequencies. Each time **Shift** and then **PEAK** is pressed, the next highest peak is displayed. After displaying the 5th highest peak, pressing **Shift** and then **PEAK** wraps back to the 2nd peak.

    Remote programming example:

    `SENS:FUNC PEAK`   ' Select peak power function.
    `READ?`   ' Trigger and request power reading.

NOTE   *Do not use the INIT;:FETCh? command sequence to trigger and return readings if the trigger count is >1. With the trigger count >1, duplicate data strings will be sent. For details, see the "Summary of read commands" on page 1-27 of this manual.*

Reference   *For details on using the "PEAK key", go to page 1-23.*

Figure 3-2
Peak power level measurements
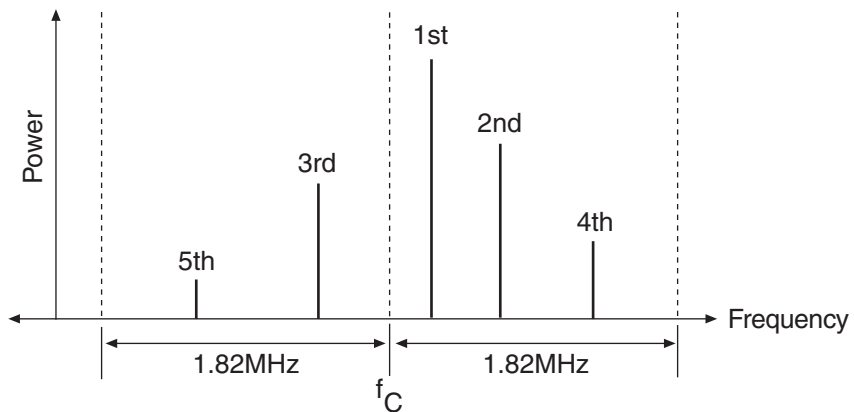
ΔF measurements

NOTE	*Remote programming locks out front panel operation. To restore front panel operation, press the **LOCAL** key.*
NOTE	*Before selecting the ΔF function, make sure the instrument is displaying a valid power reading for the desired standard. The instrument must not be in an over-range condition.*
NOTE	*The minimum amplitude that can be detected by the Model 2800 for a ΔF measurement is -35dBm.*

The ΔF function measures the difference between the set center frequency and the frequency of the highest level in the power spectrum (see Figure 3-3). Measurement resolution is 1Hz (for CDMA and CW).

1. **Mobile standard** – Press **Standard** and select the desired mobile standard.

   Remote programming example:

   ```
   INST:SEL CDMA1          ' Selects CDMAOne standard.
   INST:SEL?               ' Query mobile standard.
   ```

   Reference   For details on "Selecting mobile standard", go to page 3-35.

2. **Center frequency** – Use the **MHz** key to specify the center frequency.

   Remote programming example:

   ```
   SENS:FREQ:CENT 825.03e6   ' Sets center frequency to 825.03MHz.
   ```

   Reference   For details to set the "Center frequency", go to page 3-38.

3. Press the Δ**F** key to display the difference between the center frequency (which is displayed at the bottom) and the frequency of the highest level in the power spectrum.

   Remote programming example:

   ```
   SENS:FUNC DFR      ' Select Delta F power function.
   READ?              ' Trigger and request power reading.
   ```

NOTE	*Do not use the INIT;:FETCh? command sequence to trigger and return readings if the trigger count is >1. With the trigger count >1, duplicate data strings will be sent. For details, see the "Summary of read commands" on page 1-27 of this manual.*

   Reference   For details on using the "ΔF key" go to page 1-25.

Figure 3-3
ΔF measurements
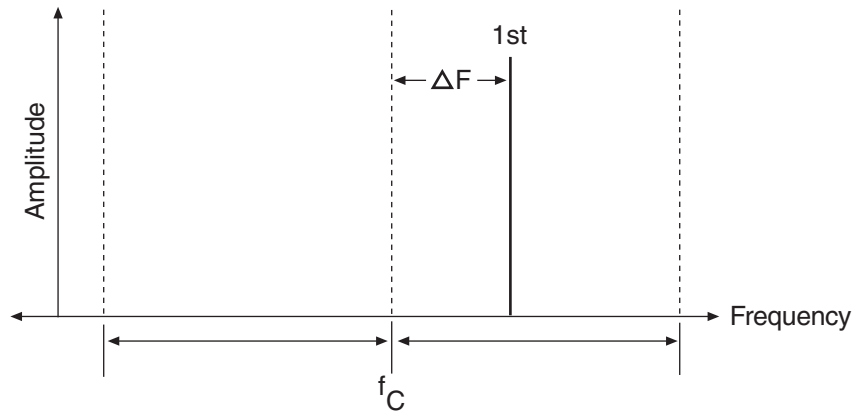
List mode

Using remote programming, the Model 2800 can perform a frequency sweep or an attenuator sweep. The points in the sweep list are either center frequency settings or attenuator settings. The sweep list can contain up to 100 listed points.

When the sweep is run, a power measurement will be performed for each sweep point setting. The order of sweep point settings in the list determines the order of the sweep.

The configured sweep can only be performed for the power function. The peak and ΔF frequency functions do not support the list mode.

Frequency list

For a frequency list, the Model 2800 sweeps a specified list of center frequencies. For example, assume the frequencies specified in a 3-point sweep list is 825.03MHz, 825.06MHz, and 825.09MHz. When the sweep is run, three power measurements will be performed: the first using a center frequency of 825.03MHz, the second using a center frequency of 825.06MHz, and the third using a center frequency of 825.09MHz.

Attenuator list

For an attenuator list, the Model 2800 sweeps a specified list of attenuator settings. For example, assume the attenuator settings specified for a 4-point sweep are 20, 22, 24, and 26dB. When the sweep is run, four power measurements will

be performed: the first using an attenuator setting of 20dB, the second using an attenuator setting of 22dB, the third using an attenuator setting of 24dB, and the fourth using an attenuator setting of 26dB.

NOTE   *The list commands to configure and run a sweep are summarized in Table 3-1 on page 3-26.*

Sweep list configuration

Enable sweep mode

The following command selects (enables) the sweep list mode:

```
SENS:POW:MODE <name>
```

```
<name> = LIST          Enable sweep list mode.
       = FIXed         Disable sweep list mode.
```

NOTE   *When finished with sweep operations, you should disable the sweep mode by selected the fixed sweep mode. You can also select the fixed mode by sending *RST or SYSTem:PRESet to return the Model 2800 to its factory defaults.*

Select sweep list type

The following command is used to select the sweep type (frequency or attenuator):

```
SENS:LIST:CONT <name>
```

```
<name> = FREQuency       Select frequency sweep list.
       = ATTenuation     Select attenuator sweep list.
       = FREQ, ATT       Select frequency and attenuator sweep list
                         (concurrent sweep).
```

Note that FREQ and ATT can be used together to allow concurrent sweeping of a frequency list and an attenuator list. When the sweep is run, both lists (frequency and attenuator) are swept at the same time.

Create sweep list

Use one of the following commands to create the sweep list:

```
SENS:LIST:FREQ <list>      ' Frequency list.
SENS:LIST:ATT <list>       ' Attenuator list.

<list> = NRf[,NRf,NRf,...NRf]
```

The <list> parameter consists of up to 100 NRf values. For a frequency list, the NRf values are center frequency settings. For an attenuator list, the NRf values are dB attenuator settings. The NRf values must be separated by commas. Examples:

```
SENS:LIST:FREQ 825.O3e6,825.06e6,825.09e6    ' Frequency list.
SENS:LIST:ATT 20,22,24,26                     ' Attenuator list.
```

Query sweep list

Use the following commands to query the frequency or attenuator values in the sweep list:

```
SENS:LIST:FREQ?              ' Query values in frequency list.
SENS:LIST:ATT?               ' Query values in attenuator list.
```

Use the following commands to query the number of frequency or attenuator values (points) in the sweep list:

```
SENS:LIST:FREQ:POIN?         ' Query number of values in frequency list.
SENS:LIST:ATT:POIN?          ' Query number of values in attenuator list.
```

It is useful to know the number of values (points) in the sweep list since the trigger count (TRIG:COUN) should be set to the number of points in the sweep.

Append sweep list

Sweep points can be added to the end of the sweep list. Use the following commands to append a sweep list:

```
SENS:LIST:FREQ:APP <list>    ' Append frequency list.
SENS:LIST:ATT:APP <list>     ' Append attenuator list.

<list> = NRf[,NRf,NRf,...NRf]
```

The <list> parameter consists of one or more NRf values. For a frequency list, the NRf values are frequencies. For an attenuator list, the NRf values are dB attenuator settings.

Set trigger count

The trigger count determines the number of measurements to be performed by the Model 2800. Therefore, the trigger count should be set to the number of points in the sweep list. For example, if there are three points in the sweep list, the trigger count should be set to three.

The following command sets the trigger count:

```
TRIG:COUN <n>        ' Specify number of measurements perform.

<n> = number of points in sweep list
```

If the trigger count is less than the number of points in the sweep list, not all points in the list will be measured. If the trigger count is greater than the number of points in the list, operation will wrap back to the beginning of the sweep list and continue to perform measurements.

Running the sweep

You can use the following command sequence to run a sweep:

```
INIT            ' Trigger the start of the sweep.
FETCh?          ' Request readings.
```

When not using LEVel or EXTernal triggering, the READ? or MEAS? command can be used to run a sweep:

```
MEAS?           ' Trigger the start of the sweep and request readings.
```

or

```
READ?           ' Trigger the start of the sweep and request readings.
```

After addressing the Model 2800 to talk, the reading strings will be sent to the computer. For example, if three sweep list points were measured, then three readings strings will be sent to the computer.

NOTE   *The READ? and MEAS? commands cannot be used with the Bus trigger source (TRIG:SOUR BUS). Use the FETCh? command after a trigger has been initiated (:INIT followed by *TRG) to run the sweep.*

With the LEVel or EXTernal trigger source selected, bus time outs may occur when using READ? or MEAS?. Use the INIT; :FETCh? command sequence to run the sweep.

For more information on read commands, see the .

External triggering

By using the external trigger source, a sweep list can be controlled by an external instrument using external triggers. The first input trigger pulse received by the Model 2800 triggers a measurement using the first sweep point in the list. The second input trigger causes a measurement using the second sweep list point. This process continues until a measurement is performed for each sweep point in the list. Sweep list programming examples using external triggering are provided in the next paragraphs.

Programming examples

Frequency sweep

The following command sequence uses external triggering to perform a 3-point frequency sweep for the CDMAOne Cell standard.

```
*RST                        ' Restore factory defaults.
INST:SEL CDMA1              ' Select CDMAOne mobile standard.
SENS:CDMA1:TYPE CELL       ' Select cell band.
SENS:FUNC POW              ' Select power function.
SENS:POW:MODE LIST         ' Enable sweep list mode.
SENS:LIST:CONT FREQ        ' Select frequency sweep.
SENS:LIST:FREQ 825.03e6,825.06e6,825.09e6 ' Create sweep list.
TRIG:SOUR EXT              ' Select external trigger source.
TRIG:COUN 3                ' Set trigger count to 3.
INIT                       ' Initiate the trigger/measure process.
*OPC?                      ' Wait until all three triggered measurements are
                           ' completed.
FETCh?                     ' Request the three reading strings.
SENS:POW:MODE FIX          ' Disable sweep mode.
TRIG:COUN 1                ' Set trigger count back to 1.
```

The INIT command takes the Model 2800 out of idle where it waits for input triggers. Each received trigger pulse causes a measurement using a sweep list point.

The *OPC? command is used to hold up the program sequence. It will not allow the next command (FETCh?) to execute until all three measurements are completed (see"Common commands" in Section 2 of the Reference Manual for details on the *OPC? command). Once the 3-point sweep is completed, FETCh? will execute to retrieve the data strings.

After using the list mode, it is good practice to disable the list mode (SENS:POW:MOD FIX) and return the trigger count back to 1 (TRIG:COUN 1).

Attenuator sweep

The following command sequence uses external triggering to perform a 4-point attenuator sweep for the CDMAOne Cell standard:

```
*RST                        'Restore factory defaults.
INST:SEL CDMA1              'Select CDMAOne mobile standard.
SENS:CDMA1:TYPE CELL        'Select Cell band.
SENS:FUNC POW              'Select power function.
SENS:POW:MODE LIST         'Enable sweep list mode.
SENS:LIST:CONT ATT         'Select attenuator sweep.
SENS:LIST:ATT 20,22,24,26  'Create sweep list.
TRIG:SOUR EXT              'Select external trigger source.
TRIG:COUN 4                'Set trigger count to 4.
INIT                       'Initiate the trigger/measure process.
*OPC?                      'Wait until all four triggered measurements
                            'are completed.
FETCh?                     'Request the four reading strings.
SENS:POW:MODE FIX          'Disable sweep mode.
TRIG:COUN 1                'Set trigger count back to 1.
```

The above command sequence operates the same as the example for the "Frequency sweep", except this example sweeps a 4-point attenuator list.

Sweep list command summary

The sweep list commands are summarized in Table 3-1.

Table 3-1
Sweep list commands

Command	Description	Default
SENS:POW:MODE \<name>	Select measurement mode: LIST or FIXed	FIX
SENS:LIST:CONT \<name>	Select sweep list type: FREQuency or ATTenuation.	FREQ
SENS:LIST:FREQ \<list>	Create frequency sweep list: NRf values.	
SENS:LIST:FREQ:POIN?	Query number of points in frequency sweep list.	
SENS:LIST:FREQ:APP \<list>	Append frequency sweep list: NRf values.	
SENS:LIST:ATT \<list>	Create attenuator sweep list: NRf values.	
SENS:LIST:ATT:POIN?	Query number of points in attenuator sweep list.	
SENS:LIST:ATT:APP \<list>	Append attenuator sweep list: NRf values.	

GSM staircase and time analysis

Using remote programming, the Model 2800 can perform additional analysis for GSM signals only, including GSM staircase and GSM power vs. time, and time mask statistics. See "GSM measurements," page 4-18 for additional information on making GSM measurements.

GSM staircase and time analysis command summary

The GSM commands are summarized in Table 3-2. Note that these commands are available only in query form.

Table 3-2
GSM staircase and time analysis commands

Command	Description
[:SENSe[1]]:GSM:STAir? <NRf>	Query GSM sequential time slots. <NRf> = number of slots.
[:SENSe[1]]:GSM:TMASk?	Query power vs. time of a GSM pulse.
[:SENSe[1]]:GSM:TMASk:STATistics?	Query time mask statistics of a GSM pulse.

GSM staircase mode

As shown in Figure 3-4, the staircase mode is designed to measure consecutive GSM slots. When initiated with GSM:STAir? command, the Model 2800 will wait until the threshold of the user set level is crossed. After the threshold has been crossed, the Model 2800 will wait the desired delay time set by the user before taking measurements on the RF input. The measurement of the second slot will begin at exactly one GSM time slot after the delay as shown in the figure. This process is repeated for the number of slot steps that are set.

Figure 3-4
GSM staircase mode
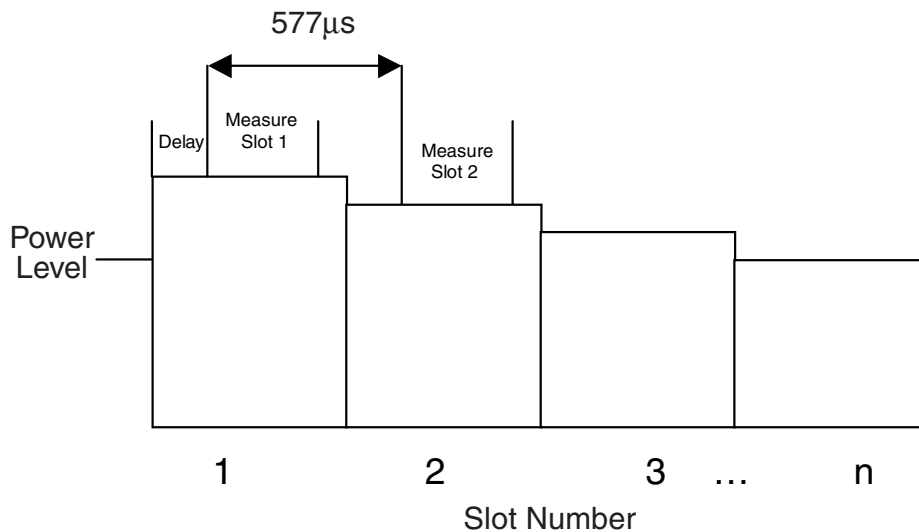
GSM staircase setup

The staircase mode can be set up and basic data acquired as follows:

1. Send the Model the *RST command to restore defaults.
2. Set the unit to the GSM standard by sending:
    INST:SEL GSM
3. Program other operating modes as needed.
4. Select the trigger level source by sending:
    TRIG:SOUR LEV
5. Set the trigger level with the following command:
    TRIG:LEV <trigger_level>
6. Send the following command including the number of slots to measure:
    GSM:STA? <slots>

NOTE   *See "Remote GSM testing," page 4-24 for more setup details.*
               After acquiring staircase data, normal testing can be resumed by
               sending commands as needed.

GSM staircase programming example

The following command sequence acquires primary power readings for five GSM slots:

```
*RST                      'Restore factory defaults.
INST:SEL GSM              'Select GSM mobile standard.
SENS:GSM:TYPE CELL        'Select GSM cell band.
TRIG:SOUR LEV             'Select level trigger source.
TRIG:LEV -50             'Set trigger level to -50dBm.
TRIG:DEL 20e-6            'Set trigger delay to 20μs.
SENS:FUNC POW             'Select power function.
SENS:POW:ATT 10           'Set attenuator to 10dB.
GSM:STA? 5                'Request data for 5 GSM slots.
```

GSM power vs. time function

This function returns the power versus time function of a GSM pulse and requires that a synchronizing pulse be sent. The function will acquire 620 samples that are spaced 0.977μs apart. The function will return some noise before and after the pulse so that the user will be able to verify that the pulse complies with the GSM standard.

GSM power vs. time setup

The power vs. time mode can be set up and basic data acquired as follows:

1. Send the unit the *RST command to restore defaults.
2. Set the unit to the GSM standard by sending:
    INST:SEL GSM
3. Program other operating modes as needed.
4. Select the trigger level source by sending:
    TRIG:SOUR LEV
5. Set the trigger level with the following command:
    TRIG:LEV <trigger_level>
6. Send the following command to acquire power vs. time samples:
    GSM:TMASK?

Power vs. time programming example

The following command sequence acquires power vs. time data:

```
*RST                        'Restore factory defaults.
INST:SEL GSM                'Select GSM mobile standard.
SENS:GSM:TYPE CELL          'Select GSM cell band.
TRIG:SOUR LEV               'Select level trigger source.
TRIG:LEV -50                'Set trigger level to -50dBm.
TRIG:DEL 20e-6              'Set trigger delay to 20µs.
SENS:FUNC POW               'Select power function.
SENS:POW:ATT 10             'Set attenuator to 10dB.
GSM:TMASK?                  'Request power vs. time data.
```

GSM pulse statistics function

This function will return the 10%-90% rise time, 90%-10% fall time, maximum and minimum values of readings taken during the delay time, and maximum and minimum values of readings taken during the acquisition time. This function also requires that a synchronizing pulse be sent.

After the synchronizing pulse, the Model 2800 will wait one entire frame (- 28µs) to ensure the inclusion of the 10% point of the rising edge of the pulse. The threshold of the second pulse is assumed to be exactly 4.61538ms after the threshold of the first pulse. The 10%-90% rise time is defined as the first time the pulse crosses 10% of the envelope power to the time when it crosses 90% of the envelope power. The 90%-10% fall time is defined as the time from when the signal crosses the 90% threshold on the falling edge of the pulse to when it crosses the 10% threshold. The maximum and then minimum reading value will be determined during the delay period. The points when measurements are taken from can be seen in Figure 3-5.

For optimum statistics, the typical trigger delay is 20µs, and the acquisition time is about 500µs.

Figure 3-5
GSM pulse statistics
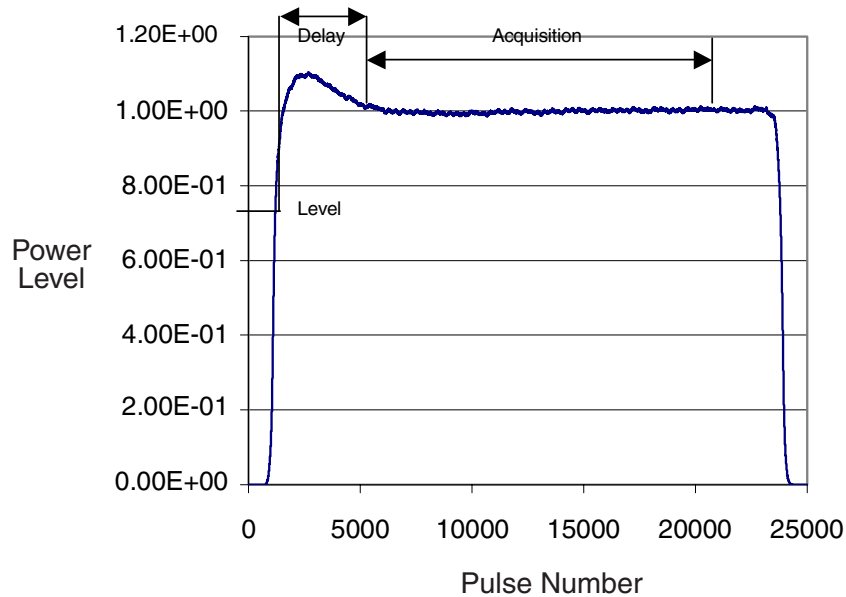
GSM pulse statistics setup

The pulse statistics mode can be set up and basic data acquired as follows:

1. Send the Model the *RST command to restore defaults.
2. Set the unit to the GSM standard by sending:
    INST:SEL GSM
3. Program other operating modes as needed.
4. Select the trigger level source by sending:
    TRIG:SOUR LEV
5. Set the trigger level with the following command:
    TRIG:LEV <trigger_level>
6. Set the desired trigger delay:
    TRIG:DEL <delay>
7. Set the acquisition time:
    SENS:ACQ:TIME <time>
8. Send the following command to acquire pulse statistics:
    GSM:TMASK:STAT?

GSM pulse statistics programming example

The following command sequence acquires pulse statistics data:

```
*RST                        'Restore factory defaults.
INST:SEL GSM                 'Select GSM mobile standard.
SENS:GSM:TYPE CELL           'Select GSM cell band.
TRIG:SOUR LEV                'Select level trigger source.
TRIG:LEV -50                 'Set trigger level to -50dBm.
TRIG:DEL 20e-6               'Set trigger delay to 20µs.
SENS:ACQ:TIME 500e-6         'Set acquisition time to 500µs.
SENS:FUNC POW                'Select power function.
SENS:POW:ATT 10              'Set attenuator to 10dB.
GSM:TMASK:STAT?              'Request pulse statistics data.
```

Data storage

Up to 2500 primary/adjacent/alternate channel power readings can be stored in the buffer for later recall. Peak and ΔF readings cannot be stored in the buffer.

Included with power readings are statistical data for the readings. Statistics include minimum and maximum readings, peak-to-peak deviation, standard deviation, and the average (mean). The stored power readings are used as the database for calculating statistics.

All measurement statistics are computed on a category basis (e.g., primary power, adjacent power, and alternate power are considered as separate data sets for each statistic).

NOTE   *Remote programming locks out front panel operation. To restore front panel operation, press the **LOCAL** key.*

Storing readings

1. Press the **PRIMARY** or **ADJ/ALT** key.
2. Press **SHIFT** and then **Store** to display the number of readings to store (e.g., **STORE 0100 READINGS**).
3. Use **PREV** and/or **NEXT** and the numerical keypad to display the number of readings to store (1 to 2500).
4. Press **Enter** to enable the data store. The asterisk (*****) annunciator will be lit while readings are being stored.

Remote programming:

```
TRAC:CLE                    ' Clear the buffer
SENS:FUNC POW               ' Select the power function
TRAC:POIN <n>               ' Set number of readings to store:
                            ' <n> = 1 to 2500.
TRAC:FEED:CONT <name>       ' Enable or disable the buffer: <name> =
                            ' NEXT (enable) or NEVer (disable).
```

NOTE   *As shown above, the power function (SENS:FUNC POW) must be selected in order to store readings in the buffer. Peak and ∆F readings cannot be stored in the buffer.*

If the Model 2800 is in the continuous measurement mode, the storage process will start as soon as the buffer is enabled. In a non-continuous mode, storage will be controlled according to how the trigger model is configured. For example, if the external trigger source is selected, each input trigger will store one measured reading in the buffer. Details on "Triggering" are provided in Section 3 of the Reference Manual.

Recalling buffer data

Readings and statistics are stored in a circular buffer. Press **SHIFT** and then **Recall** to enter the buffer recall display state. In this display state, a measured reading will be displayed along with the channel type, buffer location number, and timestamp.

Measured readings are grouped together, and the statistics are grouped together. While in the buffer recall state, you can scroll forward using the **NEXT** key or scroll backward using the **PREV** key. Use either key to locate the reading or statistic that you wish to view.

The commands for "Remote programming (buffer recall)" are listed on page 3-35.

Measured readings

While in the buffer recall state, measured readings are recalled as follows:

Channel type — Use the **Enter** key to toggle the display between primary channel power (**Primary**), lower adjacent or carrier channel power (**AdjL/Pcar**), upper adjacent or sideband channel power (**AdjU/Psb**), lower alternate channel power (**AltL**), and the upper alternate channel power (**AltU**).

Buffer location number — Each stored reading is stored at a buffer location number. The first stored reading is labeled reading #0000. Use the **PREV** and **NEXT** keys to scroll through the buffer locations.

Timestamp (TS) — Each reading is timestamped when it is measured and stored. For front panel operation, the timestamp is the time difference between each stored reading.

For remote programming, the timestamp can be referenced to 0.000 seconds (ABSolute), or it can indicate the time difference between each stored reading (DELTa).

Buffer statistics

A set of basic statistical calculations is performed on the buffer readings. While in the buffer recall state, results are accessed as follows.

Buffer statistics are grouped together in the circular buffer. To view the desired statistic, use the **PREV** key to scroll forward or use the **NEXT** key to scroll backwards to display statistics. Use the **Enter** key to display channel type for the statistic.

Buffer statistics are defined as follows:

MIN — Display the minimum value of the buffer data. The buffer location number and timestamp are also provided for this reading.

MAX — Display the maximum value of the buffer data. The buffer location number and timestamp are also provided for this reading.

AVERAGE — Display the sample mean of the buffer data. The following equation is used to calculate sample mean:

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$$

where: $\overline{X}$ is the sample mean (average).
          X_i is a stored reading.
          n is the total number of stored readings.

STANDARD DEVIATION — Display the standard deviation of the buffer readings. The following equation is used to calculate standard deviation:

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n-1} (X_i - \overline{X})^2}$$

where: S is the sample standard deviation (the positive square root of the sample variance).
          $\overline{X}$ is the sample mean (average).
          X_i is a stored reading.
          n is the total number of stored readings.

PEAK-TO-PEAK — Display the difference between the maximum and minimum values of the buffer readings.

Remote programming (buffer recall)

`TRAC:POIN:ACT?`	' Returns the number of points stored in the ' buffer.
`TRAC:TST:FORM <name>`	' Select timestamp type: <name> = ABSolute or ' DELTa.
`FORM:ELEM:TRAC ALL`	' Include primary, adjacent and alternate channel ' readings in the buffer data string.
`TRAC:DATA?`	' Returns the contents of the buffer.
`CALC3:FORM<name>`	' Select the statistic to return: <name> = MEAN, ' SDEViation, MAXimum, MINimum, or PKPK.
`CALC3:DATA?`	' Return the selected statistic.

NOTE   *Peak (:PEAK) and ΔF (:DFREquency) readings cannot be stored in the buffer. Attempting to store Peak or ΔF readings will generate error +831 "Invalid with PEAK/FREQ function active".*

Instrument settings

NOTE   *Remote programming locks out front panel operation. To restore front panel operation, press the **LOCAL** key.*

Selecting mobile standard

The frequency settings for measuring power of a selected mobile standard include bandwidths, offset frequencies, and center frequency (or, alternatively, channel number). Keep in mind that the frequency settings for a standard are unique to that standard. That is, the frequency settings for each standard are saved. When a standard is selected, the saved settings for that standard are selected.

Reference   *Details on "Measurement Techniques" for primary, adjacent, and alternate channels are provided in Section 2 of this manual.*

Select a mobile standard as follows:

1. Press **Standard** to display the mobile standards (**WCDMA**, **CDMA2000**, **AMPS**, **CDMA1, NADC, GSM,** or **PHS**).
2. Use the **PREV** or **NEXT** key to place the blinking cursor on the desired standard, and press **Enter**.

3. Use the **PREV** or **NEXT** key to display the band type (i.e., **CELL, PCS**, etc.), and press **Enter**.

NOTE   *For WCDMA standard, select the band from the **TYPE** menu item.*

Remote programming:

`INST:SEL <name>`   ' Select standard: <name> = AMPS, CDMA1,
                          ' CDMA2K, GSM, NADC, PHS, WCDMA.

• With CDMA1 selected, select band:

`SENS:CDMA1:TYPE <name>` ' Select band: <name> = CELL, PCS, or KPCS.

• With NADC selected, select band:

`SENS:NADC:TYPE <name>`   ' Select band: <name> = CELL or PCS.

• With GSM selected, select band:

`SENS:GSM:TYPE <name>`   ' Select band: <name> = CELL, PCS, DCS, or
                          ' US850.

• With CDMA2K selected, select band class and spreading rate:

`SENS:CDMA2K:TYPE <name>`' Select band class: <name> = BC0, BC1, BC4,
                          ' BC6, BC8, or BC9.
`SENS:CDMA2K:SRAT <name>`' Select spreading rate: <name> = SR1 (1x) or
                          ' SR3 (3x).

• With WCDMA selected, select operating band:

`SENS:WCDMA:TYPE <name>` ' Select operating band: <name> = OB1, OB2 or
                          ' OB3.

Frequency settings

NOTE   *Before viewing or setting frequencies, make sure the desired mobile
                standard is already selected.*

Bandwidths

With the exception of GSM, NADC, and PHS, the measurement bandwidth for the selected standard is fixed and cannot be changed by the user. The primary bandwidth for GSM can be set to either 30kHz or 400kHz, the primary bandwidth settings for NADC are 30kHz or 100kHz, and the primary bandwidth settings for PHS are 192kHz or 1MHz.

> *NOTE*   *In order to set GSM primary bandwidth (BW) to 30kHz, concurrent measurements must be enabled (SENS:POW:CONC ON). If concurrent measurements are disabled, trying to change the BW from 400kHz to 30kHz will generate error +833 "Meas BW is fixed or invalid".*
>
> *In order to set PHS primary bandwidth to 1MHz, concurrent measurements must be disabled (SENS:POW:CONC OFF). If concurrent measurements are enabled, trying to change the BW from 192kHz to 1MHz will generate error +833 "Meas BW is fixed or invalid".*
>
> *Details on "Concurrent measurements" are provided on page 3-40 of this manual. For remote programming, error +833 will also be generated when you try to set a bandwidth that is fixed.*

Bandwidths will be set automatically when a mobile standard is selected. With the desired mobile standard already selected, view the primary, adjacent, and alternate bandwidths as follows:

1. Press **SHIFT** and then **Meas BW**.
2. Use the **PREV** or **NEXT** key to place the blinking cursor on the desired bandwidth (**Primary, Adjacent, or Alternate)**, and press **Enter** to view the bandwidth setting.

> *NOTE*   *The primary BW for GSM and PHS can be changed by the user. After selecting **Primary**, use the **PREV** or **NEXT** key to select the desired BW and press **Enter**. The display returns to the bandwidth menu (step 2 above).*

3. To view another bandwidth, press **Enter** or **Exit** to return to the bandwidth menu and repeat step 2.
4. When finished viewing bandwidths, press **Exit** to return to the measure display state.

Remote programming:

```
SENS:PRIM:BAND?          ' Query primary channel bandwidth.
SENS:ADJ:BAND?           ' Query adjacent channel bandwidth.
SENS:ALT:BAND?           ' Query alternate channel bandwidth.
```

Set primary channel bandwidth for GSM (30kHz or 400kHz):

```
INST:SEL GSM             ' Select GSM standard.
SENS:PRIM:BAND <freq>    ' Set primary BW: <freq> = 30e3 or 400e3.
```

Set primary channel bandwidth for PHS (192kHz or 1MHz):

```
INST:SEL PHS             ' Select PHS standard.
SENS:PRIM:BAND <freq>    ' Set primary BW: <freq> = 192e3 or 1e6.
```

Offset frequencies

The adjacent channel offset frequency can be set by the user. The alternate channel offset cannot be set by the user. Alternate channel offset is set automatically when a mobile standard is selected.

With the desired mobile standard selected, use set/view the adjacent offset and/or view the alternate offset as follows:

1. Press **SHIFT** and then **Freq Offset**.
2. Use the **PREV** or **NEXT** key to place the blinking cursor on the desired offset (**Adjacent or Alternate)** and press **Enter** to display the offset frequency.
3. If setting the adjacent offset, use the numerical keypad and the **PREV**/**NEXT** keys to display the desired frequency.
4. Press **Enter**.
5. Repeat steps 2 and 3 to view or set the other offset.
6. Press **Exit** to return to the measure display state.

Remote programming:

```
SENS:ADJ:OFFS <NRf>        ' Set adjacent channel offset.
SENS:ADJ:OFFS?             ' Query adjacent channel offset.
SENS:ALT:OFFS?             ' Query alternate channel offset.
```

Center frequency

Center frequency can be set by selecting the channel or by setting the frequency. Set or view center frequency as follows:

Channel number:

1. Press **Ch#** to display the present channel number.
2. To change the channel, use the **PREV/NEXT** keys and the numerical keypad to key in the desired channel.
3. Press **Enter**.

Frequency:

1. Press **MHz** to display the present center frequency.
2. To change the center frequency, use the **PREV/NEXT** keys and the numerical keypad to key in the desired frequency.
3. Press **Enter**.

NOTE   *The center frequency for all standards except WCDMA can be set anywhere within a range of band classes (BC0, BC1, BC4, BC6, BC8, BC9). For WCDMA, the center frequency is bounded by the limits of each operating band.*

Remote programming:

```
SENS:FREQ:CHAN <NRf>    ' Select channel number.
SENS:FREQ:CHAN?         ' Query channel number.
SENS:FREQ:CENT <NRf>    ' Set center frequency.
SENS:FREQ:CENT?         ' Query center frequency.
```

Global instrument settings

The following settings used to configure power measurements are global to all mobile standards. That is, an instrument setting is the same regardless of which standard is selected. For example, if you enable input protection for the CDMA-One standard, it will also be enabled for the other standards.

Input protection

Input protection reduces average power to the mixer of the Model 2800 for some measurement modes, and reduces local oscillator emission. Power is only provided to the mixer during data acquisition when measurements are being performed.

Input protection also reduces local oscillator emission from the Model 2800 when it is NOT performing a measurement.

As a trade-off, input protection adds 500μs to measurement delay time. Therefore, it should not be used for high speed pulse measurements (NADC pulse and GSM pulse).

Enable or disable input protection as follows:

1. Press the **Menu** key, and use the **PREV** and/or **NEXT** key to place the cursor on **INPUT**.
2. Press **Enter**.
3. Place the cursor on **ENABLE** or **DISABLE**, and press **Enter**.
4. Press **Exit** to exit the menu structure.

Remote programming:

```
SENS:INP:PROT:STAT <b>       ' Enable or disable input protection:
                             ' <b> = 1 (on) or 0 (off).
```

Temperature compensation

With temperature compensation enabled, temperature is measured and factored into the algorithm to calculate the measured reading. With temperature compensation disabled, temperature is not routinely measured. Therefore, if the ambient temperature drifts, the measured readings will also drift.

Temperature compensation adds 2ms to the measurement time. For optimum measurement speed, temperature compensation can be disabled for short periods of time. Temperature compensation should be enabled periodically to obtain a current temperature measurement. More information on "Temperature compensation" is provided on page 2-7 of this manual.

Enable or disable temperature compensation as follows:

1. Press the **Menu** key, and use the **PREV** and/or **NEXT** key to place the cursor on **TEMP**.
2. Press **Enter**.
3. Place the cursor on **ENABLE** or **DISABLE**, and press **Enter**.
4. Press **Exit** to exit the menu structure.

Remote programming:

```
SENS:TEMP:OCOM <b>          ' Enable or disable temperature compensation:
                            ' <b> = 1 (on) or 0 (off).
```

Concurrent measurements

By default, the Model 2800 measures the primary, adjacent and alternate channels concurrently. To increase measurement speed, concurrent measurements can be disabled. When disabled, the adjacent and alternate channels are not measured.

Concurrent measurements can be controlled over the bus using the following commands:

```
SENS:POW:CONC OFF           ' Disable concurrent measurements.
SENS:POW:CONC ON            ' Enable concurrent measurements.
```

With concurrent measurements disabled, the GSM primary channel bandwidth cannot be set to 30kHz. If the GSM primary bandwidth was previously set to 30kHz, it will reset to 400kHz when concurrent measurements are disabled.

With concurrent measurements enabled, the PHS primary bandwidth cannot be set to 1MHz. If the PHS primary bandwidth was previously set to 1MHz, it will reset to 192kHz when concurrent measurements are enabled.

Averaging

Averaging can be used to improve repeatability. For details on using averaging to improve reading repeatability, see "Averaging" on page 2-5.

Configure averaging as follows:

1. Press **Avg** to display the present averaging count. The count can be set from 1 to 100.

2. To change the averaging count, use the **PREV** and **NEXT** keys, and the numerical keypad to display the number of readings to average, and then press **Enter**.
3. Use the **PREV** or **NEXT** key to place the blinking cursor on the desired averaging mode (**MOVING** or **REPEAT**) and press **Enter**.

Remote programming:

```
SENS:AVER:COUN <n>          ' Set averaging count: <n> = 1 to 100.
SENS:AVER:TCON <name>       ' Select averaging type: <name> = REPeat or
                            ' MOVing.
SENS:AVER:STAT <b>          ' Enable or disable averaging: <b> = ON or
                            ' OFF.
```

Acquisition time

Acquisition time determines the sampling time for Digital DownConverter (DDC) measurements. Details on "Acquisition time", are provided on page 2-4.

Set the acquisition time as follows:

1. Press **Acq Time** to display the present acquisition time.The time can be set to from 1μsec to 999.999msec (GSM and PHS), and from 10μsec to 999.99msec (CDMAOne, CDMA2000, and NADC).
2. To change the acquisition time, use the **PREV/NEXT** keys and the numerical keypad to key in the desired value, and then press **Enter**.

Remote programming:

```
SENS:ACQ:TIME <NRf>   ' Set acquisition time: <NRf> =
                        1e-6 or 1e-5 to 999.999e-3 or 999.99e-3 (sec).
```

Attenuator

In order to perform accurate power measurements, the input signal needs to be properly attenuated by the Model 2800. The attenuator setting depends on the set center frequency and the input power level.

NOTE   *Detailed information on "Attenuation" is provided on page 2-8 of this manual.*

Auto attenuation

For CDMA measurements, auto attenuation can by used if a high quality CDMA source with very low intermodulation products is being used. If such a source is not being used, DO NOT use auto attenuation. The "Auto attenuation (CDMA only)" process is explained on page 2-17 of this manual. Auto attenuation cannot be used with the NADC, GSM, PHS, and AMPS standards.

> ***NOTE***   *Attempting to use auto attenuation for the NADC, GSM, PHS, or AMPS standard will result in error +832 ("invalid with standard selected").*

Setting the attenuator

The attenuator of the Model 2800 is set as follows:

1. Press **Attenuator** to display the present attenuator level. The attenuator can be manually set from **0 dB** to **50 dB**. If using a qualifying source for CDMA measurements, the **Auto** setting can be used.
2. Use the **PREV/NEXT** keys to set the attenuator. For dB values, each key-press increments or decrements the level by 2dB. Also use the **PREV** or **NEXT** key to display the **Auto** setting. It is located before and after the dB values in the wrap-around menu.
3. With the desired attenuator setting displayed, press **Enter**.

Remote programming:

```
SENS:POW:ATT <NRf>        ' Manually set attenuator: <n> = 0 to 50 (dB).
SENS:POW:ATT:ACQ          ' Acquire attenuator value (auto attenuation).
```

Triggering

There are several ways to trigger the measurement process:

- **Immediate control source** – Places the Model 2800 in the continuous measurement mode.
- **External control source** – The Model 2800 is triggered when an input trigger pulse is received.
- **Bus control source** – The Model 2800 is triggered by sending it the *TRG or GET command over the GPIB. With the Model 2800 in local, pressing the **Trigger** key also triggers the instrument.
- **Level control source** – The Model 2800 is triggered when a specified input power level is detected. This control source should only be used for NADC, GSM, and PHS burst power measurements.

> ***NOTE***   *If the unit locks up while waiting for a Level trigger, press **SHIFT** and then **Abort** to restore control of the front panel keys.*

> *Reference*   *Details on "Triggering" are provided in Section 3 of the Reference Manual.*

To configure triggering, press **SHIFT** and then **SETUP** to access the trigger menu.

1. **Source** — Select the trigger source:
    a. Use the **PREV** or **NEXT** key to place the blinking cursor on **SOURCE** and press **Enter**.
    b. Use the **PREV** or **NEXT** key to place the blinking cursor on the desired source (**EXTERNAL**, **IMMEDIATE**, **BUS,** or **LEVEL**) and press Enter.
        If you selected **LEVEL**, you will be prompted to enter the trigger level (-99.99 to +20.00dBm). Use the numerical keypad and the **PREV**/**NEXT** keys to key in the desired trigger level, and press **Enter**.

2. **Delay** — Enter the trigger delay time:
    a. Press the **NEXT** key to place the blinking cursor on **DELAY** and press **Enter** to display the present trigger delay (in milliseconds). The maximum delay that can be set depends on the selected mobile standard. See the chart for "Measurement Parameters (Trigger Delay Range)" in Appendix A – Specifications.
    b. Use the numerical keypad and the **PREV**/**NEXT** keys to key in the desired trigger delay, and press **Enter**.

3. **Count** — Set the trigger count:
    a. Use the **PREV** or **NEXT** key to place the blinking cursor on **COUNT** and press **Enter**.
    b. Use the **PREV** or **NEXT** key to place the blinking cursor on **FINITE** or **INFINITE** and press **Enter**.
        If you selected **FINITE**, you will be prompted to enter the trigger count value (1 to 2500). Use the numerical keypad and the **PREV**/**NEXT** keys to key in the desired trigger count, and press **Enter**.

4. Press **Exit** to return to the measure display state.

Remote programming:

The following commands are used to select the trigger control source, and set the delay and count. "Triggering commands" are documented in Section 3 of the Reference Manual.

```
TRIG:SOUR <name>        ' Select control source: <name> = IMMediate,
                        ' EXTernal, LEVel, or BUS.
TRIG:LEV <n>            ' For LEVel control source, set power level to
                        ' trigger measurement: <n> = -99.99 to +20.00
                        ' (dBm).
TRIG:DEL <n>            ' Set time to delay the trigger: 0 to 999.999ms.
TRIG:COUN <n>           ' Specify the number of readings to measure:
                        ' 1 to 2500 or INFinite.
```

Root raised cosine (RRC) filter

Inter Symbol Interference (ISI) is the spreading and smearing of symbols. Energy from one symbol leaks over into the next symbol, possibly distorting the received signal enough to be interpreted incorrectly. For WCDMA measurements, the Root raised cosine (RRC) filter can be used to cancel the effects of ISI.

Perform the following steps to enable or disable the RRC filter:

1. Press **Standard** to display the mobile standards.
2. Use the **PREV** or **NEXT** key to place the blinking cursor on **WCDMA,** and press **Enter**.
3. Use the **PREV** or **NEXT** key to place the blinking cursor on **ENABLE** or **DISABLE**, and press **Enter**.
4. Use the **PREV** or **NEXT** key to place the blinking cursor on the **RRC FILTER** menu and press **Enter**.
5. Use the **Exit** key to back out of the menu.

> *Reference   Additional information on the "Root-raised cosine (RRC) filter" is provided on page 2-17.*

4

Mobile Transmitter Measurements

Section topics

NOTE   *A software driver to control the Model 2800 is available as a free download on the Keithley website (www.keithley.com). This driver is suitable for use with LabView, LabWindows CVI, Visual Basic, and C++. The driver is available in the download section of the 2800 product page on the website.*

Overview

Center frequencies (channels)

Each mobile standard uses a fixed set of center frequencies (channels). A center frequency can be set as a channel number or the actual frequency can be set. The valid center frequencies/channel numbers for each mobile standard are listed on the first page of the "Specifications" in Appendix A of this manual.

Test connections

All test procedures in this section assume that the Model 2800 is properly connected to the DUT (Device Under Test). See "Input connections" on page 3-4 for detailed connection information.

Bandwidth and offset settings

Except for GSM, NDAC, and PHS, bandwidth settings are fixed and dependent on the selected mobile standard. Alternate channel offset settings are fixed and dependent on the selected mobile standard.

When a standard is selected, the bandwidths and alternate offset are set automatically. Table 4-1 lists the bandwidth and alternate offset settings for the mobile standards.

Adjacent channel offset can be set by the user. The setting range for the adjacent channel offset depends on the selected standard. See the chart for "Adjacent Channel" in Appendix A – Specifications.

Table 4-1
Bandwidth and alternate channel offset settings

Mobile standard	Bandwidth			Offset	
	Primary channel	Adjacent channel	Alternate channel	Adjacent channel	Alternate channel
CDMAOne (Cell, PCS, KPCS)	1.23MHz	30kHz	30kHz	±885kHz[5,6]	±1.98MHz
CDMA2000 (1x)	1.23MHz	30kHz	30kHz	±885kHz[5,6]	±1.98MHz
CDMA2000 (3x)	3.69MHz	30kHz	30kHz	±2.65MHz	±3.10MHz
WCDMA (all op bands)	3.84MHz	3.84MHz	3.84MHz	±5MHz	±10MHz
NADC Cell and PCS	30kHz[1]	25kHz	N/A	±30kHz, ±60kHz	N/A
GSM Cell, DCS, PCS, and US850	30kHz[2]	30kHz	N/A	±200kHz, ±400kHz	N/A
PHS	192kHz[3]	192kHz	192kHz	±600kHz, ±900kHz	N/A
AMPS	30kHz	Note[4]	N/A	N/A	N/A

1. For NADC, the primary channel bandwidth can be set to 30kHz or 100kHz.

2. For GSM, the primary channel bandwidth can be set to 30kHz or 400kHz. To set BW to 30kHz, concurrent measurements must be enabled (SENS:POW:CONC ON).

3. For PHS, the primary channel bandwidth can be set to 192kHz or 1MHz. To set BW to 1MHz, concurrent measurements must be disabled (SENS:POW:CONC OFF).

4. For the AMPS standard, the bandwidth for the carrier and upper sideband is 1kHz. Details on "AMPS measurements" are provided on page 4-31 of this manual.

5. For CDMAOne Cell and CDMA2000 Cell, the adjacent channel offset can be set to 885kHz or 900kHz.

6. For CDMAOne PCS, CDMA2000 PCS, and CDMAOne KPCS, the adjacent channel offset can be set to 900kHz or 1250kHz.

Test procedures

The test procedures in this section provide abbreviated step-by-step information for testing mobile transmitters with the various standards supported by the Model 2800. For more details on CDMAOne and NADC measurements, see "Making power measurements" in Section 3 of this manual.

Reference   *See Section 2 of this manual for details on measurement techniques.*

CDMAOne measurements

Overview

A typical power spectrum for a CDMAOne signal is shown in Figure 4-1. As shown, measurements include primary channel power, adjacent channel power, and alternate channel power.

Fixed settings – The bandwidth settings for CDMAOne are listed in Table 4-2. These bandwidths are set automatically when the standard is selected. These bandwidths are fixed and cannot be changed. Also listed in Table 4-2 is the fixed alternate channel offset is also listed in Table 4-2.

Table 4-2
CDMAOne – fixed settings

Setting	Cell, PCS, KPCS
Primary Channel Measurement Bandwidth	1.23MHz
Adjacent Channel Measurement Bandwidth	30kHz
Alternate Channel Measurement Bandwidth	30kHz
Alternate Channel Offset	±1.98MHz

Default settings – The default channel number (center frequency) and adjacent channel offset settings for CDMAOne are listed in Table 4-3. These settings can be changed by the user.

Table 4-3
CDMAOne – default settings

Setting	Default Value		
	Cell	PCS	KPCS
Center Frequency (f_C)	825.03MHz	1850.05MHz	1750.05MHz
Channel Number	1	1	1
Adjacent Channel Offset	±885kHz	±1250kHz	±1250kHz

Figure 4-1
CDMAOne, CDMA2000, and WCDMA power measurements
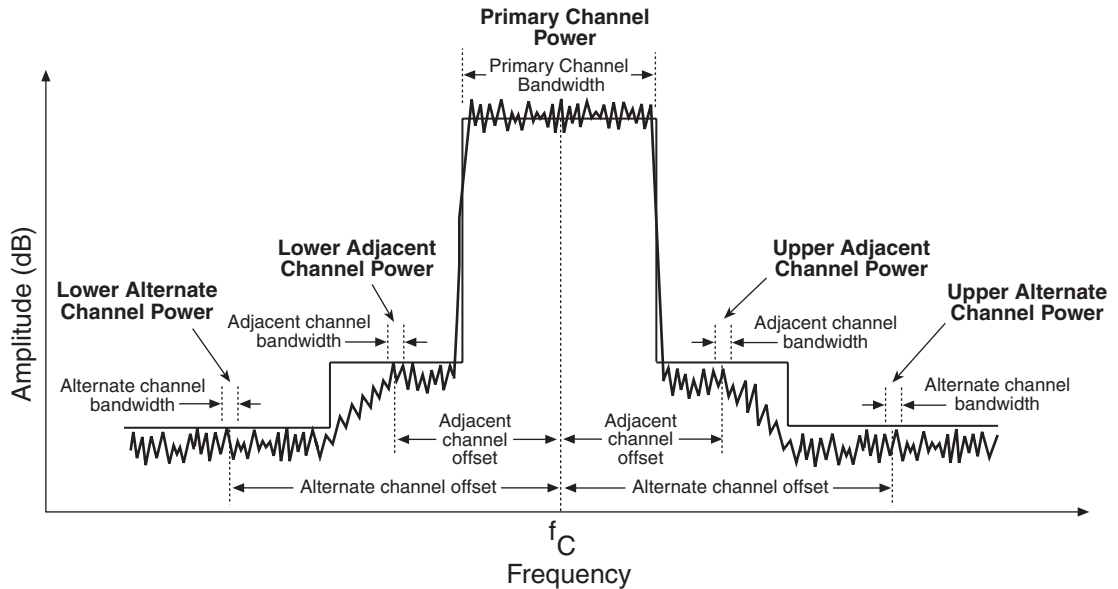
Front panel CDMAOne testing

Reference   A more detailed procedure to make "CDMAOne measurements" is provided on page 3-8 of this manual.

1. Press the **Standard** key to display the mobile standard menu.
2. Using the **PREV** and **NEXT** keys, select **CDMA1**, then press **Enter**.
3. Select either the **CELL**, **PCS,** or **KPCS** band, then press **Enter**.
4. If you want to change the adjacent offset setting, use the **Freq Offset** key to do so.
5. To average a number of primary channel readings to improve repeatability, press the **Avg** key, enter the number of readings to average, and select **MOVING** or **REPEAT** mode. Details on "Averaging" are provided on page 2-5 of this manual.
6. For optimum adjacent and alternate channel power measurements, use the **Acq Time** key to set the acquisition time as required. Details on "Acquisition time" are provided on page 2-4 of this manual.
7. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.

8. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).
9. To display primary channel power, press the **PRIMARY** key**.**
10. To display adjacent channel and alternate channel power, press the **ADJ/ALT** key. Adjacent/Alternate power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm indicates the measured power referenced to 1mW, while dBc indicates the measured power referenced to the primary channel power.

Remote CDMAOne testing

Table 4-4 summarizes the command sequence for remote CDMAOne cell testing. Although default CDMAOne settings are used in most cases, commands are included to program various settings to demonstrate programming techniques.

Table 4-4
Command sequence for remote CDMAOne Cell testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL CDMA1	Select CDMAOne cell standard.
SENS:CDMA1:TYPE CELL	Select Cell band.
SENS:FUNC POW	Select power function.
SENS:AVER:COUN 10	Average 10 readings.
SENS:AVER:STAT ON	Enable averaging.
SENS:FREQ:CHAN 1	Select channel 1.
SENS:ADJ:OFFS 885e3	Adjacent channel offset = 885kHz.
SENS:POW:ATT 10	Select 10dB RF attenuation.
FORM:ELEM ALL	Select all data elements (includes primary, adjacent and alternate).
UNIT:POW DBC	Select dBc power units for adjacent and alternate power.
READ?	Trigger and acquire readings.

* Many commands use defaults, but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

CDMA2000 measurements

Overview

A typical power spectrum for a CDMA2000 signal is shown in Figure 4-1. As shown, measurements include primary channel power, adjacent channel power, and alternate channel power.

Fixed settings – The fixed bandwidth settings for CDMA2000 are listed in Table 4-5. Also listed are the fixed settings for 3x adjacent offset and alternate offset. Adjacent offset for 1x can be changed by the user. The fixed settings cannot be changed.

Table 4-5
CDMA2000 – fixed settings

Setting	1x	3x
Primary Channel Measurement Bandwidth	1.23MHz	3.69MHz
Adjacent Channel Measurement Bandwidth	30kHz	30kHz
Alternate Channel Measurement Bandwidth	30kHz	30kHz
Adjacent Channel Offset	see Note	±2.65MHz
Alternate Channel Offset	±1.98MHz	±3.10MHz

Note: Adjacent channel offset for 1x is not fixed. The default settings are listed in Table 4-6.

Default settings – The default channel (center frequency) and 1x adjacent channel offset settings for CDMA2000 are listed in Table 4-6. These settings can be changed by the user.

Table 4-6
CDMA2000 – default settings

Setting	Default Value					
	BC0 (1x)	**BC1 (1x)**	**BC4 (1x)**	**BC6 (1x)**	**BC8 (1x)**	**BC9 (1x)**
Center Freq (f_C)	825.03MHz	1850.05MHz	1750.05MHz	1920.05MHz	1710.05MHz	880.05MHz
Center Chan	1	1	1	1	1	1
Adjacent Offset	±885kHz	±1.25MHz	±1.25MHz	±1.25MHz	±1.25MHz	±885kHz
	BC0 (3x)	**BC1 (3x)**	**BC4 (3x)**	**BC6 (3x)**	**BC8 (3x)**	**BC9 (3x)**
Center Freq (f_C)	825.03MHz	1850.05MHz	1750.05MHz	1920.05MHz	1710.05MHz	880.05MHz
Center Chan	1	1	1	1	1	1
Adjacent Offset	see Note	see Note	see Note	see Note	see Note	see Note

Note: Adjacent channel offset for 3x is fixed at ±2.65MHz.

Front panel CDMA2000 testing

1. Press the **Standard** key to display the standard menu.
2. Using the **PREV** and **NEXT** keys, select **CDMA2000**, then press **Enter**.
3. Select the desired band class (BC) and spreading rate (1x or 3x), then press **Enter**.
4. To change the 1x adjacent channel off set setting, use the **Freq Offset** key.
5. To average a number of primary channel readings to improve repeatability, press the **Avg** key, enter the number of readings to average, and select **MOVING** or **REPEAT** mode. Details on "Averaging" are provided on page 2-5 of this manual.
6. For optimum adjacent and alternate channel power measurements, use the **Acq Time** key to set the acquisition time as required. Details on "Acquisition time" are provided on page 2-4 of this manual.
7. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.
8. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).
9. To display primary channel power, press the **PRIMARY key.**
10. To display adjacent channel and alternate channel power, press the **ADJ/ALT** key. Adjacent/Alternate power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm indicates the measured power referenced to 1mW, while dBc indicates the measured power referenced to the primary channel power.

Remote CDMA2000 testing

Table 4-7 summarizes the command sequence for remote CDMA2000 testing. Commands for offsets use default CDMA2000 settings.

Table 4-7
Command sequence for remote CDMA2000 testing (band class 0, 1x spreading rate)

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL CDMA2K	Select CDMA2000 standard.
SENS:CDMA2K:TYPE BC0	Select band class 0.
SENS:CDMA2K:SRAT SR1	Select SR1 (1x) spreading rate.
SENS:FUNC POW	Select power function.
SENS:AVER:COUN 5	Average 5 readings.
SENS:AVER:STAT ON	Enable averaging.
SENS:FREQ:CHAN 200	Select channel 200.
SENS:ADJ:OFFS 885e3	Adjacent channel offset = 885kHz.
SENS:POW:ATT 10	Select 10dB RF attenuation.
FORM:ELEM ALL	Select all data elements (includes primary, adjacent, and alternate).
READ?	Trigger and acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

WCDMA measurements

Overview

A typical power spectrum for a WCDMA signal is shown in Figure 4-1. As shown, measurements include primary channel power, adjacent channel power, and alternate channel power.

Fixed settings – The fixed bandwidth settings for WCDMA are listed in Table 4-8. Also listed is the fixed adjacent and alternate channel offset settings. These settings are fixed and cannot be changed.

Table 4-8
WCDMA – fixed settings

Setting	All Op Bands
Primary, Adjacent and Alternate Channel Measurement Bandwidth:	3.84MHz
Alternate Channel Offset	±5MHz
Alternate Channel Offset	±10MHz

Default settings – The default channel (center frequency) setting for WCDMA is listed in Table 4-9. These settings can be changed by the user.

Table 4-9
WCDMA – default settings

Setting	Default Value
Center Frequency (f_C)	1922.4MHz
Channel Number	9612

Front panel WCDMA testing

1. Press the **Standard** key to display the standard menu.
2. Using the **PREV** and **NEXT** keys, select **WCDMA**, then press **Enter**.
3. From the **TYPE** menu item, use **PREV** or **NEXT** to choose the desired operating band, then press **Enter**.
4. To enable or disable the Root Raised Cosine (RRC) filter, repeat steps 1 and 2 to again select the **WCDMA** standard. Use the **RRC FILTER** menu item to enable or disable the filter. Details on the "Root-raised cosine (RRC) filter" are provided on page 2-17 of this manual.
5. To average a number of primary channel readings to improve repeatability, press the **Avg** key, enter the number of readings to average, and select **MOVING** or **REPEAT** mode. Details on "Averaging", are provided on page 2-5 of this manual.
6. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.
7. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).
8. To display primary channel power, press the **PRIMARY** key**.**
9. To display adjacent channel and alternate channel power, press the **ADJ/ALT** key. Adjacent/Alternate power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm is referenced to 1mW, and dBc is referenced to the primary channel power.

Remote WCDMA testing

summarizes the command sequence for remote WCDMA testing. Commands for offsets use default WCDMA settings.

Table 4-10
Command sequence for remote WCDMA testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL WCDMA	Select WCDMA standard.
SENS:WCDMA:TYPE OB1	Select operating band 1.
SENS:WCDMA:RRC ON	Enable Root Raised Cosine (RRC) filter.
SENS:FUNC POW	Select power function.
SENS:AVER:COUN 5	Average 5 readings.
SENS:AVER:STAT ON	Enable averaging.
FORM:ELEM PRIM,ADJU	Select primary, upper adjacent power data elements.
UNIT:POW DBC	Select dBc power units for adjacent power.
SENS:POW:ATT 10	Select 10dB RF attenuation.
READ?	Trigger and acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

NADC measurements

Overview

A typical power spectrum for a NADC signal is shown in . As shown, measurements include primary channel power and adjacent channel power. Alternate channel power can be measured by increasing the adjacent channel offset such that the measurement occurs in the alternate channel region of the spectrum.

Fixed settings – The fixed bandwidth settings for NADC bands are listed in as follows.

Table 4-11
NADC – fixed settings

| Setting	Cell and PCS
Primary Channel Measurement Bandwidth:	30kHz/100kHz
Adjacent Channel Measurement Bandwidth	25kHz
Alternate Channel Measurement Bandwidth	25kHz

Default settings – The default channel (center frequency) and adjacent channel offset settings for NADC are listed in Table 4-12. Also listed is the default trigger level that will start the measurement process. These settings can be changed by the user.

Table 4-12
NADC – default settings

Setting	Default Value	
	Cell	PCS
Center Frequency (f_C)	825.03MHz	1850.01MHz
Channel Number	1	1
Adjacent Channel Offset	±30kHz	±30kHz
Trigger Level	00.0dBm	00.0dBm

Figure 4-2
Typical power spectrum for NADC, GSM, and PHS
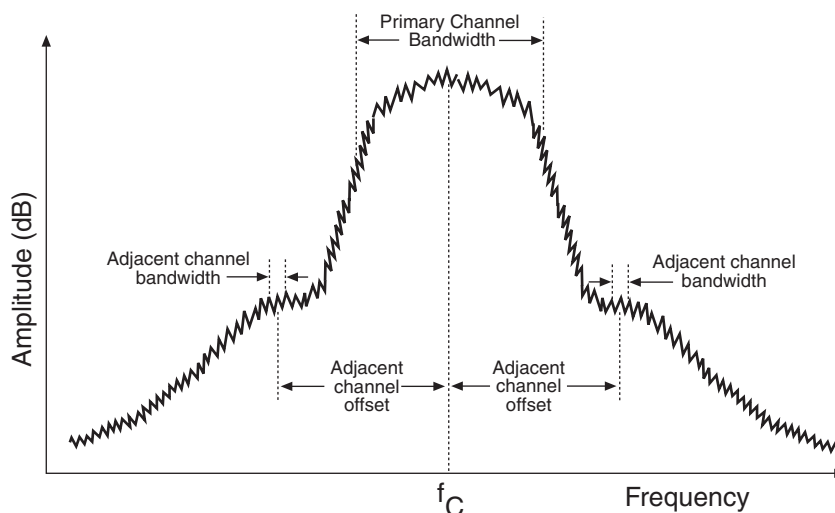
An NADC signal is a pulse train that consists of frames that are divided into slots. Each frame consists of either three or six slots. Each slot is 6.667ms in duration with a usable portion of 6.42ms. The 3-slot pulse is 20ms in duration and is called a full-rate frame. The 6-slot pulse is 40ms in duration and is called a half-rate frame. Figure 4-3 shows the burst slot for a frame.

There are two types of NADC primary power measurements: burst power and average power. As shown in Figure 4-3, burst power measurements are generally made over the active slot of the frame, while average power measurements are made over the entire frame.

Burst power – Burst power measurements require setting the trigger level, trigger delay, and acquisition time to ensure proper synchronization of the signal. The measurement process will start when the set trigger level for the pulse is detected. However, the measurement will not start until the set delay period expires.

A delay is used allow the signal to settle before starting the measurement. A typical delay period for NADC burst is 125µs. The acquisition time is to be set to a time period such that the measurement does not carry over into the next slot. A typical acquisition time for NADC burst is 6ms.

Average power – Average power measurements require only that the unit be in the continuous (immediate) trigger mode, and you select the appropriate acquisition time (20ms for full-rate frame or 40ms for half-rate frame).

Figure 4-3
NADC slot and frame duration
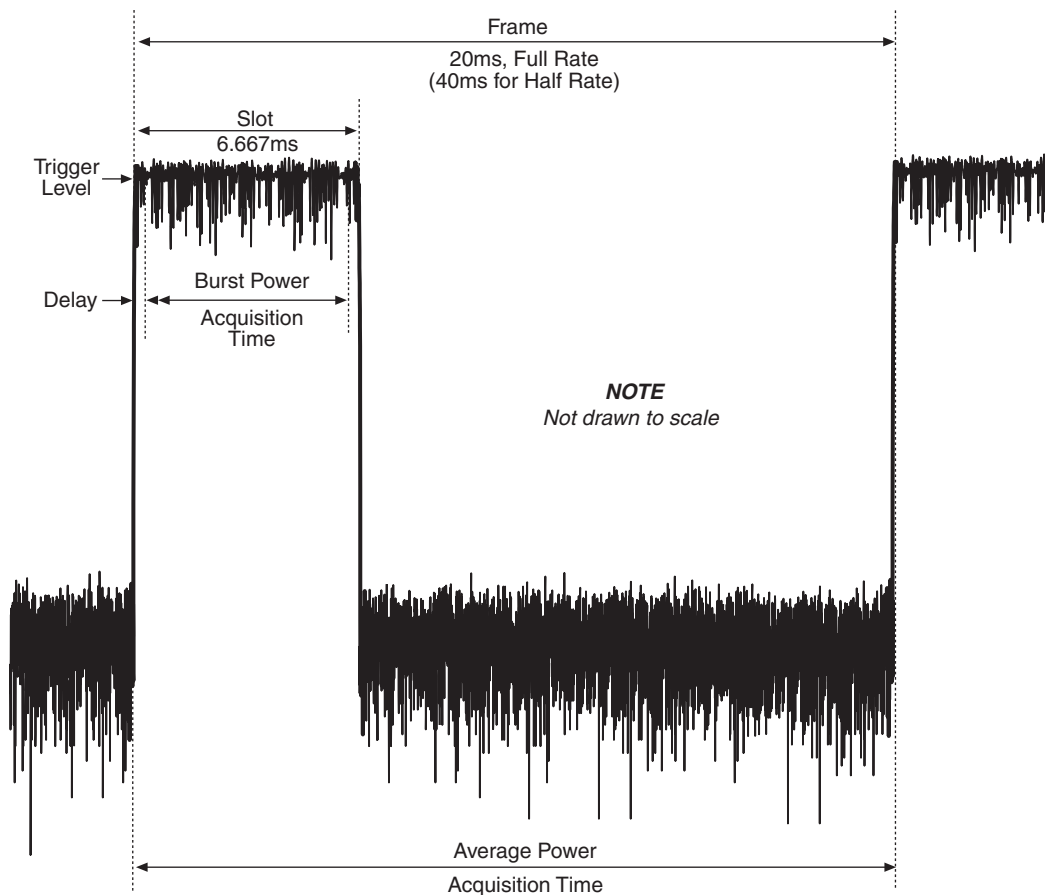
Front panel NADC testing

Reference   A more detailed procedure to make "NADC measurements" is provided on page 3-12.

Burst power

NOTE   *Burst power measurements require that input protection be disabled. To disable input protection, press **Menu**, select **INPUT** and select **DISABLE**. Details on enabling/disabling "Input protection" are provided on page 3-39 of this manual.*

1. Press the **Standard** key to display the standard menu.
2. Using the **PREV** and **NEXT** keys, select **NADC**, then press **Enter**.
3. Select either the **CELL** or **PCS** band, then press **Enter**.
4. To change the primary channel bandwidth, press **MEAS BW** and enter 30kHz or 100kHz.
5. To change the adjacent frequency offset setting, use the **Freq Offset** key.
6. Press **SHIFT** then **Setup Trigger**.
7. Select **SOURCE**, then press **Enter**.
8. Select **LEVEL**, then press **Enter.**
9. Set the trigger level for the appropriate value, then press **Enter**. Typically, you would set this value about 10dB below peak envelope power.
10. Select **DELAY**, then press **Enter**. Set the trigger delay to an appropriate value to start acquisition on the desired portion of the burst waveform. A typical delay used for NADC burst power is 20µs.
11. Using the **Acq Time** key, set the acquisition time to measure power of the slot. Use an acquisition time that measures the burst only and does not carry over into the next slot.

    For measurement during the usable part of the pulse, acquisition time should be 6.42ms or less. A typical acquisition time for this measurement is 6ms. Details to set "Acquisition time" are provided on page 3-41 of this manual.
12. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.
13. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).
14. To display primary channel power, press the **PRIMARY key.**
15. To display adjacent channel power, press the **ADJ/ALT** key. Adjacent power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm is referenced to 1mW, and dBc is referenced to the primary channel power.
16. To measure alternate channel power, use the **Freq Offset** key to manually set adjacent channel offset to 60kHz.

Average power

1. Press the **Standard** key to display the standard menu.
2. Using the **PREV** and **NEXT** keys, select **NADC**, then press **Enter**.
3. Select either the **CELL** or **PCS** band, then press **Enter**.
4. To change the primary channel bandwidth, press **MEAS BW** and enter 30kHz or 100kHz.
5. To change the adjacent frequency offset setting, use the **Freq Offset** key.

6. Press **SHIFT,** then **Setup Trigger**.

7. Select **SOURCE**, then press **Enter**.

8. Select **IMMEDIATE**, then press **Enter.**

9. Using the **Acq Time** key, set the acquisition time to either 20ms or 40ms depending on the frame rate. Use 20ms for full rate or 40ms for half rate. Details to set "Acquisition time" are provided on page 3-41 of this manual.

10. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.

11. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).

12. To display primary channel power, press the **PRIMARY key.**

13. To display adjacent channel power, press the **ADJ/ALT** key. Adjacent power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm is referenced to 1mW, and dBc is referenced to the primary channel power.

14. To measure alternate channel power, use the **Freq Offset** key to manually set adjacent channel offset to 60kHz.

Remote NADC testing

Burst power

Table 4-13 summarizes the command sequence for remote NADC burst power measurements. The acquisition time is set to 6ms (full frame rate).

Table 4-13
Command sequence for remote NADC burst power testing

Command*	Description
*RST	Restore GPIB defaults.
SENS:INP:PROT:STAT OFF	Disable input protection.
INST:SEL NADC	Select NADC standard.
SENS:NADC:TYPE CELL	Select cell band.
SENS:PRIM:BAND 30e3	Primary bandwidth = 30kHz.
SENS:FUNC POW	Select power function.
SENS:FREQ:CHAN 1	Select channel 1.
UNIT:POW DBC	Select dBc power units for adjacent power.
SENS:POW:ATT 10	Select 10dB RF attenuation.
TRIG:SOUR LEV	Select triggering on input signal level.
SENS:ACQ:TIME 6e-3	6ms acquisition time.
FORM:ELEM PRIM,ADJL,ADJU	Select primary, lower adjacent, upper adjacent elements.
TRIG:LEV -50	-50dBm trigger level.
TRIG:DEL 125e-6	125μs trigger delay.
READ?	Acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

Average power

Table 4-14 summarizes the command sequence for remote NADC average power measurements. Commands for offset use the default NADC setting. The acquisition assumes the full 20ms (frame rate).

Table 4-14
Command sequence for remote NADC average power testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL NADC	Select NADC standard.
SENS:NADC:TYPE CELL	Select cell band.
SENS:PRIM:BAND 30e3	Primary bandwidth = 30kHz.
SENS:FUNC POW	Select power function.
SENS:FREQ:CHAN 1	Select channel 1.
SENS:ADJ:OFFS 30e3	Adjacent channel offset = 30kHz.
UNIT:POW DBC	Select dBc power units for adjacent power.
SENS:POW:ATT 10	Select 10dB RF attenuation.
SENS:ACQ:TIME 20e-3	20ms acquisition time (full frame rate).
FORM:ELEM PRIM,ADJL,ADJU	Select primary, lower adjacent, upper adjacent elements.
TRIG:SOUR IMM	Select immediate triggering.
READ?	Acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

GSM measurements

Overview

A typical power spectrum for GSM signals is shown in Figure 4-2. As shown, measurements include primary channel power and adjacent channel power. Alternate channel power can be measured by increasing the adjacent channel offset such that the measurement occurs in the alternate channel region of the spectrum.

NOTE   *See "GSM staircase and time analysis," page 3-27 for details on GSM staircase and time analysis commands.*

Fixed settings – The fixed bandwidth settings for GSM bands are listed as Table 4-15.

Table 4-15
GSM – fixed settings

Setting	Cell, PCS, DCS, US850
Adjacent Channel Measurement Bandwidth	30kHz
Alternate Channel Measurement Bandwidth	30kHz

The primary channel bandwidth for GSM can be set to 30kHz or 400kHz. The default bandwidth is 400kHz but can be set to 30kHz if concurrent measurements are enabled (SENS:POW:CONC ON). If concurrent measurements are disabled, trying to change the primary BW from 400kHz to 30kHz will generate error +833 "Meas BW is fixed or invalid". The command will be ignored.

Trying to change the adjacent or alternate channel BW (which are fixed) will also generate error +833.

Default settings – The default channel (center frequency) and adjacent channel offset settings for GSM are listed in Table 4-16. Also listed is the default trigger level that will start the measurement process. These settings can be changed by the user.

Table 4-16
GSM – default settings

Setting	Default value			
	Cell (GSM 950)	DCS (DCS 1800)	PCS (PCS 1900)	US850
Center Frequency (f_C)	890.2MHz	1710.2MHz	1850.2MHz	824.2MHz
Channel Number	1	512	512	128
Primary Channel BW	400kHz	400kHz	400kHz	400kHz
Adjacent Channel Offset	±200kHz	±200kHz	±200kHz	±200kHz

A GSM signal is a pulse train that consists of frames that are divided into slots. Each frame consists of eight slots. Each slot is 577μs in duration with a usable portion of 542.8μs. Each frame is 4.615ms in duration. Figure 4-4 shows the burst slot for a frame.

There are two types of GSM primary power measurements: burst power and average power. As shown in Figure 4-4, burst power measurements are generally made over the active slot of the frame, while average power measurements are made over the entire frame.

Burst power – Burst power measurements require setting the Trigger Level, Trigger Delay, and Acquisition Time to ensure proper synchronization of the signal. The measurement process will start when the set trigger level for the pulse is detected. However, the measurement will not start until the set delay period expires.

A delay is used allow the signal to settle before starting the measurement. A typical delay period for GSM burst is 20µs. The acquisition time is to be set to a time period such that the measurement does not carry over into the next slot. A typical acquisition time for GSM burst is 500µs.

Average power – Average power measurements require only that the unit be in the continuous (immediate) trigger mode, and that you set the acquisition time to 4.615ms which is the time duration of a single frame.

Figure 4-4
GSM slot and frame duration
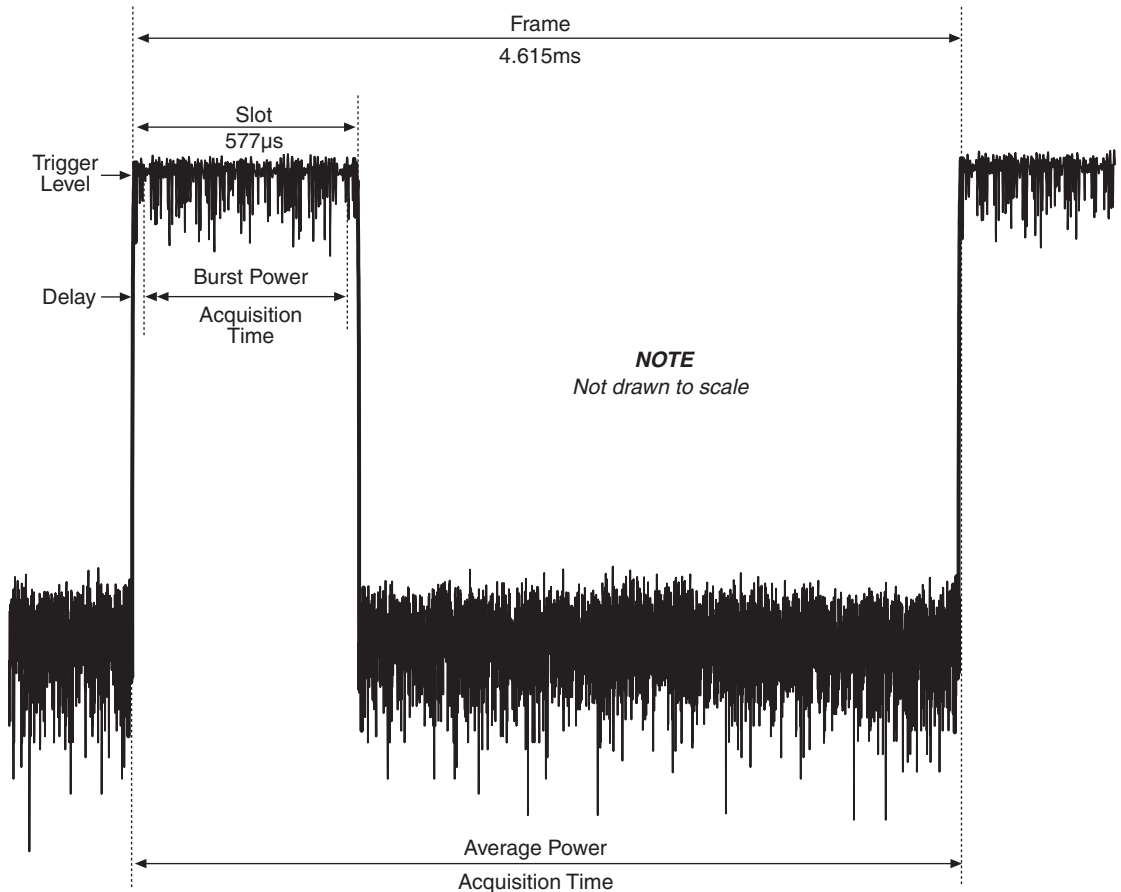
Front panel GSM testing

Burst power

> *NOTE*　　*Burst power measurements require that input protection be dis-abled. To disable input protection, press **Menu**, select **INPUT**, and select **DISABLE**. Details on enabling/disabling "Input protection" are provided on page 3-39 of this manual.*

1. Press the **Standard** key to display the standard menu.
2. Using the **PREV** and **NEXT** keys, select **GSM**, then press **Enter**.

3. Select either the **CELL**, **DCS**, **PCS**, or **US850** band, then press **Enter**.

4. Press **Menu**, use the **PREV** and/or **NEXT** key to place the cursor on **INPUT,** and press **Enter**. Select **DISABLE** and press **Enter**.

5. To change the primary channel bandwidth, press **MEAS BW** and enter 30kHz or 400kHz.

6. To change the adjacent frequency offset settings, use the **Freq Offset** key.

7. Press **SHIFT,** then **Setup Trigger**.

8. Select **SOURCE**, then press **Enter**.

9. Select **LEVEL**, then press **Enter.**

10. Set the trigger level for the appropriate value. Typically, you would set this value to around 10dB below the peak envelope power.

11. Select **DELAY**, then press **Enter**. Set the trigger delay to an appropriate value to start acquisition on the desired portion of the burst waveform. A typical delay is 16μs.

12. Using the **Acq Time** key, set the acquisition time to measure power of the slot. Use an acquisition time that measures the burst only and does not carry over into the next slot.

    For measurement during the usable part of the pulse, acquisition time should be 542.8μs or less. A typical acquisition time for this measurement is 500μs. Details to set "Acquisition time" are provided on page 3-41 of this manual.

13. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.

14. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).

15. To display primary channel power, press the **PRIMARY key.**

16. To display adjacent channel power, press the **ADJ/ALT** key. Adjacent power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm is referenced to 1mW, and dBc is referenced to the primary channel power.

17. To measure alternate channel power, use the **Freq Offset** key to manually set adjacent channel offset to 400kHz.

Average power

1. Press the **Standard** key to display the standard menu.

2. Using the **PREV** and **NEXT** keys, select **GSM**, then press **Enter**.

3. Select either the **CELL**, **DCS**, **PCS**, or **US850** band, then press **Enter**.

4. Press **Menu**, use the **PREV** and/or **NEXT** key to place the cursor on **INPUT,** and press **Enter**. Select **DISABLE** and press **Enter**.

5. To change the primary channel bandwidth, press **MEAS BW** and enter 30kHz or 400kHz.

6. To change the adjacent frequency offset setting, use the **Freq Offset** key.

7. Press **SHIFT** then **Setup Trigger**.

8. Select **SOURCE**, then press **Enter**.

9. Select **IMMEDIATE**, then press **Enter.**

10. Use the **Acq Time** key, set the acquisition time to 4.615ms. This is the time duration of the frame. Details to set "Acquisition time" are provided on page 3-41 of this manual.

11. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.

12. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).

13. To display primary channel power, press the **PRIMARY key.**

14. To display adjacent channel power, press the **ADJ/ALT** key. Adjacent power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm is referenced to 1mW, and dBc is referenced to the primary channel power.

15. To measure alternate channel power, use the **Freq Offset** key to manually set adjacent channel offset to 400kHz.

Remote GSM testing

Burst power

Table 4-17 summarizes the command sequence for remote GSM burst power measurements. Commands for bandwidths and offsets use default GSM settings.

Table 4-17
Command sequence for remote GSM burst power testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL GSM	Select GSM standard.
SENS:GSM:TYPE CELL	Select cell band.
SENS:FUNC POW	Select power function.
SENS:PRIM:BAND 400e3	Primary bandwidth = 400kHz.
SENS:INP:PROT:STAT OFF	Disable input protection.
SENS:FREQ:CHAN 1	Select channel 1.
SENS:ADJ:OFFS 200e3	Adjacent channel offset = 200kHz.
SENS:POW:ATT 10	Select 10dB RF attenuation.
TRIG:SOUR LEV	Select triggering on input signal level.
SENS:ACQ:TIME 500e-6	500μs acquisition time.
FORM:ELEM PRIM,ADJL,ADJU	Select primary, lower adjacent, upper adjacent elements.
TRIG:LEV -50	-50dBm trigger level.
TRIG:DEL 20e-6	20μs trigger delay.
UNIT:POW DBC	Select dBc power units for adjacent power.
READ?	Acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

Average power

Table 4-18 summarizes the command sequence for remote GSM average power measurements. Commands for bandwidths and offsets use default GSM settings.

Table 4-18
Command sequence for remote GSM average power testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL GSM	Select GSM standard.
SENS:GSM:TYPE CELL	Select cell band.
SENS:FUNC POW	Select power function.
SENS:PRIM:BAND 400e3	Primary channel bandwidth = 400kHz.
SENS:INP:PROT:STAT OFF	Disable input protection.
SENS:FREQ:CHAN 1	Select channel 1.
SENS:ADJ:OFFS 200e3	Adjacent channel offset = 200kHz.
SENS:POW:ATT 10	Select 10dB RF attenuation.
SENS:ACQ:TIME 4.615e-3	4.615ms acquisition time (frame rate).
FORM:ELEM PRIM,ADJL,ADJU	Select primary, lower adjacent, upper adjacent elements.
TRIG:SOUR IMM	Select immediate triggering.
UNIT:POW DBC	Select dBc power units for adjacent power.
READ?	Acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
The unit must be addressed to talk after READ? to acquire data.

PHS measurements

Overview

A typical power spectrum for PHS signals is shown in Figure 4-2. As shown, measurements include primary channel power and adjacent channel power. Alternate channel power can be measured by increasing the adjacent channel offset such that the measurement occurs in the alternate channel region of the spectrum.

Fixed settings – The fixed bandwidth settings for PHS bands are listed in Table 4-19.

Table 4-19
PHS – fixed settings

Setting	Value
Adjacent Channel Measurement Bandwidth	192kHz
Alternate Channel Measurement Bandwidth	192kHz

The primary channel bandwidth for PHS can be set to 192kHz or 1MHz. The default bandwidth is 192kHz but can be set to 1MHz if concurrent measurements are disabled (SENS:POW:CONC OFF). If concurrent measurements are enabled, trying to change the primary BW from 192kHz to 1MHz will generate error +833 "Meas BW is fixed or invalid". The command will be ignored.

Trying to change the adjacent or alternate channel BW (which are fixed) will also generate error +833.

Default settings – The default channel (center frequency) and adjacent channel offset settings for PHS are listed in Table 4-20. Also listed is the default trigger level that will start the measurement process. These settings can be changed by the user.

Table 4-20
PHS – default settings

	Default value
Setting	**Cell**
Center Frequency (f_C)	1895.15MHz
Channel Number	1
Primary Channel BW	192kHz
Adjacent Channel Offset	±600kHz
Trigger Level	00.0dBm

A PHS signal is a pulse train that consists of frames that are divided into slots. Each frame consists of eight slots. Each slot is 625µs in duration, and each frame is 5ms in duration. Figure 4-5 shows the burst slot for a frame.

There are two types of PHS primary power measurements: burst power and average power. As shown in Figure 4-5, burst power measurements are generally made over the active slot of the frame, while average power measurements are made over the entire frame.

Burst power – Burst power measurements require setting the trigger level, trigger delay, and acquisition time to ensure proper synchronization of the signal. The measurement process will start when the set trigger level for the pulse is detected. However, the measurement will not start until the set delay period expires.

A delay is used allow the signal to settle before starting the measurement. A typical delay period for PHS burst is 20µs. The acquisition time is to be set to a time

period such that the measurement does not carry over into the next slot. A typical acquisition time for PHS burst is 600µs.

Average power – Average power measurements require only that the unit be in the continuous (immediate) trigger mode, and that you set the acquisition time to 5ms, which is the time duration of a single frame.

Figure 4-5
PHS slot and frame duration
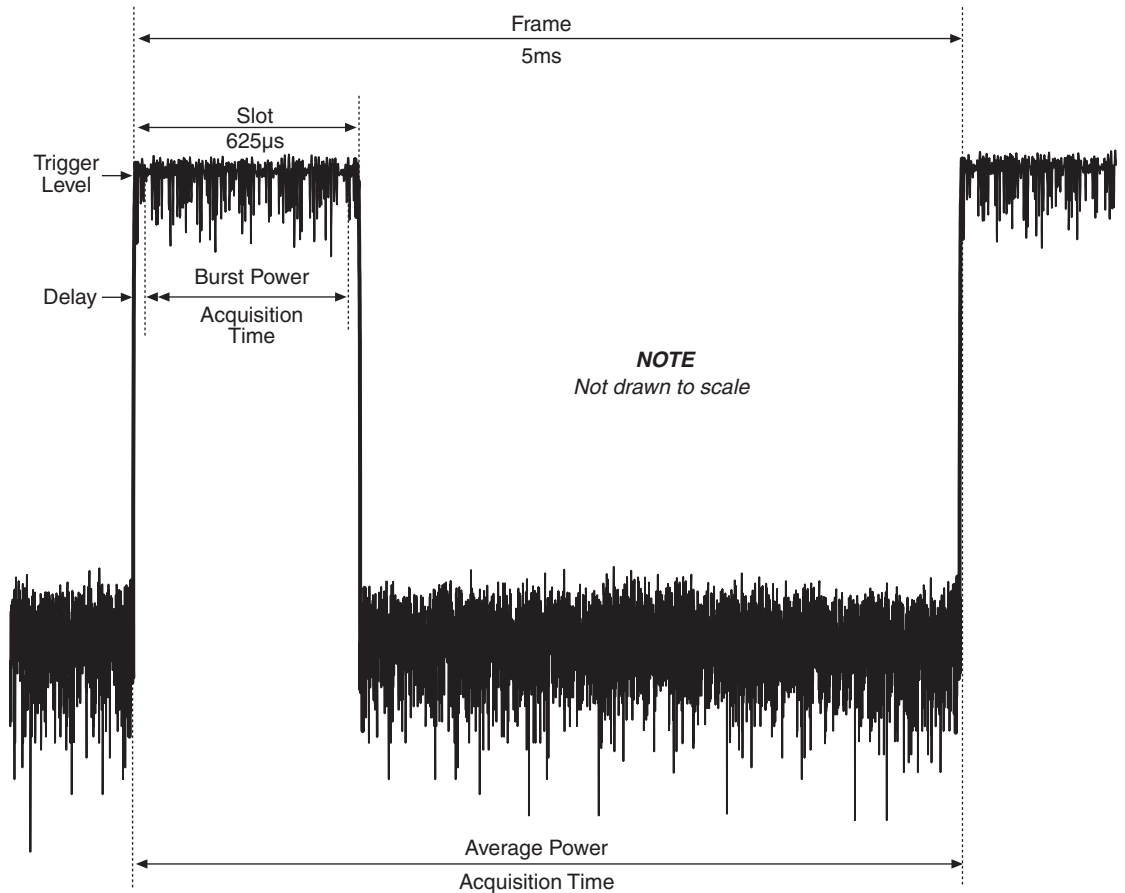
Front panel PHS testing

Burst power

NOTE   *Burst power measurements require that input protection be dis-*
                *abled. To disable input protection, press **Menu**, select **INPUT,** and*
                *select **DISABLE**. Details on enabling/disabling "Input protection" are*
                provided on page 3-39 of this manual.

1. Press the **Standard** key to display the standard menu.
2. Using the **PREV** and **NEXT** keys, select **PHS**, then press **Enter**.
3. Press **Menu**, use the **PREV** and/or **NEXT** key to place the cursor on **INPUT,** and press **Enter**. Select **DISABLE** and press **Enter**.
4. To change the adjacent frequency offset settings, use the **Freq Offset** key.
5. Press **SHIFT,** then **Setup Trigger**.
6. Select **SOURCE**, then press **Enter**.
7. Select **LEVEL**, then press **Enter.**
8. Set the trigger level for the appropriate value. Typically, you would set this value to around 10dB below the peak envelope power.
9. Select **DELAY**, then press **Enter**. Set the trigger delay to an appropriate value to start acquisition on the desired portion of the burst waveform. A typical delay is 16μs.
10. Using the **Acq Time** key, set the acquisition time to measure power of the slot. Use an acquisition time that measures the burst only and does not carry over into the next slot.

    For measurement during the usable part of the pulse, acquisition time should be 600µs or less. A typical acquisition time for this measurement is 600µs. Details to set "Acquisition time" are provided on page 3-41 of this manual.
11. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.
12. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).
13. To display primary channel power, press the **PRIMARY key.**
14. To display adjacent channel power, press the **ADJ/ALT** key. Adjacent power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm is referenced to 1mW, and dBc is referenced to the primary channel power.
15. To measure alternate channel power, use the **Freq Offset** key to manually set adjacent channel offset to 900kHz.

Average power

1. Press the **Standard** key to display the standard menu.
2. Using the **PREV** and **NEXT** keys, select **PHS**, then press **Enter**.
3. Press **Menu**, use the **PREV** and/or **NEXT** key to place the cursor on **INPUT,** and press **Enter**. Select **DISABLE** and press **Enter**.
4. To change the adjacent frequency offset setting, use the **Freq Offset** key.
5. Press **SHIFT** then **Setup Trigger**.
6. Select **SOURCE**, then press **Enter**.
7. Select **IMMEDIATE**, then press **Enter.**
8. Use the **Acq Time** key, set the acquisition time to 5ms. This is the time duration of the frame. Details to set "Acquisition time" are provided on page 3-41 of this manual.
9. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.
10. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).
11. To display primary channel power, press the **PRIMARY key.**
12. To display adjacent channel power, press the **ADJ/ALT** key. Adjacent power measurements can be expressed in either dBm or dBc by pressing the **dBm/dBc** key. dBm is referenced to 1mW, and dBc is referenced to the primary channel power.
13. To measure alternate channel power, use the **Freq Offset** key to manually set adjacent channel offset to 900kHz.

Remote PHS testing

Burst power

Table 4-21 summarizes the command sequence for remote PHS burst power measurements. Commands for bandwidths and offsets use default PHS settings.

Table 4-21
Command sequence for remote PHS burst power testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL PHS	Select PHS standard.
SENS:FUNC POW	Select power function.
SENS:PRIM:BAND 192e3	Primary bandwidth = 192kHz.
SENS:INP:PROT:STAT OFF	Disable input protection.
SENS:FREQ:CHAN 1	Select channel 1.
SENS:ADJ:OFFS 192e3	Adjacent channel offset = 192kHz.
SENS:POW:ATT 10	Select 10dB RF attenuation.
TRIG:SOUR LEV	Select triggering on input signal level.
SENS:ACQ:TIME 600e-6	600μs acquisition time.
FORM:ELEM PRIM,ADJL,ADJU	Select primary, lower adjacent, upper adjacent elements.
TRIG:LEV -50	-50dBm trigger level.
TRIG:DEL 20e-6	20μs trigger delay.
UNIT:POW DBC	Select dBc power units for adjacent power.
READ?	Acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

Average power

Table 4-22 summarizes the command sequence for remote PHS average power measurements. Commands for bandwidths and offsets use default PHS settings.

Table 4-22
Command sequence for remote PHS average power testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL PHS	Select PHS standard.
SENS:FUNC POW	Select power function.
SENS:PRIM:BAND 192e3	Primary channel bandwidth = 192kHz.
SENS:INP:PROT:STAT OFF	Disable input protection.
SENS:FREQ:CHAN 1	Select channel 1.
SENS:ADJ:OFFS 192e3	Adjacent channel offset = 192kHz.
SENS:POW:ATT 10	Select 10dB RF attenuation.
SENS:ACQ:TIME 5e-3	5ms acquisition time (frame rate).
FORM:ELEM PRIM,ADJL,ADJU	Select primary, lower adjacent, upper adjacent elements.
TRIG:SOUR IMM	Select immediate triggering.
UNIT:POW DBC	Select dBc power units for adjacent power.
READ?	Acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
 The unit must be addressed to talk after READ? to acquire data.

AMPS measurements

Overview

The measurement bandwidths and sideband frequency offset, relative to the primary channel center frequency, are as indicated in Figure 4-6. AMPS power measurements include the primary channel, carrier, and the upper sideband.

Fixed settings – The fixed settings for AMPS are listed in Table 4-23.

Table 4-23
AMPS – fixed settings

Setting	Frequency
Primary Channel Measurement Bandwidth	30kHz
Carrier Measurement Bandwidth	1kHz
Upper sideband Measurement Bandwidth	1kHz
Upper sideband Offset	10kHz

Default settings – The default channel for the AMPS standard is listed in Table 4-24.

Table 4-24
AMPS standard default settings

Setting	Default Value
Center Frequency (f_C)	825.03MHz
Channel Number	1

Figure 4-6
AMPS measurement bandwidths and sideband frequency offset
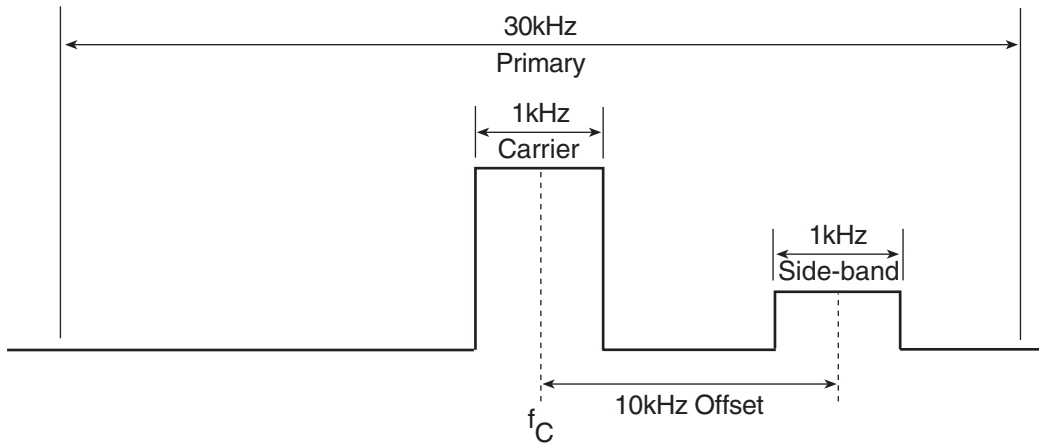
Front panel AMPS testing

1. Press the **Standard** key to display the transmission standard menu.
2. Using the **PREV** and **NEXT** keys, select **AMPS**, then press **Enter**.
3. Using the **Attenuator** key, set attenuation as needed. Details to determine the proper setting and the procedure to set the "Attenuator" are provided on page 3-41 of this manual.
4. Select the desired channel by channel number or center frequency using the corresponding **Freq Center** key (**Ch#** or **MHz**).
5. To display primary channel power, use the **PRIMARY** key.
6. To display upper sideband power, use the **ADJ/ALT** key.

> ***NOTE***   *Primary channel and carrier power are displayed in dBm units. The sideband power measurement can be displayed in dBm or dBc (use the **dBm/dBc** key to select units for sideband power. dBc is calculated from the carrier and upper sideband power.*

Remote AMPS testing

Table 4-25 summarizes the command sequence for remote AMPS testing.

Table 4-25
Command sequence for remote AMPS testing

Command*	Description
*RST	Restore GPIB defaults.
INST:SEL AMPS	Select AMPS standard.
SENS:FUNC POW	Select power function.
SENS:AVER:COUN 5	Average 5 readings.
SENS:AVER:STAT ON	Enable averaging.
SENS:FREQ:CHAN 200	Select channel 200.
SENS:POW:ATT 10	Select 10dB RF attenuation.
FORM:ELEM PRIM	Select only primary power data element.
READ?	Trigger and acquire readings.

* Many commands use defaults but are shown to demonstrate programming techniques.
  The unit must be addressed to talk after READ? to acquire data.

5
Programming Commands

Section topics

The SCPI command listings in the tables are abbreviated. That is, most query forms for the commands are not included. For example, the TRACe:POINts 100 command configures the buffer to store 100 readings. The query form for this command (TRACe:POINts?), which is not listed, returns the programmed parameter (100).

The unabridged SCPI tables that include all query commands are listed in Section 2 of the Reference Manual. Also included in that section are details on all programming commands.

NOTE   *A software driver to control the Model 2800 is available as a free download on the Keithley website (www.keithley.com). This driver is suitable for use with LabView, LabWindows CVI, Visual Basic, and C++. The driver is available in the download section of the 2800 product page on the website.*

Table 5-1
Signal-oriented measurement command summary

Command	Description
FETCh?	Returns the latest reading(s).
READ?	Triggers one or more readings and returns the readings (see Note).
MEASure?	Triggers one or more readings and returns the readings.

Note: READ? and MEAS? cannot be used when the BUS trigger source (TRIG:SOUR BUS) is selected.

Table 5-2
CALCulate3 command summary

Command	Description	Default
CALCulate3		
:FORMat <name>	Select statistic to be returned: MEAN, SDEViation, MAXimum, MINimum or PKPK.	MEAN
:DATA?	Return result of selected statistic.	

Table 5-3
DISPlay command summary

Command	Description	Default
DISPlay		(Note)
:WINDow[1]	Top line of display:	
:TEXT	Path to control user text messages.	
[:DATA] <a>	ASCII message "a" (up to 20 characters).	(none)
:STATe <b>	Enable or disable message mode for top line.	OFF
:DATA?	Read data on top display.	
:WINDow2	Bottom line of display:	
:TEXT	Path to control user text messages.	
[:DATA] <a>	ASCII message "a" (up to 32 characters).	(none)
:STATe <b>	Enable or disable message mode for bottom line.	OFF
:DATA?	Read data on bottom display.	
:ENABle <b>	Enable or disable the front panel display.	OFF

Note: *RST and SYSTem:PRESet have no effect on these commands. The listed defaults are power-on defaults.

Table 5-4
FORMat command summary

Command	Description	Default
FORMat		
:SREGister <name>	Select data format for reading status event registers: ASCii, HEXadecimal, OCTal or BINary.	ASC
[:DATA] <type>[,<length>]	Select data format: ASCii, REAL,32 or SREal.	ASC
:ELEMents	Specify data elements for read command responses:	
[:POWer] <item list>	Power function: PRIMary, ADJL, ADJU, ALTL, ALTU, TIME, STATus, or ALL.	ALL
:PEAK <item list>	PEAK function: POWer, FREQuency, TIME, STATus, or ALL.	ALL
:DFRequency <item list>	Delta F function: FREQuency, TIME, STATus, or ALL.	ALL
:TRACe <item list>	Buffer (TRACe:DATA?): PRIMary, ADJL, ADJU, ALTL, ALTU, TIME, STATus, or ALL.	ALL
:ELEMents?	Query data elements for read command responses?.	
:BORDer <name>	Specify byte order: NORMal or SWAPped.	(Note)
:SOURce2 <name>	Specify SOURce2 data format: ASCii, BINary, HEXadecimal, or OCTal.	ASC

Note: Byte order – *RST default is NORMal. SYSTem:PRESet default is SWAPped.

Table 5-5
INSTrument command summary

Command	Description	Default
INSTrument		
[:SELect] <name>	Select transmission standard: AMPS, CDMA1, CDMA2K, GSM, NADC, PHS, or WCDMA.	CDMA1
[:SELect]?	Query transmission standard.	

Table 5-6
SENSe command summary

Command	Description	Default
[:SENSe[1]]		
:FUNCtion <name>	Select function: POWer, PEAK or DFRequency.	POWer
[:PRIMary]	Primary channel:	
:BANDwidth <NRf>	Set primary BW for GSM: 30e3 or 400e3. [4]	400kHz
	Set primary BW for PHS: 192e3 or 1e6. [5]	192kHz
	Set primary BW for NADC: 30e3 or 100e3.	30kHz
:BANDwidth?	Query primary bandwidth.	1.23MHz [3]
:AVERage	Configure averaging:	
:COUNt <n>	Specify averaging count: 1 to 100.	6
:TCONtrol <name>	Select averaging type: REPeat or MOVing.	MOV
[:STATe] <b>	Enable or disable averaging.	OFF
:ADJacent	Adjacent channel:	
:BANDwidth?	Query adjacent channel bandwidth.	30kHz [3]
:OFFSet <NRf>	Set adjacent channel offset. [1]	885.0 kHz
:OFFSet?	Query adjacent channel offset.	
:ALTernate	Alternate channel:	
:BANDwidth?	Query alternate channel bandwidth	30kHz [3]
:OFFSet?	Query alternate channel offset.	1.98MHz [3]
:FREQuency	Set center frequency:	
:CHANnel <NRf>	Set as a frequency channel. [2]	1
:CENTer <NRf>	Set as s center frequency. [2]	825.03 MHz
:POWer	Mode, attenuator and concurrent readings:	
:MODE <name>	Select power measurement mode: FIXed or LIST.	FIXed
:ATTenuation <NRf>	Set power attenuator: 0 to 50 dB.	26 dB
:ACQuire	Use optimum setting (auto attenuation).	
:CONCurrent <b>	Enable/disable alternate and adjacent channels.	ON
:ACQuisition	Acquisition time:	
:TIME <NRf>	Set acquisition time: 1e-6 to 999.999e-3 (seconds). [6]	0.01
:CORRection	Cable compensation:	
:CELL <NRf>	Specify high-band correction value: 0 to 99.99 (dB).	0.00dB
:PCS <NRf>	Specify low-band correction value: 0 to 99.99 (dB).	0.00dB
[:STATe] <b>	Enable or disable cable correction.	OFF
:INPut	Input protection:	
:PROTection	Command path:	
:STATe <b>	Enable or disable input protection.	OFF
:TEMPerature	Temperature compensation:	

Table 5-6 (cont.)
SENSe command summary

Command	Description	Default
:OCOMpensated <b>	Enable or disable temperature compensation.	ON
:ACQuire	Acquire temperature and use to calculate readings.	
:CDMA1	CDMAOne:	
:TYPE <name>	Select band: CELL., PCS, or KPCS.	CELL
:NADC	NADC:	
:TYPE <name>	Select band: CELL or PCS.	CELL
:GSM	GSM:	
:STAir? <NRf>	Query sequential time slots. <NRf> = number of slots.	
:TMASk		
:STATistics?	Query time mask statistics of a GSM pulse.	
:TMASk?	Query power vs. time of a GSM pulse.	
:TYPE <name>	Select band: CELL, DCS, PCS, or US850.	CELL
:CDMA2K	CDMA2000:	
:TYPE <name>	Select type: BC0, BC1, BC4, BC6, BC8, or BC9.	BC0
:SRATe <name>	Set spreading rate: SR1 or SR3.	SR1
:WCDMA	WCDMA:	
:TYPE <name>	Select WCDMA type: OB1, OB2, or OB3.	OB1
:RRC <b>	Enable or disable Root Raised Cosine filter.	ON
:LIST	Sweep list:	
:CONTrol <name>	Select sweep list type: FREQuency or ATTenuation. [7]	FREQ
:FREQuency <list>	Create frequency list: NRf,[NRf,NRf...NRf].	
:POINts?	Query number of sweep points in list.	
:APPend <list>	Append frequency list: NRf,[NRf,NRf...NRf].	
:ATTenuation <list>	Create attenuator list: NRf,[NRf,NRf...NRf].	
:POINts?	Query number of sweep points in list.	
:APPend <list>	Append attenuator list: NRf,[NRf,NRf...NRf].	

1. The setting range for the adjacent channel offset depends on the selected standard. See the chart for "Adjacent Channel" in Appendix A – Specifications.

2. The setting ranges for center freqency and channel depend on the selected standard. See the chart for "Frequency Settings" in Appendix A – Specifications.

3. The listed default is the setting for the CDMAOne Cell standard.

4. In order to set the GSM primary BW to 30kHz, concurrent measurements must be enabled (SENS:POW:CONC ON).

5. In order to set the PHS primary BW to 1MHz, concurrent measurements must be disabled (SENS:POW:CONC OFF).

6. 1e-6 to 999.999e-3 for GSM and PHS. 1e-5 to 999.99e-3 for CDMAOne, CDMA2000, and NDAC.

7. FREQuency and ATTenuation can be used together for concurrent sweep. Parameters must be separated by a comma, for example: LIST:CONT FREQ, ATT.

Table 5-7
SOURce2 command summary

Command	Description	Default
SOURce2		
:TTL	Digital I/O port:	
[:LEVel] <NDN> or <NRf>	Specify bit pattern for the four digital output lines.	15
[:LEVel]?	Query the digital output pattern.	
:INPut?	Query digital input state: Hi (1) or Lo (0).	

Table 5-8
STATus command summary

Command	Description	Default
STATus		(Note 1)
:MEASurement	Control measurement event registers:	
[:EVENt]?	Read the event register.	(Note 2)
:ENABle <NDN> or <NRf>	Program the enable register.	(Note 3)
:ENABle?	Read the enable register.	
:CONDition?	Read the condition register.	
:OPERation	Control operation status registers:	
[:EVENt]?	Read the event register.	(Note 2)
:ENABle <NDN> or <NRf>	Program the enable register.	(Note 3)
:ENABle?	Read the enable register.	
:CONDition?	Read the condition register.	
:QUEStionable	Control questionable status registers:	
[:EVENt]?	Read the event register.	(Note 2)
:ENABle <NDN> or <NRf>	Program the enable register.	(Note 3)
:ENABle?	Read the enable register.	
:CONDition?	Read the condition register.	
:PRESet	Return status registers to default states.	
:QUEue	Access error queue:	
[:NEXT]?	Read the most recent error message.	(Note 4)
:ENABle <NDN> or <NRf>	Specify error and status messages for queue.	(Note 5)
:DISable <NDN> or <NRf>	Specify messages not to be placed in queue.	(Note 5)
:CLEar	Clears all messages from Error Queue.	

1. Commands in this subsystem are not affected by *RST and SYSTem:PRESet. The effects of cycling power,
   *CLS and STATus:PRESet, are explained by the following notes.
2. Event Registers: Power-up and *CLS – Clears all bits of the registers. STATus:PRESet – No effect.
3. Enable Registers: Power-up and STATus:PRESet – Clears all bits of the registers. *CLS – No effect.
4. Error Queue: Power-up and *CLS – Clears the Error Queue. STATus:PRESet – No effect.
5. Enable/Disable Error Queue Messages: Power-up – Clears list of messages. *CLS and STATus:PRESet – No effect.

Table 5-9
SYSTem command summary

Command	Description	Default
SYSTem		
:PRESet	Return to :SYST:PRES defaults.	
:POSetup <name>	Select power-on setup: (RST, PRESet, SAV0, SAV1, or SAV2).	
:POSetup?	Query power-on setup.	
:KEY <n>	Simulate key-press (1 to 31: see Figure 2-3 in the Reference Manual).	
:KEY?	Query the last "pressed" key.	
:ERRor?	Query (read) Error Queue.	Note 1
[:NEXT]?	Return and clear the latest error (code and message).	
:ALL?	Return and clear all errors (code and message).	
:COUNt?	Return number of errors in queue.	
:CODE	Return error code number only:	
[:NEXT]?	Return and clear oldest error (code only).	
:ALL?	Return and clear all errors (codes only).	
:CLEar	Clears codes and messages from Error Queue.	
:MEP	Select the GPIB protocol.	Note 2
[:STATe] <b>	Select SCPI protocol (1), or 488.1 protocol (0).	
[:STATe]?	Query selected protocol.	
:TIME	Timestamp:	
:RESet	Reset system timestamp to zero seconds.	
:TIME?	Query timestamp value.	
:VERSion?	Query rev level of SCPI standard.	

1. Power-up and *CLS clears the error queue.*RST, SYSTem:PRESet, and STATus:PRESet have no effect on the error queue.

2. *RST and SYSTem:PRESet have no effect on protocol. At the factory, the SCPI protocol is selected.

Table 5-10
TRACe command summary

Command	Description	Default*
TRACe		
:POINts <n>	Specify size of buffer: 1 to 2500.	100
:ACTual?	Returns number of stored readings.	
:FEED	Control buffer:	
:CONTrol <name>	Enable (NEXT) or disable (NEVer) buffer.	NEVer
:TSTamp	Timestamp type:	
:FORMat <name>	Select timestamp type: ABSolute or DELTa.	DELT
:DATA?	Returns readings stored in buffer.	
:CLEar	Clears the buffer.	

* SYSTem:PRESet and *RST have no effect on these commands. The listed defaults are set at the factory.

Table 5-11
Trigger command summary

Command	Description	Default
INITiate		
[:IMMediate]	Initiate one trigger cycle.	
TRIGger		
[:SEQuence[1]]		
:SOURce <name>	Select control source: IMMediate, EXTernal, BUS or LEVel.	IMM
:COUNt <n> | INFinite	Set trigger count: 1 to 2500 or INFinite.	1
:DELay <n>	Set delay: 0 to 999.999ms.	10µs
:LEVel <n>	Set trigger level for LEVel source: -99.99 to +20 (dBm).	0.0
:TimeOUT <n>	Set the trigger timeout; <n> = 1 to 300 (seconds).	5

Table 5-12
UNIT command summary

Command	Description	Default
UNIT		
:POWer <name>	Select units for adjacent and alternate channel readings: DBM or DBC.	DBM

Table 5-13
General bus commands

Command	Effect on Model 2800
REN	Goes into effect when next addressed to listen.
IFC	Reset interface. Goes into talker and listener idle states.
LLO	LOCAL key locked out.
GTL	Cancel remote: restore Model 2800 front panel operation.
DCL	Returns all devices to known conditions.
SDC	Returns Model 2800 to known conditions.
GET	Initiates a trigger.
SPE, SPD	Serial polls the Model 2800.

Table 5-14
IEEE-488.2 common commands

Command	Name	Description
*CLS	Clear status	Clears all event registers and Error Queue.
*ESE <NRf>	Event enable command	Programs the Standard Event Enable Register.
*ESE?	Event enable query	Reads the Standard Event Enable Register.
*ESR?	Event status register query	Reads and clear the Standard Event Enable Register.
*IDN?	Identification query	Returns the manufacturer, model number, serial number, and firmware revision levels of the unit.
*OPC	Operation complete	Sets the Operation Complete bit in the Standard Event Register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII "1" into Output Queue when all pending device operations have been completed.
*RCL <NRf>	Recall	Returns the 2800 to the user-saved setup.
*RST	Reset	Returns the 2800 to the *RST default conditions.
*SAV <NRf>	Save	Saves the present setup as the user-saved setup.
*SRE <NRf>	Service request enable	Programs the Service Request Enable Register.
*SRE?	Service request enable query	Reads the Service Request Enable Register.
*STB?	Status byte query	Reads the Status Byte Register.
*TRG	Trigger	Sends a bus trigger to the Model 2800.
*TST?	Self-test query	Performs checksum test on ROM, returns the result.
*WAI	Wait-to-continue	Waits until all previous commands are executed.

Commands to optimize measurement speed

The following commands can be used to increase measurement speed over the GPIB:

DISPlay:ENABle OFF – Turns off the display. This eliminates the time that the Model 2800 would spend updating the display while making measurements. For more information, see "DISPlay subsystem commands" in Section 2 of the Reference Manual.

INPut:PROTection:STATe OFF – Turns off input protection. Input protection sets the attenuation value of the Model 2800 to its highest setting (50dB) when not making a measurement and returns to the user-defined setting when making a measurement. Turning off input protection saves the time required by the Model 2800 to constantly change attenuation values in between measurements. For more information, see "Input protection" on page 2-7 of this manual.

TEMPerature:OCOMpensation OFF – Turns off temperature compensation. Temperature compensation reads an internal thermal sensor, selects the appropriate correction factor for the current temperature, and applies this factor to every measurement. When the temperature compensation is turned off, the Model 2800 will use the last thermal sensor reading from the last measurement that was made with the temperature compensation on. When you want to update the temperature compensation (if temperature is varying in your test environment) turn temperature compensation back on for one measurement and turn it back off again. Measurements from that point forward will be corrected for the new temperature measurement. For more information, see "Temperature compensation" on page 2-7 of this manual.

SYSTem:MEP OFF – Turns off SCPI mode (488.1 protocol). This allows "Trigger on talk". In this mode, you do not need to send a read command (e.g., READ?). Instead you only need to "talk" the Model 2800 over the bus, and the unit will trigger, read and send back the measured readings over the GPIB bus. For more information, see "GPIB protocols" in Appendix C of the Reference Manual.

[SENSe]:POWer:CONCurrent OFF;:FORMat:ELEMents[:POWer] PRIM – Use if interested in primary channel measurements only. Turn off the simultaneous measurement of the adjacent and alternates and measure only primary channel power. For more information, see "Concurrent measurements" on page 1-28 of this manual.

FORMat[:DATA] SREal – Puts data transfer in binary format. Binary data transfers over the bus faster than ASCII data. One numerical result in binary is seven bytes whereas one numerical result in ASCII is 14 bytes.

A
Specifications

Model 2800 RF Power Analyzer Specifications

FREQUENCY RANGE: 824 - 849MHz, 880 - 915MHz, 1710 – 1785MHz, 1850 - 1980MHz

FREQUENCY SETTINGS:

Cellular Standard	Channel number, N	Center Frequency, MHz	Frequency Band, MHz
cdmaOne Cellular Band	1 – 799 990 - 1023	825.000 + 0.030*N 825.000+0.030*(N-1023)	824.01MHz – 848.97MHz
cdmaOne PCS Band	0 - 1199	1850.000 + 0.050*N	1850.00MHz – 1909.95MHz
North American Digital Cellular (NADC) Cellular Band	1 – 799 990 - 1023	825.000+ 0.030*N 825.000+0.030*(N-1023)	824.01MHz – 848.97MHz
North American Digital Cellular (NADC) PCS Band	1 - 1999	1849.980+0.030*N	1850.01MHz – 1909.95MHz
AMPS	1 – 799 990 - 1023	825.000+0.030*N 825.000+0.030*(N-1023)	824.01MHz – 848.97MHz
GSM Cellular Band (GSM 850)	128 - 251	824.2 + 0.2*(N-128)	824.2MHz – 848.8MHz
GSM Cellular Band (P-GSM 900, E-GSM 900)	0 – 124 975 - 1023	890.0 + 0.2*N 890.0 + 0.2*(N-1024)	880.2MHz – 914.8MHz
DCS 1800 Band	512 - 885	1710.2 + 0.2*(N-512)	1710.2MHz – 1784.8MHz
GSM PCS 1900 Band	512 - 810	1850.2 + 0.2*(N-512)	1850.2MHz – 1909.8MHz
cdma2000 Band Class 0	1 – 799 991 – 1023	825.000+0.030*N 825.000+0.030*(N-1023)	824.04MHz – 848.97MHz
cdma2000 Band Class 1	0 - 1199	1850.000+0.050*N	1850.00MHz – 1909.95MHz
cdma2000 Band Class 4	0 - 599	1750.000+0.050*N	1750.00MHz – 1779.95MHz
cdma2000 Band Class 6	0 – 1199	1920.000+0.050*N	1920.00MHz – 1979.95MHz
cdma2000 Band Class 8	0 – 1499	1710.000 +0.050*N	1710.00MHz – 1784.95MHz
cdma2000 Band Class 9	0 – 699	880.000 + 0.050*N	880.00MHz – 914.95MHz
WCDMA Operating Band 1	9612 - 9888	0.2*N	1922.4MHz – 1977.6MHz
WCDMA Operating Band 2	9262 – 9538 12, 37, 62, 87, 112, 137, 162, 187, 212, 237, 262, 287	0.2*N 1850.1+0.2*N	1852.4MHz – 1907.6MHz
WCDMA Operating Band 3	8562 - 8913	0.2*N	1712.4MHz – 1782.6MHz
Korean PCS	0 - 599	1750.000+0.050*N	1750.00MHz –1779.95MHz
PHS	1 - 82 221 - 255	1895.15+0.3*(N-1) 1884.65+0.3*(N-221)	1884.65MHz - 1919.45MHz

INTERNAL REFERENCE OSCILLATOR REFERENCE:
  Aging per year: 1ppm
  Temperature Drift: (5°C to 40°C): 0.5ppm

EXTERNAL FREQUENCY REFERENCE INPUT:
  Frequency: 10MHz ± 5ppm
  Power: ≥2dBm
  Input Impedance: 50Ω, nominal

INPUT:
  Connector: Type N Female
  Impedance: 50Ω
  Maximum Overload Value: 22dBm, continuous, $20V_{DC}$
  VSWR: < 1.3:1

Model 2800 RF Power Analyzer Specifications

PRIMARY CHANNEL: MEASUREMENT RANGES

	CDMAOne	NADC	AMPS	GSM	CDMA2000 1X	CDMA2000 3X[2]	WCDMA[2]	PHS
Measurement Bandwidth[9]	1.23MHz	100kHz	30kHz	400kHz	1.23MHz	3.69MHz	3.84MHz	192kHz/1MHz
Accuracy (23ºC ±5ºC)[1]: 20dBm to –50dBm	±0.5dB	±0.5dB	±0.5dB	±0.5dB	All Bands ± 0.5dB	All Bands ± 0.5dB	All Bands ± 0.5dB	±0.5dB
-50.01dBm to -60dBm	Cellular: ± 0.73dB PCS: ± 0.73dB Korean: ± 0.73dB PCS	Cellular: ± 0.73dB PCS: ± 0.6dB	Cellular: ± 0.73dB	Cellular: ± 0.73dB DCS: ± 0.6dB PCS: ± 0.6dB	All Bands ± 0.73dB	Band Class 0: ±0.6dB Band Class 1: ±0.6dB Band Class 4,8: ±0.6dB Band Class 6: ± 0.72dB Band Class 9: ± 0.6dB	Operating Band 1: ±0.73dB Operating Band 2: ±0.6dB Operating Band 3: ±0.6B	±0.7dB
-60.01dBm to–70dBm[2]	Cellular: ± 1.07dB PCS: ± 0.94dB Korean PCS: ± 1.02dB	Cellular: ± 0.94dB PCS: ± 0.94dB	Cellular: ± 0.94dB	Cellular: ± 0.94dB DCS: ± 0.94dB PCS: ± 0.94dB	Band Class 0: ± 1.07dB Band Class 1: ±0.94dB Band Class 4,8: ±1.02dB Band Class 9: ±1.65dB			±0.9dB
Repeatability Mod.[3]	± 0.1dB	± 0.1dB	± 0.1dB	± 0.1dB	± 0.1dB	± 0.1dB	± 0.1dB	± 0.1dB
CW[12]	±0.05dB	±0.05dB	±0.05dB	±0.05dB	±0.05dB	±0.05dB	±0.05dB	±0.05dB
Noise Floor[19]: Cellular Band DCS Band PCS Band	≤-77.5dBm ≤-80.0dBm	≤-88.6dBm ≤-91.0dBm	≤-89.0dBm	≤-82.4dBm ≤-82.9dBm ≤-84.9dBm	Band Class 0 ≤-77.5dBm Band Class 1 ≤-80.0dBm Band Class 4,8 ≤-78.0dBm Band Class 6 ≤-73.6dBm Band Class 9 ≤-75.0dBm	Band Class 0 ≤-72.7dBm Band Class 1 ≤-75.2dBm Band Class 4,8 ≤-73.2dBm Band Class 6 ≤-68.8dBm Band Class 9 ≤-70.2dBm	Operating Band 1 ≤-68.7dBm Operating Band 2 ≤-75.1dBm Operating Band 3 ≤-73.1dBm	≤-82.0dBm

ADJACENT CHANNEL: (PRIMARY CHANNEL INPUT SIGNAL IN RANGE 5dBm TO 20dBm)

	CDMAOne	NADC	GSM	CDMA2000 1X	CDMA2000 3X	WCDMA	PHS
Measurement Bandwidth[9]	30kHz	25kHz	30kHz	30kHz	30kHz	3.84MHz	192kHz
Offset from Center Frequency: Cellular	± 885kHz, ± 900kHz	± 30kHz	±200kHz	± 885kHz, ± 900kHz			
DCS , PCS	± 900kHz, ± 1250kHz	± 30kHz	±200kHz	± 900kHz, ± 1250kHz	± 2.65MHz	± 5MHz	600kHz
Range at Specified Accuracy[15]	>55dBc	>36dBc	>40dBc	>55dBc	>55dBc	>33dBc	<–42dBm
Accuracy (23ºC ± 5ºC)[1] Relative to primary channel	± 1.0dB	± 1.0dB	± 1.0dB	Band Classes 0,1,4,8,9: ± 1.0dB Band Class 6: 1.5dB	Band Classes 0,1,4,8,9: ± 1.0dB Band Class 6: 1.5dB	± 2.0dB[20]	± 1.0dB
Repeatability[21]: CW	± 0.5dB[4]	± 0.5dB[11]	± 0.5dB[11]	± 0.5dB[4]	± 0.5dB[4]	± 1.0dB[20]	± 0.5dB[11]

ALTERNATE CHANNEL: (PRIMARY CHANNEL INPUT SIGNAL IN RANGE 5dBm TO 20dBm)

	CDMAOne	NADC	GSM	CDMA2000 1X	CDMA2000 3X	WCDMA	PHS
Measurement Bandwidth[9]	30kHz	25kHz	30kHz	30kHz	30kHz	3.84MHz	192kHz
Offset from Center Frequency: Cellular	± 1.98MHz	± 60kHz	± 400kHz	± 1.98MHz			
DCS , PCS	± 1.98MHz	± 60kHz	± 400kHz	± 1.98MHz	± 3.10MHz	± 10MHz	900kHz
Range at Specified Accuracy[15]	>55dBc	>48dBc	>60dBc	>55dBc	>55dBc	>43dBc	<–42dBm
Accuracy (23ºC ± 5ºC)[1] Relative to primary channel	± 1.0dB	± 1.0dB	± 1.0dB	Band Classes 0,1,4,8,9: ± 1.0dB Band Class 6: 1.5dB	Band Classes 0,1,4,8,9: ± 1.0dB Band Class 6: 1.5dB	± 2.0dB[20]	± 1.0dB
Repeatability[21]: CW	± 0.5dB[4]	± 0.5dB[11]	± 0.5dB[11]	± 0.5dB[4]	± 0.5dB[4]	± 1.0dB[20]	± 0.5dB[11]

Model 2800 RF Power Analyzer Specifications

OTHER MEASUREMENTS

UPPER SIDEBAND POWER (AMPS STANDARD ONLY): Measurement of Power Relative to Carrier @ 10khz offset

    Frequency Range: 824 - 849MHz
    Carrier Measurement Bandwidth: 1kHz
    Level: 20dBm to –40dBm
    Accuracy: ± 0.5dB
    Dynamic Range: 28dB

FREQUENCY[16]: RANGE: 824 - 849MHz, 880 - 915MHz, 1710 – 1785MHz, 1850 - 1980MHz

    Resolution: 1Hz
    Displayed Value: Difference between measured frequency and entered center frequency
    Measurement Window: ± 700kHz, nominal, from entered channel number or center frequency
    Level: 20dBm to –25dBm
    Accuracy: ±1Hz (with external reference)

PEAK FUNCTION: Computes power level and frequency of 5 highest power components in primary channel power spectrum

    Range: 824 - 849MHz, 880 - 915MHz, 1710 – 1785MHz, 1850 - 1980MHz
    Frequency Resolution: 5kHz
    Displayed Values: Power in dBm, Frequency in MHz
    Measurement Window: ±1.82MHz from entered channel number or center frequency
    Level: 20dBm to –25dBm
    Level Accuracy: ±0.5dBm[18]

GSM BURST POWER WAVEFORM ACQUISITION: Acquires 577µs power burst

    Parameters computed: rise time, maximum and minimum power levels of rising transient edge, maximum and minimum power levels of information transfer portion of burst
    Sample time resolution: 1µs
    Power Accuracy: ±0.5dB
    Number of waveform samples: 620

TRIGGER METHODS:

	Latency
Level	3µs
External Trigger	100µs
IEEE-488 Bus Command	2.5ms

MEASUREMENT PARAMETERS

		CDMAOne	NADC	AMPS	GSM	CDMA2000 1X	CDMA2000 3X	WCDMA	PHS
Trigger Delay:	Range	0 – 999.999ms	0 – 12.790ms		0 – 3.990ms	0 – 999.999ms	0 – 999.999ms	0 – 999.999ms	0 – 3.990ms
	Resolution	1µs	1µs		1µs	1µs	1µs	1µs	1µs
Acquisition Time:				20ms					
Primary Channel		200µs	10µs – 999.999ms		1µs – 999.999ms	200µs	200µs	200µs	1µs – 999.999ms
Adjacent/Alternate Channel		10µs – 999.999ms	10µs – 999.999ms		1µs – 999.999ms	10µs – 999.999ms	10µs – 999.999ms	200µs	1µs – 999.999ms
Resolution		10µs	10µs		1µs	10µs	10µs	10µs	1µs
Number of Averages:		1 - 100	1 - 100		1 - 100	1 - 100	1 - 100	1 - 100	1 - 100

MEASUREMENT TIME (TYPICAL)[7]:

	CDMAOne	NADC[11]	AMPS	GSM[11]	CDMA2000 1X	CDMA2000 3X	WCDMA	PHS
Primary Channel Power Measurement [5]	6ms	11ms[13]	30ms	4ms[13]	6ms	7ms	7ms	4ms[13]
Primary Channel Power Measurement, Two Adjacent Channel Power Measurements, and Two Alternate Channel Power Measurements[5,6]	26ms	16ms[10,13]	N/A	10ms[10,13]	26ms	26ms	75ms[17]	10ms[10,13]
Time to complete 10 different power measurements at a single frequency[5,8,14]	80ms	141ms[13]	330ms	81ms[13]	80ms	88ms	94ms	81ms[13]
Time to complete 10 power measurements of a single power level at different frequencies[5,14]	190ms	371ms[13]	575ms	325ms[13]	190ms	195ms	225ms[17]	325ms[13]

Model 2800 RF Power Analyzer Specifications

GENERAL

PROGRAMMABILITY: IEEE-488.2 (SCPI – 1995.0), 3 user-definable power-up states plus factory default.

MEMORY BUFFER: 2500 Sets Of 5 Readings – primary channel power, upper and lower adjacent channel power, upper and lower alternate channel power, with time stamp, peak reading, average reading, and standard deviation

DIGITAL INTERFACE:
Digital I/O: 1 – digital input, 4 – digital outputs with 250mA sink capability, maximum clamp voltage: $30V_{DC}$, 5V@100mA DC Source

REAR CONNECTIONS: RF Input – Type N connector, External Trigger, Meter Complete, External Reference In, Cal Output – BNC connector, Digital I/O – DB9 connector, IEEE-488 – 24-Pin EMI-shielded receptacle, Power – Power Switch/Line Entry Module with DPDT switch, 2 fuses, and IEC 320 plug

POWER SUPPLY: 100V/120V/220V/240V

LINE FREQUENCY: 50Hz to 60Hz

POWER CONSUMPTION: 100VA

ENVIRONMENT:
Operating: 5° to 40°C, 70%R.H., non-condensing, up to 35° C
Storage: 0° to 50°C

WARRANTY: 1year

SAFETY: Complies with European Union Directive 73/23/EEC, EN61010-1

EMC: Complies with European Union Directive 89/336/EEC, EN61326-1

VIBRATION: MIL-PRF-28800F Class 3 Random

WARM-UP: 1-hour to rated accuracy during normal operation. If the instrument has been stored in an unpowered state for more than 2 weeks, allow 2 hours for warm-up.

DIMENSIONS:
Bench configuration (with handle and feet): 104mm high x 485mm wide x 478mm deep (4.125in x 19in x 18.75in)
Rack Mounting: 89mm high x 485mm wide x 478mm deep (3.5in x 19in x 18.75in)

WEIGHT:
Net Weight: 13.14 kg (28.9 lbs)
Shipping Weight: 14.5kg (32lbs)

ACCESSORIES SUPPLIED: Hardcopy User's manual, RF Product Information CD-ROM, rack mount kit, bench assembly kit.

Notes:

1. Based on measurements of NIST traceable CW signals, and locked to the source reference. Exclusive of input mismatch. Derate by ± 0.05dB/°C beyond 23°C ± 5°C.
2. Accuracy values are based on an average of 6 measurements for CDMA2000 3X and WCDMA measurements between -50.01dBm and -60dBm, and for all standards between -60.01dBm and -70dBm.
3. Defined as 2 standard deviations of 100 consecutive readings while measuring a modulated signal. The following conditions apply: default acquisition times and signal/noise > 30dB.
4. Measurement acquisition time: 10ms.
5. Range: 20dBm to –60dBm (except CDMA2000 3X and WCDMA which are for 20dBm to –50dBm), averaging off, display off, input protection off, temperature compensation off, binary transfer, and 488.1 protocol. For measurements of only the primary channel, the adjacent channel measurements and the alternate channel measurements are disabled.
6. Adjacent channel power and alternate channel power acquisition time: 10ms.
7. Times are defined at specified repeatability and include IEEE-488 transfer times. CDMA2000 3X and WCDMA repeatability specifications are excluded.
8. Includes time required to make two attenuator changes.
9. Bandwidths are designed to conform to definitions in cellular standards.
10. Measurement times include 3 measurements: primary channel power measurements and upper and lower adjacent channel power measurements.
11. Acquisition time is one time slot: NADC = 6.0ms, GSM, PHS = 500μs. Level trigger is used.
12. Defined as 2 standard deviations of 100 consecutive measurements spaced evenly over an 8 hour period with ambient temperature of 23±1ºC. The following conditions apply: default acquisition times and signal/noise > 30dB.
13. Pulse measurement times are defined from the time the rising edge of each power pulse is detected to the completion of the data transfer.
14. Times are exclusive of DUT settling times.
15. The range is defined as the maximum detectable difference between the primary channel power and the adjacent (or alternate) channel power for the specified accuracy and specified measurement bandwidth.
16. Defined for measurements on un-modulated carrier waveforms, cdmaOne, and cdma2000 1X modulated waveforms.
17. Times are based on measurements in Operating Band One.
18. Defined for signals whose carrier is at the programmed center frequency or offset by an integer multiple of 5kHz.
19. Defined with 0dB programmed attenuation, 23°C ± 5°C, input terminated with 50Ω, and 100 readings averaged.
20. Based on a 200μs acquisition time and 6 measurements averaged.
21. Defined as 2 standard deviations of 100 consecutive measurements spaced evenly over an 8-hour period with ambient temperature of 23±1°C. The following conditions apply: default acquisition times and signal/noise > 6dB.

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Numerics

KEITHLEY	Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

❏ Intermittent　　　　　❏ Analog output follows display　　　❏ Particular range or function bad; specify

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　_____

❏ IEEE failure　　　　　❏ Obvious problem on power-up　　　❏ Batteries and fuses are OK

❏ Front panel operational　❏ All ranges or functions are bad　❏ Checked all cables

Display or output (check one)

❏ Drifts　　　　　　　❏ Unable to zero　　　　　　　　❏ Unstable

❏ Overload　　　　　　❏ Will not read applied input

❏ Calibration only　　　❏ Certificate of calibration required　❏ Data required

(attach any additional sheets as necessary)

Show a block diagram of your measurement including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.) _____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

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KEITHLEY