VXI
bus

VX4281
RF Power Meter
Service Manual

Tektronix
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VX4281
RF Power Meter

Section 1
Introduction

The VX4281 RF Power Meter Module measures RF levels from 1 nW (-60 dBm) to 100 mW (+20 dBm). A variety of low noise, low VSWR accessory sensors are available, including coaxial models operating from 0.1 Mhz to 26.5 GHz, and waveguide models from 18 to 110 GHz.

The VX4281 provides a dynamic range of 70 dB with a single sensor, and a 240 picowatt total instrument accuracy and 100 picowatt per hour typical instrument drift rate at -60 dB (1 nW).

The VX4281 Module accepts simultaneous measurements from up to four power sensors. It can make a number of calculations in addition to the basic ratio and difference measurements provided by dual channel power meters. Applications include:

▸ transmitter, signal generator and oscillator measurements;

▸ VSWR and return-loss measurements with directional couplers and slotted lines;

▸ gain and insertion loss measurements;

▸ RF attenuation measurements; and

▸ antenna measurements.

The VX4281 includes a programmable averaging filter with ten different settings to provide, on a case by case basis, automatic control of the speed vs. accuracy trade-off that is inherent in power measurements. The module also has an auto filter mode that filters an input on a continuous basis, but has the capability to reset the filter automatically when a substantial change in input signal occurs.

Calibration data for twenty sensors at seven different power ranges and at up to 20 frequencies may be stored in non-volatile memory on the VX4281. The calibration data for any of the twenty sensors may be assigned to any of the four channels, allowing more flexible use of power sources and channels.

The remotely controlled reference source can be mounted with the Power Meter sensors at the Unit Under Test (UUT) source, with a user-selected microwave transfer

switch. The transfer switch can then be controlled by the Power Meter relay driver outputs, and used to switch either the reference source or the signal to be measured into the power sensor(s) for automatic calibration and zeroing of individual Power Meter channels.

Additional features include:

- ▸ a delayed trigger mode,
- ▸ auto range, and
- ▸ a range hold feature which permits switching from auto to manual range without changing ranges.

Tek/CDS offers both diode and thermocouple type heads for the VX4281. Diode RF sensors operate by detecting the voltage developed across a precision non-inductive resistor with selected and matched microwave diodes. This gives much higher sensitivity, faster response, better temperature stability, and other important advantages over thermocouple or bolometer sensors. Diode sensors measure true RMS in the lower 40 dB of their dynamic range. This allows the instrument to accurately measure the average power of pulsed and amplitude modulated signals within the sensor's specified range. Above the true RMS range, the sensor shifts from RMS response to peak response. The VX4281 Module compensates for this, and provides a true average power reading of CW signals in this higher range.

The VX4281 also provides a frequency entry capability. Historically, power meter measurements have required reading a calibration factor printed on the sensor head and manually entering it as a correction factor. Since the VX4281 has up to 20 points of frequency data for up to twenty heads stored on the module, the module provides program entry of a frequency, and interpolation between the frequency points, to automatically supply the calibration factor.

The current VX4281 operational settings may be saved for future use through a LEARN mode. Using this mode, complete set-up information can be read, stored in non-volatile memory in one of the twenty storage register sets, and restored at any time.

Section 2
Performance Verification

Performance is verified at the factory before the VX4281 is shipped. If you require information on the verification procedures, please consult the factory (1-800-CDS-ATE1).

Section 3
Adjustment and Calibration

VX4281 Calibration

The VX4281 Module must be calibrated every 12 months for the card to meet its published accuracy specifications. Calibrate the VX4281 Module at the temperature at which it will be operating. If this is not feasible, or the module will be operating under a wide temperature variation, consult the temperature drift specifications. Allow a ten minute warm-up period before performing the calibration.

Voltage calibration is accomplished by zeroing the VX4281 on one selected channel and then supplying a precise calibration voltage for each of the seven ranges with a calibration command for each range to that channel.

Equipment Required
- DC calibration voltage source capable of producing stable, low-noise voltages at the levels shown in Table 1. Recommended accuracy is 25% of the tolerance as described in the Specifications section of the Operating Manual (Basic Uncertainty) for each power level.

- Interconnect cable to connect the DC calibrator to the Channel A input of the VX4281 module.

Equipment Preparation
Install a 0.47 microfarad capacitor between pin 2 and pin 6 of the 7-pin DIN connector.

Install another 0.47 microfarad capacitor between pin 5 and pin 6 of the same connector.

Connect a 10K ohm resistor from the positive calibrator lead to pin 5 of the DIN connector.

Connect a 10K ohm resistor from the negative calibrator lead to pin 2 of the DIN connector.

Procedures
Zeroing the VX4281

a. Send the following command to put Channel A into the voltage readback mode - PR SS99 FM7

b. Adjust the DC calibration source to supply zero volts to Channel A of the VX4281.

c. Send the command 'TR2' to the module, and read back the voltage from the module.

d. If the reading is not between zero and 1.0 E-7, send a 'ZE' command and repeat steps c. and d.

e. If a good zero reading cannot be obtained after several tries, check for ground loops or inadequate shielding of the input connections.

Voltage Calibration

a. Set the range to the range to be calibrated with the 'RMrFMf' command, where r is the range value and f is the filter value from Table 1.

b. Adjust the dc calibration source to the calibration level for the range from Table 1.

c. Send a 'TR2' command to the module and read back the voltage from the module.

d. If the reading is not within ±0.1% of the correct reading, send the calibration command 'CLv' to the module, where v is the voltage from step b.

e. Repeat for all of the ranges.

TABLE 1: VX4281 Voltage Calibration Points

Range r	Filter f	Voltage v
1	9	1.6 E-5
2	8	8.0 E-5
3	7	8.0 E-4
4	6	8.0 E-3
5	5	8.0 E-2
6	5	8.0 E-1
7	5	2.0 E+0

Following calibration, the RS-99 command may be issued to obtain the voltage calibration data for the module. (Since all channels use the same gain circuitry, the gain calibration data applies to the module, and is valid for all channels.) The format of the response is as follows:

$$SS-99,z,g_1,0,g_2,0,g_3,0,g_4,0,g_5,0,g_6,0,g_7,0<CR><LF>$$

where

z specifies the type of Power Meter:

$\underline{z}$
2   2 channel Power Meter
4   4 channel Power Meter

g_1-g_7 the voltage gain factors for range 1 through 7, where a value of 5000 is nominal for each range.

This response string may be stored by the system controller for backup, if desired. The calibration data can then be restored to the VX4281 at a later time by sending this response as an SS command. Additionally, an RS99 command may be issued to read the serial number of the module.

The format of the response is as follows:

SS99,sn,sa,sb,sc,sd<CR><LF>

where   sn   the VX4281 Module serial number.
            sa-sd   the Store Sensor (SS) number associated with Channel A through Channel D.

Calibration of Power Sensors

Calibration of the VX1811, VX1812, and VX1814 RF power sensors assumes the voltage calibration for the VX4281 (described above) has already been performed.

Power Sensor calibration is accomplished by zeroing the VX4281 and then supplying precise power levels at two or sometimes three places in each sensor range with a calibration command for each power level.

Equipment Required

Power Meter Calibrator capable of supplying stable, precisely known power levels from -60 dBm (1 nanowatt) to +10 dBm (10 milliwatts) in 1dB steps at 50 MHz into the 50 ohm RF Power Sensors. Recommended accuracy is 25% of the tolerance as described in the Specifications section of the Operating Manual (Basic Uncertainty) for each power level.

Zeroing the Power Sensor

    a.   Connect the R. F. Sensor to the Power Meter Calibrator with zero power output set on the Calibrator.

    b.   Send the following command to put Channel A into the voltage readback mode - 'PR SS99 FM9.'

    c.   Send a 'TR2' command to the module and read back the voltage from the module.

    d.   If the reading is not between zero and 1.0 E-7, send a 'ZE' command and repeat steps c. and d.

e.   If a good zero reading cannot be obtained after several tries, check for good RF ground bonding to eliminate ground loops between the calibrator and the VX4281 module.

Power Calibration

a.   Program the VX4281 Module to read power on the sensor being calibrated with the following command:

    FMf RMr SSs

where f and r are the filter number and range number from Table 1 and s is the Store Sensor (SS) number for the sensor.

b.   Apply the power level (within +10% and -25% of the value shown) from the calibrator for the low calibration point shown in Table 2.

c.   Send a 'TR2' command to the module and read back the power level from the module.

d.   If the reading is not within tolerance (see Specifications), send the calibration command 'CLn' to the module, where n is the power level in Watts from step b.

e.   Repeat steps b., c., and d. for the middle (if applicable) and high calibration points until all of the points are within tolerance.

f.   Repeat steps b., c., d., and e. for all of the ranges of the sensor from Table 2.

TABLE 2: RF Power Sensor Calibration Points

VX42811 and VX42812 Power Sensors				
Range r	Filter f	Power Level (Watts)		
		Low	Mid	High
1	9	1.0 E-9	-	1.5 E-8
2	8	1.0 E-8	-	8.0 E-8
3	7	5.0 E-8	-	8.0 E-7
4	6	5.0 E-7	2.0 E-6	8.0 E-6
5	5	5.0 E-6	2.0 E-5	1.0 E-4
6	5	6.0 E-5	5.0 E-4	3.0 E-3
7	5	2.0 E-3	5.0 E-3	2.0 E-2

VX42814 Power Sensors			
Range r	Filter f	Power Level (Watts)	
		Low	High
1	9	1.0 E-6	3.0 E-5
2	8	2.0 E-5	1.5 E-4
3	7	1.0 E-4	1.5 E-3
4	6	1.0 E-3	1.0 E-2

The RS-0 through RS-19 commands may be issued to obtain the calibration factors for each sensor. The format for the response is as follows:

$$SS\text{-}s,t,g_1,o_1,g_2,o_2,g_3,o_3,c_4,g_4,o_4,c_5,g_5,o_5,c_6,g_6,o_6,c_7,g_7,o_7$$

where

s	the Store Sensor (ss) number from 0-19.
t	the last digit of the sensor model number 1, 2, or 4.
g_1-g_7	the gain factor for each range, where 5000 is the nominal value for each range.
o_1-o_7	the offset factor, where o is the nominal value for each range.
c_4-c_7	the curvature factor for ranges 4-7, where 5000 is the nominal value for each range.

This response string may be stored by the system controller to provide storage of voltage calibration for more than twenty sensors, or simply to provide sensor data storage for several sensors in a central place. The calibration data may be restored to a VX4281 Module at a later time by using this response as an SS command.

VX1813 Milliwatt Power Reference Adjustment

1. Attach a 50 ohm test probe to a W & G EPM-1 milliwatt test set and turn on the test set.

2. Use the manufacturer's instructions to standardize the test set.

3. Connect the VX1813 to the VX4281 using a 73A-682 or 73A-683 cable. Apply power to the VX4281 and activate the reference power with the OC1 command for Channel A.

4. Allow the test set and the power reference to warm up for at least 30 minutes.

5. Connect the test probe to the VX1813 and note the power level on the milliwatt test set. The level should be within ±0.005 dB of one milliwatt.

6. If the power level is outside the specified limits, remove the VX1813 cover and adjust R21 so that the proper level is obtained when the cover is replaced. Tighten the cover screws and verify that the power level is still within specified limits.

7. Turn off power to the test set and the VX1813 and disconnect the test set.

Calibration Commands

Summary

This summary lists the commands in the order they would typically be programmed.
The detailed descriptions of each command that follow are presented in the same order.

<u>Command</u> <u>Description (Page)</u>

Command	Description (Page)
ZE	ZERO (11)
CL	CALIBRATION ADJUSTMENT (12)
ST	STORE CONFIGURATION (12)
RC	RECALL CONFIGURATION (13)
SS	STORE CALIBRATION FACTORS (13)
RS	RECALL CALIBRATION FACTORS (14)
DS	DUMP SETUPS OF CALIBRATION FACTORS (15)
RO	RELAY OPERATE (16)
OC	REFERENCE OSCILLATOR POWER SWITCH (17)
PR	PRESET (17)
FR	FREQUENCY RANGE (18)
OS	OFFSET (18)
OSDO	CALCULATE OFFSET (18)
KB	CALIBRATION FACTOR (19)

Command Descriptions

Command: ZE   ZERO

Syntax: ZE

Purpose: The ZE command automatically zeroes all of the Power Meter's ranges on the active entry channel (see AE command). The internal circuitry is adjusted for a 0 power indication when no power is applied to the sensor. Each channel of the Power Meter must be zeroed separately.

Description: Automatic zeroing takes about 10 seconds total time to read, average, and store zero corrections for all seven measurement ranges. The four Channel LEDs - CHANNEL A, CHANNEL B, CHANNEL C, and CHANNEL D - reverse their normal state to indicate that zeroing is occurring. Commands may be sent while zeroing, but the commands (other than SB and SM commands) will not be acted upon until zeroing is completed.

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CAUTION
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Make sure that all power is removed from the sensor input during zeroing. If any RF power is present, it will introduce an offset into all subsequent readings.

The Power Meter needs to be calibrated when it does not read zero power within specification with all power removed from the sensor input. These residual non-zero readings may be insignificant when added to high power measurements, but they can be unacceptable when added to low power measurements.

The power output to the reference oscillators is automatically turned off during zeroing. It is returned to its original state after the cycle is completed.

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CAUTION
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Do not power down the Power Meter during zeroing, or an error 57 (recall failure) may occur when power is reapplied because information was not stored properly.

Example: To select Channel A as the active entry channel and to zero its source, enter the command
                   AEZE

Command: CL   CALIBRATION ADJUSTMENT

Syntax: CLz<TM>

Purpose: The CL command for calibration with a reference is used after the ZE (ZERO) command to adjust the gain of the Power Meter to read 1 mW when the sensor on the active entry channel is attached to a 1.00 mW reference oscillator.

Description: z = 1e-3, except for Calibration. Values other than 1 mW (1e-3) should not be used in the CL command except for maintenance (see Calibration). If the VX1813 Reference Power Oscillator is used, use the OC command to turn on the Reference Oscillator before calibration. Use the RO command to operate any transfer switches, if they are used.

<TM> is a required terminator. Any of the terminators specified in the Command Syntax subsection may be used.

Each channel must be zeroed and calibrated separately. Zero and recalibrate when changing sensors or when the ambient temperature changes by 5°C or more.

Auto-ranging is temporarily enabled during calibration (to accommodate various sensors) and then restored to its previous setting. OS (OFFSET) settings are disregarded during calibration, as are the calibration factors entered with the KB (CAL FACTOR) command, which is used only for measurements.

Commands may be sent while calibrating, but commands other than SB and SM will not be acted upon until calibration is completed.

Example: To calibrate a sensor to the 1 mW reference, enter the command
CL1e-3EN

* *

Command: ST   STORE CONFIGURATION

Syntax: STz

Purpose: The ST command stores the present configuration for later recall in storage register z.

Description: z can be register number 1 through 19.

Register 0 always contains the previous configuration of the Power Meter. RECALL CONFIGURATION 0 can therefore be used to recover from a setup entry error.

The following information is stored by the ST command:

-   measurement mode
-   active entry channel
-   CAL FACTOR for each channel
-   OFFSET for each channel
-   RANGE for each channel
-   FILTER for each channel
-   REFERENCE OSCILLATOR on/off status for each channel
-   measurement units (linear or logarithmic)
-   on/off status of REL mode
-   reference value, if in REL mode

Example: To store the present configuration in Register 2, enter the command   ST2

* *

Command: RC   RECALL CONFIGURATION

Syntax: RCz

Purpose: The RC command sets the Power Meter to the configuration stored in register z.

Description: z can be register number 0 through 19. Register 0 always contains the previous
                  configuration, so the RC0 command can be used to recover from an entry error.
                  Registers 1 through 19 contain the last configuration stored by the ST command
                  in that location.

Example: To recall the configuration that was stored in Register 2, enter the command
                  RC2

* *

Command: SS   STORE CALIBRATION FACTORS

Syntax: $SSz_1,...,z_n$

Purpose: The SS command allows the frequency calibration factors supplied with a sensor,
                  for up to twenty sensors, to be entered into non-volatile memory for future use.
                  The SS command is also used to assign the calibration factors for a particular
                  sensor to a channel when that sensor is attached to a particular Power Meter
                  channel.

Description: z_1 is the sensor number 0 through 19.

                  z_2 is the serial number of the sensor and can contain up to 10 alphanumeric
                  characters.

                  z_3 is the calibration factor frequency in GHz for the first calibration factor from
                  the calibration chart for the sensor. Frequency values from 0.01 to 0.99 with a
                  decimal point and values from 1 to 127 without a decimal point are valid.

Frequencies must be entered in ascending order starting from the lowest and proceeding in order through the highest.

z_4 is the calibration factor in dB corresponding to the preceding frequency value. Values of -1.25 to 1.25 are valid.

$z_5, z_6, ..., z_{n-1}, z_n$ are additional pairs of ascending frequency/calibration factor parameters for the sensor. If the number of calibration points for a particular sensor exceeds 20, simply assign another sensor number and enter the continuing series of calibration points as if the next point was the first point for that sensor.

If z_2 through z_n are not specified, then already stored calibration factors for sensor number z_1 will be assigned to the active entry channel specified by the last AE, BE, CE, or DE command. The SS command may also be used to assign sensor numbers to all channels with a single command. For this capability, z_1 is the value 99, z_2 is the module serial number, and z_3 through z_6 are the sensor numbers to be assigned to channel A through D respectively.

Example: The command string

SS5,11975,1,.04,2,.12,3,.01,4,-.23,5,-.38,6,-.48,7,-.44,8,-.43,9,-.42,10,-.31, 11,-.26,12,-.16,13,-.03,14,.32,15,-.16,16,-.26,17,-.46, 18,.19

stores as sensor number 5 the calibration data for a sensor with serial number 11975. The calibration factors in dB are stored for 1 GHz intervals from 1 through 18 GHz.

NOTE: The SS command is also used to restore voltage calibration data for each of the seven power ranges for either the VX4281 Module itself or for a particular sensor to the VX4281. z_1 will have a value of -99, or -0 through -19 for these functions. The definition of z_1 and the additional arguments following z_1 for these functions are described in the Calibration Procedure section of this manual.

* *

Command: RS   RECALL CALIBRATION FACTORS

Syntax: RSz

Purpose: The RS command recalls the frequency calibration data for sensor number z.

Description: z is a number from 0 through 19.

An input request immediately following the RS command will return a string with the format of the SS command (including the SS at the beginning of the command) for the requested sensor. This response may be stored by the system

controller to permit storage of data for an unlimited number of sensors in a host controller.

The serial number of the module and sensor numbers assigned to each channel may be obtained with an RS99 command. The format of the response is as defined by the SS99 command. (Gain and offset calibration data at each of the seven power ranges may also be recalled for either the VX4281 Module itself, or for up to twenty sensors.) z has a value of -99, or -0 to -19 for these functions.

Example:

If the command string "RS5" is sent and the last SS command sent for sensor 5 was the one in the previous example, the returned string would be

SS5,11975,1,.04,2,.12,3,.01,4,-.23,5,-.38,6,-.48,7,-.44,8,-.43,9,-.42,10,-.31,1
1,-.26, 12,-.16, 13,-.03,14,.32,15,-.16,16,-.26,17,-.46,18,.19

* *

Command: DS   DUMP SETUPS OF CALIBRATION FACTORS

Syntax: DS

Purpose: The DS command is identical to the RS command except that it returns the frequency calibration data for all twenty sensors.

Description: The frequency calibration data is formatted into up to 42 SS command strings, each terminated with a carriage-return <CR> and line-feed <LF>. If more than twenty sensors need to be stored, the set of 42 SS setup strings returned by the DS command can be stored by the system controller and sent back to the Power Meter when this set of sensors is used.

The order of returned data is as follows:

               SS0.....   <CR> <LF>
               SS-0....   <CR> <LF>
               SS1.....   <CR> <LF>
               SS-1....   <CR> <LF>
                 .
                 .
                 .
               SS99....   <CR> <LF>
               SS-99...   <CR> <LF>

The format for the SS0, SS1, SS2, SS3, SS4, SS5, and SS99 responses are described in the SS (Store Sensor) command description. The SS-0, ..., ss-19, and SS-99 responses are described in the Procedures section of the Service Manual.

If all twenty sensors have not been assigned, then fewer than fourteen responses will be returned. For example, if sensor information for only sensors 0 and 1 has been stored, only six response lines will be returned:

SS0, SS-0, SS1, SS-1, SS99, and SS-99.

* *

Command: RO RELAY OPERATE

Syntax: ROz

Purpose: The RO command is used to turn on or off the open collector relay driver specified by z.

Description: Valid values for z are:

z	Channel	Relay Status
0	A	OFF
1	A	ON
2	B	OFF
3	B	ON
4	C	OFF
5	C	ON
6	D	OFF
7	D	ON

Relay drivers are typically used to control a remote transfer switch to select either the Unit Under Test measurement point or a VX1813 calibration reference oscillator source for input to the VX4281. It is recommended that the signal input be wired to the OFF contact of the transfer relay, and the reference source to the ON contact. The calibrator is selected prior to using the CL command for calibrating the gain of a VX4281 channel.

Use of this command assumes the use of a VX1682 Cable containing wiring from the relay driver to the transfer switch. This command is not required if the calibrator is manually connected to the VX4281 signal input.

Example: To operate the Channel A relay, enter the command
RO1

****

Command: OC   REFERENCE OSCILLATOR POWER SWITCH

Syntax: OCz

Purpose: The OC command is used to turn power on or off to any of the calibration reference power outputs.

z is a number from 0 to 7, which switches the power as indicated:

z	Channel	Power
0	A	OFF
1	A	ON
2	B	OFF
3	B	ON
4	C	OFF
5	C	ON
6	D	OFF
7	D	ON

A command to turn power on is required for using a VX1813 calibration source for calibrating the VX4281 with the CL command. It is recommended that the calibrator be powered off even if switched off by a transfer switch, to minimize power leakage through the transfer switch.

Example: To operate the Channel A calibration source, enter the command
                OC1

****

Command: PR   PRESET

Syntax: PR

Purpose: The PR command sets the Power Meter to a known state.

Description: On receipt of the PR command, the VX4281 is set to the following known state:

Reference Oscillators	Off
Remote Relay Drivers	Off
Channels A, B, C, and D	
CAL FACTOR	100%
OFFSET	0.00 dB
Filter	Auto
Range	Auto
Measurement Mode	Channel A
Active Entry Channel	Channel A
Measurement Units	Watts

Relative Mode	Off
Channels A, B, C, and D	
Low Limit	0.000dBm
High Limit	0.000dBm
Limits Checking	Disabled
Trigger Mode	Free Run
LEDs Channel A	ON
Channel B	OFF
Channel C	OFF
Channel D	OFF
dB	OFF
MNL	OFF
OFS	OFF
ERR	OFF

The PR command resets the calibration factor as programmed by the KB command to a value of 100%. It does not affect the zero and calibration information stored for each channel, or any of the calibration data stored for sensors in non-volatile memory.

If a data error is detected in the non-volatile memory due to battery failure or powering down during a calibration or zero cycle, storage register 0 (see ST command) will be set to the PRESET state.

* *

Command:	FR FREQUENCY RANGE
Syntax:	FRz<TM>
Purpose:	The FR command can be used to enter the input frequency for automatic reading and interpolation of calibration chart information for sensors that have previously been entered with the SS (STORE SENSOR) command.
Description:	The FR command is a simple, less tedious alternative to the KB command.
	z is the frequency value for the FR command, entered in GHz, with the format xxx.xx. Leading and trailing zeros may be omitted.
	<TM> is a required terminator. Any of the terminators specified in the <u>Command Syntax</u> subsection may be used.
Example:	To enter the calibration factor at 1.5 GHz, enter the command FR1.50EN

* *

Command:	OS OFFSET OSDO CALCULATE OFFSET
Syntax:	OSsz<TM> OSDO
Purpose:	The OS and OSDO commands set an offset value for the active entry channel. Offset values are added to the measured power to compensate for gain or loss.
Description:	s indicates that this is a signed value. s must be - for negative values; the + is optional for positive values. z is the offset value, entered in dB, with values from -99.99 to +99.99 dB in 0.01 dB increments. Leading and trailing zeros are optional. <TM> is a required terminator. Any of the terminators specified in the <u>Command Syntax</u> subsection may be used. To enter the offset necessary to cause the measurement value to read 0.00 dB or dBm for logarithmic units, or 100% or 1.00 mW for linear units send "OSDO". The OSDO command ignores the REL mode when calculating the offset value. If the calculated offset value is not in the allowable range, an offset entry error (ERROR 51) will result.
Example:	To enter an offset of 1.5 dB, enter the command OS1.5EN

* *

Command:	KB CALIBRATION FACTOR
Syntax:	KB(z)<TM>
Purpose:	The KB command enters a calibration factor to compensate for the effective sensitivity of the sensor on the active entry channel and for mismatch losses.
Description:	z is the optional calibration factor value. Values of 1.0 to 150.0% are accepted. If no data value is entered, the calibration factor is set to 100%. <TM> is a required terminator. Any of the terminators specified in the <u>Command Syntax</u> subsection may be used. The appropriate calibration factor can be read from the cal. factor vs. frequency chart on the side of the sensor. If the sensor data has been entered previously with the SS command, the FR command can be used instead of the KB command to enter the calibration factor. The calibration factor set with the KB command is used only during measurements, not during calibration.
Example:	To enter a calibration factor of 102.4%, enter the command KB102.4EN

Section 4
Assembly And Disassembly

The VX4281 is shipped fully assembled. A schematic diagram that may be used as a reference is included with this manual.

PRELIMINARY

The following lists give the name and part number for all field replaceable parts of the VX4281. To order replacement parts, call your Tektronics representative.

SERVICE MANUAL

VX4281

2-4 CH MICROWAVE PWR METER

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
	96000-00015	1	1 IN WHT FRONT AND SPINE VXI BUS MANUAL	0546	96000-00015
	VX1813	1	REMOTE CALIBRATOR FOR VX4281	0026	VX1813
TO BE USED WITH HS 1111,1121	47000-04880	2	HEAT SINK MOUNTING KIT TO-220	0204	4880
USER INSTALLED (P5 AND P6)	45002-75641	2	CONN PHONE 4 PIN T ADAPTER PIGGYBACK CONFIG	0437	267A2
B63	79805-01213	1	IC CMOS SRAM SOCKET W BATTERY FOR 8K OR 32K X 8	0238	DS1213C
C021,022,04,1111,1121,1162,1181 891	22022-20008	8	CAP FXD TA 22UF 10-20% 20-25VDCW	0106	199D226X9025CA1
C03,05,06,09,1021,1041,11,1112 1122,1123,1161,1171,1191,12,1221 1241,14,15,17,23,24,27,29,312,33 38,43,45,46,53,55,58,69,75,76 811,812,813,83,84,88,892,911,912 913,914,915,916,917,921,922,94 95,96,99	20128-47006	55	CAP FXD CER .47UF 20% 50VDCW	0075	RPE123Z5U474M50V
C1124,1222	22022-22008	2	CAP FXD TA 22UF 10-20% 35WVDC	0106	199D226X0035EE2
C1151	25070-10005	1	CAP FXD POLYPROP .01UF 2.5% 50VDCW	0340	KP1830-.01 50 2.5%
C1152	21528-10003	1	CAP FXD MICA 100PF 5% 500VDCW	0025	CD10FD101J03
C1251	22022-10008	1	CAP FXD TA 10UF 10-20% 25VDC	0106	199D106X9025CA1
C21,311,411,412	21528-10004	4	CAP FXD MICA 1000PF 5% 100VDCW	0012	DM-15-102J
C26,36	21528-10002	2	CAP FXD MICA 10PF 5% 100VDCW	0012	DM15-100D
C721,722	21528-20003	2	CAP FXD MICA 200PF 5% 500VDCW	0012	DM-15-201J
C814	22022-47007	1	CAP FXD TA 4.7UF 10-20% 16-25	0106	199D475X0016BA1
C815,82	21528-15003	2	CAP FXD MICA 150PF 5% 100VDCW	0025	CD5FA151J03
CR1181	32000-04001	1	DIODE SILICON 50V 1A 5%	0357	1N4001

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
CR79,94	32000-04148	2	DIODE SILICON 75V 1A 5%	0078	1N4148
DCL1	40408-14281	1	LABEL VX4281 DRW 03244 REV 910	0026	40408-14281
DCL2	40409-14281	1	LABEL VX4281 DRW 03245 REV 910	0026	40409-14281
DS011,111,112,113,114,117,211 212,213	32000-02303	9	DIODE LIGHT EMITTING GREEN WITH RESISTOR	0039	547-2303
DS012	32000-02003	1	DIODE LIGHT EMITTING RED WITH RESISTOR 0	0039	547-2003
F1281,1282	42202-73020	2	FUSE MICRO 2AMP 125V FAST PLUG IN CLEAR CAP	0061	273 002
F1283	42202-73010	1	FUSE MICRO 1AMP 125V FAST PLUG IN CLEAR CAP	0061	273 001
F79	42202-73040	1	FUSE MICRO 4AMP 125V FAST PLUG IN CLEAR CAP	0061	273 004
FL1131,1231	26000-00002	2	EMI FILTER 0.5 MHZ-1GHZ PC BD MNT	0075	BNX002-01
FP1	47006-14281	1	FACE PLATE VX4281 CARD DRW 02327 REV 910	0026	47006-14281
FP10,11	92505-25005	2	WASHER WAVY 2.7MM	0026	92505-25005
FP12,13	92501-25010	2	SCREW M2.5X10 CHEESEHEAD	0026	92501-25010
FP14	92502-25008	1	SCREW PHIL M 2.5 X 8 CSK BRITE ZINC	0137	PHIL M 2.5 X 8 CSK
FP15	92500-25008	1	SCREW M 2.5 X 8 SELF TAP	0266	21100-710
FP16	92520-00183	1	VME PCB-FRONT PANEL HOLDER	0266	60807-183
FP17	92500-25025	1	HEX NUT M2.5 ZINC	0266	21100-144
FP18,20	92500-25011	2	COLLAR SCREW M 2.5 X 11 SL NICKEL	0266	21100-379
FP19,21	92510-00464	2	SLEEVE CAPTIVE SCREW GRAY	0266	21100-464
FP2,22,4,8	40406-00140	1	EJECTOR HANDLE C-TOP VX1400	0266	20817-328
FP23,3,5,9	40406-00141	1	EJECTOR HANDLE C-BOTTOM VX1400	0266	20817-327

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
FP6,7	92500-25005	2	SCREW 2.5MM PHIL CSK 5MM	0026	92500-25005
HS1111,1121	47000-06073	2	HEAT SINK FOR TO 220 PKG 20 DEGC W RSA	0204	6073-B
L1231	27051-00200	1	INDUCTOR WIDE-BAND FERRITE CHOKE	0042	VK 200 10-3B
L79	27051-50007	1	INDUCTOR 5 UH 5A .015 OHMS 50MHZ FR	0037	IHA-501
P1,2	45003-09600	2	CONNECTOR DIN 96 PIN MALE RT ANGLE SOLDER	0265	10-8457-096-00209Y
PCB1	41140-42810	1	P.C. BOARD VERSION 9112	0498	41140-42810
Q01,19	51100-00300	2	TRANSISTOR VMOS N-FET	0102	VN0300L
Q691,692	51100-03906	2	TRANSISTOR PNP SWITCHING	0107	2N3906
Q81	52000-17805	1	VOLTAGE REGULATOR 5V 100MA 5%	0074	MC78L05ACP
Q92	52000-17905	1	VOLTAGE REGULATOR -5V 100MA 5%	0074	MC79L05ACP
R011,02,1071,15,28,441,442	10117-18005	7	18K RES COMP 1-4W 5%	0087	R25J-18K-5%
R012,013,1021,1061,1081,112,1152 1161,1251,96	10117-10004	10	1K RES COMP 1-4W 5%	0087	R25J-1K-5%
R07,17,18	12008-33004	3	3.3K RES NETWORK SIP 5% 1.5W 9-PKG	0027	750-101-R3.3K
R1011	10117-33005	1	33K RES COMP 1-4W 5%	0087	R25J-33K-5%
R1031,1032	14024-49902	2	49.9 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D49R9F
R1041,1051,1151,211,311,313,411 412,417,692,693,811,94	10117-10005	13	10K RES COMP 1-4W 5%	0087	R25J-10K-5%
R111,1171,1272,691	10117-33004	4	3.3K RES COMP 1-4W 5%	0087	R25J-3.3K-5%
R1111	10117-51004	1	5.1K RES COMP 1-4W 5%	0087	R25J-5.1K-5%
R1153,1154	14024-20006	2	200K RES FILM 1-4W 1% 100PPM	0035	RN55D2003F
R1155	10117-22005	1	22K RES COMP 1-4W 5%	0087	R25J-22K-5%

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
R1181,1182,1271,214,414,68,781 782,783	10117-47004	9	4.7K RES COMP 1-4W 5%	0087	R25J-4.7K-5%
R1183	14024-82503	1	825 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D8250F
R1252	10117-68005	1	68K RES COMP 1-4W 5%	0087	R25J-68K-5%
R212,314,35,413,418	14014-10007	5	1M RES FILM 1-4W 1% 50PPM	0035	RN55C1004F
R213,312,415,416	10117-10003	4	100 OHM RES COMP1-4W 5%	0087	R25J-100-5%
R23	12006-33004	1	3.3K RES NETWORK SIP 5% 1.1W 7-PKG	0027	750-81-R3.3K
R64	12006-10005	1	10K OHM RES NETWORK SIP 5% .9W 5-PKG	0027	750-61-R10K
R812,813,821,826	14036-20005	4	20K RES FILM 1-4W .1% 25PPM	0035	RN55E2002B
R822,827	14024-82504	2	8.25K OHM RES FILM 1-4W 1% 100PPM	0037	RN55D8251F
R823,828	14024-49904	2	4.99K RES FILM 1-4W 1% 100PPM	0035	RN55D4991F
R824,829	14024-49903	2	499 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D4990F
R825	14024-11003	1	110 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D1100F
S1,2	41550-42810	1	WIRE ASSY FOR VX4281 -07049	0000	
S1181	42050-10101	1	SWITCH DIP 1POS SPST	0093	JS-8794-01
S471,472	42050-10301	2	SWITCH DIP ROTARY HEX	0007	DRW-16C
S5,6	45002-75640	2	CONN MOD PHONE 4 PIN PCB JACK 6 POSITION	0071	15-43-7564
S78	42050-10300	1	SWITCH DIP ROTARY BCD ENCODED	0007	DRW-10C
SH1	47007-14281	1	SHIELD FRONT VX4281 CARD DRW 02627 9103	0026	47007-14281
SH10,11,13,14,17,2,20,31,4,5,7,8	92500-25010	12	SCREW M 2.5 X 10 CSK OVAL PHIL NIK PL	0266	21100-500

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
SH12,3,6,9	92519-25019	4	STANDOFF HEX M2.5 X 19.5MM DRW 01801 REV 900	0026	92519-25019
SH15,18,21,33	92201-19451	4	STANDOFF HEX M2.5 THRU X .538L DRW 01673 REV 920	0026	92201-19451
SH16,19,30,34	92500-25017	4	SCREW 2.5MM X 16MM 90 DEG CSK FLHD PHIL STAINLS	0420	DIN965M2.5X16
SH22	47007-74002	1	SHIELD BACK CONN MTG CONFIG -01816 REV 9004	0026	47007-74002
SH23,24,25,26,27,28,29,32	92519-25004	8	REAR SHIELD SPACER 73A DRW 01807 REV 890	0212	19501-A-0029
U01	74200-09602	1	IC TTL DUAL RETRIGGERABLE MONOSTABLE	0078	9602
U02,12	77825-07432	2	IC TTL ALS QUAD 2-INPUT OR GATE	0107	74ALS32
U03	73002-74652	1	IC TTL LS OCTAL TRANSCEIVER WITH REGISTERS	0107	74LS652
U04,1071	77203-07408	2	IC TTL ALS QUAD 2-INPUT AND GATE	0107	74ALS08
U05,291,48,69	73308-74246	4	IC TTL ALS OCTAL BUFFER NON INV 48MA IOL	0107	SN74ALS244A-N
U06	73006-74573	1	IC TTL AS OCTAL D-TYPE LATCH	0107	74AS573
U07	73003-74574	1	IC TTL ALS OC TRI LATCH NON INV TI ONLY	0107	74ALS574
U08,1041,18,33,43	73005-74574	5	IC HCT OCTAL TRISTATE LATCH NON-INVERT	0107	74HCT574
U09,19	73308-74645	2	IC TTL ALS OCTAL BUS TRANSCEIVER	0107	74ALS645-1
U1011	81001-00211	1	IC CMOS ANALOG SWITCH SPST QUAD	0102	DG211CJ
U1021	20100-07226	1	IC QUAD D-A CONVERTER 8-BIT	0011	AD7226KN
U1051	76606-07400	1	IC HCT QUAD 2-INPUT NAND GATE	0088	74HCT00
U1061,1081,96	73005-07474	3	IC HCT DUAL D-TYPE FLIP FLOP	0092	74HCT74N
U11	73005-74564	1	IC HCT OCTAL TRISTATE LATCH	0107	74HCT564

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U1141	73405-02803	1	IC HIGH-VLT-CUR DARLINGTON TRANS ARRAY	0531	ULN2803A
U1151,1181	78403-07414	2	IC HCT HEX SCHMITT INVERTING BUFFER	0088	74HCT14
U1161,86	76510-07410	2	IC TTL ALS TRIPLE 3-INPUT NAND GATE	0107	74ALS10
U1171	73300-07406	1	IC TTL HEX INVERTER BUFFER-DRIVER	0107	7406
U13,22,23,32,42,72	81001-04052	6	CMOS ANALOG MUX DUAL 4 CHANNEL	0088	CD74HCT4052
U14	79008-74238	1	IC HCT 3-TO-8 LINE DECDR DEMULTIPLEXER	0107	74HCT238
U15	79813-00241	1	PROGRAMMED PROM U15 VX4281	0000	
U16	79825-88002	1	IC SUPER 8 CPU ROMLESS 20 MHZ	0117	Z08800A20PSC
U17	73311-74245	1	IC TTL AS OCTAL BUS TRANSCEIVER	0107	SN74AS245
U24,68	73001-07431	2	IC LS DELAY ELEMENT	0107	74LS31
U27,87	73309-74244	2	IC HCT OCTAL BUFFER NON-INVERTING	0107	74HCT244
U28	73308-74245	1	IC TTL ALS OCTAL BUS TRANSCEIVER	0107	74ALS245
U292	76602-07438	1	IC TTL S QUAD 2-INPUT NAND BUFFER W-OC	0107	74S38
U34	79814-00186	1	PAL PROGRAMMED 18P8L REV B 73A-256 AND 342	0000	
U35	79805-58256	1	IC CMOS 32K X 8 SRAM 120NS	0052	HM62256P-12
U37	79814-00371	1	PAL PROGRAMMED EP310-2 REV A 73A-SUPER 8	0000	
U38	79814-00374	1	PAL PROGRAMMED C16L8 REV A 73A-332	0000	
U39,89	77203-07430	2	IC TTL ALS 8-INPUT NAND GATE	0107	74ALS30
U44,58,85	79008-74138	3	IC HCT 3-TO-8 LINE DECDR DEMULTIPLEXER	0107	74HCT138

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
U491	79814-00468	1	PAL PROGRAMMED 20L8 REV C 73A-SUPER 8	0000	
U492	71701-74682	1	IC TTL LS 8-BIT COMPARATOR	0107	74LS682
U53	79825-84010	1	IC CMOS Z80 CPU 10 MHZ	0117	Z84C0010PSC
U59	73313-74760	1	IC TTL AS OCTAL BUFFER NON-INV	0107	74AS760
U63	79805-01208	1	IC CMOS 8K X 8 SRAM 100NS 1 UA STANDBY	0173	TC5565APL-10L
U64	79813-00242	1	PROGRAMMED PROM U64 VX4281	0000	
U65	79814-00400	1	PAL PROGRAMMED 5C032 REV A 73A-581	0000	
U66	79814-00470	1	PAL PROGRAMMED EP1810 REV A 73A-SUPER 8	0000	
U75	79814-00401	1	PAL PROGRAMMED 5C032 REV A 73A-581	0000	
U81	61000-00404	1	OP AMP FET QUAD HIGH-SPEED PRACISION	0023	OPA404KP
U88,97,98	73005-74273	3	IC HCT OCTAL D-TYPE FLIP FLOP W RESET	0088	74HCT273N
U92	81001-04051	1	CMOS ANALOG MUX 8 CHANNEL	0088	CD74HCT4051
U93	20100-09414	1	DATA ACQ MODULE 12BIT 4CHANNEL WITH PGA AND S-H	0309	HS9414C-1
U94	71200-04520	1	IC HCT DUAL 4BIT COUNTER BINARY	0088	CD74HCT4520
U95	79814-00419	1	PAL PROGRAMMED EP310-2 REV A 73A-581	0000	
VR1111	52000-07815	1	VOLTAGE REGULATOR 15 1.5A	0078	LM7815CT
VR1121	52000-07915	1	VOLTAGE REGULATOR -15V 1.5A	0074	MC7915CT
VR1141	32000-05260	1	DIODE ZENER 43V .5W 5%	0074	1N5260B
VR81	32000-18069	1	DIODE REF 1.23V 100PPM 5MA	0055	ICL8069DCZR
X1281,1282,1283,79	42300-28105	4	FUSE SOCKET MICRO VERTICAL .025 LEADS .1 CNT	0061	281 005

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
X15,64	45012-28100	2	SOCKET 28-PIN DIP LOW PRO	0089	ICO-286-S8A-TG
X16	45010-48100	1	SOCKET 48-PIN DIP	0089	ICN-486-S5-G
X53	45012-40100	1	SOCKET 40-PIN DIP LOW PRO	0089	ICO-406-S8A-TG
X66	45010-80186	1	SOCKET 68 PIN PLCC	0243	QILE68P-410T
Y36	89500-20000	1	CRYSTAL 20.000 MHZ 50 PPM	0062	MP-1 20.000
Y85	89499-20000	1	CRYSTAL OSC 20.000MHZ 50 PPM	0037	XO-43A-20.000

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
	47000-00711	1	ENCLOSURE RF CAL SRCE TYPE N DRW00711 REV 8713	0026	47000-00711
	45050-03322	1	DECAL SERIAL NUMBER DRW-00085 MAT.798	0026	45050-03322
	45002-83363	1	CONNECTOR DIN CIRC 5 PIN FEMALE PNL MNT	0255	703-91T-3363-1
	91100-16820	1	CABLE ASSY FOR VX1813	0000	
C111	21528-30002	1	CAP FXD MICA 30PF 5% 500VDCW	0012	DM10-300J
C112	21528-20003	1	CAP FXD MICA 200PF 5% 500VDCW	0012	DM-15-201J
C121,141	25028-20002	2	CAP VAR CER 2.3-20PF	0057	9308
C122	21528-10003	1	CAP FXD MICA 100PF 5% 500VDCW	0025	CD10FD101J03
C142	22022-47007	1	CAP FXD TA 4.7UF 10-20% 16-25	0106	199D475X0016BA1
C143	21528-10004	1	CAP FXD MICA 1000PF 5% 100VDCW	0012	DM-15-102J
C15	21528-20002	1	CAP FXD MICA 20PF 5% 500VDCW	0025	CD6ED200J03
C241,242	20128-10005	2	CAP FXD CER .01UF 20% 50VDCW	0106	1C25Z5U103M050B
CR131,22	32000-02811	2	DIODE SILICON SCHOTTKY 15V 20 MA	0050	5082-2811
CR132	32000-01650	1	DIODE VARACTOR TUNING 50-100PF	0074	MV1650
L11	27051-33007	1	INDUCTOR 3.3UH 10% 150MW	0175	1840-18
L13	27051-56006	1	INDUCTOR 4.56 UH 10%	0037	IM 4 .56 UH 10%
L21	27051-30005	1	INDUCTOR .03UH DWG 00000-00713	0026	27051-30005
PCB	41530-58199	1	P.C. BOARD VERSION 2S 8901	0498	41530-58199
Q14	51100-04959	1	TRANSISTOR PNP SI RF	0074	2N4959

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
R11	14024-49902	1	49.9 OHM RES FILM 1-4W 1% 100PPM	0069	RN55D49R9F
R131,133,222	10117-10006	3	100K RES COMP 1-4W 5%	0087	R25J-100K-5%
R132,23	10117-10004	2	1K RES COMP 1-4W 5%	0087	R25J-1K-5%
R14	14024-10005	1	10K RES FILM 1-4W 1% 100PPM	0069	RN55D1002F
R21	15138-10004	1	1K RES VAR CER 25TRN 1-2W 100PPM	0021	3299W-1-102
R221	14024-12104	1	1.21K RES FILM 1-4W 1% 100PPM	0069	RN55D1211F
R223	14024-15004	1	1.5K OHM RES FILM 1-4W 1% 100PPM	0069	RN55D1501F
R241	14024-51104	1	5.11K RES FILM 1-4W 1% 100PPM	0069	RN55D5111F
R242	10117-12004	1	1.2K RES COMP 1-4W 5%	0087	R25J-1.2K-5%
R243	14024-69802	1	69.8 OHM RES FILM 1-4W 1% 100PPM	0069	RN55D69R8F
U23	61000-00007	1	OP AMP BIPOLAR ULTRA LOW DRIFT	0082	OP07EP
U24	52200-00001	1	REFERENCE 10V 20MA 0-25 PPM	0082	REF01CP