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Section 1

General Information



DESCRIPTION

The 54X series is a microprocessor-based heterodyne device. The standard 545 and 548 cover the frequency range from 10 Hz to 18 GHz and 10 Hz to 26.5 GHz, respectively. The model 548, when equipped with frequency extension capability (option 06), is used in conjunction with a remote sensor (model 591) to cover the range from 26.5 to 40 GHz. Additional remote sensors extend measurement capability into higher narrowband mm ranges (e.g. 90-96 GHz).

Utilizing keyboard control, the 54X series counters provide frequency offsets and frequency selectivity. Options include power measurement, full systems capability via GPIB or BCD/Remote Programming and D/A Converter output.

Full frequency range is covered in three bands. Band 1 is a high (1 M ohms/20 pF) impedance input, and covers a 10 Hz to 100 MHz range, with a sensitivity of 25 mV RMS. Band 2 has an input impedance of 50 ohms, a 10 MHz to 1 GHz range, with a sensitivity of -20 dBm. Band 3 has an input impedance of 50 ohms nominal over its microwave range of 1 GHz to 18 or 26.5 GHz, and a sensitivity to -30 dBm. For frequencies above 26.5 GHz, a remote sensor, with an appropriate waveguide input, is designated as Band 4.

Measurements are presented on a 12 digit, LED display that is sectionalized to read GHz, MHz, KHz, and Hz. When the optional power measurement function is activated, the digits on the far right display power in dBm to 0.1 dB and frequency resolution is limited to 100 kHz.

SPECIFICATIONS

BAND 1	
RANGE	10 Hz to 100 MHz
SENSITIVITY	25 mV rms
IMPEDANCE	1 M Ω /20 pF
CONNECTOR	BNC (female)
MAX. INPUT LEVEL	120 V rms *
DAMAGE LEVEL	150 V rms *
	* (Above 1 KHz max. input will decrease at 6 dB/octave down to 3.0 V rms.)

BAND 2	
RANGE	10 MHz to 1 GHz
SENSITIVITY	-20 dBm
DYNAMIC RANGE	30 dB
IMPEDANCE	50 Ω Nominal
CONNECTOR	BNC (female)
MAX. INPUT LEVEL	+10 dBm
DAMAGE LEVEL	+27 dBm
ACQUISITION TIME	< 50 msec

BAND 3	
RANGE	1 GHz to 18 GHz (26.5 GHz for model 548)
SENSITIVITY	-30 dBm: 1 GHz-12.4 GHz -25 dBm: 12.4 GHz-18 GHz -20 dBm: 18 GHz-22 GHz -15 dBm: 22 GHz-26.5 GHz
DYNAMIC RANGE	1 GHz to 12.4 GHz, 37 dB 12.4 GHz to 18 GHz, 32 dB 18 GHz to 26.5 GHz, 27 dB
IMPEDANCE	50 Ω Nominal
CONNECTOR	Model 545 - Precision type N, (female) Model 548 - SMA (female)
MAX. INPUT LEVEL	+7 dBm
DAMAGE LEVEL	5 Watts (+37 dBm)
ACQUISITION TIME	~ 250 msec Independent of frequency
AUTO AMPLITUDE DISCRIMINATION	(Automatic amplitude discrimination of two frequencies) 10 dB
FM MODULATION	20 MHz P-P up to 10 MHz rate
VSWR	< 2.5:1 typical
FREQUENCY LIMIT	Keyboard control of desired limits (standard). Counter will measure largest signal within programmed limits. Signal outside operating band must be separated by at least 100 MHz from either limit. For signals more than 10 dB above desired signal, separation is typically 200 MHz

TIME BASE	
FREQUENCY	10 MHz TCXO
AGING RATE	< 3 x 10 ⁻⁷ per month
SHORT TERM	< 1 x 10 ⁻⁹ rms for one second averaging time.
TEMPERATURE	< 2 x 10 ⁻⁶ 0° to + 50° C
LINE VARIATION	< 1 x 10 ⁻⁷ \pm 10% change.
WARM UP TIME	NONE
OUTPUT FREQUENCY	10 MHz, square-wave, 1 V p-p minimum into 50 ohms.
EXT. TIME BASE	Requires 10 MHz, 1 V p-p minimum into 300 ohms.

SPECIFICATIONS, continued

GENERAL	
RESOLUTION	Front panel keyboard input select 1 Hz to 1 GHz
MEASUREMENT TIME	1 msec for 1 KHz resolution 1 sec for 1 Hz resolution
DISPLAY	12 digit LED sectionalized
ACCURACY	± 1 count \pm time BASE ERROR
TEST	Front panel selected diagnostics
SAMPLE RATE	Controls time between measurements variable from 100 msec typ. to 10 sec. Switchable Hold position holds display indefinitely.
RESET	Resets display to zero and initiates new reading
OFFSETS	Keyboard control of frequency offsets (standard) and power offsets (standard with power measurement Option 02). Displayed frequency (power) is offset by entering value to 1 Hz resolution (0.1 dB power).
OPERATION TEMP.	0°C to 50°C
POWER	100/120/220/240/VAC $\pm 10\%$ (selectable) 50 to 60 Hz, 60 VA typical
WEIGHT, NET	~ 20 lbs. (9.07 kg)
WEIGHT, SHIPPING	~ 25 lbs. (11.34 kg)
DIMENSIONS (HWD)	3.5" x 16.75" x 14.0" (89 mm X 425 mm X 356 mm)
ACCESSORIES FURNISHED	Power Cord and Manual

REMOTE SENSOR 591

RANGE	26.5 GHz to 40 GHz
SENSITIVITY	-20 dBm
CONNECTOR	UG599/U Waveguide Flange (WR 28 Waveguide)
MAXIMUM INPUT LEVEL	+ 5 dBm
DAMAGE LEVEL	+ 10 dBm

OPTIONS

See Section 10 for detailed information.

- 01 D TO A CONVERTER
DAC will convert any three consecutively displayed digits into an analog voltage output on rear panel.
- 02 POWER METER
1 to 18/26.5 GHz will measure sine wave amplitude to 0.1 dBm resolution and display simultaneously with frequency.
Power offset to 0.1 dB resolution, selectable from front panel.
Option will not degrade the basic performance of the counter.

TIME BASE OSCILLATOR OPTIONS:

	03	04	05
AGING RATE/24 HOURS (After 72 hour warm-up)	$< 5 \times 10^{-9} $	$< 1 \times 10^{-9} $	$< 5 \times 10^{-10} $
SHORT TERM STABILITY (1 second average)	$< 1 \times 10^{-10}$ rms	$< 1 \times 10^{-10}$ rms	$< 1 \times 10^{-10}$ rms
0° to +50°C TEMPERATURE STABILITY	$< 6 \times 10^{-8} $	$< 3 \times 10^{-8} $	$< 3 \times 10^{-8} $
$\pm 10\%$ LINE VOLTAGE CHANGE	$< 5 \times 10^{-10} $	$< 2 \times 10^{-10} $	$< 2 \times 10^{-10} $

SPECIFICATIONS, continued

OPTIONS, cont.	
06	EXTENDED FREQUENCY CAPABILITY – 548 Use in conjunction with models 59X series Remote Sensors.
07	REMOTE PROGRAMMING/BCD OUTPUT
08	GPIB – Provides programming and output capability per IEEE 488-1975.
09	REAR INPUT
10	CHASSIS SLIDES

Section 2

Installation

INSTALLATION

There are no special installation instructions. The counter is a self-contained bench or rack mounted unit, and only requires connection to a standard, single-phase, 100/120/220/240 volt 50-60 Hz power line for operation.

CAUTION

Check current rating of counter fuse and setting of rear panel VAC selector switch before applying power to counter.

COUNTER IDENTIFICATION

This counter is identified by two sets of numbers. The model number 545 or 548, and a serial number that is located on a label that is affixed to the rear panel. Both numbers must be mentioned in any correspondence regarding your counter.

SHIPPING AND STORAGE

Wrap the counter in heavy plastic or kraft paper, and repack in original shipping carton. If the original container is no longer available, use a heavy (275 lb test) double-walled carton with approximately four inches of packing material between the counter and the inner carton. Seal carton with strong filament tape or strapping.

Mark the carton to indicate that it contains a fragile electronic instrument. Ship to EIP at address on the title page of this manual.

PERFORMANCE CHECKOUT PROCEDURE

The following procedure may be conducted without special tools or equipment.

1. Turn counter POWER switch off. Check fuse rating and setting of AC POWER switch on rear panel.
2. Connect power cord to 100/120 or 220/240 volt, 50-60 Hz single-phase power source. The ground terminal on the power cord plug should be grounded.
3. Turn POWER switch on. Dashes will be displayed for about one second, followed by all 0's. This indicates that the automatic self-check has been completed.

- 4. PRESS: 0 1 Display should read 200 000 000.
- 5. PRESS: 0 2 Display should read all 8's and all annunciators should be lit.
- 6. PRESS: 0 3 Each display segment should light in turn.
- 7. PRESS: 0 4 Each digit should light in turn.

- 8. This completes the performance checkout procedure.

Section 3

Operation

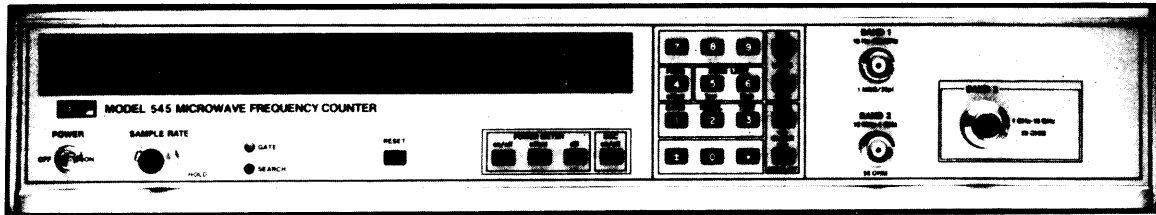


Figure 3-1. Front Panel, Model 545

FRONT PANEL CONTROLS AND INDICATORS

DISPLAY

- The 12 digit LED display provides a direct numerical readout of a measurement or of an input frequency. The frequency readout is displayed in a fixed position format that is sectionalized in GHz, MHz, kHz and Hz. Power information is displayed in dBm to 0.1 dB resolution, on the three right-most digits. When both power and frequency are displayed, frequency resolution is limited to 100 kHz.
- POWER switch turns counter on.
- SAMPLE RATE/HOLD varies time between measurements from 0.1 to 10 seconds (nominal) per reading. (Gate time is added to sample time, thus the minimum reading for 1 Hz resolution is 1.1 seconds.) The last reading is retained indefinitely in HOLD.
- GATE lights when the signal gate is open and a measurement is being made.
- SEARCH lights when the counter is not locked to an input signal.
- RESET manually over-rides all controls, resets the counter and converter, and initiates a new reading.

OPERATING STATUS

The operating status of the counter is indicated by a series of LEDs. When the counter is displaying input data, instead of a measurement, the appropriate LED status indicator will flash.

- REMOTE lights to indicate that front panel controls are disabled, and that the counter is being controlled by the GPIB option (08), or by the BCD/Remote Programming option (07).
- EXT REF lights to indicate the counter is set to an external time base reference.

CAUTION

When EXT REF lights it does NOT indicate that correct signal level has been applied.

- PWR dBm lights to indicate that the Power Meter option (02) is active.
- FRQ LMT, LOW/HIGH lights when frequency limits for counter operation have been selected.
- OFFSET, PWR/FRQ lights when power and/or frequency readings are offset from their actual value.
- BAND 1, 2, 3, 4 lights to indicate which operating range has been selected. When Band 4 is lit it indicates that the Extended Frequency Capability option (06) has been selected.
- DAC OPT lights to indicate that the Digital-to-Analog Converter option (01) is active.

POWER METER/DAC OPTION KEYBOARD

Four keys control the operation of these options.

- ON/OFF push button activates/deactivates power meter .
- OFFSET push button activates the power offset function.
- dB pushbutton acts as a terminator for the input of power offsets.
- DAC pushbutton, followed by two digits (00-12), activates the DAC option. The number keyed in will select the most significant digit (00 = OFF, 01 = 1 Hz, 12 = 10 GHz).

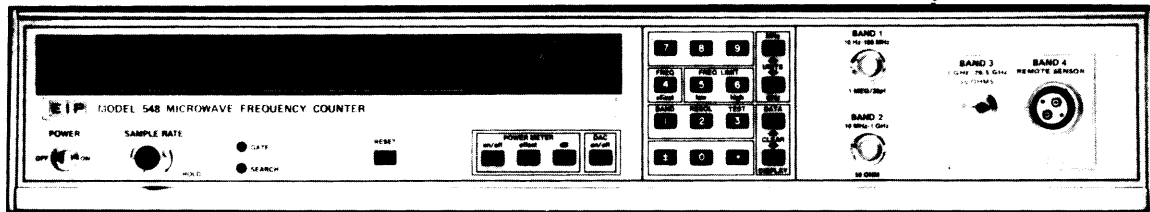


Figure 3-2. Front Panel, Model 548

SIGNAL INPUT

- BAND 1 input connector (BNC female) has a nominal input impedance of 1 Meg ohms, shunted by 20 pF. It is used for measurements in the range of 10 Hz to 100 MHz.
- BAND 2 input connector (BNC female) has a nominal input impedance of 50 ohm . It is used for measurements in the range of 10 MHz to 1 GHz.
- BAND 3 input connector on the model 545 is a precision type N female. It is used for counter operation in the range of 1 GHz to 18 GHz. Model 548 has a precision type SMA female connector that is used for operation in the range of 1 GHz to 26.5 GHz.
- BAND 4 is used in conjunction with the Extended Frequency capability option (06). It provides the interface between the Remote Sensor assembly and the 548 counter.

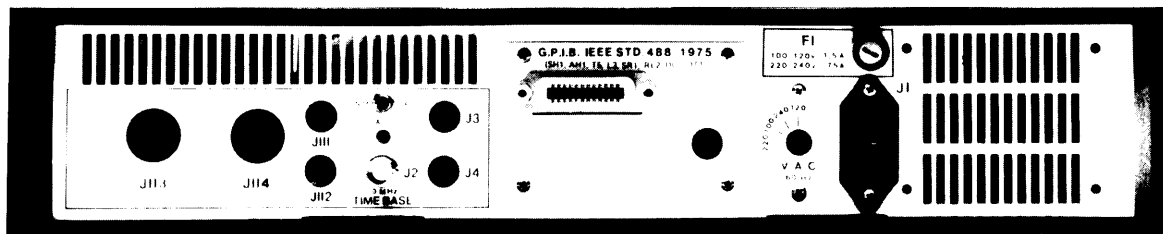


Figure 3-3. Rear Panel

REAR PANEL CONTROLS AND CONNECTORS

- AC POWER connector accepts the power cord supplied with the counter.
- FUSE provides overload protection. Use only a 0.75A slow-blow MDL type fuse for 100/120V operation. Use a 0.40A slow-blow FST type fuse for 220/240V operation.
- VAC SWITCH sets the operating voltage of the counter to match power line. There are 4 settings: 100, 120, 220, and 240 VAC. Counter will operate at voltages within $\pm 10\%$ of selected line voltage, at frequencies of 50 to 60 Hz.

CAUTION

Switch setting and fuse rating must match power line voltage.

- GPIB connector is used with the IEEE 488-1975 General Purpose Interface Bus option (08).
- BCD OUTPUT and REMOTE PROGRAMMING connectors (not shown) replace the GPIB connector when the counter is equipped with the BCD OUTPUT/REMOTE PROGRAMMING option (07).
- TIME BASE ADJUST control is used with options 03, 04, or 05 only. Screwdriver adjustment allows precise setting of the internal ovenized crystal oscillator.
- TIME BASE INT/EXT switch selects either the internal time base or an external 10 MHz reference.
- TIME BASE connector (BNC female) allows monitoring of internal 10 MHz time base, or input of an external 10 MHz reference.
- DAC OUTPUT connector (BNC female) provides analog output voltage for the Digital-to-Analog Converter option (01).

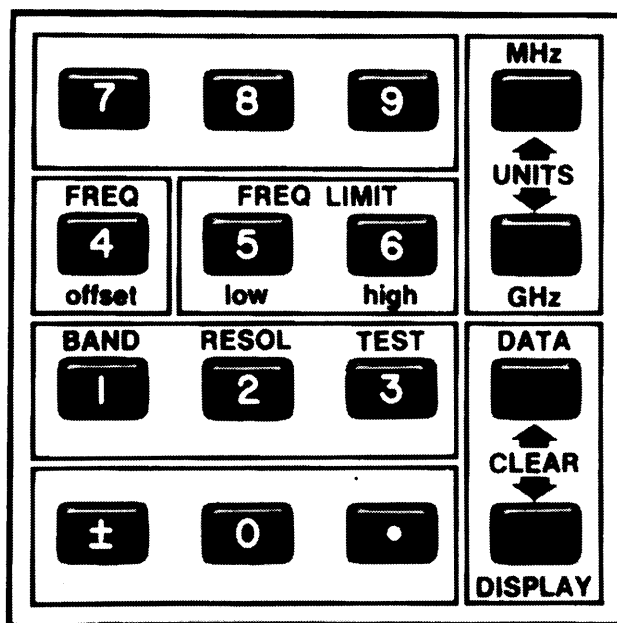


Figure 4-4. Keyboard

KEYBOARD

The keyboard consists of 16 pushbuttons that control major functions of the counter. Twelve keys are used for numerical data entry, the digits 0 through 9, the decimal point and the minus sign. Two keys (MHz and GHz) act as terminators for the input of frequency offset or frequency limits. The CLEAR DATA and CLEAR DISPLAY keys are used to clear stored or displayed data. Six of the numerical keys are also used to select the band, resolution, test function, frequency offset and frequency limits.

UNITS (MHz/GHz)

PRESS: MHz Completes Entry Sequence

PRESS: GHz Completes Entry Sequence

CLEAR (DATA/DISPLAY)

PRESS: DATA
CLEAR Clears selected "STORED" data, i.e. Limits (Low/High), Offsets, and clears DAC operation.

PRESS: CLEAR
DISPLAY Clears display. Does not affect stored data. Restores counter to measurement mode.

BAND SELECTION

To select one of three standard operating bands on the model 545 or 548.

PRESS: **BAND** 1 or **BAND** 2 or **BAND** 3

Notice annunciator flash and selected band number will light when chosen. This feature allows multiple inputs to be connected and selected in turn.

The "BAND" KEY followed by a numeric key enables the following band selection.

PRESS: **BAND** 1 10 Hz - 100 MHz Input

PRESS: **BAND** 2 10 MHz - 1 GHz Input

PRESS: **BAND** 3 1 GHz - 18 GHz (Model 545) 26.5 GHz (Model 548)

On the model 548, equipped with option 06 and a 59X series Remote Sensor, Band 4. is selected by:

PRESS: **BAND** 4 X

For example, with the 591 Sensor you will press **BAND** 4 1

RESOLUTION / GATE TIME SELECTION

The "RESOL" key followed by a numeric key enables following resolutions.

PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="0"/>	1 Hz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="1"/>	10 Hz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="2"/>	100 Hz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="3"/>	1 KHz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="4"/>	10 KHz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="5"/>	100 KHz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="6"/>	1 MHz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="7"/>	10 MHz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="8"/>	100 MHz RESOLUTION
PRESS:	RESOL <input type="checkbox"/>	<input type="checkbox" value="9"/>	1 GHz RESOLUTION

As the resolution is decreased from 1 Hz to 1 kHz, the gate time LED should cycle faster:

- 1 Hz resolution equals a gate time of 1 sec.
- 10 Hz = 100 msec Gate time
- 100 Hz = 10 msec Gate time
- 1 KHz to 1 GHz = 1 msec Gate time

DISPLAY AND DATA ENTRY SEQUENCE

The keyboard display and data entry sequences are segmented into four main groups. All keyboard operations must be started by choosing the function first.

DATA ENTRY - enter offsets or limits

- Sequence :
1. FUNCTION , SIGN (plus sign not required) , NUMBER , DECIMAL , NUMBER , UNITS
(decimal and second number is optional)
 2. FUNCTION , NUMBER

Example :

1.

FREQ		±	1	•	2	
OFFSET						GHz
2.

BAND		2

DISPLAY DATA - display previously entered data

- Sequence :
- FUNCTION , CLEAR DISPLAY

Example :

FREQ		CLEAR	
OFFSET		DISPLAY	

CLEAR DATA - clear entered data

- Sequence :
1. FUNCTION , CLEAR DATA
 2. FUNCTION ,

 , UNITS
 3. FUNCTION , UNITS

Example :

1.

OFFSET		DATA	
		CLEAR	
2.

OFFSET		0	dB	
3.

OFFSET		dB	

CLEAR ENTRY - clear display before completing data entry

- Sequence :
- FUNCTION , STRING , CLEAR DISPLAY

Example :

FREQ		1	•	2	CLEAR	
OFFSET					DISPLAY	

FREQUENCY LIMITS

Frequency limits can be entered to 10 MHz resolution .

FREQ LIMIT

PRESS: Notice flashing annunciator.
low

PRESS: # Number keys corresponding to desired frequency low limit to 10 MHz resolution.

PRESS: MHz or GHz To terminate input sequence. Notice FRQ LMT LOW annunciators solidly lit.

FREQ LIMIT

PRESS: Notice flashing annunciator
high

PRESS: # Key numbers corresponding to desired freq. Hi limit. High and low limits should be separated by at least 100 MHz.

PRESS: MHz or GHz To terminate input sequence. Notice Hi annunciator solidly lit.

To recall stored limits.

PRESS: and then and
low DISPLAY high DISPLAY

To clear data memory and remove frequency limits.

PRESS: and then and Vary Source. Notice
low CLEAR high CLEAR selected limit (s) are erased. Also notice "FREQ LMT LOW HI" annunciators are out.

TEST SELECTION

The following tests will verify proper operation of most functional areas of the counter. At the initial turn on the counter performs a RAM and PROM check. During this check dashes are displayed until the check has been completed.

RAM and PROM

The processor writes a sequential bit pattern to each RAM location, then independently reads that pattern. Thus each bit in each location is checked. If the RAM check fails the display will show all "E's". This indicates that the RAM or the RAM decoding is faulty.

The PROM check verifies the PROM bit pattern. If the PROM check fails an error message will be displayed. This indicates that the PROM decoding is faulty. See Section 6.

If both RAM and PROM check are good the counter will begin normal operation about one second after turn on. The counter will now display all 0's.

200 MHz SELF TEST

TEST
PRESS: 0 1

Notice display is 200 MHz. This verifies operation of the time base reference and it's associated circuits, the signal selection, the count chain, and the local oscillator.

LED TEST

TEST
PRESS: 0 2

Notice all LED segments and yellow annunciators are lit. This verifies operation of all visual indicators

LED SEGMENT TEST

TEST
PRESS: 0 3




Notice each segment of each display digit is lit in turn. The sample rate pot will change the rate, and may be adjusted. This checks the segment drivers.

DISPLAY DIGIT TEST

TEST
PRESS: 0 4


Notice all segments of each digit are lit in turn to verify that each digit operates independently. The sample rate pot will change the rate, and may be adjusted.

KEYBOARD TEST

PRESS:   

Notice display is 05. Press any key and display will indicate a two digit number showing the position of that key within the matrix thus checking keyboard operations.

TO EXIT TESTS

PRESS:  to exit a test and return to normal operation.

To exit tests 1 through 4, 6 and 7 you can press any function key. This will exit the test and enter the function selected.

Tests 6 through 10 are used for calibration and troubleshooting. See section 6 and 7.

SET-UP FOR BASIC FREQUENCY MEASUREMENT

Choose the input band by pressing **BAND** and a number key corresponding to the band. Choose resolution by pressing **RESOL** and a number key corresponding to required resolution. The signal coupled to the selected input Band Connector will be automatically displayed to the resolution chosen.

NOTE: When pressing the RESOL key the display will go blank for approximately 1/4 second.

FREQUENCY OFFSETS

Frequency OFFSETS can be added or subtracted from the measured value. These OFFSETS can be entered via the front panel keyboard to 1 Hz resolution:

PRESS: **FREQ** Notice the flashing annunciator.
OFFSET

PRESS: Number keys corresponding to desired frequency OFFSETS. If OFFSET is to be subtracted press ± and notice polarity sign indicator at far left of display.

PRESS: **MHz** or **GHz** to integrate Programmed OFFSET into actual frequency measurement. Notice solidly lit annunciator indicating instrument memory is loaded.

PRESS: **FREQ** Recalls OFFSET to display, FRQ and OFFSET annunciators flashing.
OFFSET

PRESS: **CLEAR** Notice frequency displayed includes OFFSET; annunciators are lit continuously.
DISPLAY

PRESS: **FREQ** Recalls OFFSET to display; FRQ and OFFSET annunciators flashing.
OFFSET

PRESS: **CLEAR** Clears data memory and clears offset.
DATA FRQ and OFFSET annunciators are out.
Display is actual frequency without offset.

DISPLAY ERROR MESSAGES

When an error occurs the error number will be displayed. The probable cause of each error is listed below.

- 01 Illegal Key Sequence.
- 02 A Resolution Number Was Not Entered; Or The Number Entered Was Too Small.
- 03 A Band Number Was Not Entered; Or The Number Entered Was Too Large.
- 04 No Power Reading In Current Band.
- 05 Frequency Limit High > 18.5 GHz (545), 27 GHz (548).
- 06 (Freq. Limit Hi) – (Freq. Limit Lo) $<$ Min. (100 MHz) Difference.
- 07 Frequency Limit Low $< .95$ GHz (545, 548).
- 08
- 09 Illegal Test Mode Key Sequence.
- 10 Illegal DAC operation.
- 31 Check sum Error PROM 1 (C800 - CFFF) A105, U20
- 32 Check sum error PROM 2 (D000- D7FF) A105, U8
- 33 Check sum error PROM 3 (D800 -DFFF) A105, U7
- 34 Check sum error PROM 4 (E000 -E7FF) A105,U6
- 35 Check sum error PROM 5 (E800 - EFFF) A105,U13
- 36 Check sum error PROM 6 (F000-F7FF) A105, U12
- 37 Check sum error PROM 7 (F800 -FFFF) A105, U11
- 38 Check sum error PROM 8 (4000 - 47FF) (Power Meter PROM)

