Boonton

8201

Modulation Analyzer

Quick Start Guide

Taking performance to a new peak

8201 Quick Start Guide

Version 1.00
(PN: 98406800A)

The 8201 is a versatile, precision, solid-state instrument with features and performance characteristics suitable for laboratory and industrial applications. It covers a frequency range of 100 kHz to 2.5 GHz. The 8201 modulation analyzer is easy and convenient to use. This document briefly describes the operating information for the Model 8201 Modulation Analyzer and all 8201-S models including the descriptions of the front and rear panel controls, displays, connectors, option selections, and instructions for local and remote modes of operation. Typical measurement situations are also described.

Content

Safety and Caution Summary

The following general safety precautions must be observed during all phases of operation and maintenance of the Boonton 8201 Modulation Analyzer. Failure to comply with these precautions or with specific warnings in this guide or instruction manual violates safety standards of design, manufacture, and intended use of the instruments. Boonton Electronics Corporation assumes no liability for the customer's failure to comply with these requirements.

SAFETY

- INSTRUMENT MUST BE GROUNDED (must be connected to an electrical ground at the power outlet)

- DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE

- KEEP AWAY FROM LIVE CIRCUITS

- DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

- NON IONIZING RADIO FREQUENCY RADIATION HAZARD

- ELECTRIC SHOCK HAZARD

CAUTION

- Please check the power requirements as per the product specifications.

- Ensure at least 2'' of clearance around the instrument.

- Before powering the unit on make sure there are no indications of exposure to extensive force such as dents, torn off pieces or loose parts in the case.

- DO NOT touch connectors of components with bare fingers.

- DO NOT connect or disconnect any component of the test setup with power switched on.

- To maintain the optimal performance of the unit, prevent exposure to unnecessary force, keep accessories clean and dry, and regularly check for wear and tear.

Limited Warranty

Boonton Electronics warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment for instruments, probes, power sensors and accessories. Boonton Electronics further warrants that its instruments will perform within all current specifications under normal use and service for one year from date of shipment. These warranties do not cover active devices that have given normal service, sealed assemblies which have been opened, or any item which has been repaired or altered without Boonton's authorization. Boonton's warranties are limited to either the repair or replacement, at Boonton's option, of any product found to be defective under the terms of these warranties. There will be no charge for parts and labor during the warranty period. The purchaser shall prepay inbound shipping charges to Boonton or its designated service facility and shall return the product in its original or an equivalent shipping container. Boonton or its designated service facility shall pay shipping charges to return the product to the Purchaser for domestic shipping addresses. For addresses outside the United States, the Purchaser is responsible for pre-paying all shipping charges, duties and taxes (both inbound and outbound). THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Boonton will not be liable for any incidental damages or for any consequential damages, as defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by the foregoing warranties.

Instrument Displays & Operating Controls

The 8201 instrument displays are shown as below in Figure-1. The front panel of the Model 8201 is organized for simple instrument operation. It consists of a display window and a separate keyboard area. The display area contains the carrier FREQUENCY/LEVEL display, the AUDIO display, the MODULATION display, and the SPCL/PRGM display. The keys are organized as function keys, data keypad, and measurement control keys.

The controls, indicators and connectors used during the operation of the instrument are listed in Table-1 , Table-2 and shown in Figure-2 and Figure-3.

Getting Started

The following instructions walk through a basic operation and functionality tests to verify that the unit is working properly.

1. Turn ON the instrument and press LCL (INIT) key.
2. After a while, the FREQUENCY/LEVEL display will show up with 8201 firmware reference number and the other displays will contain dashes for about 3 seconds.
3. The message ''UNLOC'' will then appear in the display window.
4. The audio and modulation displays will contain the [==] message
5. The SPCL/PRGM displays will contain 99, the initialization program number (Please refer to Table 3-8 of the instruction manual for the meaning of any reported errors).

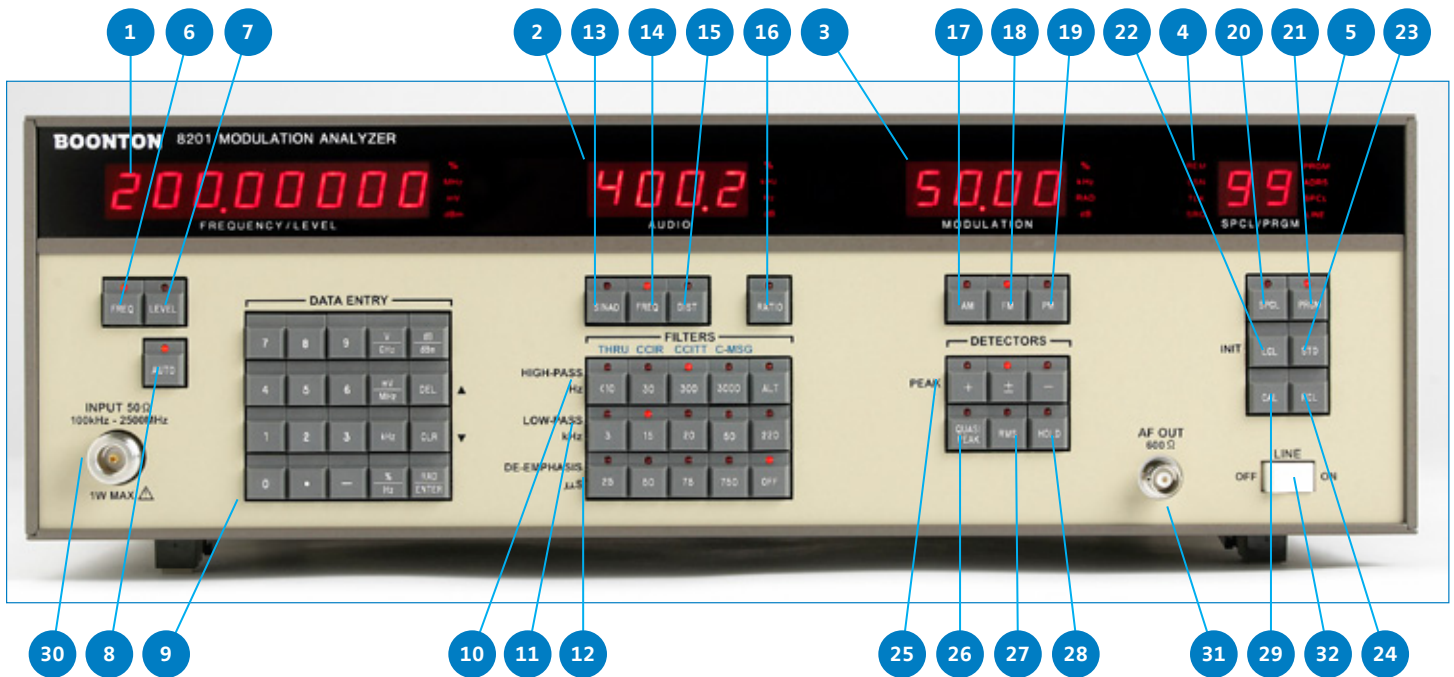Figure-1: 8201 Modulation Analyzer Displays

Figure-2: Front View of 8201 Modulation Analyzer

Table-1: Controls, Displays and Connectors of Front Panel of 8201 Modulation Analyzer (Fig-2)

Control, Indicator Or Connector	Index Number	Function
FREQUENCY/LEVEL display	1	Displays carrier frequency in kHz or MHz, and RF level in dBm or mV. Alternately displays error codes and messages. The display is eight characters wide and displays the measurements of carrier level and frequency. In ratio mode the frequency can be displayed in % or delta frequency and the level in % or dB.
AUDIO display	2	AUDIO display is four characters wide and it displays modulation frequency in Hz or kHz and distortion in % or dB SINAD. In ratio mode distortion and SINAD can be displayed in % or dB and the audio frequency can be displayed in % or delta frequency.
MODULATION display	3	The MODULATION display is four characters wide and it displays modulation in % for AM, kHz for FM deviation, and RAD for PM deviation. Also displays ratio in % or dB.
BUS Status display	4	Displays current IEEE-488 bus status; REM (remote enabled), LSN (listener addressed), TLK (talker addressed), and SRQ (service request active).
SPCL/PRGM display	5	The SPCL/PRGM display is an entry only display which is two characters wide and display the current program number or selected special function. Units are PRGM for program number, SPCL for special function, and ADRS for IEEE-488 bus address. Also included a LINE annunciator which indicates that ac power is applied.
FREQ key	6	Selects carrier frequency as the active function. Use before setting carrier frequency or to activate carrier frequency display.
LEVEL key	7	Selects carrier level as the active function. Use before setting carrier level or to activate the level display.
AUTO key	8	Forces the selected function to the measurement mode. Not active for the PRGM and SPCL functions.

6

Control, Indicator Or Connector	Index Number	Function
DATA ENTRY keys:	9	
0 – 9 keys		Number entry keys.
. key		Select decimal point during data entry.
- key		Prefix for negative quantity.
V/GHz key		Selects volts or gigahertz units.
mV/MHz key		Selects millivolts or megahertz units.
kHz key		Selects kilohertz units.
%Hz key		Selects percent or Hertz units.
dBm key		Selects decibels referenced to 1 milliwatt.
DEL(↑) key		Deletes the last entered digit, or increments parameter.
CLR(↓) key		Clears errors or current data entry, or decrements parameter.
RAD/ENTER		Selects radians or unitless number termination.
High-pass Hz keys:	10	
<10/THRU		Selects the < 10 Hz high-pass or THRU bandpass filter.
30/CCIR		Selects the 30 Hz high-pass or CCIR bandpass filter.
300/CCITT		Selects the 300 Hz high-pass or CCIIT bandpass filter.
3000/C-MSG		Selects the 3000 Hz high-pass or C-MSG bandpass filter.
ALT		Toggles filter selection from high-pass to bandpass.
Low-pass Hz keys:	11	
3		Selects the 3 kHz low-pass filter.
15		Selects the 15 kHz low-pass filter.
20		Selects the 20 kHz low-pass filter.
50		Selects the 50 kHz low-pass filter.
220		Selects the 220 kHz low-pass filter.
De-emphasis uS keys:	12	
25		Selects the 25 us de-emphasis filter.
50		Selects the 50 us de-emphasis filter.
75		Selects the 75 us de-emphasis filter.
750		Selects the 750 us de-emphasis filter.
OFF		Deselects the de-emphasis filters.
SINAD key	13	Selects SINAD audio distortion measurement.
FREQ (audio)	14	Selects audio frequency as the active function.
		Use before setting audio frequency for SINAD measurements, or to activate the audio frequency display.

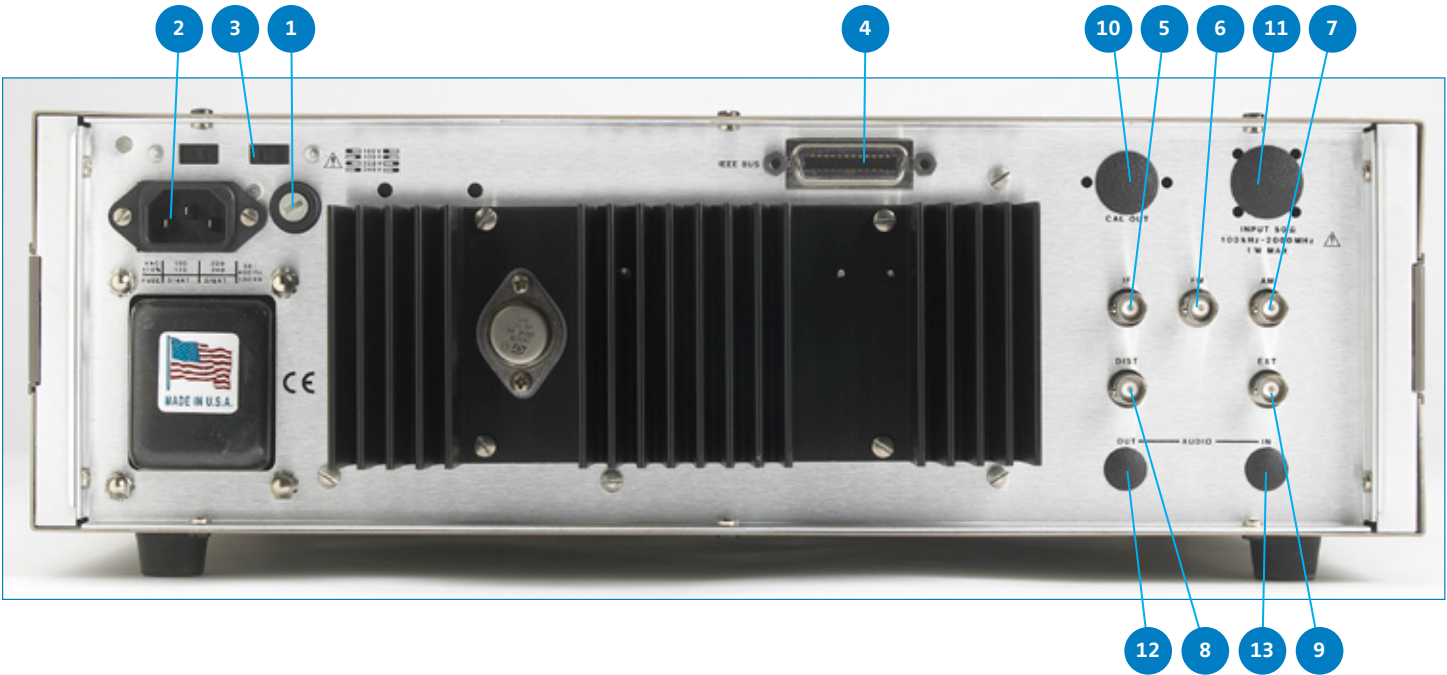| Control, Indicator Or Connector	Index Number	Function
DIST key	15	Selects audio distortion measurement.
RATIO key	16	Alternate action key. Changes the active display from absolute to relative. Units keys may be used to select displayed units.
AM key	17	Selects AM modulation as the active function.
		Use before setting AM modulation reference for subsequent ratio measurement, or to activate the AM modulation display.
FM key	18	Selects FM modulation as the active function.
		Use before setting FM modulation reference for subsequent ratio measurement, or to activate the FM modulation display.
PM key	19	Selects PM modulation as the active function.
		Use before setting PM modulation reference for subsequent ratio measurement, or to activate the PM modulation display.
SPCL key	20	Selects special function as the active function.
		Use before selecting special function.
PRGM key	21	Selects instrument program as the active function.
		Use before selecting program number for store or recall.
LCL/INIT key	22	Causes instrument to ''go-to-local'' if local lockout is not active and remote is active, or initialize when the instrument is in the local state.
STO key	23	Stores the instrument setup at selected program number.
RCL key	24	Recalls instrument setup from selected program number.
PEAK keys:	25	
+key		Selects + peak detector for display.
-key		Selects - peak detector for display.
±key		Selects peak average modulation display. The display is (+ peak (+) -peak)/2.
QUASI-PEAK key	26	Selects CCIR 386-3 peak detector for display. The display is peak responding, calibrated in RMS.
RMS key	27	Selects a true RMS detector for modulation display.
HOLD key	28	Alternate action key used to display the greater of the current or last modulation reading.
CAL key	29	Causes the selected function to be calibrated. Active for carrier LEVEL, AM, FM, and PM.
RF IN connector	30	RF input connector, used to apply an external carrier signal.
AF OUT connector	31	Audio output connector, used to connect the demodulated signal to external test equipment.
LINE switch	31	Switches the instrument ac power supply ON or OFF.

Figure-3: Rear View of 8201 Modulation Analyzer

Table-2: Controls, Displays and Connectors of Back Panel of 8201 Modulation Analyzer (Figure-3)

Control, Indicator or Connector	Index Number	Function
Fuse holder	1	Holds fuse for ac line protection.
Line connector	2	Permits connection of instrument to ac power supply.
Voltage Selector Switch	3	Permits the selection of various ac power supply voltages.
IEEE-488 bus connector	4	Provides a means for connecting the Model 8201 to a system control bus.
IF out connector	5	Provides a means for connecting the intermediate frequency signal to external test equipment.
FM out connector	6	Provides a means for connecting the demodulated FM signal to external test equipment.
AM out connector	7	Provides a means for connecting the demodulated AM signal to external test equipment.
DIST out connector	8	Provides a means for connecting the distortion analyzer signal output to external test equipment.
EXT REF connector	9	Provides a means for connecting an external 10 MHz frequency standard to the internal time base circuits.
Optional: CAL OUT connector	10	Provides a means for connecting the optional 50 MHz, 0 dBm calibrator to the Model 8201 for level calibration.
RF IN connector	11	Optional RF input connector, used to apply an external carrier signal.
AUDIO OUT connector	12	Provides a means for connecting the modulation signal to external filters or processing circuits.
AUDIO IN connector	13	Provides a means for connecting an external audio signal to the internal baseband processing circuits.

Getting familiar with Function Keys

The function keys of 8201 modulation analyzer are described as below:

The top row of illuminated switches are the function keys. These keys are used to select the parameter to be displayed and to enable the data keypad for subsequent data entry. The functions are carrier FREQ, carrier LEVEL, audio SINAD, audio FREQ, audio DIST, AM, FM, PM, SPCL, and PRGM. The LED in the switch of the selected function will be illuminated continuously; the others will be off unless a measurement of that function is in progress. In this case the LED will flash during the measurement interval.

FREQ function key
To select a function press the desired function key. The units legends associated with that function will appear immediately to the right of the numeric display.

For example, select the carrier FREQ function and press the 1 and V/ GHZ keys. The display will now contain the number 1000.0000 and the active legend will be MHz

FM function key
Depress the FM function key. The LED in the carrier FREQ key will go out, and the LED is the FM key will illuminate. Depress the 1, 0, and kHz keys. The number 10.00 will now be displayed in the modulation display.

All other function keys operate in the same manner, except that data cannot be entered when the DIST or SINAD functions are selected.

Getting familiar with Data Keypad

Operation of the data keypad is conventional. The data keypads of the 8201 Modulation Analyzer are described as below:
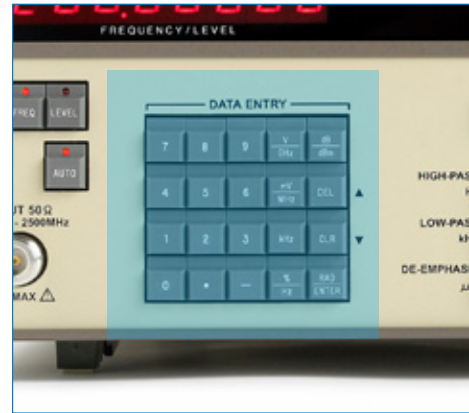

Figure-5: Data Keypad of 8201 Modulation Analyzer

MHz key
Select the carrier FREQ function and depress the [8] key. The carrier frequency display will indicate '8 and the unit's legend will go out. The tick mark (') indicates that the number displayed has not yet been entered.

Continue by depressing the [2], [.], [1] and [5] keys and the MHz key to enter the number. The display will now indicate 82.15000 MHz. (Note: It is not necessary to enter any trailing zeroes, nor is it necessary to depress the ENTER key if a units key is used. While this is the most efficient way to enter 82.15 MHz, it is equally valid to enter 82150 kHz, 82150000 Hz, etc).

DEL and CLR Key
If at any time before entry the wrong digit is entered, depress the DEL key to clear the digit, or depress the CLR key to clear all input and restore the previous frequency display.
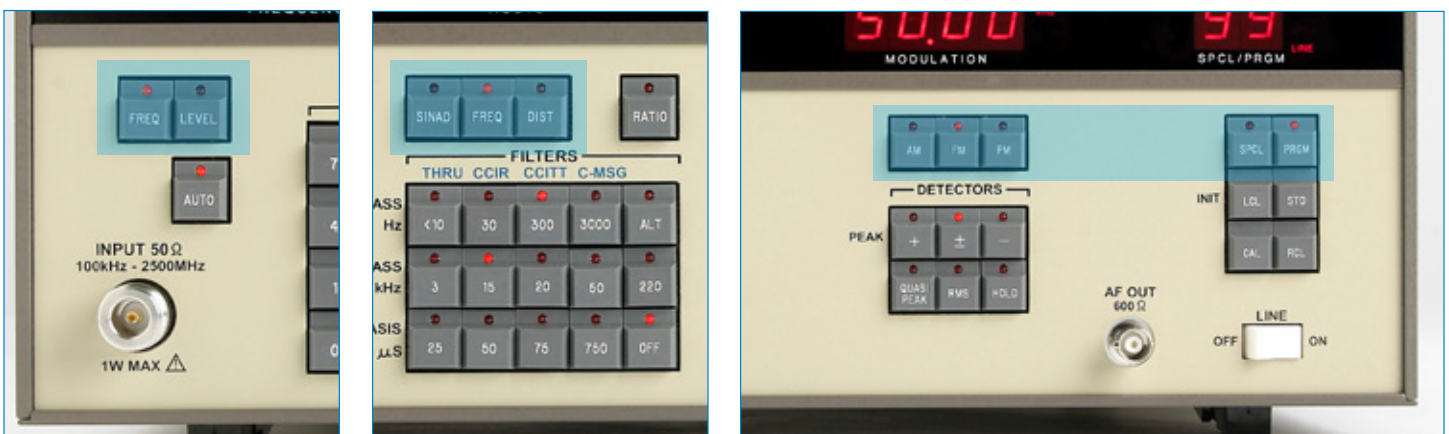

Figure-4: Function Keys of 8201 Modulation Analyzer

kHz and GHz Keys

The kHz and GHz keys are provided for convenience when entering frequency; however, the display will only indicate in MHz. Similarly, the V key can be used for entering input level; however, the display will indicate in millivolts.

ENTER key

The ENTER key is used for unitless quantities, such as special function and program numbers.

CLR key

The CLR key is used to recover from errors. Without changing function, depress the dBm key. The FREQUENCY/LEVEL display will now indicate Error 9 or 11. This means that an inconsistent units key has been depressed to terminate a data entry.

Depress the CLR key. The display will return to normal. A list of error codes is presented in Table 3-8, at the end of the section 3-26 of the 8201 instruction manual.

LEVEL Function key

Depress the carrier LEVEL function key, then the 0 and dBm keys. The FREQUENCY/LEVEL display will now indicate 0.00 dBm.

mV/MHz key

Depress the mV/MHz key. The display will change to 223.6 m V. Carrier level may be entered in millivolts, volts, or dBm. The control program will recalculate or rescale numbers as required.

The DEL and CLR keys are also labeled as up- and down-arrow keys for scrolling through SPCL function menus.

Getting familiar with Measurement Control Keys

The measurement control keys consist of the groups of switches marked FILTERS and DETECTORS. These keys may be operated at any time and will affect the MODULATION and AUDIO displays. The filter switches are arranged as self-cancelling groups of four and five keys. Depressing any high-pass switch will cause the selected filter to be placed into the measurement channel and cancel any other selected high-pass filter. Similarly, depressing any low-pass filter will cause the selected filter to be placed into the measurement channel and cancel any other selected low-pass filter.
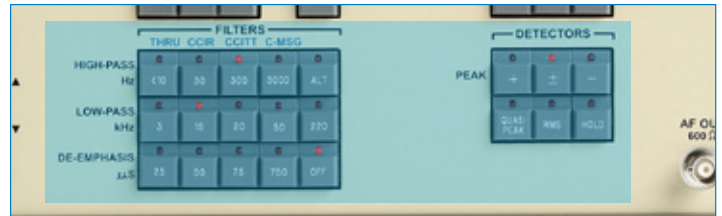

Figure-6: Measurement Control Keys of 8201 Modulation Analyzer

HIGH-PASS Filter keys

Depressing any high-pass switch will cause the selected filter to be placed into the measurement channel and cancel any other selected high-pass filter.

LOW-PASS Filter keys

Similarly, depressing any low-pass filter will cause the selected filter to be placed into the measurement channel and cancel any other selected low-pass filter.

The maximum low-pass bandwidth selection is a function of carrier frequency. The control program will automatically adjust the low-pass filter cutoff frequency as required. The carrier breakpoints and low-pass filters are:

Carrier	Filter
< 500 kHz	15 kHz max
< 10 MHz	50 kHz max
> 10 MHz	220 kHz max

DE-EMPHASIS Filter Keys

The de-emphasis filters are normally available when measuring FM only. They are selected in the same manner as the high-pass and low-pass filters, but are automatically removed from the measurement channel when AM or PM modulation function is selected. The selected de-emphasis filter will be restored when the FM function is again selected.

Additionally, the de-emphasis filters may be placed before or after the modulation display. This is accomplished by selecting SPCL function 7 for pre-display and SPCL function 8 for post-display de-emphasis. SPCL function 9 permits the de-emphasis filters to be selected in the AM measurement function. This is useful for performance verification of the filter 3 dB points.

OPTIONAL Filter Keys

The ALT key is active if optional filters are installed in the Model 8201. Optional filters available are:

THRU	Permits connection of external filters in the audio path
CCIR	CCIR recommendation 468-3 bandpass filter
CCITT	CCITT recommendation P.53 bandpass filter
C-MSG	Bell System Technical Reference 41009 bandpass filter

Any or all of these filters can be installed at one time; however, the A15 option board is required with any of the filters. The ALT key will activate the filters marked above the corresponding high-pass key, if the filters are installed. Error 19 will be displayed if an optional filter is not installed and the key is depressed.

DETECTOR Switches

The second group of measurement control keys is the DETECTOR switches. The peak detectors are normally used to measure modulation, however, precision RMS detectors are included in the Model 8201. These detectors are used primarily to characterize noise residuals and complex or distorted modulation signals. Two detectors are provided.

RMS Key

The normal function of the RMS key is to select an rms calibrated display; however, SPCL function 18 can be executed to change the RMS key to select rms detection calibrated in peak for sinusoidal modulation. This is particularly useful when comparing peak and RMS indications of noisy signals.

QUASI-PEAK Key

A quasi-peak detector, compatible with CCIR 368-3, is available for use with the CCIR filter option. This detector is always available, whether the optional filter is installed or not.

PEAK Keys

The Peak +, -, and ± keys, the RMS key, and the QUASI-PEAK key are arranged such that only one detector can be selected at a time.

HOLD Key

The HOLD key is used to activate the hold detector mode. It is an alternate action key which can be used with any detector. In operation, as modulation measurements are made, the larger of the current measurement or the previous measurement becomes the displayed modulation. Depress the HOLD key to activate this mode, and then depress the key again to cancel.
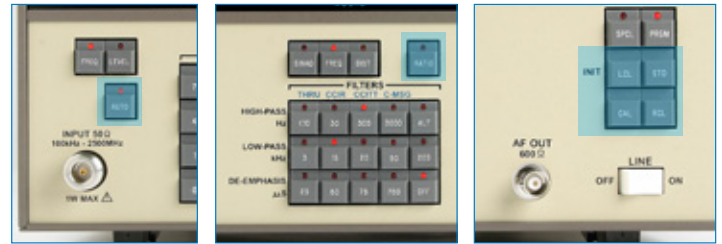
Other Keys

Figure-7: Other Keys of 8201 Modulation Analyzer

RATIO Key

The RATIO key is an alternate action key which changes the active display from absolute to relative. In addition, the ratio measurement can be made relative to the current display, or to a set value. Ratio can be displayed in percent, measurement units, or dB by using the %, units, and dB keys in the data keypad. For relative frequency measurements use the % key or for delta frequency use kHz, MHz or GHz keys.

AUTO key

The AUTO key is used to resume automatic operation of a particular function. It is active for the carrier FREQ, carrier LEVEL, audio FREQ, AM, FM, and PM functions. When numerical data is entered into a particular function window, the LED in the AUTO key will go out. This indicates that the selected function is not displaying a measured value. To resume measurement, depress the AUTO key. If carrier FREQ is the active function, depressing the AUTO key will always force the Model 8201 to reacquire the carrier signal.

LCL(INIT) key

The LCL(INIT) key is a dual function key. If the Model 8201 is in the local IEEE•488 bus state and the key is depressed an initialization restart occurs. This is similar to a power on reset except that the current instrument status is lost. This does not include bus address or end-of-string selection. If the Model 8201 is remote enabled, and the local lockout bus state is not active, the instrument will return to front panel control.

STO and RCL Keys

The STO and RCL keys are used with the PRGM function key to store and recall one of the 100 possible instrument control settings.

CAL key

The CAL key is used to calibrate the active function. It is active for carrier LEVEL, AM, FM, and PM modulation.

Displayed Messages

UNLOC message

When the Model 8201 unlocks, the FREQUENCY/LEVEL display will be overwritten with the 'UNLOC' message and the AUDIO and MODU-LATION displays will be overwritten with the [= =] symbol, which means display out of range. When a valid carrier is acquired, the displays will return to normal.

'IFHI' and 'IFLO' messages

The 'IFHI' and 'IFLO' messages appear in the modulation display and indicate that the intermediate frequency level is not within range to make an accurate measurement. SPCL functions 13 and 14 allow the operation of these messages to be modified.

'-CAL-' Message

When the CAL key is depressed, or during the execution of SPCL function 30, the message '-CAL-' is written to the FREQUENCY/LEVEL display to indicate that a calibration sequence is in progress.

'Error' message

A normal error response is for the word 'Error' to appear in the FRE-QUENCY/LEVEL display followed by a number indicating the nature of the error. Error codes are tabulated in Table 3-8 of the 8201 instruction manual along with a description of the error.

'SELFCHK' message

The message 'SELFCHK', followed by a changing digit, appears in the FREQUENCY/LEVEL display at power on, and indicates that a hardware check is in progress. Any error messages displayed indicate a hardware problem. See Table 3-8 of the 8201 instruction manual for the meaning of any reported errors.

Other displayed messages are described in detail in the pertinent operation section.

Special Functions

Several of the Model 8201 operating features are internally programmable by selecting a SPCL function. These functions allow the operator to change measurement configuration, as well as change the hardware state of the instrument. Some of the more useful SPCL functions are listed, the others are included in Table 3-2 of the instruction manual.

SPCL 0 (CLEAR ALL SPECIALS)

SPCL function 0 allows the operator to reset any active SPCL functions. The instrument special status is returned to the defaults indicated in Table 3-2 of the instruction manual.

SPCL 1-4 (MODULATION RANGE SETTINGS)

SPCL functions 1 through 4 permit the operator to select the modulation display range. This is useful for speeding up measurements where modulation may be removed temporarily, or in situations where the modulation range is known. This feature is also useful when decreased display resolution is desired. SPCL 1 is the default function which is auto range. The others are:

> **SPCL2   5.000 full-scale**
> **SPCL3   50.00 full-scale**
> **SPCL4   500.0 full-scale**

SPCL 5 (ENABLE SLOW PEAK DETECTOR MODE)

SPCL function 5 is provided to slow the response of the peak detectors for modulation signal frequencies below 200 Hz. The detectors are optimized for signal frequencies greater than 200 Hz for maximum measurement speed. Below 200 Hz additional filtering is required.

SPCL 6 (DISABLE SLOW DETECTOR MODE)

SPCL function 6 allows the operator to cancel SPCL 5. This is the default setting.

SPCL 7 (SET PRE-DISPLAY DE-EMPHASIS)

SPCL function 7 allows the operator to change the de-emphasis filter location from post -display to pre-display. This means that the de-emphasis filters will affect the displayed modulation readings as well as the AF OUT signal. This is useful for comparison of receiver de-emphasis networks to the precision network used in the Model 8201.

SPCL 8 (SET POST-DISPLAY DE-EMPHASIS)

SPCL function 8 allows the operator to change the de-emphasis filter location from pre-display to post -display. This means that the de-emphasis filters will not affect the displayed modulation readings, but will affect the AF OUT signal. This is the default setting for the de-emphasis filters.

SPCL 11 and 12 are related to setting dB resolution for ratio measurements.

SPCL 15, 16 and 17 are related to IEEE-488 which is described in details on the Table 3-2 of the instruction manual.

SPCL 30 (MODULATION DETECTOR CALIBRATION):

SPCL function 30 is the modulation detector calibration program. When executed the –CAL- message will appear in the FREQUENCY/LEVEL display and detector calibration will begin. The calibration routine will take about 80 seconds to complete. The AM detector is calibrated first, followed by the rms detector, the FM detector and finally the PM detector. If calibration error occurs, they will be displayed as the particular is being calibrated.

Calibration and Performance Tests

The internal calibrators of the 8201 Modulation Analyzer provide modulation standards for AM, FM and PM measurements. They are activated by the operator as required by the measurement.

Specifications

AM	0.1% accuracy
FM	0.1% accuracy
PM	1.0% accuracy

FM Calibration

The calibration process consists of:

1. Applying to the FM discriminator , in alternation, two accurately controlled frequencies
2. Measuring the resulting recovered modulation information
3. Computing a correction factor for subsequent FM measurements.

AM Calibration

The operation of the AM calibrator is similar to that of the FM calibrator.

For detailed theory of operation of the calibration for both AM, FM and PM, please refer to section 5 ''Performance Test 12'' of the instruction manual. The mathematical procedures used to determine the accuracy of the calibration is disclosed in this section. Since the calibrators are so precise, measurement verification of the stated accuracy is not practical.

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