Test Solutions

Precision Carrier:Noise E_b/N_o Generators

Carrier to Noise Generators

Micronetics' CNG instruments are designed to automatically add noise to a signal to a precise settable power ratio for testing bit error rate (BER) and other parameters. The quality of these tests are only as good as the accuracy of the signal to noise ratio. This signal to noise ratio is often expressed as Carrier:Noise (C/N) or in digital modulation terms, bit energy:noise density (E_b/N_0). In this data sheet for purposes of discussion, E_b/N_0 encompasses all ratio modes that include C/N and C/N_0. Micronetics CNG series instruments are designed to very accurately set a signal to noise power ratio over a wide dynamic range of noise and signal powers while offering long term stability and repeatability. This is accomplished by using high quality RF componentry, built-in calibration routines, a complex signal power measurement system and sophisticated software algorithms to pull it all together.

MICRONETICS
TEST SOLUTIONS

Distinguished From Traditional E_b/N_o Instruments

CNG instruments are used in a wide range of applications. Commonly noise is added at intermediate frequency (IF) including 70/140MHz and L-band Satcom testing noise is also added at radio frequency (RF) in the case of CDMA phone and base-station testing and even at baseband often when complex DSP algorithms are used such as for digital beam-forming systems. There are several attributes where Micronetics' CNG instruments distinguish themselves from traditional E_b/N_o boxes. These are detailed as follows:

E_b/N_o Accuracy:

Figure 1 is a block diagram of a typical satellite modem loop test set up. This set-up benchmarks the demodulator against its theoretically ideal performance of BER vs E_b/N_o. The CNG instrument sets up the E_b/N_o and a communication analyzer measures the bit error rate. Plotting BER vs. E_b/N_o produces what is known as a waterfall curve due to its shape when plotted on a log/log graph.

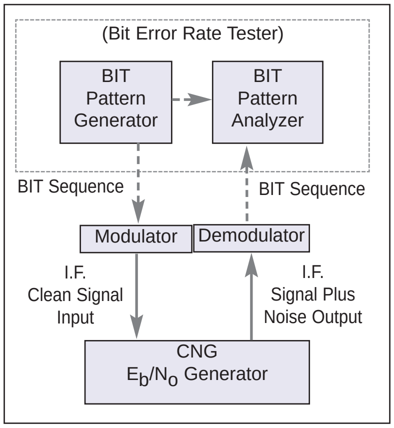
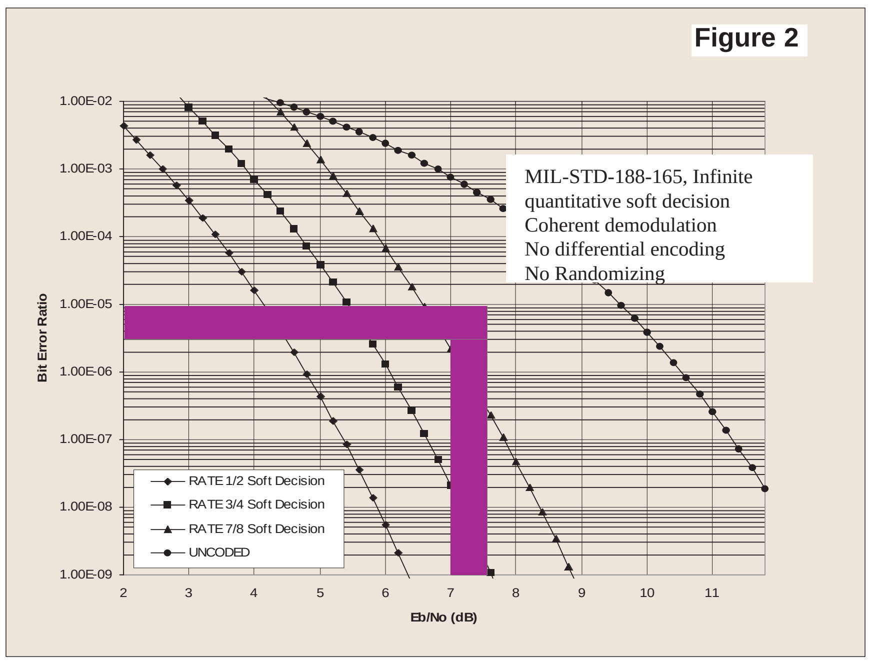


Figure 1

Figure 2 shows several different theoretical curves corresponding to different modulation formats. What is striking is that a fairly small amount of E_b/N_o uncertainty translates into a large uncertainty of bit error rate due to the steep slope of the theoretical curves as depicted by the shaded area. This is the reason Micronetics' design architects would not compromise on the accuracy, repeatability and stability of E_b/N_o. At the heart is a sophisticated power measurement system able to accept complex time variant amplitude and crest factor signals such as 7/8 coded QPSK and 256 QAM. This power measurement system is crucial for accuracy.



Application Note 701 discusses in more detail how the CNG instruments achieve accuracy and what the user can do to minimize uncertainty.

Built-in Self Calibration: Micronetics' CNG instruments have built-in calibration functions which can be performed by a keystroke or remote command at any time. Lesser E_b/N_o boxes can only perform these by hand during the annual factory calibration. The two primary routines are:

- *Noise Base:* The noise engine inside is a regulated amplified noise module. Several gain stages are required to test over a wide dynamic range of noise power. However, no active device has perfectly stable gain, so the noise base test uses the internal power meter to check any slight differences and update a data table if needed.

- *Power Meter Calibration:* A built-in highly stable crystal reference signal used to calibrate the power meter sensor. Any drift is automatically detected and zeroed out.

Annual Calibration: We polled users of E_b/N_o instruments about what they would like to see improvements on. What was universal is that users did not like the high price of proprietary annual calibration and having to send the unit back to the factory for calibration. Micronetics listened and has incorporated automated easy to follow menu driven calibration screens right on the CNG's Graphical User Interface (GUI) itself. This allows the equipment to be calibrated by standard equipment at any certified calibration house without complex procedures or specialized calibration equipment.

Ease of Use: Micronetics incorporates an intuitive GUI making it easy for a technician to start testing without having to pour over pages and pages of the manual, conversion tables and nomographs. Math functions are built right-in, making front panel operation easy and remote programming less complex. See Figure 3

Modular Architecture: Micronetics has also found that different test requirements require different features. For this reason, users can select which features they want without paying for ones they will never use. The description of standard options section will help you to determine which are needed or not. In addition to the standard options, Micronetics offers capability of specialized options for users who have unique requirements such as noise filter banks, extended ranges, special connectors etc. The flexible hardware and software architecture allows customization without major surgery and without the high custom price.

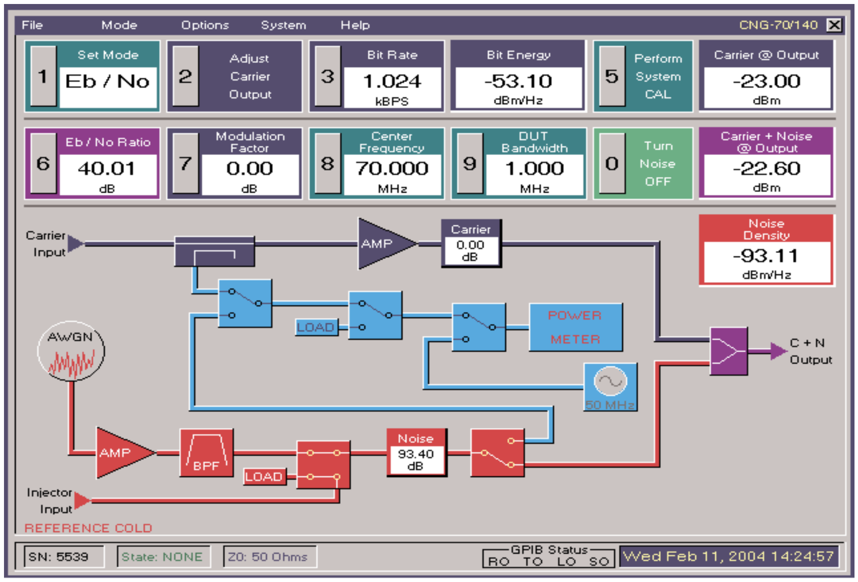


FIGURE 3

Rugged Construction: Micronetics uses only high quality components with very high MBTF. Special consideration is given to critical components such as the low EMI power supply and the PC104 based CPU. Micronetics manufactures its own critical RF components such as the amplified noise module and the embedded power meter. These components are rigorously tested prior to installation in the instrument for high reliability. Micronetics is the pioneer in amplified noise modules and has noise sources installed in such places as the USAF F-14 and F-16 fighters and weather satellites. The same hi-rel manufacturing processes are used for the amplified noise modules embedded in each CNG instrument.

Service: Micronetics uses a very modular design with a floppy disk drive for easy software upgrades and we regularly develop new algorithms and options. These updates can be installed by simply downloading an executable and/or data file onto a floppy and installing into the floppy drive of the CNG. Other E_b/N_o generators require sending the instrument back to the factory. The modular architecture of the CNG often allows faulty components to be changed in the field.

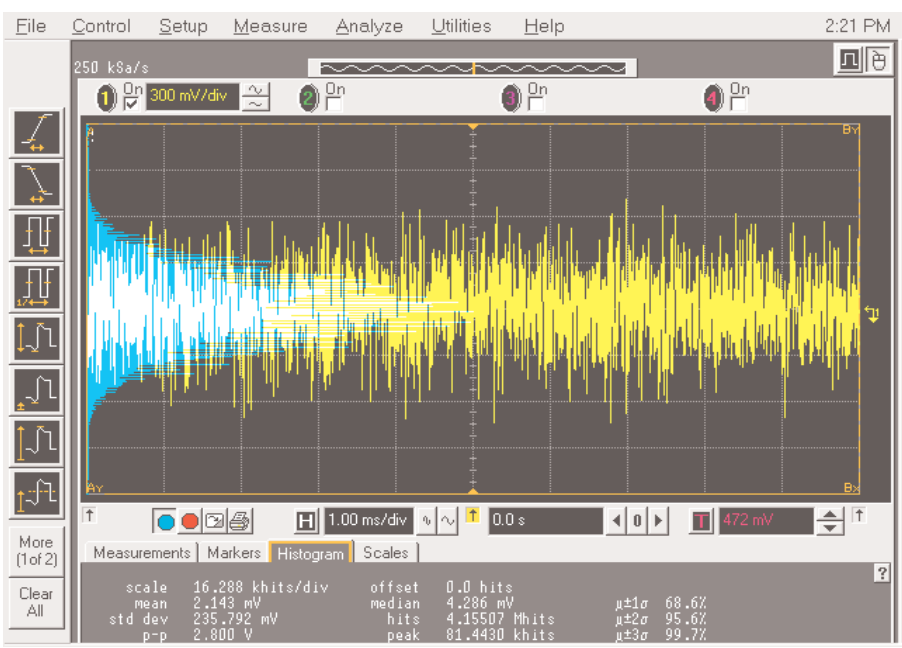


FIGURE 4

True Gaussian Noise: The validity of the BER vs E_b/N_o test is dependent on the noise source being truly Gaussian. Micronetics designs its noise sources to be as close to pure Gaussian as possible, only analog (not pseudo-random) solid-state devices are used. The noise source is also generated at the operating band required, even for broadband or higher frequency ranges. Lesser E_b/N_o generators may upconvert from a low frequency noise generator. This approach typically compromises Gaussianity because of mixer product spurs and LO bleed-thru. Lastly, Micronetics tests each unit for Guassianity rather than assuming the noise to be Gaussian. Figure 4 shows historgram data from an actual E_b/N_o generator.

Ratio Modes:

E_b/N_o: This is the most commonly used ratio for systems using digital modulation. Most digital modulation schemes are conventionally specified in terms of theoretical BER vs E_b/N_o performance. Modems typically have a spec in which actual performance must be within some amount of theoretical. E_b is calculated by the following expression:

E_b= C/(data rate)	Eqn 1:	(linear expression)
E_b = C - 10log(data rate)	Eqn 2:	(decibel expression)

The CNG requires the operator to enter in the data rate. The CNG measures the signal power, normalizes it to the output port and displays the results. The user enters in the desired ratio and the instrument automatically makes the conversion using Eqn 2. As both E_b and N_o are expressed in units of dBm/Hz, the ratio is dimensionless and is expressed simply in dB. Typical testing requires set ratios in the range of 3 to 12 dB.

C/N Mode: This mode of operation is traditionally used in analog radios where N is the receiver or channel noise equivalent bandwidth. In this mode, the operator enters in the noise equivalent bandwidth of the channel under test. The operator then enters in the desired ratio of the carrier power C to the noise power N in this channel bandwidth. The CNG automatically normalizes the noise to the user's entered channel bandwidth to achieve the correct ratio. Mathematically, the expression is:

N = N_o * Bandwidth	Eqn 3:	(linear expression)
N = N_o +10log(Bandwidth)	Eqn 4:	(decibel expression)

As in E_b/N_o mode, the ratio is dimensionless and is expressed simply in dB. Typical ratio ranges are in the range of 10 to 40 dB.

C/N_o Mode: In this mode, there are no operator dependent variables. The C is measured and N_o is independent of bandwidth.
As C is in units of power in dBm and N_o is in units of spectral density or dBm/Hz, the ratio is not dimensionless and in decibel form is expressed as dB*Hz.

Additional Handy Features:

1) **Dynamic display of signal power at the S+N output port**
2) **Display of bit energy, noise density, noise power in user specified BW, signal power, and E_b/N_o ratios, and S+N total power**
3) **Noise, Carrier and data rate increment function (one touch operation)**
4) **Ratio Scaling: When enabled, dynamic ratio-scaling automatically preserves E_b/N_o (also C/N or C/N_o) ratio even if carrier power amplitude is fluctuating.**
5) **Noise on/off toggle button: At any time noise can be turned on/off (one touch operation)**
6) **User settable defaults for configuring the GUI**
7) **Duty Cycle feature: when selected, the user can enter in a duty cycle percentage and the instrument automatically scales the noise power to match the "signal on" state**

Standard Options

OPT001: *Make Before Break Carrier Path Attenuator* This allows the user to change the amplitude in the signal path without losing lock; especially useful in modem loop back testing where a break in the IF connection from the modulator to the demodulator requires the entire test to be reset. Along with the actual hardware, this option allows reverse setting of E_b/N_o which is defined as fixing the noise to a constant amplitude and adjusting the signal amplitude. Some test protocols require this method for generating waterfall curves. The range of the attenuation is 100 dB with a step size of 0.1 dB.

OPT002: *Standard Carrier Path Attenuator* This is similar to OPT001 but the attenuator will briefly break circuit when changing amplitude potentially causing the system to lose lock. This attenuator is less costly so if losing lock when adjusting the carrier signal amplitude is not a concern, than this may be preferable. This option does allow for reverse E_b/N_o setting. This option is typically selected for two primary reasons:

1) When the receive section requires a much lower signal amplitude than the transmit amplitude (i.e., the transmit amplitude is -20 dBm and the test requires the receive amplitude to be -80 dBm)

2) For R&D and qualification where it may be desired to run waterfall curves over several different carrier amplitude ranges to fully characterize a design. This option is also selected as purely a convenience if in the overall test system if there are no other ways to adjust the signal path amplitude.

OPT003: *Zero Carrier Path Loss* This option utilizes a high 3rd order intercept, low distortion amplifier in the signal through path to make up for the instrument's typical carrier path loss. This loss is caused by a combination of the path components which include the coupler that sends a portion of the signal to the power meter, the combiner which adds noise to the signal, the attenuator (if ordered) and the impedance transformer (if ordered). The magnitude of the loss is from 5 to 12 dB depending on the model and option package ordered. Generally, if the loss does not pose a problem, this option should probably not be ordered. Despite the high quality amplifier used, it is better not to have any unnecessary active devices in the test signal path.

OPT004: *Coupled Carrier Path Low Noise Amplifier* This option calls out a low noise amplifier in the coupled carrier path. This does not affect the test signals through path. It is selected if weak signal levels will be used going into the CNG carrier input port. The embedded power meter in the CNG units can accurately measure input signals corresponding to an optional input range of about from -30 dBm to -7 dBm. This option boosts the coupled signal path 30-35 dB for an accurate input range of -12 dBm to -62 dBm, and is typically selected for mobile telecom or terrestrial radio applications in which the noise is added to the RF signal. This is opposed to satellite modem loop back testing in which the noise is injected at IF, such as at 70/140 MHz. Mobile telecom test protocols typically use weaker signals (from -25 dBm to -60 dBm). In addition noise is often added after multi-path fading simulation such as in the case of IS-95 or 3GPP CDMA phone/base-station receive testing.

OPT004A: *Coupled Carrier Path LNA Bypass Switch* This option is selected to increase the dynamic range of the input signal. It is only ordered if OPT004 is also ordered. It allows signals to be accurately measured from -62 to +10 dBm. The default switch position is in the bypass state.

OPT005: *Interfering Signal Input for C/I Mode* This mode allows the user to set C/I ratios as well as C/N or E_b/N_o ratios. The interfering signal is generated externally and connected to the injector input port of the CNG. When selected, a transfer switch substitutes the interference signal for the noise signal. This option is typically not used in Satellite applications but is sometimes used in mobile telecommunications where the interfering signal simulates adjacent channel interference. This option has been offered as standard traditionally and was included in the now obsolete HP3708A. However, in our market survey, we found most programs did not require this feature, so we decided to make it optional.

OPT006: *Impedance* 75 Ohm impedance instead of 50 Ohm.

OPT006A: *Switchable Impedance* 75 Ohm impedance/50 Ohm impedance switchable.

OPT007: *RS/232 Interface* This option allows the CNG to be operated remotely using an RS/232 serial connection.

RF Specifications

Noise Generator:

Noise Spectral Density:	-80 dBm/Hz *(min @ 0dB attenuation state for CNG225 and CNG70/140 Models)*
	-85 dBm/Hz *(min @ 0dB attenuation state for CNG70/140-L Model @ 70/140 MHz bands)*
	-98 dBm/Hz *(min @ 0dB attenuation state for CNG70/140-L Model @ L-band)*
	-90 dBm/Hz *(min @ 0dB attenuation state for all other Models)*
Noise Crest Factor:	15 dB (min)
Noise Flatness: +	0.8 dB/400 MHz

Signal Path:

Amplitude Range	*See Chart 1*
Signal Input Impedance:	50 ohm (OPT003 for 75 ohm)
Insertion Loss:	model/option dependent
Input VSWR:	1.5:1 (max)
Connector:	Choose Type N, BNC or SMA Connector
Attenuator (optional)	0 - 100 in 0.1 dB Steps

Combined Output Path

Modes of Operation:	E_b/N_o, C/N, C/N_o
E_b/N_o* Step Size:	0.1 dB
E_b/N_o Accuracy:	0.15 dB RSS
E_b/N_o Ratio Range:	Depends on input signal level, data rate
E_b/N_o Ratio Range limits:	Dynamically displayed on screen/GPIB bus
Output Impedance:	50 ohm (OPT003 for 75 ohm)
Connector:	Type N, BNC or SMA

+ Flatness is defined as the overall window of the difference between the highest and lowest amplified peaks across the band.

* *E_b/N_o encompasses C/N, C/N_o ratio modes.*

General Specifications

Operation interfaces:	Front Panel keypad, keyboard, IEEE-488 interface
Display	Active Matrix Color LCD
19" Rack Mount:	Included as standard
Computer Hardware:	3.5" Floppy, PC keyboard
Software Upgrades:	Via 3.5" floppy disk.
Dimensions:	20" x 17" x 5.25" (3U rack)
Weight:	18 kg (max)
Shipping weight:	22 kg (max)
Shipping dimensions:	24" x 24" x 9.5"

Special Options

Special options can be available to meet specific customer requirements, consult factory.

1. Noise Filter Bank: this feature incorporates a switch filter bank in the noise (and sometimes the signal) path. Typically the filters have fairly high roll-off so the noise equivalent bandwidth can be accurately measured. In this mode, testing can be done with a known noise power in a known noise equivalent bandwidth. For this mode, the customer typically specifies 3 dB bandwidth, center frequency and filter type. For filter type, sometimes the construction such as 7-pole Tchebychev or 5-Pole Butterworth is specified. Other times a rejection spec is supplied. Still others actually supply the filters to Micronetics. Along with the filter bank, often times, one of the switch positions is to an external in/out connectors so an external filter can be used.

2. Special GUI: Some customers have special test routines often as a result of custom equipment which the Micronetics CNG is replacing. The extra cost of the software change is often well worth it if it negates having to update documented procedures, require external calculations and prevent human error.

3. Alternate Specifications. Sometimes special cases require more noise power, higher signal power dynamic range or other requirements. Micronetics can usually accommodate these simply by altering a component inside and/or altering the software.

Available Models

Model	Frequency Range	Applications
CNG-055	1 to 10 MHz	Baseband
CNG70/140	50 to 90 MHz; 100 to 180 MHz	70/140 MHz Modem and Satellite IF Loopback, HP3708A
CNG225	50 to 400 MHz	General purpose IF
CNG1015	30 to 2000 MHz	Terrestial Radio, UHF, VHF, L-Band
CNG1600	950 to 2250 MHz	L-Band Modem and Satellite Loopback Testing
CNG70/140-L	50 to 90; 100 to 180; 850 to 2250 MHz	70/140, L-band Modem & Satellite IF Loopback Testing
CNG892/1850	822 to 962; 1710 to 1990 MHz	CDMA Mobile Phone and Base Station Receiver Testing
CNG2105	1710 to 2500 MHz	3G Mobile Telecom, CDMA Wireless Local Loop
CNG2442	2400 to 2484 MHz	ISM, Wifi, Bluetooth

Chart 1

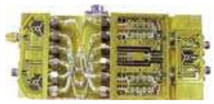
All values in dBm

CNG70/140 and CNG225		Range Total Signal In	Range Ideal Signal In	Range Total Signal Out	Range Ideal Signal Out	In max (No Damage)	Insertion Loss
notes:	Plain	-37 to 0	-30 to -7	-44 to -7	-37 to -37	+20	7 dB
Output range @ 0 dB carrier Attenuation	Opt001/002	-37 to 0	-30 to -7	-46 to -9	-39 to -39	+20	9 dB
	Opt003	-37 to 0	-30 to -7	-37 to -0	-30 to -7	+12	0 dB
	Opt004	n/a	n/a	n/a	n/a	n/a	n/a
	Opt004A	n/a	n/a	n/a	n/a	n/a	n/a
CNG892/1850, CNG1600, CNG1015 and CNG70/140-L		Range Total Signal In	Range Ideal Signal In	Range Total Signal Out	Range Ideal Signal Out	In max (No Damage)	Insertion Loss
notes:	Plain	-37 to 0	-30 to -7	-46 to -9	-39 to -16	+20	9 dB
Output range @ 0 dB carrier Attenuation	Opt001/002	-37 to 0	-30 to -7	-48 to -11	-41 to -18	+20	11 dB
	Opt003	-37 to 0	-30 to -7	-37 to -0	-30 to -7	+12	0 dB
Opt004/4A apply only to CNG892/1580	Opt004	-67 to -30	-60 to -37	-76 to -39	-51 to -46	0	9 dB
	Opt004A	-67 to 0	-60 to -7	-76 to –9	-69 to -9	+12	9 dB
CNG2105 and CNG2442		Range Total Signal In	Range Ideal Signal In	Range Total Signal Out	Range Ideal Signal Out	In max (No Damage)	Insertion Loss
notes:	Plain	-37 to 0	-30 to -7	-46 to -9	-39 to -16	+20	9 dB
Output range @ 0 dB carrier Attenuation	Opt001/002	-37 to 0	-30 to -7	-49 to -12	-42 to -19	+20	12 dB
	Opt003	-37 to 0	-30 to -7	-37 to -0	-30 to -7	+12	0 dB
	Opt004	-67 to -30	-60 to -37	-76 to -39	-51 to -46	0	9 dB
	Opt004A	-67 to 0	-60 to -7	-76 to –9	-69 to -9	+12	9 dB

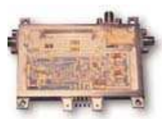
Interpreting Chart 1:

The matrix above gives both the input and output ranges in dBm for each CNG model with each of the standard options. There are two sets of ranges, one is the ideal range for highest accuracy and the other is the total or functional range. The reason for the two sets is that the very complex signals such as 256 QAM, Faded CDMA base station receive signals, and 7/8 coded QPSK have a very high peak factor and large time constant. The built-in power meter can accurately measure these, but over a narrower dynamic range than less complex signals. The built-in power meter does have powerful signal processing and curve fitting algorithms to accurately measure complex signals. Micronetics chose these limited ideal ranges based on extensive data taken over many modulation schemes and data rates. We chose to be conservative because the CNG instruments are universal to any modulation type, the output corresponds to the input signal amplitude range less any insertion loss from input to output. If the carrier signal attenuator option is ordered, The output signal range corresponds to the 0 dB attenuation setting of the carrier attenuator. Obviously the overall output range is much greater corresponding to the range at the 0 dB setting plus 99 dB.

Noise Products Group
Hudson, NH
Tel 603-883-2900
Fax 603-882-8987
noisesales@micronetics.com



Receiver Subsystems
Hudson, NH
Tel 603-883-2900
Fax 603-882-8987
ccsales@micronetics.com



Converter Subsystems
Fairfield, NJ
Tel 973-244-1040
Fax 973-244-1188
apospishil@micro-con.com

Switch Filters
Danbury, CT
Tel 203-792-7474
Fax 203-792-7475
mvsmicro@att.net

High Power Components
Topsfield, MA
Tel 978-887-8234
Fax 978-887-2341
sales@enonmicrowave.com

Voltage Controlled Oscillators
Hudson, NH 03051
Tel 603-579-0900
Fax 603-579-0776
vcosales@micronetics.com

MICRONETICS
TEST SOLUTIONS

26 Hampshire Drive Hudson, NH 03051
Tel: (603) 883-2900 Fax: (603) 882-8987
Email: testsales@micronetics.com
www.micronetics.com