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.

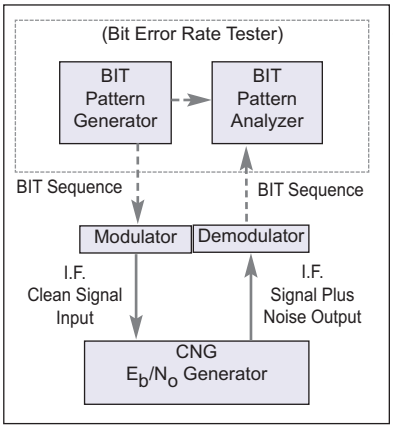
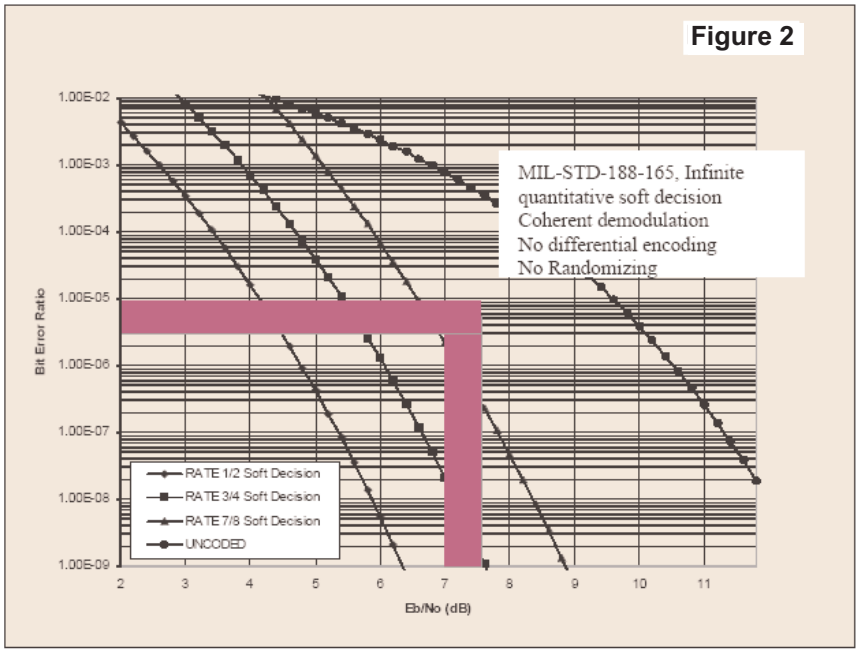


Figure 1

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.

Figure 2



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:

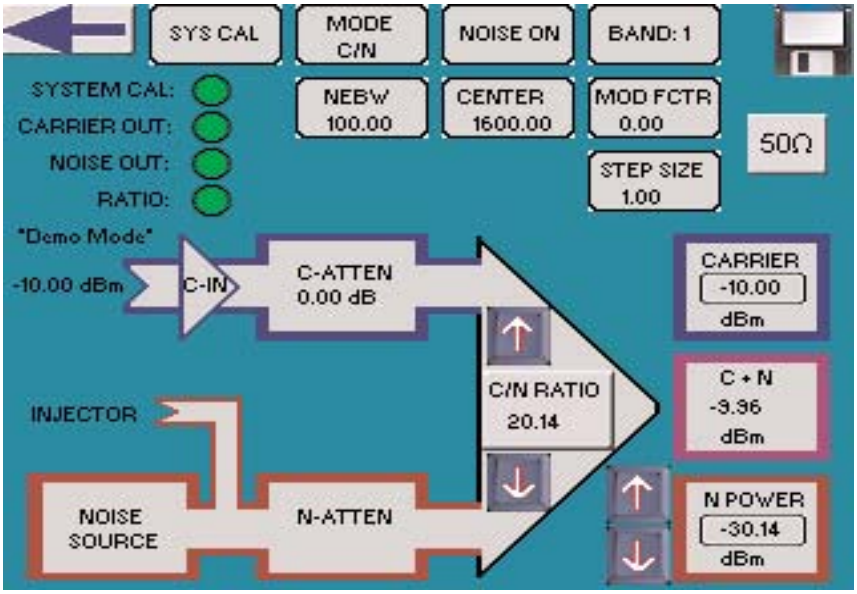
• *Noise Base:* The noise engine inside is a regulated amplified noise module. Several gain stages are required to test over a wide dynamic range of noise power. However, no active device has perfectly stable gain, so the noise base test uses the internal power meter to check any slight differences and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

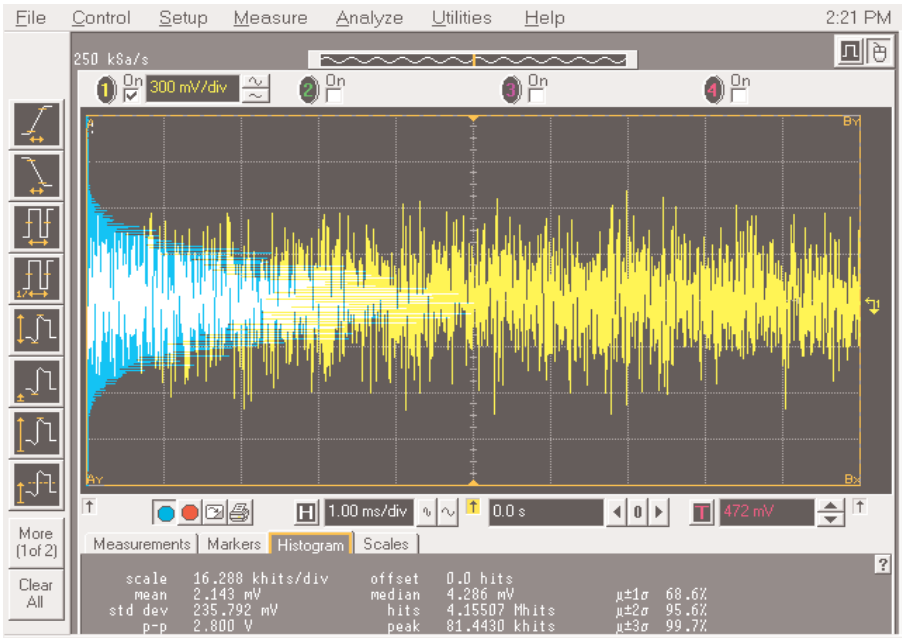
Ease of Use: Micronetics incorporates an intuitive touch screen GUI making it easy for a technician to start testing without having to pour over pages and pages of the manual, conversion tables and nomographs. The ethernet interface allows for simple remote network operation. Math functions are built 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.



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 single board computer and ompact flasht memory 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 USB port 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 USB and installing into the USB port 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.



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 express-ed 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 +10 log(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 No 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: ***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.

OPT003: ***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.

OPT004: ***Impedance*** 75 Ohm impedance instead of 50 Ohm.

OPT005: ***Switchable Impedance*** 75 Ohm impedance/50 Ohm impedance switchable.

RF Specifications

Noise Generator:

Noise Spectral Density:	-80 dBm/Hz *(min @ 0dB attenuation state for CNG70/140 & CNG225 Models)*
	-85 dBm/Hz *(min @ 0dB attenuation state for CNG70/140-L Model @ 70/140 band)*
	-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 (OPT004 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
Eb/No* step size:	0.1 dB
Eb/No Accuracy:	0.15 dB RSS
Eb/No Ratio Range:	Depends on input signal level, data rate
Eb/No Ratio Range limits:	Dynamically displayed on screen/GPIB bus
Output Impedance:	50 ohm (OPT004 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 ethernet interface
Display	Active Matrix Color LCD
19" Rack Mount:	Included as standard
Computer Hardware:	Single board computer, compact flash PC Card, Touch Screen
Software Upgrades:	Via USB
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.

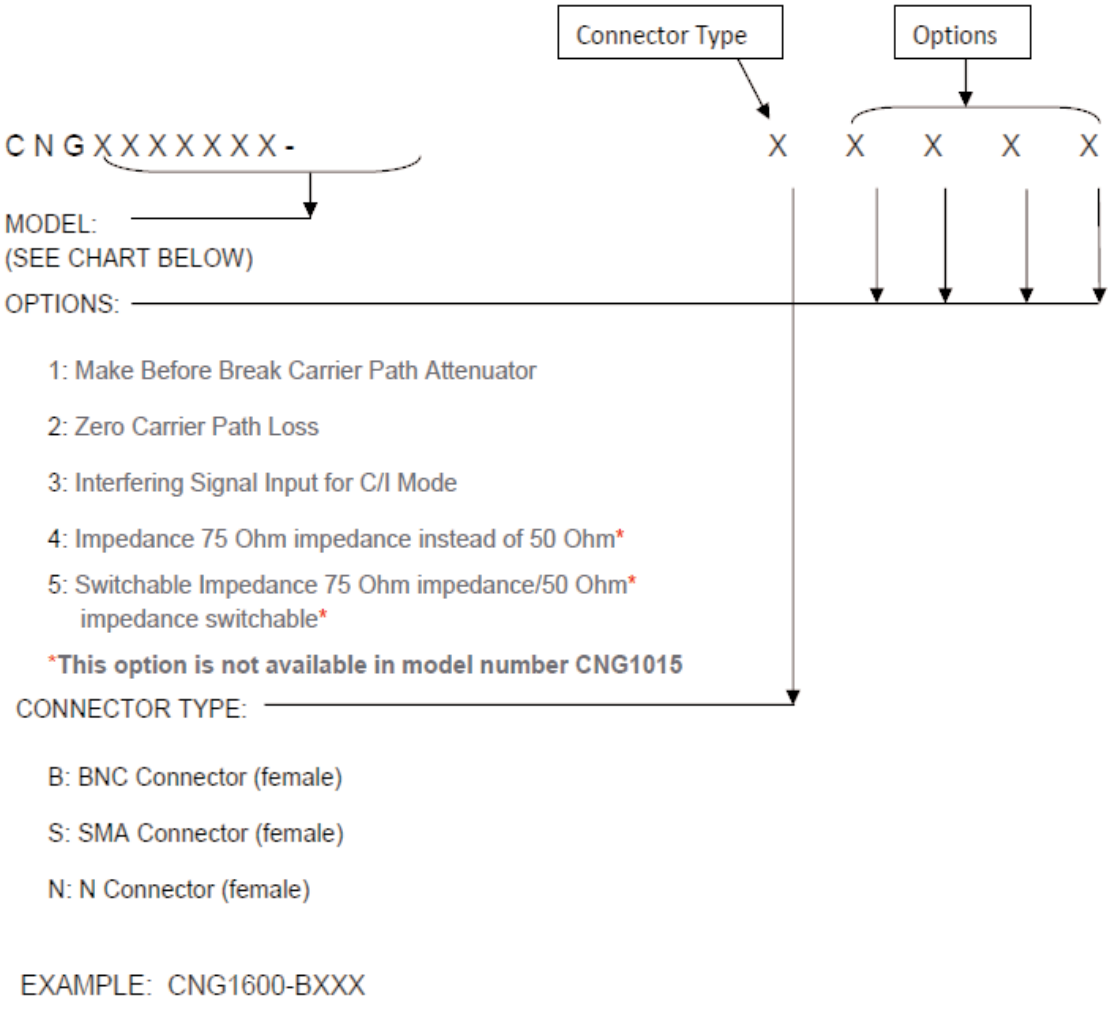
1. Noise Filter Bank: this feature incorporates a switch filter bank in the noise (and sometimes the signal) path. Typically the filters have fairly high roll-off so the noise equivalent bandwidth can be accurately measured. In this mode, testing can be done with a known noise power in a known noise 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
CNG70/140	50 to 90 MHz; 100 to 180 MHz	70/140 MHz Modem Testing, Satellite IF Loopback, HP3708A Replacement
CNG225	50 to 400 MHz	General purpose IF
CNG1015	30 to 2000 MHz	Terrestrial Radio, UHF, L-Band
CNG1600	950 to 2250 MHz	L-Band Modem and Satellite Loopback Testing
CNG70/140-L	50 to 90; 100 to 180; 950 to 2250 MHz and 1710 to 1990 MHz	70/140, L-band Modem & Satellite IF Loopback Testing
CNG2105	1710 to 2500 MHz	3G Mobile Telecom, CDMA Wireless Local Loop
CNG2442	2400 to 2484 MHz	ISM, Wifi, Bluetooth



www.micronetics.com

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About Micronetics:

Micronetics manufactures microwave and radio frequency (RF) components and integrated sub-assemblies that are the enabling technology used in a variety of wireless, aerospace and defense applications (satellite communications, electronic warfare and counter-measures). We also design and manufacture test equipment and components that test the strength, durability and integrity of signals in communications and internet infrastructure equipment.

Our Facilities:

Our principal design center and corporate offices are located in Hudson, NH. We operate four additional manufacturing facilities located throughout the Northeastern corridor and California

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- In 2007, we acquired **Mica Microwave, Inc**., located in Manteca CA. This acquisition provides our customers with the addition of a comprehensive line of high performance mixers and ferrite devices.
- In 2005, we acquired **Stealth Microwave, Inc**., located in Trenton NJ. This acquisition provides our customers with a broader range of Microwave RFproducts, including world class amplifiers.
- In 2003, we acquired **Microwave Concepts, Inc.**, located in Fairfield NJ. This acquisition is consistent with our goal of continuing to expand our RF Microwave capabilities by building up our resources to manufacture and design complex integrated subassemblies.
- In 2002, we acquired **Enon Microwave, Inc,** located in Topsfield MA; adding expertise in high power microwave control components.
- In 1999, we acquired **Microwave & Video Systems (MVS)** which became our Switch Filter Products Group. This manufacturing facility is located in Danbury, CT.

Quality:

Micronetics is an ISO9001 certified company. We are further strengthening our internal processes and controls with the implementation of Lean Manufacturing.






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Receiver Components Group

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For more information contact our sales and engineering teams listed above, or visit our website for product specifications and more @ www.micronetics.com

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