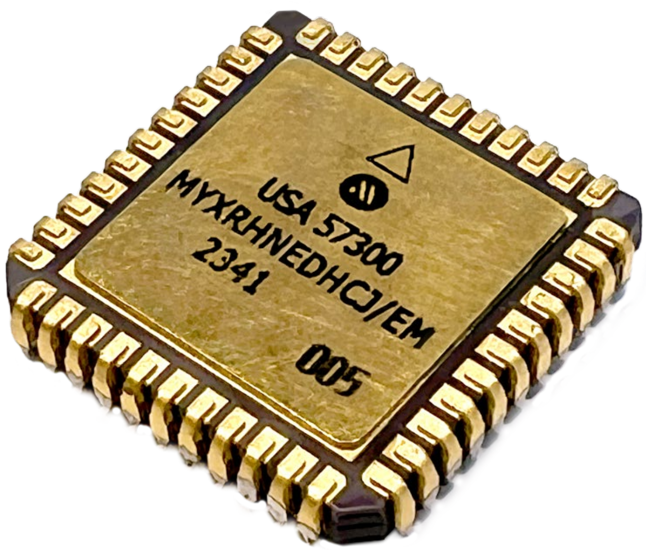
Nuclear Event Detector (NED)

Advance Information Datasheet

Part Number: MYXRHNEDHCJ/X

Rad-Hard



Preliminary Data Sheet

Micross Components' MYXRHNEDHCJ/X Nuclear Event Detector provides a functional replacement for the nearly 40-year old legacy NED solution. However, the MYXRHNEDHCJ/X provides improvements in multiple areas including reductions in size, weight and power of the implemented function; reduced minimum dose rate threshold, (4X lower), reduced detector delay time (25% faster), reduced dose rate threshold variation over temperature, packaging options, and improvements in obsolescence mitigation and reliability (in-house sourced PIN diode and ASIC).

Key Features

- Gamma dose rate sensitivity threshold range adjustable from 5×10^4 to 2×10^7 rads(Si)/sec.
- 44 pin J-Lead SMT package
- Differential line drivers and receivers
- Radiation specs:
  - Total Dose (device survivability): 1×10^6 rads(Si)
  - Dose Rate (operate through): 1×10^{12} rads(Si)/sec
  - Neutron Fluence (operate through): 5×10^{13} neutrons/cm^2
- Delay from radiation detected to output signal asserted: 15 ns
- 3.3V power requirement
- -55 to +125° C temperature range
- Differential line drivers and receivers all operate through prompt dose without extra shielding

Benefits

- Low minimum dose rate sensitivity
- Fast delay time to enable rapid shutdown and minimize damage to other electronics
- Rad hard for strategic environments
- Small size
- Built-in differential drivers and receivers provide improved noise immunity
- Use output signal to shut down power supplies, take processors offline and block memory write operations

Applications

- Aircraft and drones
- Missiles and bombs
- Satellites
- Military ground vehicles
- Nuclear Material Storage

Revision History

Revision	Description	Release Date
0.1	Initial Draft of Advanced Information Datasheet	08/15/2023
0.2	Updated After Testing	03/22/2024
1.0	Initial Release of Advanced Information Datasheet	04/08/2024
1.1	Correction to Table 1, Neutron Fluence	04/09/2024

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1.0 Description

Micross Components’ MYXRHNED Nuclear Event Detector (NED, Figure 1) can detect gamma radiation pulses from a nuclear event. Within 15 ns following the leading edge of an incoming gamma radiation pulse, the NED will assert its differential pulse and level output signals. The NED’s level output may then be reset by the assertion of a differential input signal. The MYXRHNED features a minimum dose rate threshold of 5 x 10^4 rads(Si)/sec, thereby providing higher sensitivity than currently available NEDs. Users can increase the dose rate threshold upwards, to up to 2 x 10^7 rads(Si)/sec, by means of an external adjustment resistor. The NED, which is available in a 44 pin J-Lead ceramic package, is radiation hardened, enabling it to operate reliably in environments with high gamma doses and dose rates, neutrons and heavy ions; and provide immunity to latch up. It achieves this by using a rad-hard-by-design ASIC designed specifically for this purpose. Since the ASIC contains the line drivers and receivers on-board as Rad Hard blocks, no additional consideration is need for those functions.

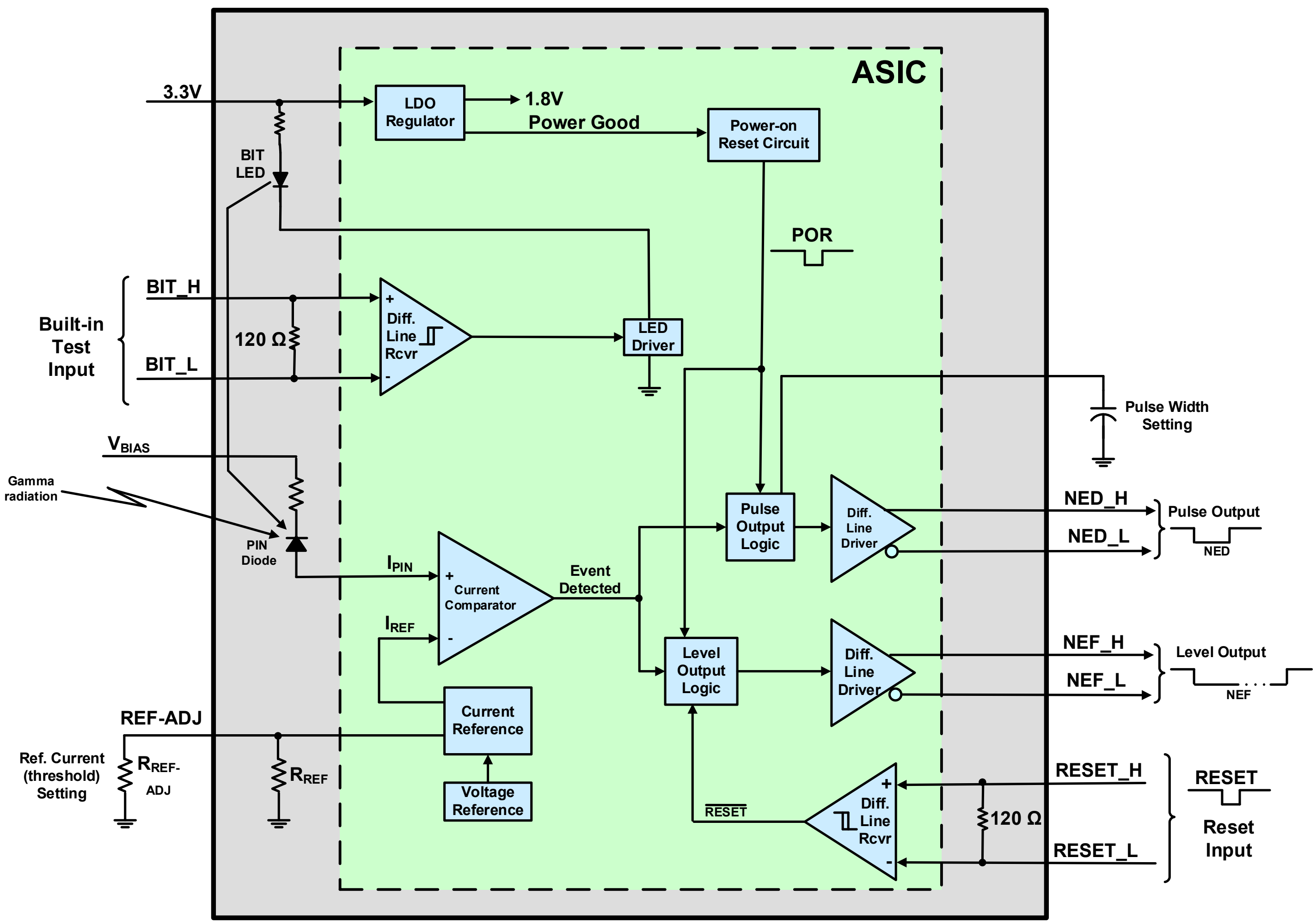

Figure 1. Nuclear Event Detector (NED) Block Diagram

2.0 Specifications

Table 1 provides the absolute maximum ratings for the MYXRHNEDHCJ/X nuclear event detector (NED), while Table 2 provides the electrical and mechanical specifications and characteristics.

Table 1. Absolute Maximum Range

Parameter	Min	Max	Unit
Hardened Supply Voltage	-0.5	5.0	V
PIN Diode Bias Voltage	0	100	V
Differential Receivers Line Voltage	-8.0	8.0	V
Differential Drivers Line Voltage	-0.5	3.6	V
ESD Sensitivity	Class 2		
Junction Temperature, TJ	-55	150	°C
Storage Temperature Range	-65	150	°C
Total Dose (Device Survivability)		1×10^6	rads(Si)
Dose Rate (Operate Through)		1×10^{12}	rads(Si)/sec
Neutron Fluence		5×10^{13}	neutrons/cm^2
SEE LET Threshold		40	MeV-cm^2/g

Table 2. Electrical Specs and Characterisitics

Parameter	Symbol	Conditions	Min	Max	Unit	Group A Subgroups
Approximate Dose Rate Detection Range		V_{BIAS} = 20 volts	5×10^4	2×10^7	Rads(Si)/sec	
Dose Rate Threshold Variation Over Temperature		Relative to Room Temperature Threshold Over Temperature Range	-20	+20	%	
Hardened Power Supply Operational Voltage	V_{CC}		3.0	3.6	V	1,2,3
Hardened Power Supply Current (Notes 1 and 2)	I_{CC}	V_{CC} = 3.3V				1,2,3
Both differential driver output circuits unterminated				5	mA	
One differential driver output circuit terminated				35	mA	
Both differential driver output circuits terminated				65	mA	

Parameter	Symbol	Conditions	Min	Max	Unit	Group A Subgroups
PIN Diode Bias Voltage	V_{BIAS}		4.5	100	V	1,2,3
PIN Diode Bias Current Standby	I_{BIAS}			10	µA	1,2,3
Radiation propagation delay time (Notes 3 and 4)	t_D	V_{BIAS} = 20 Volts			ns	
Gamma dose rate = 1 x 10^5 rads(Si)/second				20		
Gamma dose rate = 2 x 10^5 rads(Si)/second				15		
Gamma dose rate = 2 x 10^7 rads(Si)/second				7		
Differential Receivers' Voltage Threshold	V_{DR}	V_{CC} = 3.3V	-0.2	0.2	V_{PK}	1,2,3
Differential Receivers' Common Mode Voltage Range	V_{CM}	V_{CC} = 3.3V	-7.0	7.0	V	1,2,3
Differential Receivers' Hysteresis Voltage	$V_{RX\text{-}HIST}$	V_{CC} = 3.3V	50 typ.		mV	1,2,3
Differential Line Driver Differential Output Voltage	V_{DT}	V_{CC} = 3.3V	3.0	10.0	$V_{PK\text{-}to\text{-}PK}$	1,2,3
Pulse Output Pulse Width Range	t_{PULSE}	Adjustable by External Capacitor	0.1	10	ms	
RESET Pulse Width	t_{RESET}		250		ns	9,10,11
Operating Temperature Range	$T_{OPERATION}$		-55	+125	°C	
Package Options			Plastic and Ceramic BGA			
Outline Dimensions			8 x 8 x 3 typ (0.31 x 0.31 x 0.12 typ.)		mm (in)	
Mass (weight) Plastic BGA			0.2 typ. (0.007 typ.)		g (oz)	
Ceramic BGA			0.5 typ. (0.018 typ.)		g (oz)	
Lot Qualification and Acceptance Testing			In accordance with MIL-PRF-38534 Class H			

Notes:

1. The max. values for I_{CC} assume the dose rate threshold is set to its minimum value of 5 x 10^4 rads(Si)/sec. For the external adjustment threshold resistor selected for the maximum dose rate threshold of 2 x 10^7 rads(Si)/sec, the max. value of I_{CC} increases by 7 mA.
2. For the NED and NEF line drivers, the termination loads on the line drivers are assumed to be 120 ohms differential (resistive). The use of RC terminations will reduce power dissipation accordingly.
3. Dose rate threshold is set to its minimum value of 5 x 10^4 rads(Si)/sec.
4. Delay time t_D is defined as the time from the 50% point of the rising edge of the incoming gamma radiation pulse to the 50% point of the high-to-low voltage transition for the NED and NEF differential output signals.

3.0 Operations

3.1 ASIC-Based Design

Micross' ASIC-based design provides multiple benefits relative to legacy nuclear event detectors:

1. It enables construction of a NED in a smaller and lighter package, capable of surviving prompt dose radiation.
2. Inclusion of differential drives on chip improves overall response time, while legacy products suffer further response time degradation when external drivers are added.
3. By greatly reducing the number of components, wire bonds and interconnects, the Micross NEDs' reliability (MTBF) will be significantly higher than that of other NEDs.
4. Use of sub-micron ASIC technology and operation from lower power supply voltages will reduce the NED's power consumption and dissipation.
5. As a means of mitigating against obsolescence, Micross is not dependent on third-party suppliers for key components.
6. Micross' selected Trusted foundry is on-shore and offers a 180 nm process with the capability to produce chips that meet the NED's radiation requirements. These requirements are:
   - Total gamma dose: 300 krads (Si), with a goal of 1 Mrads (Si)
   - Gamma dose rate (operate-through): 1 x 10^{12} rads(Si)/sec
   - Neutron fluence: 10^{13} n/cm^2

3.2 Functional Overview

As shown in Figure 1, the MYXRHNEDSP(C)B/H NED includes a 3.3V-to-1.8V LDO regulator. With the exception of the PIN diode and the two differential line drivers, all circuitry in the NED is powered by this on-ASIC 1.8V supply rail. The two differential line drivers are powered directly by the 3.3V input power.

The NED includes a PIN diode to sense incoming gamma radiation from a nuclear explosion. Gamma radiation will result in current flowing through the reverse-biased PIN diode into the "+" side of a current comparator.

The input to the "-" side of the current comparator is provided by a reference circuit. This reference current is user-adjustable by means of the external resistor RREF-ADJ (see Figure 1). Installing a lower value for RREF-ADJ will increase the value of the reference current and as a result, increase the value of the NED's dose rate threshold.

When the PIN diode current exceeds the reference current, the output state of the comparator will assert active, thereby indicating that a nuclear event has been detected.

Following power turn-on, when the 1.8V regulator senses that its output has exceeded a voltage of approximately 1.0 volt, it will assert its POWER GOOD output signal. This will result in the generation of a negative-going “POR” (power-on reset) pulse. This pulse will reset the NED’s two differential outputs NED and NEF to their quiescent (inactive) states of logic “1”. Once this occurs, the NED and NEF outputs will remain in their de-asserted states (high) until a nuclear event is detected.

Following the detection of a nuclear event, NED and NEF will transition from their quiescent, de-asserted states of logic “1” (high) to their active, asserted states of logic “0” (low). The NED output will assert low for a fixed amount of time, as determined by the value of an external capacitor (Figure 1). The NEF (Flag) output will remain asserted until the receipt of a negative going pulse on the RESET differential input. A logic “0” pulse on the RESET input of 250 ns or more will clear the NEF output back to its de-asserted state.

3.3 PIN Diode

Similar to most existing NED designs, the sensing element in Micross’s Nuclear Event Detector is a PIN diode. Most commercially available PIN diodes targeted to sensing applications are designed to operate at longer wavelengths, such as RF, visible, infrared and X-ray. In particular, they’re not designed to be optimized for detecting gamma radiation. For use in its NED, Micross has designed and fabricated its own PIN diode that’s optimized for detecting gamma radiation. This internal development and captive manufacturing will ensure Micross with a reliable supply of PIN diodes, providing very strong mitigation against future obsolescence.

During the PIN diode development, Micross Components focused on the goals of wide dynamic range and fast response time in response to short duration pulses of gamma radiation. The PIN diode development involved extensive testing and characterization of the PIN diode in a Flash X-Ray facility.

3.4 Detector Circuit

In addition to the PIN diode, the most critical functional block of the NED is its detector circuit. For this function, Micross designed a current comparator circuit in its NED ASIC. In contrast to the voltage comparator used in legacy NEDs, Micross’s use of a current comparator provides better speed performance by minimizing the impedance seen by the detector. This minimizes the value and effect of the circuit’s inherent RC time constant.

The detector circuit includes a reference current circuit. The reference circuit provides a DC current output based on the input from a precision voltage source. To allow users to set the value of the NED’s dose rate threshold, the reference current and therefore the dose rate threshold is programmable by means of an external resistor. The reference current circuit includes temperature compensation to offset temperature-dependent variations in the PIN diode and the current comparator. One of the goals for the detector’s current comparator circuit is to provide very fast detection speed that’s largely independent of the NED’s threshold sensitivity setting.

Based on the use of a custom PIN diode and the inherent advantages of a current comparator, the MYXRHNEDSP(C)B/H provides superior performance for minimum dose rate threshold and delay time performance. The MYXRHNEDSP(C)B/H provides a minimum dose rate threshold of to 5 x 10^4 rads(Si)/sec or lower. The major benefit of this is to detect the fast rising edge of the nuclear event sooner and to reduce the number of false negative indications.

Relative to other NEDs, the MYXRHNEDSP(C)B/H also provides a significant improvement for the delay time between the leading edge of a gamma radiation pulse and the assertion of its output signal. The MYXRHNEDSP(C)B/H will reduce the value of this internal time delay to 15ns. For users, NED delay time is a critical parameter, since shorter delays enable improved protection of other on-board electronic circuitry.

3.5 Differential Line Drivers and Receivers

As shown in Figure 1, the MYXRHNEDSP(C)B/H includes differential line drivers and receivers for the various digital output and input signals. It includes differential drivers for the NED pulse output and NEF level output, and differential receivers for the RESET and BIT input signals.

Differential drivers and receivers provide improved signal integrity, noise rejection and common mode rejection relative to single-ended divers and receivers, especially single-ended drivers consisting of open-collector or open-drain circuits. Micross designed the differential drivers and receivers to provide reliable operation in the presence of the types of noise transients that occur during nearby nuclear events. To lessen the effects of noise, the receivers include built-in circuit protection, hysteresis and common mode rejection. The NED's differential drivers and receivers are designed to meet or exceed the requirements of the EIA RS-422 standard. For the transmitter outputs, this will include a minimum differential output voltage of 3.0 volts peak-to-peak.

The differential receiver for the RESET input will be biased to provide a logic "1" (inactive) output when there's no incoming signal, while the differential receiver for the BIT (Built-in Test) input will be biased to provide a logic "0" (inactive) output when there's no incoming signal. In addition, the differential receivers will include positive and negative threshold voltages of less than ±0.2 V peak, provide a minimum hysteresis voltage of 50 mV and operate with common mode voltages equal to or greater than the range of -7V to +7V.

The external signals for the differential and single-ended line drivers and receivers will include clamping diodes to VCC and GROUND to protect against electrostatic discharge (ESD).

The delays through the MYXRHNEDSP(C)B/H's on-ASIC differential line drivers are approximately 5 ns. Note that other NEDs provide single-ended open-collector drivers rather than differential drivers. In order to gain the benefit of differential signaling using these NEDs, it's necessary to use external differential drivers. For the MYXRHNEDSP(C)B/H, the inclusion of the internal differential drivers provides a large improvement over the use of external drivers, which add additional delays of approximately 15 ns.

3.6 Radiation Testing

Each MYXRHNEDSP(C)B/H will be tested for a dose rate threshold of approximately 5 x 10^4 rads(Si)/sec, the specified minimum value within the range. The user will be able to increase the dose rate threshold by the addition of external resistance between the threshold adjust pin and ground.

3.7 Built-In Self-Test

To enable Built-in self-test (BIT), the MYXRHNEDSP(C)B/H will include an LED. This LED will be controlled by the differential BIT (built-in test) input signal. When BIT is asserted to logic "1", the LED will illuminate the PIN diode. During this test, if the Event Detected signal asserts high, the self-test will be considered to have passed and the

NED's output signal will assert active (low). However, if the Event Detected signal remains inactive (low), the self-test will be considered to have failed and the NED's output signal will remain inactive (high).

3.8 Packaging

For the MYXRHNEDHCJ/X, the package size is a 44 pin J-lead surface mount package 12 x 12 x 3 mm (0.31 x 0.31 x 0.12 in.)

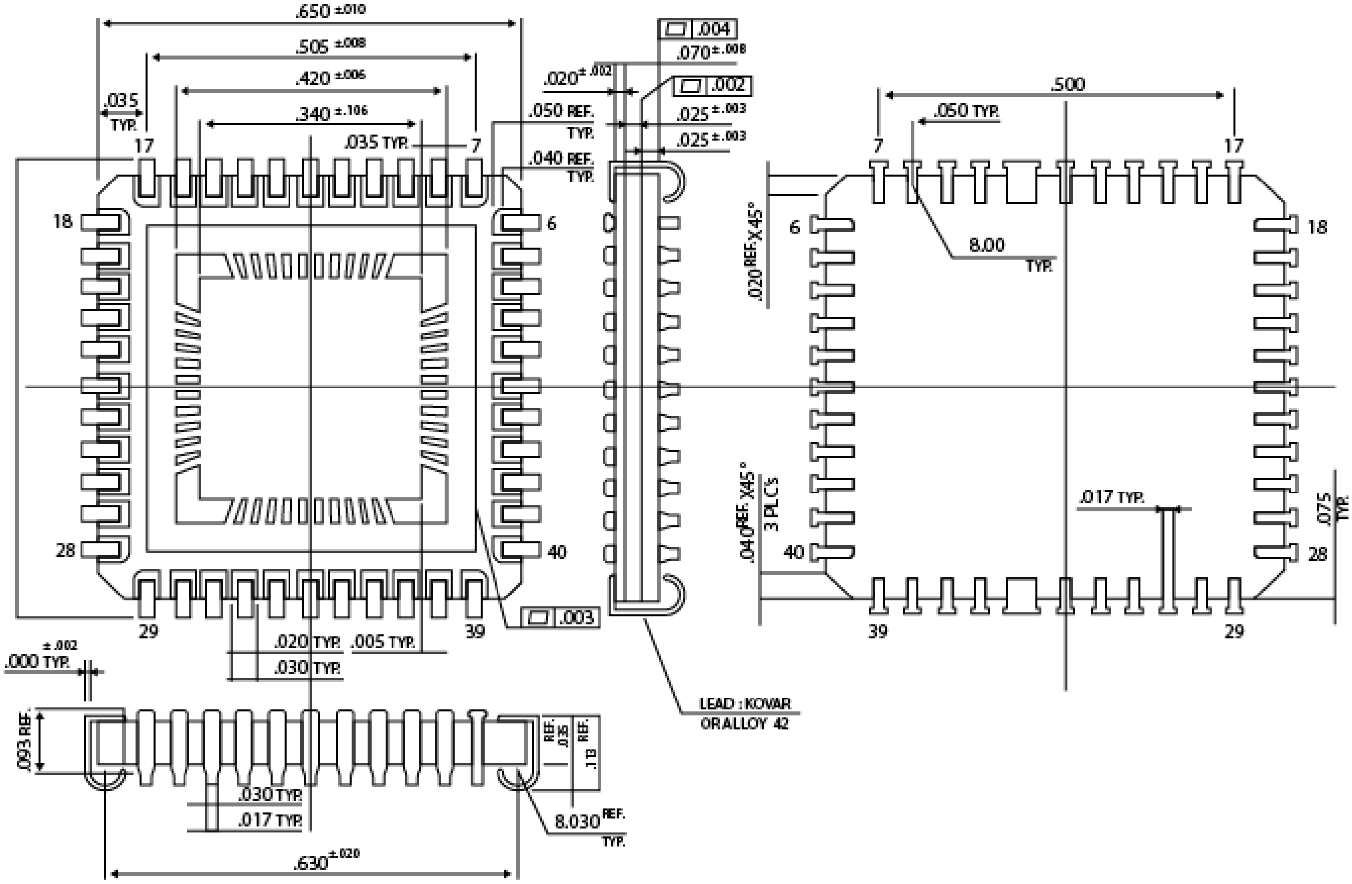

Figure 2. 44 Pin J-Lead Surface Mount Package

4.0 Ordering Information

MYX RH NED H CJ / X

Screening Flow

K	Space Flow
H	Mil Flow

Package

CJ	Ceramic 44 Pin J-Lead

Configuration

H	High Performance Functional Replacement for DDC HSN-3000 with Differentail Drivers and Receivers

Product

NED	Nuclear Event Detector

Radiation Rating

RH	Rad-Hard

Micross