OMNETICS
CONNECTOR CORPORATION

7260 Commerce Cir E, Minneapolis MN 55432

sales@omnetics.com | www.omnetics.com

+ 1 763 572 0656

THE MINIATURE CONNECTOR REVOLUTION IN DEFENSE ELECTRONIC DESIGN

Bob Stanton, Director of Technology

Our electrified defense industry, today, is rapidly expanding the use of centralized data management that reaches down and throughout all sectors of military operations. We see the focus on the eye-in-the-sky battlefield-coordination satellites supply data collection and processing, signal sensing and transmit directions to and from central control centers in the field. The same systems send directions directly onto the battlefield and actively monitors troop activities. There are sensors, detectors and surveillance devices mounted on equipment and from soldier-worn electronics on individuals. To serve this advanced technology, updated embedded electronics are designed to operate at higher signal speeds, offer more data processing, transmission, and storage. The solid-state circuitry industry has changed extensively to support this new wave and to compete with new military devices from near-Peer competitors.

New chip and materials such as GaAs (Gallium-arsenide) are being employed in much of the latest military technology for higher speed signal processing in microwave circuitry. Silicon chip technologies, using CMOS (Complementary Metal-Oxide-Semiconductor) offer improved base-line portable circuitry for memory storage, and digital processing in military computers, observation devices and remote-control circuitry for drones and autonomous weapons. These field-effect transistors and integrated circuits function rapidly on very low energy systems. Newer GaN (Gallium Nitride) circuits are improving surveillance and high end Ultra-violet

Nano Circulars Connectors

signal management (EUV). These Laser pulsed plasma circuits generate high power laser beams for very short wavelength light that can significantly increase the resolution of scanned images from as far away as satellites with LIDAR scanning equipment on board.

Newer defense based solid-state circuits operate on lower current and lower voltages which extends battery-life in the field. Portable radar systems are carried in backpacks. Multimode surveillance devices are carried or mounted on helmets and soldiers are individually monitored and report position on GPS systems. These new defense instruments also operate at high signal speeds while being increasingly more portable which demands their electronics must be smaller, rugged, and lightweight. As technical and data collection capabilities expands it is requiring the transport of additional data storage and transmission modules to be added. Quick and easy, but rugged and reliable, electronic cable and connector exchange is critical within the battlefield environment.

Micro-wave and coax cabling are also smaller and more miniaturized. Trends will include more applications for higher speed switching multiple frequencies in both transmit and receive modes. The shorter wavelengths of RF frequencies will insure miniaturization of more portable antennas. More densely packet modules can result from the miniaturization process and add to potential EMI and ESD sensitivity.

Electromagnetic Interference (EMI) issues are requiring improved shielding and RF leakage protection within the instrumentation as well as cable shielding and metal connector back-shells for the portable equipment. Interconnects will be needed to ensure low noise and crosstalk (NEXT) specifications are met. As signal speeds and multi-signal levels transmissions, such as in PAM (pulse amplitude modulation) methods increase noise and crosstalk will emerge as key specifications for cable and connectors, as well.

Army Portable Missile Guidance System

As PAM, techniques are being adapted to voltage level modulation methods the coax will carry multiple signals on one line. More portable and rugged Nano-and Micro Coax are emerging through a process of adaption on P.C board modules and evolving out to EOU (end of unit) to reduce size and weight. Specially designed Nano-coax and connectors are adapted for board to cable routing in instruments requiring high mobility.

As signal speed goes up and voltages decrease signal integrity design and management is critical to the functions needed in mobile military and aerospace systems. Connector to cable design requires a perfect match to the electrical application of the circuit. Digital signal quality is more often assured by using differential cable design that matches the impedance of the output and or input system of the processor boards and detectors. Secondly, proper shield and drain wire interconnections increase accuracy of the system and help ensure appropriate eye pattern quality. Eye patterns are used to evaluate the combined effects of channel noise and interference of pulsed-transmission system inside the cable. Shielding also improves the transmitted signal through the connector and cable assembly and reduce jitter and crosstalk. Reduced size, lower weight and ruggedness immediately follow in the list of important specifications to serve the needs of portable ground troop electronics, airborne equipment -such as UAVs - and in military satellite systems. Military connector designers must seriously plan and implement the use of military pin to socket elements that exceed the minimum requirements of wear during insertion and retraction force.

UAV Hand Launch Equipment

Entering a new era for military connector and cable

As in the past, the electronics are often exposed to wide ranges of environmental temperature ranges, constant vibration and high shock. They must also last for many years of non-use storage and they must be used immediately. Meeting military reliability specifications are often paramount in getting a connector and cable approved.

Key in meeting the specifications

1. Materials used to make the product.

2. Design for rugged sustainability in a wide extreme environment.

3. On large machines, the mounting and higher electrical current capacity often mandates design. On dismounted-soldier key issues include the need for rugged and lightweight performance.

4. On robotic or unmanned military systems, key elements include remote signal control integrity amid high electrical noise or cyber interruptive environments.

5. EMI and electrical noise protection is becoming more critical in many applications. Today, we must include adding the Rapid and Reliable Quick Exchange of Modules in the field. That includes various forms of disconnecting and reconnecting connector and cables to replacement units. A focus on ruggedized miniature designs are necessary today.

Quick and easy connections in the field

Connectors are designed to offer quick and easy replacement of modules from within the systems while on missions in the field. Military quality specialists such as Omnetics and other suppliers offer a variety of down-sized designs from circular and rectangular designs to strip and PZN formatted connectors.

Circular Micro and Nano-Connectors serve USB 3.0 speeds and higher in many signal formats from digital circuitry to sensor and detector information. Circular connectors by design are a natural shape for handling smaller and more flexible round cabling used for higher speed in tight environments including power systems. A portion of the industry still uses rectangular connectors for cable to board interface systems and panel-to-device equipment.

Circular shaped Micro and Nano Breakaway connectors provide a "Quick Release" function and have proven reliability and service. They are often designed with all-metal back shells and match braided shielded cable. Variations occur in both cable designs and pin arrangements and are designed to application specific needs.

Soldier Borne USB Connector

Note the image of a high-speed USB circular connector that carries both power and digital signals on a mixed signal cable with differential signal wiring. By including mixed signals, such as power and signals inside the same cable, we have reduced the total size and weight as well as cost of two parallel cable and connectors to serve the computers, communications and other functions often used on a warrior's uniform and helmet. This "quick release" system has proven to offer easy plug and remove functions while retaining signal integrity for high shock and vibrations such as those experienced in helicopter and UAV functions, as well.

Metal Micro-D rectangular connectors continue to fit well and reliability in many applications. Micro-Ds with reference to MIL-DTL-83513 offering wire to wire spacing at .050" handle wiring sizes up to 26 AWG and carry up to 3 amperes per line. The flex-pin mating elements are made in a one-piece design stamped from Beryllium Copper per ASTM B488 and ASTM B194 BeCu respectively.

Omnetics Latching Micro-d Connectors

The spring characteristics of BeCu is ideal for withstanding high shock and vibration situations and are plated with 50 micro inches (1.27 µm) of gold over 50 micro inches (1.27 µm) of nickel. All pins are plated post forming to insure a non-porous surface.

Quick Connection Latching Micro-D connectors have extended the old standard designs with rapid field change-over and installations

formats. The squeeze-latches are made of Stainless Steel springs and handles. The new latching connectors have been proven to work from -55˚C to +125˚C while maintaining signal integrity in shock up to 50gs and vibration to over 20gs as in the long-standing military specs. Metal backshells and braided shielding helps protect the system from EMI and potential cyber intrusion.

Board mount latching Micro-Ds are designed for mil. specification P.C layouts in both through-hole and SMT configurations. Shells can include sheer control brackets when specified.

Metal Nano-D rectangular connectors are being employed at a rapid pace as they have achieved performance of MIL-DTL-32139 that assures rugged reliability are significantly smaller for HDMI type signaling. Omnetics Nano-D connectors accept up to 30 AWG wiring that can handle up to 1 ampere per line. Mixed signaling is accomplished thru allocating sections of the connector for high speed and other areas to carry power.

Latching Nano-D Connector

Internal foil shielding in the cable isolate sections from one another. With lower weight and mass, the Nano-D connector is very popular in Defense Satellite systems. Hand launched drones and soldier- borne autonomous weapons are a perfect fit for Nano-D connectors. UAVs provide an improved value in surveillance and offer close control for monitoring wide area moving target indicators (MTIs), ground targets, and airborne early warning (AEW) radar surveillance in support of theater missile to ground defense. Aircraft sensors, GPS and guidance circuits must be small, lightweight and rugged

enough to function continuously during constant vibration and thermal changes. Often times they are squeezed into unique shapes and tiny spaces to support minimum size and weight needed for hand launch and or to be small enough to avoid visual detection from the ground.

Latching Nano-D mechanisms are also made of stainless steel are frequently used for reduced space and quick replacement of memory and control circuitry in autonomous defense systems. As Nano connector weight is significantly lower than larger connectors and cable, this helps when facing the physics of mass affects in shock and vibration during use. One test has proven to assist UAV re-use as often drone landings experience higher shock than during flight.

Testing and Certification of Micro and Nano connector Latches

Independent test labs are often used to insure that material selection and design can sustain the quality of a connection system when it experiences extreme environmental challenges. Omnetics latching systems have been tested for those extremes.

Key functions tested included:

- Mechanical Shock to evaluate the latching mechanism holding the plug to the receptacle in its

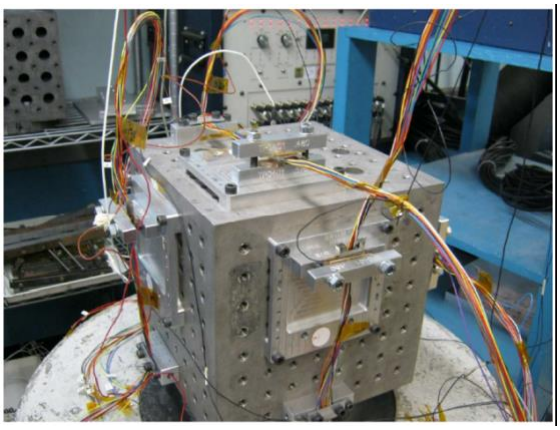
mated position. The receptacle was clamped into position as the plug was not restrained. Testing was according to MIL-DTL-83513 or 32139 to check both sizes of Micro and Nano connectors.

- LLCR (Low Level Circuit Resistance) tests were run at 100 milliamps and 20 millivolts with resulting resistance remaining well within specifications of the circuit.
- Sinusoidal Vibrations tests were run at 10 to 2000 Hz to 20 Gs for 4 hours over 3 axis.

Miniature Connectors Check-List

A first step in selecting Micro and Nano connectors is to review the design requirements of your system. Some key questions below are worth your time:

- *Size and shape – Will it fit and can you mate and de-mate at reduced size?*
- *Cable type and shape – Diameter of cable to enter back of the connector?*
- *Mate/De-mate method – Do you need ease & speed over very rugged screw-on method?*
- *Circuit type – Can signal impedance and power work for your circuit?*
- *Circuit speed – Analog or Digital, data rate or speed are your signals?*
- *Power – Can you share power with two pins or more?*
- *Shielding & EMI – Is your cable in the instrument and are there Noise or Crosstalk inside your circuits?*
- *Reliability and ruggedness – What environments will the cable be used?*
- *Mixed signals – Will you have mixed signal technologies, to be addressed?*
- *Overall Shielding and concerns about Cyber intrusion.*
- *Do you need quick and easy mating and de-mating for device replacement?*
- *How much and where is the space for latching mechanisms in your design?*



Shock and Vibration Testing

Getting the best fitting connector for your application

This begins with the above analysis and looking at your suppliers list of proven standard connectors. Select a standard device if you can. If you need changes, contact your connector supplier and ask to work on-line with a solid modeling expert. Online solid modeling and 3D samples for early prototypes are part of the new era. System designers are encouraged to call and work directly with connector designers for application specific adjustments to current mil. quality connectors. Most solid models should take less than 2 days and 3D fabrication less than 2 days. In a week, you can place it into your circuitry for fit and confirmation.

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