NOVA
POWER SOLUTIONS, INC.

Power Protection Selection for Military Applications

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1.0 Abstract

Large power supply manufacturers specialize in producing commercial-off-the-shelf (COTS) uninterruptible power supplies (UPS). These COTS products are designed for use in indoor, air-conditioned spaces and operate from clean power provided by the same local electric-utility provider that power our homes and businesses.

While these products are inexpensive and perform well in commercial and residential applications, they were not designed nor manufactured for the harsh environments and strict operational requirements of military applications. To meet the requirements of these more demanding applications it is essential that a high-quality, rugged product designed to pass strict military standards and made specifically for these harsh operating environments is deployed.

2.0 Differing Technologies

There are several different types of UPS's available. The most common are:

- Standby, or Off-line
- Line-Interactive
- True Online, Double Conversion

COTS UPS's are typically designed to operate using the clean, stable electricity provided to commercial and residential buildings. Standby (Off-line) and Line-interactive UPS's can be a suitable selection for these applications, but Online UPS's should be used when the input power is neither clean nor reliable, in harsh environments, and when the load equipment absolutely cannot fail.

Standby or Offline UPS

A Stand-by UPS typically offers only surge protection and battery backup capability. This type of UPS spends most of its life in stand-by mode, or off-line, waiting for a power loss event. It passes input electricity through to the output and performs little, if any, power conditioning during normal operation.

When a power loss event occurs, the inverter is switched on and the inverter from a battery provides output power. The time to switch from input electricity to inverter/battery power is typically 8-10ms, so the term "uninterruptible" probably isn't accurate and this interruption can cause load equipment to shutdown.

Additionally, the inexpensive inverter designs typical in Standby (Offline) and Line Interactive UPS's often produce a square or quasi-sine output waveform, and not a true sine wave. The lack of a pure sine wave output power waveform may cause sensitive load equipment to not work properly, constantly cycling on and off or just not working period.

LINE INTERACTIVE UPS

A Line Interactive UPS is similar to a Stand-By UPS in that Line Interactive UPS's also pass input electricity through to the output with little or no power conditioning, and the inverter only provides power during a power loss event.

The primary difference between a Standby (Offline) and Line Interactive UPS is a Line Interactive UPS may also feature an autotransformer on the input. The autotransformer allows the UPS to ride through brownouts and a wider range of sags, swells and excursions in the input line voltage before switching to inverter/battery backup power.

ONLINE UPS

An Online UPS is superior to Stand-by, Offline and Line Interactive UPS designs because an Online UPS works 100% of the time. Input AC electricity is continuously rectified to a DC bus and inverted back to AC (*def.* Double-conversion) where a true AC output sine wave form is provided. The AC-DC rectification stage eliminates electrical disturbances on the input power line, and the pure sine wave output waveform generated by the inverter provides the clean, reliable output power.

A True Online, Double Conversion UPS is truly uninterruptible because the inverter is online all the time so there is no interruption (0ms) in the output power waveform when the AC input source is lost. The inverter seamlessly transitions from AC input utility power to battery backup power without any interruption or disturbances in the true sine wave output waveform.

Most military applications are not afforded the luxury of having a clean, stable power source. Electricity for military applications can be generated many ways including but not limited to: shipboard turbine-diesel or nuclear generators, gasoline-powered field generator, vehicular battery power, or from a foreign electrical grid. In these instances, a True Online, Double Conversion UPS should be used to ensure clean, reliable power is provided.

3.0 Military Environments

There are several military standards products used in DoD systems must meet to ensure survivability in harsh environments. These military standards and specifications outline the minimum requirements products must meet for use in DoD systems.

MIL-STD-461, ELECTROMAGNETIC INTERFERENCE

The US Navy and Coast Guard shipboard environment is unique in that sensitive, electronic systems are often bunched close together in confined spaces. Individual electronic components may radiate and/or be susceptible to electromagnetic interference (EMI). Electronics that emit EMI may cause electronics that are sensitive to EMI to function improperly, which may cause a failure of the system.

MIL-STD-461E was established to identify requirements for the control of the electromagnetic interference (EMI) emission and susceptibility characteristics of electronics used in Department of Defense applications. There are eighteen (18) different sections for conducted emissions, conducted susceptibility, radiated emissions and radiated susceptibility. There are different limits for Army and Navy applications, and there are different limits for surface ships and submarines.

MIL-STD-167, MECHANICAL VIBRATION

The shipboard propulsion system produces a constant vibration felt throughout the ship that varies by the size, or length, of the ship. This constant vibration will slowly shake apart or loosen fasteners, connectors, solder joints, etc. and cause premature failures in electronic components. A properly designed cabinet will feature shock-mounts to dampen the vibration, but shipboard vibration can still reduce the life expectancy of sensitive electronic components.

MIL-STD-167 simulates ten years of shipboard life in just a few days by sweeping a range of frequencies across all three principle axis, identifying resonant frequencies, and vibrating at those resonant frequencies for at least two hours. The test can take several days to complete and is considered destructive.

MIL-STD-1399 SECTION 300, AC ELECTRIC POWER

A ship floating out in the ocean can't use the earth as a ground-plane, so the shipboard power generator produces a delta, ungrounded electrical system that is very different from the wye, or grounded, power we're familiar with in residential and commercial (land-based) buildings.

Delta power is comprised of two "hot" lines with a 60° phase difference and is not referenced to ground. The two hot lines measure 115VAC when referenced to each other, but may measure between 45-165VAC when measured to an unreferenced ground. Wye power is comprised of one "hot", one neutral and one ground and the hot measures 115VAC when referenced to either neutral or ground.

Load equipment that is provided delta power and referenced to ground may see voltage swings as low as 45VAC and as high as 165VAC where it's normally expecting 115/120VAC. The low voltage is enough to cease normal operation (shutdown) and the high voltage is enough to permanently damage many electronic component parts.

Also, small, closed shipboard electrical systems should isolate electrical disturbances from re-entering the electrical system. Electrical disturbances such as load harmonics may be generated in one section of the ship and cause electronic equipment to malfunction in another section that shares the same electrical circuit. Power factor-corrected UPS's and isolation transformers have been shown to keep closed electrical systems clean and prevent load harmonics from re-entering the electrical system.

MIL-S-901, Shock

The most impressive of the military standard or specification testing is probably the MIL-S-901 Heavyweight Barge Test. This test simulates an instant mechanical shock to the ship's hull and it's effect on nearby ships systems. There are three types: the Lightweight and Medium weight tests are "hammer" tests where a large pendulum swings and hits a platform the system is mounted to, and the Heavyweight test involves a barge floating in a water-filled quarry and large explosives.

Electronic equipment mounted in a cabinet undergoing the Heavyweight Barge test can be subjected to 10-100G's of force in all three principle axis depending on whether the cabinet is mounted with shock-absorbing mounts, or hard-mounted to the ship's hull. These forces are enough to bend and twist steel enclosures and the electronics contained within.

This is probably the most difficult test to pass due to the extremely high amount of mechanical stress introduced to the components mounted inside the cabinet and is considered the gold-standard for MIL-STD compliance by many.

MIL-STD-810, Environmental

US Army, Marine Corps and Air Force applications may include ground-based and vehicular applications deployed in geographic regions prone to high heat, high humidity, shock and blown sand/dust. There is a slightly different but similar group of tests for these conditions in the MIL-STD-810 requirements.

Section 501.4, High Temperature

Most of the component parts used in electronics generate heat as electricity passes through them. Some integrated circuits (IC's) get so hot they require a heat sink to dissipate that heat energy even at room temperature. Overheated electronic component parts may be inefficient or not function properly, and if they are allowed to overheat they may combust causing a hard failure.

Heat reduction and airflow are included in the design process of most electronic components nowadays, but the heat requirements of military applications typically far exceed anything most COTS products are designed for. Whereas most COTS UPS's are designed for a maximum temperature of 35°C (95°F), rugged, military UPS's should be designed for a maximum temperature of 50°C (122°F) or higher.

Section 510.4, Blown Sand and Dust

Most electronic manufacturers dissipate heat energy generated by electronic component parts with forced-air (fans) as the simplest and most straightforward solution. Military systems are deployed in the hottest geographic regions of the world where even most plant life is unsustainable and the landscape is covered in sand and fine dust.

Electronic systems with forced-air cooling deployed in desert regions will accumulate a large amount of sand and dust on electronic circuit boards and contacts. The accumulation build-up can short out electronic circuits, corrode contacts causing electronic components to fail, and otherwise shorted the life expectancy of electronic parts.

There are designs that utilize a combination of conduction and forced-air cooling that prevents environmental elements like sand, dust, and precipitation from being introduced directly to electronics, like flow-through heat sink designs. These designs are ideal for these applications.

Sections 516.4 and 514.5, Shock and Vibration

Many US Army and Marine Corps applications are mounted in field-deployable transit cases. These transit cases are transported in vehicles designed for rough terrain where roads may not exist yet. The mechanical shock and vibration electronics mounted in a transit case in these applications can be very different from the mechanical shock and vibration experienced in shipboard applications.

There are a series of different tests designed to introduce similar shock events, including a “drop” test the transit case, or component is tested to ensure it works properly should human handlers drop the case or component from a short height. Even at a just a few feet the mechanical shock can be enough to permanently damage components.

These environments and conditions were not factors during the design of COTS UPS’s like they are in the development and design of Rugged UPS’s. To install a COTS product into a military application is to introduce an inherent weakness into IT architecture.

Military applications require compliance to at least some part of the eighteen different sections, so electromagnetic interference, vibration, electricity, shock, temperature and blown sand/dust should be a design consideration of any electronic manufacturer supporting the DoD.

4.0 Lifecycle Costs

The initial investment of a Stand-by or Line-interactive COTS UPS will look, on paper, to be cheaper than a True Online rugged UPS. That perception, however, masks the true total cost of ownership.

The lifecycle cost of the True Online rugged UPS will likely be much lower as it has been designed to operate in a military environment subject to shock, vibration, EMI, and harsh temperature conditions. It has been manufactured and tested to meet these application requirements. By definition, they will last much longer than a COTS product that was designed for use in a commercial, air-conditioned server room.

It is therefore important that other considerations besides initial purchase price be factored in to your UPS selection criteria, including:

- How often am I replacing an UPS due to failure?
- Do I have to replace my UPS's during every Tech Refresh?
- How much am I spending on my spare UPS inventory?
- What is the logistics and supply chain cost to rush out a replacement when an UPS fails?
- What is the impact of downtime while we wait for a replacement UPS?

A COTS UPS with a much lower initial price can end up being much more expensive to replace several times during the lifespan of a single Rugged UPS. The initial investment in a Rugged UPS may be 2x-5x higher than a COTS UPS, but if your Rugged UPS lasts 5-10 years and you are replacing your COTS UPS every 1-2 years (or less) the COTS UPS will cost more over the life of your system.

The purchase price is the most obvious expense, but the logistics involved in maintaining spare inventory and shipping replacements can quickly add up. Components that fail regularly are stocked in higher quantity in anticipation of frequent failures/replacements, so if you use a COTS UPS, you may be already stocking 2-3 times more COTS UPS's than you would if you used a Rugged UPS.

Most deployed systems are in remote locations where delivery is difficult, dangerous and expensive. In some cases the cost alone of shipping a replacement could well exceed the value of the COTS UPS you're replacing.

The most expensive hidden cost, however, may be system downtime while waiting for a replacement COTS UPS. Uninterruptible Power Supplies are a critical component of IT and network architecture because Military personnel rely on their electronic systems, and those systems can be rendered useless if they don't have dependable, reliable power.

5.0 Customer Service

Working with a vendor who specializes in DoD sales and understands the importance of the government and military mission and operating environment is invaluable. Differences in operating environments and IT Architectures require that your UPS provider have the ability to adapt, modify and change existing designs to meet strict requirements that are expected, and in many cases required, in this industry.

The large-scale commercial success of COTS power supply manufacturers requires their market focus is on high-volume commercial applications. While the Department of Defense may spend millions of dollars with these vendors on an annual basis, and these vendors support the United States Armed Forces, the percentage of their annual sales contributed by the DoD is likely very small and therefore does not garner as much attention as a smaller company focused on military sales.

6.0 Conclusion

"Make sure you have the right tool for the job."

The inexpensive COTS UPS's manufactured by large power supply manufacturers for residential and commercial applications may not be an appropriate, or cost-wise choice for military applications. The technology may be inadequate, the mechanical and electrical design may be incapable of passing strict military-standards, and the hidden life cycle costs may be considerably higher than an UPS specifically designed for military applications -- a rugged UPS.

Standby, or Offline, and Line-Interactive UPS's compromise power protection for cost. A true online, double-conversion UPS is the best protection for sensitive electronic equipment. It best protects both your load from electrical disturbances, and your closed electrical system from harmful load harmonics.

The DoD has commissioned hundreds of military standards detailing the different electrical, mechanical, and environmental conditions products used in military applications must pass. These standards typically far exceed the technical specifications of COTS UPS's, and compliance to these standards usually requires a rugged UPS.

While a COTS UPS may have a lower initial investment than a rugged UPS, you may pay much more over the total life cycle of the UPS for that COTS UPS. If your COTS UPS can't survive the harsh environment because it wasn't designed to pass the military standards, your sparing and logistics costs to replace that inventory is going to be high, but so is your system downtime as you deal with a failure or wait for a replacement.

When choosing an uninterruptible power supply, power conditioner, battery backup or power distribution system for military applications, it is critical to the mission that reliability and survivability in harsh operating environments be considered in the context of the true life cycle costs of the purchasing decision. The UPS with the lowest initial investment may cost much more over the life of the system when replacement, sparing, logistics and downtime costs are considered.

About NOVA Power Solutions

NOVA Power Solutions, Inc., has been a leading supplier of high quality power solutions to the U.S. Military since 1988. We deliver award-winning technical support and customer service for our unsurpassed power protection solutions provided to mission-critical electronics throughout the world. NOVA Power's customizable rack-mount rugged and ruggedized uninterruptible power supplies are designed to MIL-STD compliance and particularly suited to shipboard, tactical military and other harsh operating environments. Our power conditioners, converters, distribution and battery backup solutions provide customers with a wide-range of power protection and backup alternatives. NOVA Power Solutions is a certified woman-owned, small business.

Our mission is to provide dependable power protection products to mission-critical electronics throughout the world. We strive to offer our customers industry-leading customer service and peace of mind that they are protected with our high-quality power supplies. To prevent power failure when it's not an option, we continue to specialize in customizable, rugged power solutions designed to customer specified requirements and that are particularly suited to shipboard, tactical military and other harsh operating environments. www.novapower.com