Designing for a Ruggedized Environment

Abstract:

This paper describes the key focal points when designing for extreme environments, and shows through example how the XF series meets these requirements. With the proven reliability of the Xgen series, Advanced Energy now takes the same high performance and incorporates this into a modular based configurable power supply, and extends the environment and operating conditions on which this platform can be used. With the introduction of the XF series, users can now extend the lower operating condition to -55 degrees Celsius and incorporate a part into their design which has specifically been designed to meet the stringent vibration requirements of MIL-STD-810G, with selected tests from MIL-STD-46IF, MIL-STD-1399 Section 300 Type 1 and MIL-STD-704F.

What defines a ruggedized environment?

If we start with medical applications we will typically see an operating ambient requirement for 0 to 40 degrees Celsius. While the majority of medical applications will be used in a fixed location, there will be a requirement for applications to withstand some vibrations during transportation, in particular for mobile equipment. These requirements will be increased for industrial type applications, and additional pollution degrees may be required to match the industrial areas in which a power supply may be used. A ruggedized environment will extend on these requirements for the operating ambient ranges, shock, and vibration. Some of these environments could also include a wide operating line voltage (85 to 264 VAC), line frequency (47 to 440 Hz), and EMI and Vibration requirements as defined by MIL-STD-461 and MIL-STD-810 respectively. So designing for these environments can be a significant challenge, but one that is achievable if you are aware of these challenges.

How to go about designing for such an environment:

Extensive testing will be required to verify compliance with the operating requirements, and typically an independent test house will be used to ensure that the design is compliant with the harsher environments that they are expected to be used in. These include

- Thermal cycling between -55 and + 70 degrees Celsius, with a 5 degree Celsius per minute thermal rate
- Thermal Shock Profile according to MIL-STD-810G, method 503.5, between -55 and + 70
- Vibration MIL-STD-810G Method 514.6. During this test the unit was powered on for the duration with the output rails monitored for any intermittent nature or failure
- Testing was also carried out to simulate a 50km forward supply journey , an 800 km paved and off road, cargo vibration, jet craft vibration exposure, and helicopter vibration exposure as per MIL-STD-810G

EMC testing should also be completed in order to unit to assess its Electromagnetic Compatibility characteristics in general accordance with selected tests from MIL-STD-46IF, MIL-STD-1399 Section 300 Type 1 and MIL-STD-704F. These include

- MIL-STD-461F Ship Above Decks CVF EMC Control Plan Digital VLA, Test clauses CS114, RS103, CS101
- MIL-STD-1399, SECTION 300A, Shipboard Electric Power, EN61000-4-2 (Voltage Spikes)
- MIL-STD-704F, Aircraft Electric Power Characteristics, Voltage and frequency tolerance.

As part of the XF design process, our platform has been tested and verified by independent test houses. Full test reports are available under NDA from Advanced Energy. Please contact Advanced Energy for further details on this. Along with these reports, we also have a full characterisation completed of operating conditions unique to a ruggedized environment, these are details below.

Operation at 440 Hz line:

Depending on the rectification stage of your design, it may not be possible to use the platform at higher line frequencies. Alternatively it may function, but may require extensive derating, depending on the choice of bridge rectifiers. The XF series, not only uses passive components, they are also suitably derated so that a 5% derating of power is required if the part is used at 440Hz operation. The power factor correction control loop has also been tuned to maintain extremely high functionality over the entire range of operating line frequencies. Fig1 below shows the variation in Power Factor Correction as we sweep the line frequency from 50 Hz to 450 Hz. Testing was carried out at a line voltage of 115 VAC , and a 950 Watt load on the XF under test.

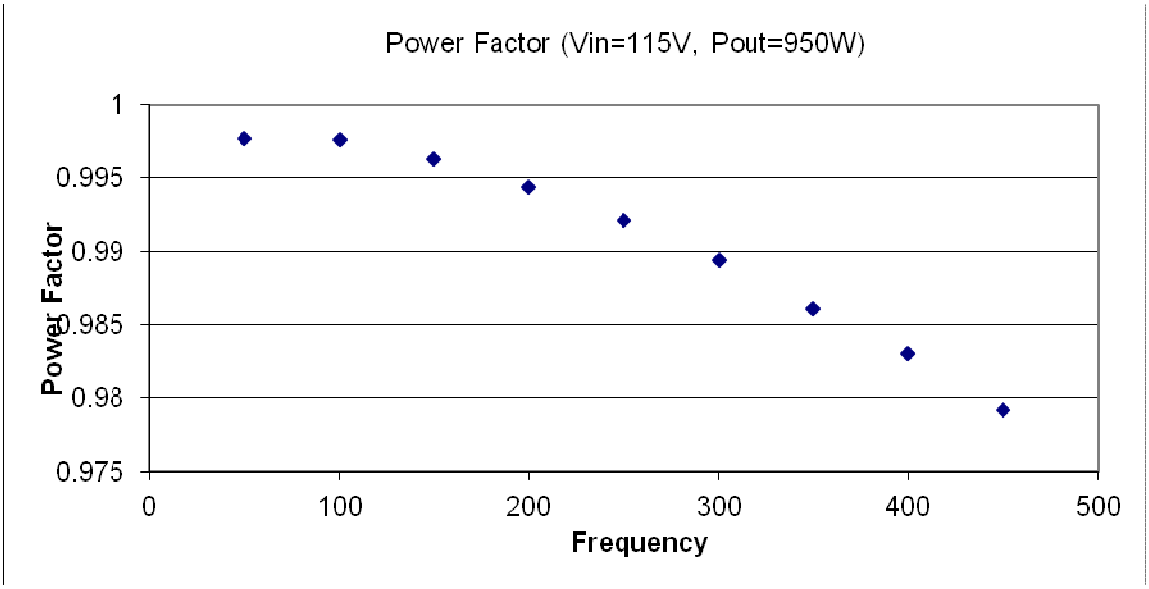

Fig 1: PFC V's Line Frequency, Vin = 115V , Pout = 950 Watts

How does this have an impact on the final design?

Now that we have defined the requirements, how do we go about designing a unit in order to meet these requirements?

- Bulk capacitors are military grade. Rated down to -55°C degrees
- Anti Vibration compound added to key bulky components (Momentive RTV 6708: Mil Grade)
- Loctite used on all internal screws. This ensures they do not loosen in extreme vibration enviornments.
- Conformal coating is required to protect against condensation as the power supply self heats at low temperatures.
- Add on cards will need to be fixed in place with Loctitie material.
- Due to low temperatures, with the variation in diode drops, Vbe of bipolars, and drift of resistors, there may be a requirement for further requirement to derate existing designs platforms.

It is also important that the selection of all components used on the design adhere to MIL standards, such as

- Resistance to Solvents: MIL-STD-202 Method 215, 2.1a, 2.1d
- Low Temperature Storage and Operation: MIL-STD-26E
- Moisture Resistance: MIL-STD-202 Method 106
- Storage Life at Elevated Temperature: MIL-STD-202 Method 108-F

In summary:

While the design requirements to meet the demands of harsh operating environments may be more complex, they are not insurmountable. As a working example the XF family is ruggedized to withstand extremes in shock and vibration and is certified to MIL-STD 810G, Integrity Test for Vibration. It is well suited for use in applications that ate subject to extremes in temperature, and vibration requirements. The XF family will deliver up to 1 kW over a wide temperature range from -55 to 70°C. The XFN series is a subset of the XF series which can operate from –40 to + 70°C. All configurations carry full safety agency approvals, including UL60950 and EN60950 and are fully characterised for EMI according to MIL-461F.

About Advanced Energy

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

AE's power solutions enable customer innovation in complex semiconductor and industrial thin film plasma manufacturing processes, demanding high and low voltage applications, and temperature-critical thermal processes.

With deep applications know-how and responsive service and support across the globe, AE builds collaborative partnerships to meet rapid technological developments, propel growth for its customers and power the future of technology.

For further information on our products, please visit www.advancedenergy.com.