Today's civilian, military power conditioning

Here's what you need to know to keep up with the increasing complexity of power requirements

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The increasing complexity of global applications for electronic products in every conceivable commercial environment and power paradigm causes problems similar to those created by the current effort of the military to use up-to-date modern electronics. As a result, there is increasing emphasis on conditioning the input power so that it meets the published requirements of the commercial equipment under the widest possible conditions.

Many previously "Full Mil" systems are now being configured with "off-the-shelf" displays, computers, routers, disk drives and other such commercial products. Virtually all the major defense contractors are designing new systems using standard electronics.

The system designer then conditions the environment so that it doesn't exceed the commercial specifications. This conditioning may include things such as shock mounts to reduce shock and vibration, heaters to minimize temperature extremes and conditioning of the input power so that voltage and frequency variations and transients do not go beyond the commercial specifications.

A variety of specs

Each branch of the service uses a different specification to define its ac and dc input power requirements. MIL-STD-1399 is used for shipboard power and MIL-STD-704 for aircraft; the Army uses specifications such as MIL-STD-1332, MIL-STD-633, MIL-STD-705 and MIL-STD-1275. In addition, commercial aircraft have power requirements specified in D0160. Each military specification has its own unique requirements, and very few commercial items are tested to and guaranteed to meet them.

Commercial adaptation

So what can a system designer do to use off-the-shelf electronics with these types of inputs? The answer is to condition the raw power with some type of power supply that can accept the Mil Spec inputs and provide a good old-fashioned well-regulated ac output; usually 115 Vac, 60 Hz. The exact type of power supply selected depends on which input is being provided as well as the actual system operating requirements.

For example, on most Navy ships, both new and old, the ac power is defined by MIL-STD-1399. The preferred frequency is 60 Hz, and the voltages available are 115 Vac or 440 Vac ungrounded three-phase delta. There are 20% voltage variations for up to 20 s and power can be lost in emergency conditions for up to 2 min. If a system must operate during these emergency conditions, obviously some type of UPS must be used.

The other significant requirement of MIL-STD-1399 is that for systems requiring over 1 kVA of power, the input harmonic current must contain no single harmonic greater than 3% and a total harmonic distortion of no more than 5%. Most standard power-factor-corrected (PFC) input supplies won't meet this without special tweaking.

An ideal unit to meet all Navy requirements would be a UPS with a high-quality power factor corrector and good input transient suppression. The supply would also have EMI filtering to meet MIL-STD-461 conducted and radiated emission and susceptibility requirements. Batteries would be required so the system could ride through power interruptions. These are of relatively short duration, (2 min), so the size and weight of the batteries usually do not have to be very large.

The system designer may add more holdup time just as a precaution in critical systems. The output

	EQUIPMENT CATEGORY	A(CF)	A(NF)	A(WF)	
Max	Voltage (Vrms)	Highest phase	122	122	122
		Average of three phases	120.5	120.5	120.5
	Frequency (Hz)	Normal	410	650	800
		Emergency	440	650	800
Min	Voltage (Vrms)	Lowest phase	100	100	100
		Average of three phases	101.5	101.5	101.5
	Frequency (Hz)	Normal	390	360	360
		Emergency	360	360	360

Table 1. The 2004 RTCA specification 16.5.1.1. Voltage Frequency (ac) is typical of the way information is conveyed to engineers. This chart is only a tiny part of the total D0160 specification.

would be a clean regulated ac and or dc voltage as required by the commercial electronic load.

Aircraft requirements

For military aircraft applications, input power conditioning is required to meet MIL-STD-704 and MIL-STD-461, EMI and transient requirements, but a UPS function with batteries is usually not required because power interruptions are limited to 50 ms, except for a 200-ms requirement on D0160 for digital equipment. This can generally be handled using only holdup capacitors.

There are problems with some types of capacitors related to altitude and temperature requirements, but these problems can usually be resolved. The other areas of input conditioning that are being required, especially on new commercial aircraft, is input harmonic current limiting similar to the Navy requirement above, but at power levels of 35 W or less. Also the ability to handle a wild frequency input, usually around 300 Hz to 800 Hz is being required.

These requirements are specified in detail in D0160 Rev E. Aircraft manufacturers are now starting to realize that this is important for airborne systems and that it greatly improves overall aircraft performance. Most airborne requirements can be met with a custom frequency converter or inverter that accepts whatever ac or dc input is available and produces the required voltage for the commercial equipment.

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An example of one of the many tables in MIL-STD-704 is provided above.

Steady-state characteristics	Limits
Steady-state voltage	108.0 to 118 Vrms
Voltage unbalance	3.0 Vrms max
Voltage modulation	2.5 Vrms max
Voltage phase difference	116° to 124°
Distortion factor	0.05 max
Distortion spectrum	Figure 7
Crest factor	1.31 to 1.51
Dc component	+ 0.10 to - 0.10 V
Steady-state frequency	393 to 407 Hz
Frequency modulation	4 Hz
Transient characteristics	**Limits**
Peak voltage	±271.8 V
Voltage transient	Figure 3
Frequency transient	Not to exceed steady-state values of 360 to 800 Hz
Maximum rate of exchange of frequency	250 Hz/s

Table 2. Ac normal operation characteristics -- 400 Hz (see 5.2.3)

Requirements for ground-based systems can be even more complicated than for the other systems above. The problems arise because the input power sources are usually much more varied. Also, the environments encountered are usually less easily controlled. The Army is currently attempting to come up with ideas for standardizing its future power system requirements. Fuel savings is becoming very important and studies have even shown a relationship between fuel savings and human casualties. Less fuel demand translates into fewer convoys delivering fuel and less exposure to attack.

Using alternative power

The current initiatives are to maximize the use of alternate power such as wind turbines, solar power, and fuel cells. The efforts are to have systems able to accept any input, switch between them in an efficient intelligent manner and produce reliable output power necessary for the completion of various Army missions.

In addition to the alternative power sources discussed above, power input might also come from any foreign power grid, when available. These of course may vary anywhere from dc to a variety of frequencies and voltages.

Inputs may also be from any number of different standard motor generator sets that the Army has in inventory. In this future view, all these varied inputs need to be converted to some yet undefined "standard bus" format, (probably dc).

This standard power source could then be switched under computer control to the output system load to make the most efficient use of available resources. The actual output would be supplied by a standard inverter which would take the appropriate dc input and provide clean, reliable power to support a particular mission.

Typical mission loads may vary from 10 kW for a small system to several hundred kW for loads such as a mobile hospital unit. The great variety of input and output combinations amplifies the complexity of these ground based systems.

Current programs are underway to define appropriate system architecture. Modern power supplies and inverters are available to perform specific functions but no "one stop solution" is currently available to meet all needs.

What is certain, however, is that the complexity of power requirements will increase for both civilian and military applications, and advances made in this area benefit all who design, manufacture, and use electronic products.

For more on conditioning power, visit *http://www.electronicproducts.com/power.asp.*