

POWER QUALITY TESTING

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POWER QUALITY TESTING

About Me

- BSEE and MSEE from Capital College in Laurel, Maryland focusing on RF and microprocessors.
- 20 year career in electronic hardware design and compliance for Military and Aerospace applications
 - SAIC - Maryland RF vehicle tracking product line.
 - Collins Aerospace/Raytheon wireless design (both cellular and 802.11x wifi)
 - EMI/EMC engineer
 - Full circle, testing intentional radiators
- Overseen thousands of tests products from tip to tail and top to toilet tank.
- Collins Aerospace Subject Matter Expert for EMI/EMC working toward Fellow.
- Engineer and intern EMC trainer, have produced EMI/EMC experts for other top Minnesota companies.
- Attend RTCA/DO160 Special Committee 135 for Environmental and Electrical Test Conditions activity in the User's Guide
- Developed and taught college level Intro to Designing for EMI/EMC Compliance
- Authored ~100 technical and entertaining articles for NERD magazine

COMING UP

1. Power Quality i.e. Power Input Testing
2. Industry Test Standards - origin
3. Required Equipment
4. What to expect from the perspective of a designer - levels
5. What to expect from the perspective tester – setup

Trade Studies from three industries

1. Aerospace – All Electric Aircraft
2. Medical – Oxygen Concentrator
3. Automotive – Electric Vehicle

POWER QUALITY I.E. POWER INPUT TESTING – WHY YOU CARE

- Formal test campaigns take up to a month to complete* Provided you pass the first time
- Third party lab time is a necessary evil to demonstrate compliance. Be ready before you dance \$\$\$\$ (How?)
- Customer's requirements often change late in the program
 - Good requirements are best
 - Building in margin
 - helps when requirements are undetermined
 - Avoid expensive respins and the time penalty (caught at test time)
 - Understanding intent regarding unfamiliar requirements saves time (spin, spin, spin)
- Standards continually evolve, being involved has advantages at equal (first to market)

POWER QUALITY I.E. POWER INPUT TESTING

- Power Quality and Power Input testing in general are NOT the same (tomato tomato)
- Power Input is a UUTs response to interrupted and distorted power
- Power Quality is the measured harmonic content of a UUT and inrush current, for example
- Most engineers have a passing familiarity with emissions or susceptibility (immunity) power input testing is more of a specialty – training and assumptions

INDUSTRY TEST STANDARDS

- Committees: IEC, ISO, CISPR, MIL STD, DO160
- I must thank the guys at Element Materials Technology for the following list.
- These are the Power Input test standards for several industries:
 - IEC 61000- 4-5 Voltage Surge
 - 4-11 Voltage Dips and Interrupts
 - 4-16 Voltage Conducted Susceptibility
 - 3-2 Harmonics (Current)
 - 3-3 Fluctuations (Current)
 - ISO - 7637- 2 Transients Conducted Coupling
 - 6750- 2 Electric Loads
 - CISPR 32 Emissions – Multimedia **Power Input?**
 - 11 Emissions -. Industrial Medical Equipment **Power Input?**
 - Mil Std 704 Aircraft Electric Power Characteristics
 - DO160 Section16 Power Input (Aircraft)
- TÜV has done a fantastic presentation for RF device compliance. You are encouraged to view the material

REQUIRED EQUIPMENT

- You will not be able to perform these tests with a benchtop supply and a steady hand!
- Size your supplies appropriately for your product line(s) – go big!
- Old equipment may be economical, but will not perform modern revisions of standards.
- Communication interfaces
 - require specific hardware adapters
 - tied to new or obsolete OS
 - Speed
 - Intermittent operation
 - Driver installation may be prohibited by your company (online, USB stick, CD/DVD)
- Programs: Optional from Manufacturer, LabVIEW, Visual Basic, other
- Modern equipment, modern standards, modern OS, warranties, support, justifiable, not interoperable with older equipment and other vendor equipment
- Understand what is meant by “Pre-Compliance” – How is it limited?, measured with calibrated equipment

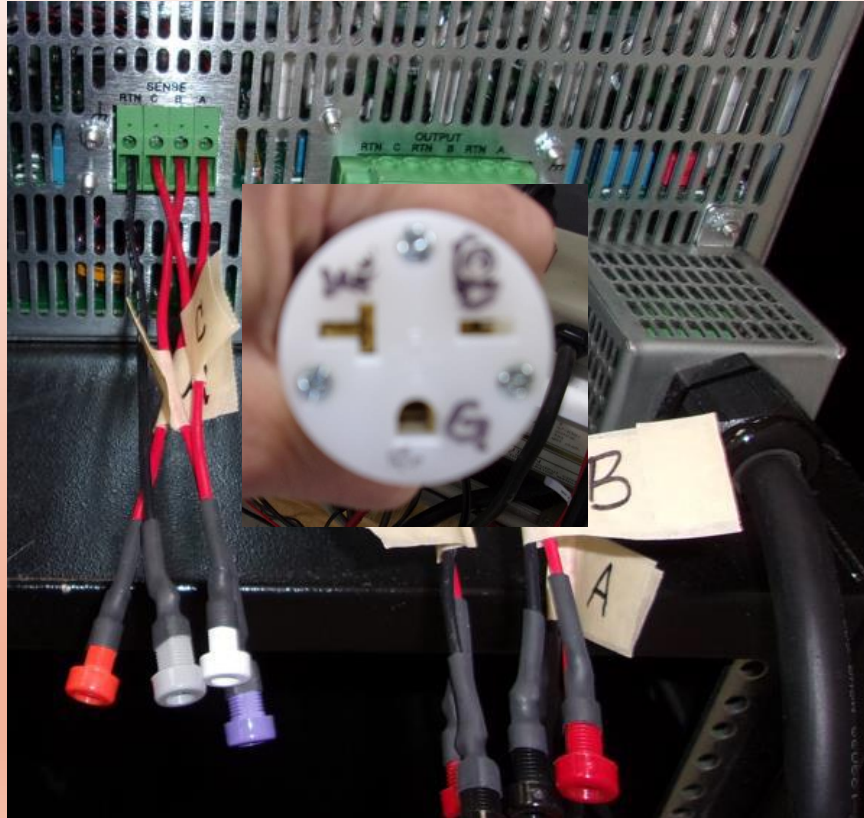
REQUIRED EQUIPMENT – NOT COMPREHENSIVE

Equipment Description	Manufacturers
Programmable Power Supplies	Ametek – Asterion, California Instruments, Elgar Keysight AE Techron Chroma Pacific Power BOLAB Systems – power source
Oscilloscopes	Keysight Rhode & Schwarz Tektronix Lecroy Yokogawa BK Precision Fluke
Power Amplifiers	AE Techron Rhode & Schwarz Amplifier Research Solar
Audio Transformers , Transducers (clamps)	Solar
LISNs and coupling decoupling networks	Com-Power
Signal Generators	Keysight Rhode & Schwarz EM Test Teseq Hilo-Test - trans NI
Controlling PC/Software	
Benchtop Multimeters	Keysight Fluke BK Precision
Harmonic, Inrush, and Flicker Measurement	Yokogawa Tektronix Rhode & Schwarz

REQUIRED EQUIPMENT – PROGRAMMABLE POWER SUPPLIES



REQUIRED EQUIPMENT – PROGRAMMABLE POWER SUPPLY CABLES



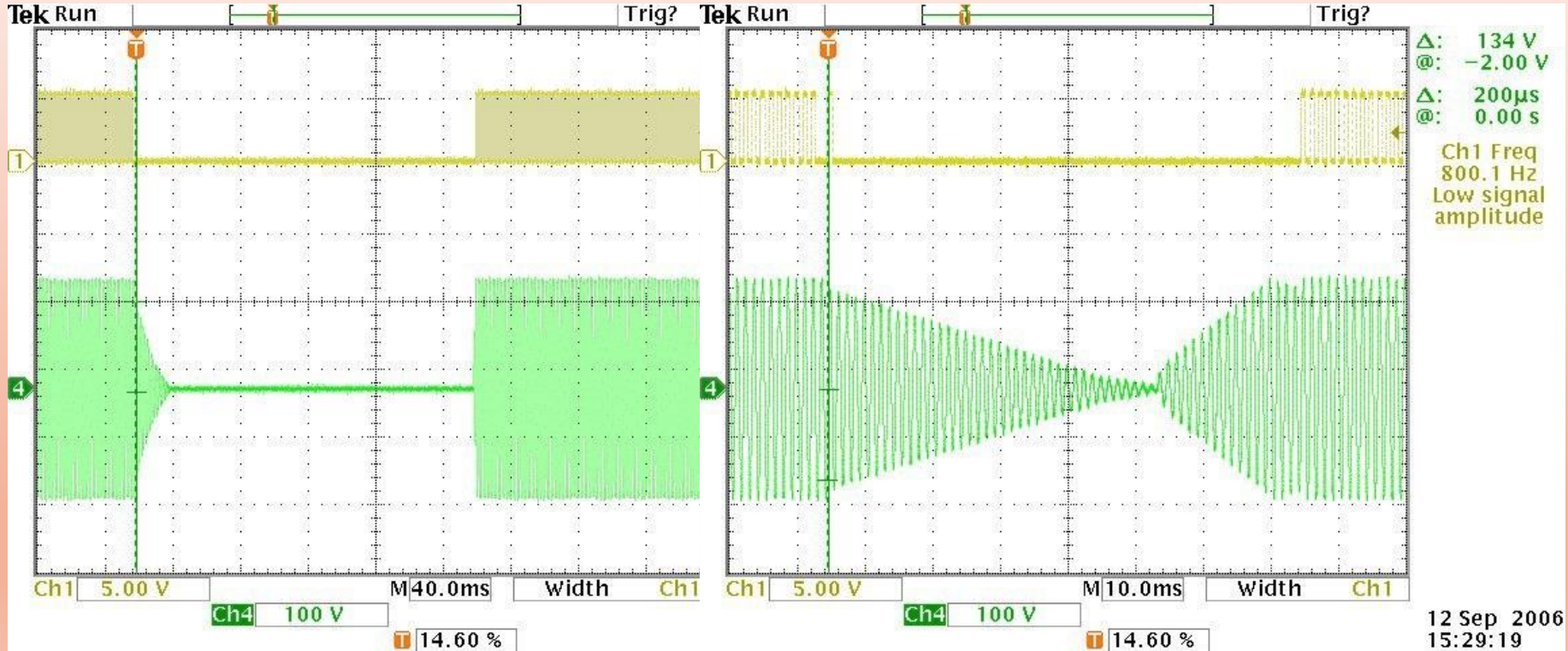
WHAT TO EXPECT FROM THE PERSPECTIVE OF A DESIGNER - LEVELS

- Congratulations on your working design...you've made it 1/10th of the way
- Performance is monitored and Pass/Fail criteria will be a level of **UPSET**
- Interrupts – usually trapezoidal, ramps, and dwells are defined. In aerospace these originate from power switching say from ground to aircraft, in medical they originate from grid to backup generator change over.
- All standards have tests that modulate the power and apply transients
- Surge voltage and under voltage conditions expected in your environment
- Electric vehicle power transient tests are some of the harshest power conditions in all of the industries
- Your device is a load on the system, characterization per specified harmonics, current surge, flicker, and other parameters must fall within the limits

WHAT TO EXPECT FROM THE PERSPECTIVE OF A TESTER – SETUP

- Your programmable power supply unfortunately will not perform all of the tests without additional equipment – period
- Renting a supply: your own cables PwrIn, PwrOut, and Sense/time/cost per down day
- Manufacturer's have excellent packages tailored to the standards – Feature: need to **PROGRAM**, uprev, or downrev, and experiment
- Calibrated measurement equipment, capturing all waveforms into a simulated load guarantees that you will perform the entire test program twice - time
- Arguably sense lines can be your friend (DC drop) – argue

COMPOSITION OF A TRAPEZOID AND YOU



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WHAT TO EXPECT FROM THE PERSPECTIVE OF A TESTER – SAFETY

- Have a dead man switch close. Self resonance on the line, humming, china syndrome
- Isolation is a beautiful protection approach, but unintended ground corruption V. BAD
- Exposed energy points are hazardous – cover them
- Crossing power and ground (red, and black are not the AC convention)

TRADE STUDIES FROM THREE INDUSTRIES

Don't tell me your not curious

- Remember Slide 6...a lot of standards
- There are standards for Industries, Military, and Product type, International, country specific, etc...
- Members of the standards committees come from their product's industries
- Prepare before entry into these markets to speed your time to market whether it's to introduce a product or provide a test service

AEROSPACE – ALL ELECTRIC AIRCRAFT POWER INPUT

*NOT A PRESCRIBED TEST PLAN / ILLUSTRATION ONLY

STANDARD	NAME	RANDOM DETAIL
DO160D,E,F,G,(H)	Section 16	All conditions in one section
MilStd704	All	Do not cite as a requirement

Components must be compatible with each other. Removal, insertion, and normal operation Can not disrupt the power system. Each “type” currently evaluated per manufacturer’s G1 and G2 submission to the FAA.

Those familiar with these standards must understand that they were created for fuel driven generators which may be very different. However, the subcomponent compatibility aspect remains and validates their use.

MEDICAL – OXYGEN CONCENTRATOR POWER TEST

*NOT A PRESCRIBED TEST PLAN / ILLUSTRATION ONLY

STANDARD	NAME	RANDOM DETAIL
IEC61000-4-4	EFT power lines	+/-2kV
IEC61000-4-5	Surge	Based upon UUT current
IEC61000-4-8	Pwr freq magnetic field	
IEC61000-4-11	Volt dips, interrupts, variations	Pass/Fail recover w/o user intervention
IEC61000-3-2	Harmonic Emissions	By Class, A is general
IEC61000-3-3	Voltage fluctuations/ Flicker emissions	Got a minute – Curt?

AUTOMOTIVE – ELECTRIC VEHICLE

STANDARD	NAME	RANDOM DETAIL
ISO - 7637- 2	Trans Cond supply lines	Cond. Immunity transients injected onto power leads
ISO - 21498-2	Class B	Load dump, slope variation

ISO-21498-1 is required to define the classes of vehicles. Class B is high voltage compared to class A. Both AC and DC voltage are defined. The power perturbations in this standard are specific to those seen when powered by a powerful battery and inverter. Rise times are sharp and special equipment is required

BE SAFE!

Thank You