emc STANDARDS

Another EMC resource
from EMC Standards

15 - Protecting from poor AC (mains) and DC power quality - Updated Jan 2021

emc14i v2.2

Helping you solve your EMC problems

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Module 15: Protecting from poor AC (mains) and DC power quality

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Change Record: v2 to v2.2, January 2021

- **Safety note applied to the top of all slides, in red**
- **Confidentiality note applied to the foot of all slides**
- **New slide 15.0.1a added on Good EM Engineering and on De-Risking a project's EMC**
- **Slides 15.2.2, 15.3.2, 15.4.2, 15.6.2, 15.7.2, 15.8.2, 15.9.2, and 15.9.7 – titles improved**
- **Slide 15.6.4 – standards list updated**
- **Slides 15.7.12 and 15.7.13 – useful references added**
- **Slide 15.9.7 – text slightly improved**
- **Slide 15.9.8 – graphic slightly improved**
- **Slide 15.10.9 – text slightly improved**
- **Slide 15.10.15 – graphic slightly improved**
- **Slides 15.12.2 and 15.12.3 updated and improved**
- **Slides 15.12 (References) – moved to before the end slide 15.0.3**

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Good Electromagnetic (EM) Engineering…

– **is cost-effective SI, PI and EMC engineering: well-proven to save time & money in all lifecycle stages, helping to increase profits & reduce financial risks…**

– **for PCBs, modules, sub-assemblies, devices, products, equipment, vehicles, sub-systems, systems, installations, etc., etc.; of any size, in all applications**

– ***see Module 1 especially 1.15 (also in Webinar 1c) and 1.16 (also in Webinar 1d)***

■ **This Module contains guidelines that should be used as an initial design checklist to De-Risk a project's EMC: *any guidelines that can't or won't be followed identify a project risk!*** ***see Module 1, section 1.16 (also in Webinar 1d)***

– **to adapt any λ-based design guidelines to different EMC standards, *see Module 1, section 1.18* *(also in Webinar 1d)***

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For safety requirements, see our courses on designing for safety compliance

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15. Protecting from poor AC (mains) and DC power quality

15.1

Introduction

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Introduction: AC mains power quality

- **Mains power suffers from many electromagnetic disturbances….**
  - **surges, spikes, transients, bursts of fast transients, electrostatic discharge, common-mode radio-frequency (RF) voltages and currents, etc…**
  - **all of which are common to all conductors and are dealt with by our other course modules**
- **This module covers 'non-RF' mains power quality issues…**
  - **frequencies below 150kHz**

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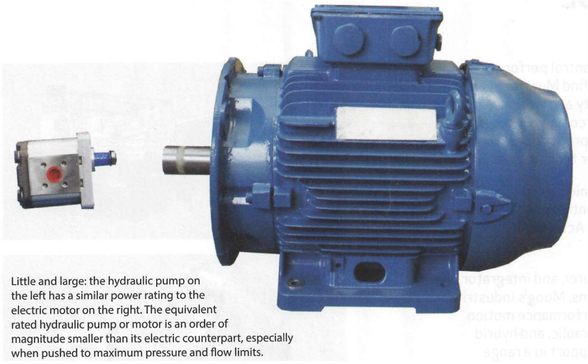
Intro: AC mains power quality continued…

- One way of avoiding all interference due to poor mains power quality (and all emissions too) is not to use electrical motive power…
  - use hydraulic, pneumatic, mechanical, etc., instead



These two motors have similar power ratings!

(the one on the left is the hydraulic motor)

From: "Hydraulic *vs* Electrical drives: is there a winner?" by Stuart Diesel of Group HES, in Drives & Controls magazine, Sept 2013, pages 61-63

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Intro: AC mains power quality continued…

- The quality of the delivered mains power can be measured in a variety of ways…
  - but proper tests use instruments that comply with IEC 61000-4-30
- Poor mains power quality generally causes more problems when the mains voltage differs from equipment's nominal supply voltage
  - so it is best to ensure that equipment's mains inputs are set for the correct nominal voltage for the mains supply

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15. Protecting from poor AC (mains) and DC power quality

15.2

Overvoltages (swells)

Overvoltages: Swells

(e.g.: as tested by EN/IEC 61000-4-11)

- Swells are when the supply voltage is higher than normal limits, for a while (e.g. a few seconds)
  - generally assumed to have very slow rise and fall times (e.g. seconds)
- They can cause overvoltage or overheating damage
  - and can cause surge protection devices to start to operate, overheat and burn up

Designing equipment to protect from swells…

- Design power converter input circuits with higher-voltage devices and circuits
  - or choose power converters with higher voltage ratings
- Use a multi-tapped mains transformer with automatic tap selection (see later)
- Run DC-powered equipment from a "float charged" battery or supercapacitor...
  - the charger circuit designed to handle the overvoltage

Designing equipment to protect from swells…

- Use series resistance, PTC, fuse or circuit-breaker
  - followed by an overvoltage protection device such as a metal-oxide-varistor (MOV)…
    - only use PTC, fuse or circuit-breaker if it is acceptable to remove power from the equipment during a swell

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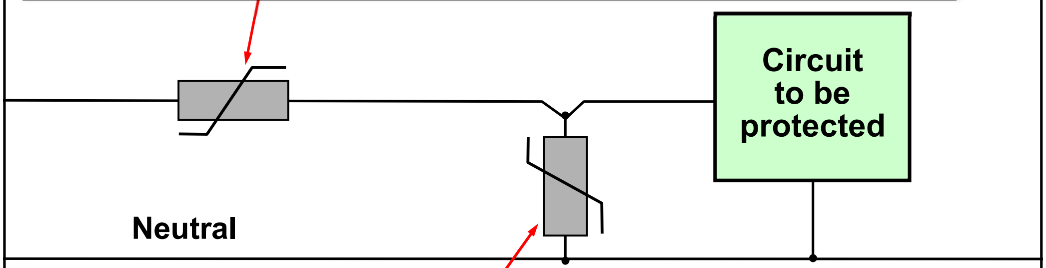
An example of ‘swell’ protection

a) High voltage surge/pulse rated resistor (preferably a ‘fusible resistor’ that open-circuits safely if overloaded), or…

b) PTC (Positive Temperature Coefficient Thermistor) sometimes called a ‘self-resetting fuse’, or…

c) Fuse or overcurrent circuit-breaker



Appropriate type of overvoltage suppressor (e.g. a MOV)

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15. Protecting from poor AC (mains) and DC power quality

15.3

Frequency variations

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Frequency variations
(e.g.: as tested by EN/IEC 61000-4-28)

- **These can cause problems for circuits which rely upon the mains frequency for timing**
  - **and large frequency drops can cause problems for mains transformers, direct-on-line (DOL) AC motors, relays solenoids and contactors**
    - **this problem has occurred when equipment designed for 60Hz mains (e.g. USA) was operated on 50Hz (e.g. Europe)**
  - **magnetic saturation, excessive currents, overheating**
  - **transformer ratio is reduced, causing electronic loads to run on reduced DC voltage**

Designing equipment to protect against frequency variations…

- **Timers and real-time clocks can use stable reference oscillators (e.g. as used in wristwatches)**
  - **for the highest precision: use existing on-air frequency references from terrestrial or satellite transmitters (GPS)**
- **Increase the core size of transformers or AC motors, and/or use more turns on their windings**
    - **so they normally operate with less saturation and lower magnetising currents**
  - **for relays, contactors and solenoids: choose types that have lower drop-out voltages**