Another EMC resource
from EMC Standards

2 - EMC in Interconnections - Updated for Jan 2021

emc10sm v3.8

Helping you solve your EMC problems

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Module 2: EMC in interconnections

(techniques for cables and connectors)

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Change Record: v3.4 – v3.8, Jan. 2020

- **Safety note added to all slides, and some reformatting was done as a result**
- **Slide 2.0.1a – text improved**
- **Slide 2.0.2 – Contents list updated to show the change to the title of section 2.4**
- ***New slide 2.1.3a added, on Ground Bounce emitting CM noise from all IC pins***
- **Slides 2.3.2 and 2.3.3 – texts improved**
- **Slide 2.4.1 – Section 2.4 title improved**
- **Slide 2.4.3 – text and formatting improved**
- **Slide 2.5.3 – text improved**
- **Slide 2.5.6 – text and formatting improved**
- **Slides 2.5.9 and 2.5.10 – texts improved**
- **Slide 2.5.20 – text improved**
- **Slides 2.6.3 and 2.6.4 – texts improved**
- **Slide 2.6.6 – text improved**
- **Slide 2.6.7 – text improved**
- **Slide 2.6.14 – more weblinks added**
- ***New slides 2.7.5a-c added: backshell termination methods, inc. 'braid socks'***
- **Slide 2.7.6 – formatting improved**
- **Slide 2.7.7 – new text box added (an observation and a warning)**
- **Slides 2.7.20 and 2.7.21 – texts improved**
- **Slide 2.10.2 – reference improved**
- **Slide 2.10.6 – new text box added**
- **Slide 2.11.2-4 – new references added, formatting improved**

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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 <u>any</u> size, in <u>all</u> applications**

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

- **<u>This</u> Module contains many EM Engineering guidelines that should *also* be used as an initial design checklist: *any that <u>can't</u> or <u>won't</u> be followed identify a project risk!***

see Module 1, section 1.16 (also Webinar 1d)

- **the λ-based design guidelines are for compliance with IEC 61000-6-1 and -3; to adapt them to different EMC standards, *see Module 1, section 1.18***

(also Webinar 1d)

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Contents

2.1 Accidental antenna behaviour of *<u>all</u>* conductors
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2.4 Cable classification and EM Zoning (segregation)
2.5 Good practices for both shielded and unshielded interconnections: controlling DM & CM return paths
2.6 Shielding techniques for cables
2.7 Terminating cable shields
2.8 Interconnecting shielded enclosures
2.9 'Ground loops'
2.10 Transmission-line interconnections
2.11 Some useful references

For safety requirements – see our courses on designing for safety compliance
For interconnections in PCBs (traces) – see Modules 6A and 10A on PCBs

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2. EMC in interconnections

(techniques for cables and connectors)

2.1

The 'accidental antenna' behaviour of *all* conductors

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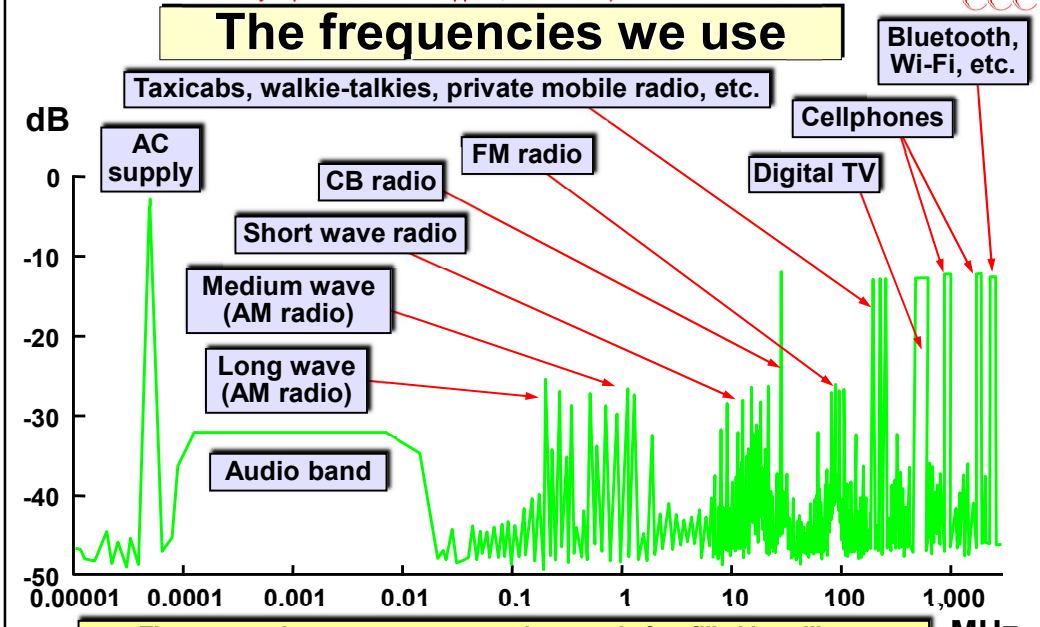
The frequencies we use



The apparently empty spectrum regions are in fact filled by military, government, telecomm's, other private users, or reserved for radio astronomy

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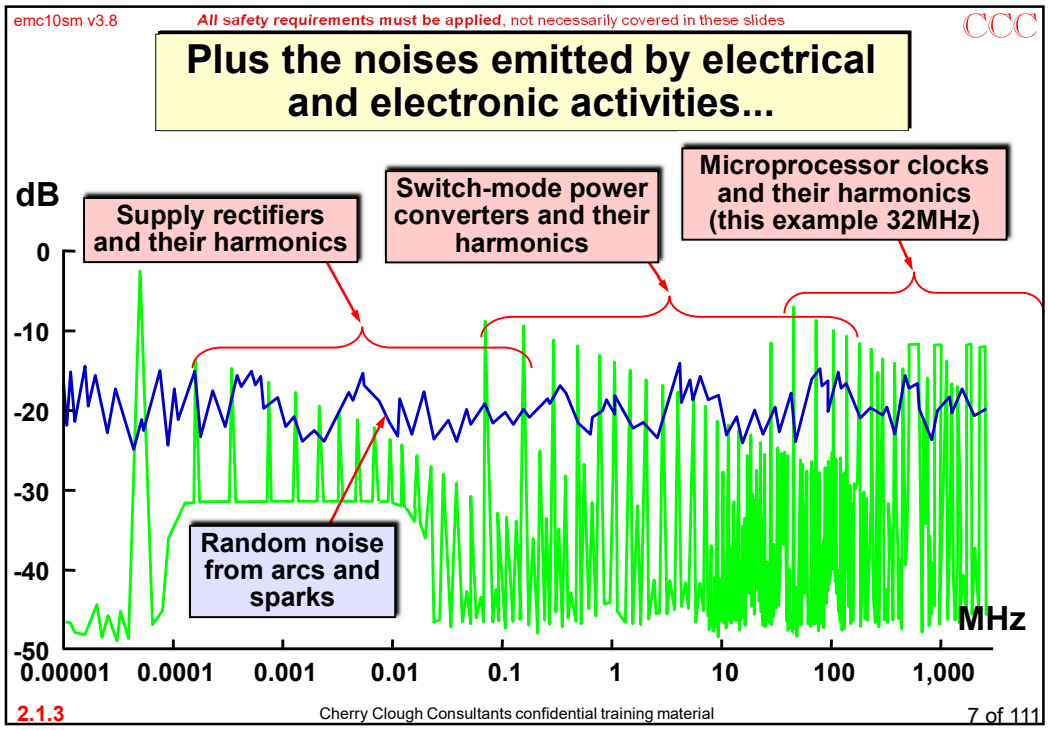
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CCC
Plus the noises emitted by electrical and electronic activities...
dB
Supply rectifiers and their harmonics
Switch-mode power converters and their harmonics
Microprocessor clocks and their harmonics (this example 32MHz)
Random noise from arcs and sparks
0
-10
-20
-30
-40
-50
0.00001
0.0001
0.001
0.01
0.1
1
10
100
1,000
MHz
2.1.3
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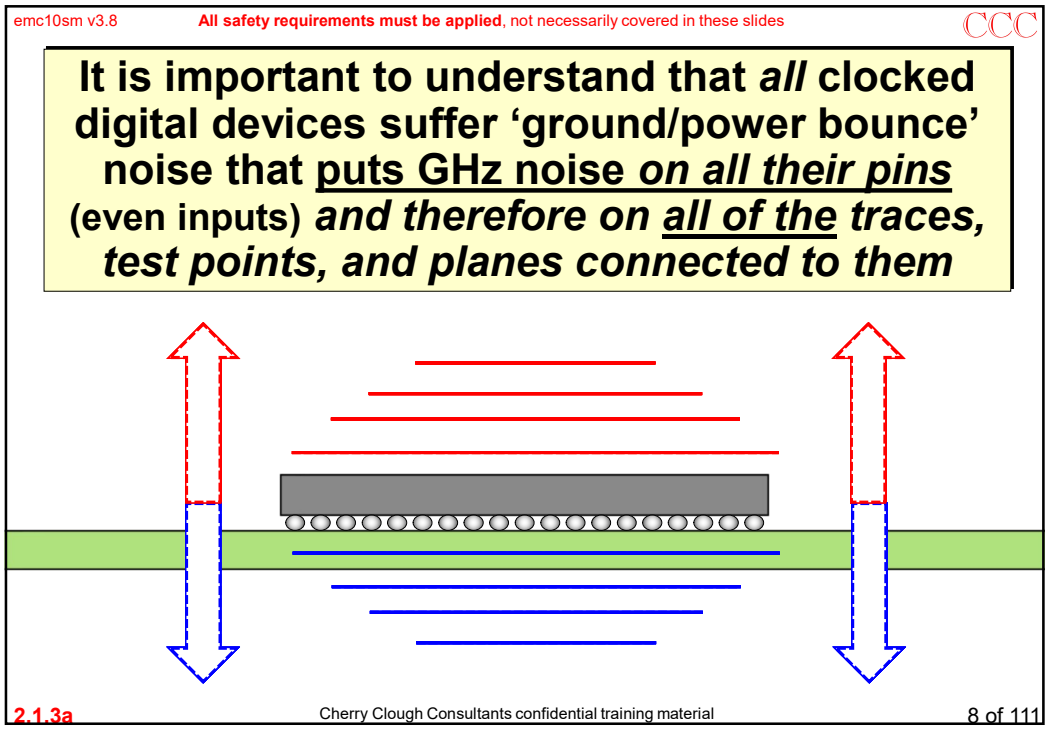
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CCC
It is important to understand that all clocked digital devices suffer 'ground/power bounce' noise that puts GHz noise on all their pins (even inputs) and therefore on all of the traces, test points, and planes connected to them
2.1.3a
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Problem: all conductors are now antennas
(but matched transmission lines are very poor antennas)

- Wires, cables and other conductors are accidental antennas, so they always leak the signals (or noises) they are carrying (emissions problems)
  - either as electric (E) or magnetic (H) fields
- They also pick up RF currents and voltages from any electric (E); magnetic (H), or electromagnetic (EM) fields around them (immunity problems)
- This is not what we want our conductors to do, but it is unavoidable

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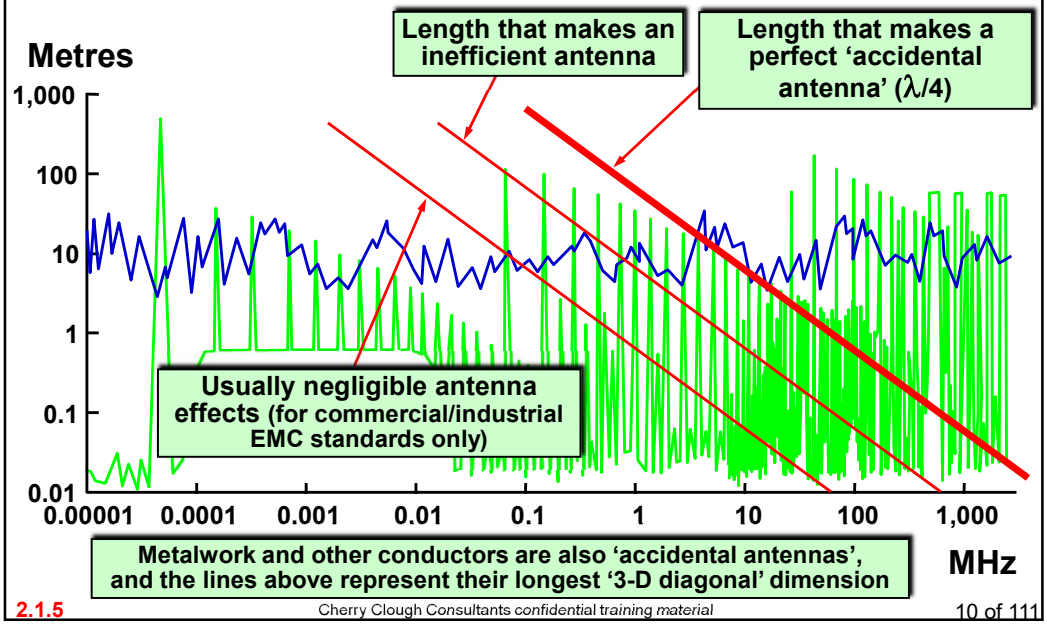
All conductors are 'accidental antennas'



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2. EMC in interconnections

(techniques for cables and connectors)

2.2

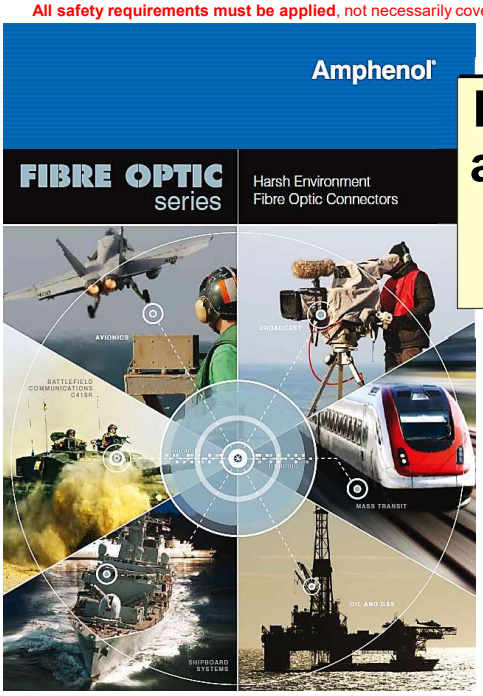
Use fibre optics or alternatives instead of conductors

Interconnections that are much better for EMC than conductors (1)

- **Fibre-optics are often the most cost-effective**
  (when achieving EMC compliance is taken into account)…
  - **25Mbps plastic f/o devices made in high-volume for the auto industry are very low-cost…**
  - **f/o replacements are available for RS232, RS485, USB1, USB2 & USB3: 3m – 400m lengths, from a few 10s to a few 100s of Pounds (e.g. from Lindy, Ircon, etc.)**
- **Free-space lasers can achieve > 1Gbps,**
  and can be used outside (kilometres) or inside equipment
- **Power: use pneumatics, hydraulics, or mechanical drive instead, and fibre-optics can carry a few watts**

Interconnections that are much better for EMC than conductors (2)

- **Ordinary LEDs can achieve 100Mbps, and can be used outside or inside equipment…**
  - e.g. 'Li-Fi' products use LED luminaires to provide 100Mbps to PCs and personal 'devices'…
  - IrDA protocols provide 2.4kbps – 1Gbps, typically up to 1m range (and 10m range exists)
- **Wireless data links (e.g. Bluetooth, IEEE 802.11, etc.)...**
  - if located near a PCB the electronics can suffer EMI from transmitters, and cause EMI to receivers (see Module 16)…
  - 60+GHz can communicate between PCBs within products…
  - Toshiba's 'TransferJet' industrial microwave links can provide 375Mbps in factories



Fibre-optics are available for the very harshest environments

2. EMC in interconnections

(techniques for cables and connectors)

2.3

The "RF Reference"

We need to identify (or create) the RF Reference – RF_{REF}

- For an external cable, this is generally the metal body of an enclosure that shields the PCBs…
  - which is RF-bonded to the PCBs' RF Reference planes

see Module 6A on essential PCB EMC design

- But, if no metal (or metallised) enclosure, and for internal cables…
  - it is the RF Reference plane – usually 0V(GND) – of the PCB that a cable connects to, << λ/10 away from its connection point (ideally at a PCB edge, see Module 6A)
- A cable has at least two ends, and each one has a *different* RF_{REF}