

# EMC

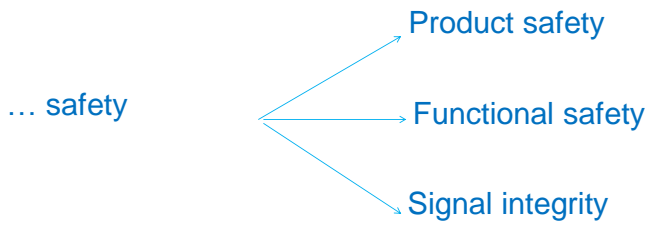
## INTRODUCTION & INDUSTRIAL CASES

*jos.knockaert@ugent.be*

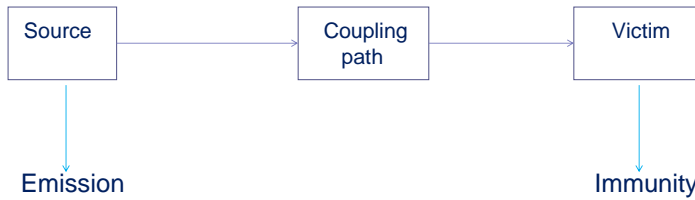
CINI 4.0 Conference June 16th 2022



### EMC IS ABOUT ...

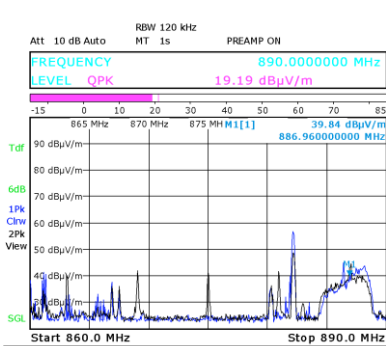


Three ways to solve the problem



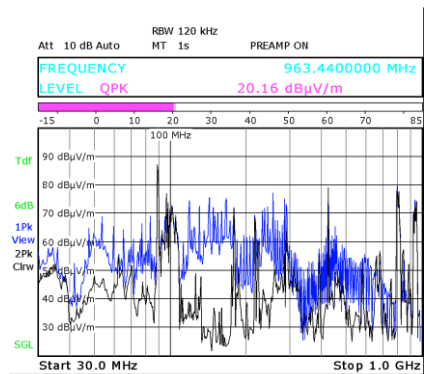
? Question: disturbance of uplink mobile phone at 887 MHz

What is the main source?



Date: 30.SEP.2019 10:52:02

Black = disturbing source on  
Blue = disturbing source off



Date: 30.SEP.2019 10:24:07

Black = disturbing source off  
Blue = disturbing source on



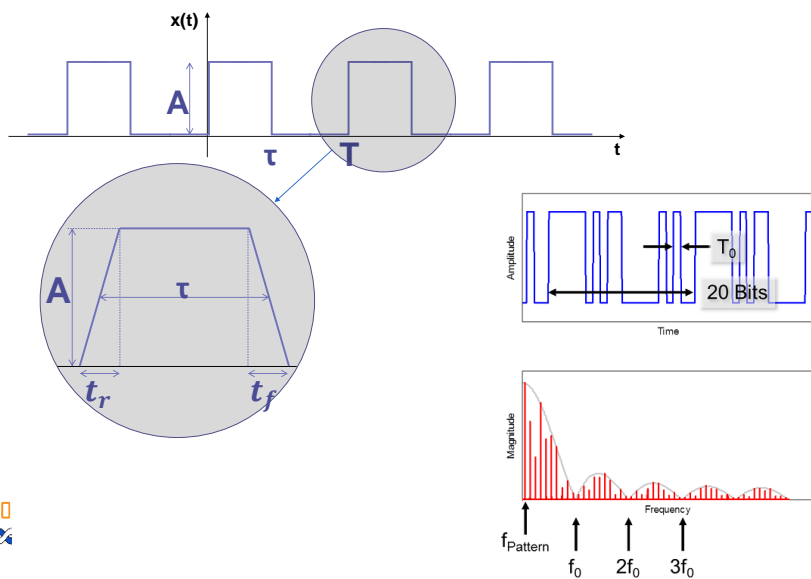
## Rising/falling egde (dv/dt)



## “HIGH FREQUENCY” PROBLEMS

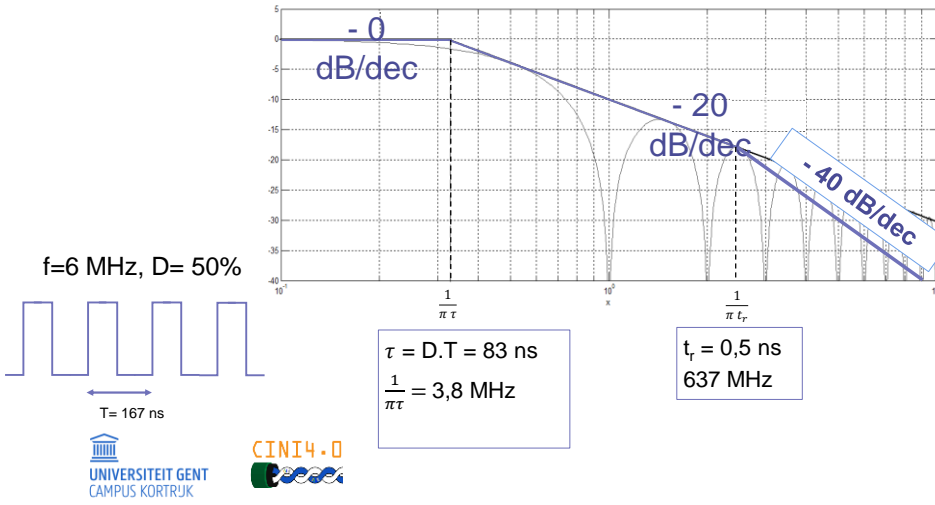
- PWM
- CLK
- Data

## Rectangular signal with finit rise/fall time

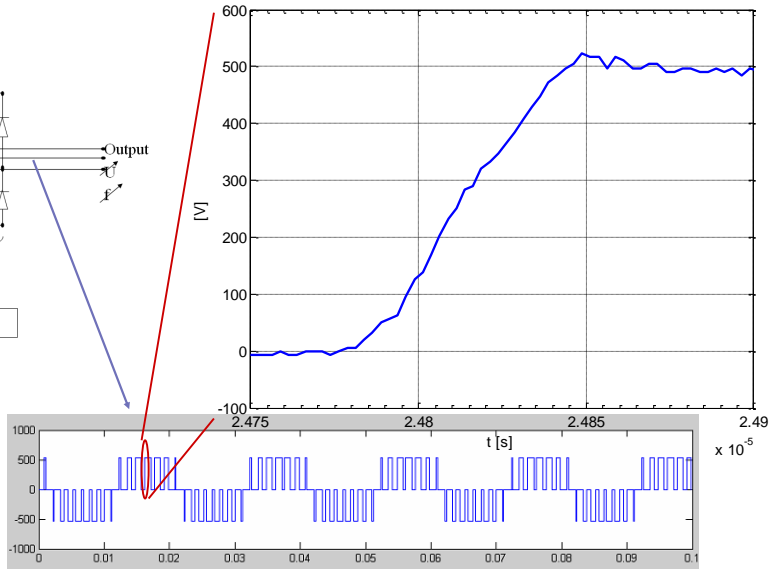
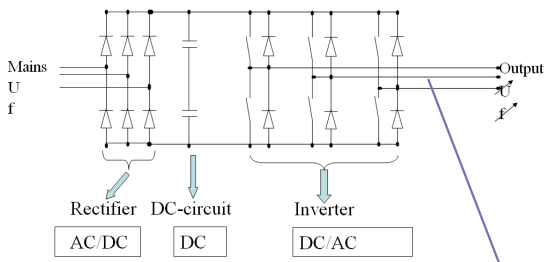


Spectral envelope data

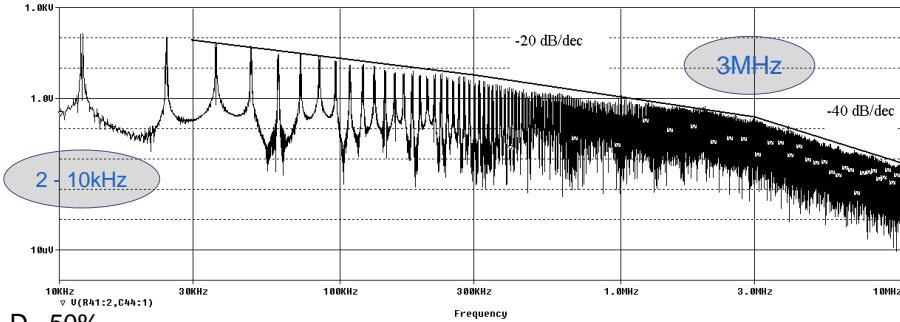
(Consider  $t_r = t_f$ )



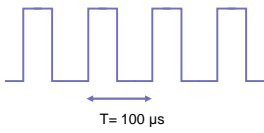
Basic drive:



### What does it mean for your industrial installation?



f=10 kHz, D= 50%



$$\tau = D.T = 50 \mu s$$

$$\frac{1}{\pi\tau} = 6,4 \text{ kHz}$$

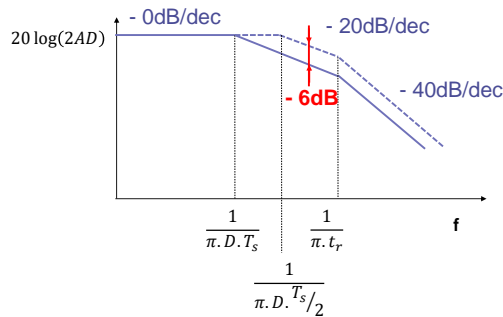
$$t_r = 100 \text{ ns}$$

$$3,2 \text{ MHz}$$

Conclusion: new drives cause larger EMI problems than old drives, so better precautions are needed



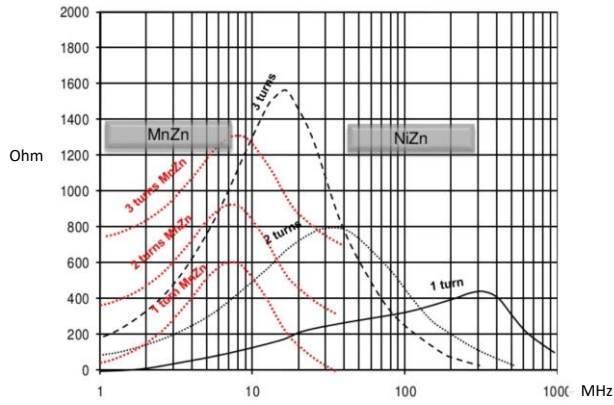
### Influence of switching frequency



Conclusion: never use higher switching frequencies than needed



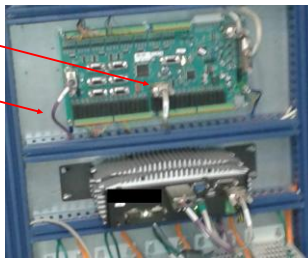
Ferrite beads



Check the active bandwidth: for power electronic problems Mn-Zn or Fe not NiZn

Ferrite beads

- Example:
- 125 MHz EMI-problem
- Emittor is cable 1
- Ferrite on cable 1 increases the emission
- Reason: emission is pushed to cable 2, which acts as a better antenna



? **Question:** do you connect your shielded cable (motor cable, network cable) to ground at

- 2 sides (beginning and end)
- 1 side (beginning, e.g. drive, PLC)
- 1 side (end, e.g. motor, encoder)
- none of both sides

### English terminology:

#### Bonding



Connecting two conductive parts

Bonded parts are normally connected to earth, but can be floating

3.1.18

earth

local earth

ground (US)

local ground (US)

part of the Earth which is in electric contact with an earth electrode and the electrical potential of which is not necessarily equal to zero

#### Grounding

N-Amerikaans  
NEC, IEEE

Providing a low impedance path to earth



#### Earthing

Europees  
IEC

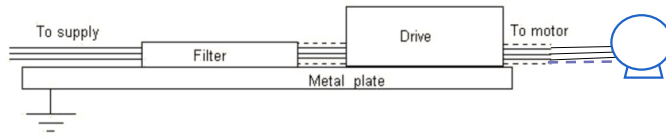


? Question: do you connect your shielded cable (motor cable, network cable) to ground at



- 2 sides (beginning and end)
- 1 side (beginning)
- 1 side (end)
- none (both sides)

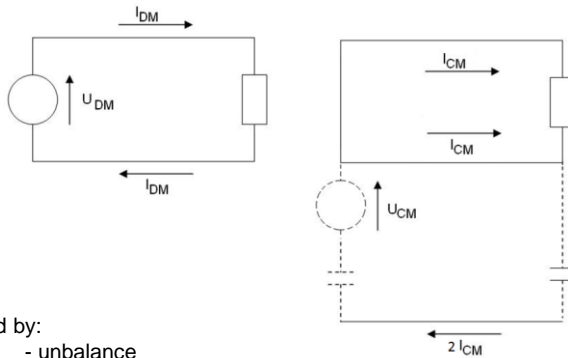
Your shield creates a common reference for both sides  
= bonding at both sides



Protective earth ≠ HF equipotential bonding



Current can be split into differential mode (DM) and common mode (CM) components:

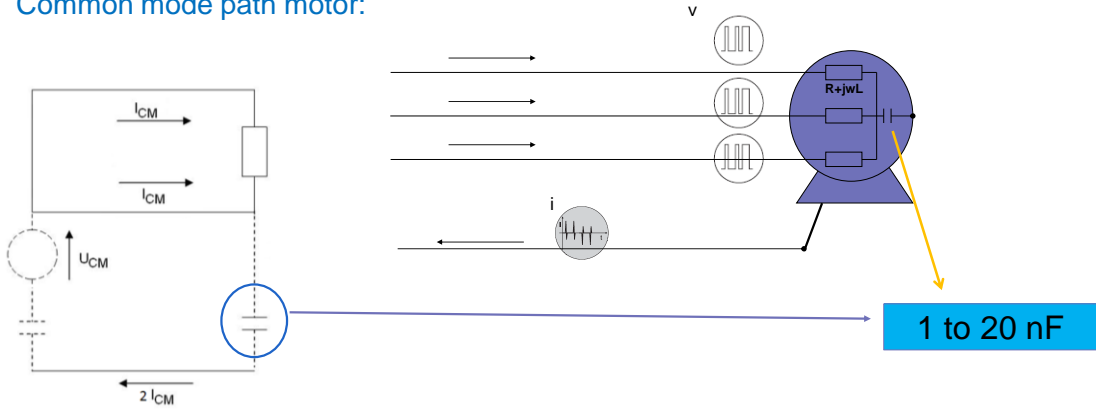


- Caused by:
- unbalance
  - common mode source



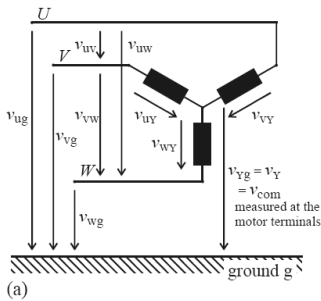


Common mode path motor:

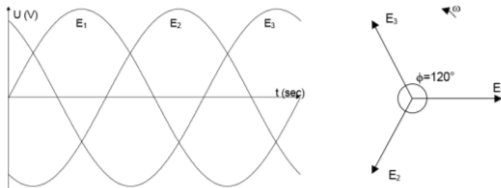


Common mode voltage:

$$v_{com} = \frac{v_{ug} + v_{vg} + v_{wg}}{3}$$



Symmetric three phase voltage

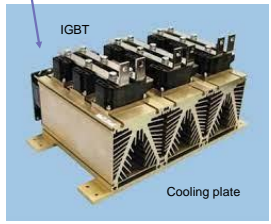
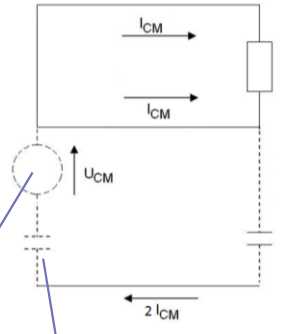
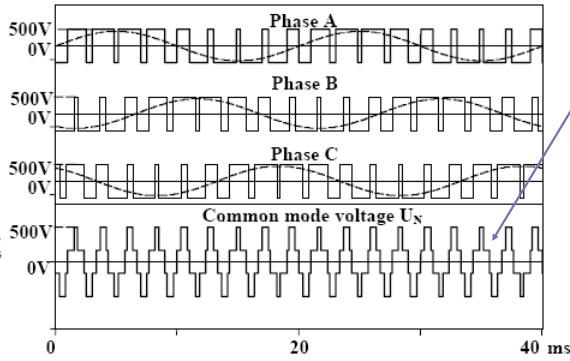
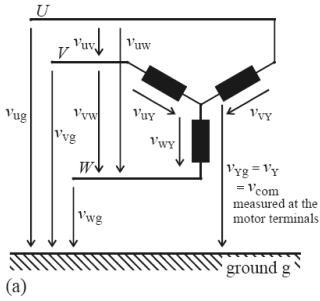


Common mode voltage = 0

Common mode voltage:

$$v_{com} = \frac{v_{ug} + v_{vg} + v_{wg}}{3}$$

Symmetric three phase voltage



Common mode voltage ≠ 0



Common mode causes EMI-problems:

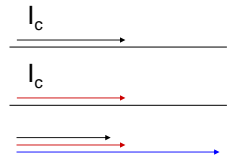
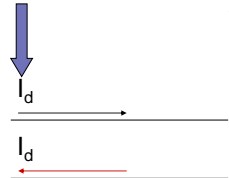


$$I_1 = I_d + I_c$$

$$I_2 = I_d + I_c$$

$$I_d = \frac{I_1 - I_2}{2}$$

$$I_c = \frac{I_1 + I_2}{2}$$



Radiated emission at distance d:  
 Conductor 1  
 Conductor 2  
 Combined field

DM

CM

Principle of shielding: return path (grounding) close to feeding path.

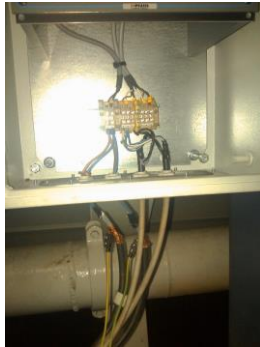


### What does it mean for your industrial installation?

Connect the shielded motor cable in a proper way at drive and motor to create the same reference



Do not use pigtails



Do not interrupt the shield

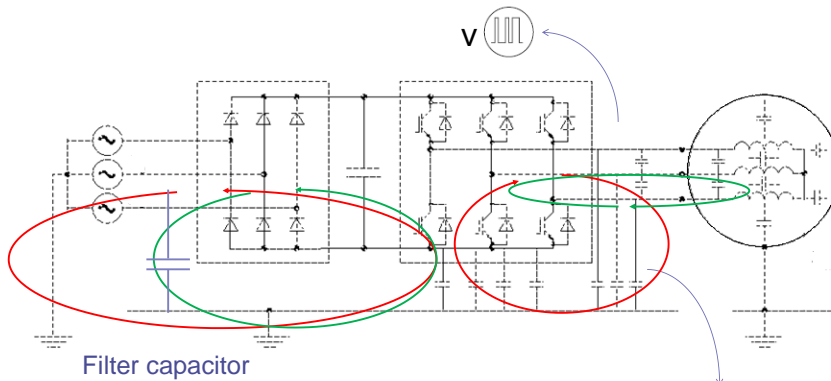


Use cable glands

Use metallic fasteners



### Inverter

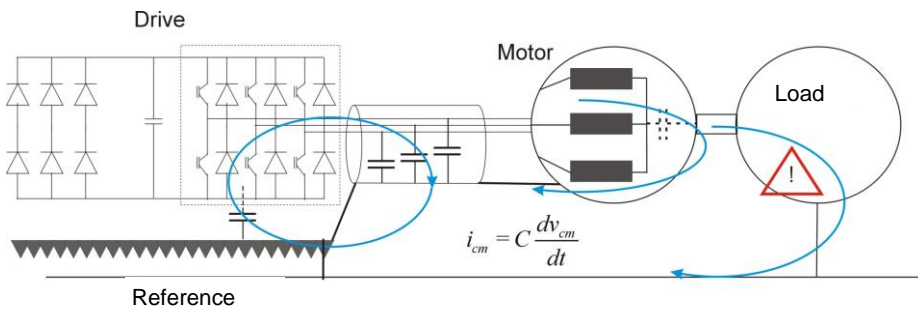
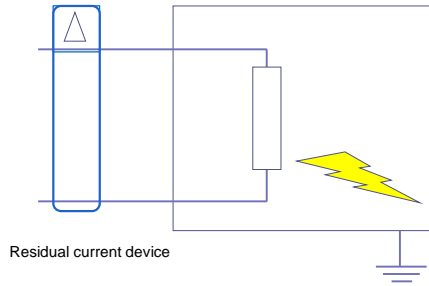


Filter capacitor

$$i = C \frac{dv}{dt}$$

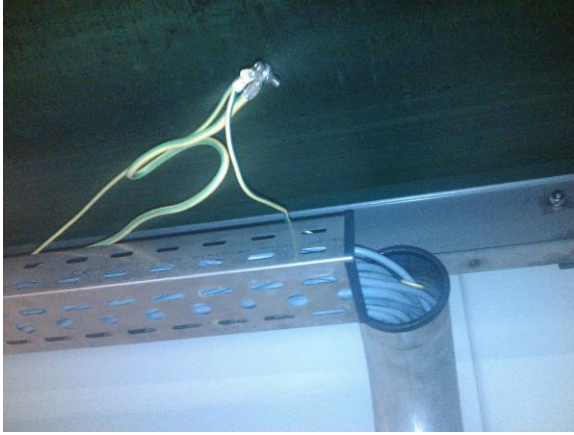


OK Jos, but I disconnected the shield of my motor cable and my communication problem was solved?

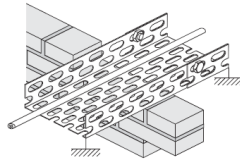
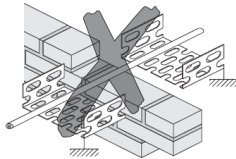
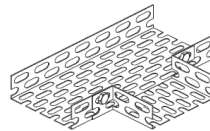
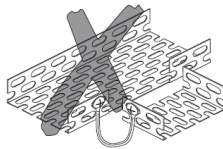


### Some pictures

- What is wrong?



### Some pictures

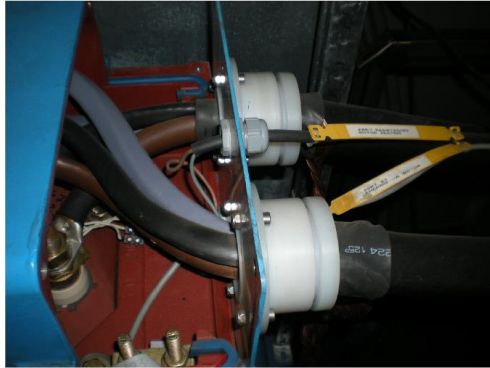


Flat braid wire



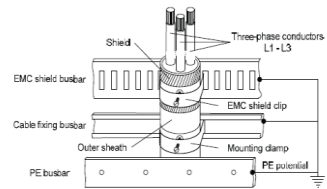
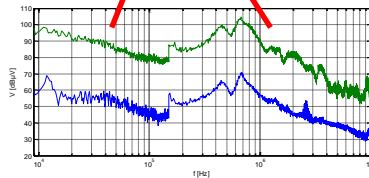
Some pictures

- What is wrong?



Some pictures

- What is wrong?



Shield bonding to the EMC shield busbar in the converter using an EMC shield clip



## Profinet

Two pair cabling: minimum cat5 up to 100 Mbps

- two twisted pair

or

- one quad

Network: PN devices

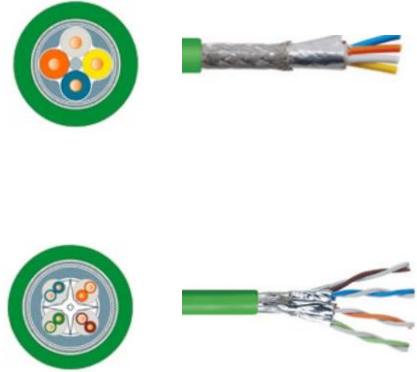
Four pair cabling: minimum cat 5 up to 10 Gbps

- four twisted pair

or

- two star quad

Network: PN and other IT devices

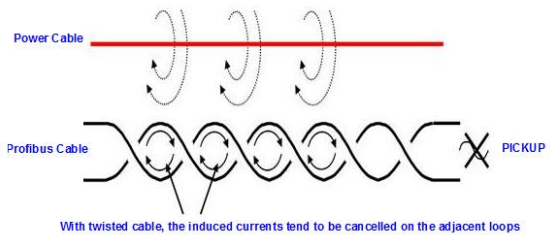
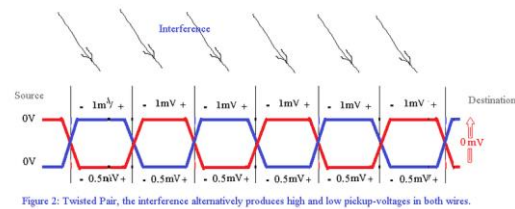
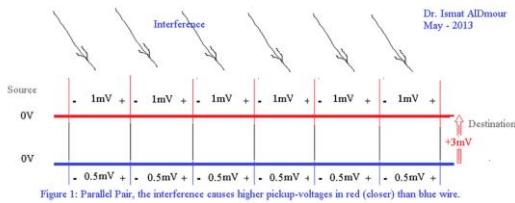
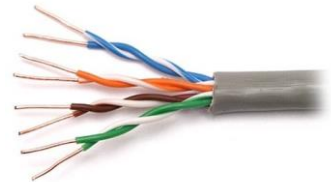


Application type	Type A	Type B	Type R	Type C
Installation	Stationary	Flexibile (occasional movement and vibration)	Robot applications	Special applications, permanent movement
Strands	AWG 22/1	AWG 22/7	-	AWG 22/1 to 19



## Twisted pair

- Limit interference and crosstalk
- Principle of cancelling/equalizing induced voltages



Equalizing

Cancelling

 FACULTEIT INGENIEURSWETENSCHAPPEN  
EN ARCHITECTUUR

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