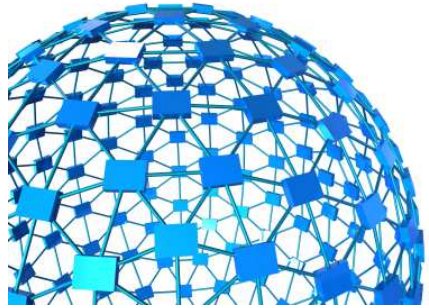
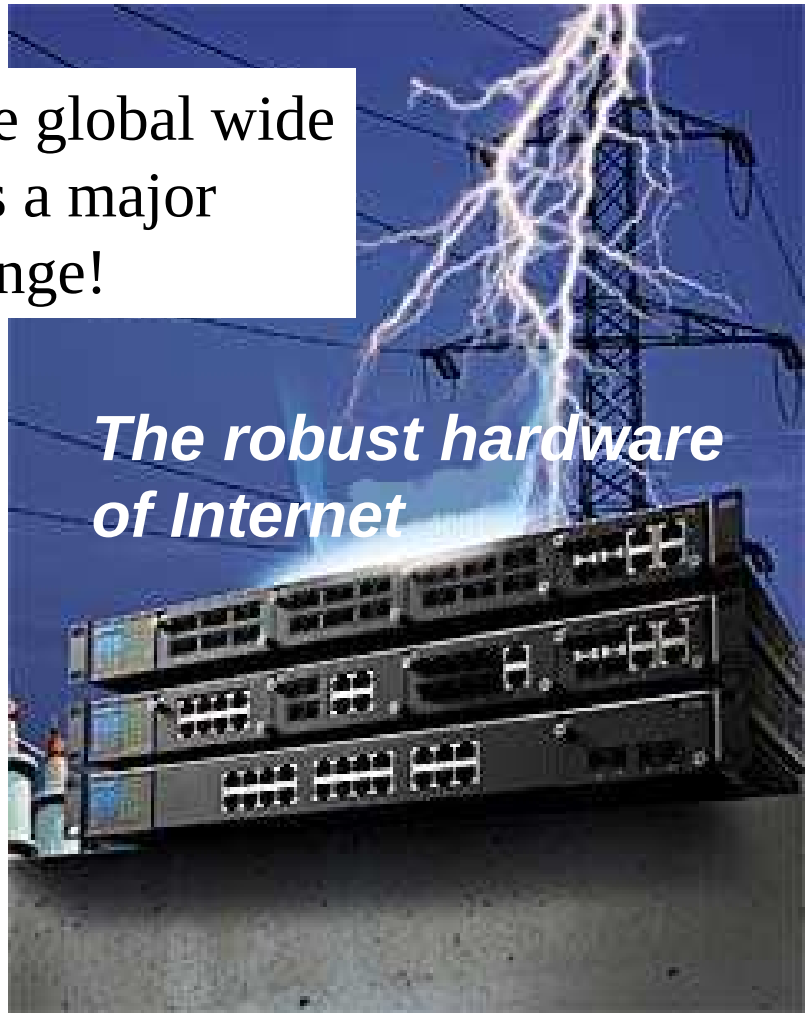
Internet consists mostly of wired data communication equipment



To build a stable global wide area networks is a major electrical challenge!



How do you fight the electrical interference?

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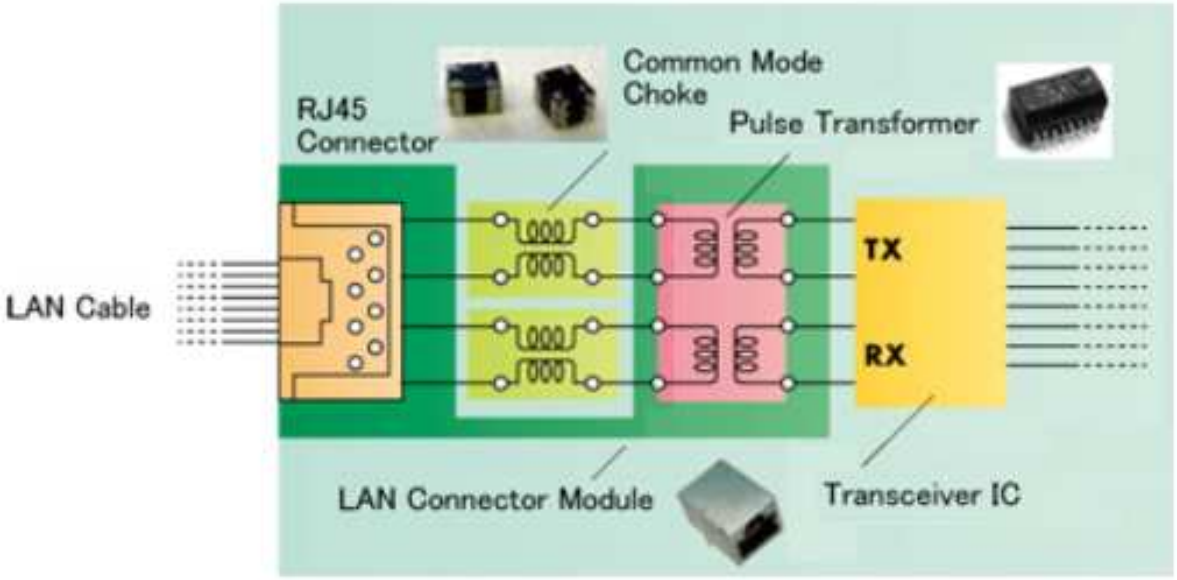
Ethernet contact



《LAN Connector Module》
Comprises the pulse transformer and common mode filters

Ethernet contact contains:

- Pulse transformer
- Common Mode Choke

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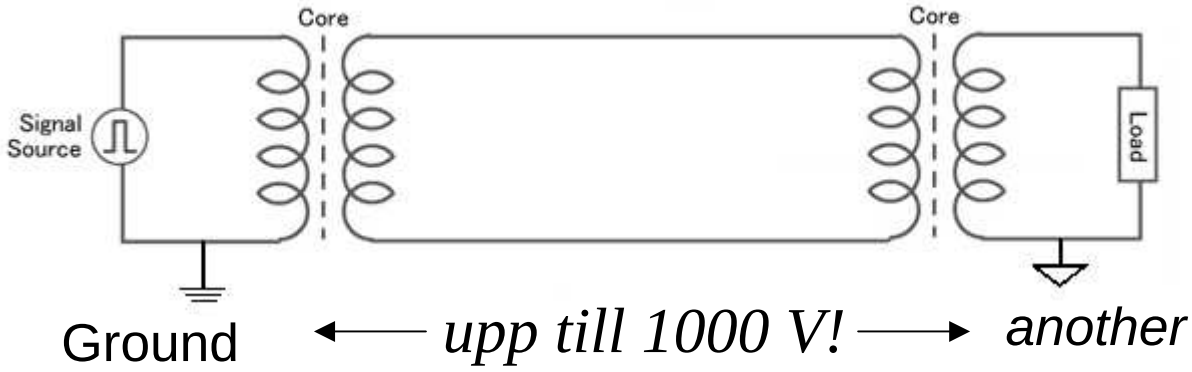
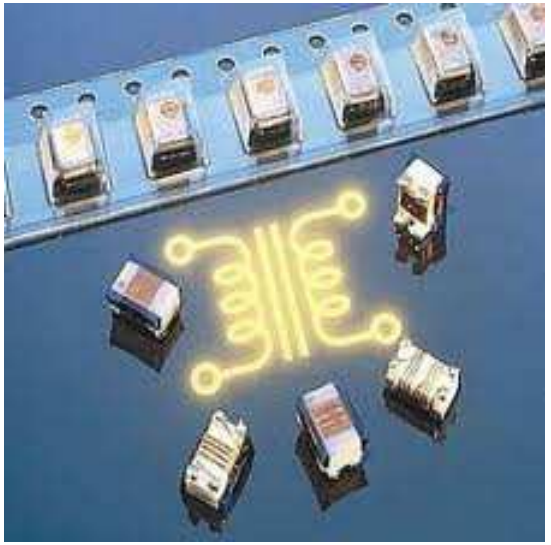
Isolatin with transformer



The transformers isolate different devices from each other even if the ground potentials should happen to differ by up to 1000 V!



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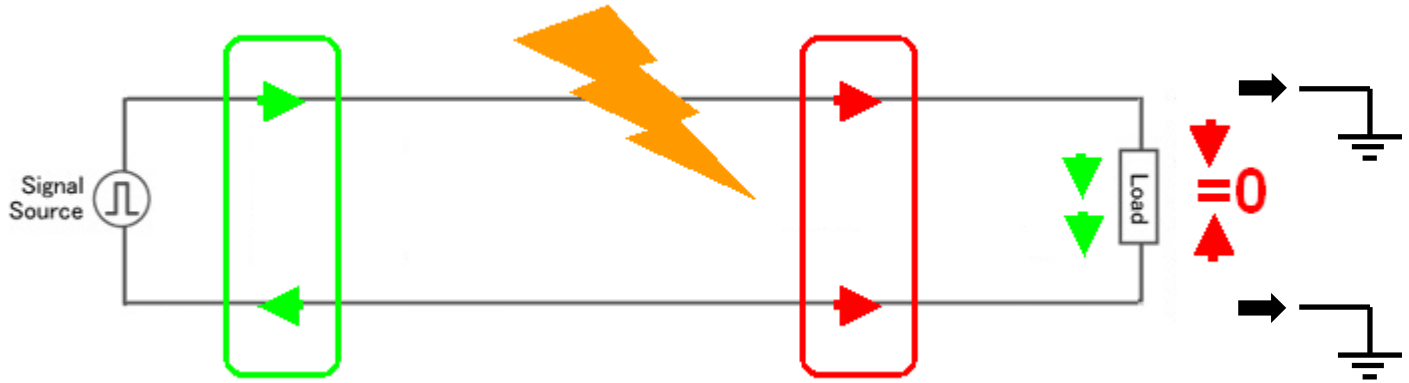
Signals and Interference

All wires has capacitance against the earth (ground). Signals can ”leak” from the wires to ground.



*Signals are differential mode **DM***

*Interference are common mode **CM***

- Signals are **differential mode**, they hawe different current direction in the they have different current direction in wire and return wire.
- Interference are **common mode**, they have been generated from outside and has the same current direction in both wires.

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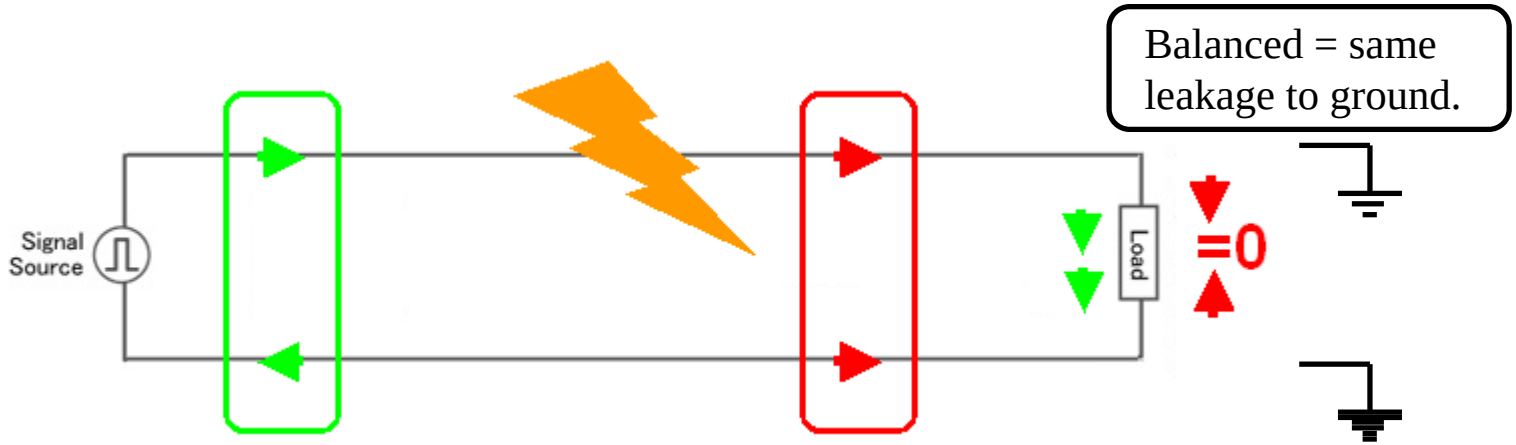
Balanced equipment



*Signals are differential mode **DM***

*Interference are common mode **CM***

Commonmode-interference has *no* impact on signal if it we have a balanced equipment.

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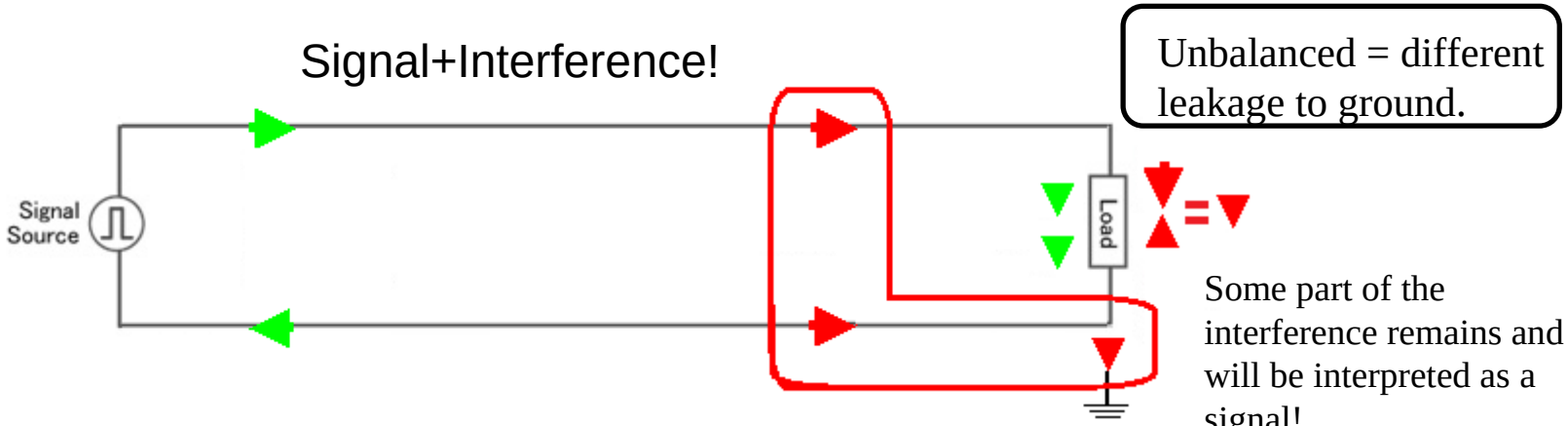
Unbalanced equipment



*Signals are differential mode **DM***

*Interference are common mode **CM***

An unbalanced equipment has "closer" to the ground for one conductor, a part of the interference then takes that way – the remaining rest of the interference is perceived as if it were the signal.

Balanced equipment is, therefore preferable.

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Which instrument suppress common mode interference?

10000 kr

100 kr

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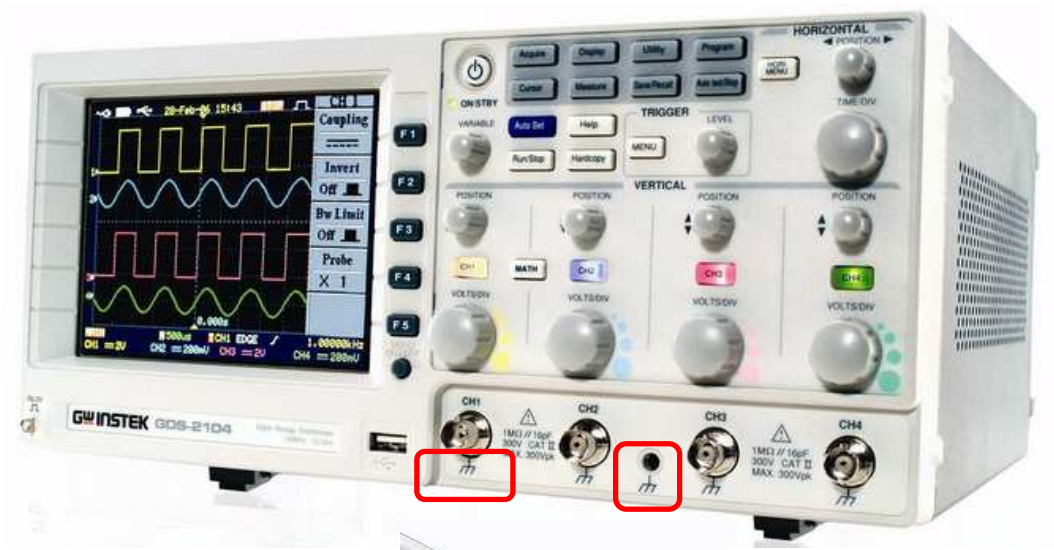
Which instrument suppress common mode interference?



- The cheap handheld instrument is isolated from ground and is completely insensitive to common mode voltages!

- The expensive oscilloscope has grounded inputs, thus becoming sensitive to common mode interference!

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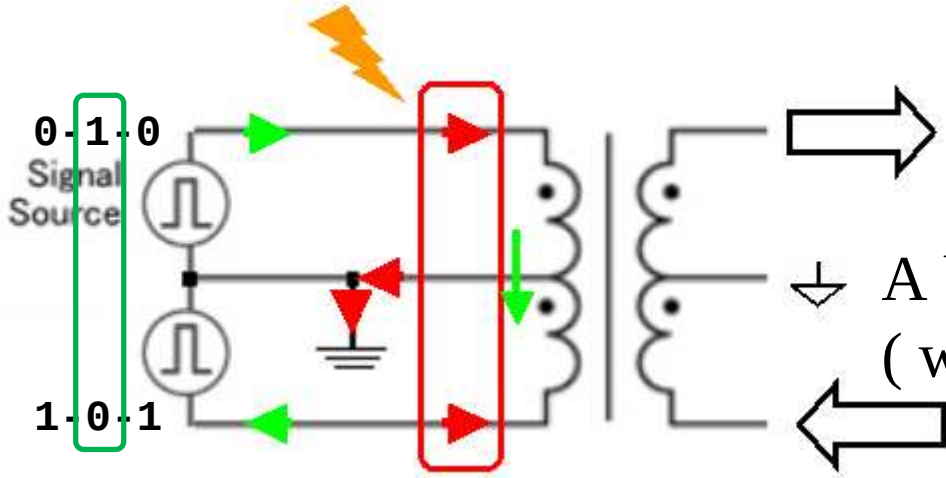
Balanced pulse transformer



A balanced DM-signal
(with respect to ground)

The transmitted data signal consists of two "opposing" pulses which together run a current through both winding halves. Local interference occurs common mode and will instead be led to ground, and never reach the transformer's secondary side.

The result is an isolated and balanced DM signal relieved of "local" interferece.

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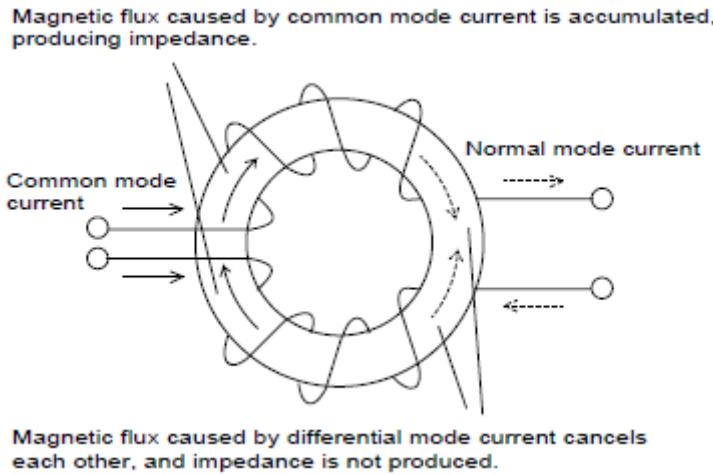
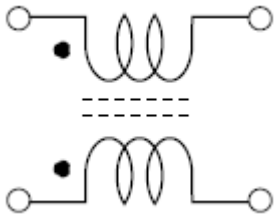
Common mode choke

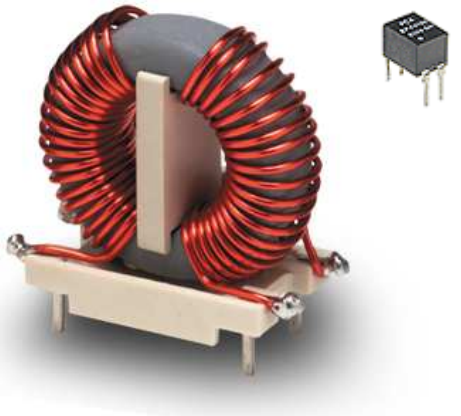
$$L_{SER} = L_1 + L_2 - 2M$$

$$L_{PAR} = \frac{L_1 \cdot L_2 - M^2}{L_1 + L_2 - 2M}$$

CM-Choke







- **Interference**, common-mode current (= parallel connected coils), meets inductance and is retarded

$$k = 0,9 \quad \Rightarrow \quad M = 0,9L \quad L_{TOT} = \frac{L \cdot L - (0,9L)^2}{L + L - 2 \cdot 0,9L} = \frac{0,19}{0,2} L \approx L$$

- **Signal**, differential-mode current (= series connected coils), meets hardly any inductance at all!

$$k = 0,9 \quad \Rightarrow \quad M = 0,9L \quad L_{TOT} = L + L - 2 \cdot 0,9L = 0,2L \approx 0$$

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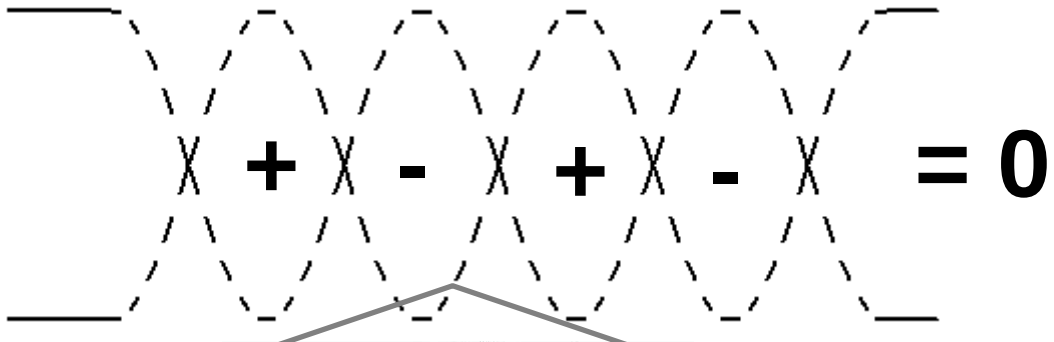
Twisted pair cable

- Between equipment twisted pair cable is used.



A twisted pair cable becomes insensitive to magnetic interference from outside, resulting induced emf becomes≈0!

The wires are tightly connected to each other $k \approx 1$.

$$L_{TOT} = L + L - 2L \approx 0$$

- The wire inductance get ≈0 for signal, but ≠ 0 for the interference!

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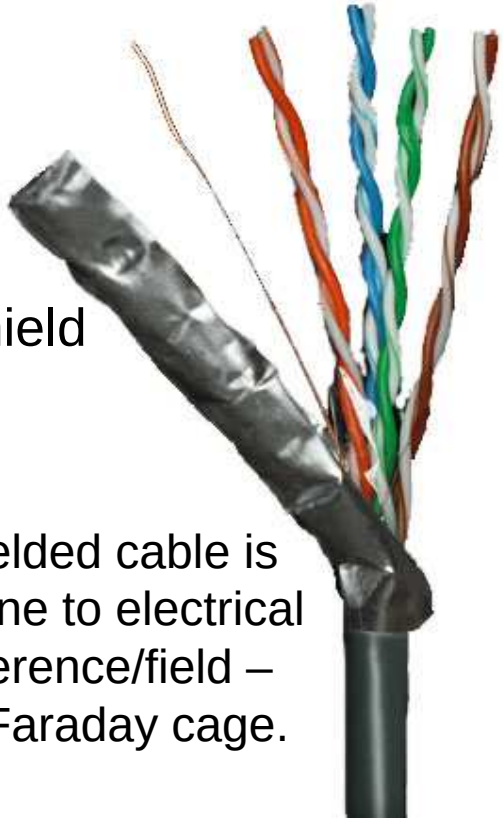
shielded cable?

Foil shield



A shielded cable is immune to electrical interference/field – as a Faraday cage.

Ltake it easy, he will survive …

- Against radio frequent interference can a shielded Ethernet cable be used.

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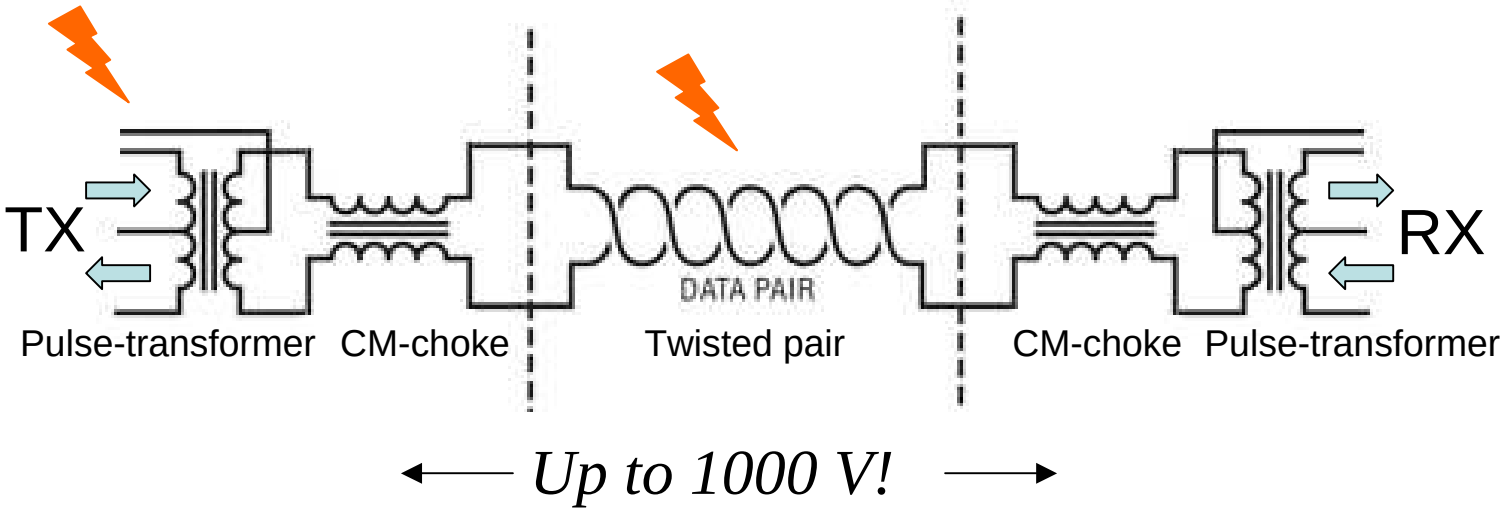
The entire data transfer



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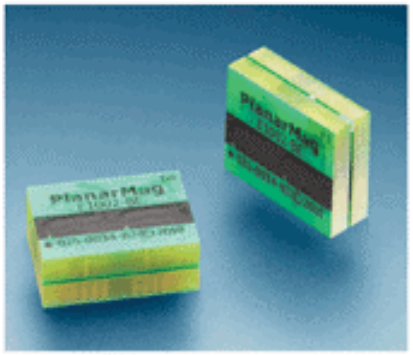
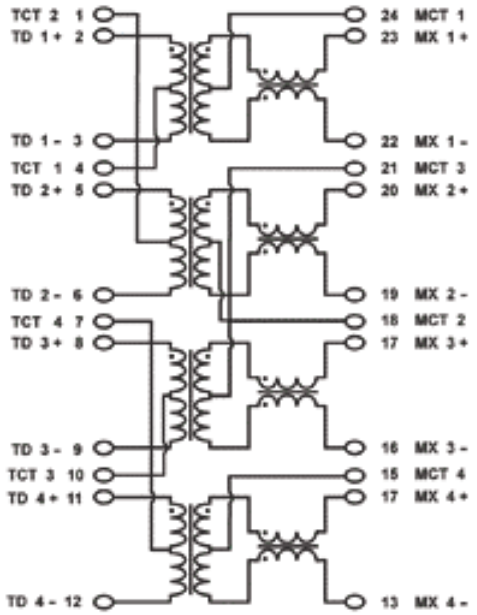
Ethernetfilter as a component

Ethernet filter can be purchased as a finished component, mounted in the contact.





1000BASE-CX **Gigabit Ethernet** for twisted pair cable.

Contains both **Pulse transformer** and **CM-Choke**

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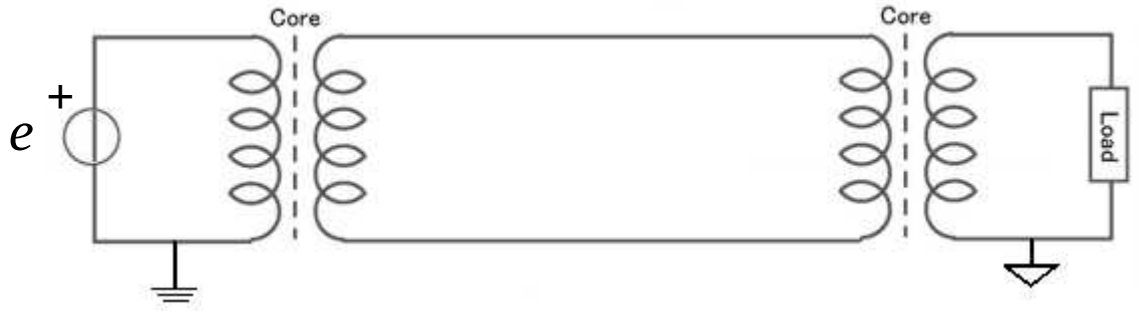
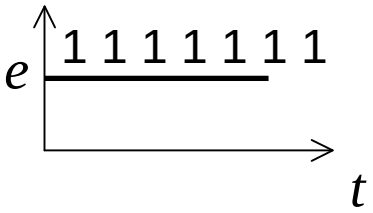
Data through a transformer?





Data may not be constant for any length of time because ”direct voltages" can not pass through transformers!

- Therefore, data is "Manchester Coded".

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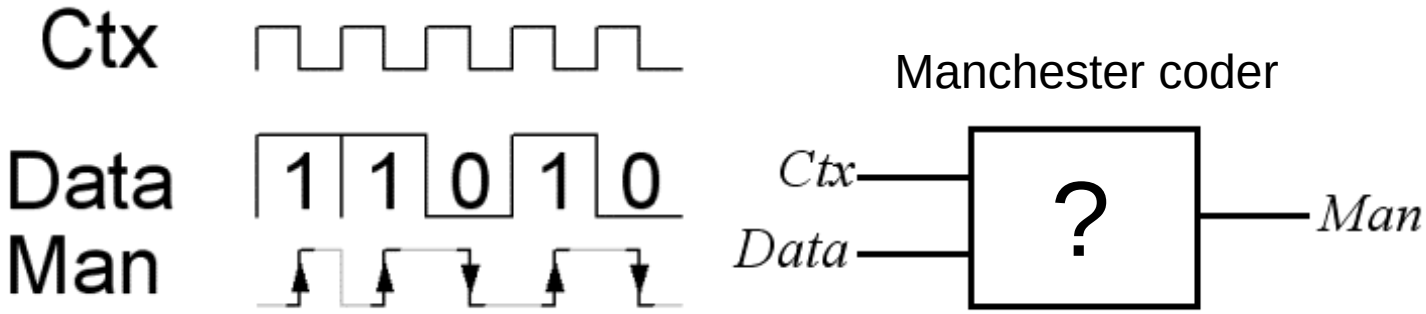
Manchester Code

Manchester encoding implies that 1 and 0 are represented by positive and negative edges. The signal change all the time even when the data is constant and can therefore pass through transformers!



(Do you remember the gates from Digital Design?
What do you think is inside the Manchester coder?)

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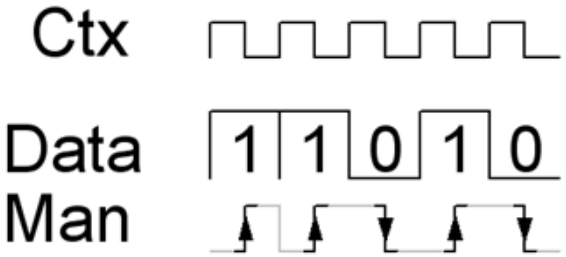
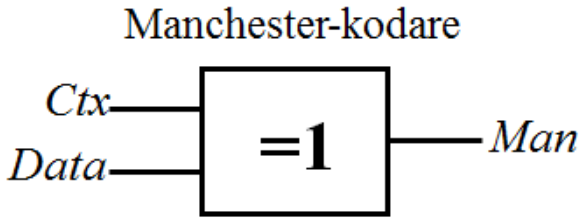
(Manchester coder)



Ctx	*Data*	*Man*
0	0	0
0	1	1
1	0	1
1	1	0

$Man = Ctx \oplus Data$



It is sufficient with a single exclusive OR gate for producing a Manchester signal from the data and clock pulses!

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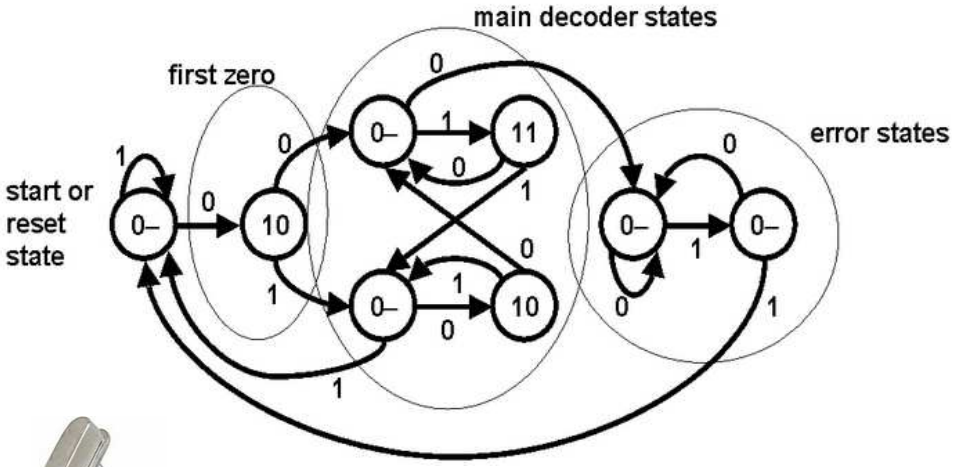
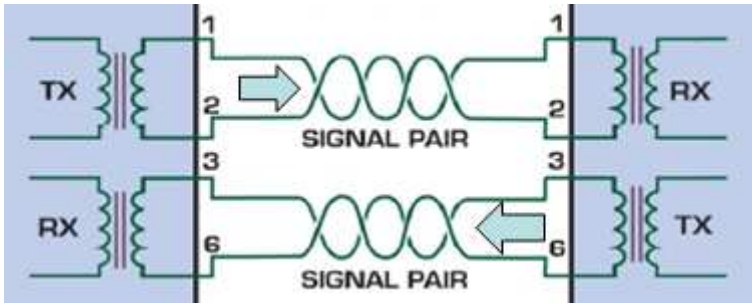
(Manchester decoder)

- With a sequential circuit on the receiving end one can then extract both the clock signal **`Ctx`** and the signal **`Data`** from the manchestersignal **`Man`**.
- Both sides have their own local clock pulses need not be exactly equal.



Sequence circuit for the manchester decoder is a bit too complicated to be part of a digital design written exam!

`Ctx1`



`Ctx2`

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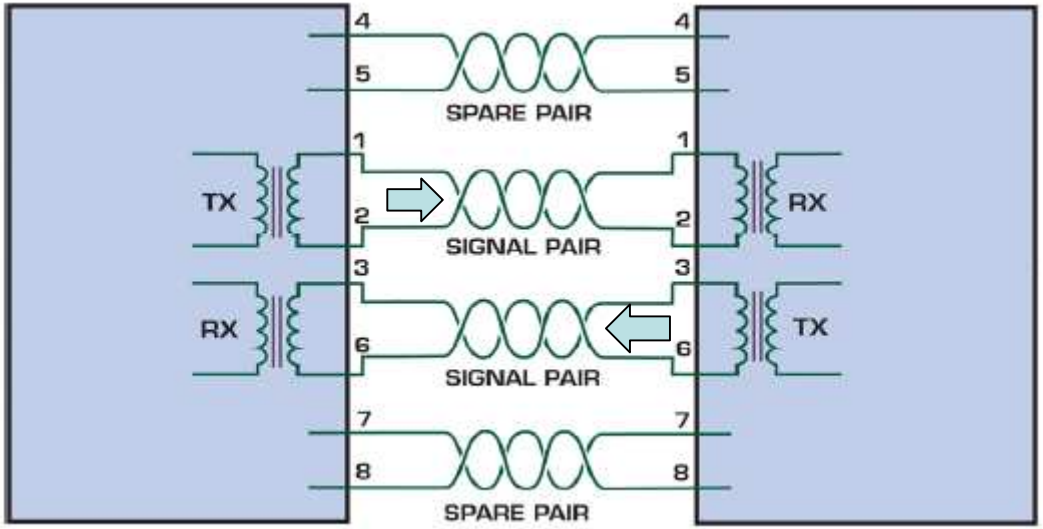
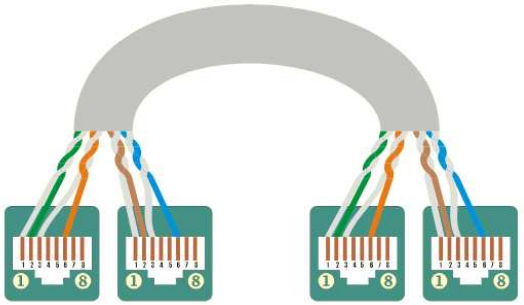
Ethernet contact



4 signal pairs, two spare wires.
What can you use the spare wires to?



Spare wires?

- two devices can share a single cable (100Mb/s),

or

- higher transmission speed (1000Mb/s) !

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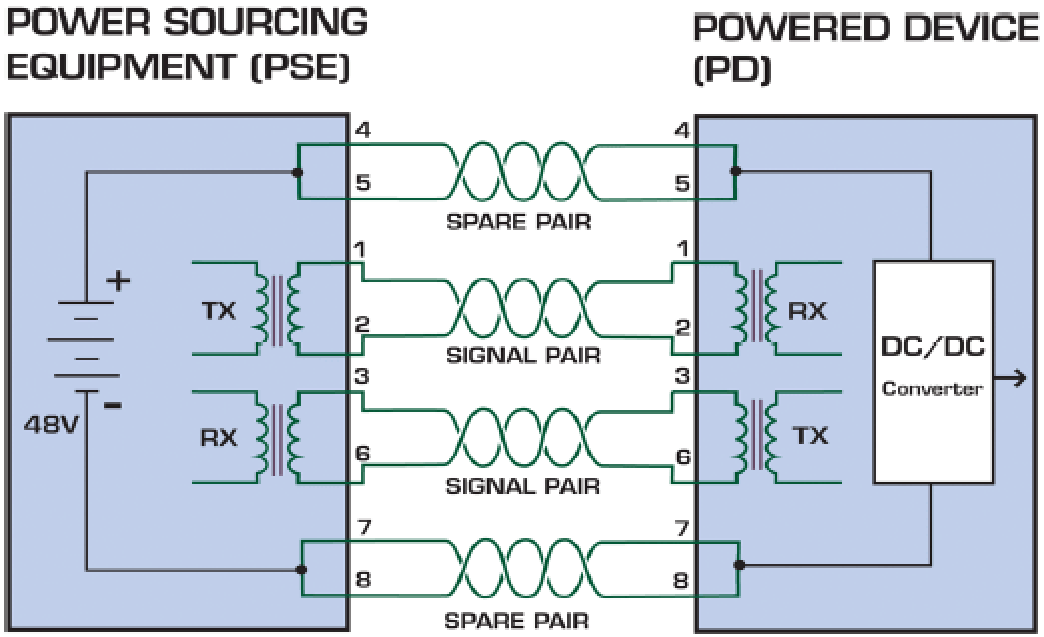
Power over ethernet



Spare wires? • power over ethernet

Silly to use "spare wires" (Spare pair) to power - it is better to use them for data transfer (1000Mb/s).

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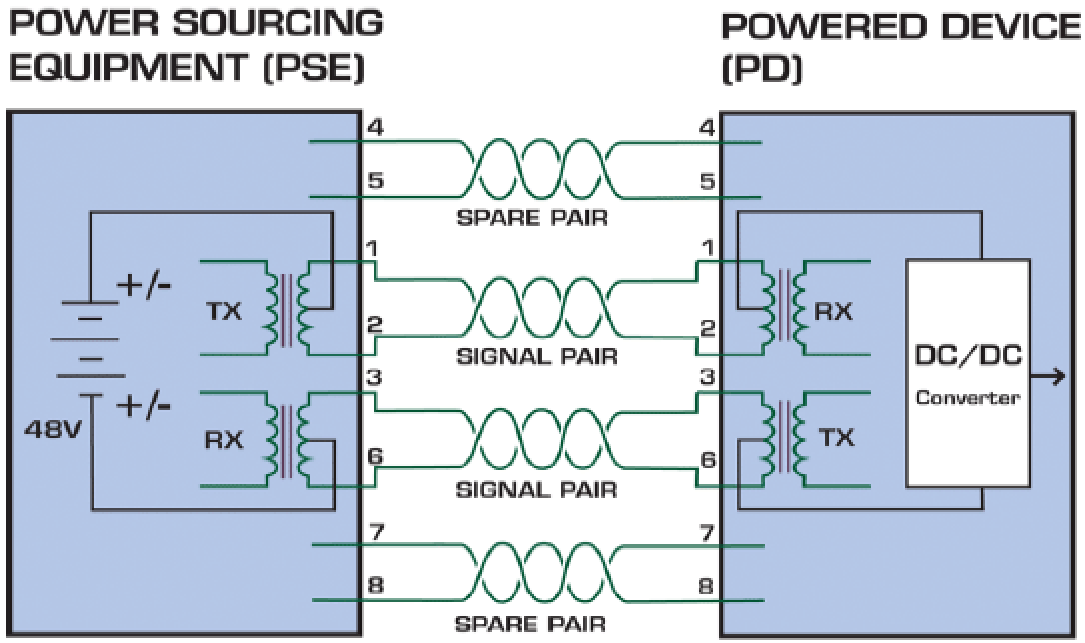
Power over ethernet



- The ”smart” way that ***does’nt*** use the ”spare pairs” …

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