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Use and abuse of screened cables

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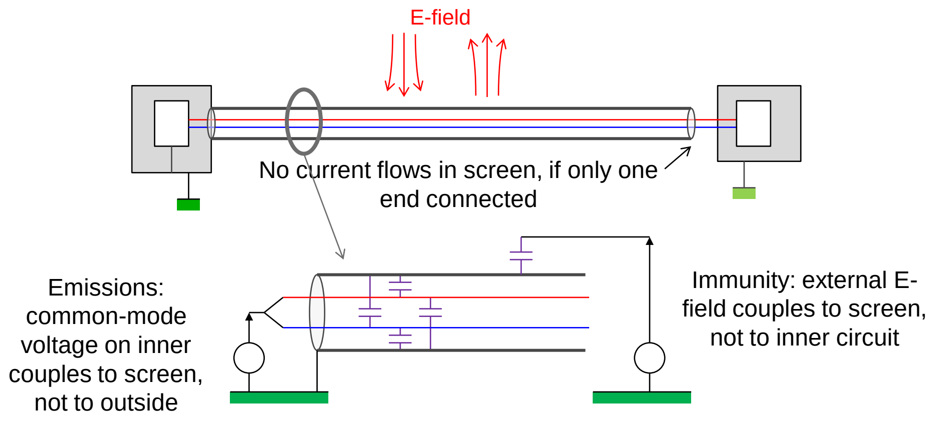
Outline

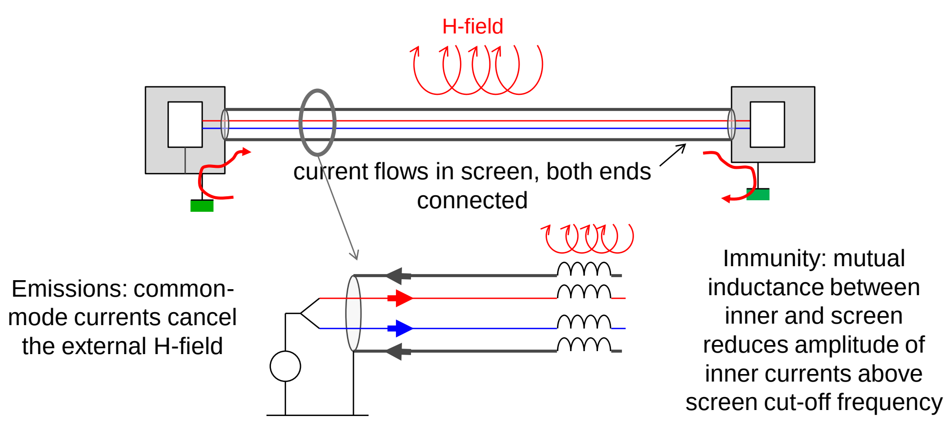
- How does a screened cable work?
  - electric fields, magnetic fields, low versus high frequency
- Types of screen
- Transfer impedance
  - definition, examples, correlation with shielding effectiveness
- Termination:
  - full screening, pigtail, no connection at one end

The electric field screen (LF)



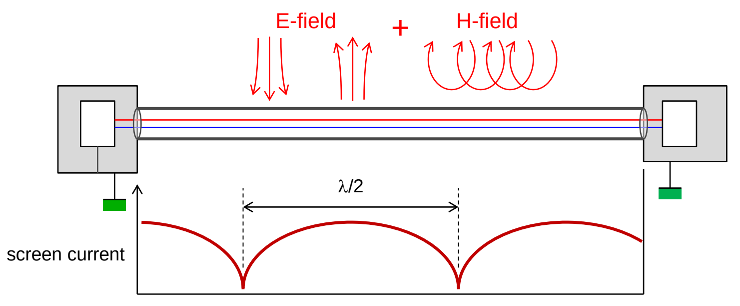
• Need only be connected at one end: screen coverage must be good, e.g. wrapped foil

The magnetic field screen (LF)



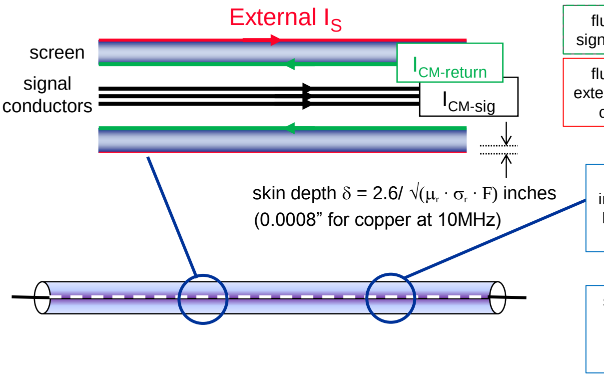
• Must be connected at both ends: screen conductivity and coaxiality must be good

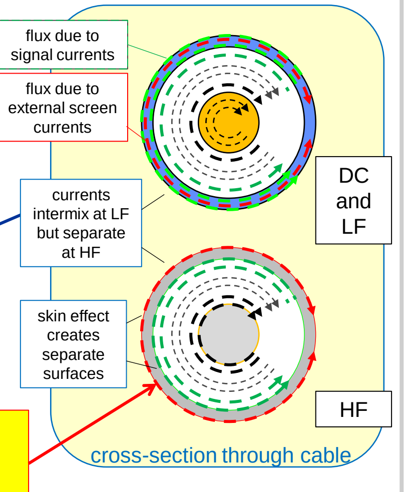
Radiated field screen (RF)



- RF coupling involves both electric and magnetic fields, ratio determined by the wave impedance
- Both good conductivity and good coverage are necessary, current must be allowed to flow at both ends

Currents in cross-section: LF vs HF



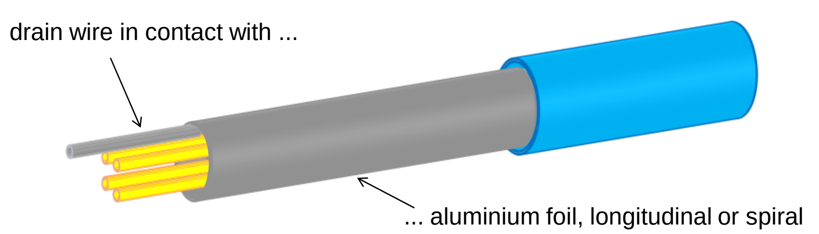


- solid screen allows perfect separation
- braided screen compromises effect through weave and "porpoising"

Types of screen

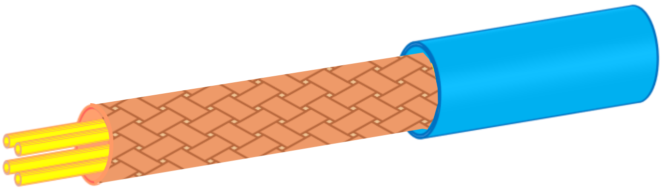
- The selection of cable type always forms part of the *total* EMC design, i.e. the design of the circuits, the choice of reference system, the screening, etc.
  - – Jasper Goedbloed, *Electromagnetic Compatibility* 1992

Types of screen: foil and drain wire



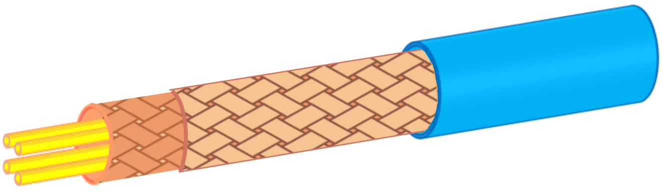
- Not much good for anything except LF capacitive screen
- Cheap, light and flexible

Types of screen: single braid



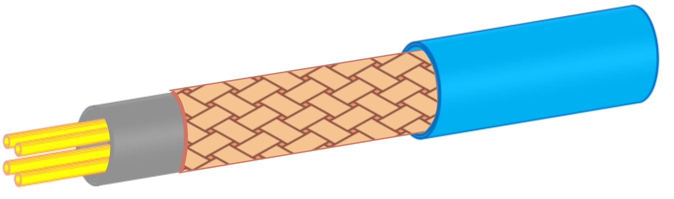
- Standard, general purpose; e.g. RG58 coax, multi-conductor instrumentation
- Reasonably cheap, light and flexible, not especially good screening

Types of screen: double braid



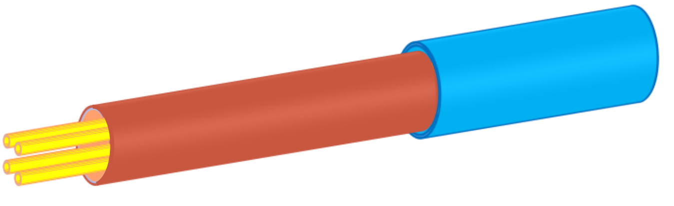
- Noticeably better performance at HF than single braid; braids may be in contact or separated
- Expensive, can be heavy and stiff

Types of screen: foil & braid



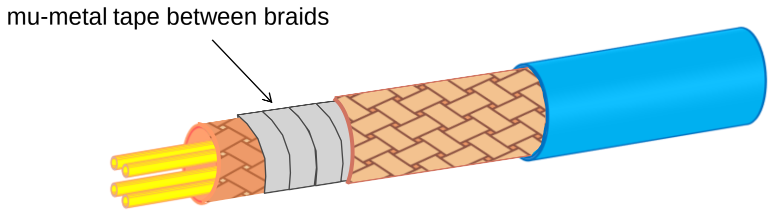
- Good all-round performance, reasonable compromise between performance, weight, flexibility and cost

Types of screen: solid tube (semi-rigid)



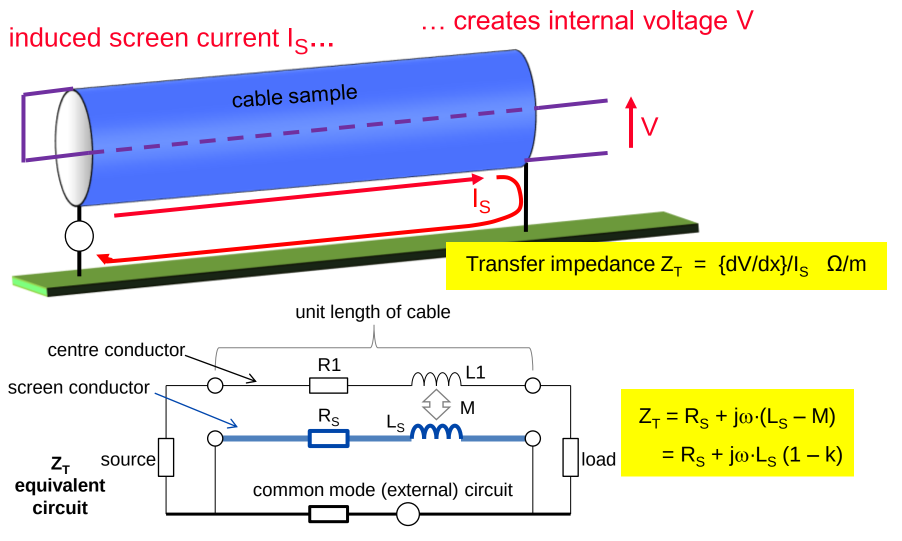
- Excellent for RF, performance just gets better and better as frequency increases
- Can't be repeatedly flexed, good for permanent installation

Types of screen: superscreen

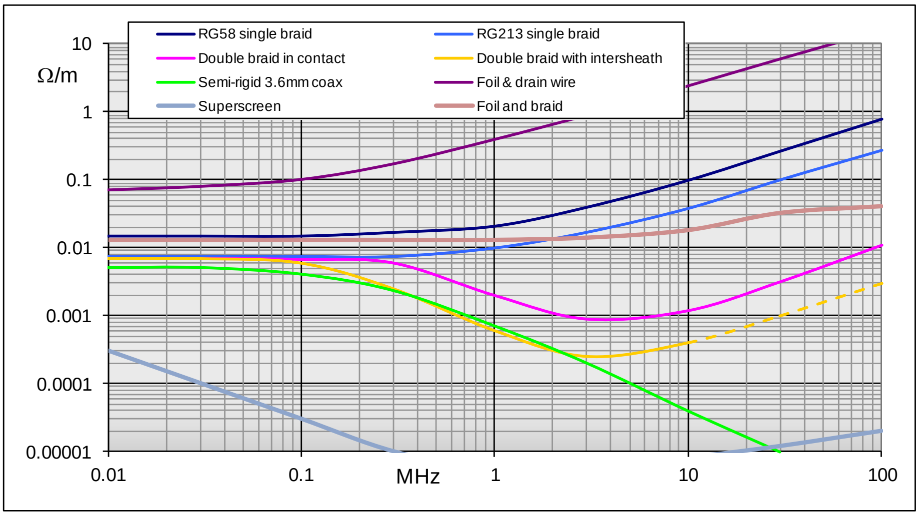


- Absolutely superb screening across the whole spectrum
- Very expensive, heavy, little flexibility

Transfer impedance: definition



Transfer impedance: examples



Transfer impedance vs. shielding effectiveness

- If shielding effectiveness is defined as:

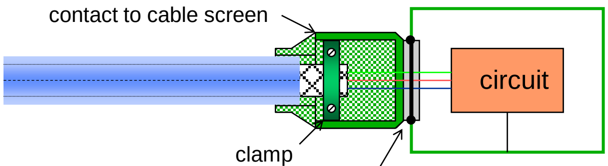
  SE (dB) = $10 \log_{10} (|P_{feed}/P_{rad,max}|)$

  where P_{feed} = feed power into cable, $P_{rad,max}$ = power radiated from outside of cable
- then you need to know the detail of the outer environment (dielectric and characteristic impedance) to know $P_{rad,max}$ – not generally known
- Z_T is a function of the cable only, and so is useful for comparing different constructions, but doesn't directly relate to the SE of the cable
- A practical, simple but inexact expression for the conversion is

  SE (dB) = $36 - 20\log_{10}(Z_T) - 20\log_{10}(L)$

  where Z_T is in ohms per metre and L is cable length in metres; 36dB is a fudge factor for typical environments

Termination: best practice

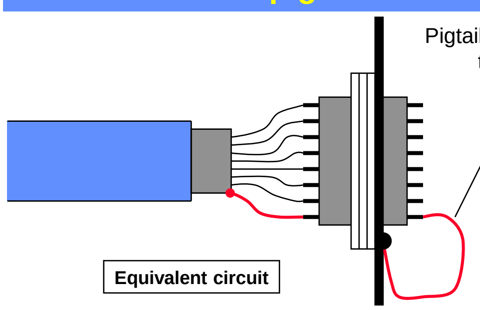


cable screen can be clamped to shell

MIL-C-38999

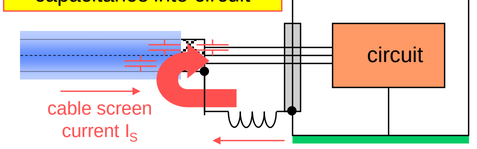
- To avoid compromising the cable assembly's transfer impedance, screen continuity must be maintained around the whole of the inner conductors right through the mating shells

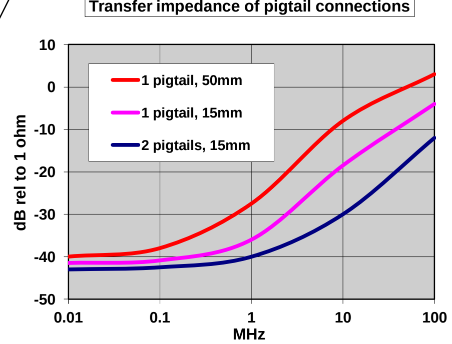
Termination: the pigtail



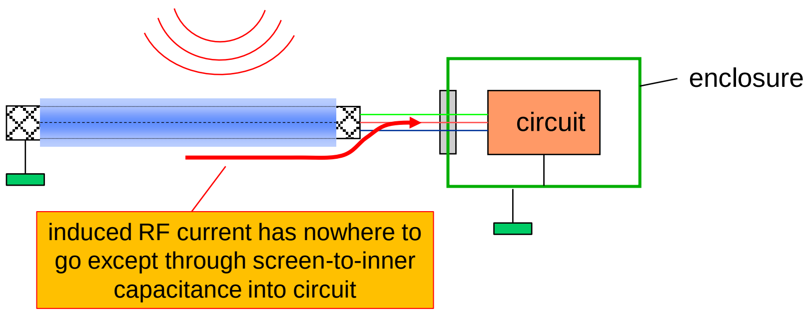
Equivalent circuit

$V_{pigtail}$ couples through cable capacitance into circuit





Termination: one end open



- If one end of the screen is left open then there is no RF screening effect: only LF capacitive screening is provided

Suggested reading

- Jasper Goedbloed, *Electromagnetic Compatibility*, Chapter 5, Prentice Hall 1992 (Updated version, Mart Coenen, MYbusinessmedia BV 2010)
- Anatoly Tsaliovich, *Cable Shielding for Electromagnetic Compatibility*, Van Nostrand Reinhold 1995
- Pat Fowler, *Superscreened cables*, The Radio and Electronic Engineer Vol 49 No 1 pp 38-44 Jan 1979
- A.A. Smith, *Coupling of External Electromagnetic Fields to Transmission Lines*, John Wiley & Sons, 1977
- E.F. Vance, *Coupling to Shielded Cables*, Krieger, 1978
- IEC TS 62153-4-1:2014, Metallic communication cable test methods - Part 4-1: Electromagnetic compatibility (EMC) - Introduction to electromagnetic screening measurements
- EN 50289-1-6:2002, Communication cables - Specifications for test methods - Part 1-6: Electrical test methods - Electromagnetic performance

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THE END

Thanks for your attention!

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