EE 521: Instrumentation and Measurements

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1. **Sources of Coherent Interference**
   - Capacitive Coupling
   - Inductive Coupling
   - Ground Loops
   - Power Line Lowpass Filters
2. **Cures of Coherent Interference**
   - Transient Voltage Suppressors
   - Coaxial Cable Grounding
   - Choke or Neutralizing Transformer
   - Circuit Grounding
   - Interruption of Ground Loops
3. **Summary**

Capacitive Coupling

Conductors in the close proximity interfere with each other.

- Implements highpass RC filter across the noise source and the signal.

Capacitive Coupling

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- Noise appearing on the signal is proportional to the noise source level.

Capacitive Coupling

Conductors in the close proximity interfere with each other.

- Problem with high frequency and high impedence signals.

Inductive Coupling

Magnetic flux generated due to noise circuit will induce current in neighboring circuits.

- Roughly proportional to the areas of the two circuits.

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- Noise generated is an added voltage in parallel, therefore, independent of signal level.

Inductive Coupling

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- Can be differentiated from capacitance by changing the load impedence (if noise level stays the same then we have inductive coupling).

Conductive Loop

A time-varying B field in exist in space in the vicinity of a loop of area A. May be caused by unshielded power transformer or strong radio frequency electromagnetic field.

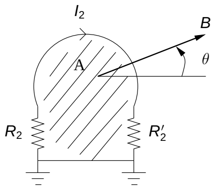

Figure: Induction of a coherent interference current, I_2, in a conductive loop enclosing a current carrying conductor.

By Faraday's Law

$$E = -\frac{d}{dt}\int Bds \qquad (1)$$

Conductive Loop - Special Case

In case of a sinusoidally varying B field intersecting the plane of the loop at an angle θ

$$E = j\omega BA\cos\theta \qquad (2)$$

and the interference current induced in the loop is:

$$I_2 = \frac{j\omega BA\cos\theta}{R_2 + R_2'} \qquad (3)$$

Ground Loop - Definition

Two ground points are not at exactly zero potential causing ground loop current to flow.

Quick Fixes

- Use grounded shielded cables to deal with capacitive coupling.

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- Twist wires when possible.

Transient Voltage Suppressors

Prevents high voltage, spike-like transients occurring on the power mains input to an instrument system from causing damage to the system's components. Common transient voltage suppressors are varistors and zener diodes.

Metal Oxide Varistors (MOV)

MOV Device conducts the transient current that the source can supply under conditions of overvoltage and hence protecting the circuit it is connected to.

Cable Grounding

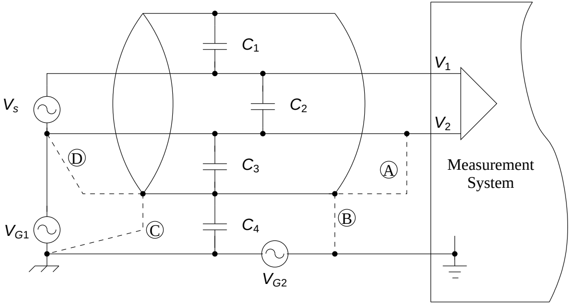

Figure: Different ground locations where systems and source have different grounds

Attenuation of Common-Mode Coherent Interference

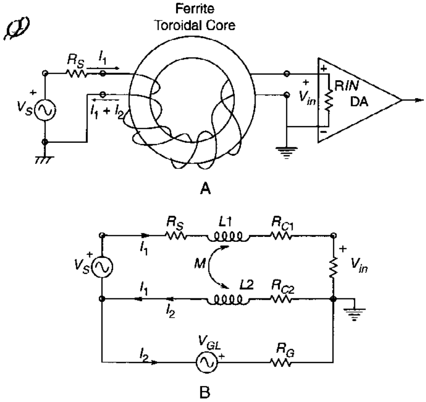

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Figure: ©R. Northrop, *Introduction to Instrumentation and Measurements*, 2nd Edition, CRC Press, 2005

No Attenuation of High Freq. Signal Component

Setting $V_{GL} = 0$, and assuming $L_1 = L_2 = M_{12} = M_{21} = L$ and $R_{in} \gg R_s \gg R_{C1}, R_{C2}, R_G$.

$$\frac{V_{in}}{V_s} = \frac{I_1 R_{in}}{V_s} = \frac{R_{in}(R_G + R_{C2} + j\omega L_2)}{(R_s + R_{in})(R_G + RC2 + j\omega L_2)} \approx 1 \qquad (4)$$

Attenuation of Ground Loop Interference

Setting $V_s = 0$,

$$\frac{V_{in}}{V_{GL}} = \frac{R_{C2}}{R_{C2} + R_G} \frac{1}{[1 + j\omega L_2/(R_G + RC2)]} \tag{5}$$

Separate Ground Path

Digital and analog ground path should be seperated and only connected at a single point close to the grounding point of the chassi.

Isolation Transformers

Simple add-on between subsystems. Blocks DC and interference caused ground loops.

Photo-Optic Couplers

Non-linear devices typically used in digital interfaces providing complete ground and signal isolation between digital circuits.

- Don’t ground both ends of a shield.
- Connect the shield at the signal source end only.
- Don’t allow shield current to flow, except for driven shields to cancel magnetic fields.
- Reduce magnetic fields by physical separation, proper orientation, and/or twisted pairs.
- Minimize wire length.
- Keep field at right angles.
- Separate ground path.