Lecture 5

Noise and Coherent Interference in Measurements

EE 521: Instrumentation and Measurements

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5.1

Contents

5.2

1 Sources of Coherent Interference

1.1 Capacitive Coupling

Capacitive Coupling

Conductors in the close proximity interfere with each other.

- Implements highpass RC filter across the noise source and the signal.
- Noise appearing on the signal is proportional to the noise source level.
- Problem with high frequency and high impedence signals.

5.3

1.2 Inductive Coupling

Inductive Coupling

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

- Roughly proportional to the areas of the two circuits.
- Noise generated is an added voltage in parallel, therefore, independent of signal level.
- Can be differentiated from capacitance by changing the load impedence (if noise level stays the same then we have inductive coupling).

5.4

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.

See Figure 1

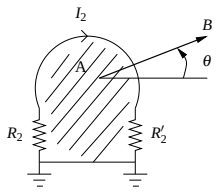

Figure 1: Induction of a coherent interference current, I_2, in a conductive loop enclosing a current carrying conductor.

By Faraday's Law

$$E = -\frac{d}{dt}\int Bds \tag{1}$$

5.5

Conductive Loop - Special Case

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

$$E = j\omega BA\cos\theta \tag{2}$$

and the interference current induced in the loop is:

$$I_2 = \frac{j\omega BA\cos\theta}{R_2 + R'_2} \tag{3}$$

5.6

1.3 Ground Loops

Ground Loop - Definition

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

5.7

1.4 Power Line Lowpass Filters

2 Cures of Coherent Interference

Quick Fixes

- Use grounded shielded cables to deal with capacitive coupling.
- Make current return path as close to the signal path as possible to reduce the area of conductive loops.
- Twist wires when possible.

5.8

2.1 Transient Voltage Suppressors

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.

5.9

Metal Oxide Varistors (MOV)

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

5.10

2.2 Coaxial Cable Grounding

Cable Grounding

See Figure 2

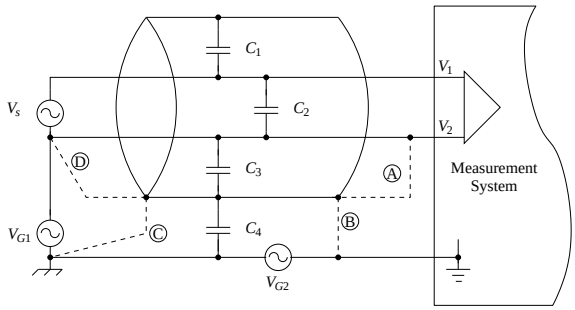

Figure 2: Different ground locations where systems and source have different grounds

5.11

2.3 Interruption of Ground Loops

Isolation Transformers

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

5.12

Photo-Optic Couplers

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

5.13