Power line spectrum sensing

Manoj Gulati

IIIT-Delhi
www.iiitd.ac.in

Jan 15, 2014

Table of Contents

1. Design Goal
2. Power line disturbances
3. Categories of EMC
4. Coupling and propagation of Electromagnetic Disturbances
5. Conducted EMI
6. Low frequency disturbances
7. High frequency disturbances
8. References

Design Goal

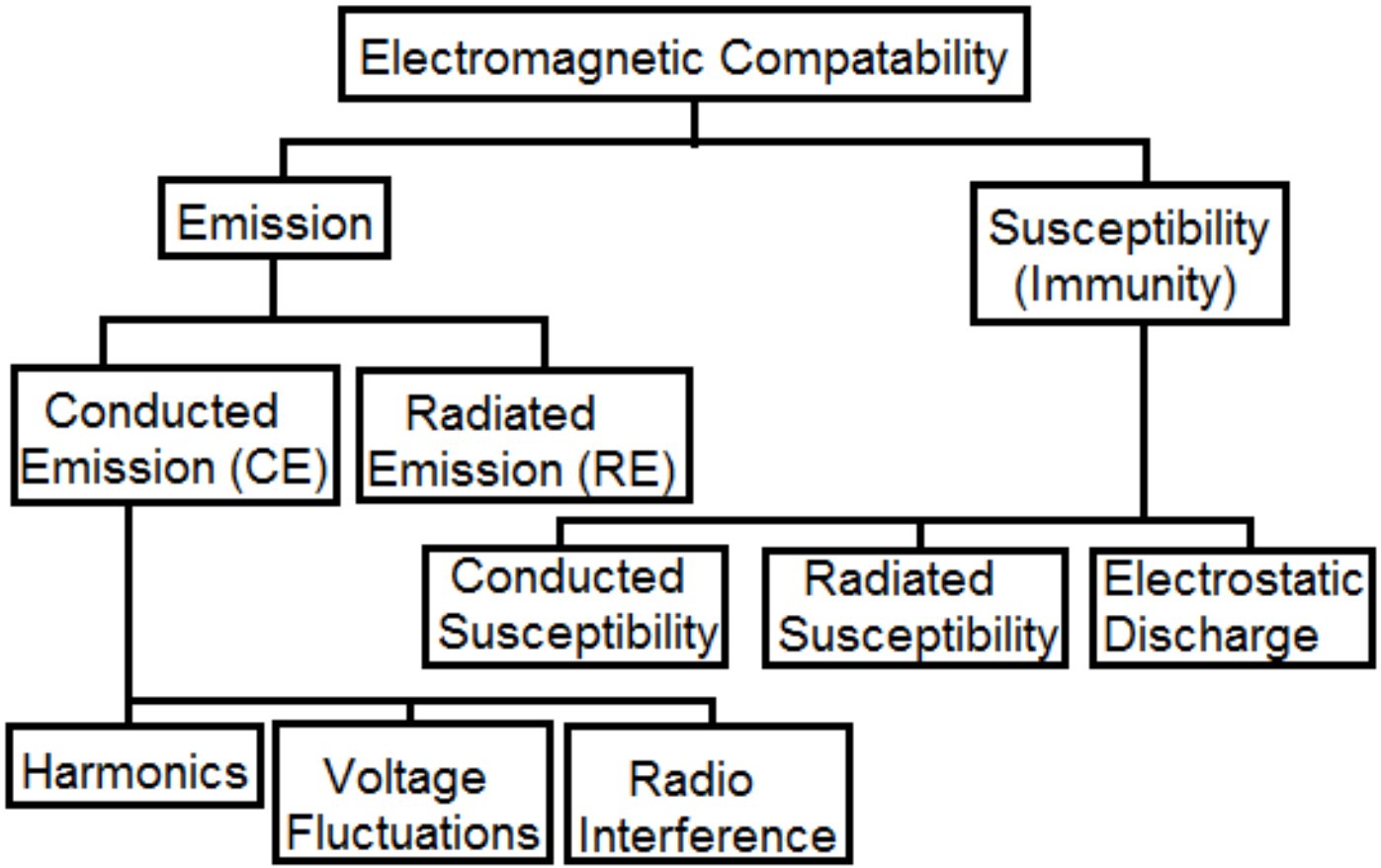
Goal: To study effect of voltage fluctuations and building architecture on Conducted EMI.
Steps:

- Design a sensor to sense low and high frequency components in power line.
- Analyze traces of spectrum with and without test power load.
- Analyze traces with EMI filter placed on source side. . . .

Power line disturbances

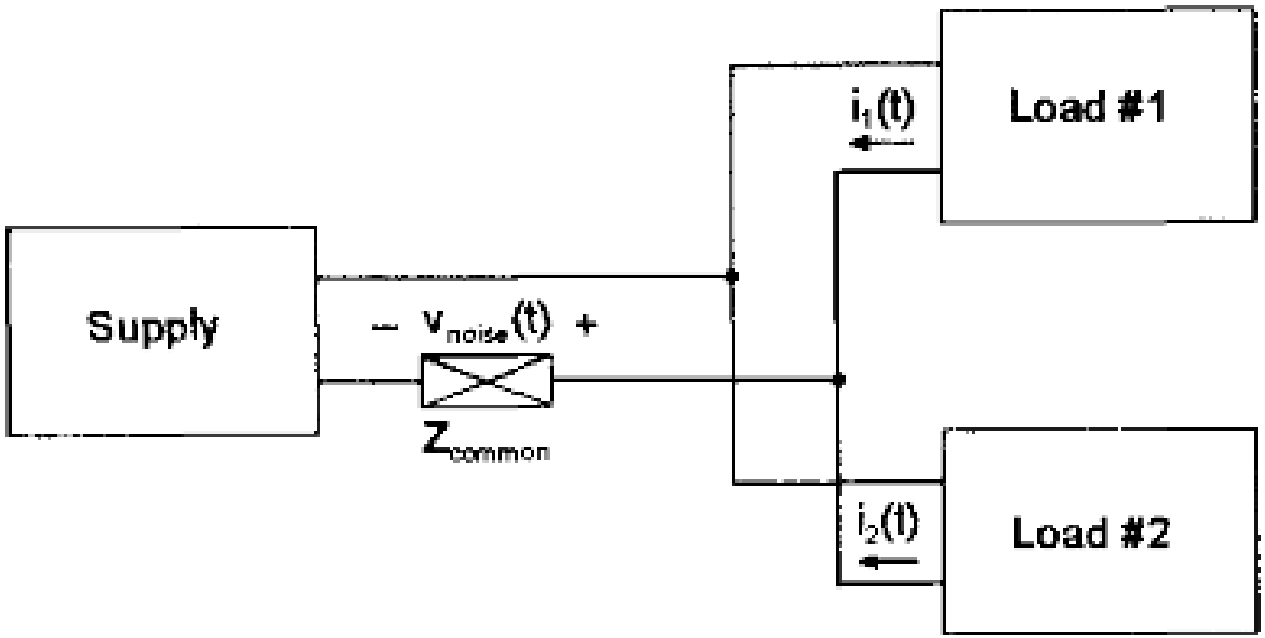
Major cause : Power electronics has become a dominant factor in the deterioration of electromagnetic environment and quality of line power.
EMC: Electromagnetic compatibility is a set of norms laid to restrict amount of low and high frequency disturbances introduced in power line.

Categories of EMC



Coupling and propagation of Electromagnetic Disturbances

- Galvanic Coupling: Disturbing current flows in a common circuit impedance. Galvanic coupling is reason for conducted emission



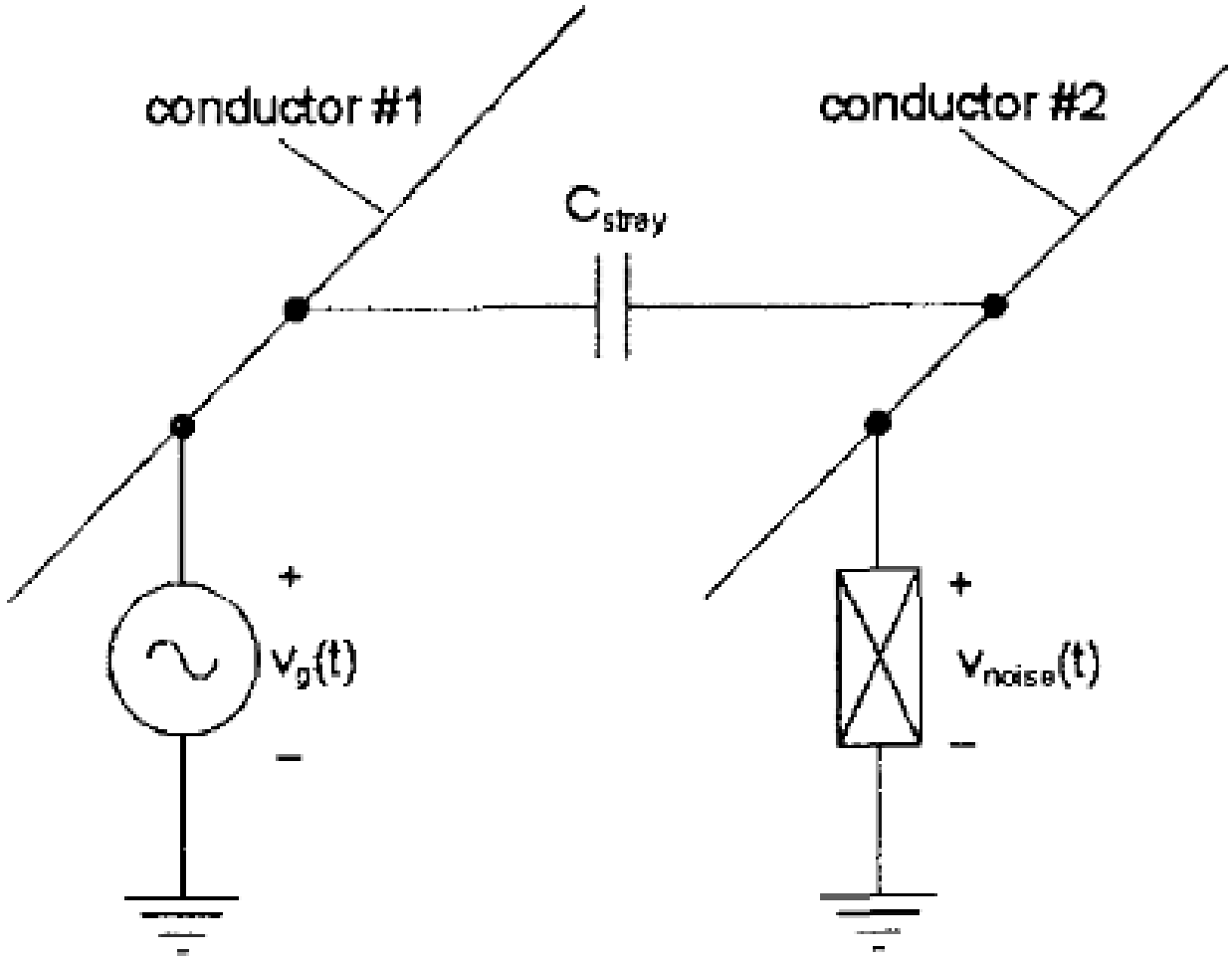
Coupling and propagation of Electromagnetic Disturbances

- Coupling through electromagnetic near field: Occurs when distance between two conductors is less then $\lambda/2$.
  - Capacitive(or electric) Coupling: Disturbing current flows in the capacitance between conductors with ac voltage across them.
  - Inductive(or magnetic) Coupling: Disturbing current flowing in a loop generates noise voltage across an impedance terminating another loop with mutual inductance to the first loop.

Note: EM Field coupling both near field and far field is reason for radiated emission.

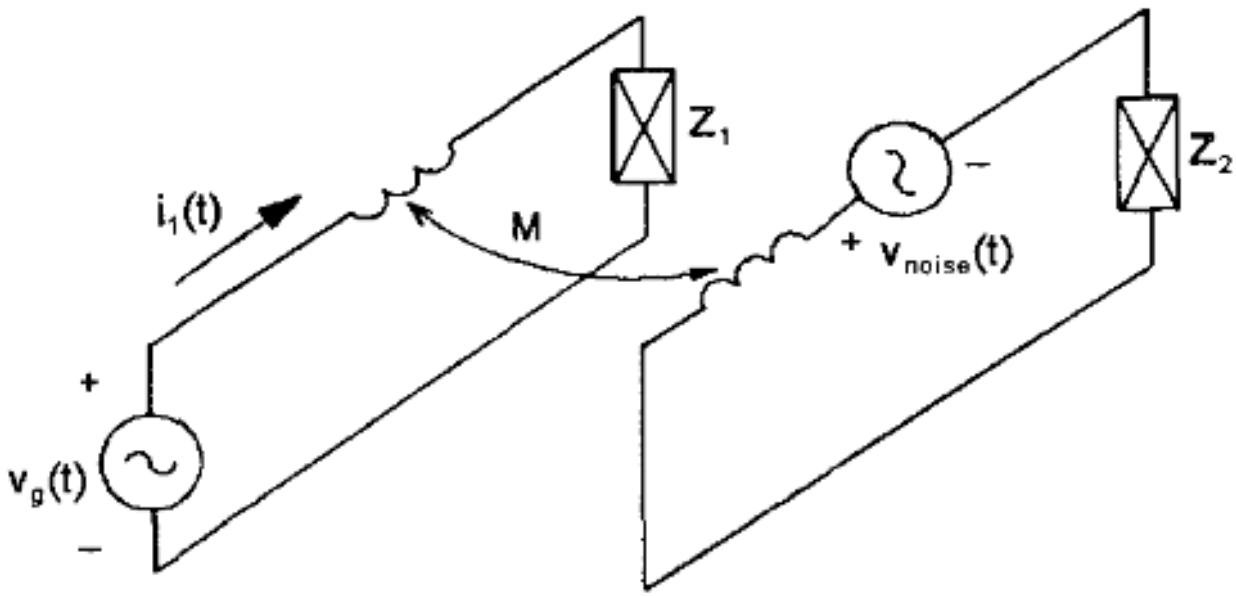
Coupling and propagation of Electromagnetic Disturbances

- Capacitive Coupling:



Coupling and propagation of Electromagnetic Disturbances

- Inductive Coupling:



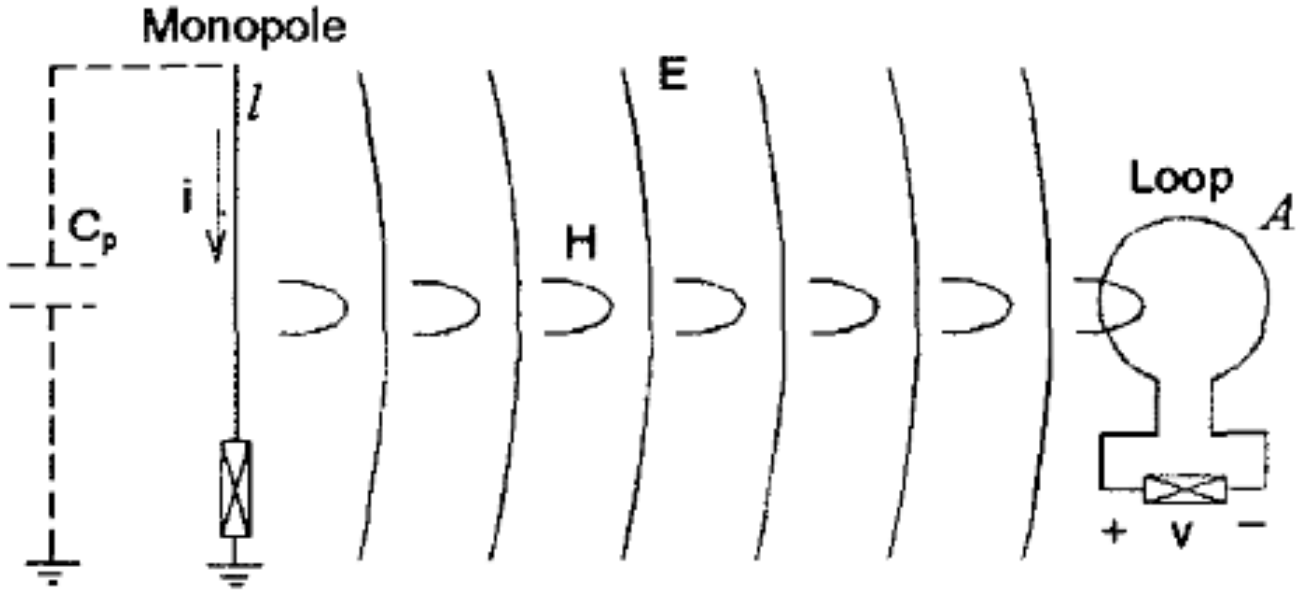
Coupling and propagation of Electromagnetic Disturbances

- Coupling through electromagnetic far field: Occurs when distance between two conductors is much larger then $\lambda/2$.

Note: In power electronics coupling through far field is less significant.

Coupling and propagation of Electromagnetic Disturbances

- Coupling through electromagnetic far field:



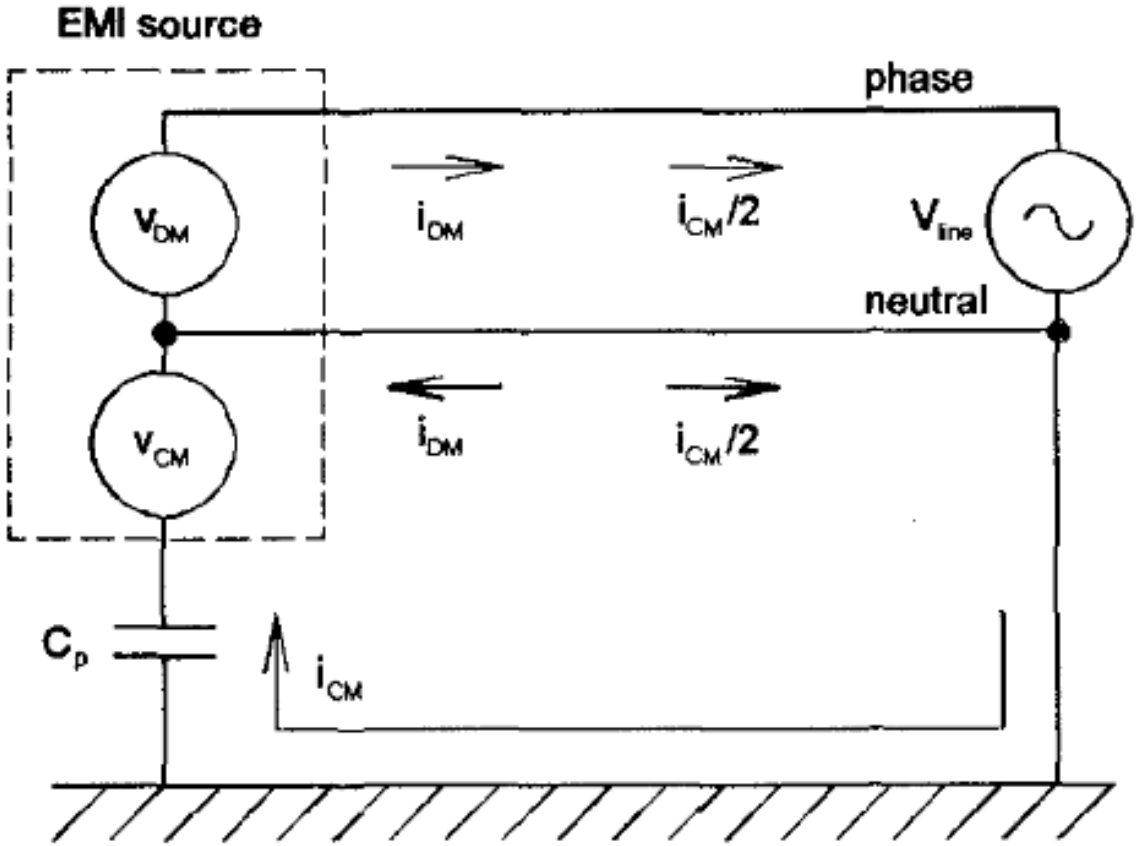
$$\frac{E}{H} = \sqrt{\frac{\mu_0}{\varepsilon_0}} \approx 377\,\Omega$$

Conducted EMI

Conducted EMI propagates in two ways:

- Differential mode (or symmetrical): Takes place b/w two conductors, which form a conventional return path.
- Common mode (or asymmetrical): Takes place between group of conductors and ground.

Conducted EMI

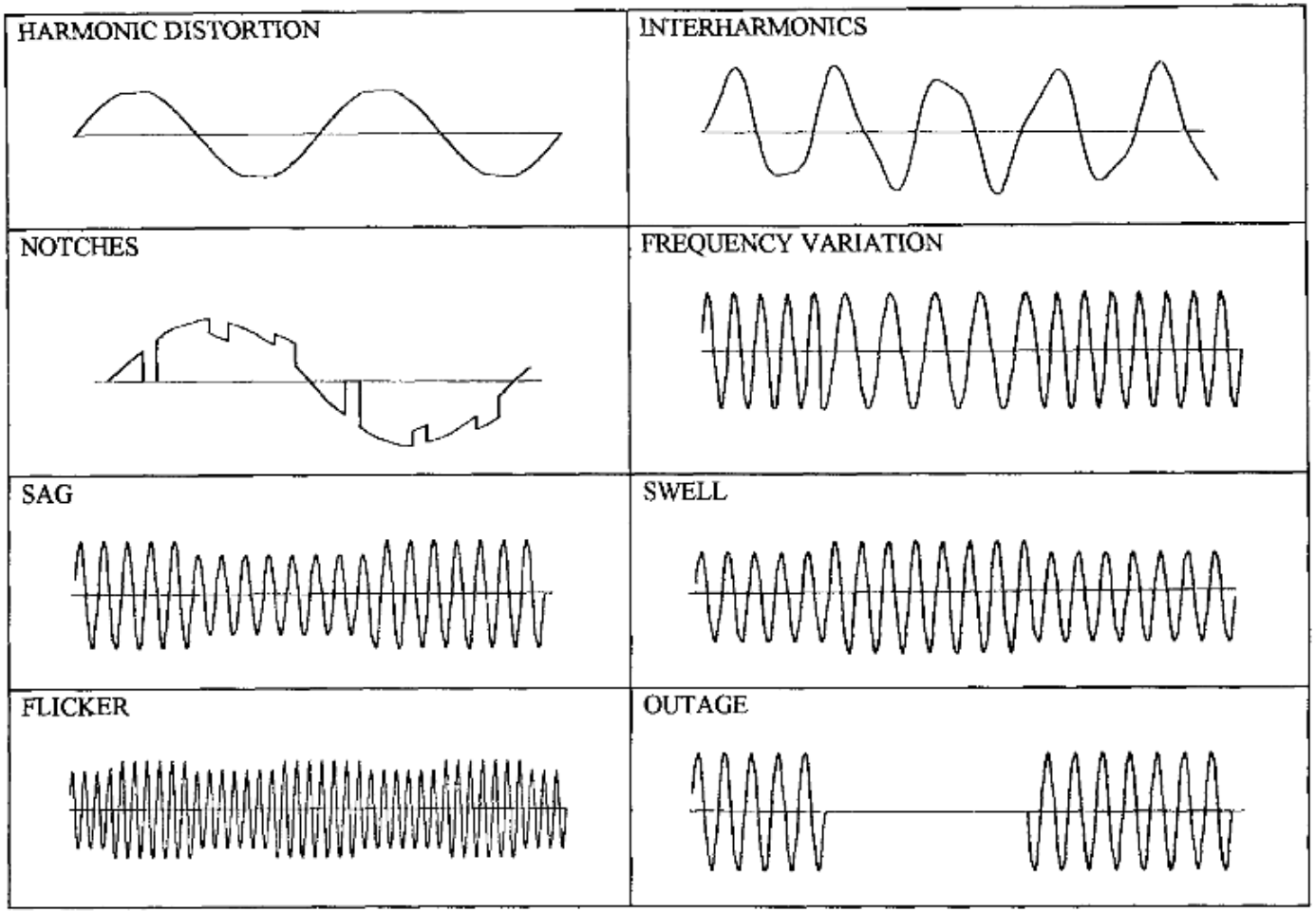


Differential-mode and common-mode conducted EMI.

Low frequency disturbances

LF disturbances are harmonic currents and voltages. Harmonic voltages are generated by the voltage drops across distribution impedances while harmonic currents are generated by non-linear loads like diode rectifiers, phase angle controllers etc.

Low frequency disturbances



High frequency disturbances

HF disturbances are generated by the switching action. Mechanical switches (relays) have high inrush current (capacitive effect) and spark over at breaking contact (inductive effect) and cause wide band emission with continuous spectrum which propagates both with conduction and radiation.

High frequency disturbances

Another major contributors are periodically switched semi conductor switches (rectifiers, SCRs, BJTs, MOSFETs). They cause differential mode conducted EMI through basic power conversion process and common mode conducted EMI through capacitive or inductive coupling.
HF($>$10MHz)EMI spectrum also propagates through radiation.

References

- Power Electronics and Electromagnetic Compatibility
- Electromagnetic Interference (EMI) in Power Supplies
- ElectriSense: Single-Point Sensing Using EMI for Electrical Event Detection and Classification in the Home
- Coupling mechanisms (Click to access web link)