Electromagnetic Interference

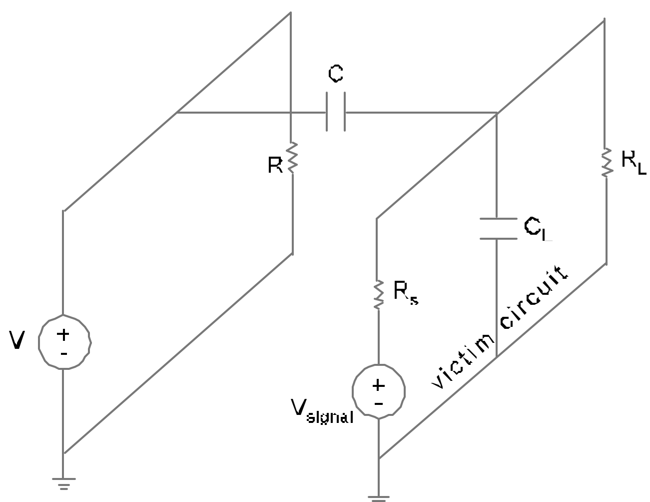
Electromagnetic Interference (EMI) is a field in which engineers from a variety of disciplines work together to solve system-level design problems.

There must be a source of EM energy, a coupling path, and a receiver. EMI occurs is via electric-field coupling, magnetic field coupling, or electromagnetic wave coupling.

Electric-field coupling

An electric field is produced by a voltage difference.

Electric field coupling typically is via unintentional (parasitic) capacitance. The metal from an interfering circuit forms one plate of the capacitance and and metal from the “victim” circuit forms the 2nd plate.

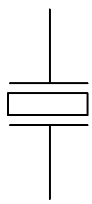


In the above circuit C represents the capacitive coupling between the two circuits. How could one predict voltage in the victim circuit present due to electric coupling?

The voltage coupled via the electric field in the second circuit is directly proportional to the capacitive coupling, C.

The question is how can C be reduced?

Recall the parallel plate model for a capacitance. While not a perfect model for the coupling above, the model can be used to point out some important factors in reducing C.



$$C = \varepsilon A / d$$

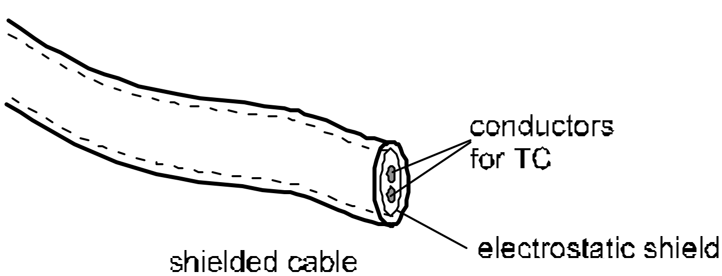
1st increasing circuit separation (increasing d) will reduce C.

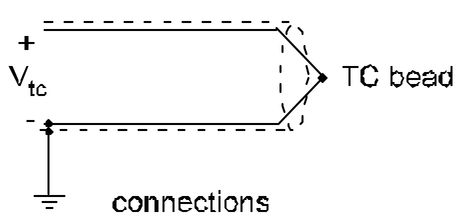
The most common way of doing this is to orient the two circuits so that they do not run near and parallel for a distance.

2nd decreasing the area of the plates (reduce A) will reduce C.

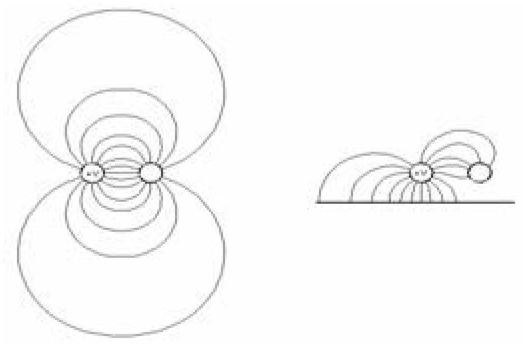
In practice, this is often not a practical solution. Instead, the same end is accomplished using an *electric shield*.

For example, TC circuits are very susceptible to electric field coupling from other circuits (especially, of course, high-voltage circuits). This is due to the V_{tc} being small—in the mV range.





It is common to route circuits near a conductive plane.



a) b)

Placing the circuit conductors next to a conductive plane can diminish electric field coupling by a factor of 10. This is the reason for the common practice of routing cables next to the metal chassis in electronic equipment or next to the metal frame in a car or plane.

Magnetic field coupling

1. A magnetic field is produced by an electric current. Ampere's law describes this process.

2. A time-varying magnetic field is produced by a time-varying current.

3. These changing magnetic fields can induce voltages in a second circuit. Faraday's law describes this process.

$$V_m = B_o A \omega \cos \theta$$

For a given interfering magnetic field of frequency ω, coupling into the second circuit may be reduced in three ways.

1. Reduce the magnitude of B_o by separating the circuits.

2. Change, θ, the orientation of the victim circuit. (rule of thumb: reduction is limited to a factor of 100).

3. Reduce the "linkage" of the loop in the victim circuit.

   One way is simply to reduce the area A.

Another technique is to use twisted-pair wires. (rule of thumb: reduction limited to a factor of 1000)

Example

The read head of a disk drive puts out a string of pulses, each with a peak amplitude of 100 μV. A pair of wires connects the head to an amplifier over a distance of 2 inches. Suppose that the disk is located near a television transmitter operating on Channel 2 (55.25 MHz) with an effective power of 100 kW. At this standard power level, the peak magnetic flux density, *B*, ¼ mile away from the antenna is 2×10^{-8} webers/m^2.

i) Compute the peak voltage induced in the circuit if the wires are spaced at a center-to-center distance of 0.1 in.

ii) What is the peak induced voltage if the wires are twisted together at the rate of 8 twists/inch? Assume the same center-to-center spacing used in i)