

UNDERSTANDING AND FINDING THE INVISIBLE ANTENNAS IN YOUR DESIGN

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CONVENTIONAL WISDOM

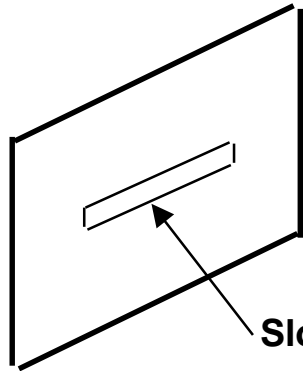
**Conventional Wisdom Says: If it Looks Like a Duck
and If it Walks Like a Duck and it Quacks Like a
Duck, it Probably is a Duck**

**EMC Wisdom Says: If it Radiates Like an Antenna
and it Receives Like an Antenna and it Doesn't Look
Like an Antenna, it Probably Still is an Antenna**

OVERVIEW

- Describe the Basic Types of Antennas
- Understand What Configurations (Electrical & Mechanical) Form Antenna Structures
- Learn to Look at Your Design as if it Was an Antenna
- Understand What Parameters Affect the Radiation
- Learn to Avoid Using Antenna Configurations in Your Design
- If You Must Use an Antenna Structure, Know How to Minimize it's Radiation Efficiency

MISC. ANTENNAS



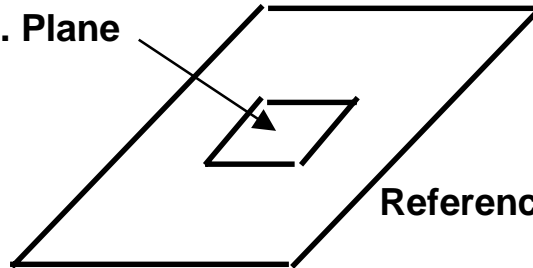
Slot in a Metal Plate

Slot Antenna

Fringing Fields
Produce Radiation



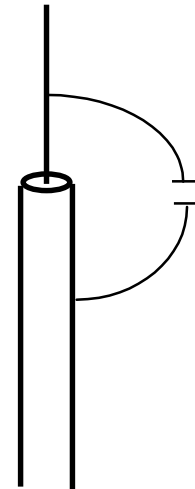
Metallic Patch
Above Ref. Plane



Reference Plane

Patch or Microstrip
Antenna

Unshielded Center
Conductor



Sleeve Antenna

BASIC ANTENNA STRUCTURES

- **Wire Antennas**
 - Dipole
 - Loop

- **Aperture Antennas**
 - Slot
 - Horn

CHARACTERISTICS OF ANTENNAS

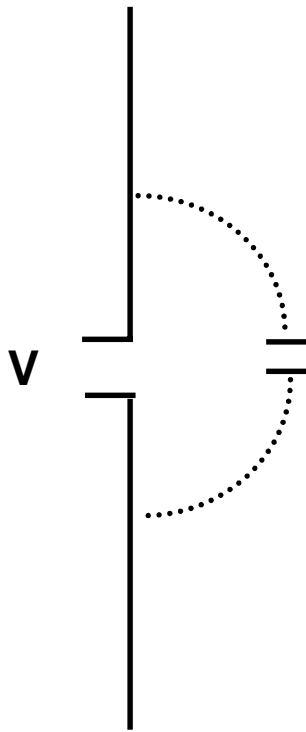
- Size
- Bandwidth
- Polarization
- Antenna Factor or Gain
- Radiation Pattern
- Front to Back Ratio
- Effective Height or Aperture
- Radiation Resistance

DIPOLE ANTENNA

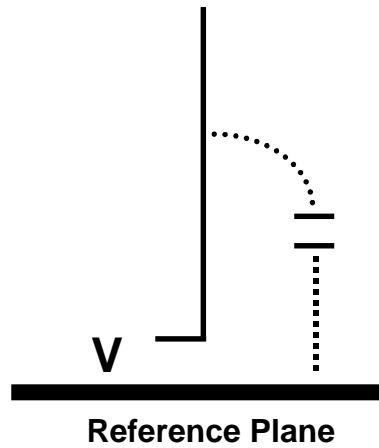
- **A Dipole Requires Two Parts**
- **What About a Monopole?**
- **If You Do Not Provide the Second Part, The Antenna Will Find Something to Serve the Purpose (Usually The Largest Piece of Metal Nearby)**
- **It is Better to Provide the Second Half of The Dipole Intentionally, at Least Then You Know What and Where it is**
- **The Way to Make an Antenna, is to Have an rf Potential Between Two Different Pieces of Metal**
- **To Prevent the Radiation, Tie the Two Halves of the Antenna Together So That They Are at the Same Potential and, Therefore, Cannot Radiate.**

INTENTIONAL RADIATORS

Dipole

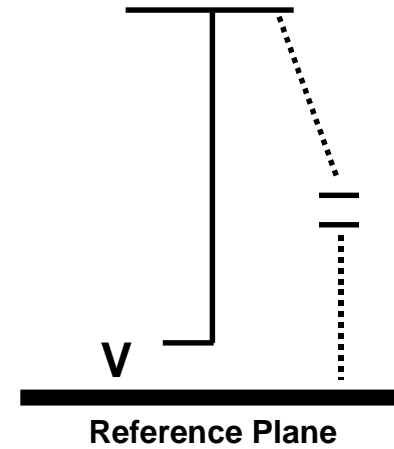


Monopole



**Radiates as Good
as a Dipole & is
Half as Long**

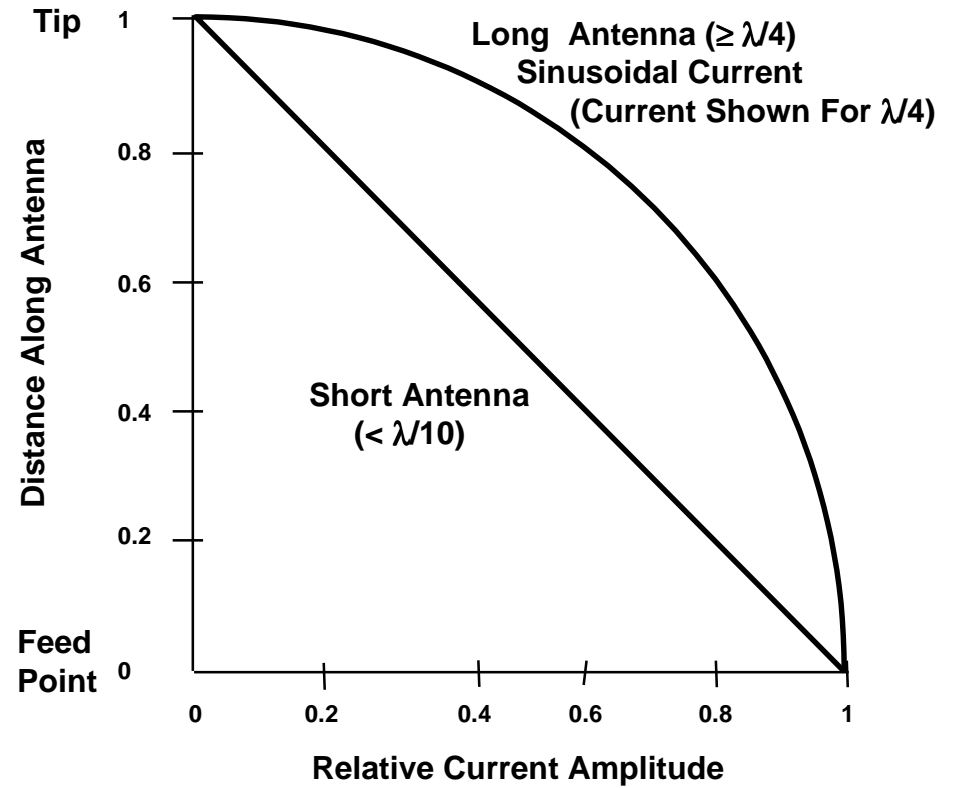
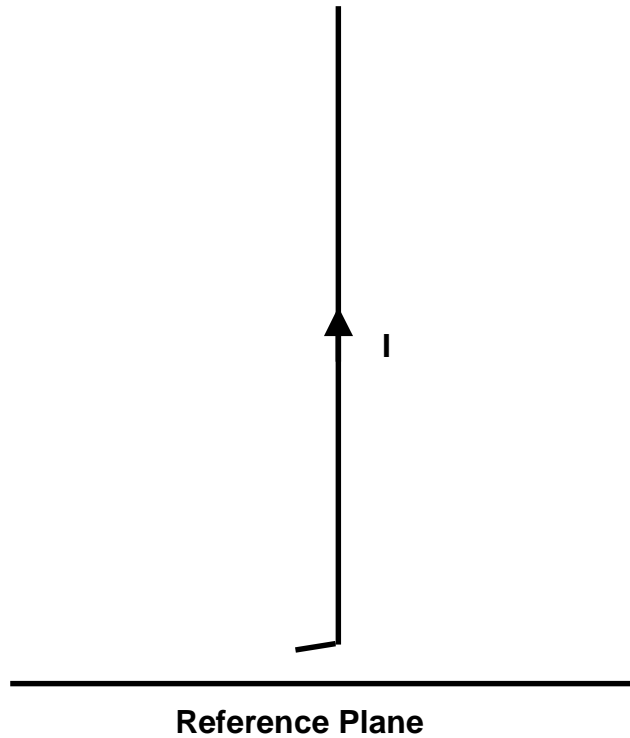
Top Hat



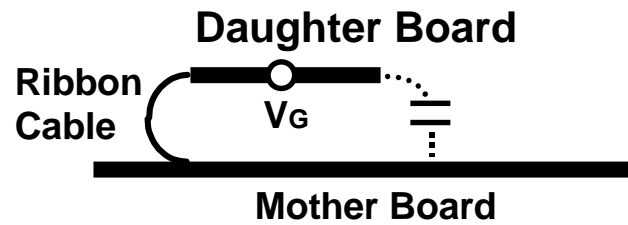
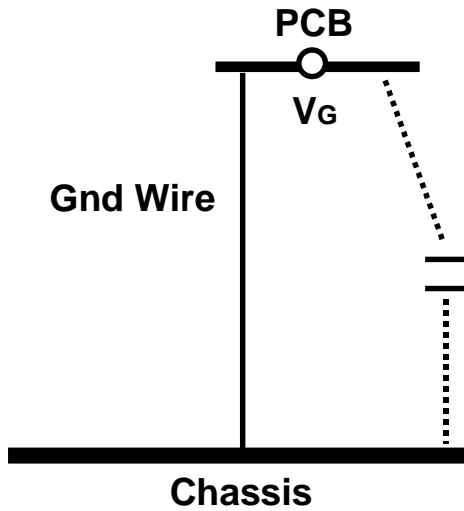
**Radiates Better
Than a Monopole
(Up to Twice as Much)**

MONOPOLE CURRENT DISTRIBUTION

MONOPOLE



UNINTENTIONAL MONOPOLES



LOOP ANTENNA

- **For Small Loops the Shape of the Loop Does Not Matter**
- **All Loops of the Same Area Will Radiate the Same**

FAR FIELD RADIATION FROM A SMALL ANTENNA

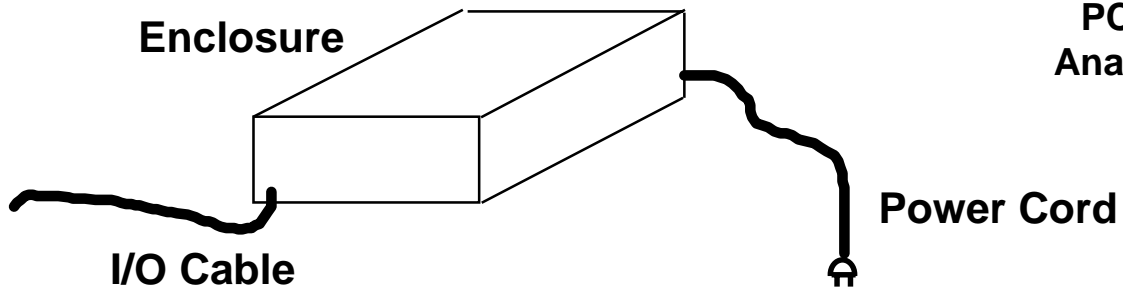
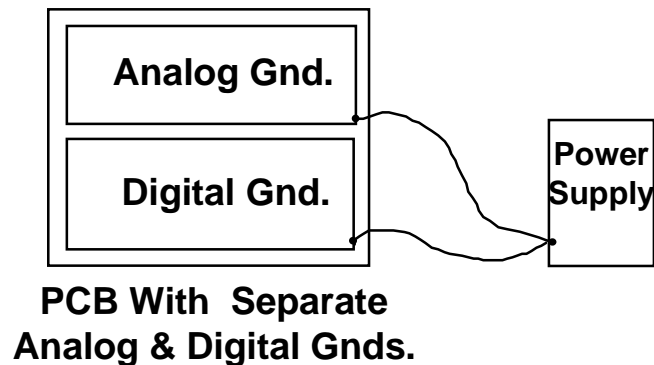
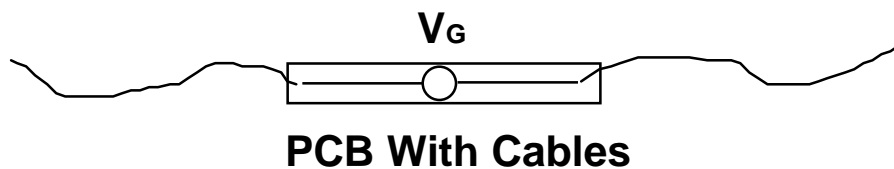
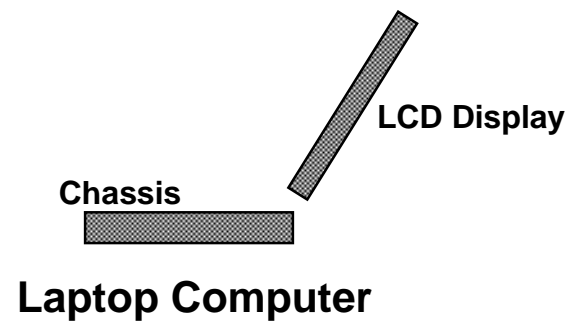
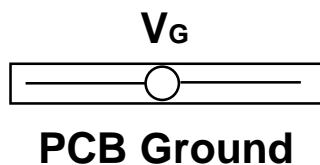
- Loop (Differential-Mode)
- $E = K f^2 A I$
- Radiation is Proportional to the Square of the Frequency
- Area is the Basic Control Parameter
- Dipole (Common-Mode)
- $E = K f L I$
- It only Takes 5 μ A of Current in a 1-Meter Antenna to Fail FCC Class B Requirements
- Current is the Basic Control Parameter

REDUCING ANTENNA RADIATION EFFICIENCY

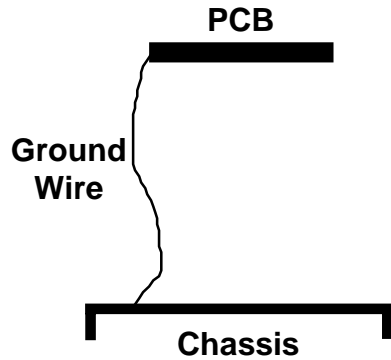
- **LOOP**
 - Reduce Area
 - Canceling Loops
 - Dithering of Frequency
- **DIPOLE / MONOPOLE**
 - Reduce Dipole Current
 - Short Out The Two Halves of the Antenna
- **APERTURE**
 - Minimize the Max. Linear Dimension
 - Form into a Waveguide Below Cutoff

Note: In All Cases Reducing the Frequency and/or Rise Time is Effective in Reducing Radiation

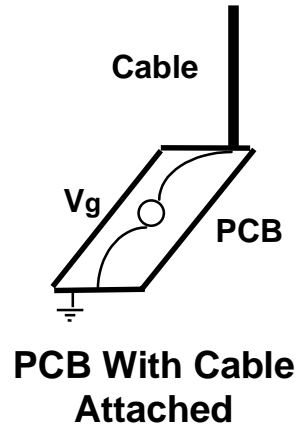
EXAMPLES OF UNINTENTIONAL DIPOLES



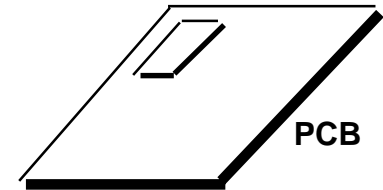
EXAMPLES OF UNINTENTIONAL MONOPOLES



PCB Separated From Chassis & Connected With a Ground Wire



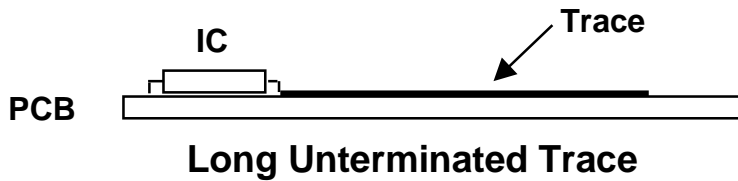
PCB With Cable Attached



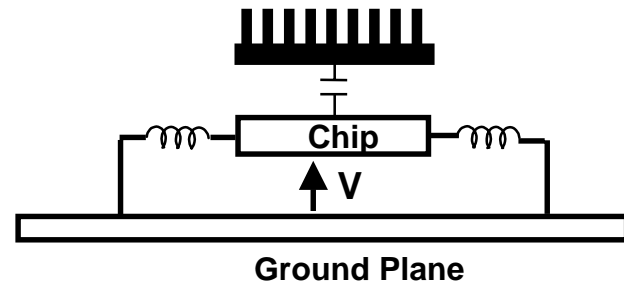
Ungrounded Metalization on PCB (Patch Antenna)



Mother/ Daughter Board

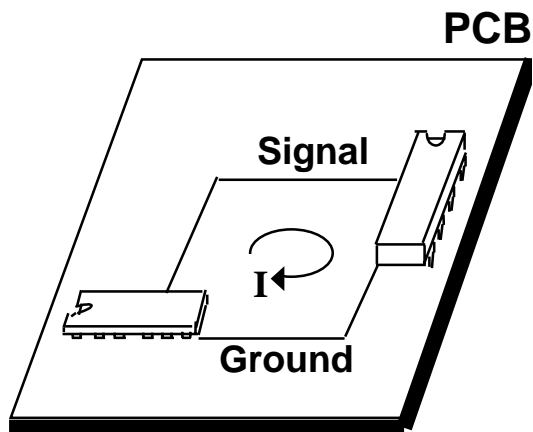


Long Unterminated Trace

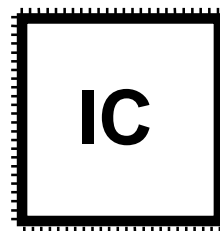


Ungrounded Heatsink

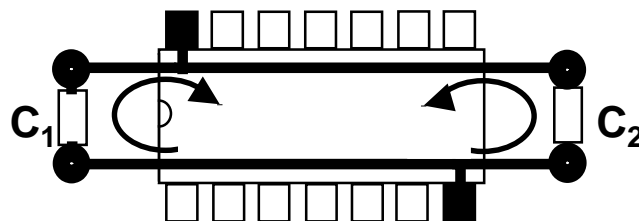
EXAMPLES OF UNINTENTIONAL LOOPS



Clocks on PCBs

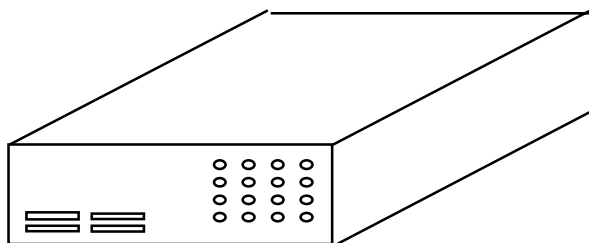


Large ICs ($\geq 1''$)

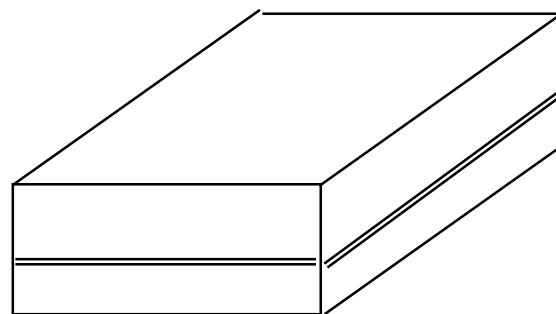


Decoupling Capacitors

EXAMPLES OF UNINTENTIONAL APERTURE ANTENNAS



Cooling Holes



Seams

SUMMARY

- **Many Structures That We Use as Part of Our Systems & PCB Designs Are Antennas**
- **As Much as Possible We Would Like to Eliminate the Use of These Structures**
- **If We Cannot Eliminate These Structures, Minimize their Radiation Efficiency**
- **Learn to Look at Your Design From an Antenna Point of View**
- **Remember Your Electronic Systems are Antennas, and What You Don't Know About Them Could Hurt You**