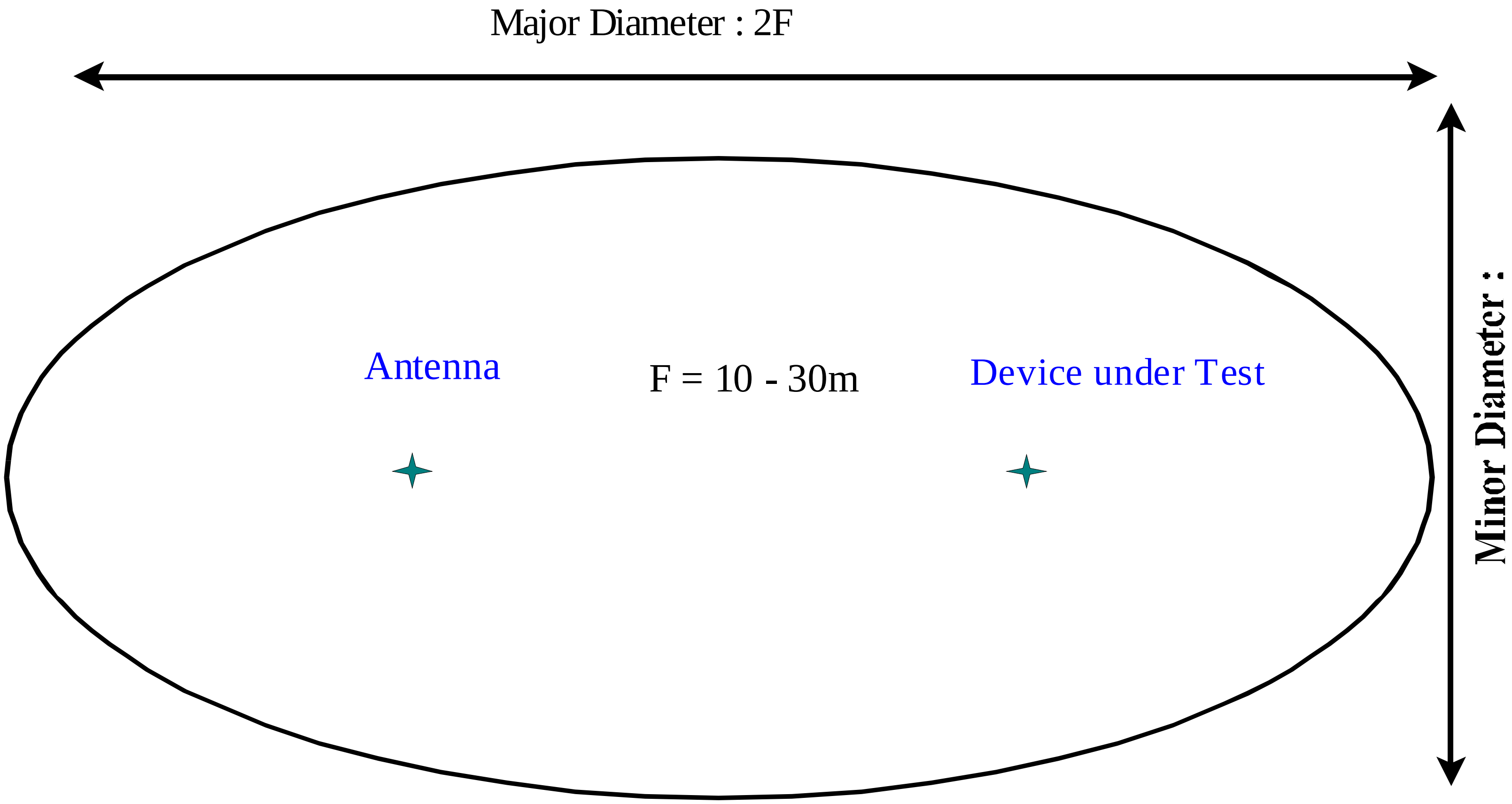
EMC Measurements

Test Site Locations

- Open Area (Field) Test Site
  - Obstruction Free
    - Trees, vegetation, buildings etc.
- Chamber or Screened Room
  - Smaller Equipments
  - Attenuate external fields (about 100dB)
  - External fields could be 10V/m if close to a transmitter.

Open Area Test Site



EMC Test Chamber

- Courtesy of MIRA

What do we need to measure?

- Start with a Requirement
  - Emissions or Susceptibility
- Emission Testing
  - Susceptibility structure is basically the same
- Divide into
  - Conducted
  - Radiated

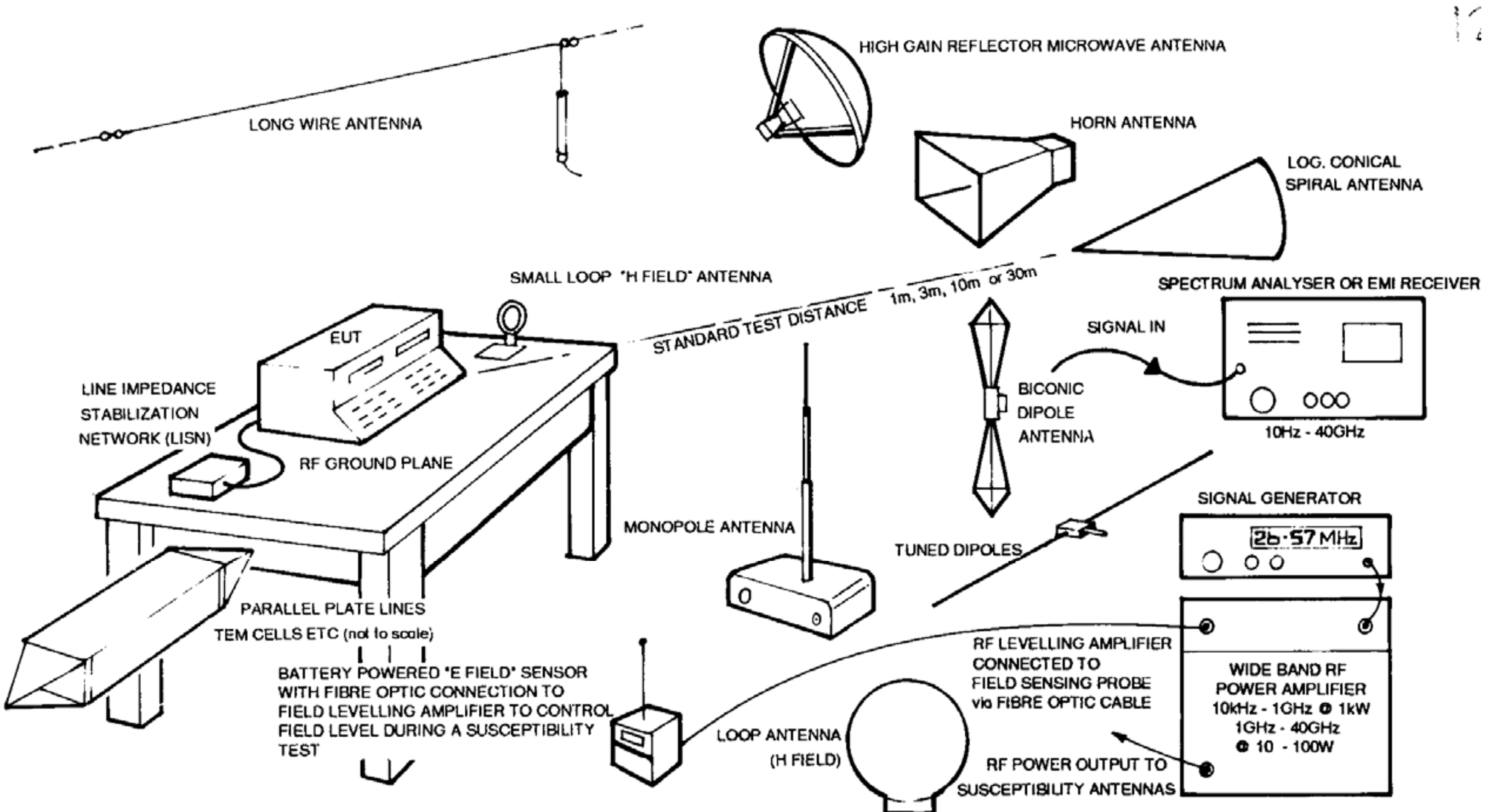
Conducted Emission Tests

- Power Leaks
  - R.F.
  - Spikes
- Control and Signal Lines
- Metalwork

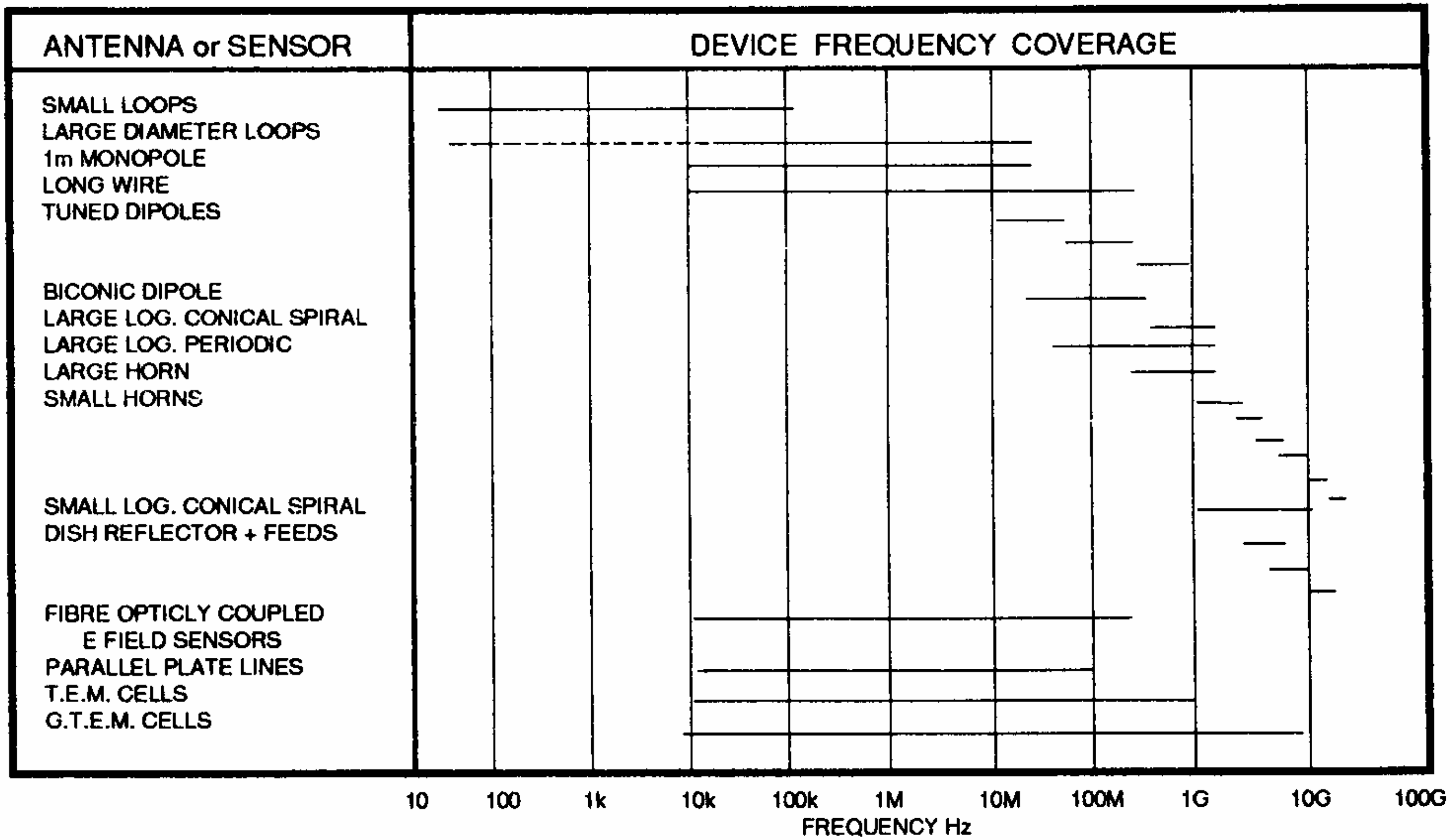
Radiated Emission Tests

- Magnetic Fields
- Electric Fields
- EM fields
  - TEM
  - Far Field

Radiated Emission Measurements



Radiated Emission Measurements



Radiated Emission Probes

- Frequencies from 20Hz to 20GHz
- Wide Variety available
- Low Impedance Probes
  - H-Field Sensor
    - 20Hz – 100kHz
  - H-Field Loop
    - 10kHz – 30MHz
  - H-Field Sniffer Probe
    - 10kHz – 230MHz
    - For finding leakage

Radiated Emission Probes

- High Impedance Probes
- E - Field Passive Rod Dipole
  - 20MHz – 200MHz
    - Approx 1m length
    - Tuned with tunable inductor across 10uF capacitor
    - Output impedance might be too high

Radiated Emission Probes

- High Impedance Probes
- E – Field Active Rod Dipole
  - 10kHz – 30MHz
  - Includes active matching network
  - Gives low output impedance (50Ω) to match receiver
- E – Field Capacitive Sniffer Probe
  - 10kHz – 1GHz

Radiated Emissions

- Sniffer probes are uncalibrated
- Antenna output fed via transmission line to receiver
  - Superheterodyne receiver
    - Lower cost for production line testing
  - Spectrum analyser
    - More expensive

Radiated Emissions

- Wave impedance for near field Electric Field measurement is very high
  - Impedance matching is hard
  - Sensitivity may suffer
- Receiver measures in V.
  - Conversion to Tesla is required
  - Normally within test equipment

Radiated Emission Measurements

- Probe converts **E** or **H** fields to Volts for the receiver
- Use Antenna Factor to evaluate this

$$AF = \frac{E}{V} = \frac{Measured \quad Field}{Antenna \quad Voltage} = \frac{1}{l_{em}} \qquad m^{-1}$$

- or

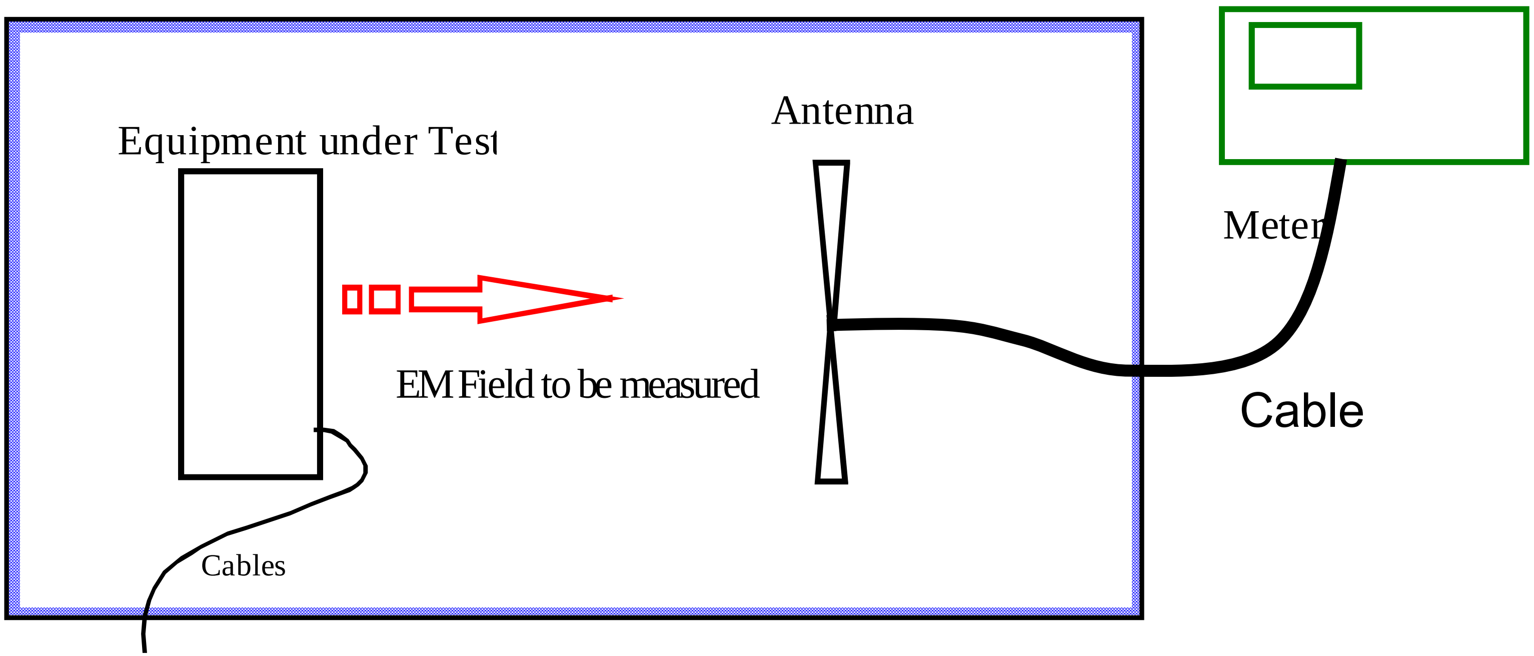
$$AF(dBm^{-1}) = E(dB\mu Vm^{-1}) - V(dB\mu V)$$

Antenna Factor

- Figure of merit
- Low AF implies high sensitivity

Passive Rod Dipole	
Tuneable Dipole	AF = -2 – -14dB at 30 - 200MHz

EMC Chamber Measurement



Radiated Immunity

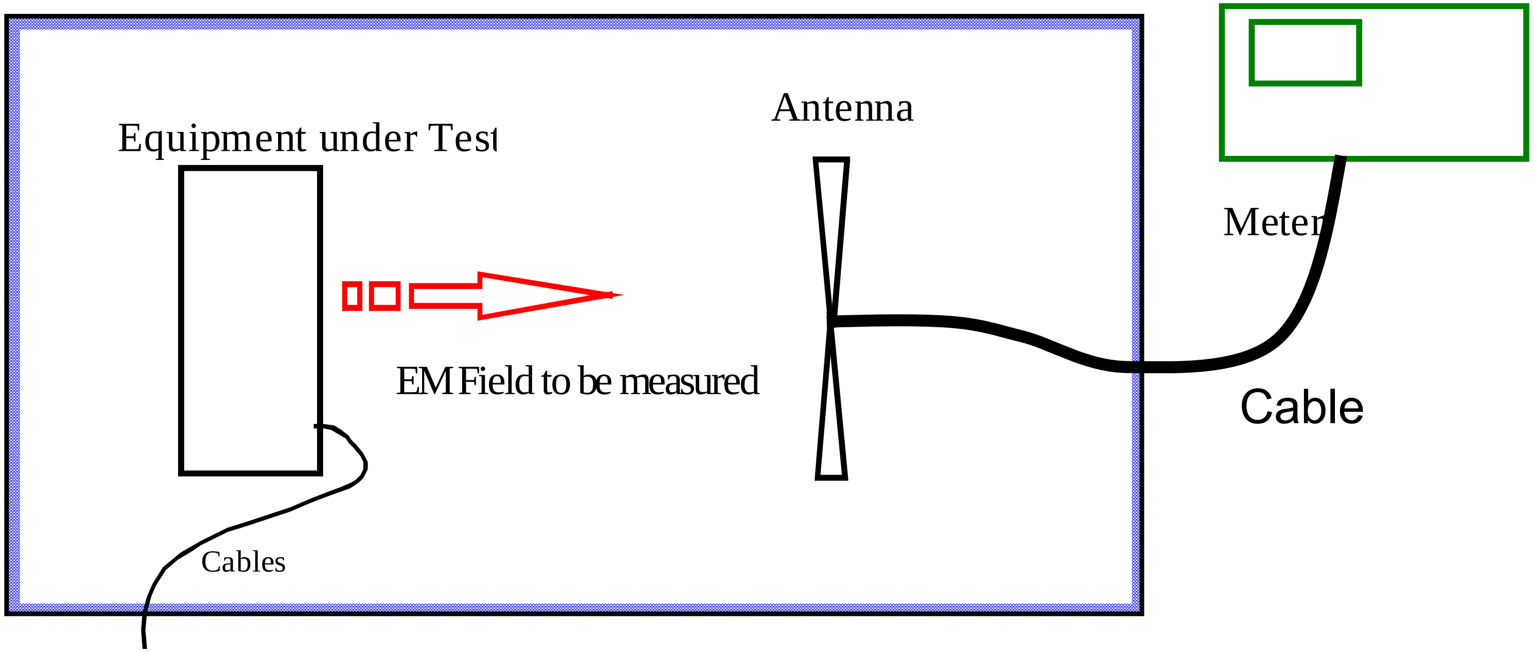
- Basic requirement include
  - RF signal source
  - Broadband power amplifier
  - Transducer (antenna)
  - Test Chamber

$$E = \frac{\sqrt{30\,ERP}}{r} = \frac{\sqrt{30\,PG}}{r} = k\,\frac{\sqrt{P}}{r}$$

Errors and Uncertainty Factors

- Meter Accuracy
  - Calibration
  - Drift
  - Faults
- Cable
  - Length
  - Unbalanced currents reduce interference immunity
  - Impedance match at each end

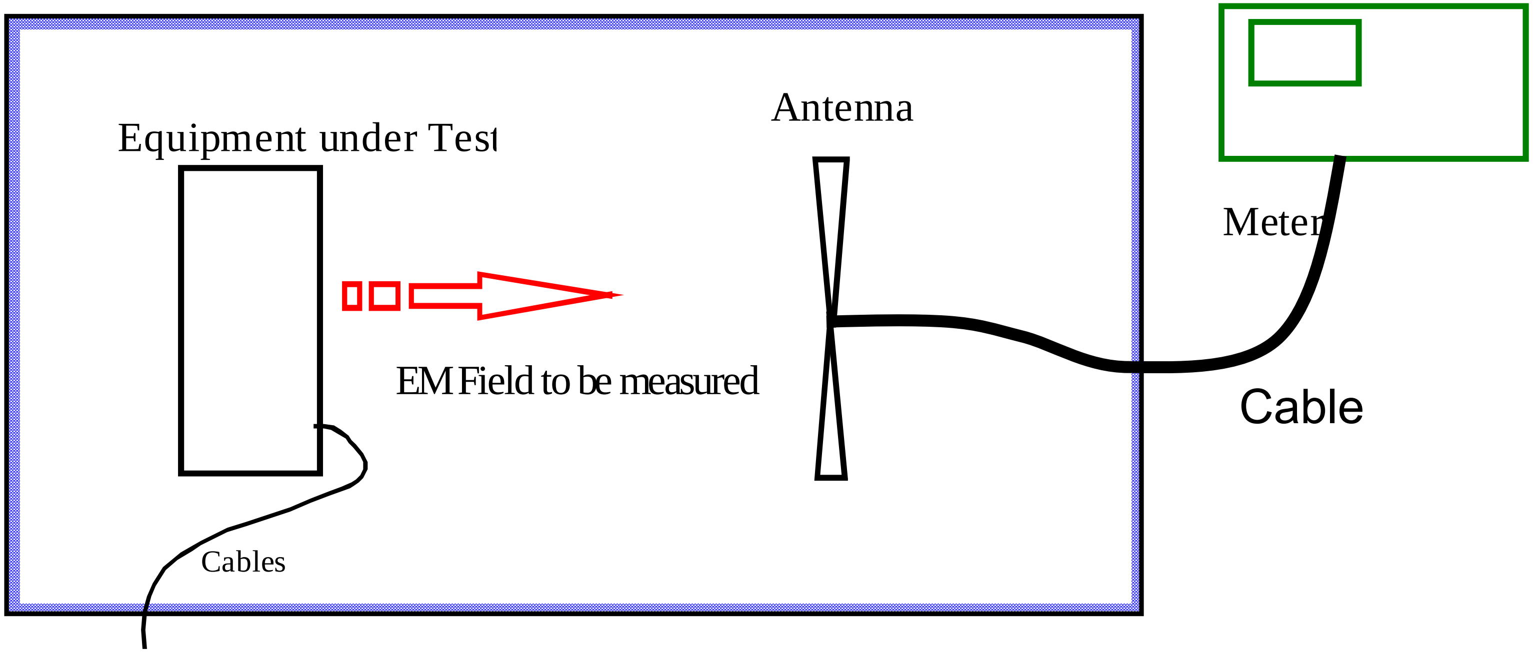
Errors and Uncertainty Factors



Errors and Uncertainty Factors

- Antenna
  - Large and averages field strength
  - Poor screening can give electrical image through screen
    - Mutual coupling to this may change calibration
- Radiation Field
  - Inaccurate distance measurement
  - Unknown field pattern

EMC Chamber Measurement

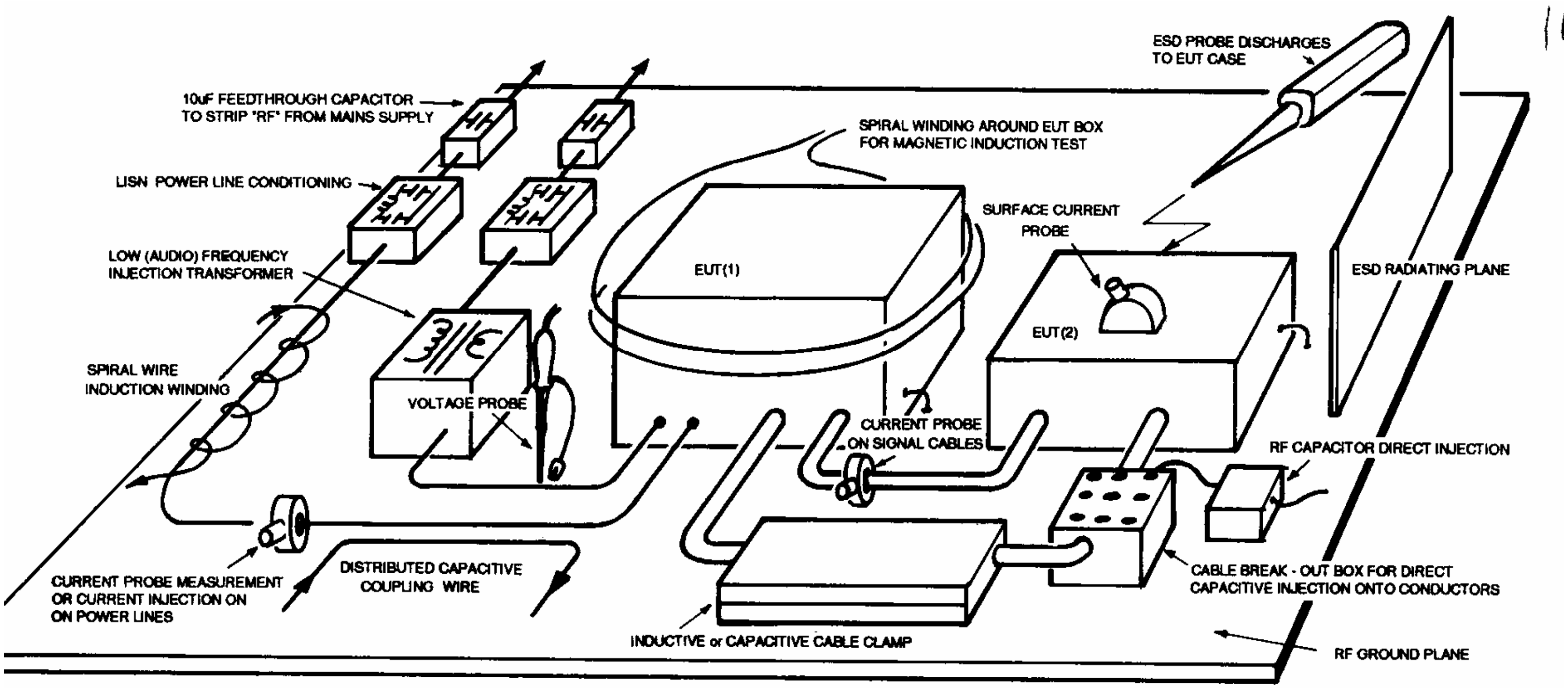


Errors and Uncertainty Factors

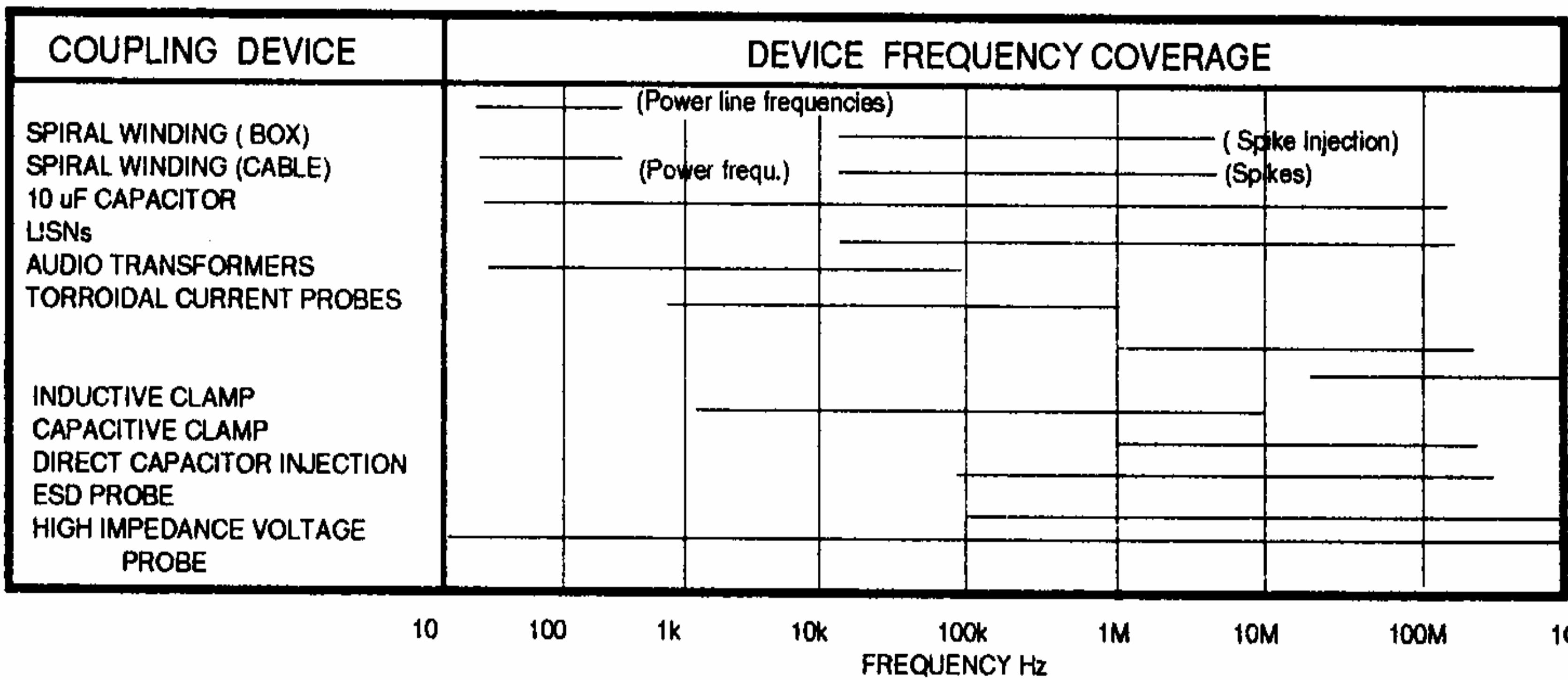
- Equipment under Test
  - Accuracy of placement
  - Height above ground
  - Placing of cables
- Chamber
- Poor screening
  - External fields affect antenna and EUT

Conducted Interference

- Range of probes and techniques are used.



Conducted Interference Probes



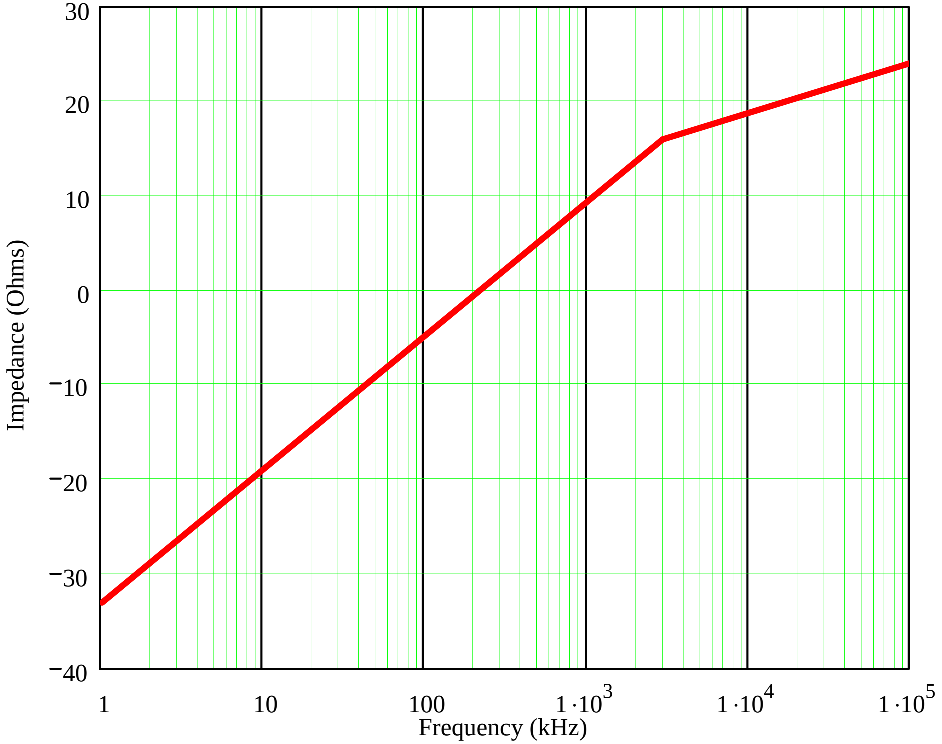
Conducted Interference

- EMI Current Probes
  - Clamp round a conductor
  - Magnetic loop
  - High Permeability
  - High turns count
  - Saturation of core a problem

Conducted Interference

- Transfer Impedance

$$Z_T = \frac{V_{out}}{I_{measured}}$$



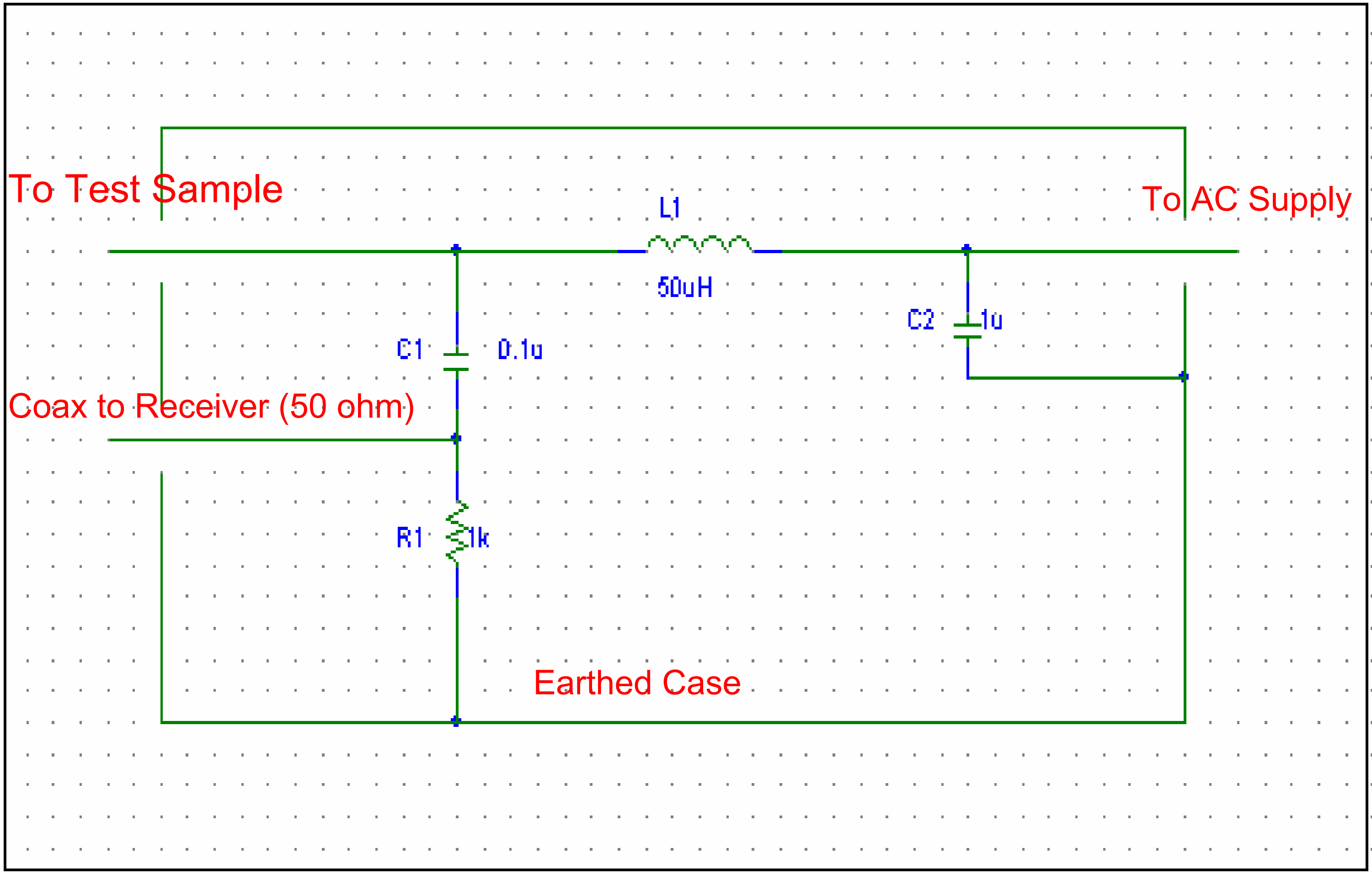
Conducted Interference

- Line Impedance Stabilisation Networks
  - Mains Isolation Network
  - Vee Network
    - Connection between
      - Line – Earth
      - Neutral - Earth
  - Various versions exist depending on standards used

LISN

- Functions
  - Pass AC or DC power to Test sample
  - Block EM noise going into power system
  - Blocks power borne EMI entering test system
  - Stabilises supply source impedance

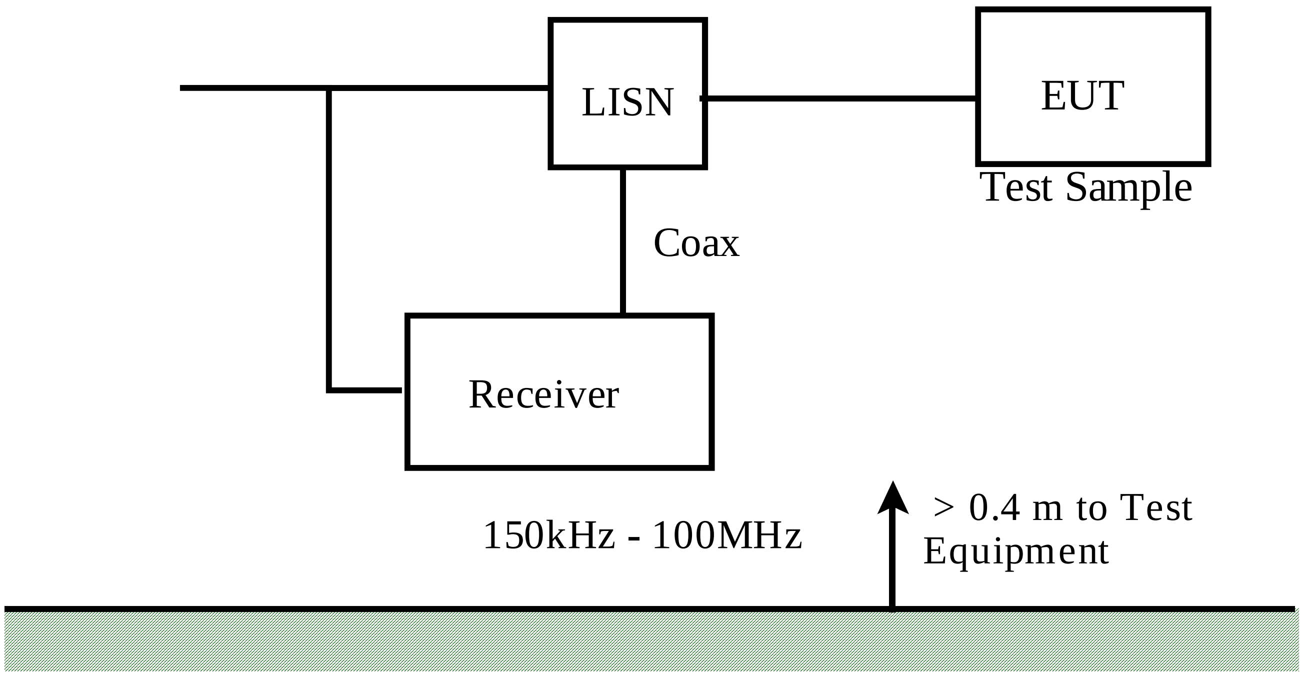
LISN Circuit



LISN

- In 3-phase systems three LISNs are used.
- Receiver switched between them for measurements
- L1 and C2 provide a Lowpass filter to remove RF from the power line

Use of LISN


LISN
EUT
Test Sample
Coax
Receiver
150kHz - 100MHz
> 0.4 m to Test Equipment

Use of LISN

- EUT earthed through normal means
  - 3 core cable via supply
  - 2 core double insulated mains lead used if EUT is not insulated through supply lead
- Supported by non conducting table
  - 0.4m above ground plan
  - 0.8m from any other conducting surface

Measurement Receivers

- Spectrum analysers
  - Higher cost
  - Narrow band swept measurement
  - Shows full spectral content
  - Very accurate
- Superheterodyne receivers
  - Routine testing
  - Lower cost
  - Measures narrow or broadband interference

Measurement Types

- True Peak
- Quasi Peak
- Average
- RMS

- See Williams, p86

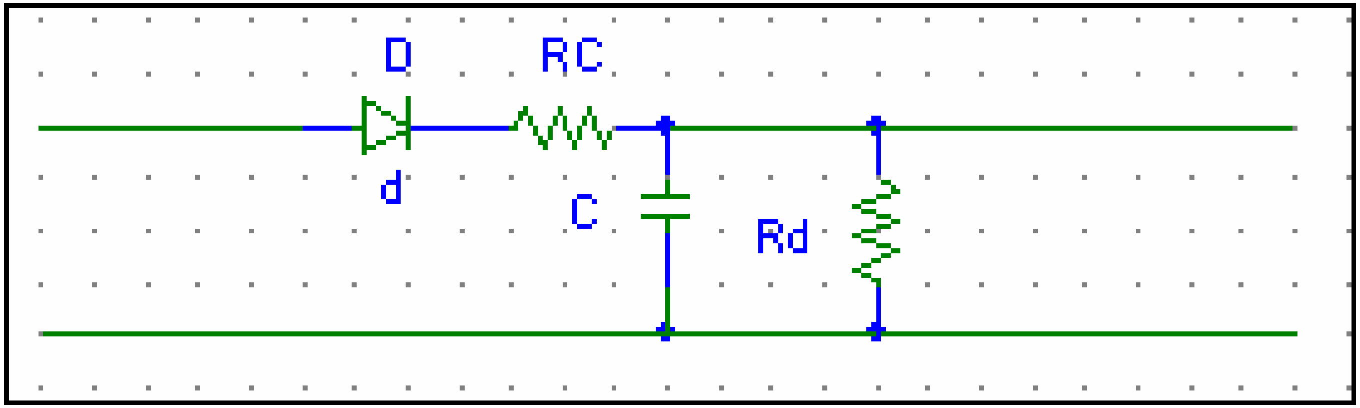
- Last two types are obvious

True Peak and Quasi-Peak

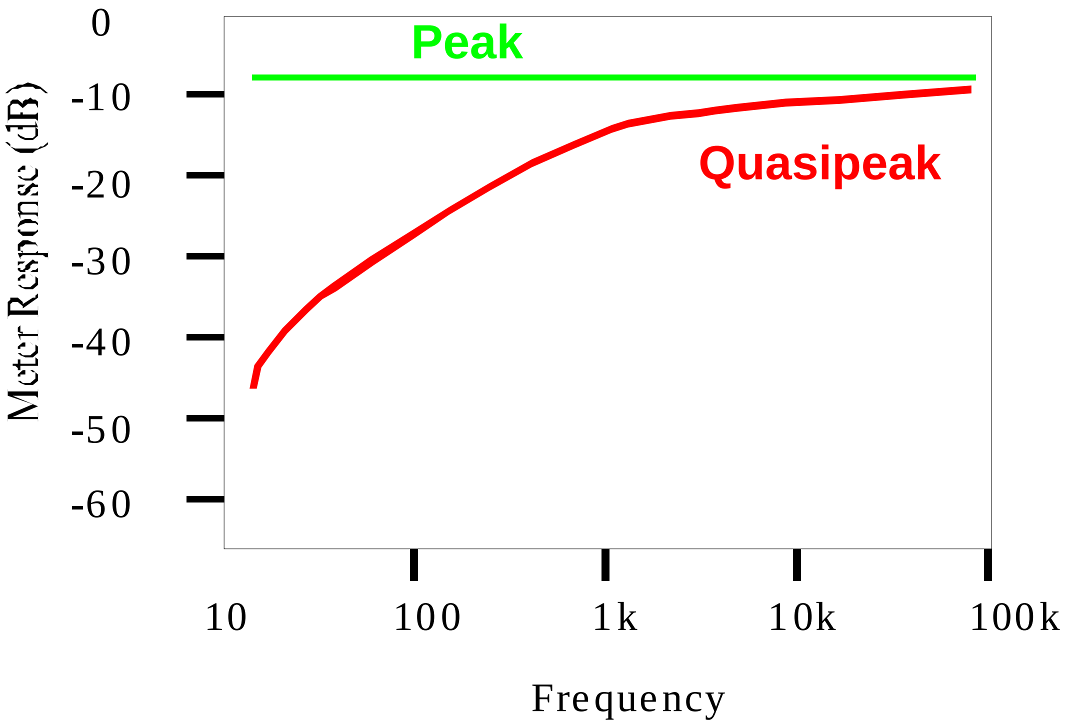
- True peak will register the maximum value of a repetitive waveform
  - Also called Envelope Detector as follows the envelope of a single frequency.
- Quasi-Peak
  - Weighted to take account of human response to repetitive pulse interference.
  - Low repetition rates less annoying than high repetition rates

Quasi-Peak Detector

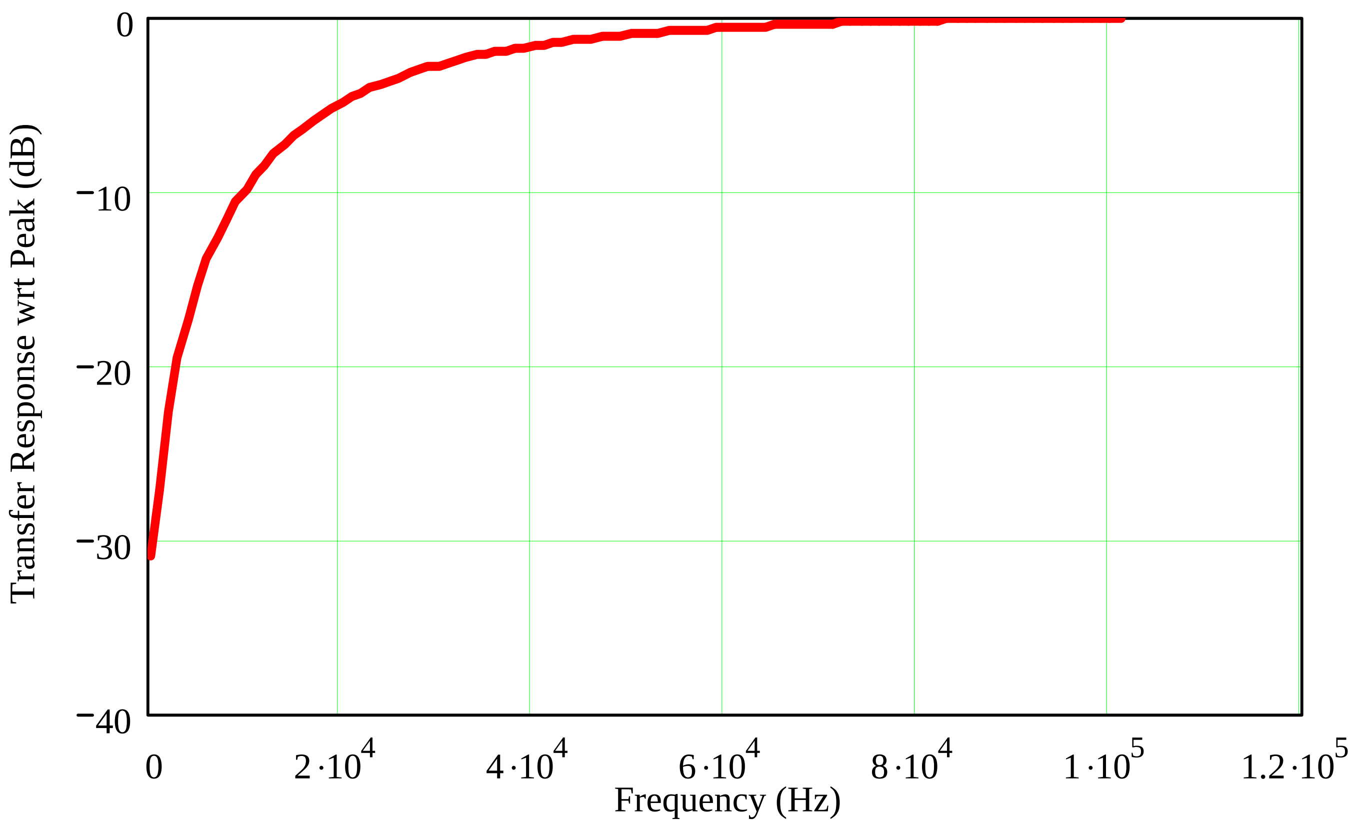
- Charge Time Constant – 1ms
- Discharge Time Constant – 160ms



Approximate Response



Simulated Response

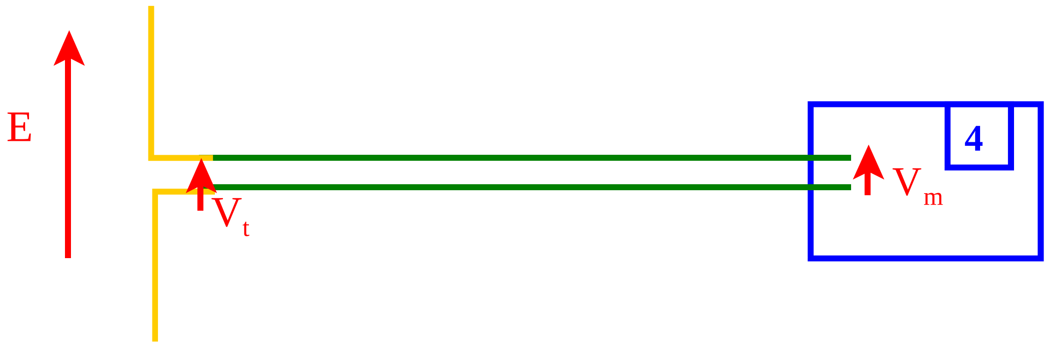


Measurement Example

- A measurement system measures 4dBμV at a receiver.
- The measurement antenna is a dipole connected to the receiver by a coaxial cable
- Assume that the cable is perfectly matched to the antenna and receiver
- What information do you need to calculate the measured Electric Field at the antenna?

Measurement Example

- What does it look like?
- Receiver
- Coaxial Cable
- Antenna
- Want **E**
- Need V_t



Measurement Example

- What do we need?
  - Cable
    - Loss
      - Length
      - Loss per metre
- Takes us back to antenna terminals
  - Antenna
    - Antenna Factor
- Takes us to the Electric Field

Measurement Example

- Some Numbers
  - Cable Length = 2.5 m
  - Cable Loss = 0.5 dB/m
  - Antenna Factor = 6dB/m
- Now calculate the Electric Field

Measurement Example

- Total Loss = Length x loss per metre
  - This gives 1.25 dB
- Voltage at Antenna Terminals
  - 4dBµV + Total Loss
    - This gives 5.25 dBµV
- Electric Field is Terminal Voltage + AF
  - This gives 11.25 dBµV/m

Final Comments

- EMC measurements are difficult to do well
- There are many techniques for
  - injecting signals
  - sampling signals
- An understanding of the underlying theory will help make good measurements