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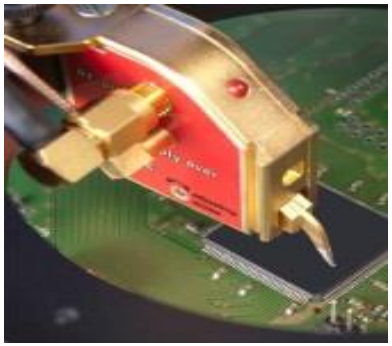
# Linecard

## Emission

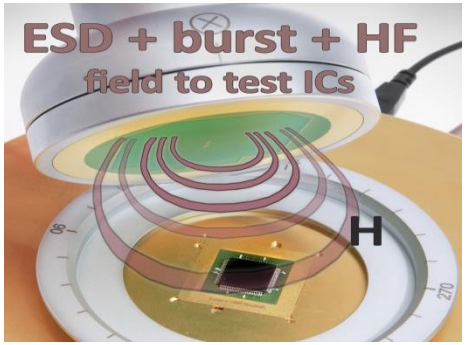
## Immunity

**PCB**


**IC**







# Understanding Physics behind Emissions

## Interactions Between PCB´s and Their Surroundings

Speaker: Dipl. Ing. Jörg Hacker

1 Disturbance Emission Sources

2 Magnetic and Electric Coupling Effects

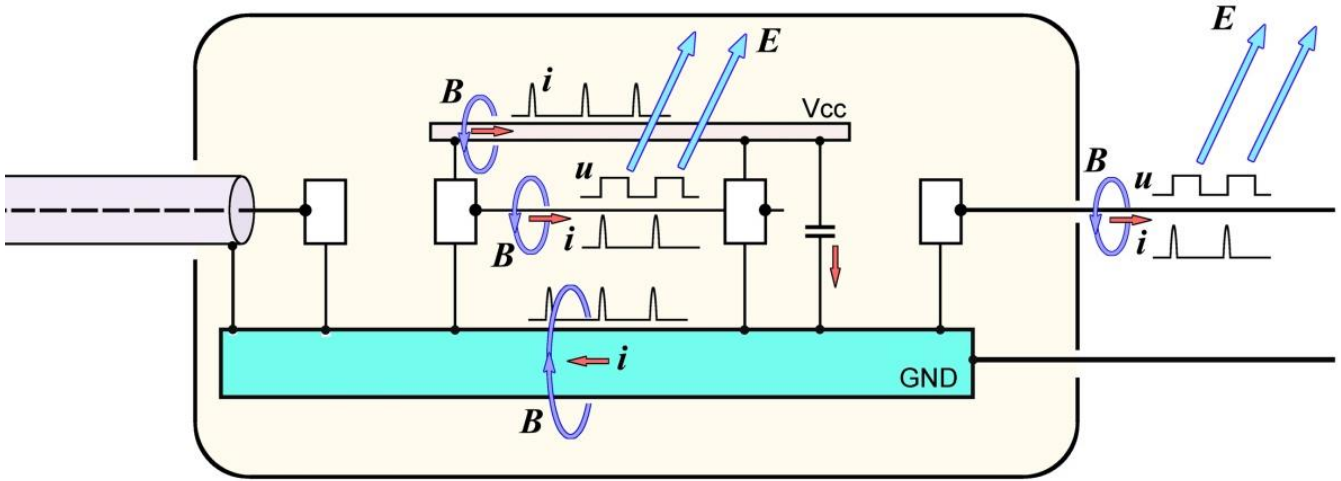
3 Pre-Compliance Measurement Methods

4 Practical Examples

# Disturbance Emission Sources

**ICs are the sources of disturbance emission:**

- ICs operate with clocked signals.
- The signal‘s current and voltage create emission via magnetic and electric near-field coupling into an antenna.

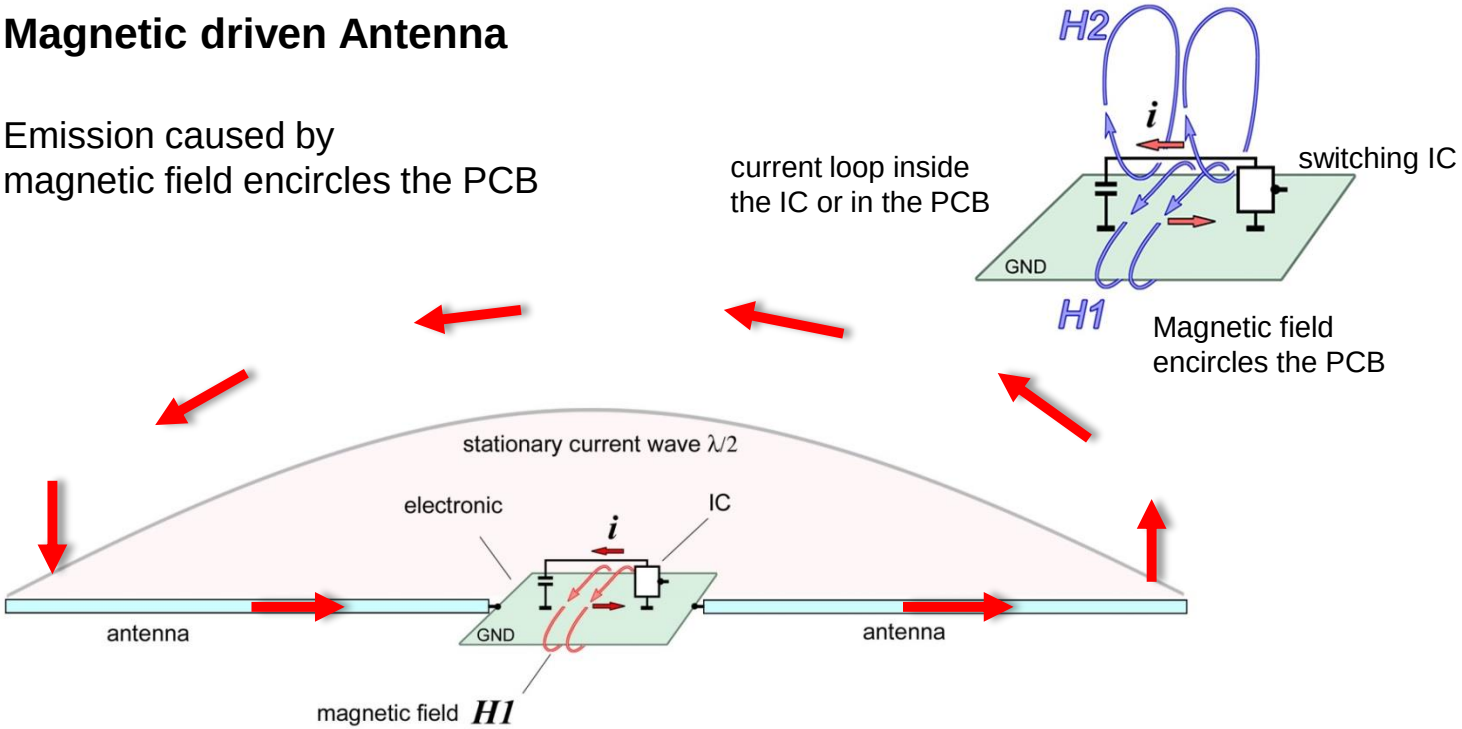



Most sources are very small in relation to the wavelength => an antenna is needed.

# Magnetic Coupling Effects

## Magnetic driven Antenna

Emission caused by
magnetic field encircles the PCB

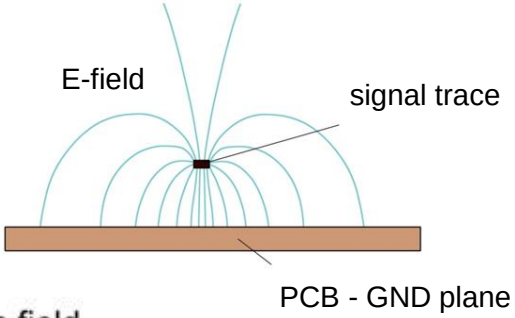


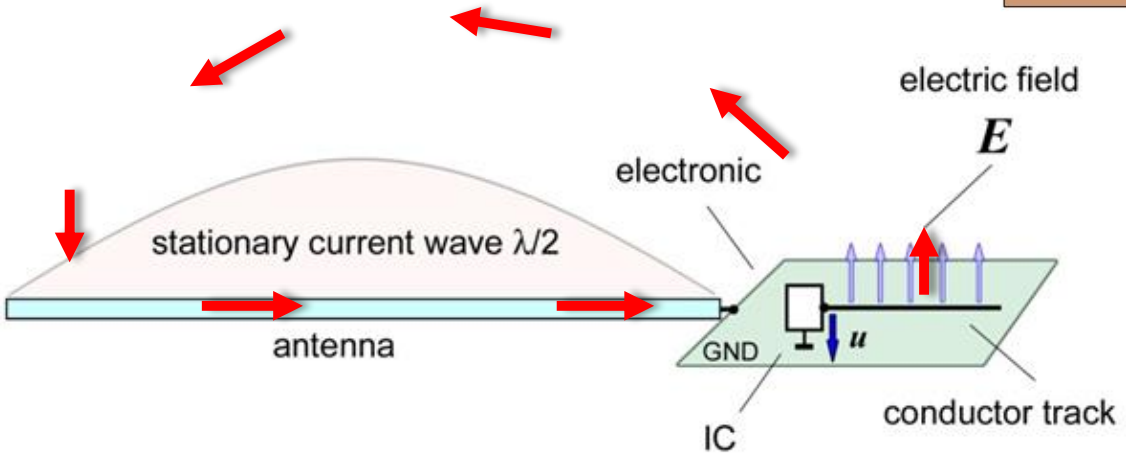

Radiation depends on the position of the near-field source in the antenna!

# Electric Coupling Effects

## Capacitive driven Antenna

electric fields associated with displacement currents can cause current waves on connected metal parts

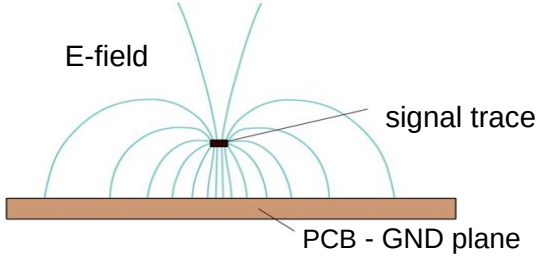


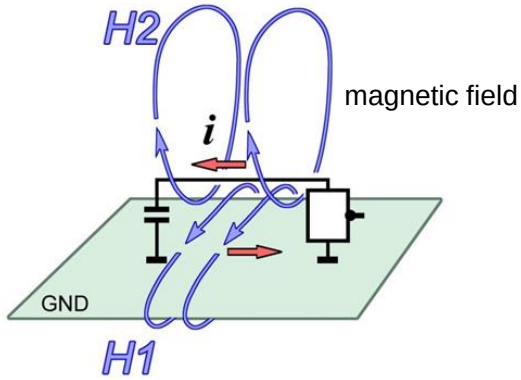




Radiation depends on the position of the near-field source in the antenna!

# Disturbance Emission Sources

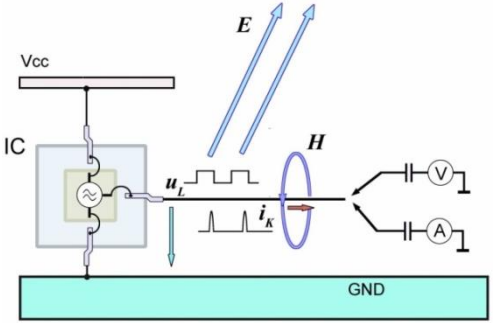
Comparison of electric and magnetic field source




Determining an ICs relevant emission parameters by:

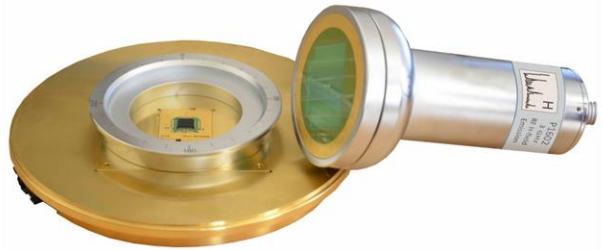
- Measuring voltage and current at the IC pin
  (non load and short-circuit measurements )




non-load voltage

short-circuit current

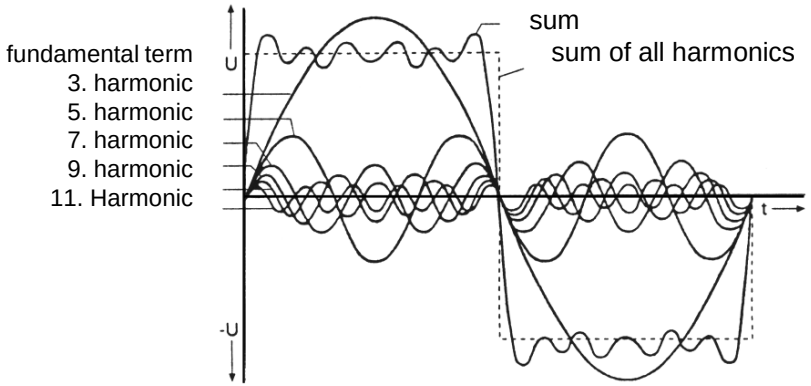
- Measuring magnetic and electric field above the IC



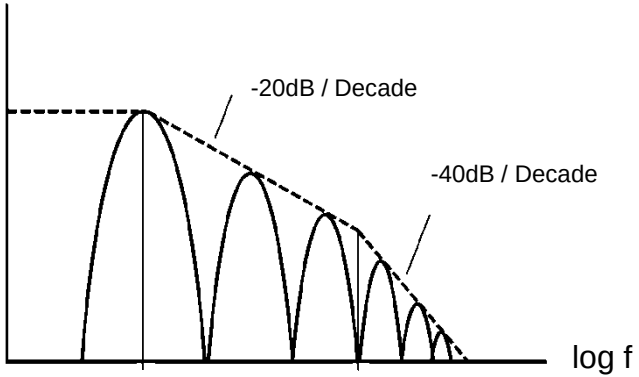
# Disturbance Emission Sources

Relationship between time domain and frequency domain:

Example: digital signal (50% high, 50% low, no DC component):



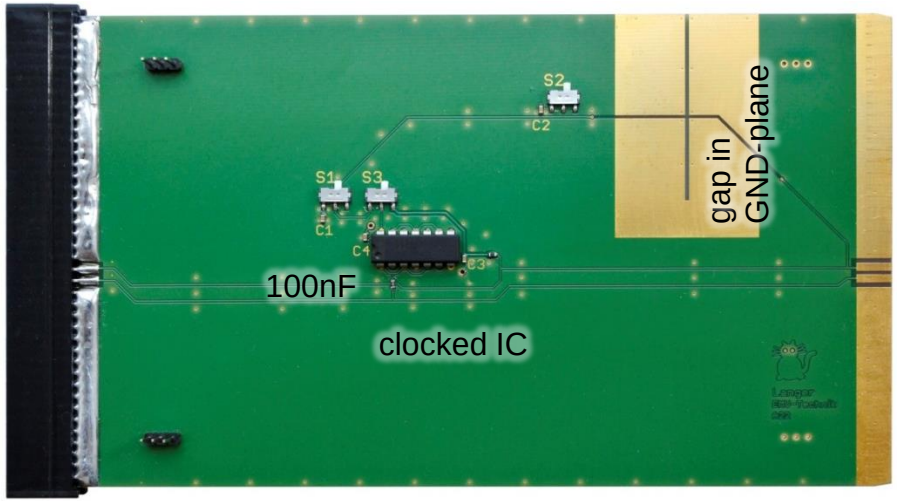

$$u(t) = \frac{4}{\pi}(\sin t + \frac{1}{3}\sin(3t) + \frac{1}{5}\sin(5t) + \frac{1}{7}\sin(7t) + ....)$$



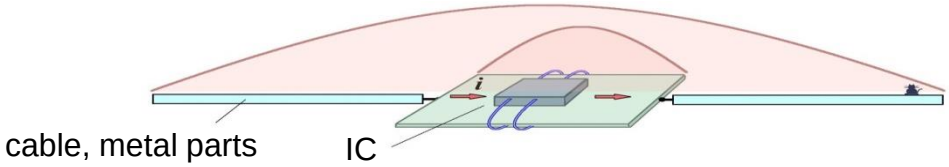
# Magnetic Coupling Effects

**Sample:** magnetic field on a PCB with clocked IC

- four-layer PCB
- closed GND-plane



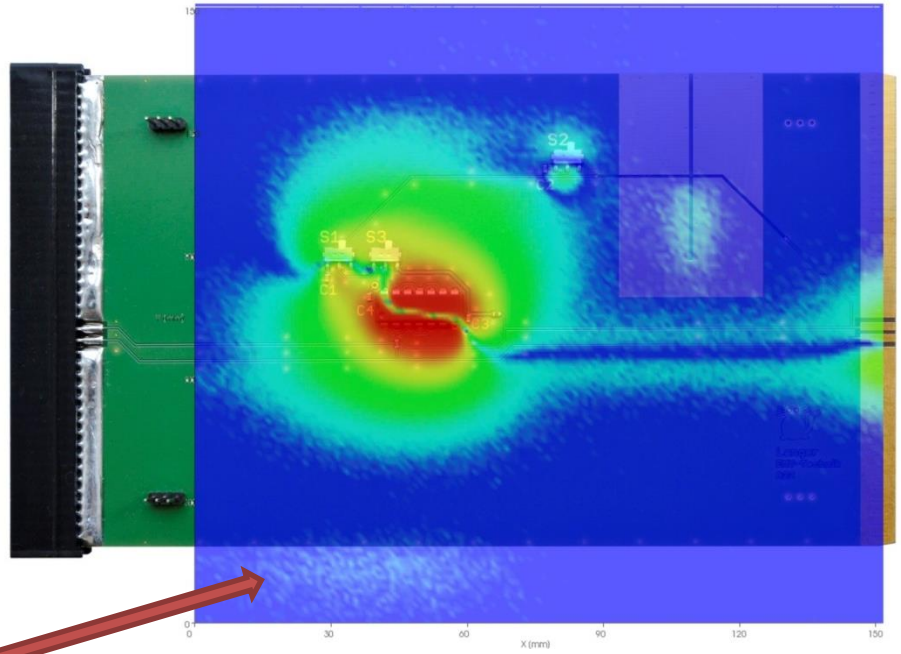

- power supply
- clock signal



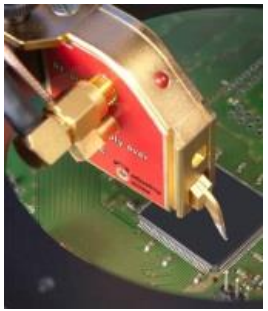
# Magnetic Coupling Effects

**Sample:** magnetic field on a PCB with clocked IC

- decoupling cap active -




critical
magnetic field

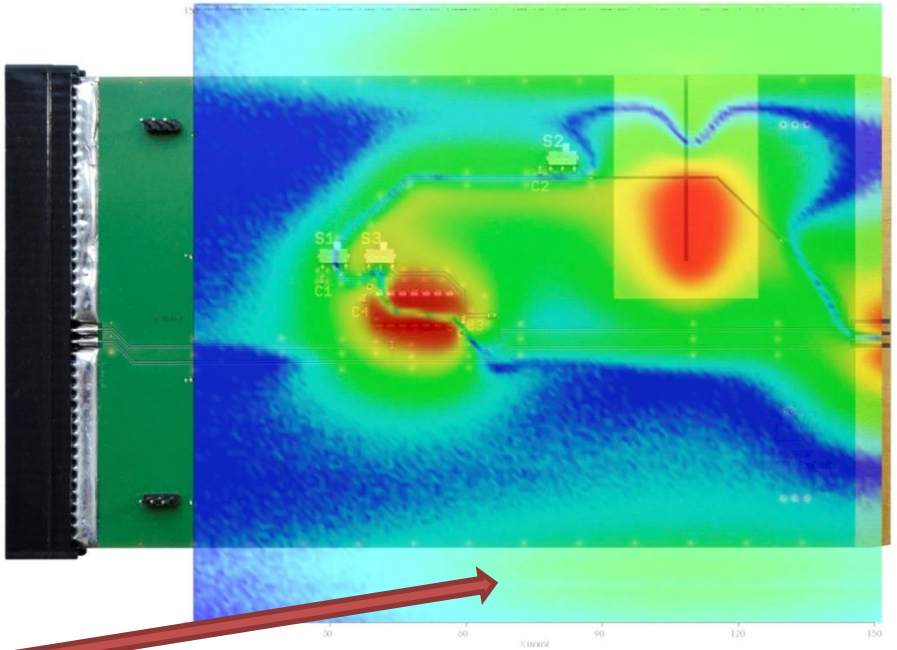


Magnetic field measurement
with scanner and probe
ICR H500

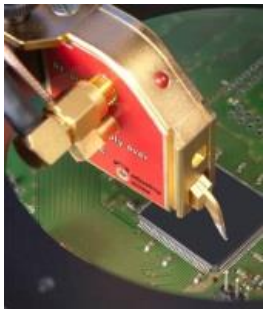
# Magnetic Coupling Effects

**Sample:** magnetic field on a PCB with clocked IC

- without decoupling cap -




critical
magnetic field



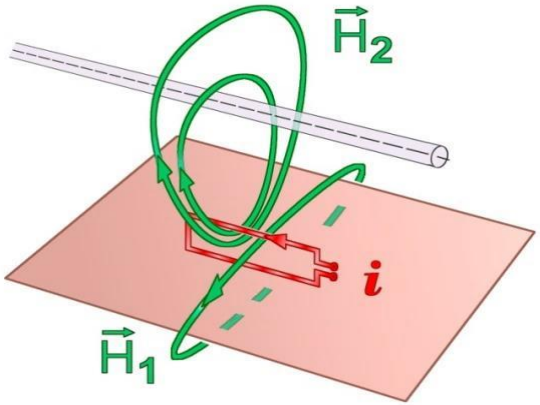
Magnetic field measurement
with scanner and probe
ICR H500

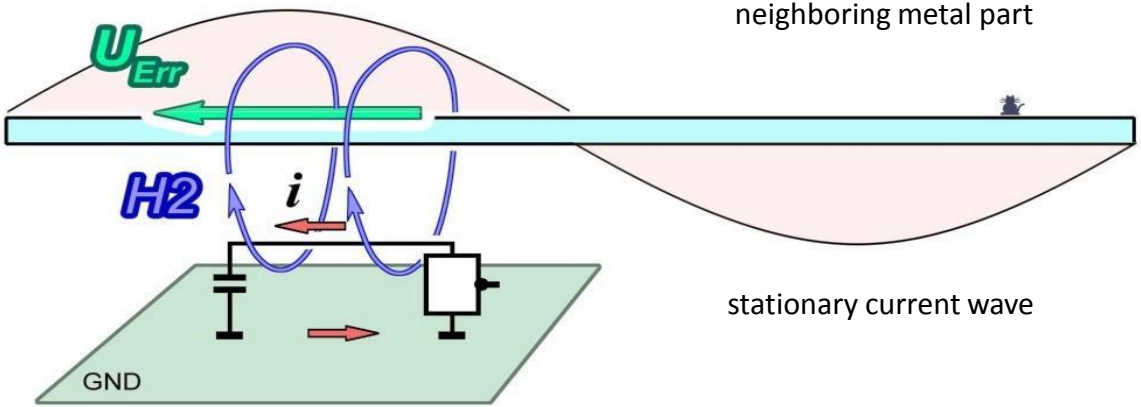
# Magnetic Coupling Effects

Various objects can function as an antenna:

The induction effect in neighboring metal parts causes radiation!

Beware! H2 is often significantly bigger than H1!




neighboring metal part

stationary current wave

Emission depends on the position of the source!

# Pre-Compliance Measurement Methods

## Field measurement with near-field probes

Two different measurement tasks:

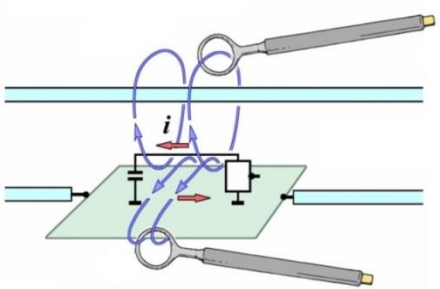
- qualifying the emission effects

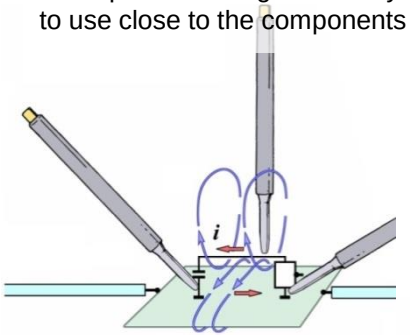
  big (sensitive) probes
  to use in a distance to the PCB

- localizing the source

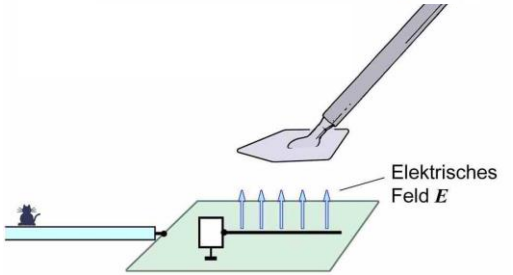
  small probes for high accuracy
  to use close to the components

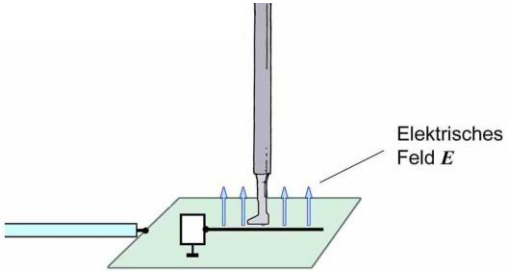
magnetic field:




electric field:



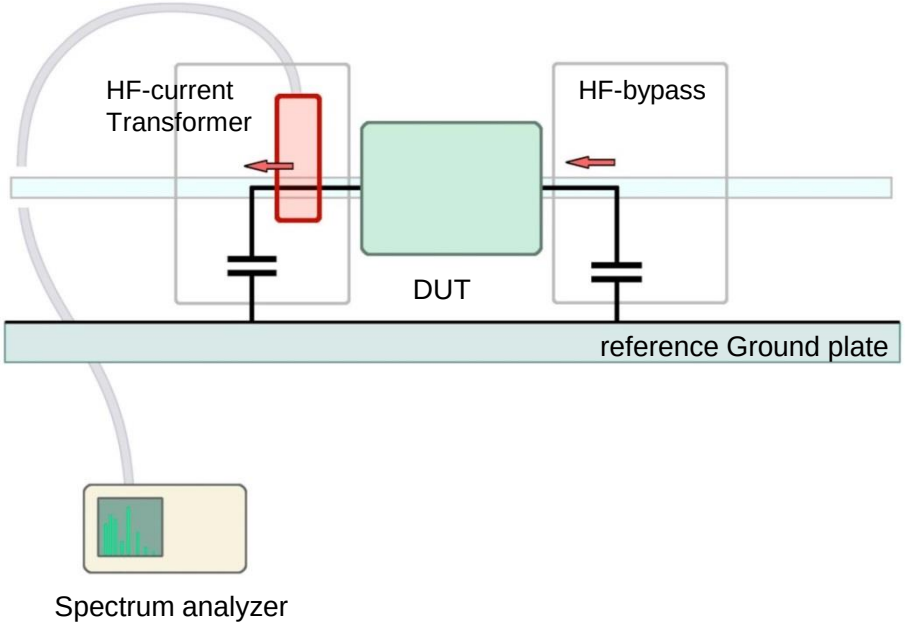



# Pre-Compliance Measurement Methods

## How emission measurements can be done on the developers desk?

Excitation currents are short-circuited through the reference Ground plate (capacitively) and measured with an HF-current transformer.

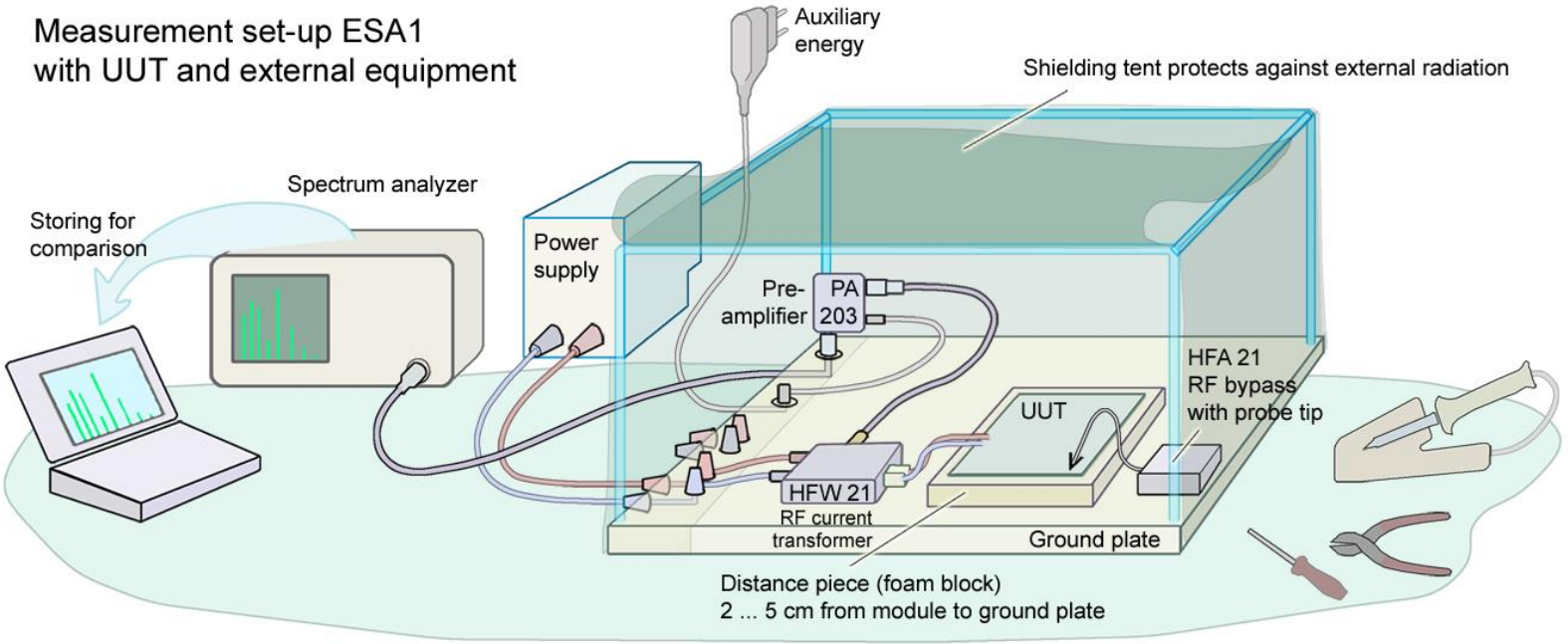
The current path should be shorter than half of the wavelength to prevent standing waves.




Measurement method characteristics**:**

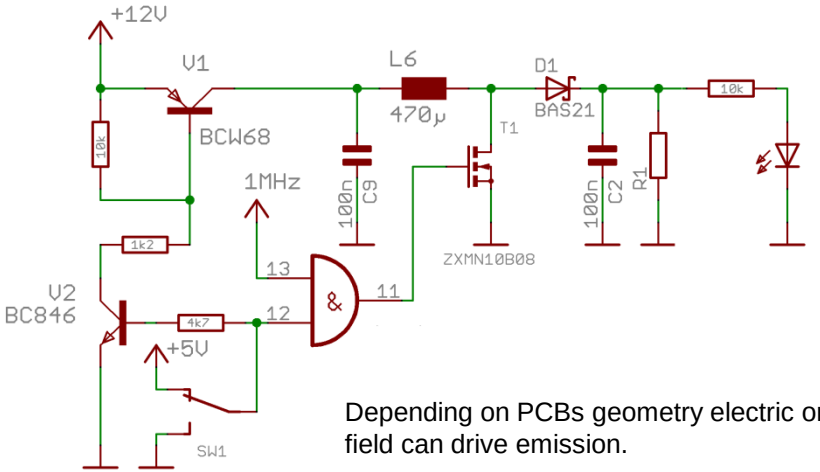
- total device emission values not possible to measure
- applicable during the development stages only
- useful for quick valuation of modifications
- portable enough to use at the developer‘s desk

# Pre-Compliance Measurement Methods



# Practical Examples

Electric Field Source: Step-Up converter

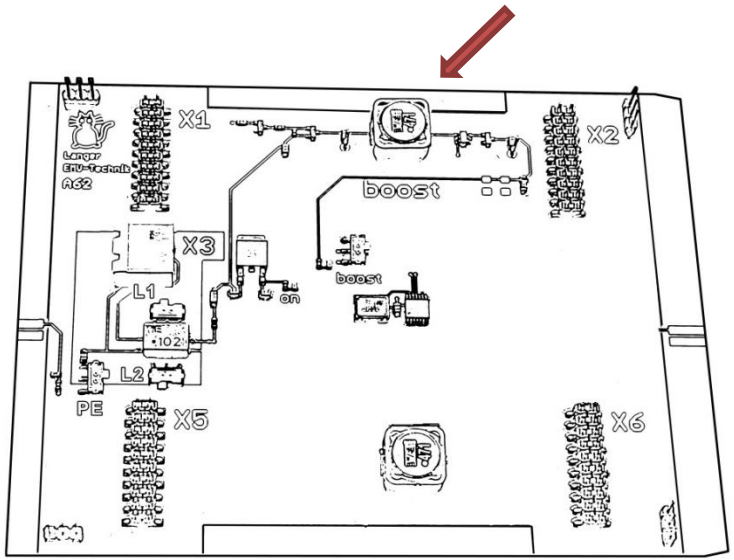



Depending on PCBs geometry electric or magnetic field can drive emission.

In this example the electric field generated by the boost converter coil determines the emission.

Test setup: ESA1

Boost converter coil



# Practical Examples

## Electric Field Source: Step-Up converter

converter coil (high element) acts as an electric field source:

Maybe shielding is needed!

Resonance effects can occur!
capacitance between both PCBs and inductance of the connector = resonant circuit

Problem-solving strategy:
significant reduction of the inductance by using more connectors (or screws or contact springs) in parallel