

# Föreläsning 5

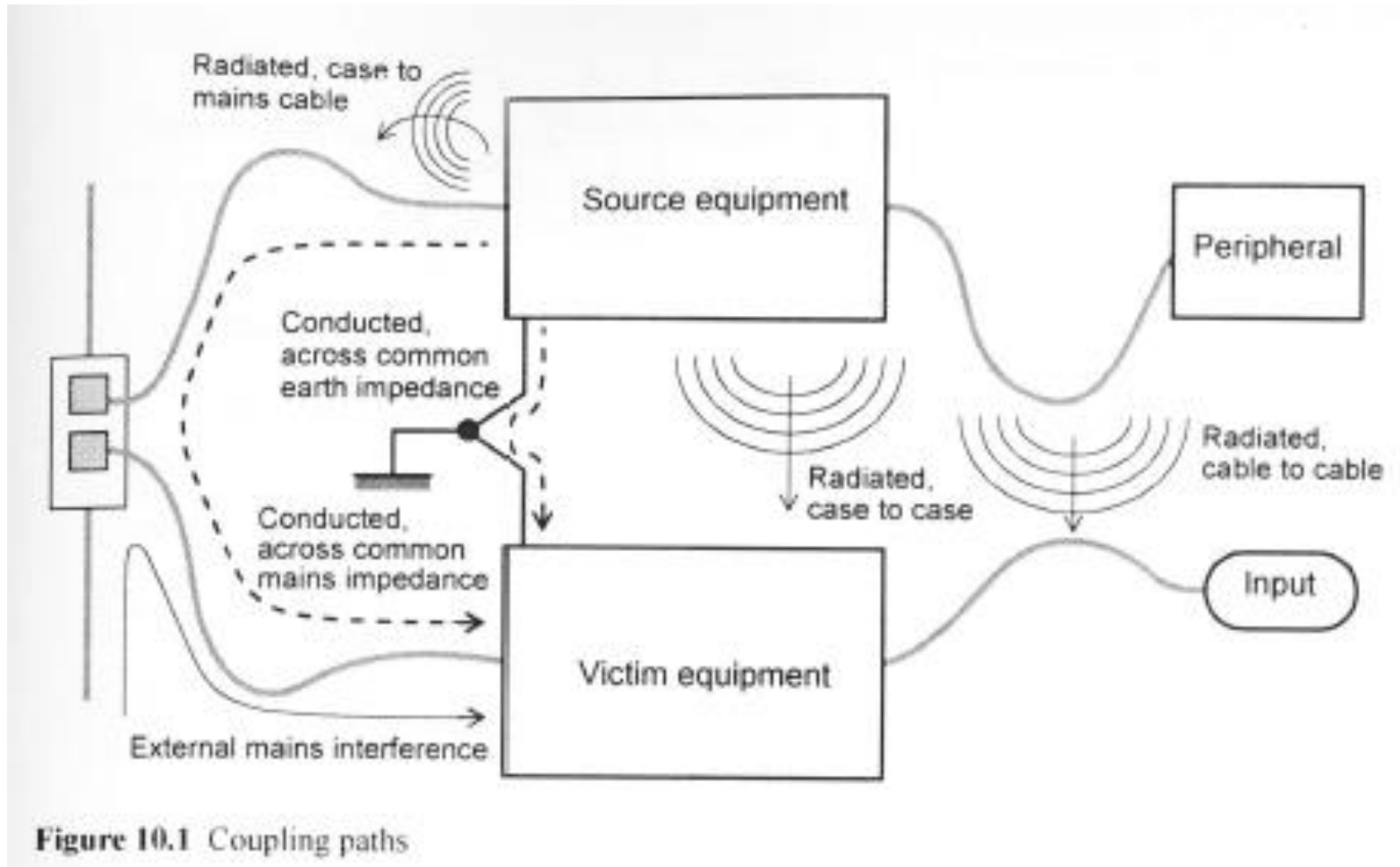
## IE1332 Utveckling av elektronikprodukter

- Kapitel 10 Interference coupling mechanisms
- Kopplingsvägar
  - Gemensam jord
  - Induktiv och kapacitiv koppling
  - Via elnätet, ledningsbundet
  - Via elektromagnetiskt fält, utstrålat
- Emission

# Först lite kursinfo

- Litteraturuppgift. Välj ämne senast till tisdag 16/4!
- För att leta forskningsartiklar kan du använda [IEEE Xplore](#)
- Seminarieuppgift till torsdag 18/4 kl 13-15
  - Deadline för skriftlig inlämning 17/4!
  - Poäng från seminarierna adderas till tentamen enligt
$$P_{\text{tentamen}} = P_{\text{seminarie}}/2$$
- Tentamen
  - Del A utan lärobok – grundläggande begrepp max 2 timmar, max 20p
  - Del B med lärobok – mer komplexa frågeställningar och räkneuppgifter, max 20p
  - A 36-40, B 31-35, C 26-30, D 22-25, E 20-21, Fx 18-19, F ≤ 17

# Kopplingsvägar



# Koppling via gemensam jord

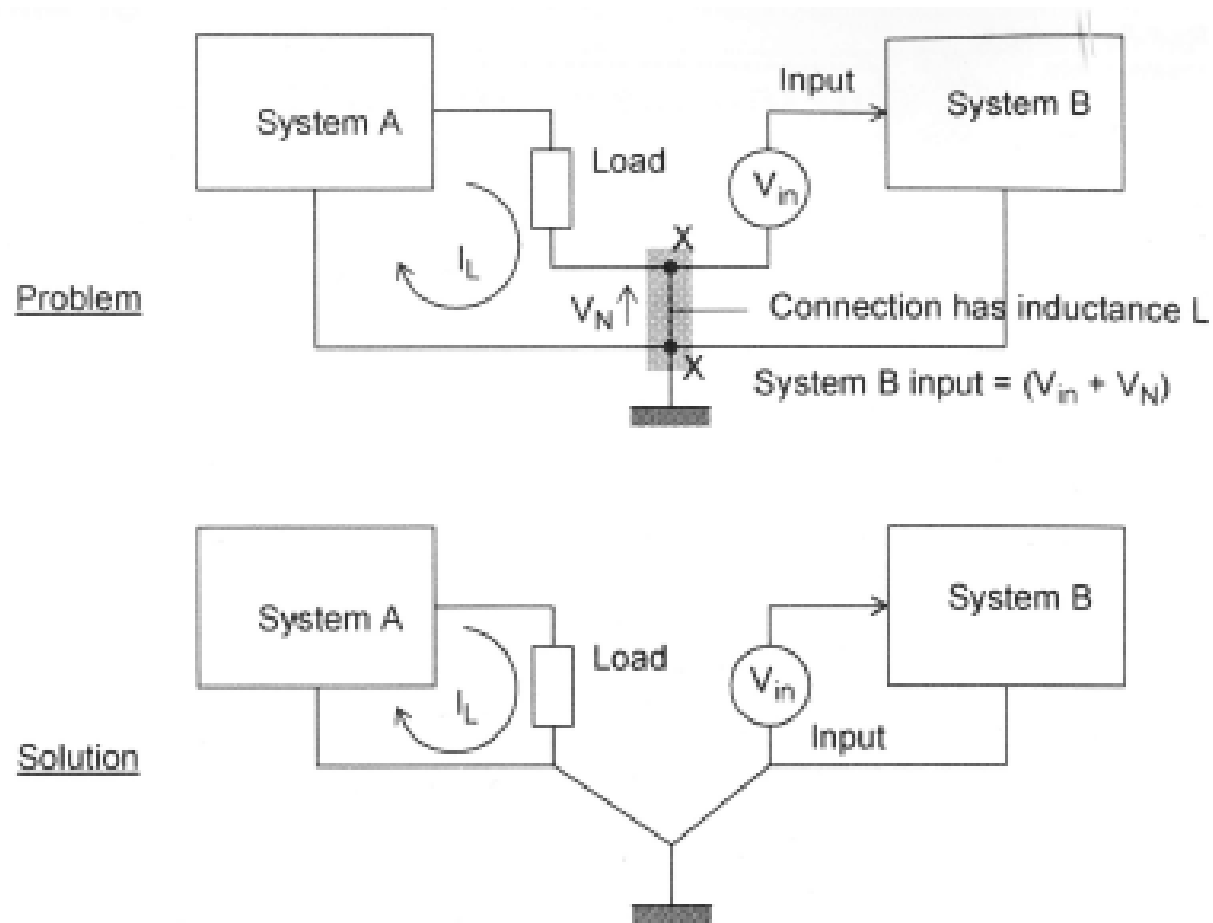
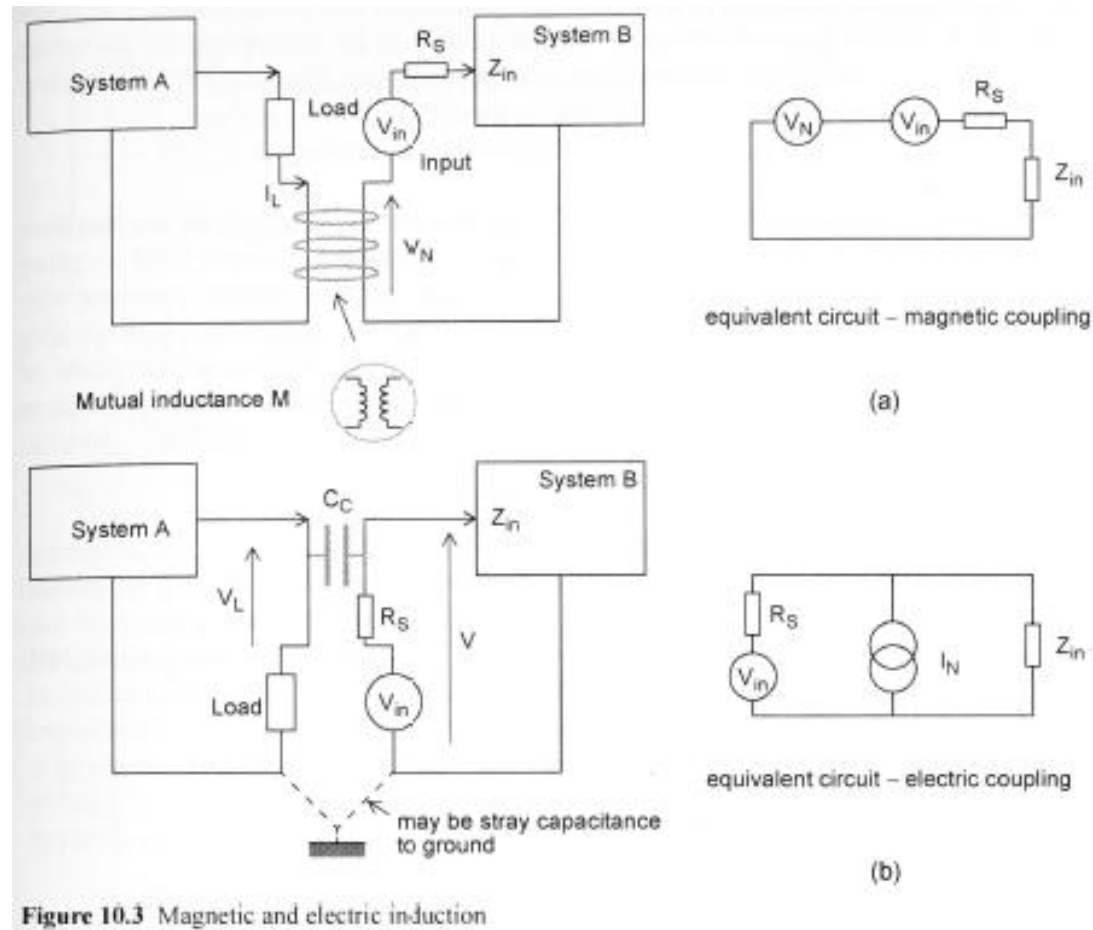


Figure 10.2 Conducted common impedance coupling

# Induktiv och kapacitiv koppling



# Ömsesidig kapacitans och induktans

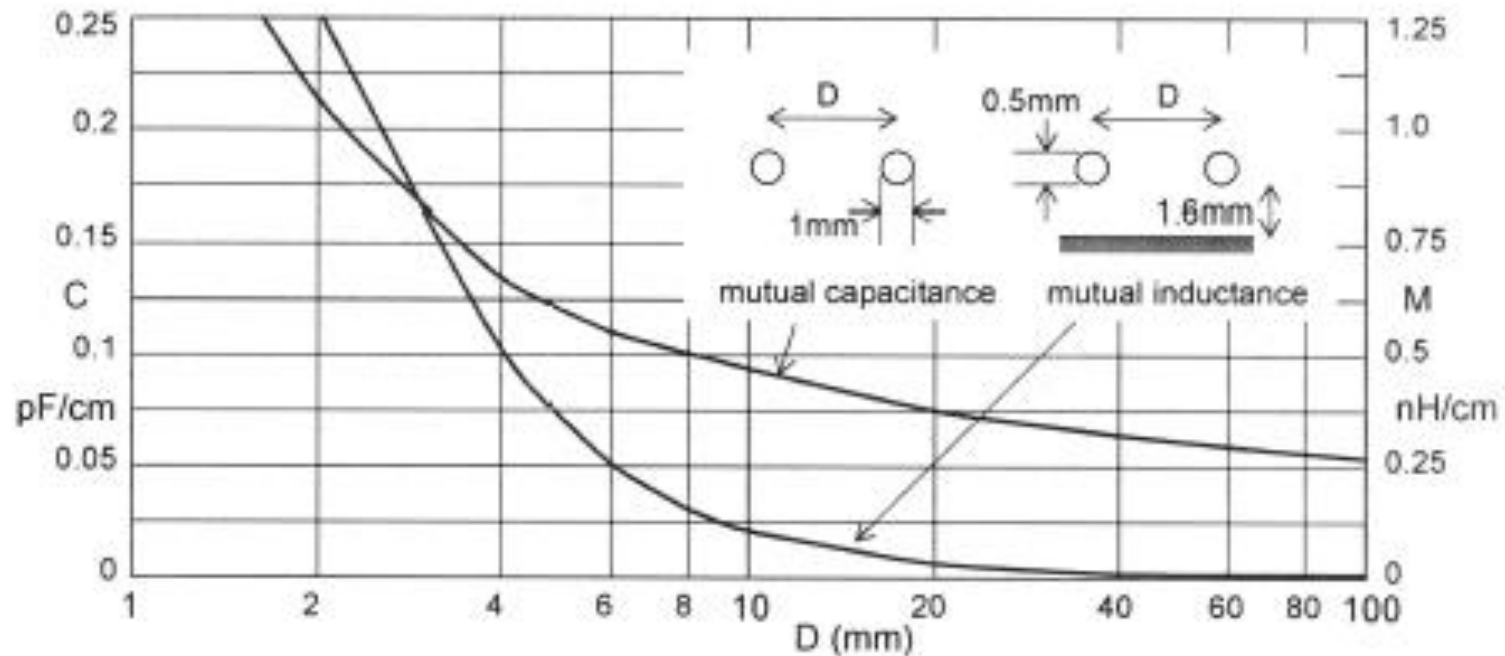
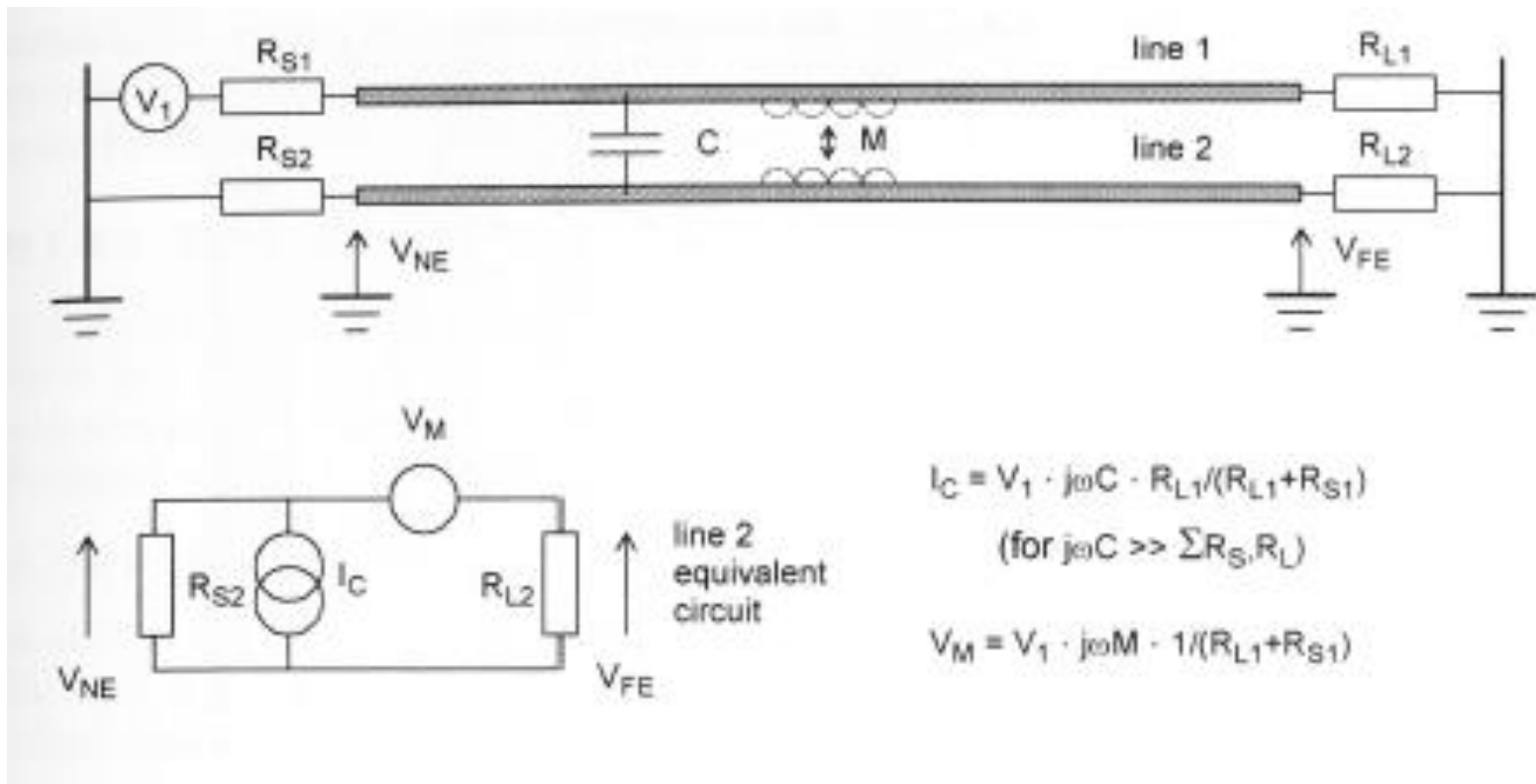


Figure 10.4 Mutual capacitance and inductance versus spacing

# Superposition av induktiv och kapacitiv koppling



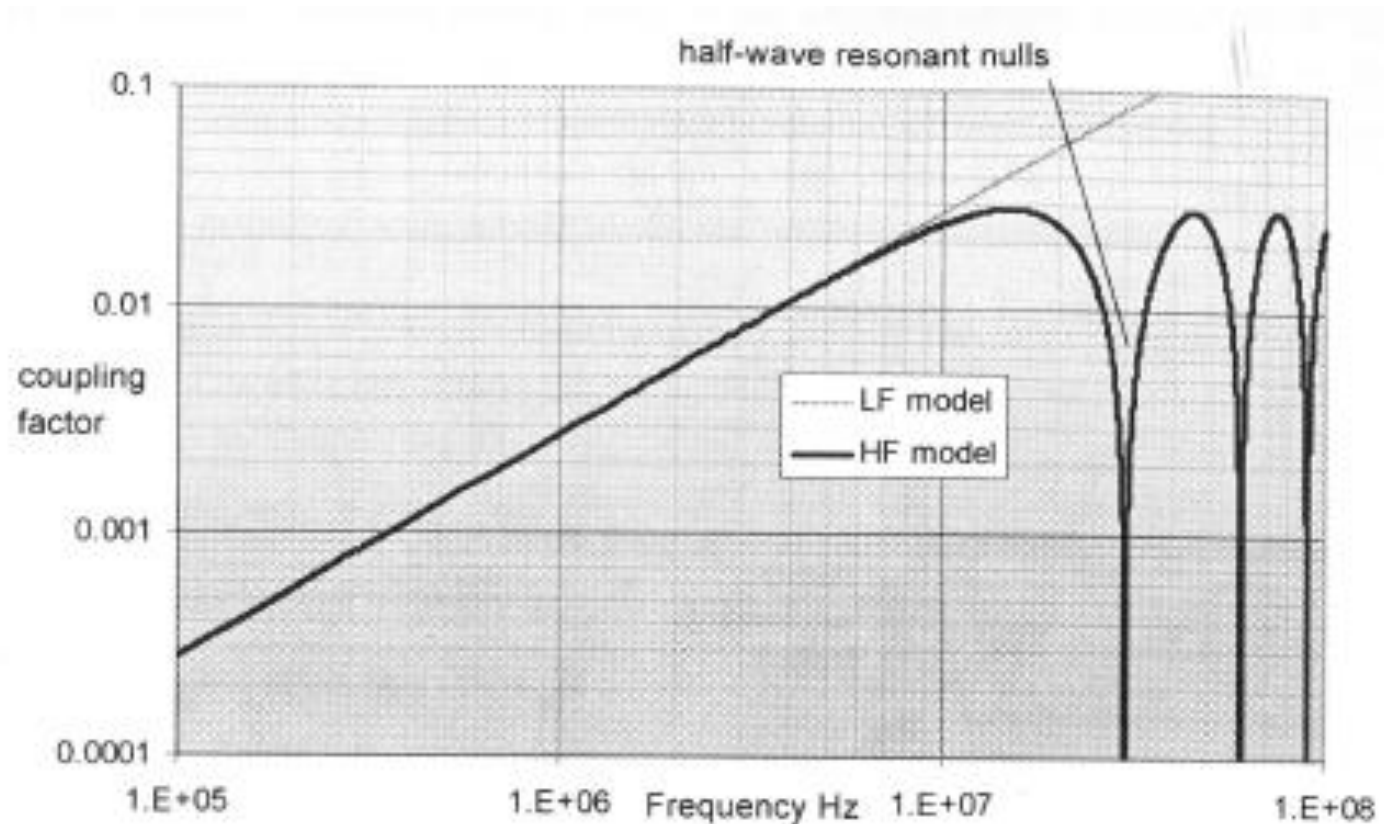
$$I_C = V_1 \cdot j\omega C \cdot R_{L1} / (R_{L1} + R_{S1})$$

(for  $j\omega C \gg \sum R_S, R_L$ )

$$V_M = V_1 \cdot j\omega M \cdot 1 / (R_{L1} + R_{S1})$$

**Figure 10.5** Superposition of inductive and capacitive coupling

# Koppling vid höga frekvenser



**Figure 10.6** High frequency line coupling, line length 5m



# Koppling via elnätet

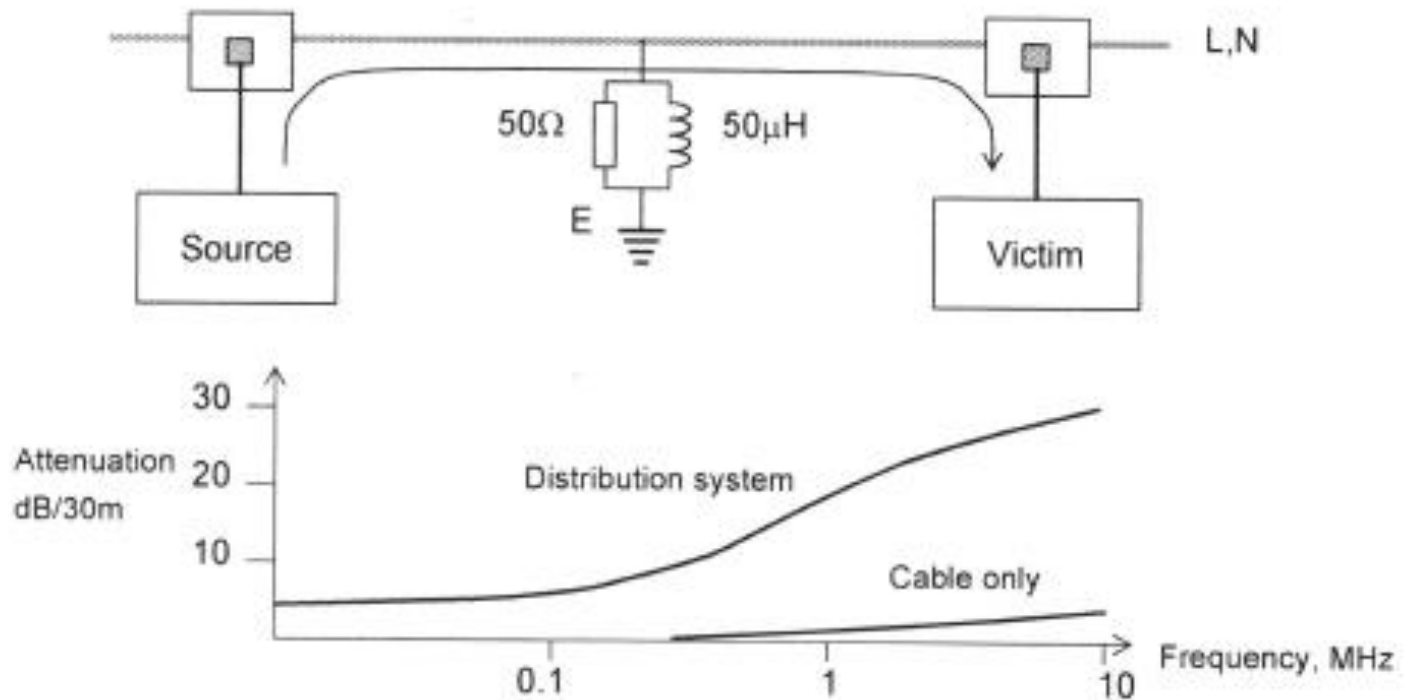
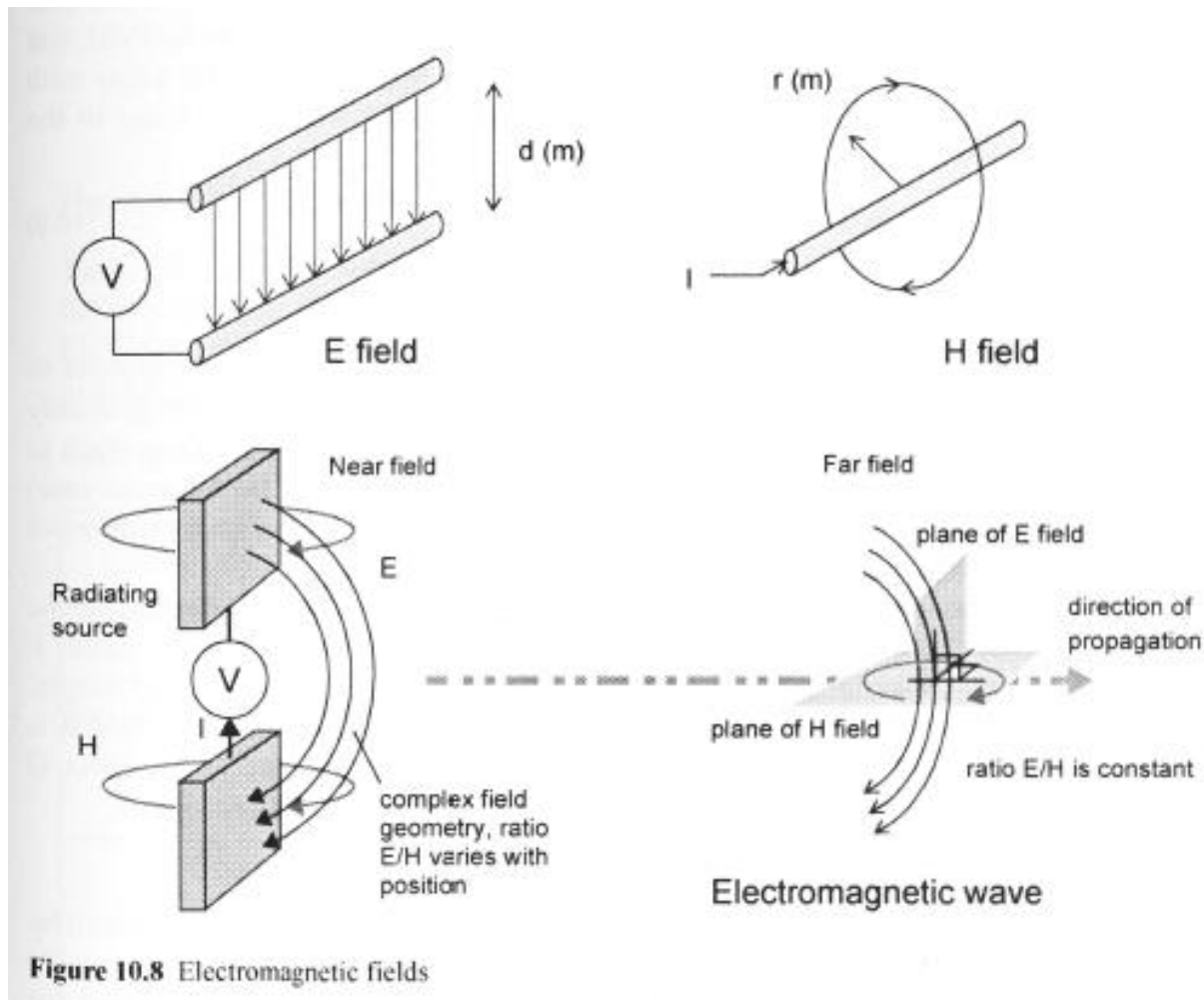


Figure 10.7 Coupling via the mains network

# Koppling via elektromagnetiskt fält



# Vågimpedans elektromagnetiskt fält

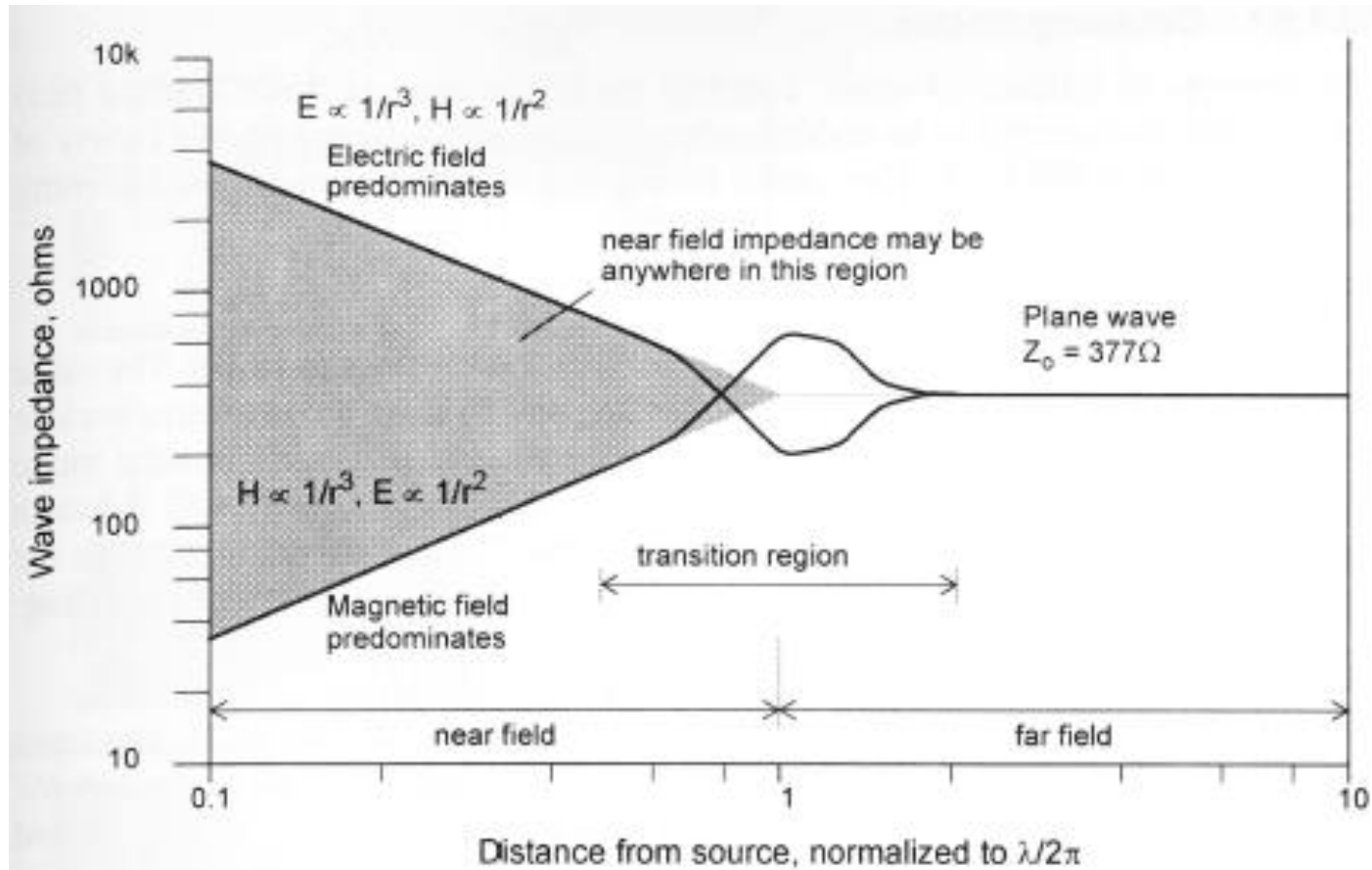
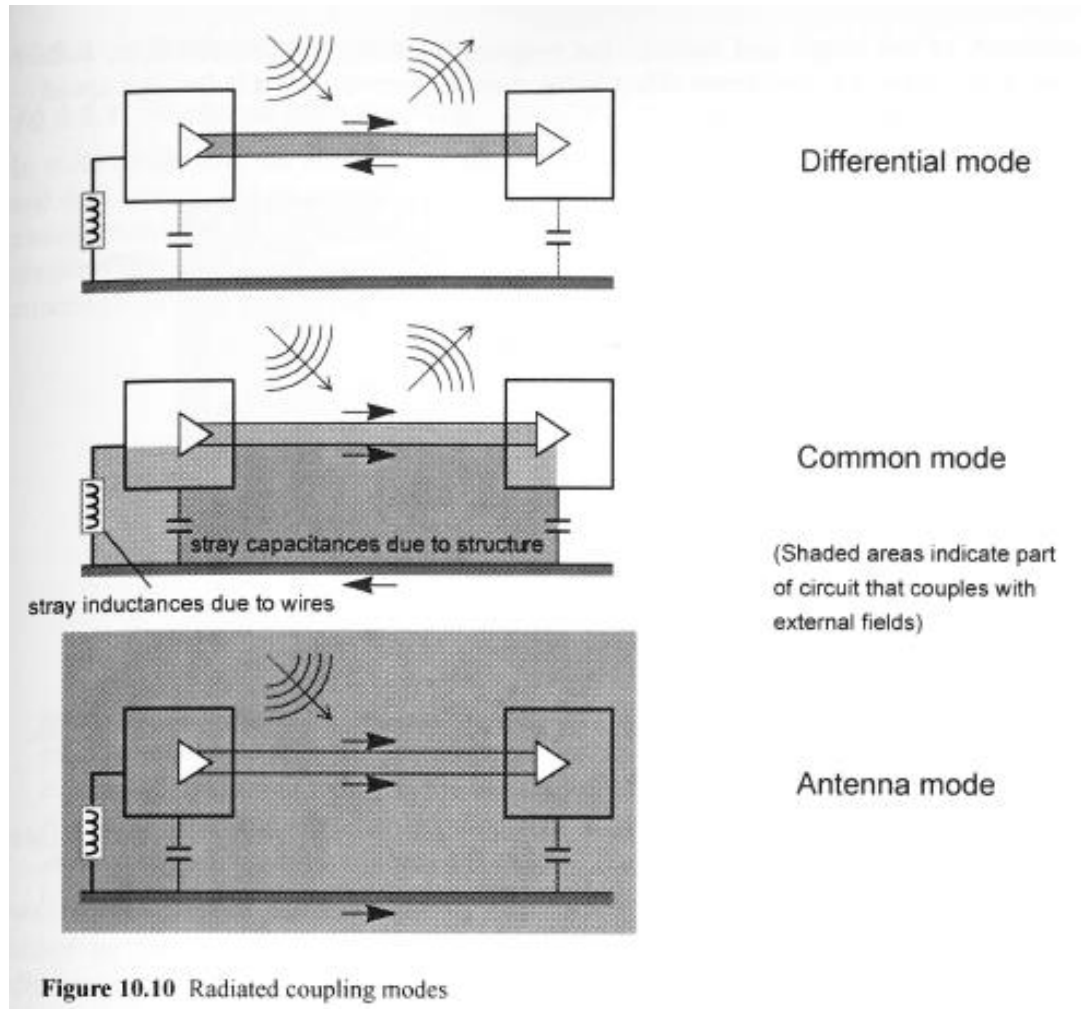


Figure 10.9 The wave impedance from Maxwell's laws

# Kopplingsmoder



# Differentiell till common mode

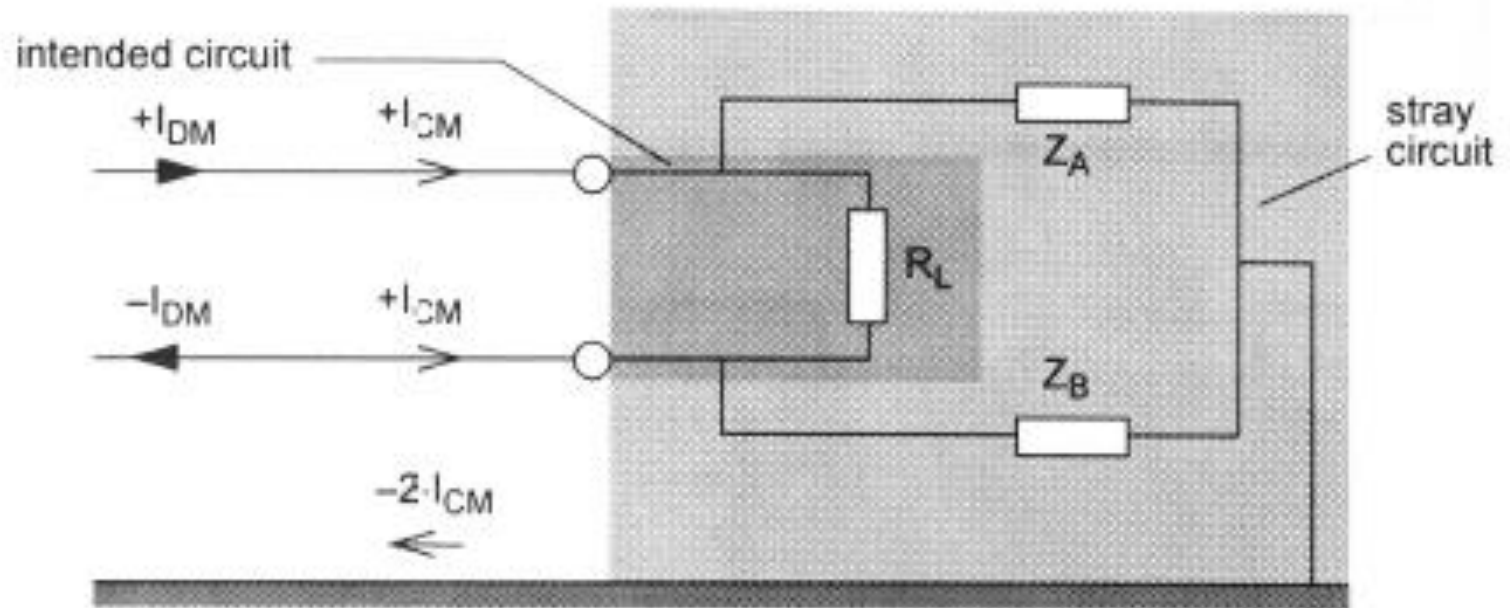
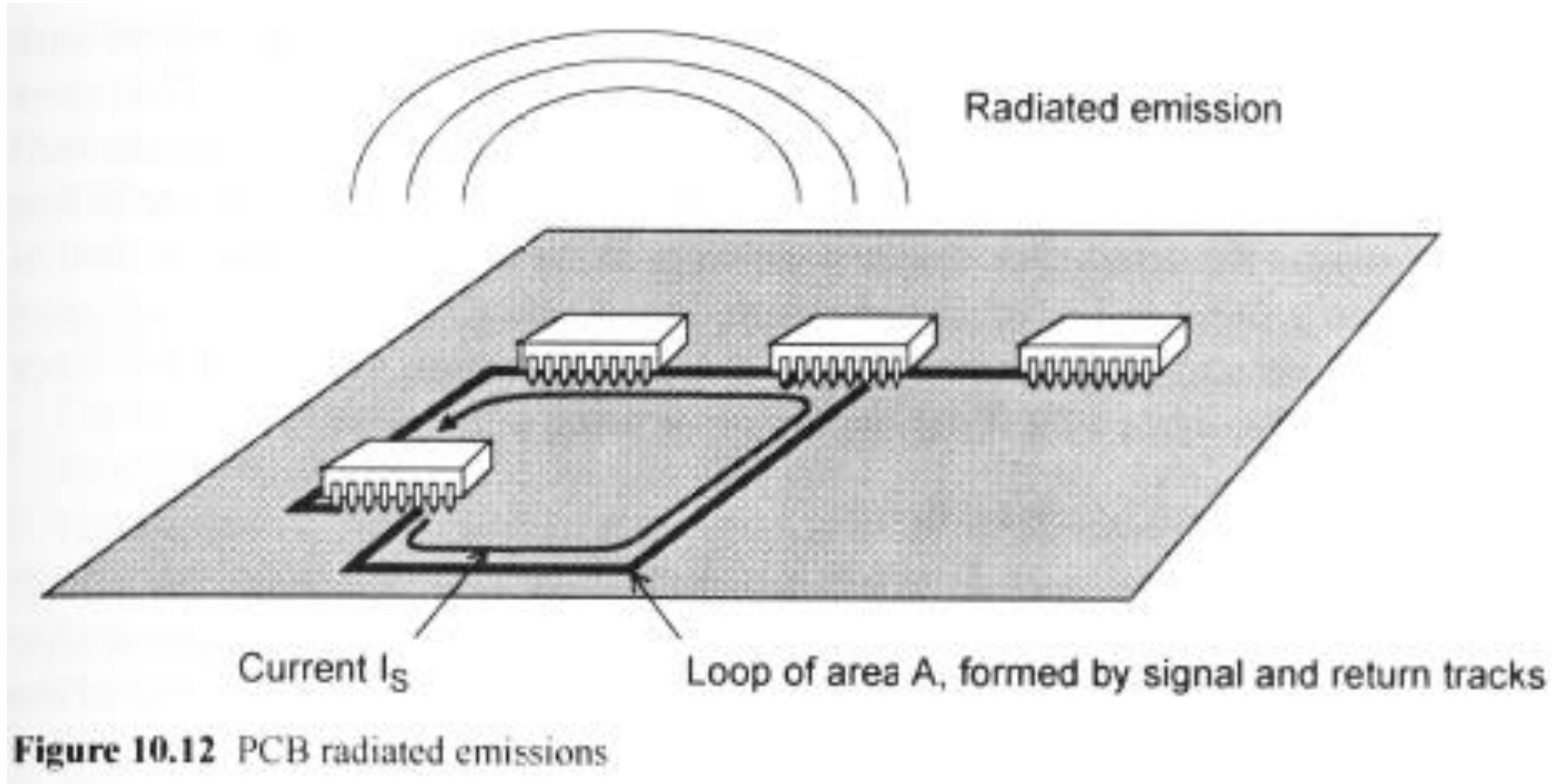


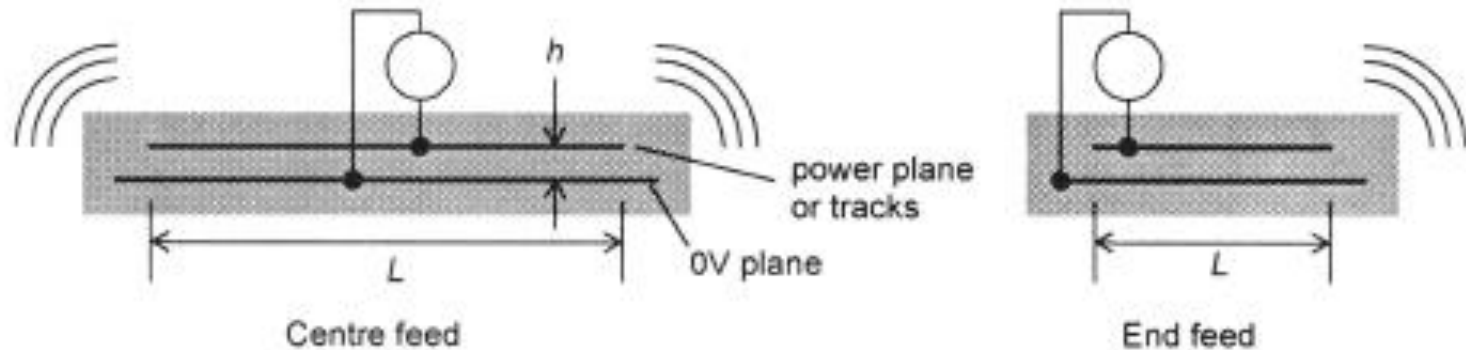
Figure 10.11 Differential to common mode conversion

# Emission från PCB



# Patch-antenn

edge radiation increases with  $h$  and is maximized when  $L = n \cdot \lambda/2$  (centre feed) or  $n \cdot \lambda/4$  (end feed)



**Figure 10.13** The patch antenna model

# Strålning från kabel

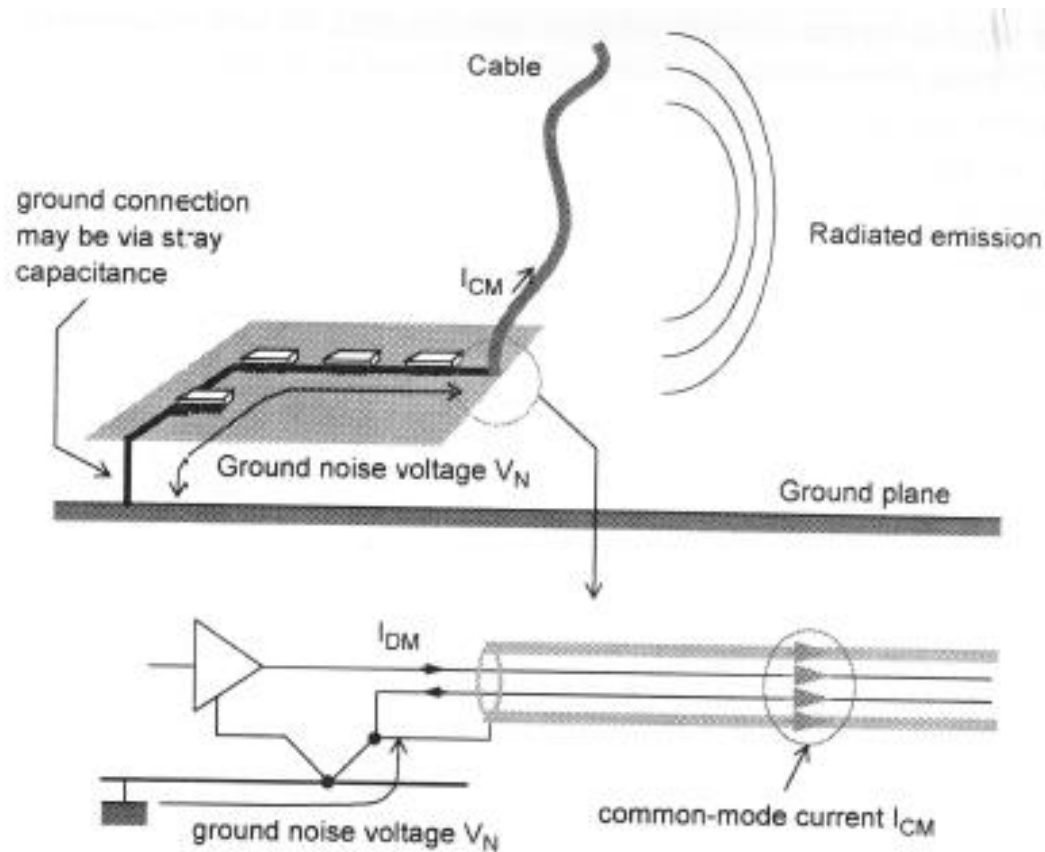
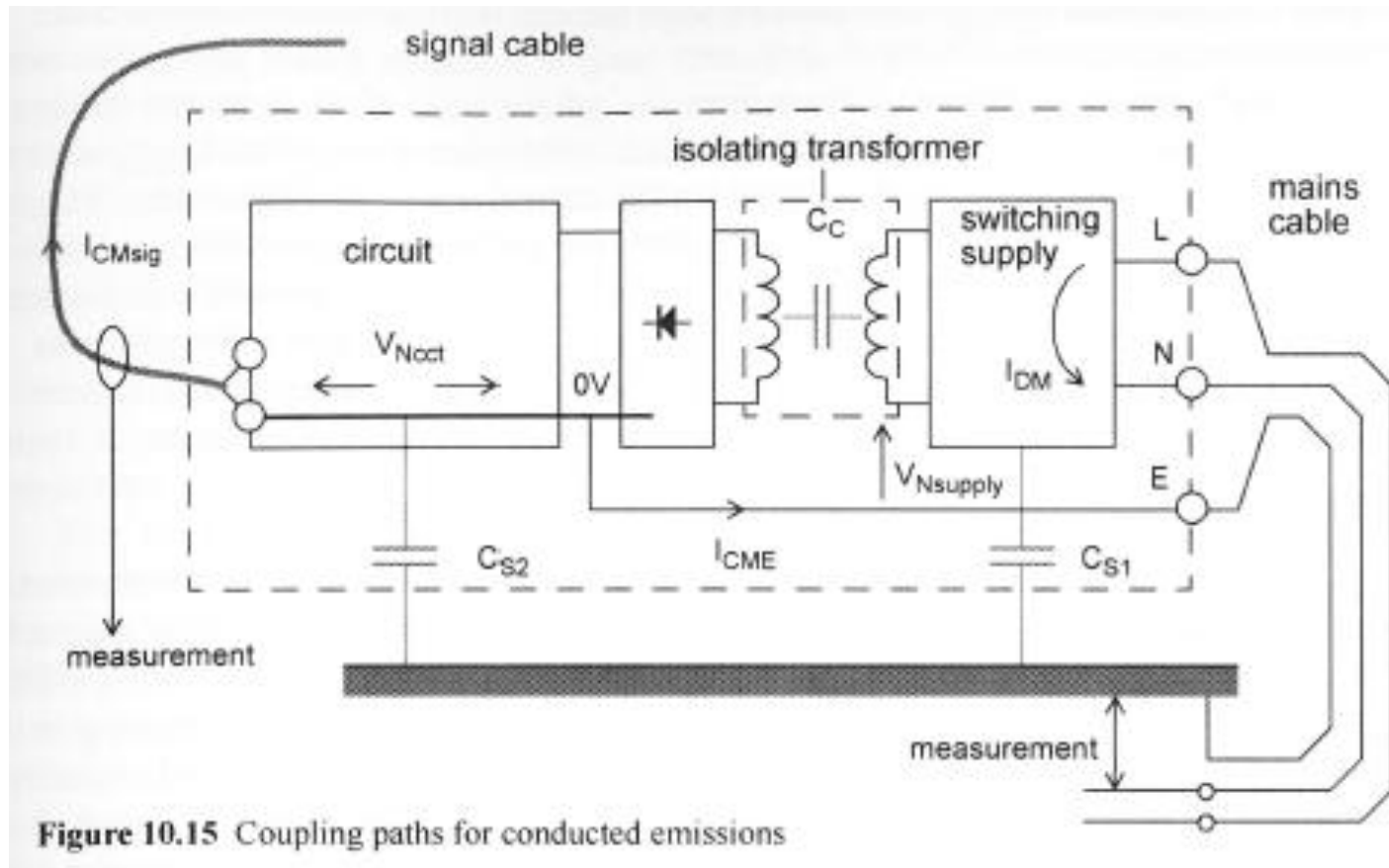


Figure 10.14 Cable radiated emissions



# Ledningsbunden emission



# Koppling utstrålat fält

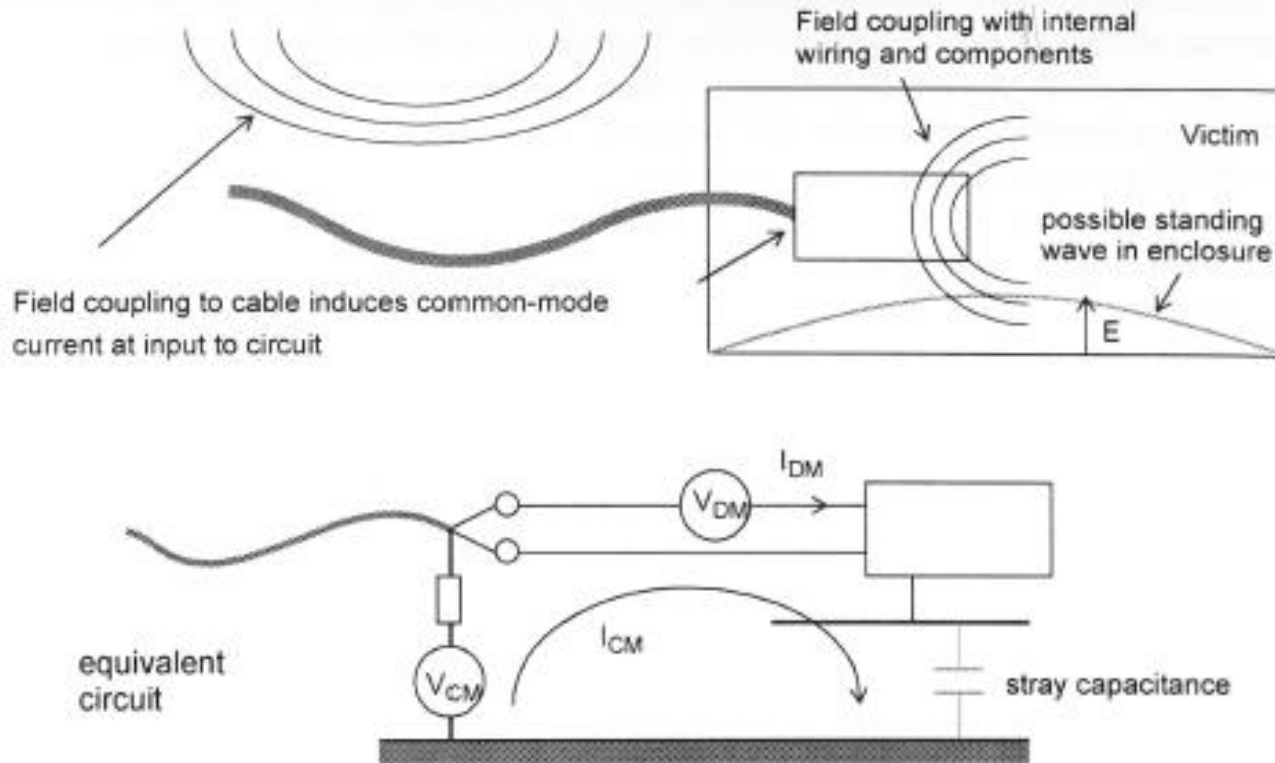


Figure 10.17 Radiated field coupling

# Koppling kabel till utstrålat fält

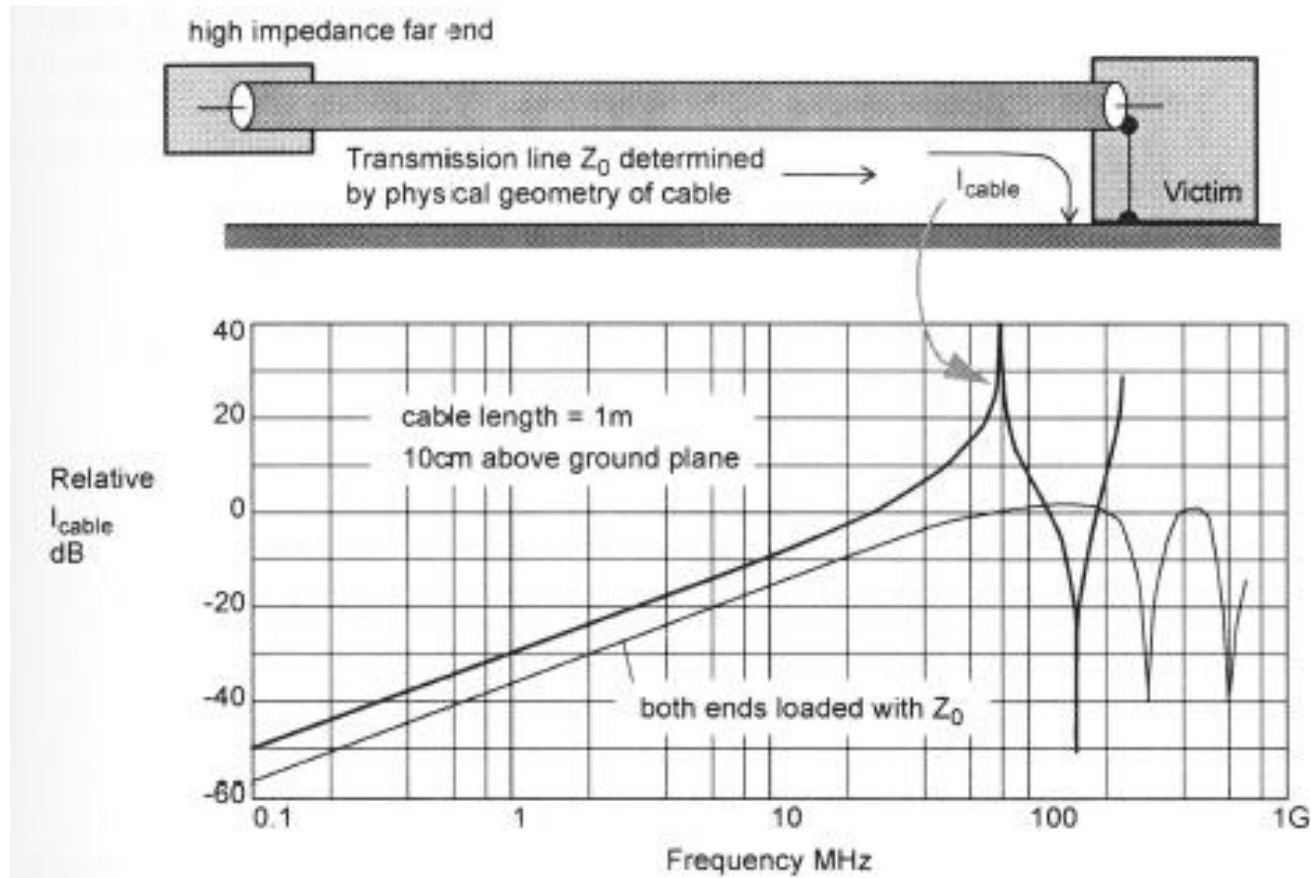


Figure 10.18 Cable coupling to radiated field

# Spänning och ström på resonant kabel

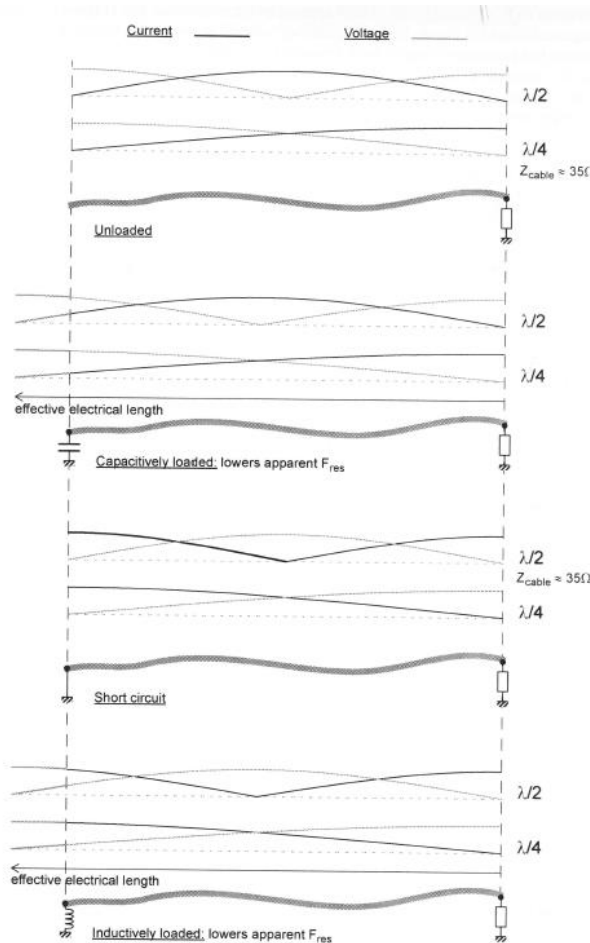
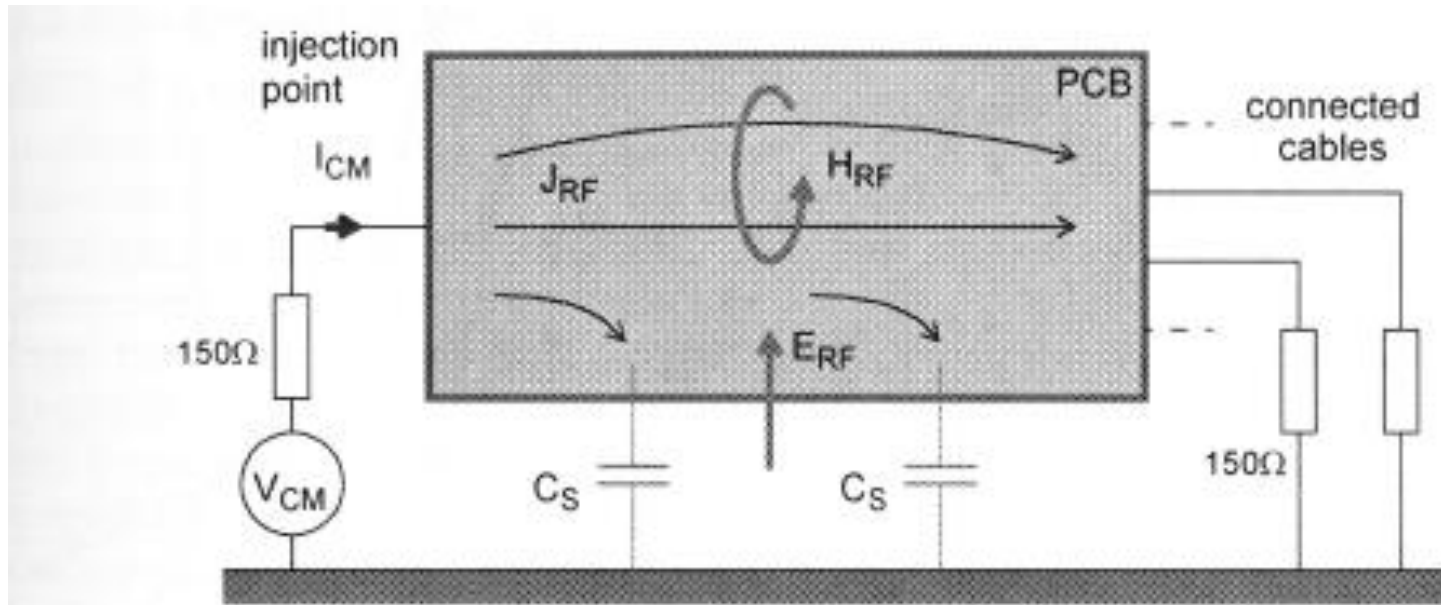


Figure 10.19 Current and voltage distribution along a resonant cable

# Common mode RF injektion



$J_{RF}$  represents common mode RF current density through the PCB

**Figure 10.20** Common mode RF injection