



# Electromagnetic Compatibility ( *EMC* )

Introduction about Components





# Agenda

- Ferrite Core

- Isolation

  - Transformers

  - Opto-Isolators

- Transient and Surge Suppression Devices

  - Varistors

  - Gas-Tube Surge Suppressors

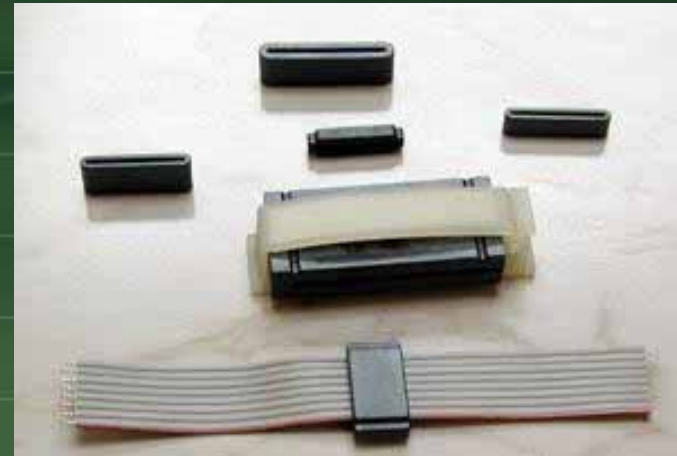
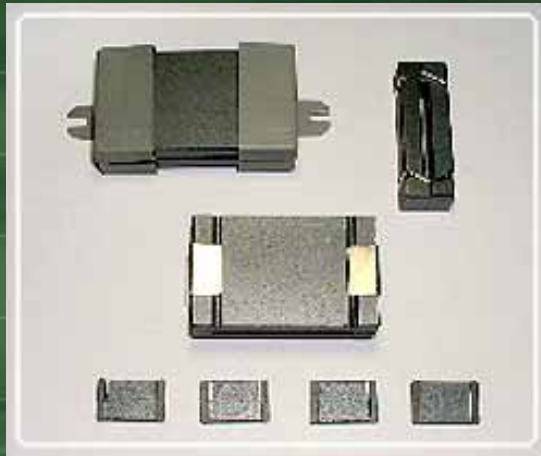
  - Semiconductor Transient Suppressors



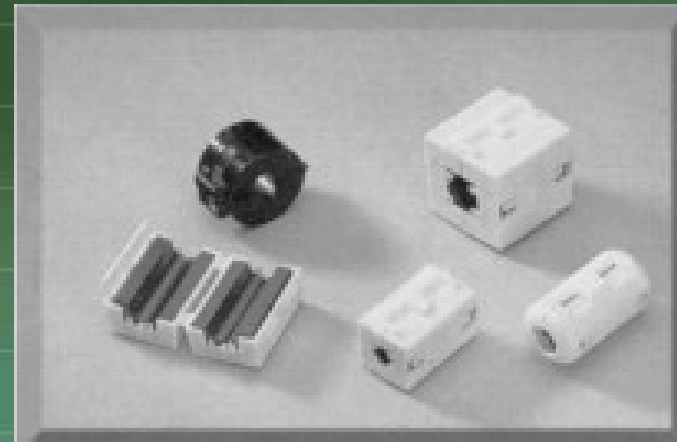


# Ferrite Core

## Split EMI Ferrite Cores for Ribbon Cables



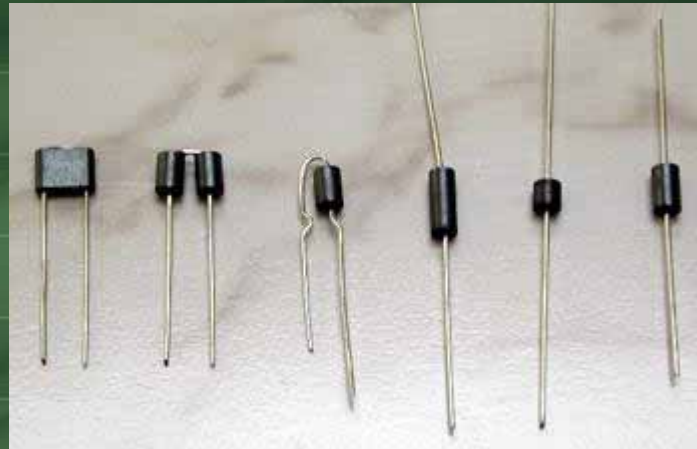
## Snap EMI Ferrite Cores





# Ferrite Core

## EMI Suppression Ferrite Beads



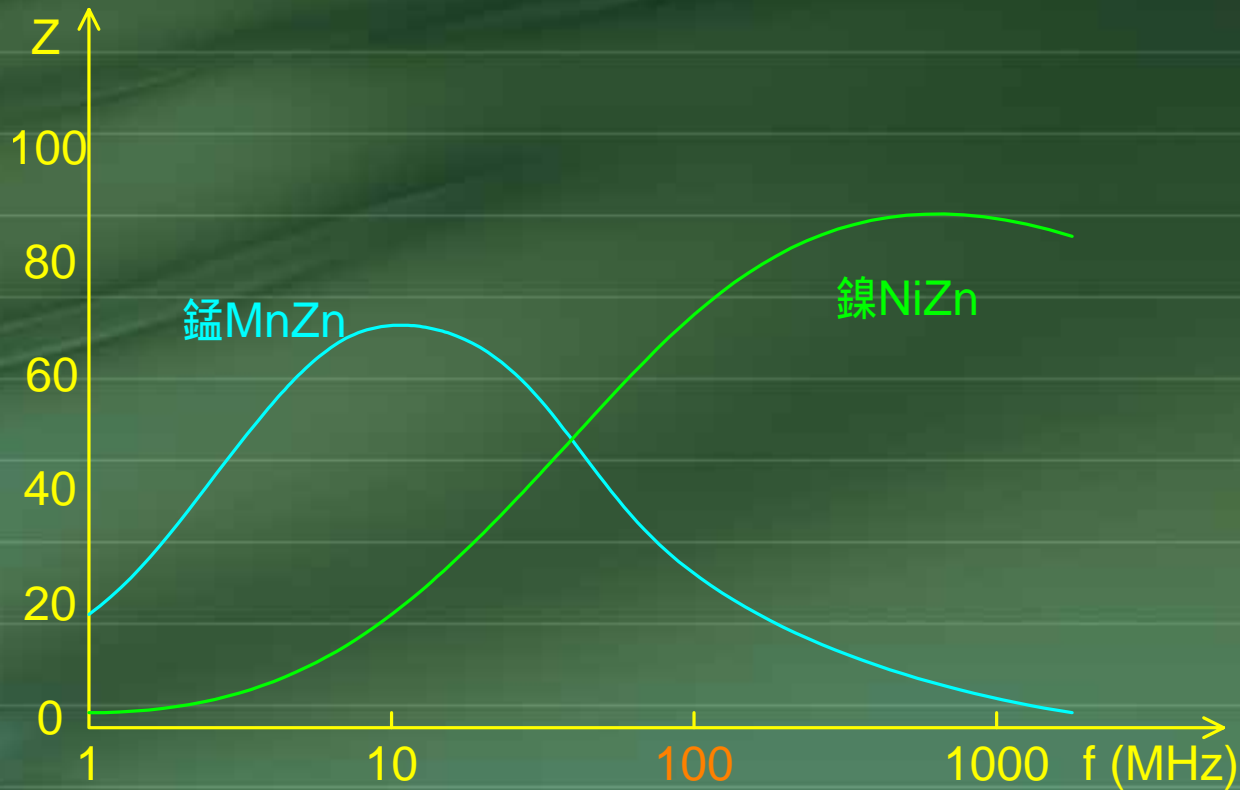
## Ferrite Cores





# Ferrite Core

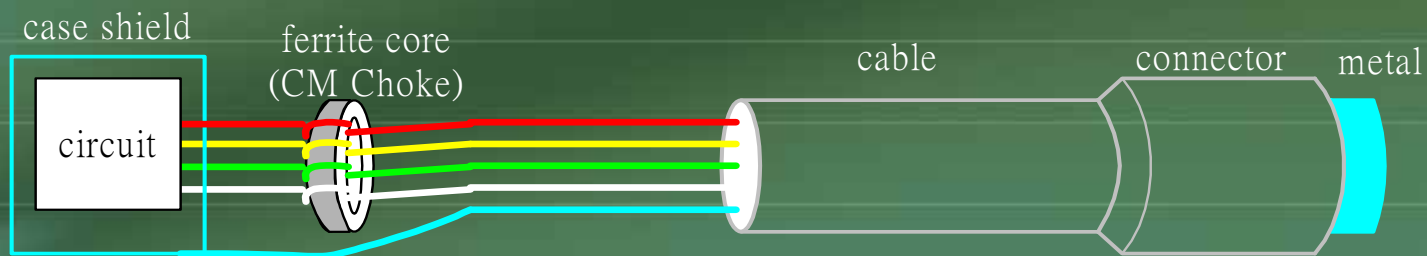
- Use the proper ferrite material for EMI / EFT / ESD frequency range





# Ferrite Core

- **Ferrite Bead** ( $X\text{Fe}_2\text{O}_3$ ,  $X=\text{Mn}, \text{Ni}$ )
  - low frequency  $\rightarrow$  inductor
  - high frequency  $\rightarrow$  resistance
- Ferrite bead + stray capacitance  $\rightarrow$  useful filter
- Not to use multi-turn ferrite core, because the larger inductance a ferrite core forms, the larger stray capacitance it will have to couple the noise into around circuit

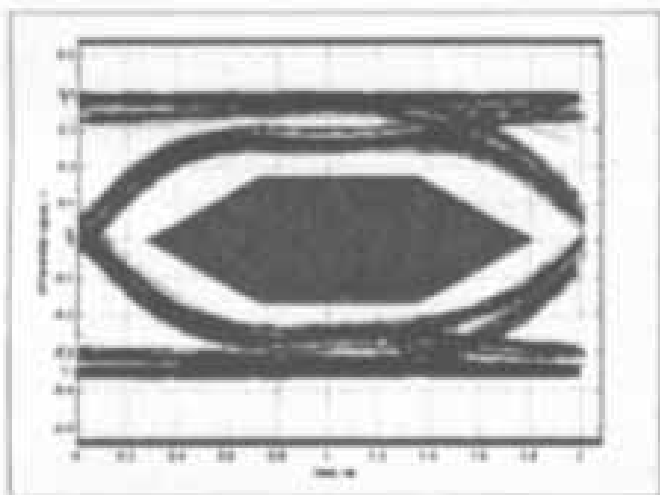
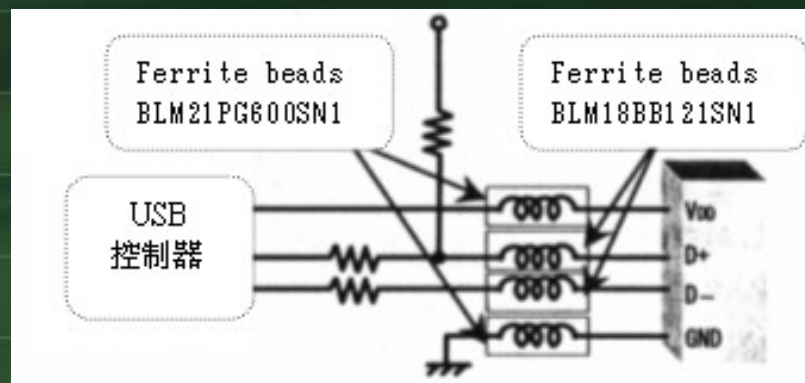




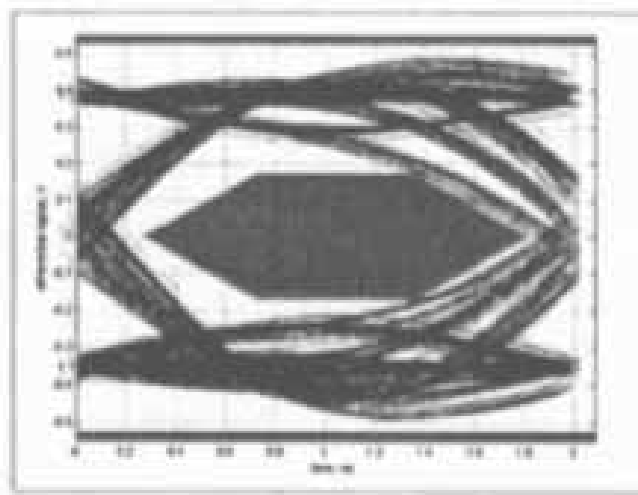


# Ferrite Core

## USB 2.0 Example



無濾波器的波形



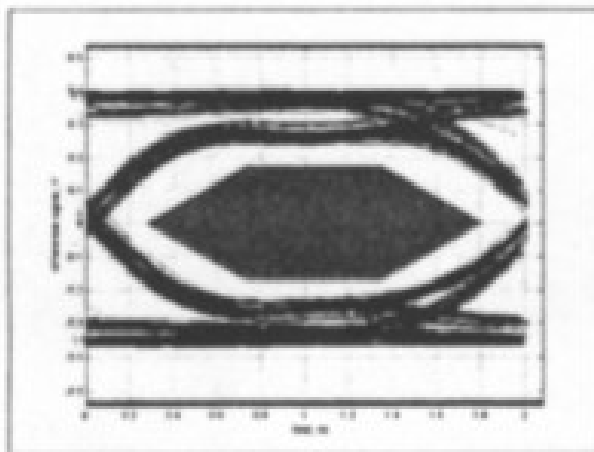
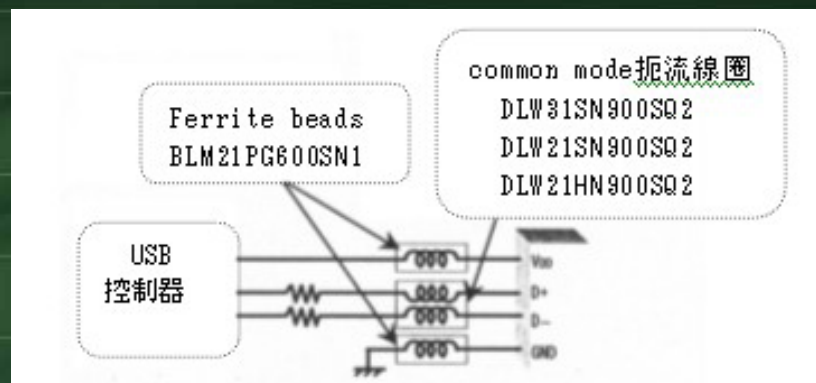
有Ferrite beads(BLM18BA220SN1；日本村田製)濾波器的波形



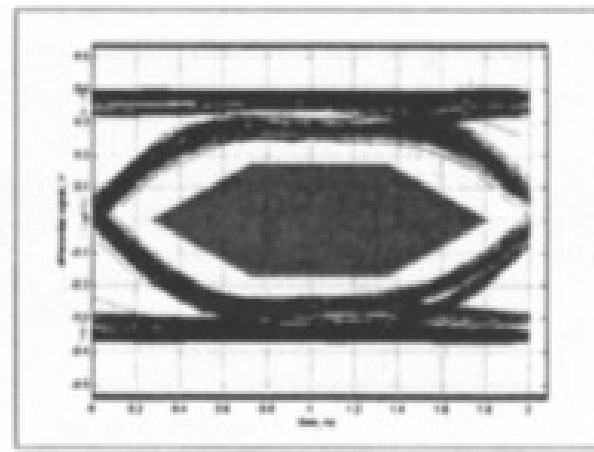


# Ferrite Core

## USB 2.0 Example



無滤波器的波形



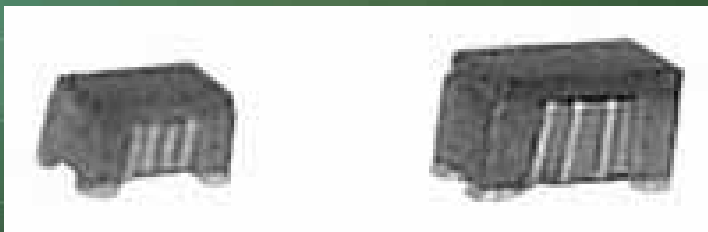
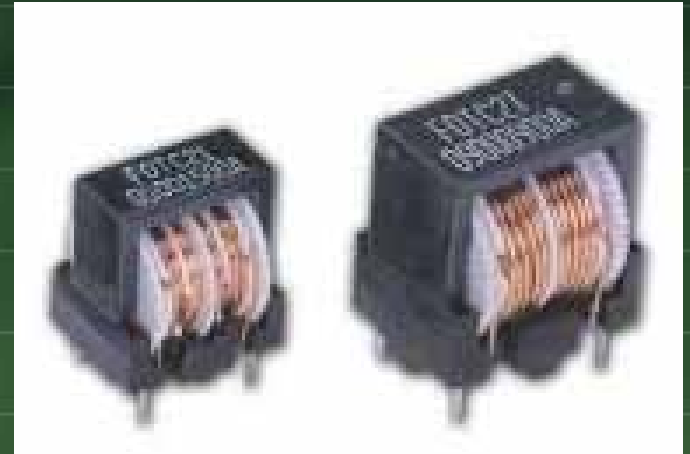
使用 common mode 扼流線圈的波形  
(DLW21SN900SQ2; 日本村田製)







# Common Choke





# Agenda

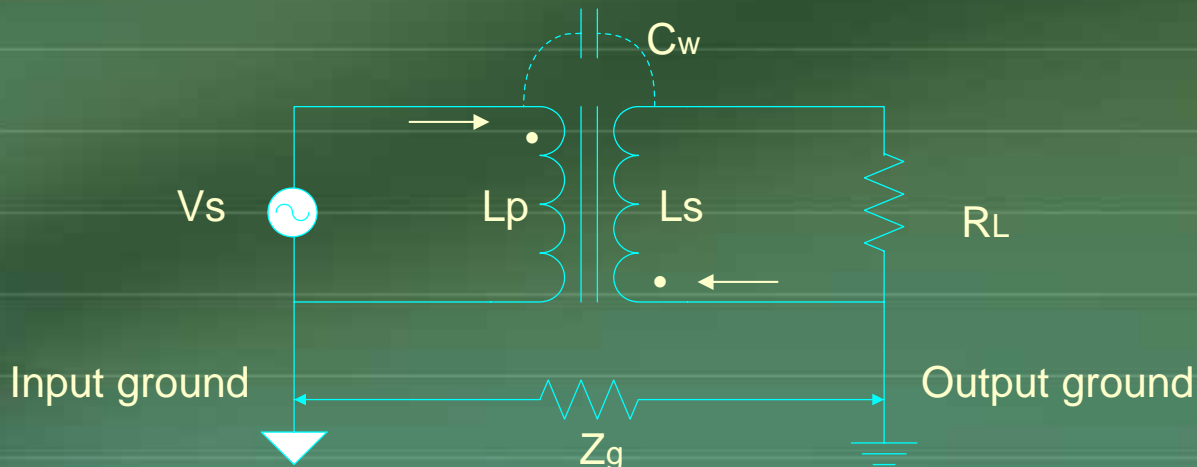
- Ferrite Core
- Isolation
  - Transformers
  - Opto-Isolators
- Transient and Surge Suppression Devices
  - Varistors
  - Gas-Tube Surge Suppressors
  - Semiconductor Transient Suppressors





# Transformers

- Transformers are used to isolate ground current loops, and it can suppress CM and DM interference.
  - Isolated ground decreases CM interference
  - Inductor itself decreases DM interference
- In addition to a desired magnetic coupling between the primary ( $L_p$ ) and secondary ( $L_s$ ) winding, an EMI coupling takes place through interwinding capacitance ( $C_w$ ) between the primary and secondary winding.
  - Aside from heat sink stray capacitance, transformer parasitic capacitance  $C_w$  is the main CM EMI source.

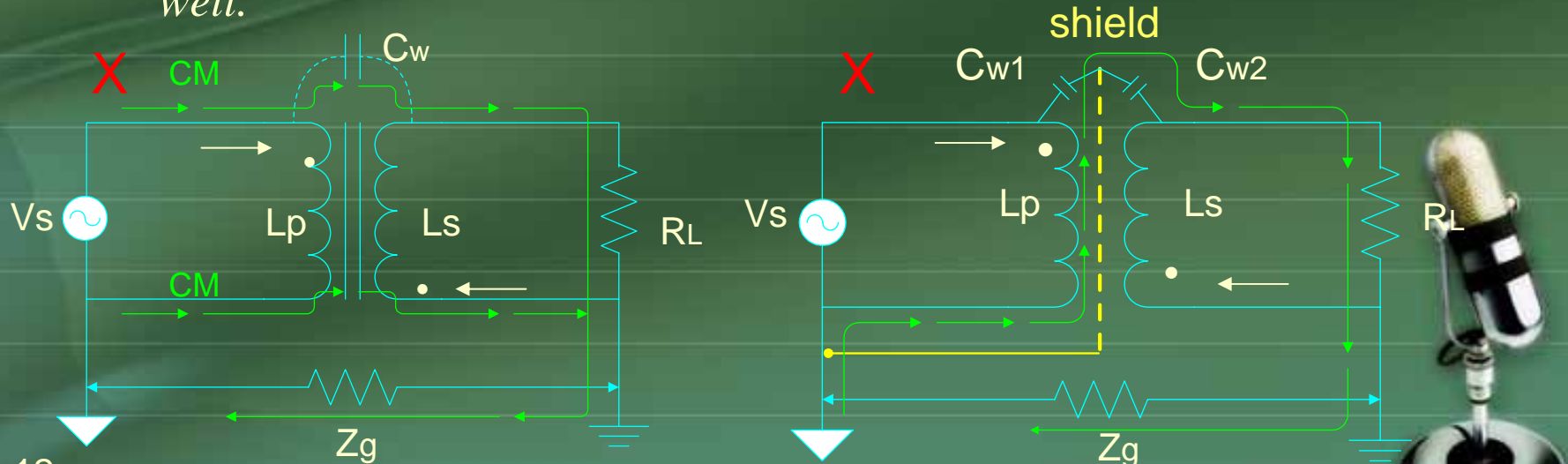




# Transformers

## Single-shield isolation transformer

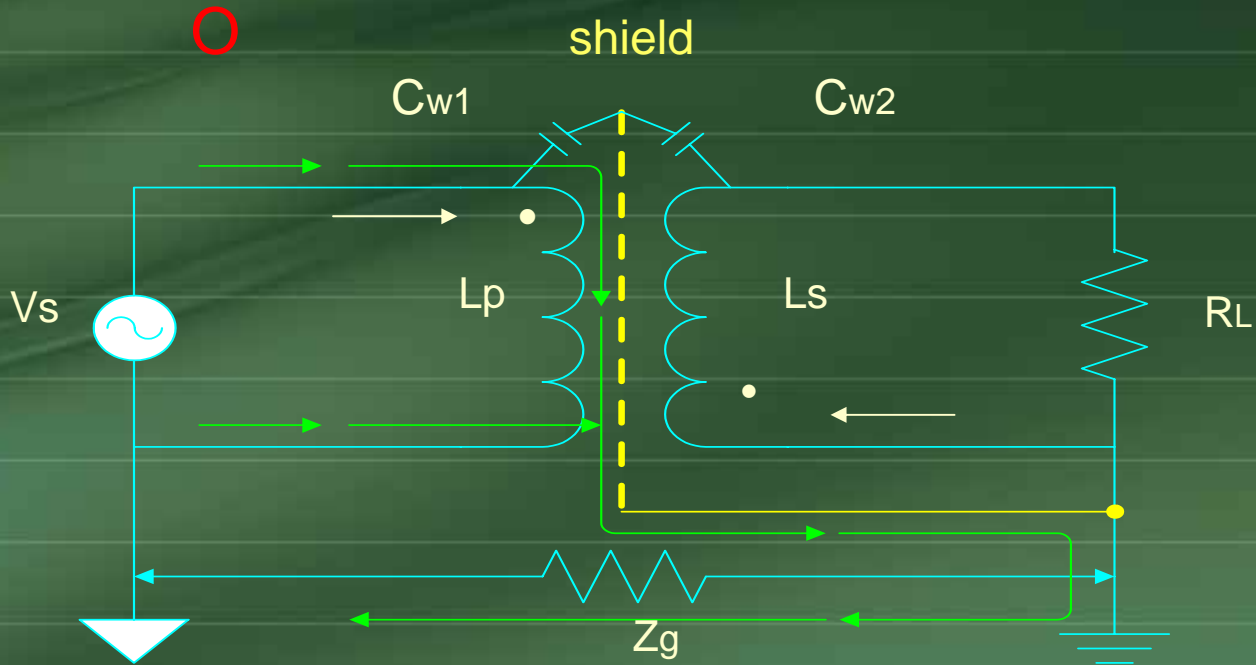
- A single-shield isolation transformer performs well to suppress CM interferences at low frequency of up to 100KHz, but
  - *CM rejection will decrease with increasing frequency above 100KHz because of capacitance reactance.*
  - To avoid common-impedance  $Z_g$  coupling, shield must be grounded to the load side.
- *A single-shield isolation transformer don't suppress DM coupling well.*





# Transformers

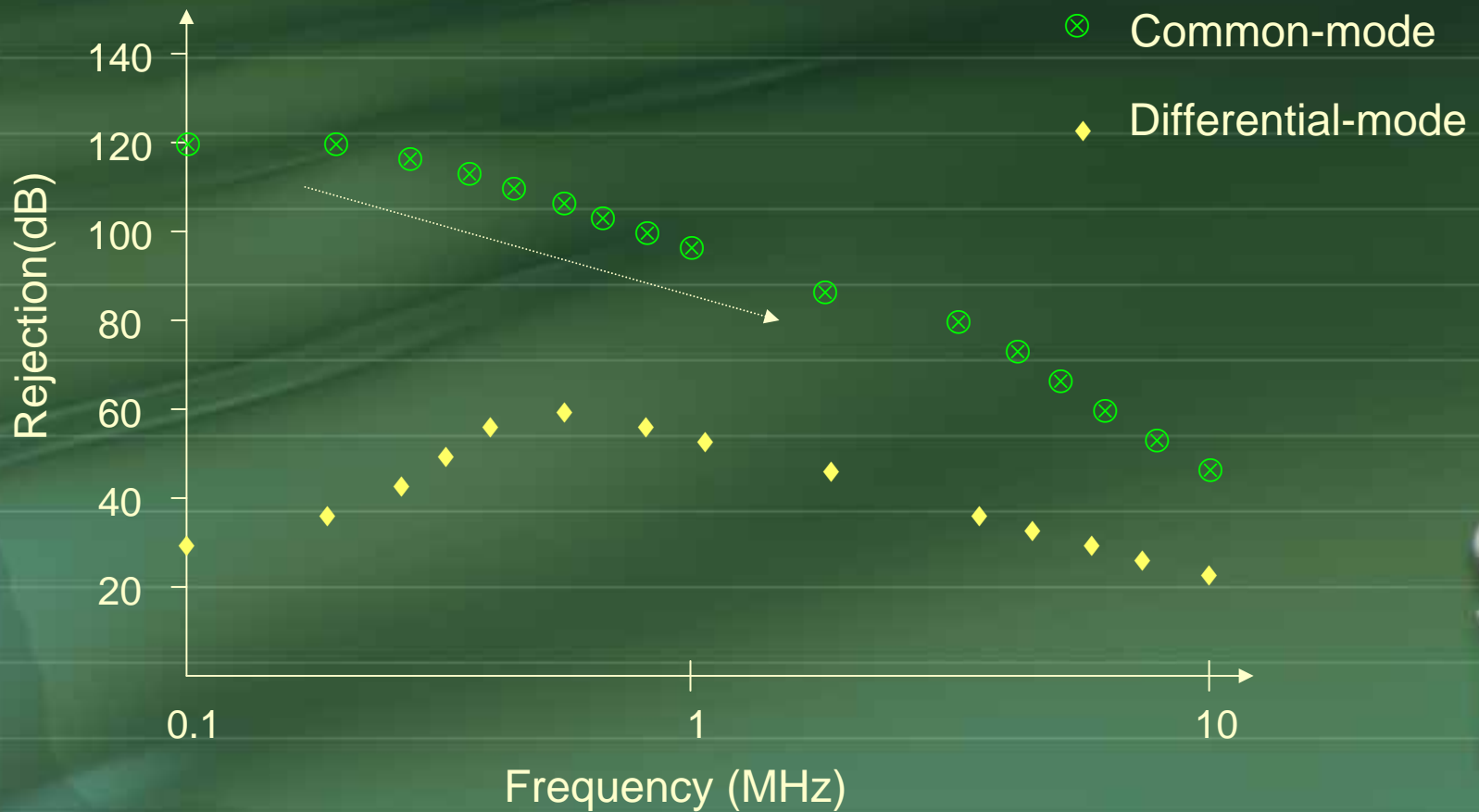
## Single-shield isolation transformer





# Transformers

## Single-shield isolation transformer



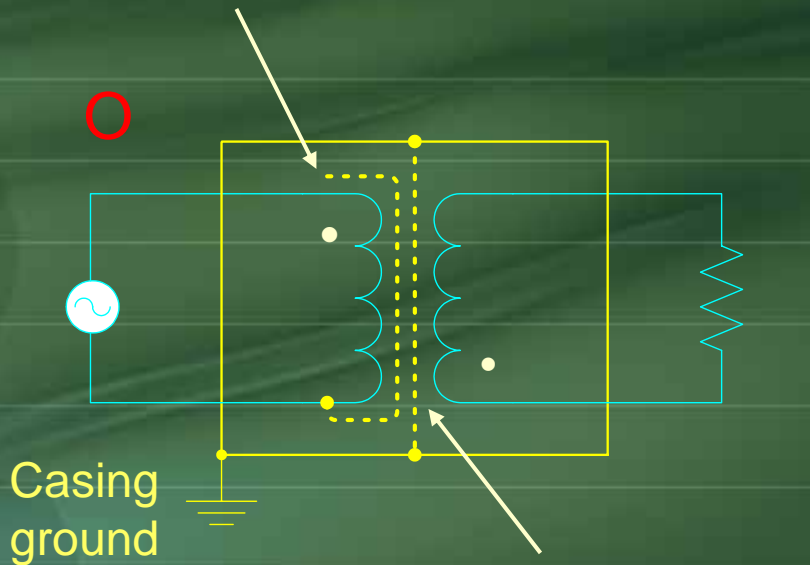


# Transformers



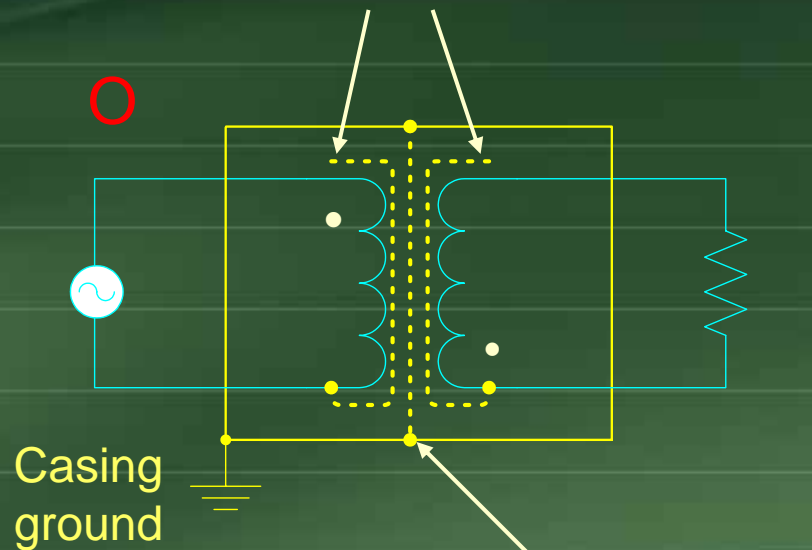
## Double-shield / Triple-shield isolation transformer

Suppress DM interferences



Suppress CM interferences

Suppress DM interferences



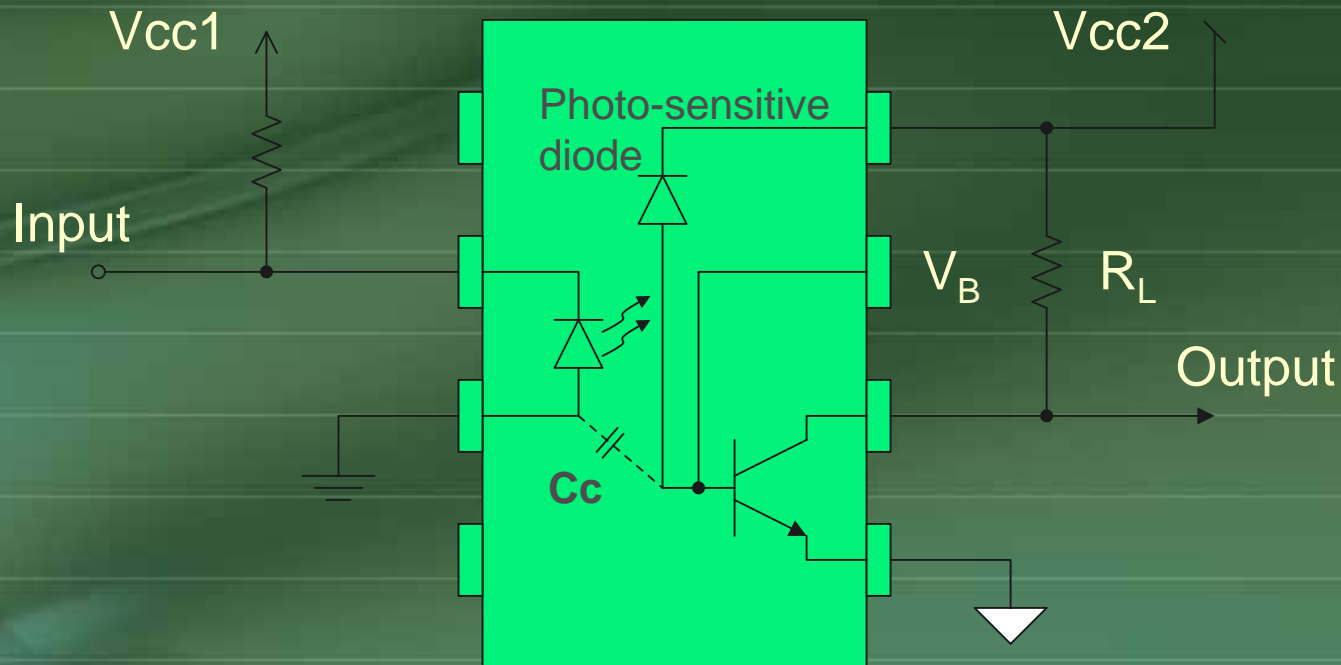
Suppress CM interferences





# Opto-isolators

- Power line isolator – Transformers
- Signal transmission line isolator – Opto-isolators
  - Ground-current loops are also broken;  $C_c \approx 1\text{pF}$





# Agenda

- Ferrite Core
- Isolation
  - Transformers
  - Opto-Isolators
- *Transient and Surge Suppression Devices*
  - Varistors
  - Gas-Tube Surge Suppressors
  - Semiconductor Transient Suppressors





# Varistors





# Gas-Tube Surge Suppressors

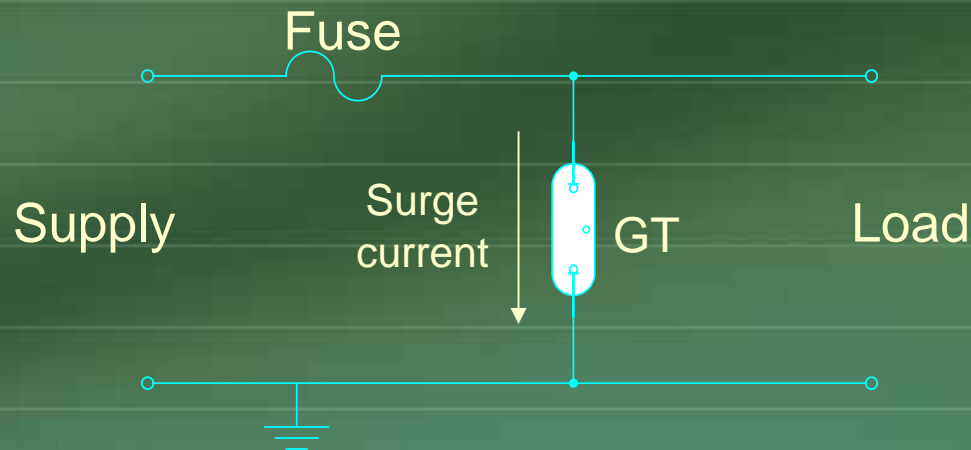
- *It handle very large transient current (>10KA).*
  - When transient EMI voltage in a line exceeds the striking voltage of the gas-tube, an arc discharge occurs and the ionized(解離的) gas produces a low-impedance path from line to ground.
  - Leakage resistance of a gas tube measured at the circuit operating voltage should be high to avoid its insertion loss.
- The gas tube is normally specified for a breakdown voltage higher than the circuit operating voltage to avoid unwanted clipping(修剪) of signals.
  - It is used in AC power distribution lines and in telecommunication lines as lightning or other high-energy surge arrestors.





# Gas-Tube Surge Suppressors

- There are two major disadvantages
  - Response time is slow*
  - It remains in a conducting state even after the surge is removed, that is, it can not extinguish (熄滅) follow current after a surge*
    - Adding a resistor ( $\Omega$ ) or a fast-action circuit breaker in series can prevent this condition.

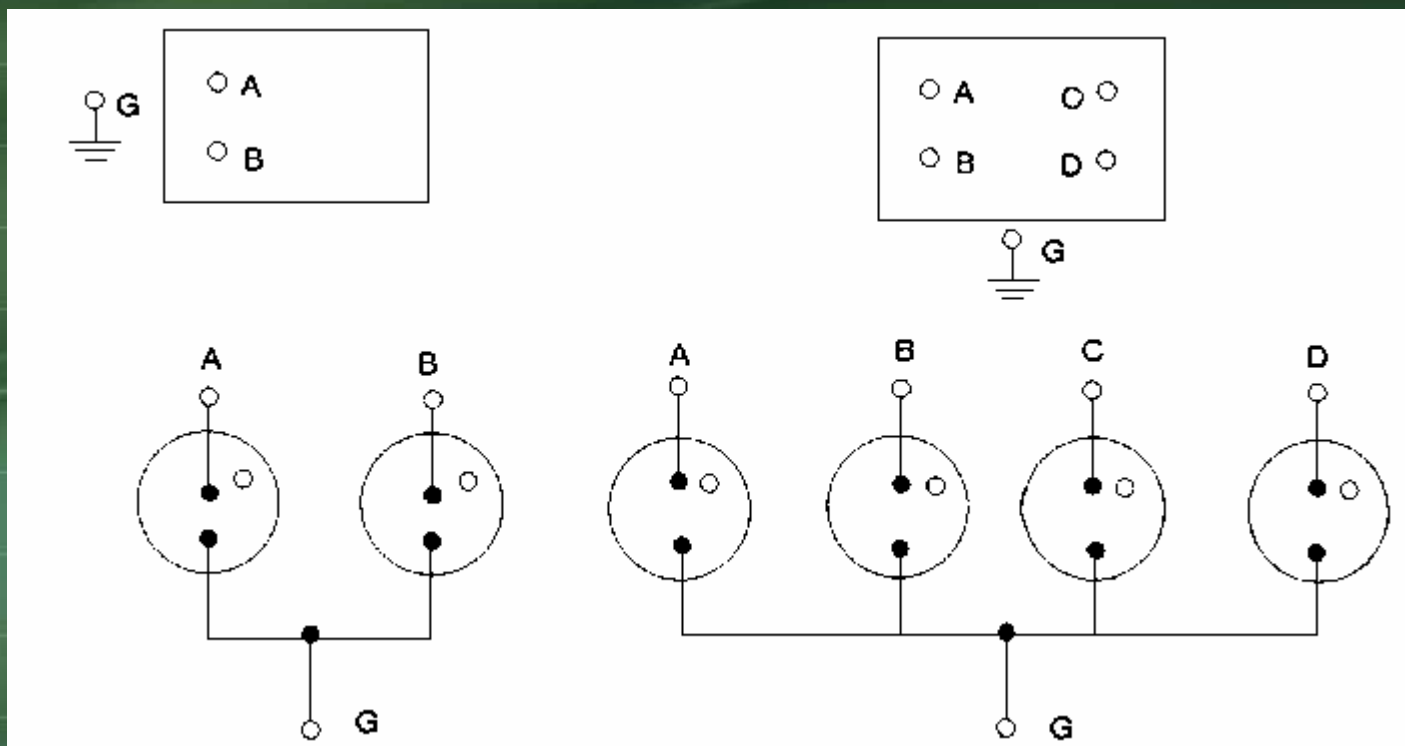






# Gas-Tube Surge Suppressors

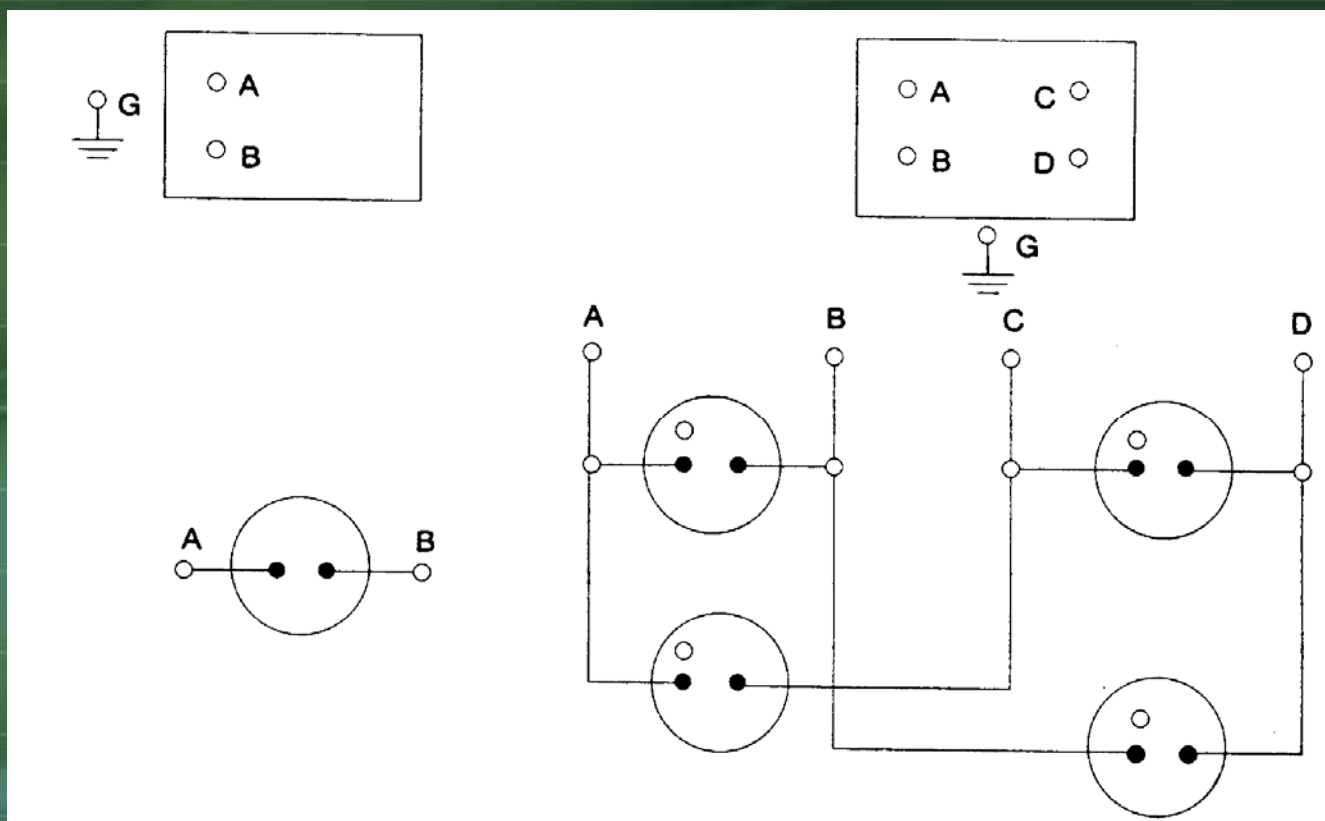
- The configuration limiting CM surges





# Gas-Tube Surge Suppressors

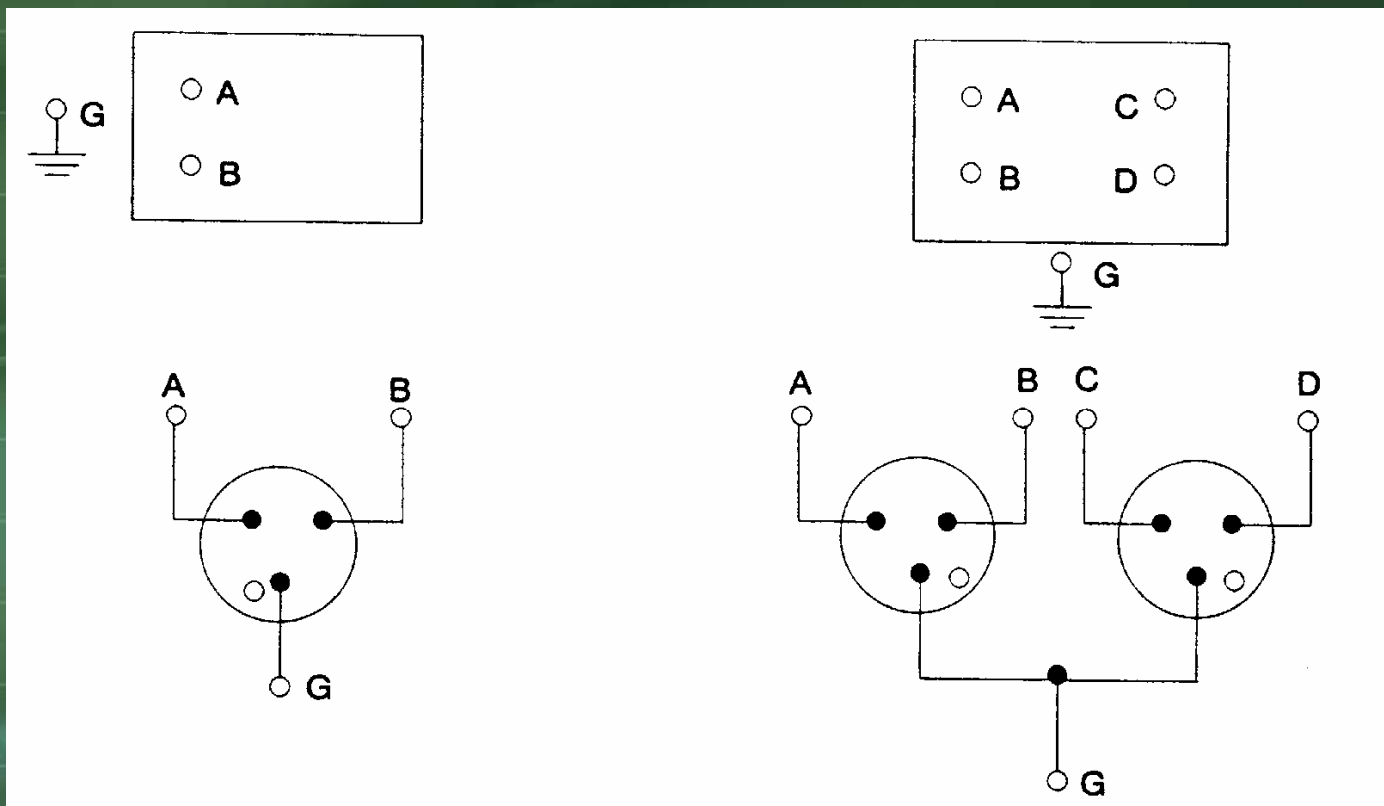
- The configuration limiting DM surges





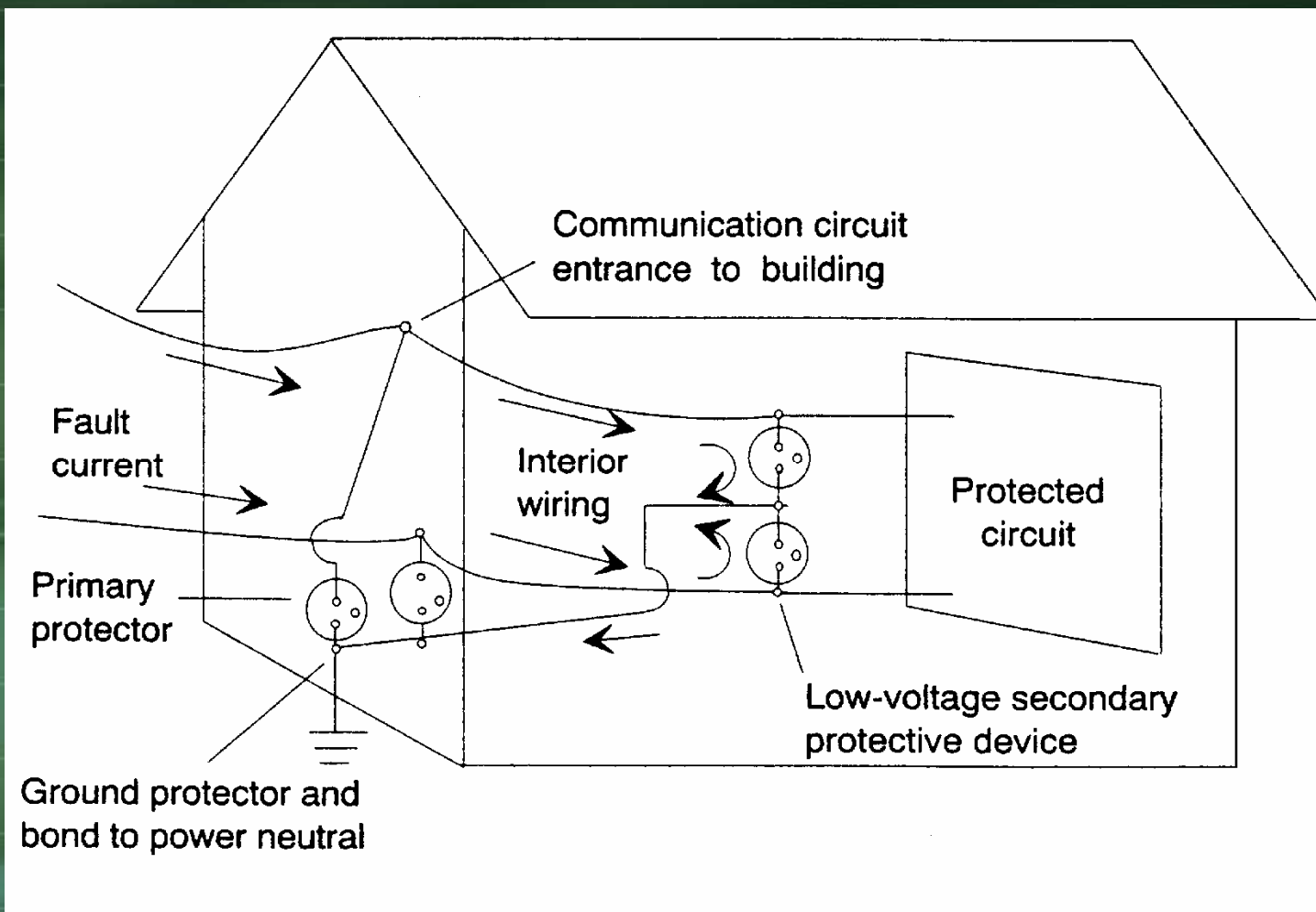
# Gas-Tube Surge Suppressors

- The configuration limiting CM and DM surges
  - Multigap arrestors(避雷器) can afford a size reduction.





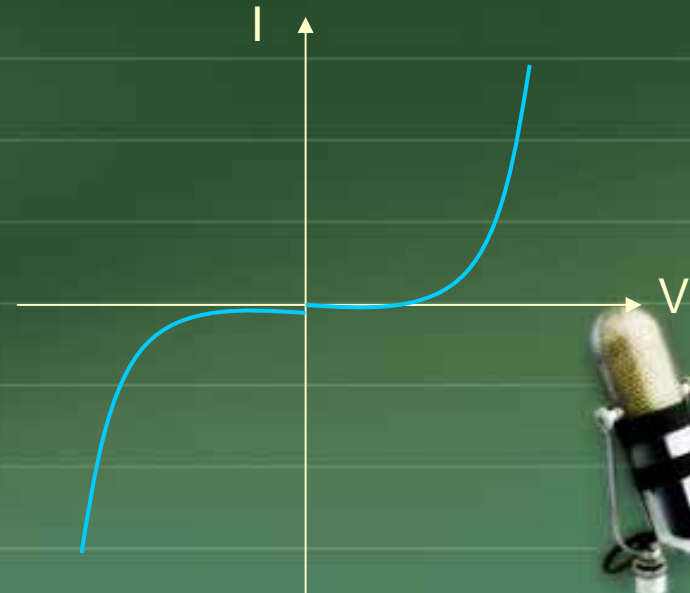
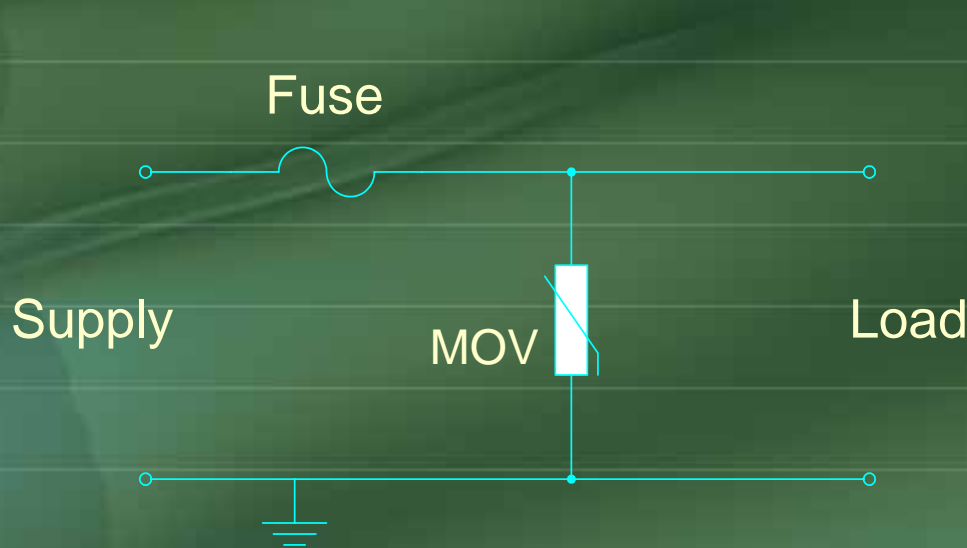
# Gas-Tube Surge Suppressors





# Semiconductor Transient Suppressors

- Metal Oxide Varistors (MOVs)
- Voltage-dependent resistance

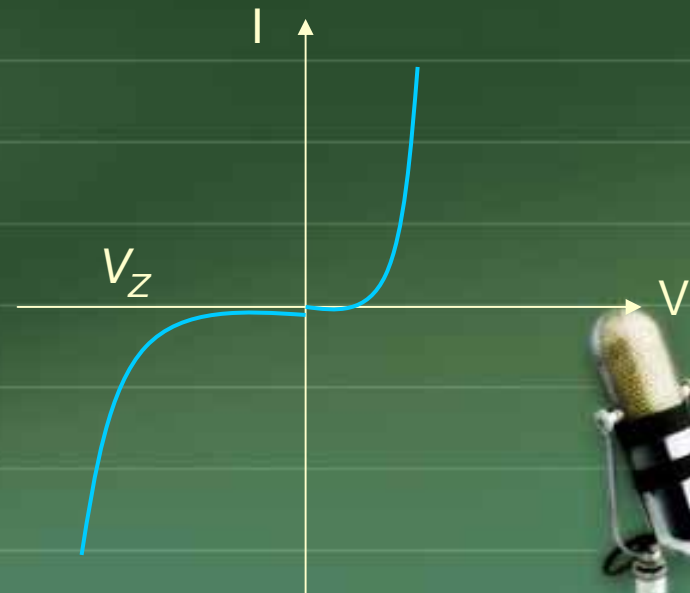
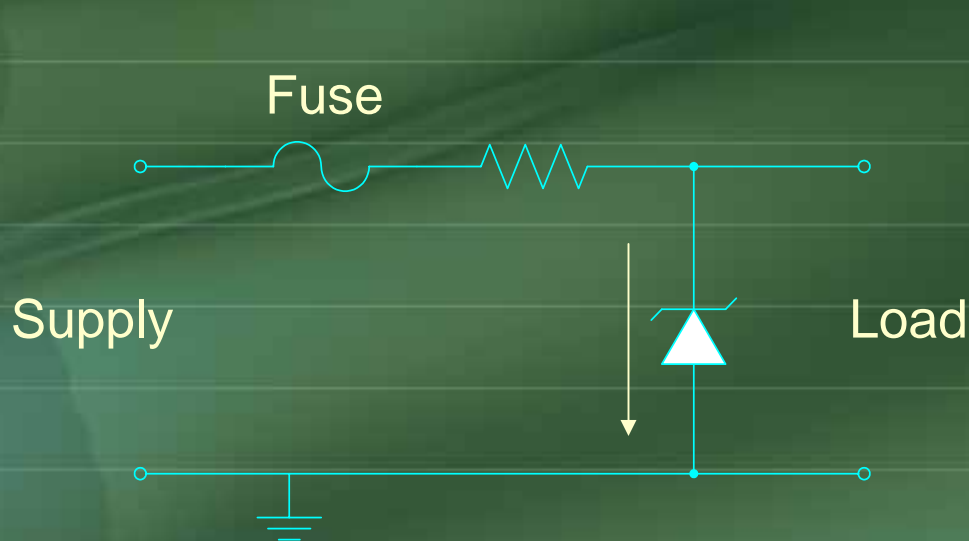




# Semiconductor Transient Suppressors

## ■ Silicon Zener Diode

- *Operated in a reverse biased condition*
- Provide an accurate transient limiting element  $V_z$  even for high rise-time transients

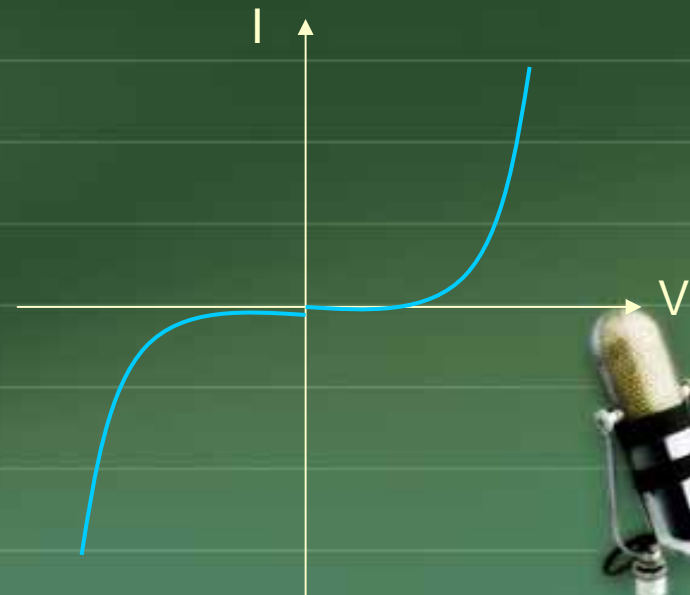
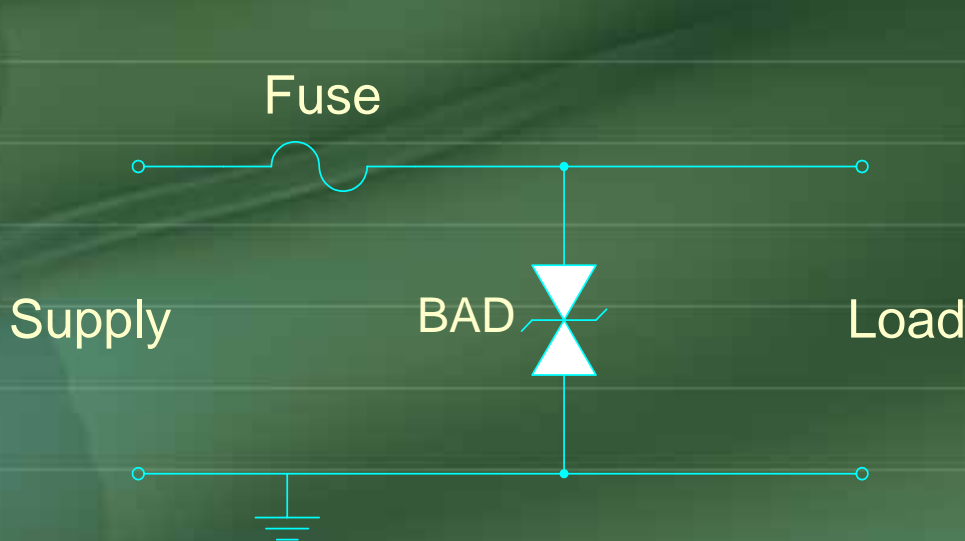






# Semiconductor Transient Suppressors

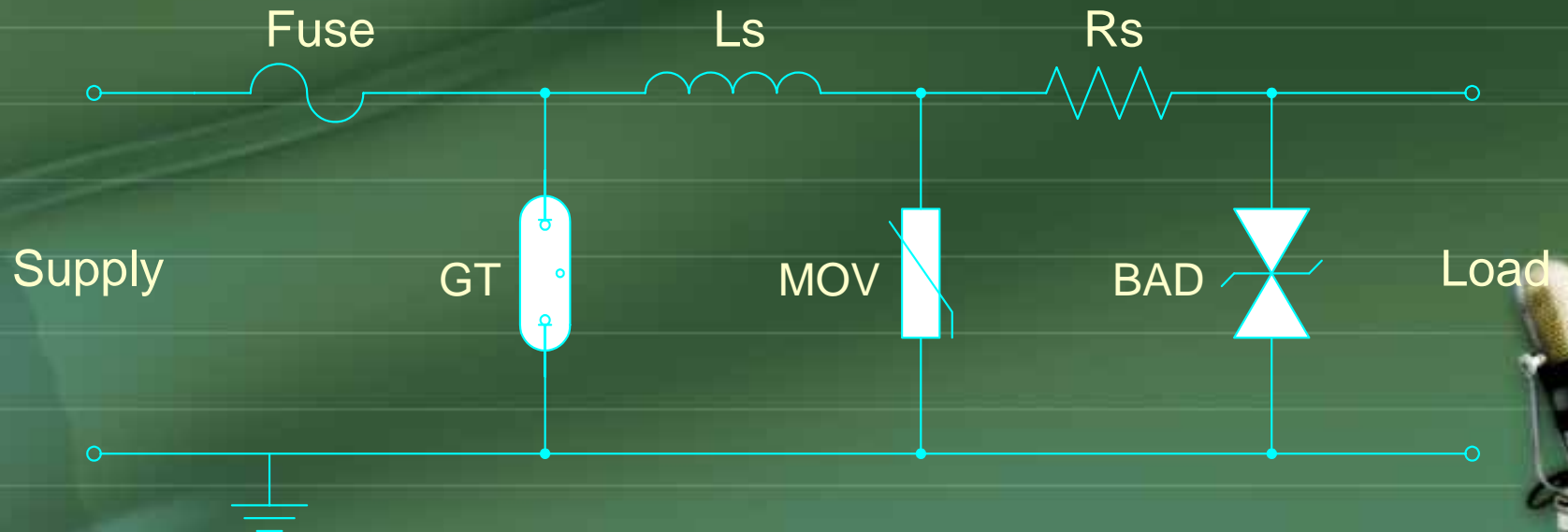
- Bipolar Avalanche Diode (BAD)
  - It can absorb transient energy with voltages of either polarity.
  - High speed (1ps) but high cost





# Semiconductor Transient Suppressors

- Because of the probability of existence of many surge waveforms, a combination of more than one surge arrestor might be used.





# Summary

- *Transformers are used to isolate ground current loops, and it can suppress CM and DM interference.*
- A single-shield isolation transformer performs well to suppress CM interferences at low frequency of up to 100KHz, but
  - CM rejection will decrease with increasing frequency above 100KHz because of capacitance reactance.
  - A single-shield isolation transformer **don't** suppress DM coupling well.
- While using the inductances (ferrite cores), it is necessary to pay attention to avoiding saturation and resonance.





# Summary

- 氣體放電管(Gas Discharge Tube)
  - 反應速度慢，有記憶效應，但適合大功率應用
- 金屬氧化變阻器(Metal-Oxide Varistor)
  - 反應快，且有額定功率寬廣的產品
- 雪崩(Avalanche)元件/齊納二極體
  - 反應快，可提供精準的逆偏電壓，但額定功率小
- 矽控整流器(Silicon Controlled Rectifier)
  - 反應速度慢，有記憶效應，但適合大功率應用

