

# 高性能EMI滤波器及其小型化技术

## High performance EMI filter & its miniaturization

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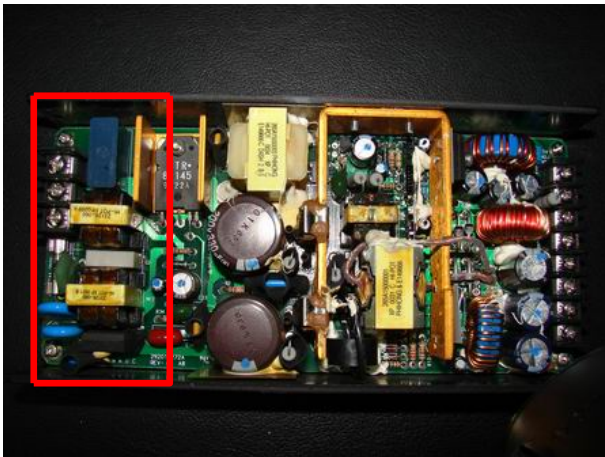
# 内 容

- 一. 开关电源EMI滤波器性能
- 二. EMI滤波器高频性能改善设计
- 三. EMI滤波器小型化设计技术
- 四. 结束语

# 一. 开关电源EMI滤波器的性能要求

开关电源三高一低的发展趋势，

EMI滤波器面临着持续改进压力！



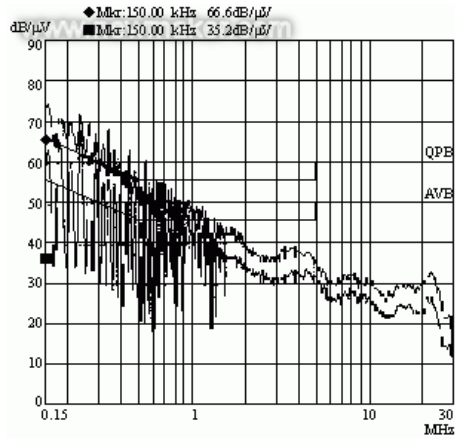
体积占1/3, 6个器件



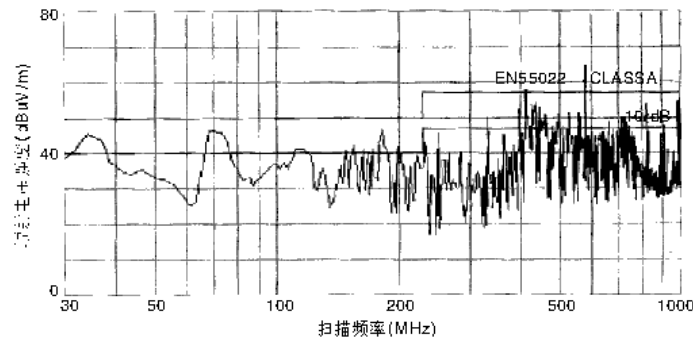
体积占1/2~1/3

EMI滤波器应达到高衰减性能、小体积、低成本

# EMI滤波器常见问题



低频传导发射高



高频传导/辐射发射高

高性能  
小体积



体积大!

## 影响滤波器性能/体积的因素

L、C最小否？ 主电路结构、控制、频率

拓扑优化否？ 阻抗失配

材料影响否？ 磁芯  $B_s/u' + ju''$

寄生/耦合影响否？ 器件工艺/布局

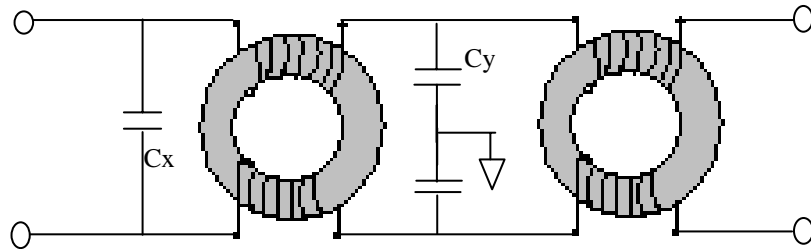


## 改善滤波器性能/体积的可能方法

低通滤波器的精细设计

新型滤波器结构设计

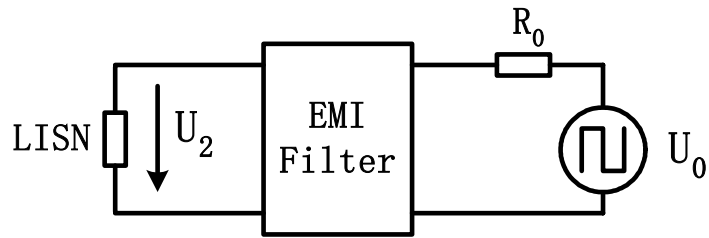
## 二. EMI滤波器高频性能改善设计



无源LC反射滤波或吸收滤波，可覆盖150kHz-1GHz。

- EMI滤波器应处于阻抗失配状态
- 电感、电容应有足够的电压、电流容量
- Ldm电感、Cx、Cy电容有最大值限制

How to select the best EMI filter topology?



$Z_g \backslash Z_1$	High	Low
High		
Low		

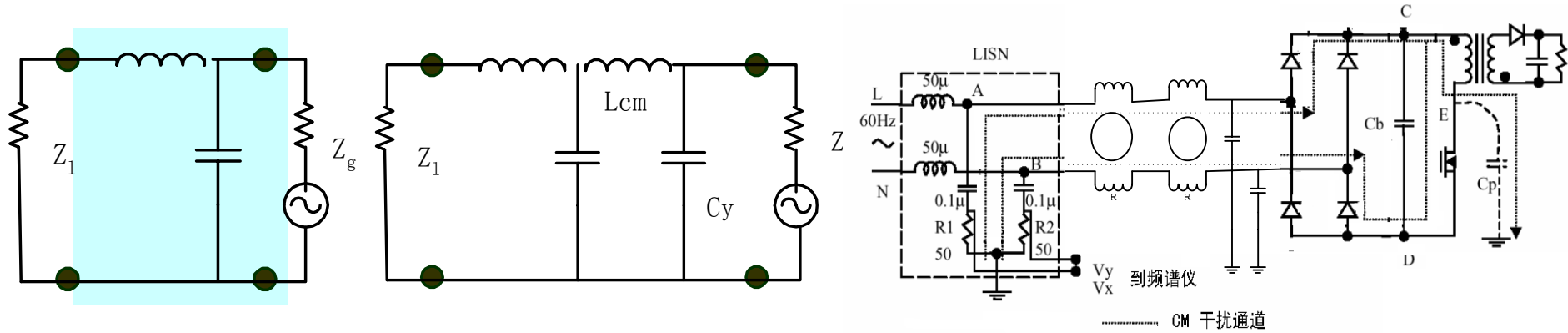
$Z_g$ : Noise Impedance

$Z_1$ : Load Impedance

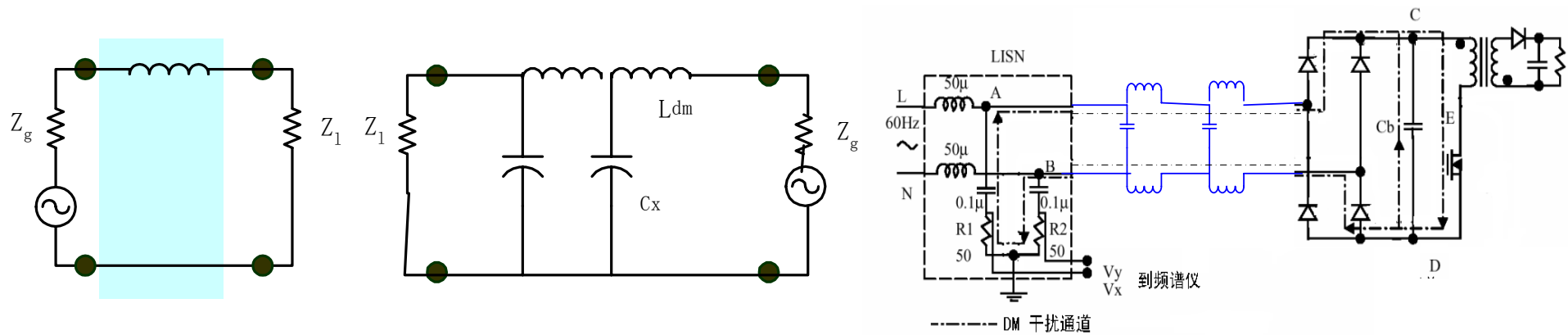
**If one stage is not enough, several stages filter can be used!**



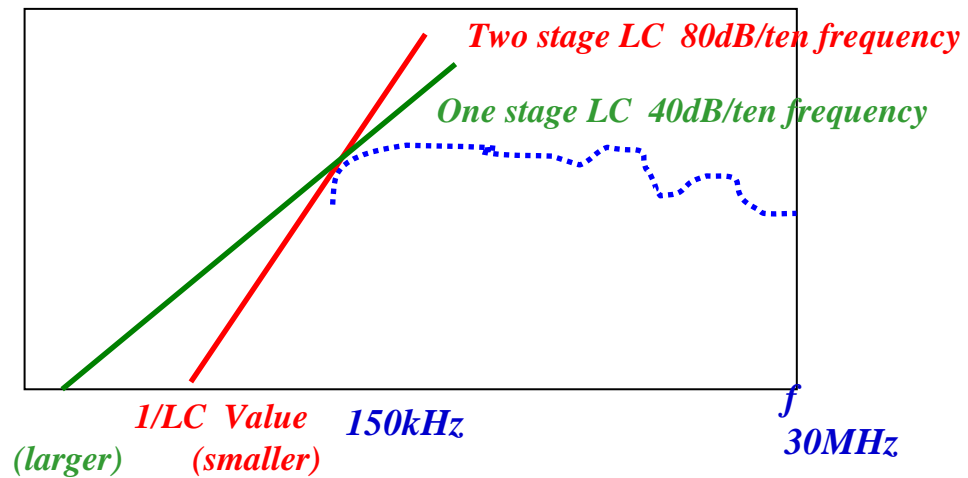
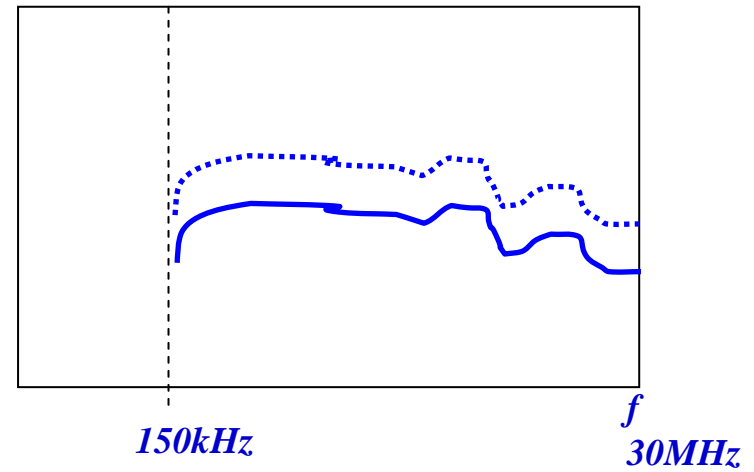
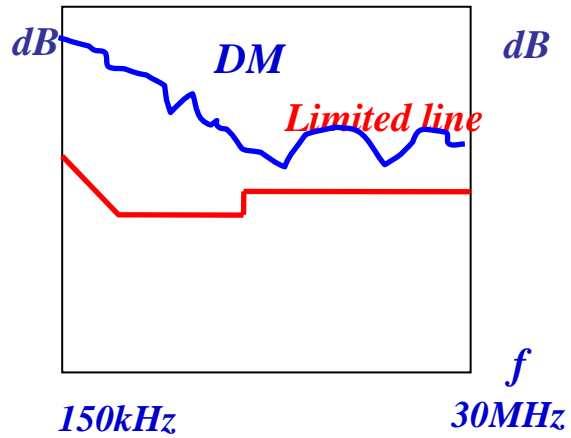
better CM filter topology



better DM filter topology

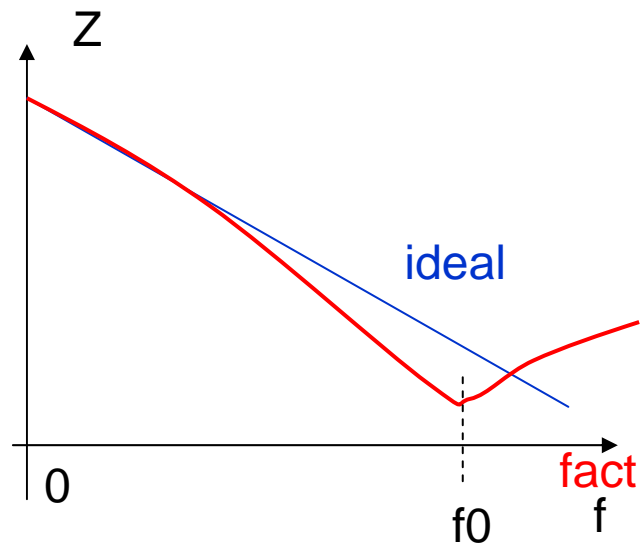
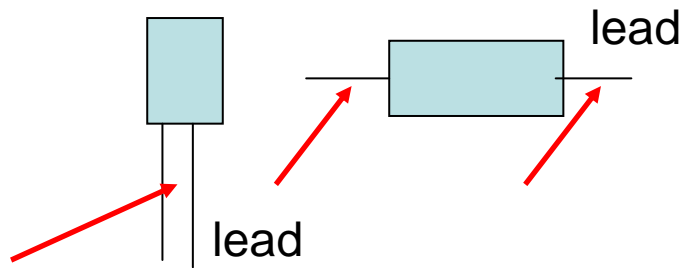




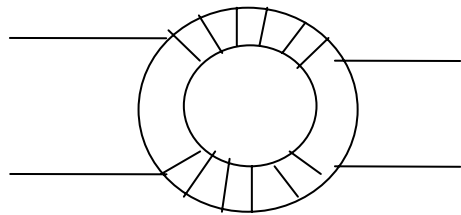


# 滤波器L/C器件性能影响因素分析

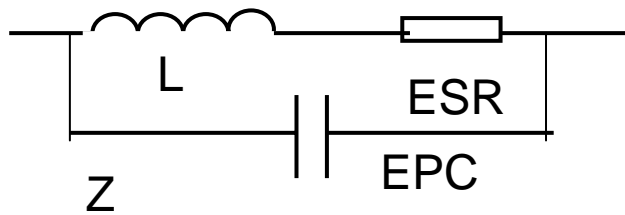
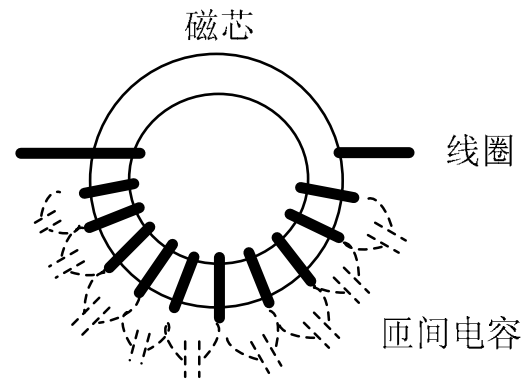
## Capacitor:



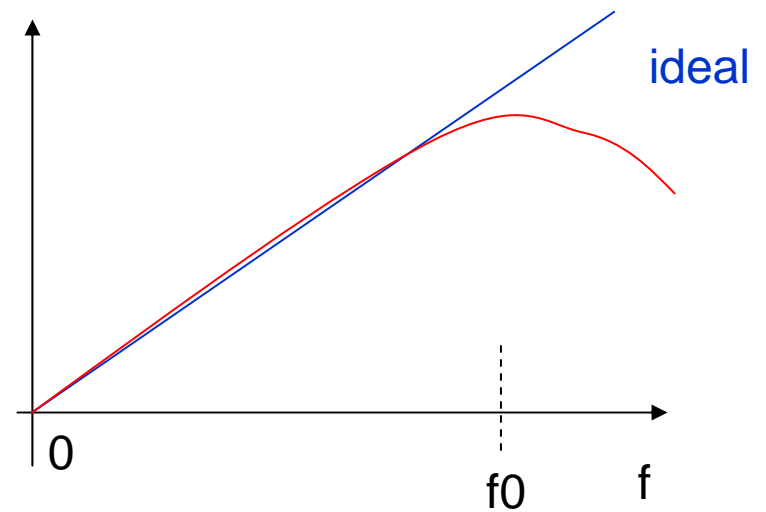
# Inductor:

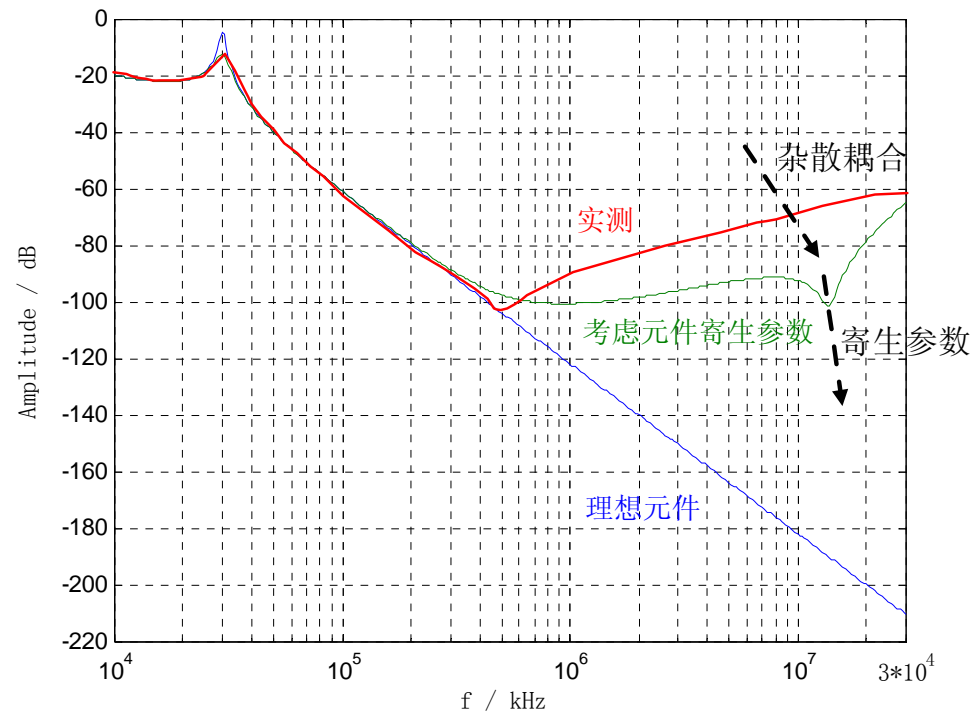
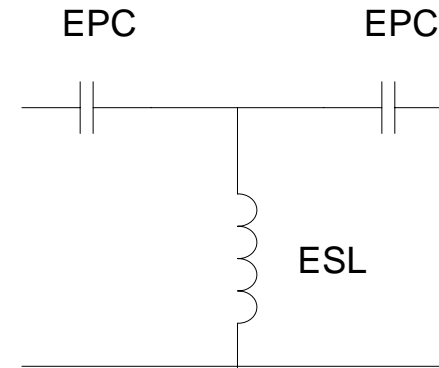
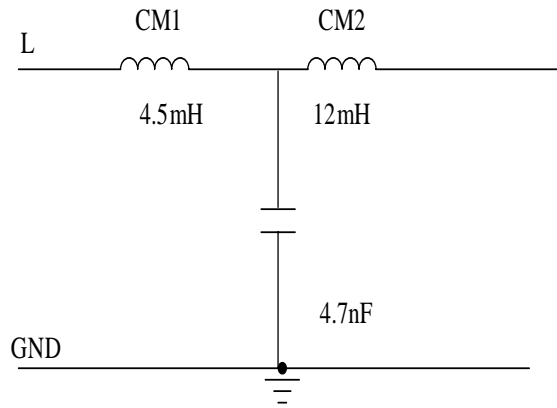


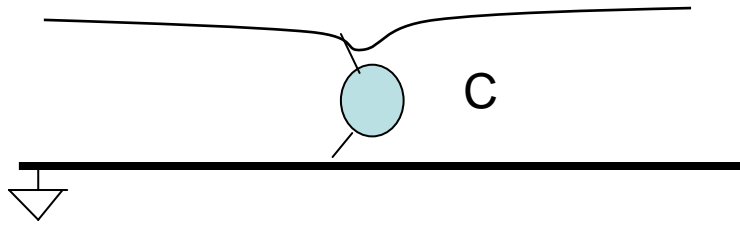
Common mode inductor



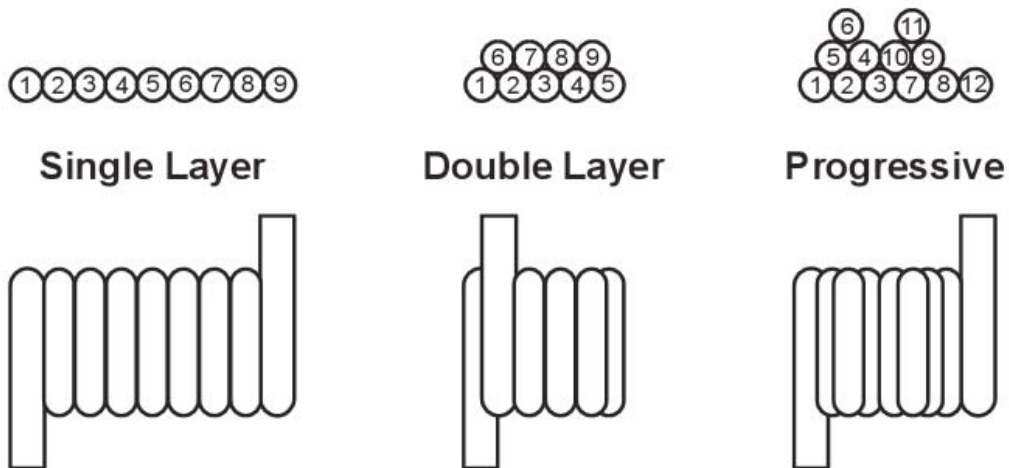
fact





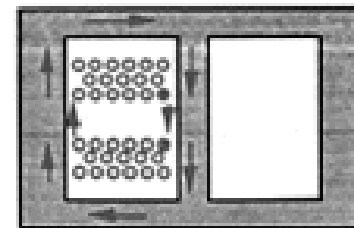
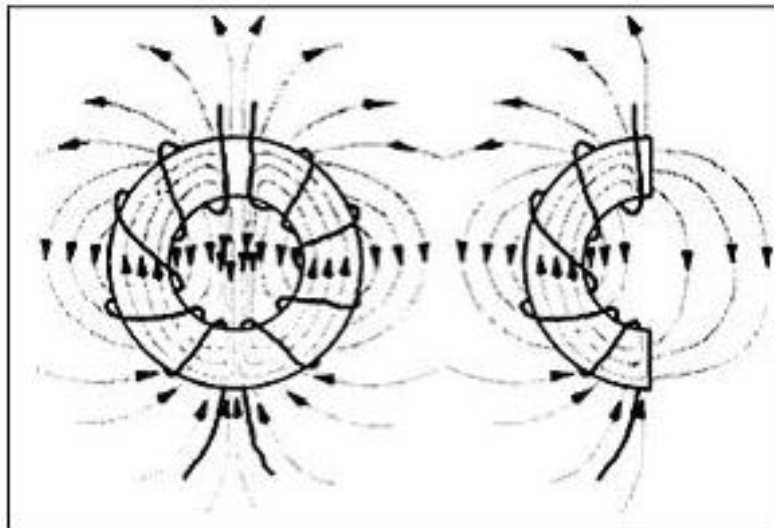
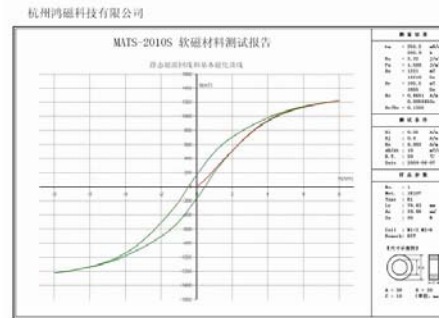
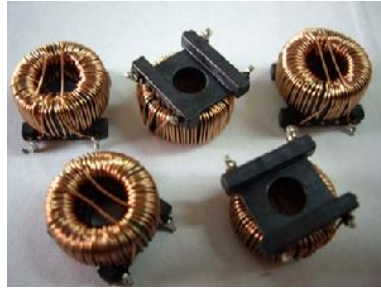


短管脚  
并小容值电容  
PCB引线也要短

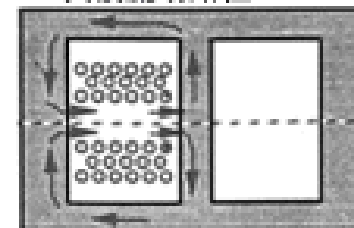


加大匝间距  
渐进绕组

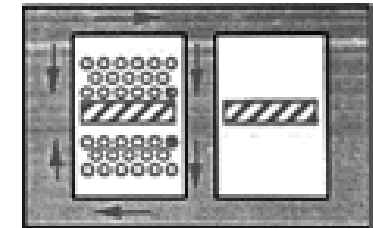
# L磁饱和/频率的影响



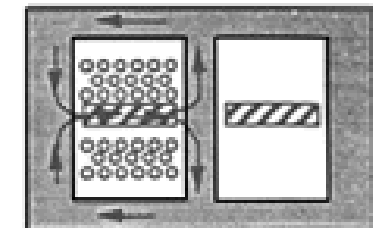
共模流动路径



差模流动路径

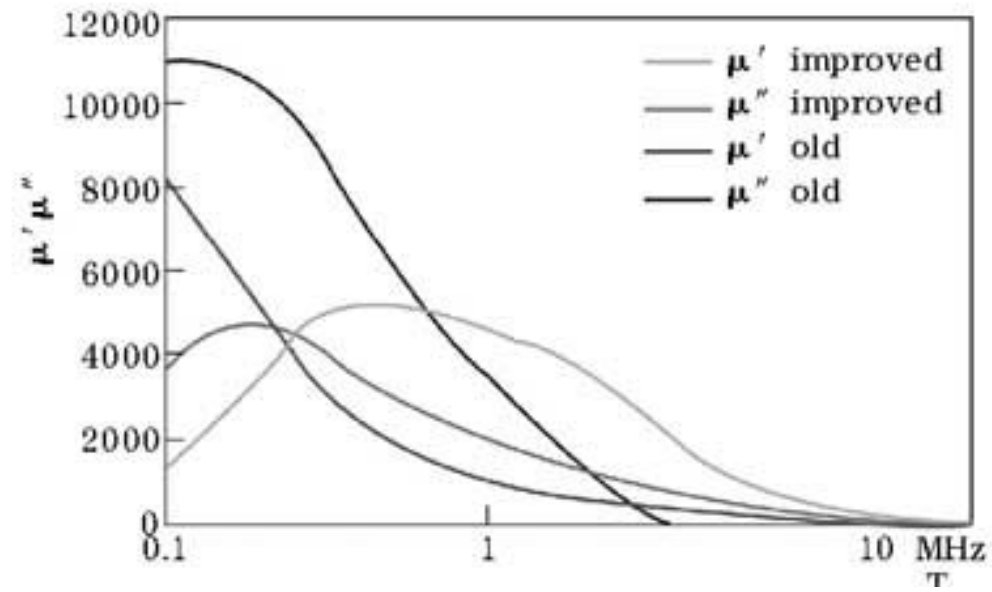


共模流动路径



差模流动路径

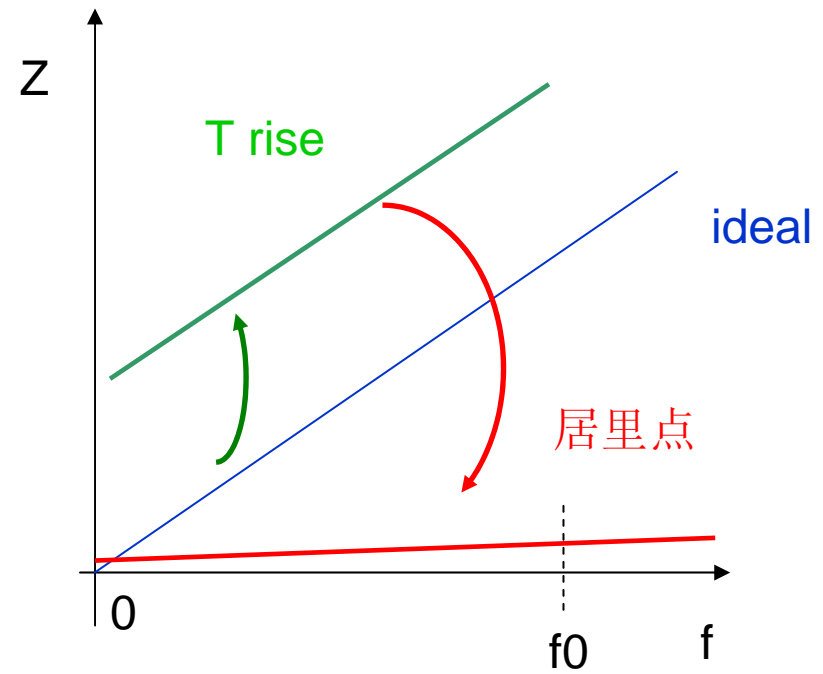
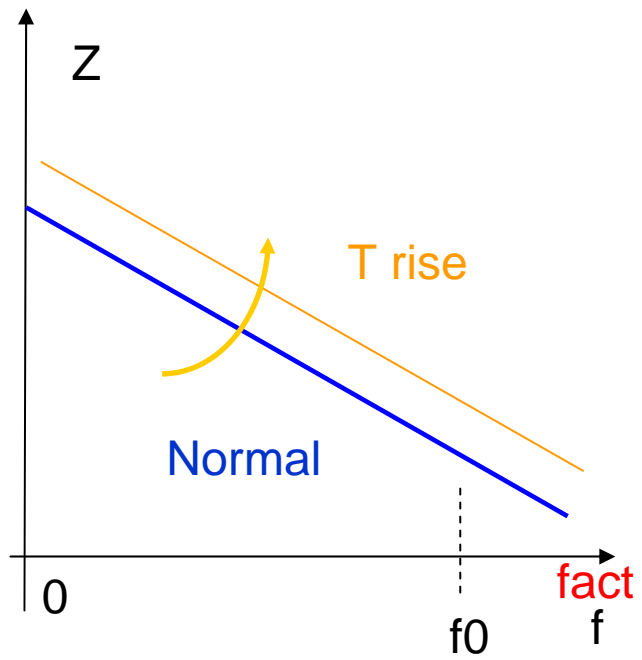
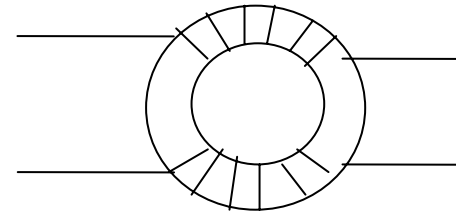
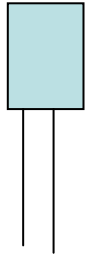
高饱和密度磁芯  
合适横截面积



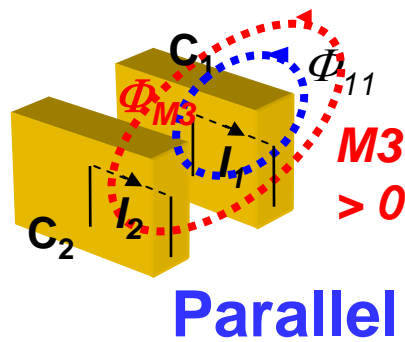
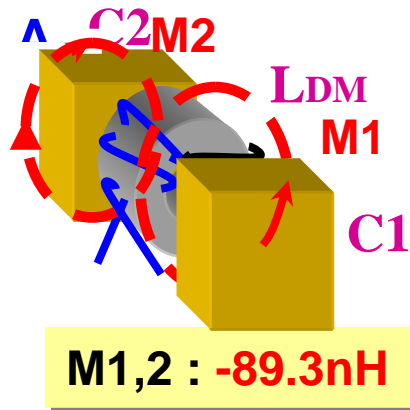
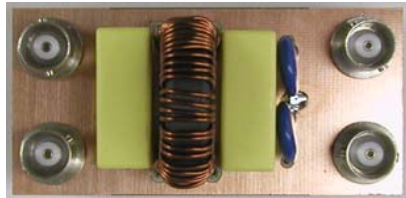
选择宽带磁材料、  
 $\mu''$ 大的材料更适合高频



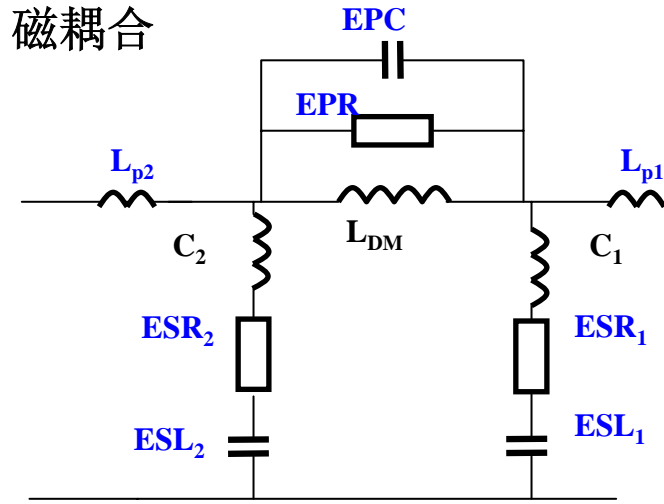
# LC温度的影响



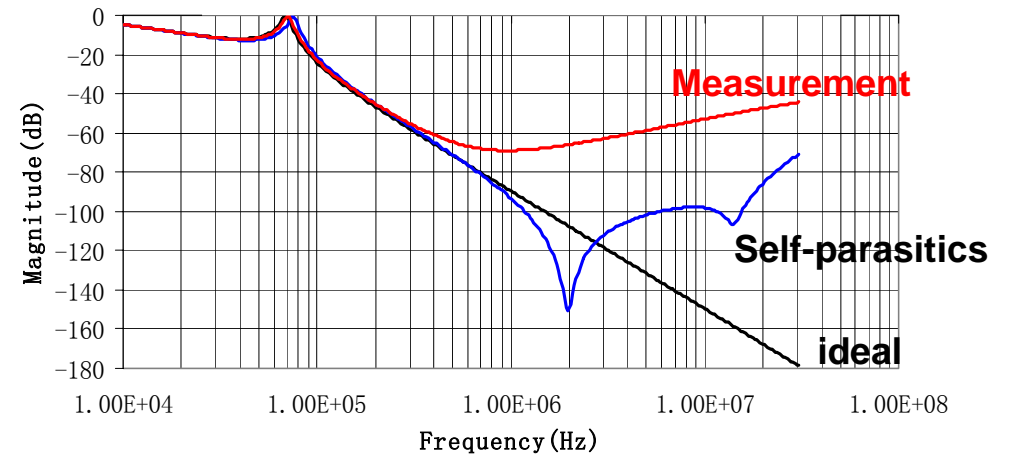
# 滤波器L/C器件杂散耦合的影响

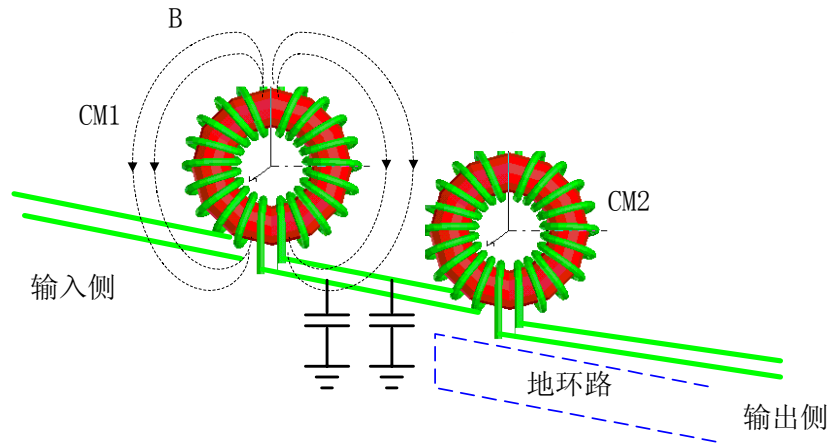


磁耦合

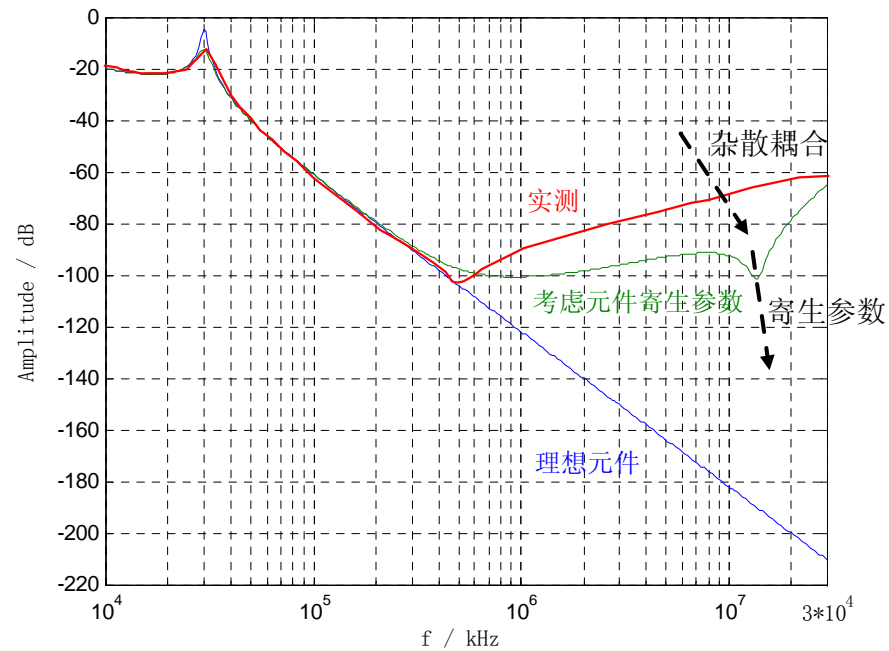
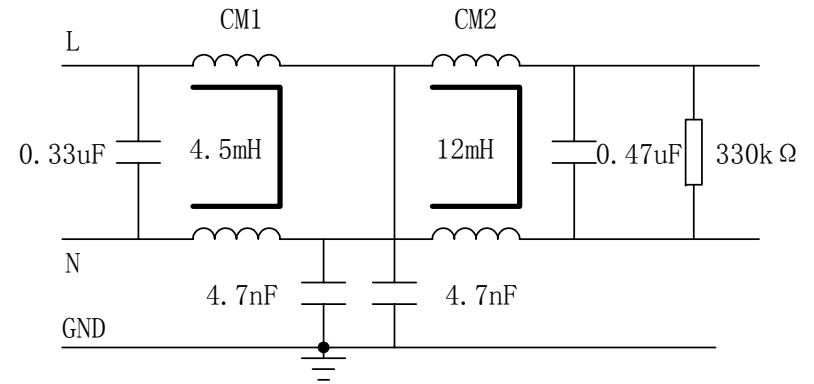


Insertion Voltage Gain

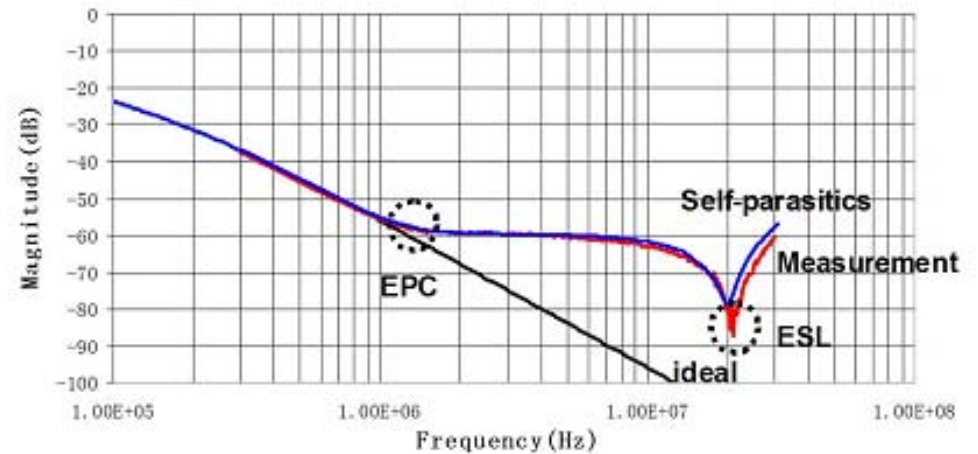
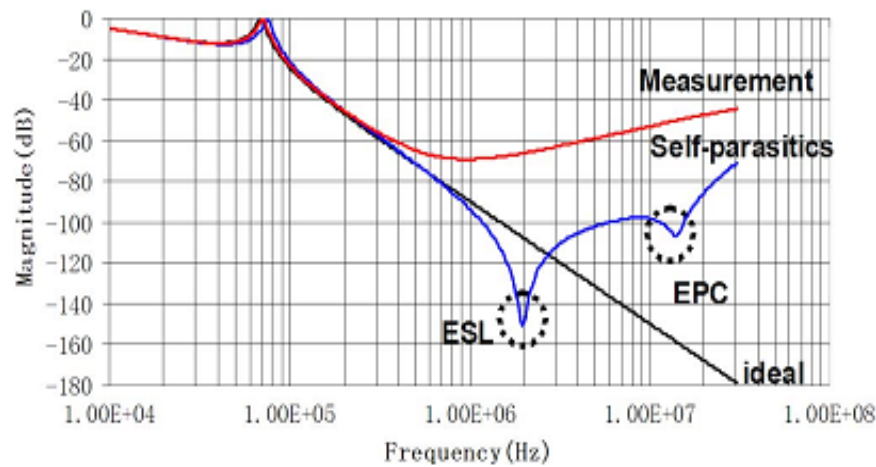
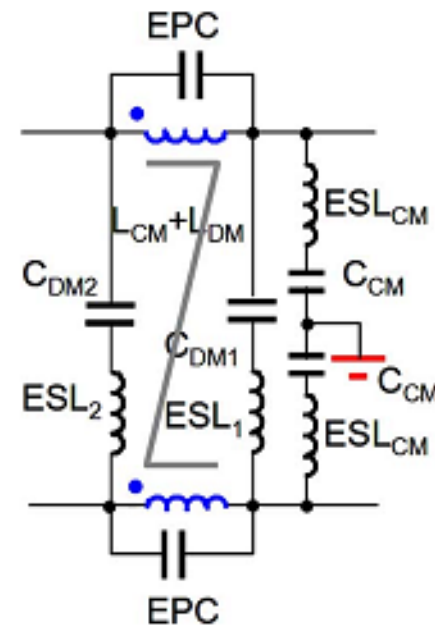
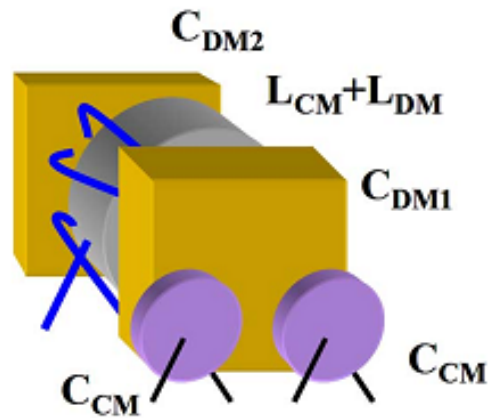


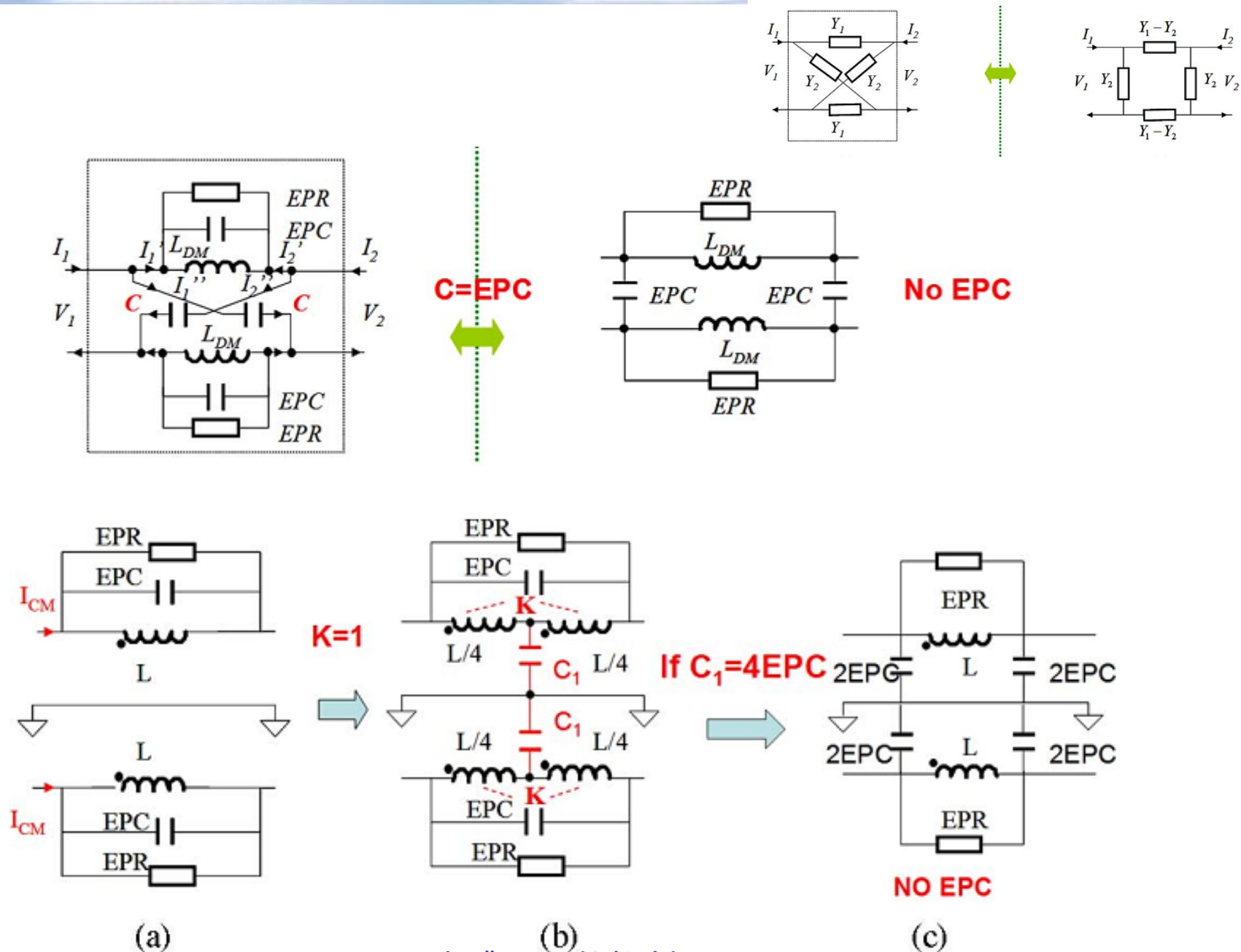


### 电耦合

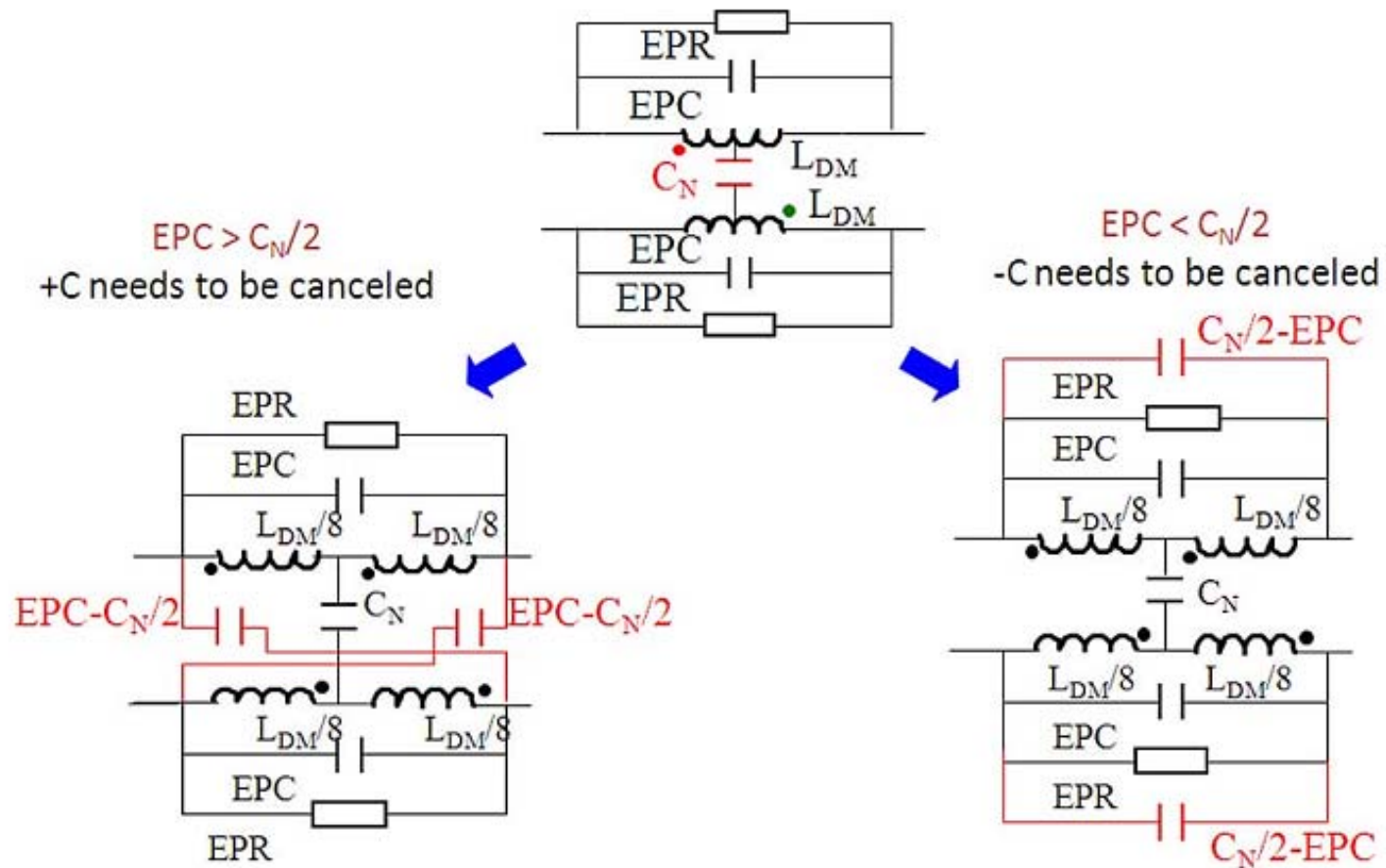


# 寄生参数/耦合的抑制

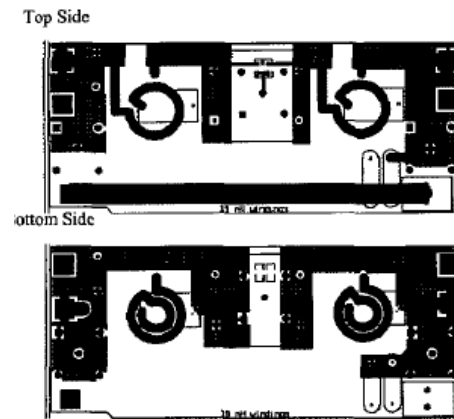
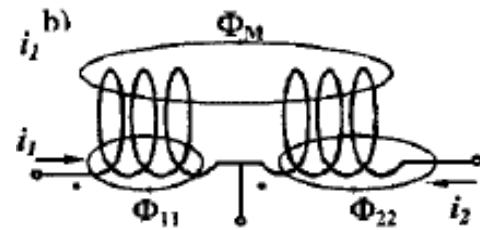
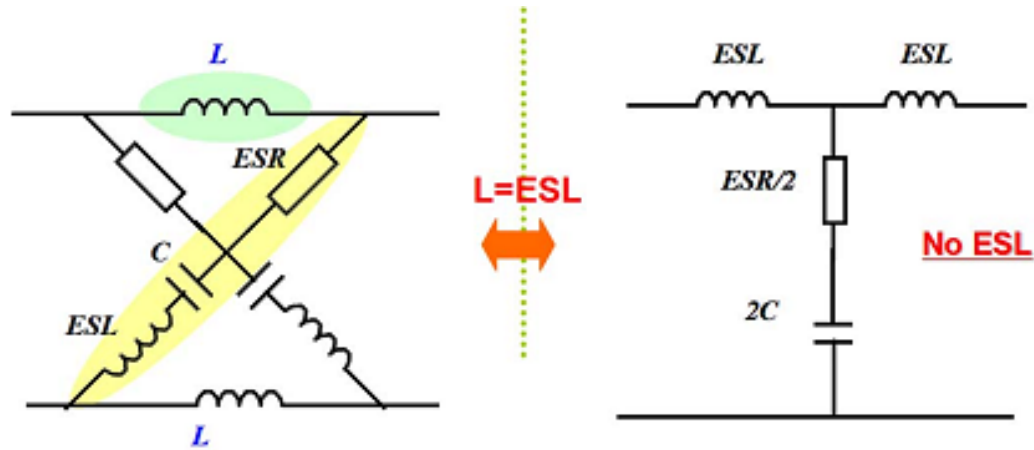
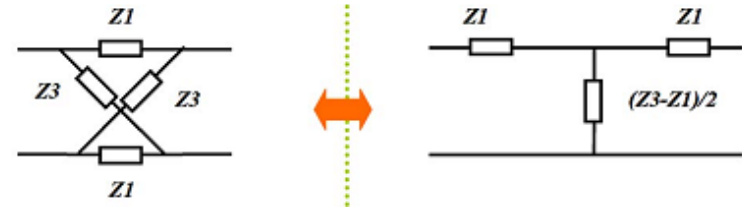




电感EPC的抑制

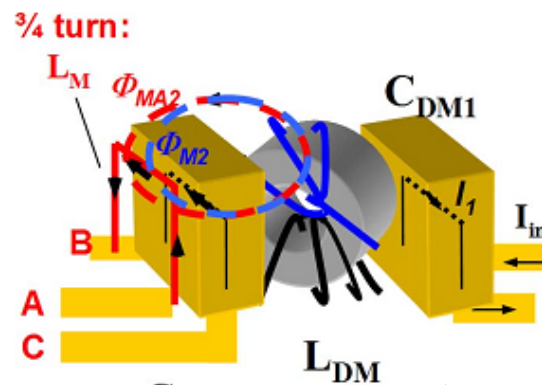
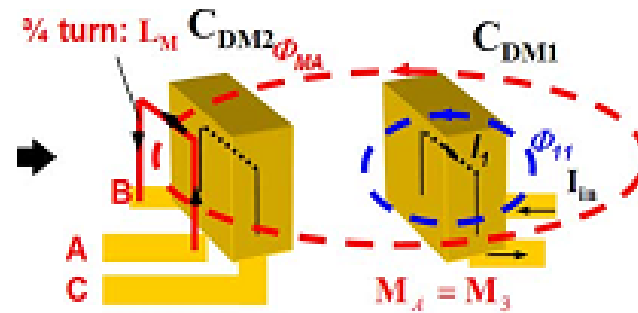
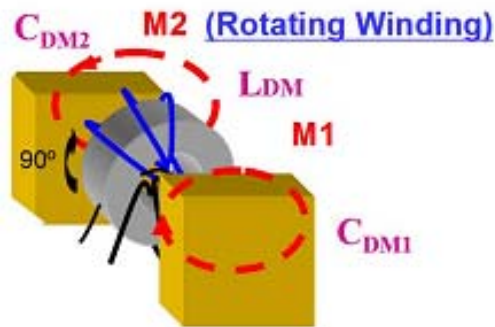
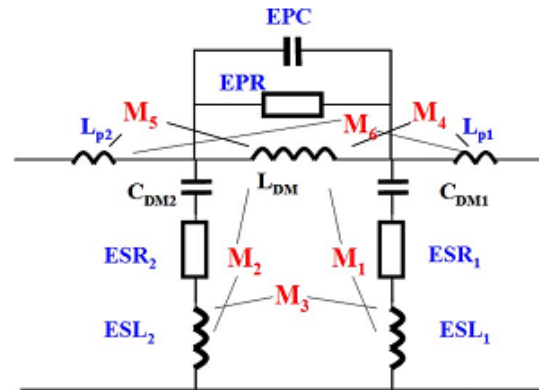
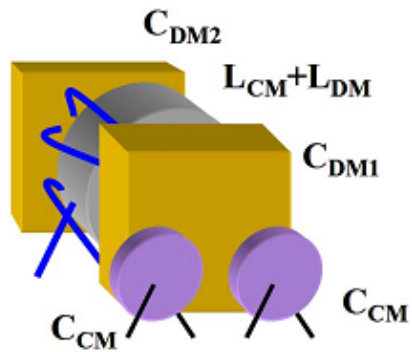


电感EPC的抑制

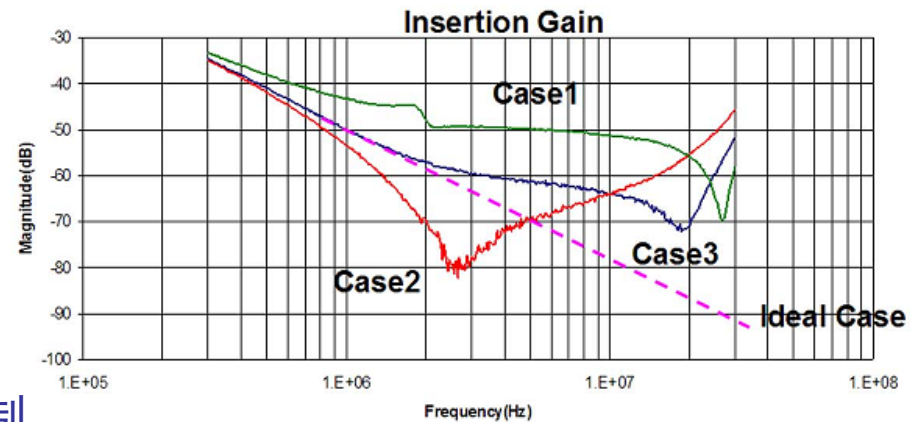


电容ESL抑制



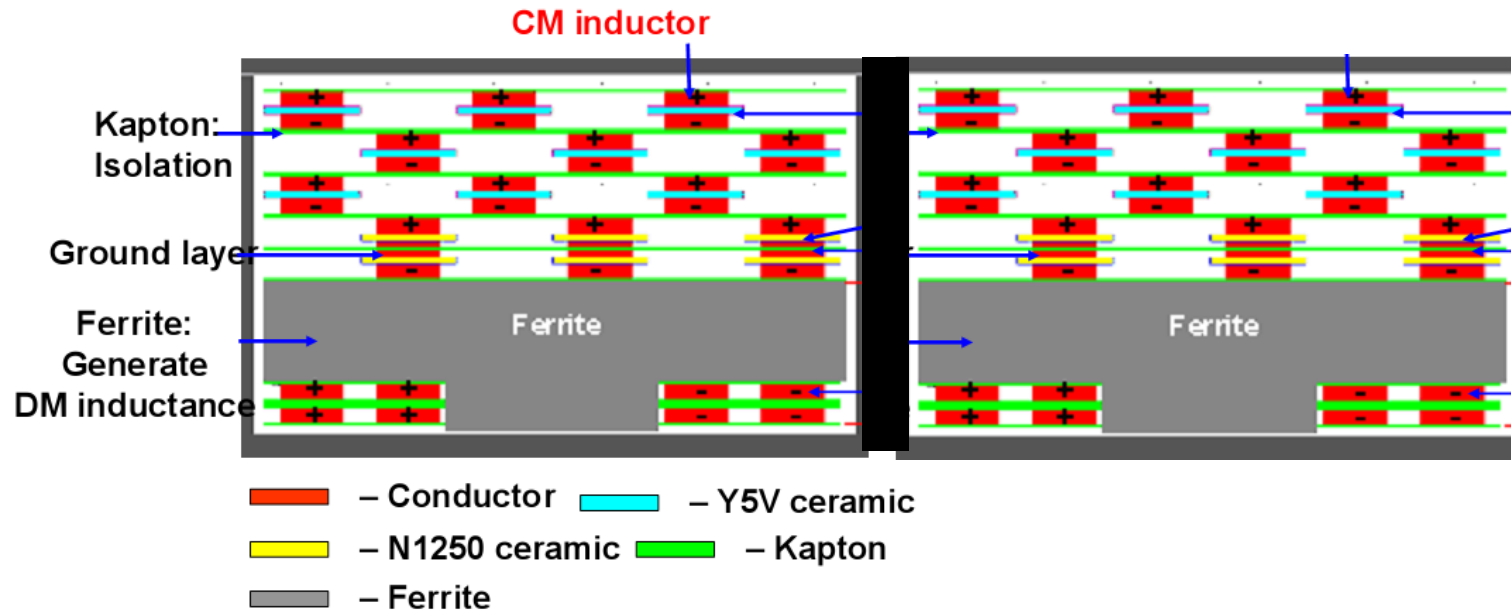
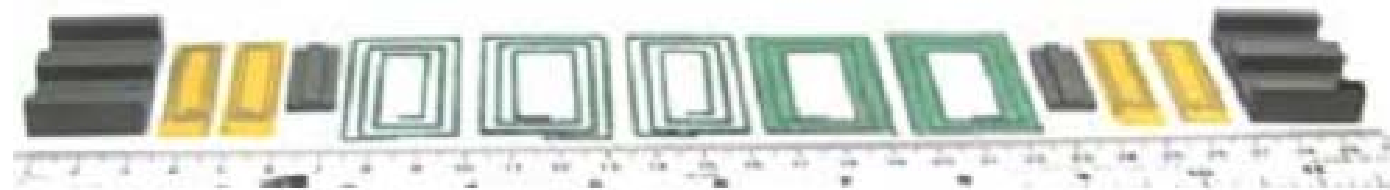
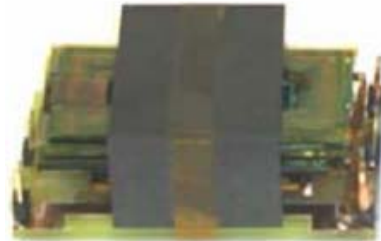
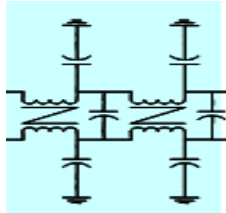


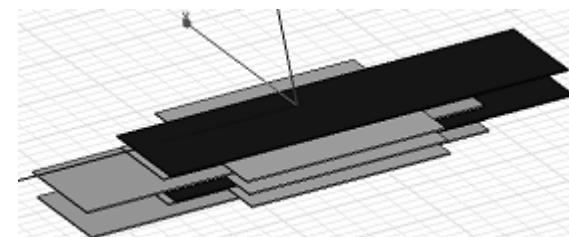
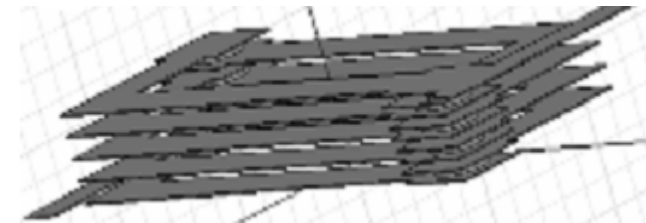
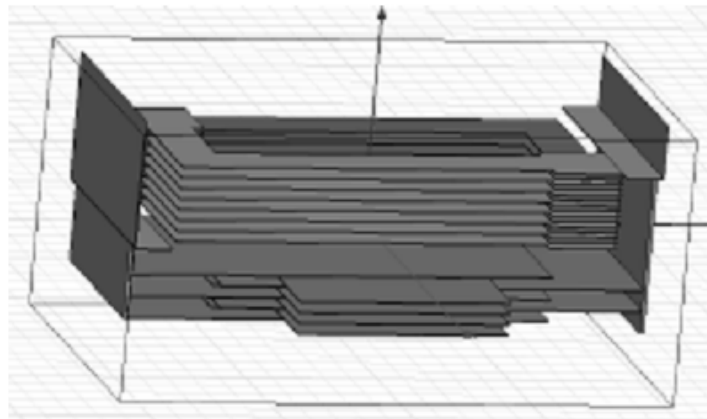
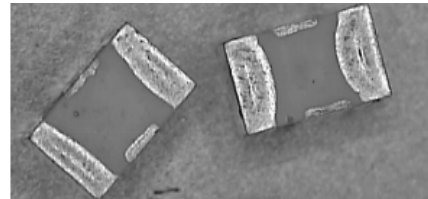
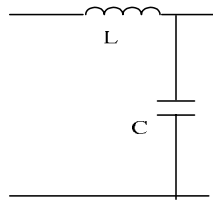
耦合的抑制

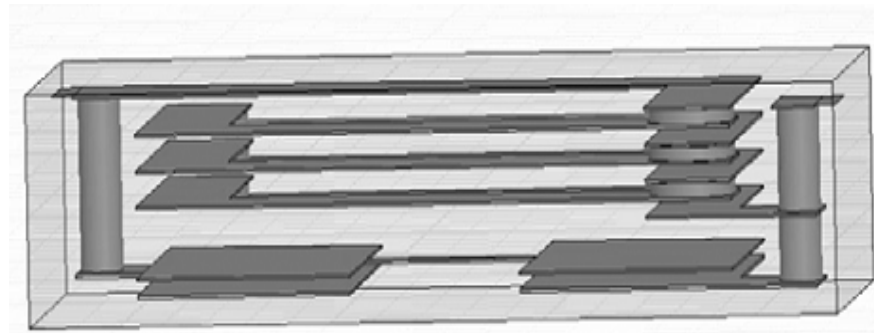
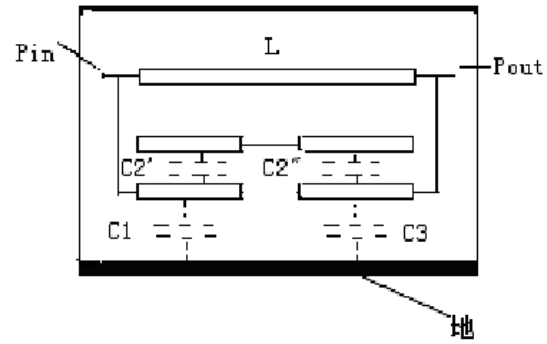
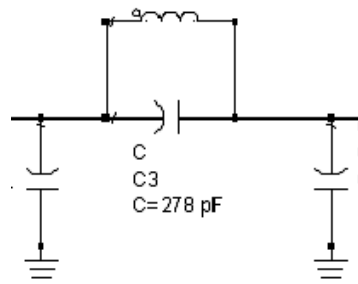


# 三. EMI滤波器小型化设计技术

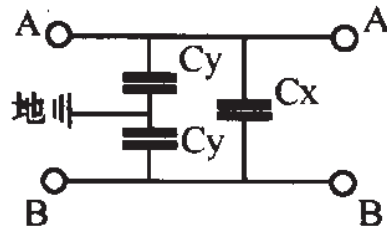
## 平面集成化







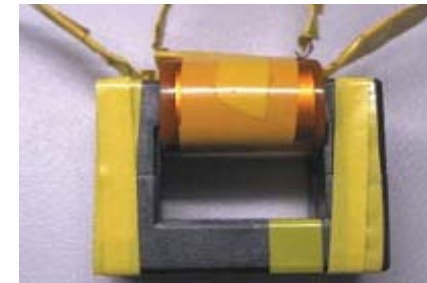
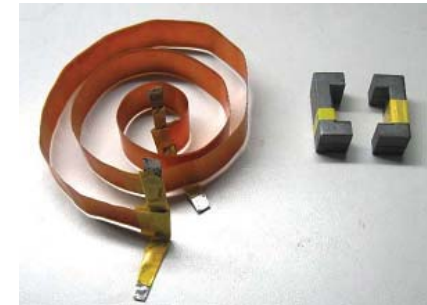
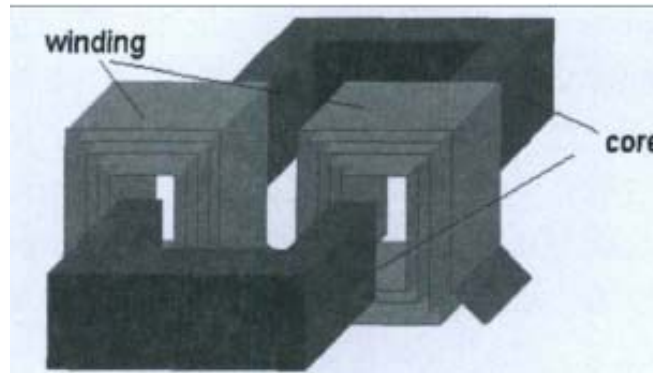
# 平面化电容、电感

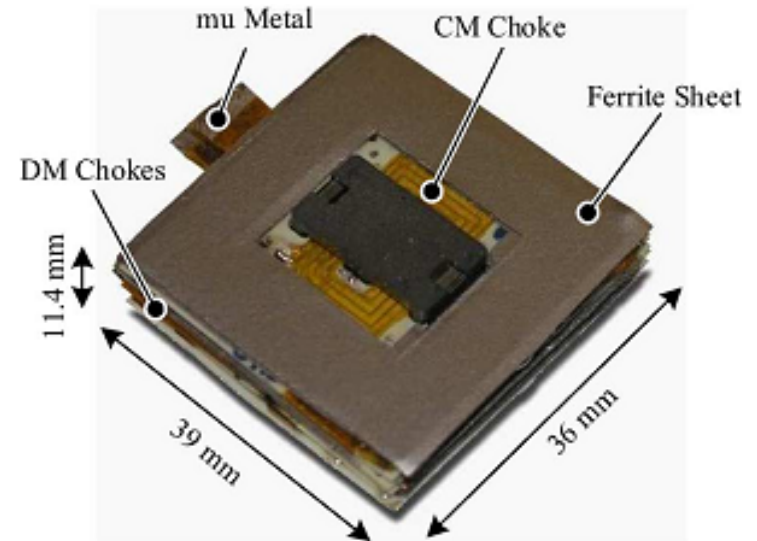
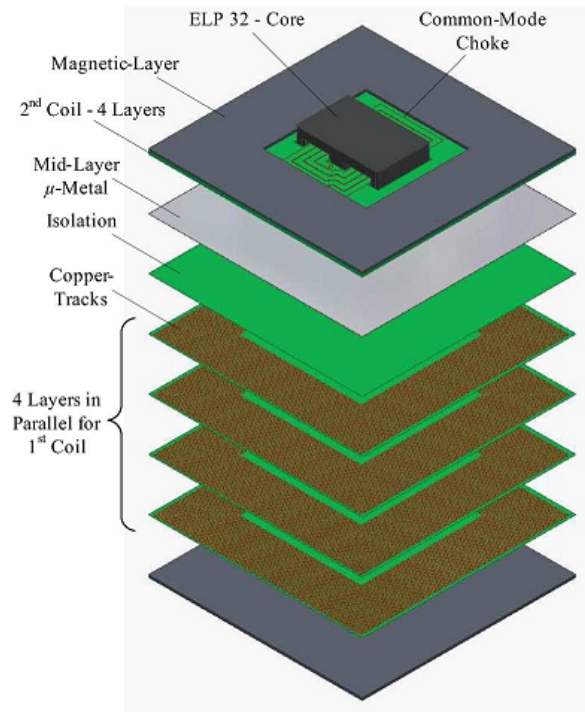
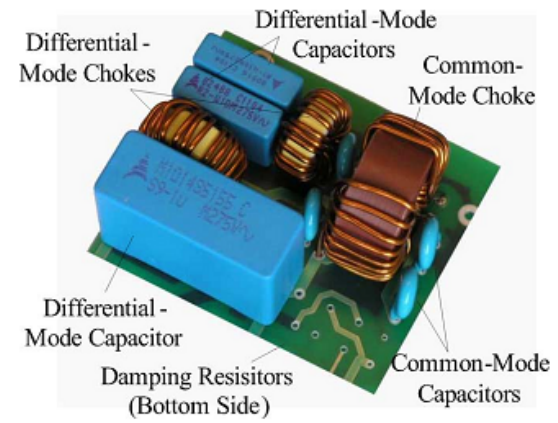
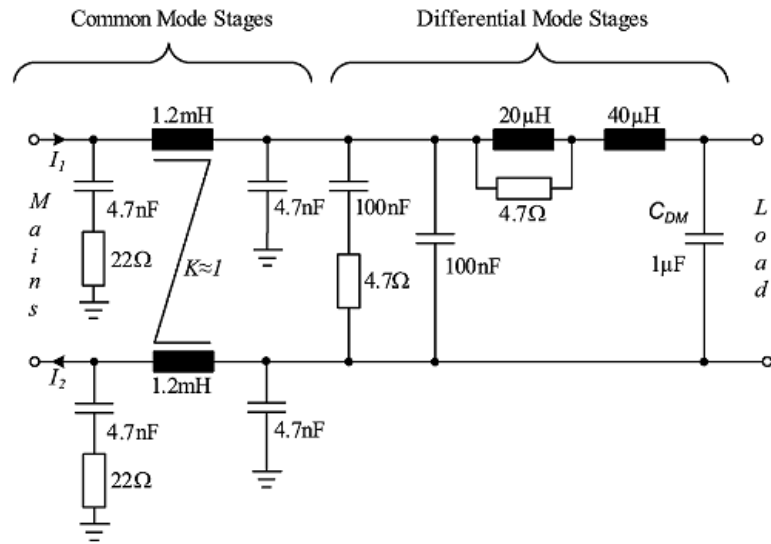


多层电容器

屏蔽电极

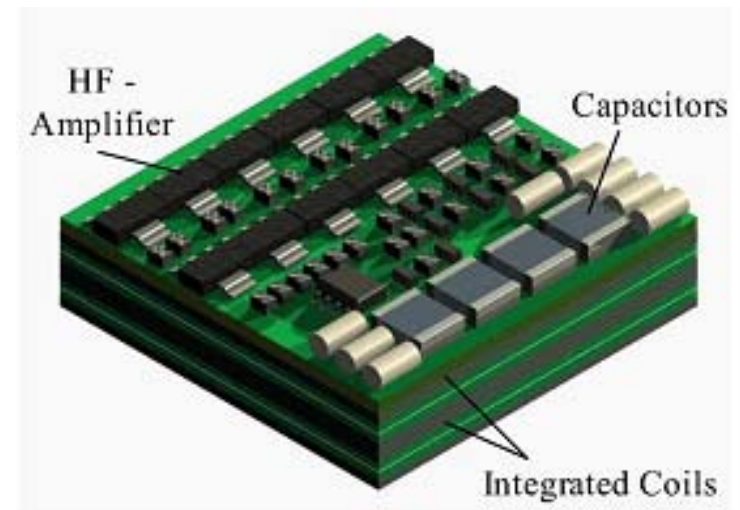
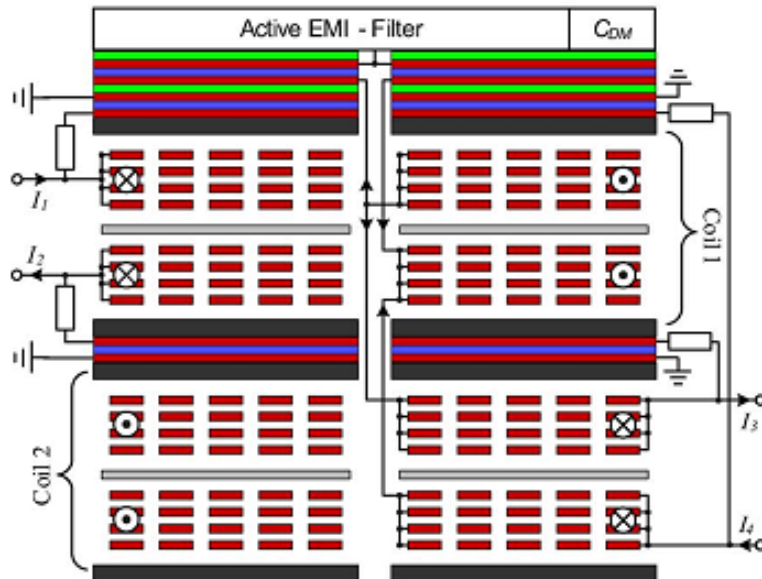
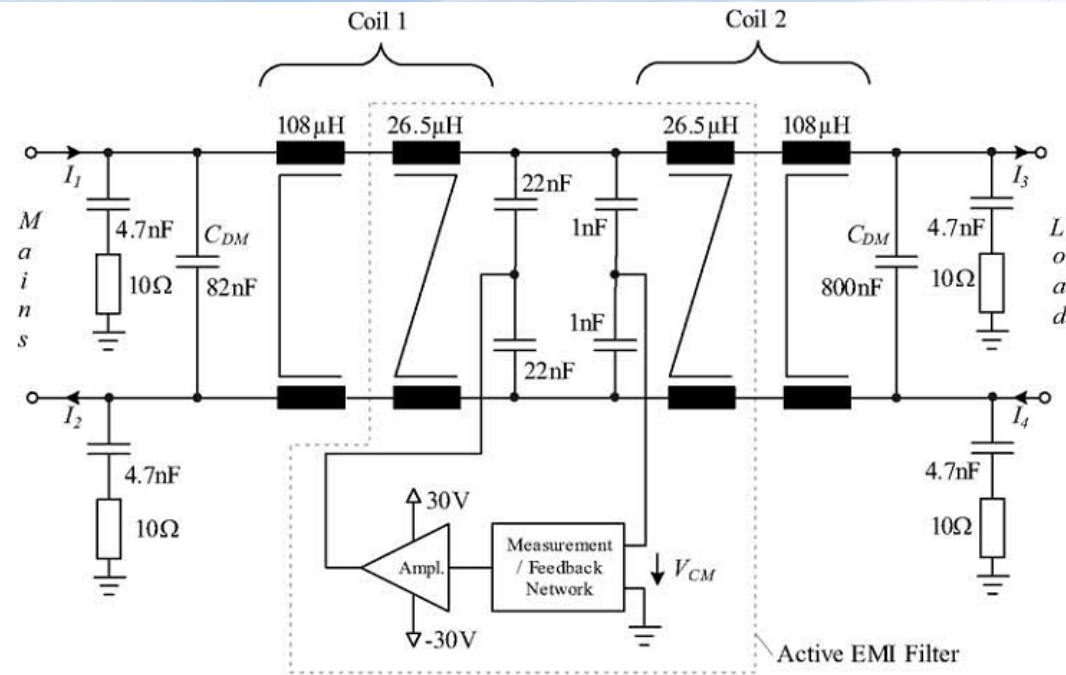
X2Y组合







混合集成化





## 四. 结束语

- 1: EMI滤波器性能主要受拓扑、寄生参数、杂散耦合等因素的影响，在设计、安装时应仔细，可避免这些因素的负面作用。
- 2: EMI的小型化主要受电源原始噪声大小、电感与电容体积影响，通过采用新型磁材料、平面化集成设计、混合滤波器设计等方式，可以有效减小其体积。

*Any questions?*

谢谢大家!



*Thanks for your attention!*