Application Guide of EMI Filter

CitrusCom Corporation
www.citruscomsemi.com

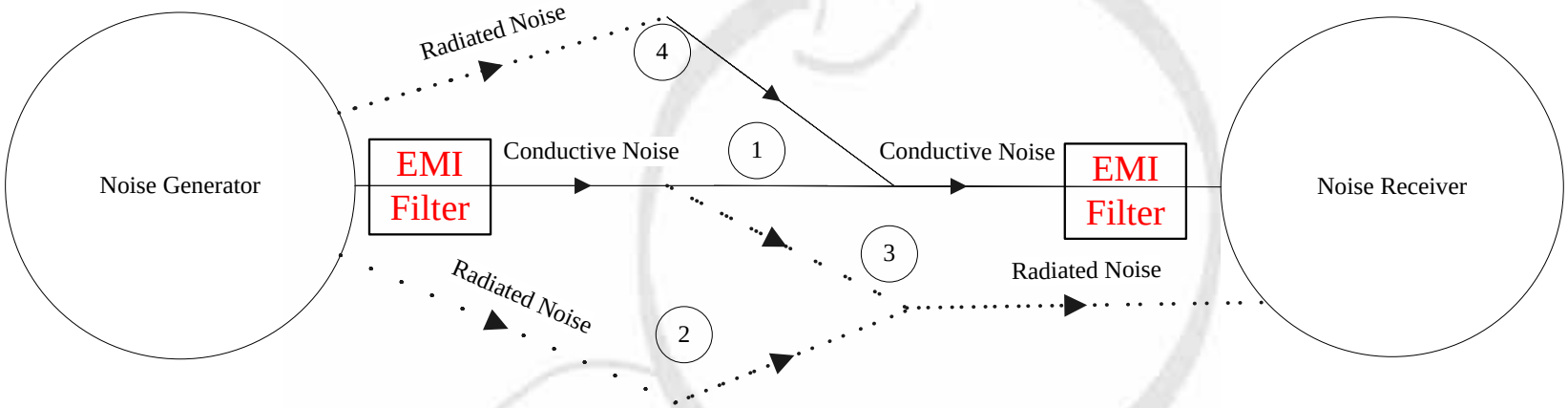
Outline

- EMI and ESD Hazards to Electronic Devices
- Applications of EMI Filter
- Structure of EMI filters: RC Filter vs. LC Filter
- How to Select an EMI Filter
- EMI Filter vs. Discrete Components
- Package

EMI and ESD Hazards to Electronic Devices

- EMI: Electro-Magnetic Interference
- ESD: Electro-Static Discharge

EMI and ESD Hazards to Electronic Devices



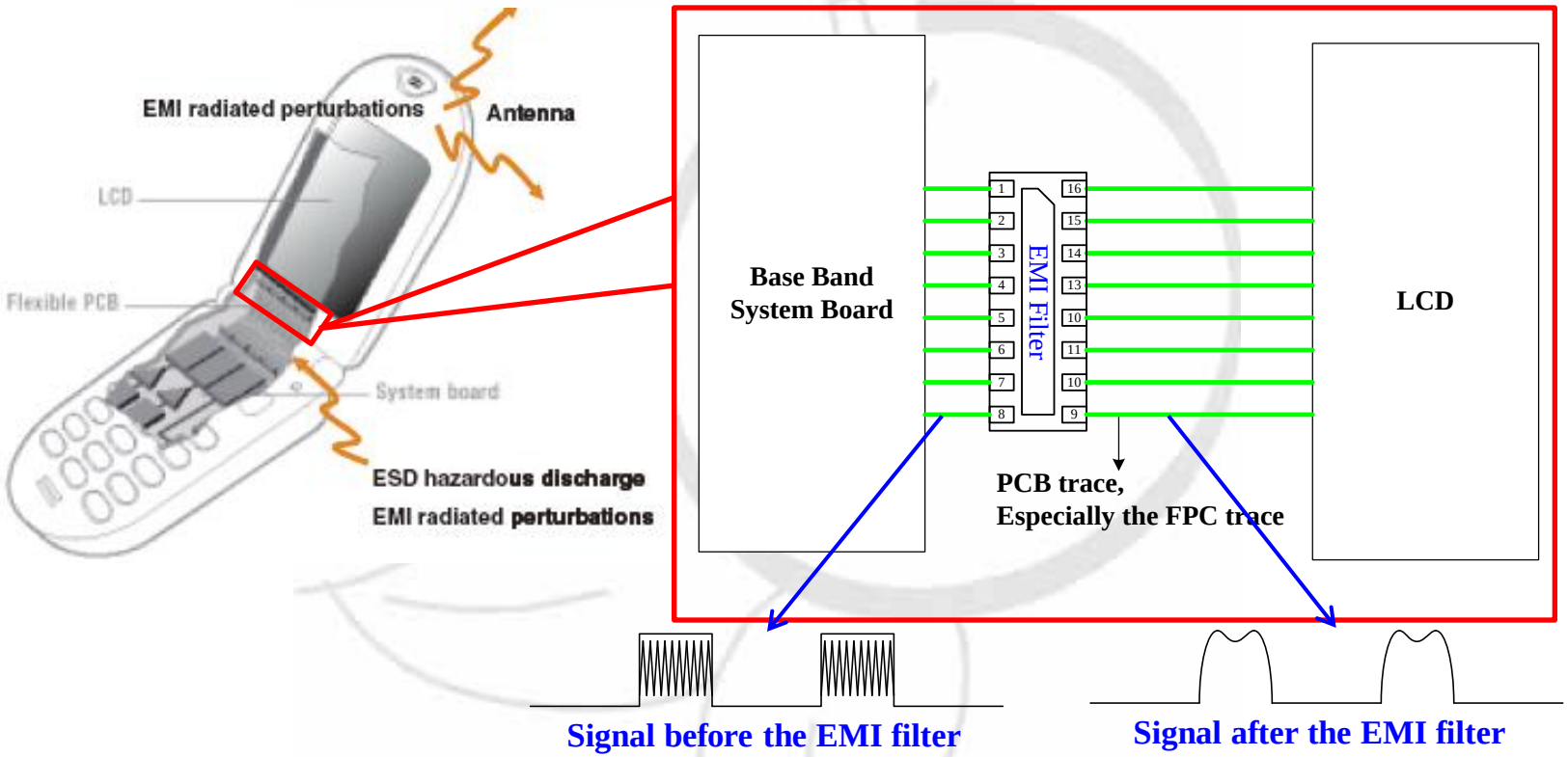
EMI Transition Paths

EMI Transition Path	Can be filtered by EMI filter
Conductive – Conductive	YES
Radiated – Radiated	NO
Conductive – Radiated	YES
Radiated – Conductive	YES

Applications of EMI Filter

- LCD and camera data lines in mobile devices
- High-speed electronic devices, especially wireless handsets and smart phones
- I/O port protection for mobile handsets, notebook computers, PDAs etc.

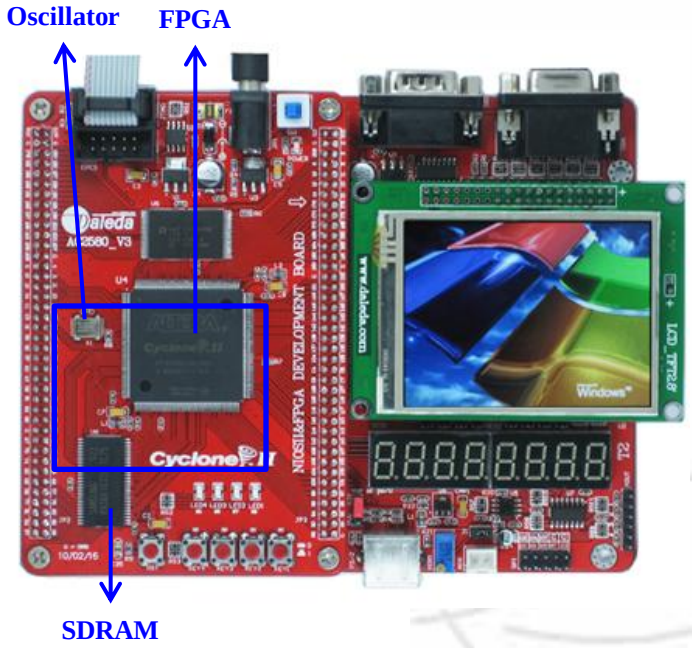
Example for LCD Module in Mobile Phone

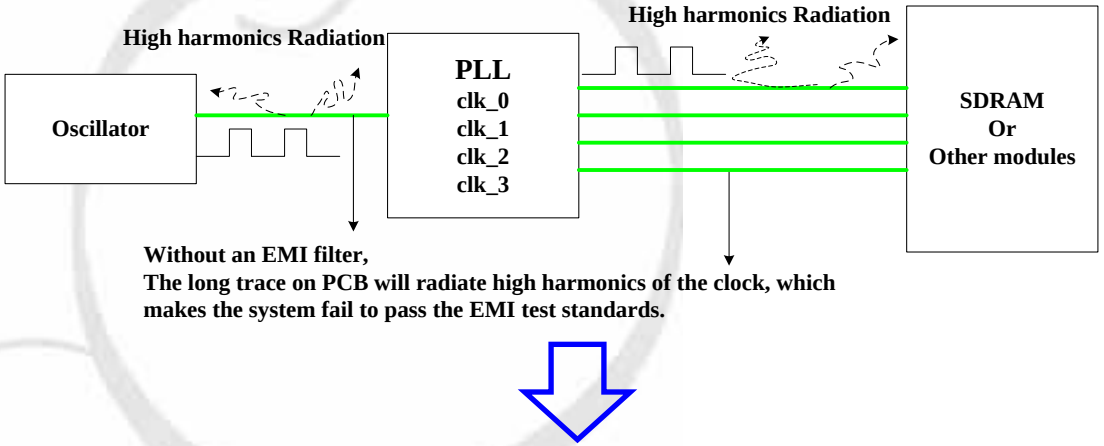


The long PCB trace, especially the FPC trace, connecting the system board and the LCD module, will works as an antenna to radiate the RF noise. Then the radiated RF noise will distort the communication terribly. With the EMI filter, the noise will be rejected.

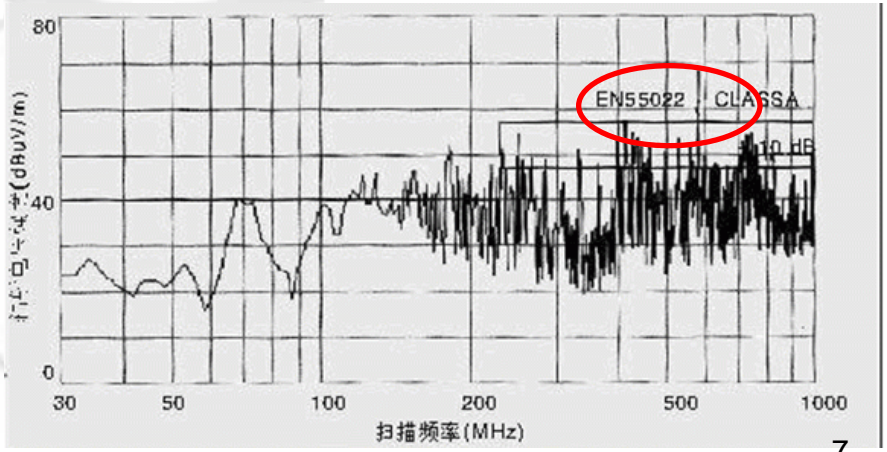
Therefore, to get the best performance, the EMI filter should be put as close to the I/O ports of the Base Band System Board as possible.

Example for System EMI Suppression

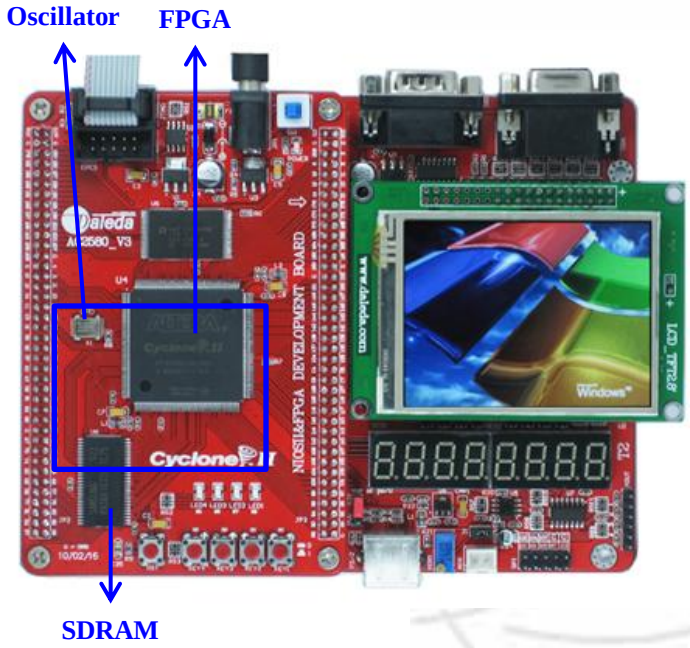


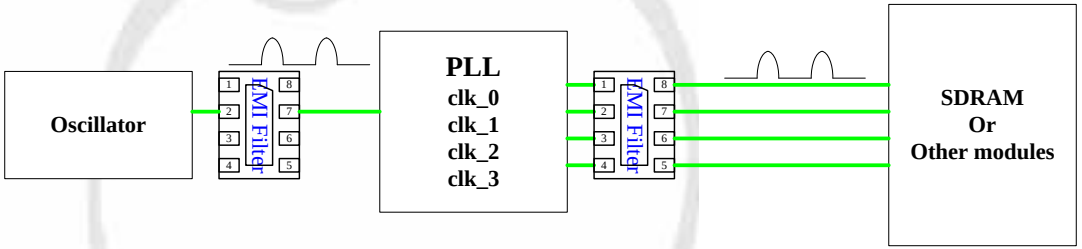


The high harmonics radiation makes the system fail to pass CLASS A of CISPR.



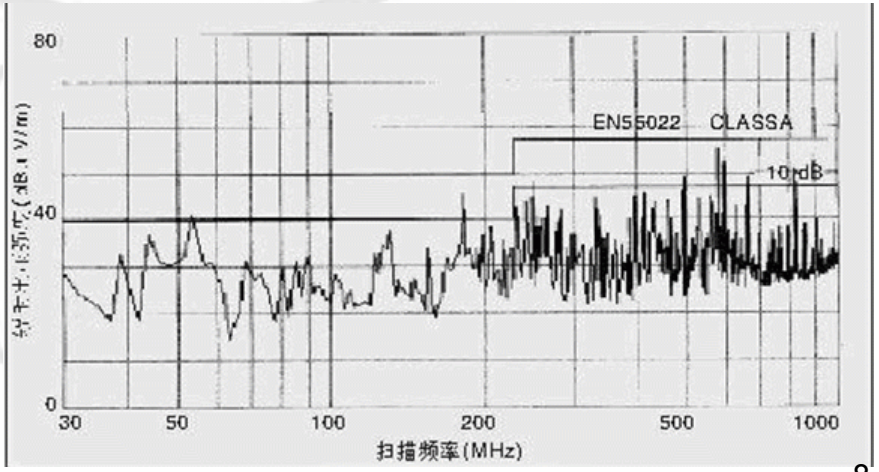
Example for System EMI Suppression





The high harmonics of the clock are rejected by the EMI filter.
Therefore, there's no radiation any more.

The high harmonics radiation is limited by the EMI filter.



Layout Guidelines of PCB for EMI Filter

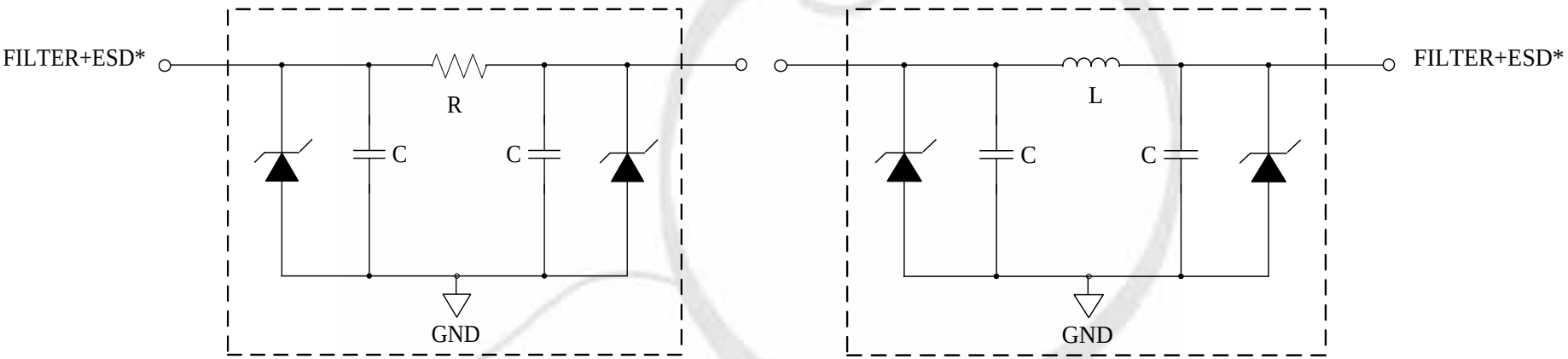
Optimizing the performance of the EMI filter

- Keep all traces as short as possible.
- Filter all I/O signals entering / leaving the noisy environment
- Locate the EMI filter as close to the I/O connector as possible
- Use ground planes to minimize the PCB's ground inductance

Ground Connection Recommendation

- Use multiple vias to make the connection to the ground plane
- Bringing the ground plane closer to the signal layer

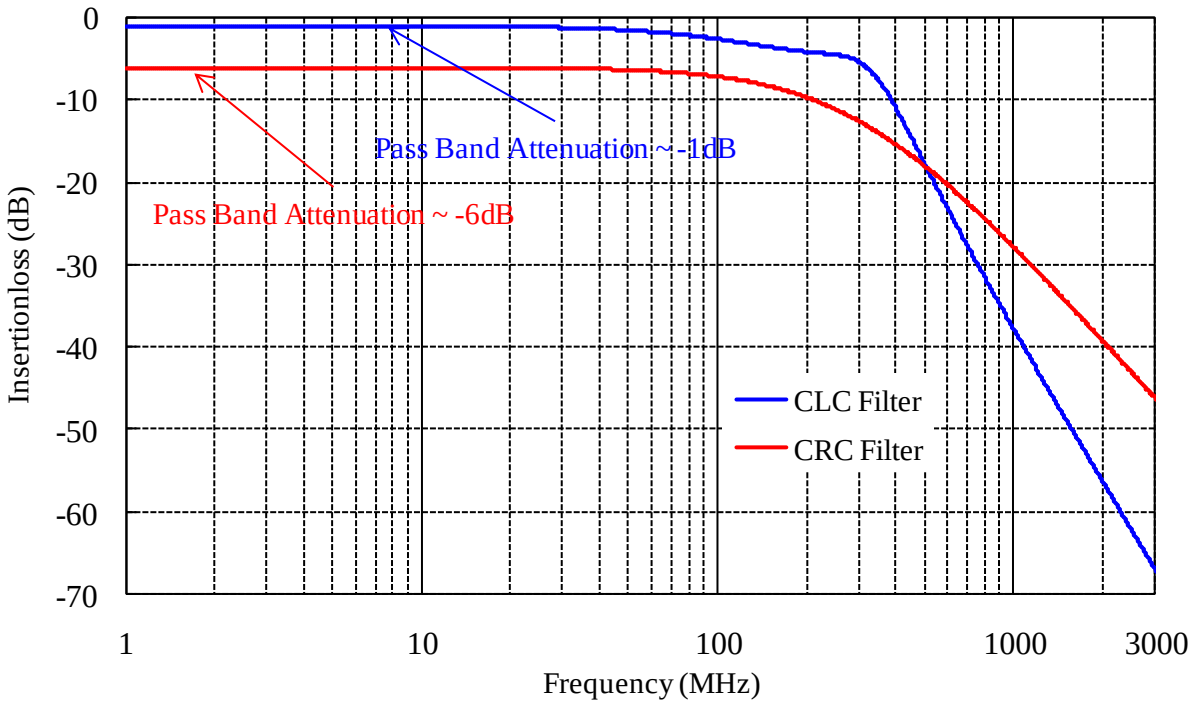
Structure of EMI Filters: RC Filter vs. LC Filter



How to Select an EMI Filter with ESD Protection

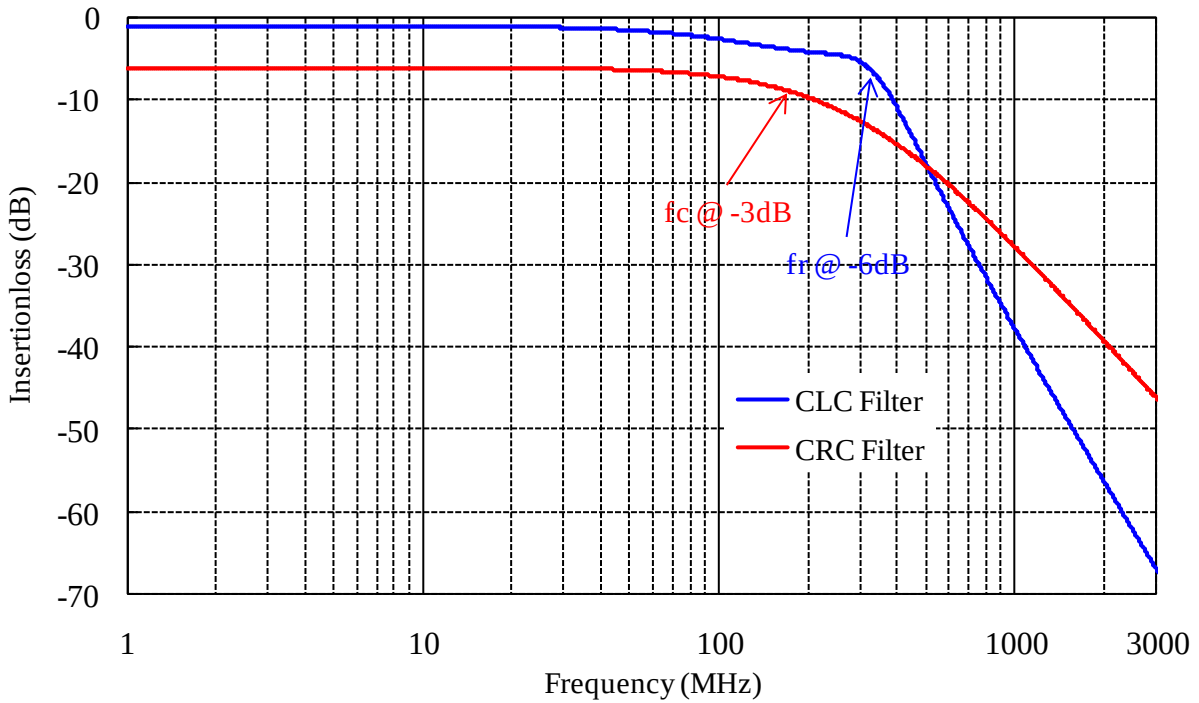
- High f_C (cut-off frequency): to support high data rates and maintain the highest level of signal integrity
- Minimum Insertion Loss (S21) in the pass band
- Sharp roll-off after f_R (roll-off frequency) in S21 curve
- Great level of attenuation in the rejection band
- High level of ESD protection

How to Select an EMI Filter with ESD Protection by Pass Band



The pass band attenuation is determined by the sensitivity of the receiving end of the network. If the insertion loss in the pass-band is high, a receiver with greater sensitivity is needed to acquire the signal. So Lower pass band attenuation is preferred.

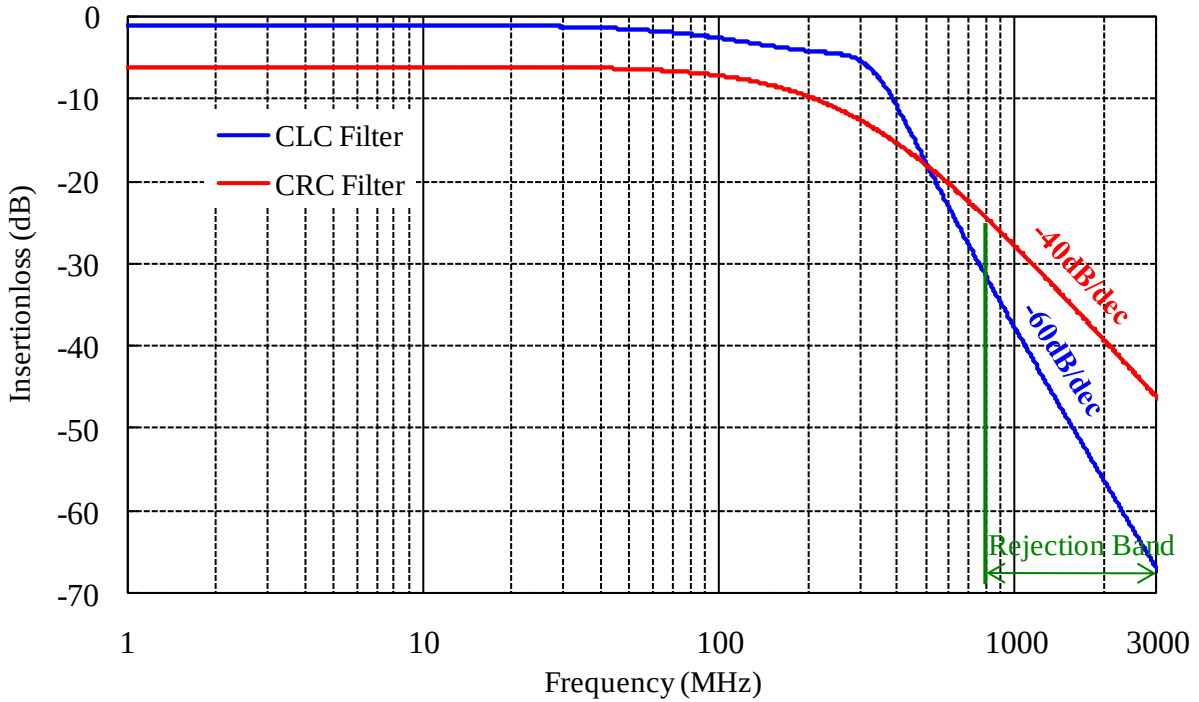
How to Select an EMI Filter with ESD Protection by Cut-off frequency



When applying a filter to a square wave signal, all the harmonics above f_C in RC filter or f_R in LC filter are discarded. So keeping as many harmonics as possible is key in order to preserve signal integrity. Generally, keeping three or five harmonics is acceptable.

$$f_C \geq 3 f_{signal} \quad \text{Or} \quad f_C \geq 5 f_{signal} \quad \text{Better}$$

How to Select an EMI Filter with ESD Protection by Rejection Band



The EMI filter arrays should provide effective filtering performance in the rejection band frequencies (800MHz – 3GHz for example).

25dB or more attenuation is preferred.

How to Select an EMI Filter with ESD Protection by ESD Protection Ability

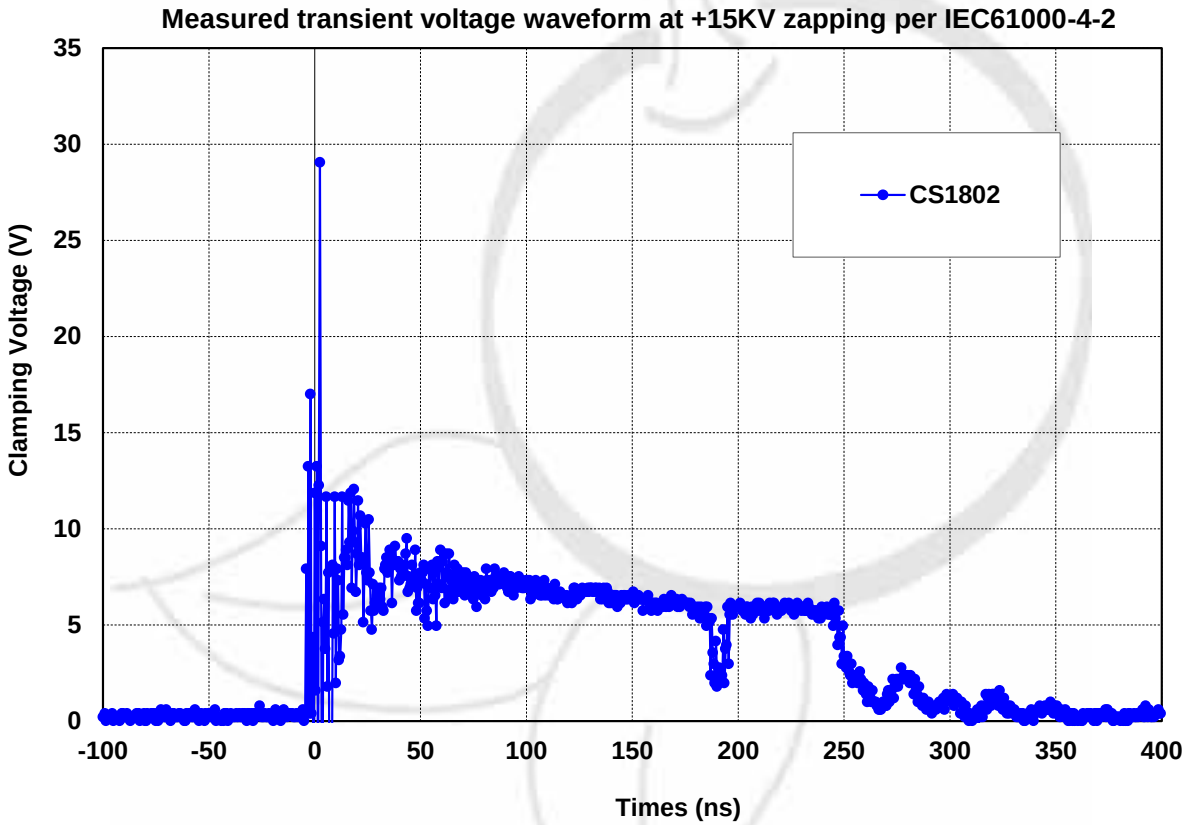
Table 1. IEC61000-4-2 Test Levels

Contact Discharge		Air Discharge	
Level	Test Voltage (kV)	Level	Test Voltage (kV)
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15
X[1]	Special	X[1]	Special

Notes
1. "X" is an open level. The level has to be specified in the dedicated equipment specification. If higher voltages than those are specified, special test equipment may be required.

All EMI filters from CitrusCom are over IEC61000-4-2 Contact Discharge Level 4, most of which can provide a excellent protection over IEC61000-4-2 15kV.

How to Select an EMI Filter with ESD Protection by ESD Protection



Low Clamping Voltage is always preferred for the protected devices. Too high Clamping Voltage may fail the protected devices even before the protection devices are damaged.

How to Select an EMI Filter with ESD Protection

Comparison between RC and LC EMI filters

Critical Parameter	RC	LC	COMMENTS
Attenuation of Insertion Loss in Pass Band	~-6dB	~-1dB	LC filter is better as it degrades the signals less and needs less sensitive receiver.
Cut-off Frequency	Lower	Higher	LC filter is better as it can afford higher operation frequency in data line and preserve better signal integrity.
Attenuation of Insertion Loss in Rejection Band	Lower	Higher	LC filter is better as it can filter more EMI in the rejection band.
Roll-off	Lower	Higher	LC filter is better as it can provide higher attenuation in rejection band.
ESD Protection	Decided by the ESD ability of ESD protection devices in EMI filter. High f_C RC filters usually has lower ESD protection ability than LC filters with similar f_C.		

This comparison is based on typical RC and LC filters.
Generally, performance of RC filters cannot be better than LC filters in all key parameters simultaneously.
However, it has its own benefits. RC filter has simpler structure and is comparatively easy to design.
It is also influenced less by impedance mismatch.

EMI Filter vs. Discrete Components

EMI Filter with ESD Protection	**Discrete Components**
Integrated	Not integrated
One chip for several channels	each protected line needs one or more components
Save PCB area	Use more PCB area
Include high ESD protection ability	Usually no ESD protection ability
Parasitic Parameter is carefully considered and controlled	Larger parasitic parameters which are difficult to control will influence the performance

Package

EMI Filters can be provided in these packages with low profile and small PCB size.

- uDFN-8L, -12L, -16L
- TDFN-8L, -12L, -16L
- CSP-10, -15, -20

射 频 和 天 线 设 计 培 训 课 程 推 荐

易迪拓培训(www.edatop.com)由数名来自于研发第一线的资深工程师发起成立，致力并专注于微波、射频、天线设计研发人才的培养；我们于 2006 年整合合并微波 EDA 网(www.mweda.com)，现已发展成为国内最大的微波射频和天线设计人才培养基地，成功推出多套微波射频以及天线设计经典培训课程和 ADS、HFSS 等专业软件使用培训课程，广受客户好评；并先后与人民邮电出版社、电子工业出版社合作出版了多本专业图书，帮助数万名工程师提升了专业技术能力。客户遍布中兴通讯、研通高频、埃威航电、国人通信等多家国内知名公司，以及台湾工业技术研究院、永业科技、全一电子等多家台湾地区企业。

易迪拓培训推荐课程列表： http://www.edatop.com/peixun/tuijian/

射频工程师养成培训课程套装

该套装精选了射频专业基础培训课程、射频仿真设计培训课程和射频电路测量培训课程三个类别共 30 门视频培训课程和 3 本图书教材；旨在引领学员全面学习一个射频工程师需要熟悉、理解和掌握的专业知识和研发设计能力。通过套装的学习，能够让学员完全达到和胜任一个合格的射频工程师的要求…

课程网址：http://www.edatop.com/peixun/rfe/110.html

手机天线设计培训视频课程

该套课程全面讲授了当前手机天线相关设计技术，内容涵盖了早期的外置螺旋手机天线设计，最常用的几种手机内置天线类型——如 monopole 天线、PIFA 天线、Loop 天线和 FICA 天线的设计，以及当前高端智能手机中较常用的金属边框和全金属外壳手机天线的设计；通过该套课程的学习，可以帮助您快速、全面、系统地学习、了解和掌握各种类型的手机天线设计，以及天线及其匹配电路的设计和调试...

课程网址： http://www.edatop.com/peixun/antenna/133.html

WiFi 和蓝牙天线设计培训课程

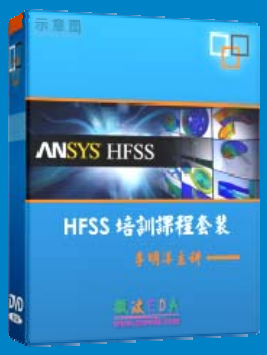
该套课程是李明洋老师应邀给惠普 (HP)公司工程师讲授的 3 天员工内训课程录像，课程内容是李明洋老师十多年工作经验积累和总结，主要讲解了 WiFi 天线设计、HFSS 天线设计软件的使用，匹配电路设计调试、矢量网络分析仪的使用操作、WiFi 射频电路和 PCB Layout 知识，以及 EMC 问题的分析解决思路等内容。对于正在从事射频设计和天线设计领域工作的您，绝对值得拥有和学习！…

课程网址：http://www.edatop.com/peixun/antenna/134.html

CST 学习培训课程套装

该培训套装由易迪拓培训联合微波 EDA 网共同推出，是最全面、系统、专业的 CST 微波工作室培训课程套装，所有课程都由经验丰富的专家授课，视频教学，可以帮助您从零开始，全面系统地学习 CST 微波工作的各项功能及其在微波射频、天线设计等领域的设计应用。且购买该套装，还可超值赠送 3 个月免费学习答疑…

课程网址：http://www.edatop.com/peixun/cst/24.html

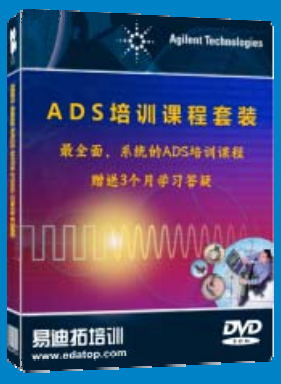


HFSS 学习培训课程套装

该套课程套装包含了本站全部 HFSS 培训课程，是迄今国内最全面、最专业的 HFSS 培训教程套装，可以帮助您从零开始，全面深入学习 HFSS 的各项功能和在多个方面的工程应用。购买套装，更可超值赠送 3 个月免费学习答疑，随时解答您学习过程中遇到的棘手问题，让您的 HFSS 学习更加轻松顺畅…

课程网址：http://www.edatop.com/peixun/hfss/11.html

ADS 学习培训课程套装



该套装是迄今国内最全面、最权威的 ADS 培训教程，共包含 10 门 ADS 学习培训课程。课程是由具有多年 ADS 使用经验的微波射频与通信系统设计领域资深专家讲解，并多结合设计实例，由浅入深、详细而又全面地讲解了 ADS 在微波射频电路设计、通信系统设计和电磁仿真设计方面的内容。能让您在最短的时间内学会使用 ADS，迅速提升个人技术能力，把 ADS 真正应用到实际研发工作中去，成为 ADS 设计专家...

课程网址： http://www.edatop.com/peixun/ads/13.html

我们的课程优势：

※ 成立于 2004 年，10 多年丰富的行业经验，

※ 一直致力并专注于微波射频和天线设计工程师的培养，更了解该行业对人才的要求

※ 经验丰富的一线资深工程师讲授，结合实际工程案例，直观、实用、易学

联系我们：

※ 易迪拓培训官网：http://www.edatop.com

※ 微波 EDA 网：http://www.mweda.com

※ 官方淘宝店：http://shop36920890.taobao.com