

Openning

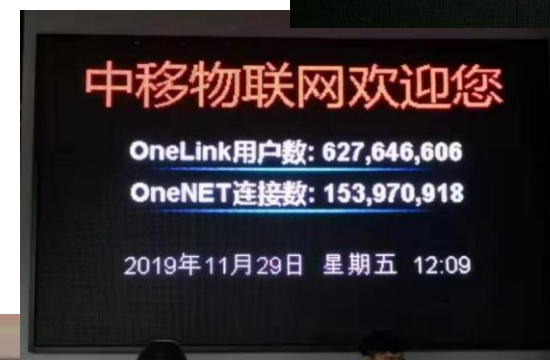
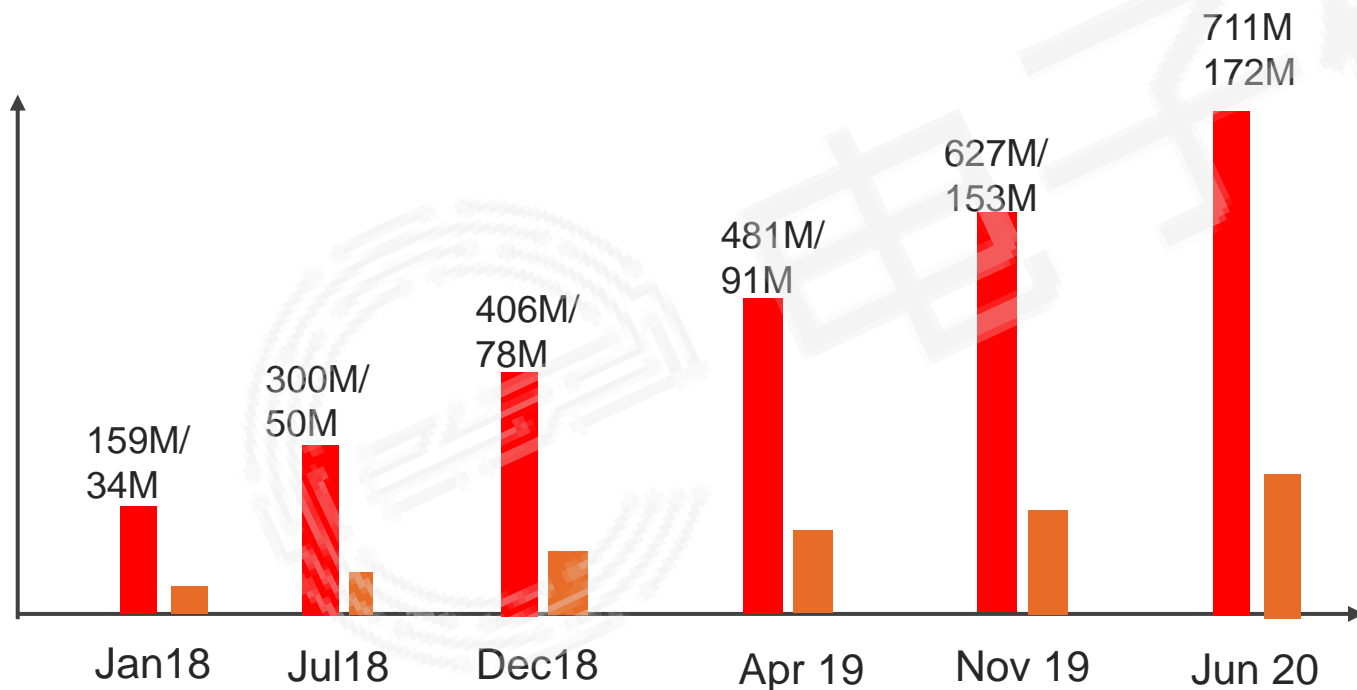


电子研习社

新基建、新机遇

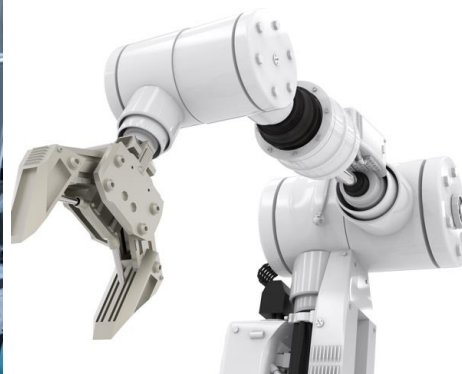
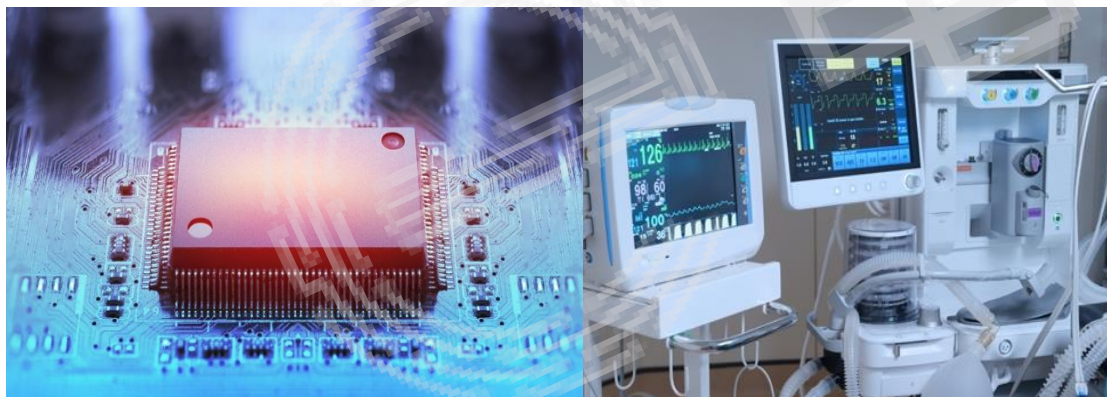
冰山之一角：物联网终端的高速发展

■ 用户数
■ 连接数



资料来源: Keysight

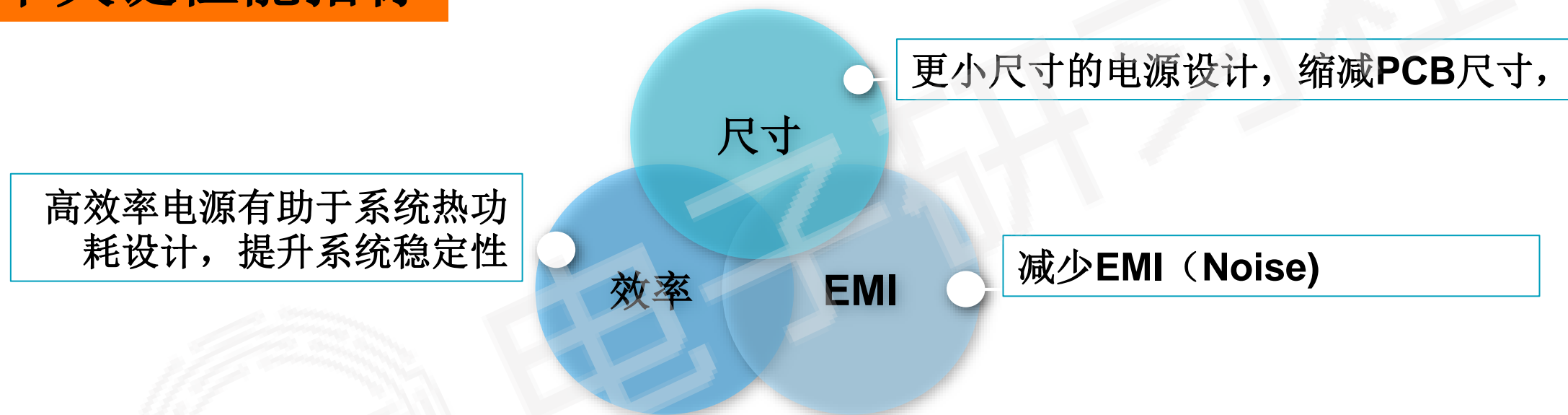
新热点， 成就高品质DC-DC巨大市场机会



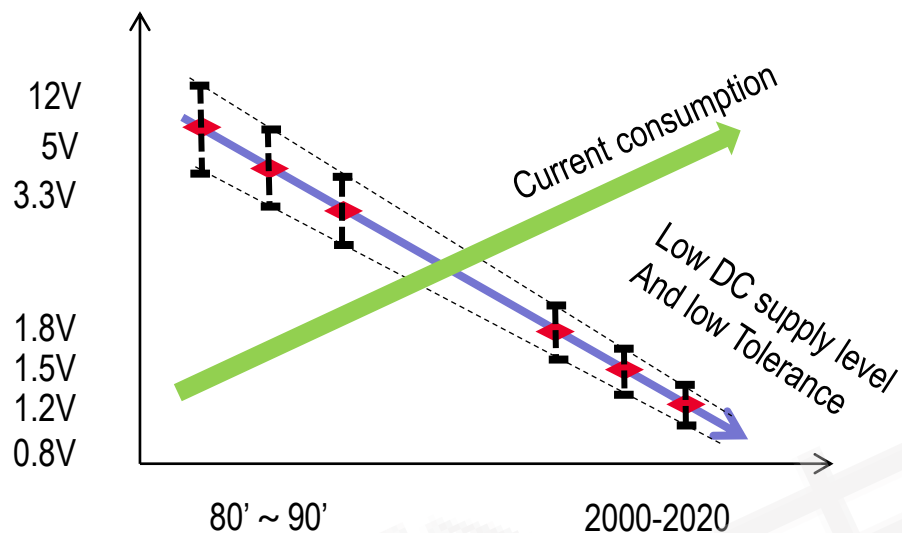
资料来源: Keysight

电源设计的发展与挑战

3个关键性能指标



新技术带来的挑战之一：大电流和稳定性



DC 电平 5V/3.3V ⇒ 2V ~ 1V ~ 0.8V

电流： 数十安培， 峰值电流超过100A

失真 5V ± 10% (±500mV) ⇒ 1V ± 3% (±30mV)

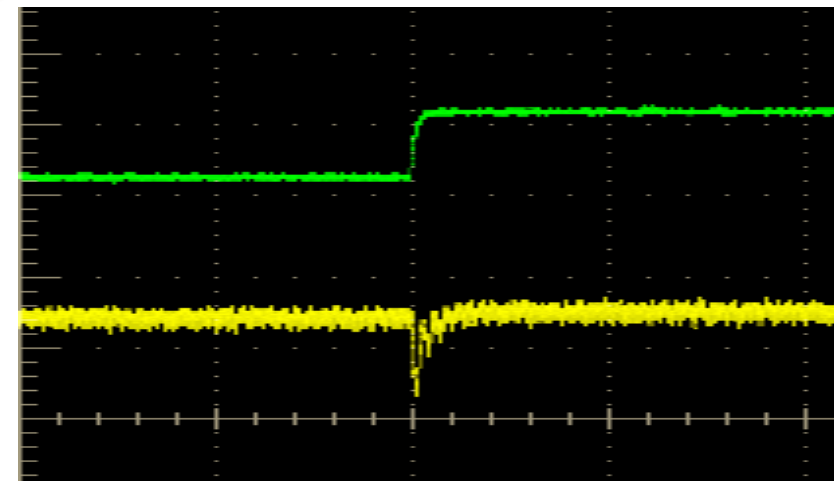
瞬态特性 例如动态电流 60-120A瞬变时， 电压瞬间跌落不超过 25%

应用领域 超算、5G, 数据传输、云设备等大型系统



FPGA/CPU

APS Power Supply



快速变化的大电流， 造成900mV 供电电压明显的跌落。

80% 的硬件电气问题源于电源



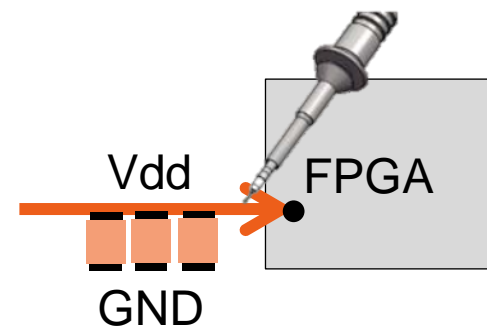
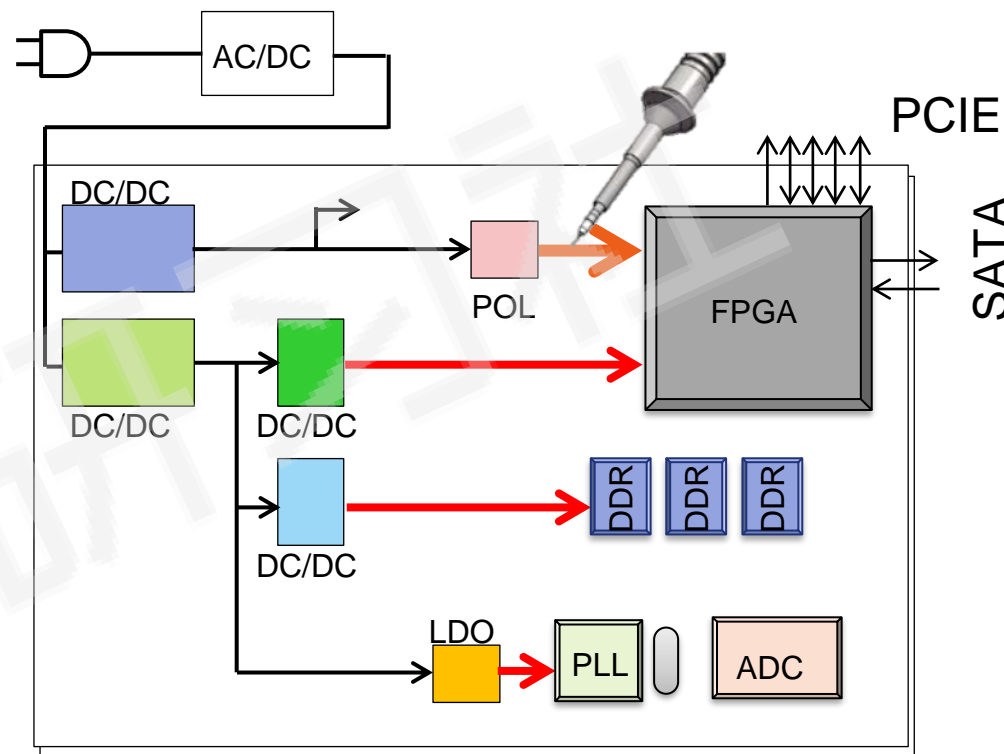
电源的完整性对
数字电路的可靠性和质量至关重要

资料来源: Keysight

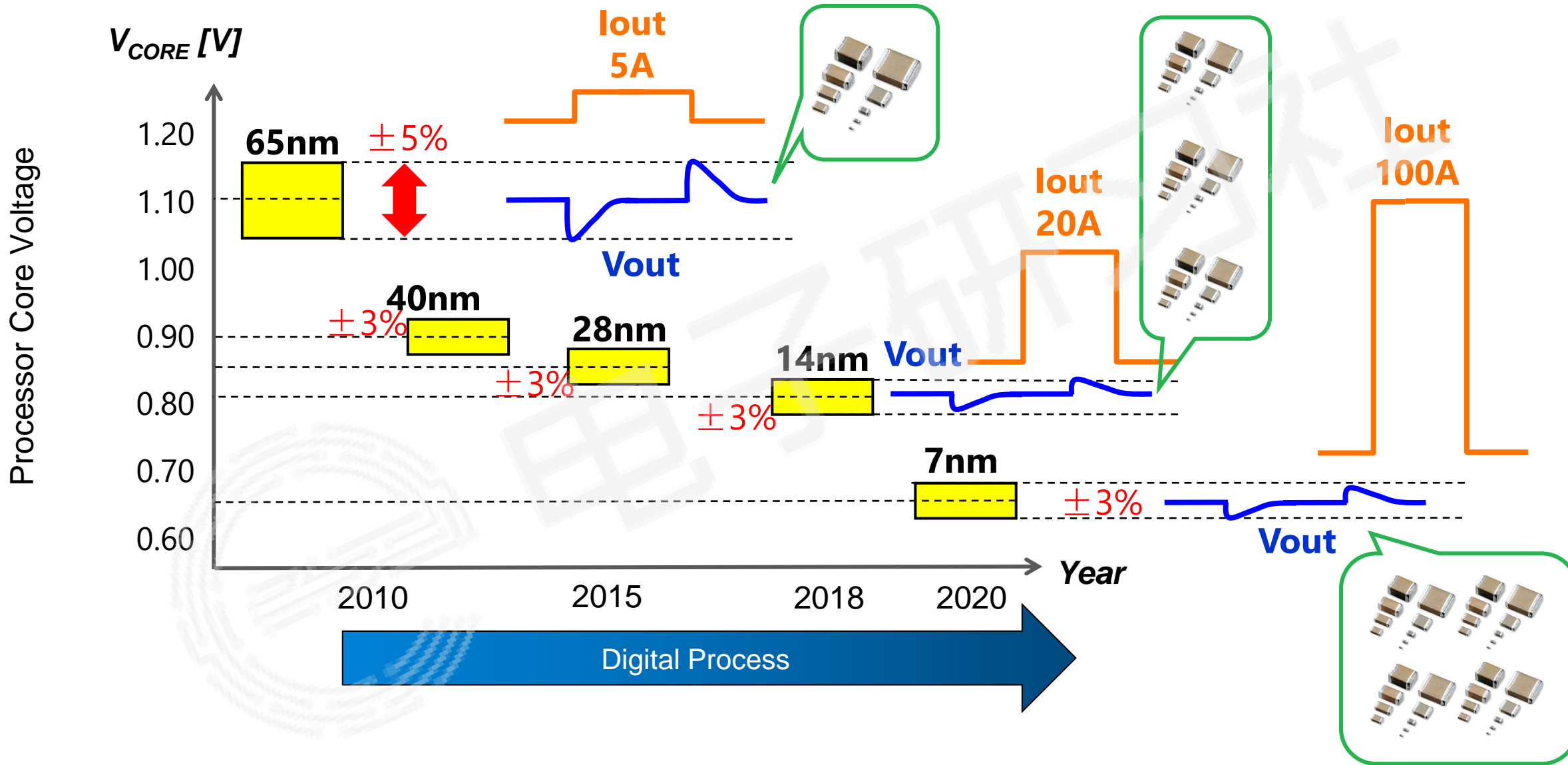
电源信号

传输信号
的抖动趋势

数据传输信号

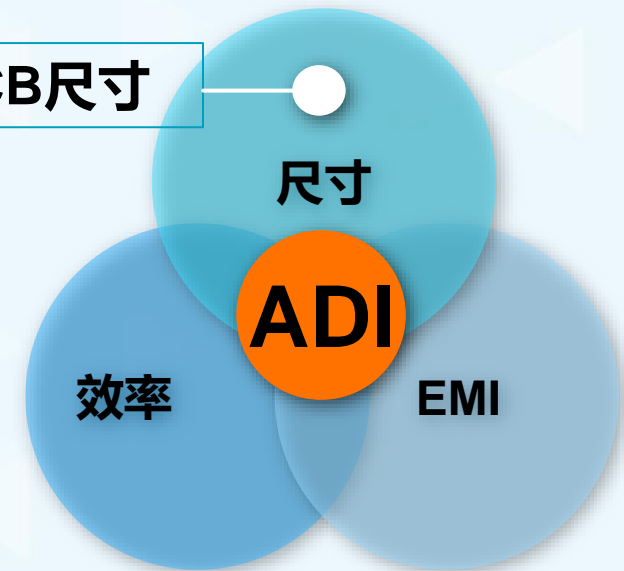


Bypass Cap to reduce noise



高集成度电源模块 uModule

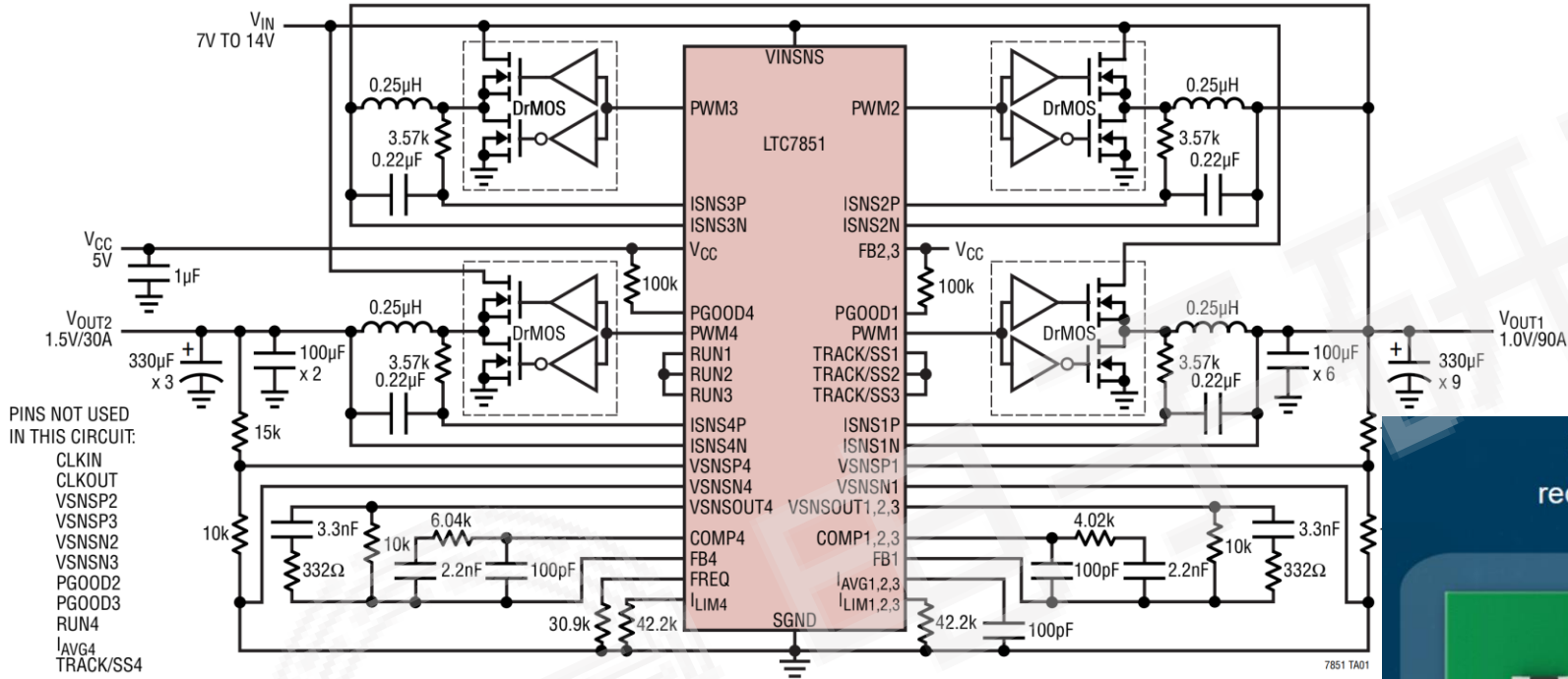
更小尺寸的电源设计，缩减PCB尺寸



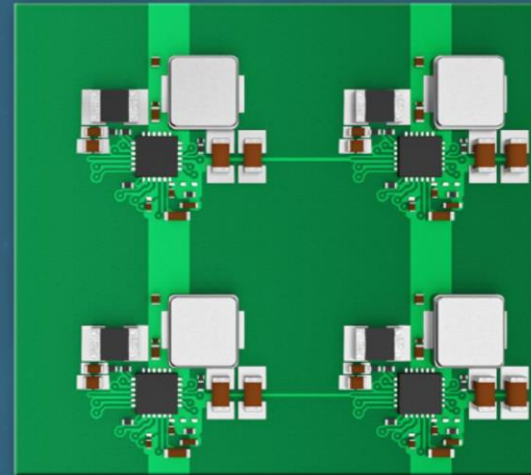
如何减少PCB面积，提升功率密度

TYPICAL APPLICATION

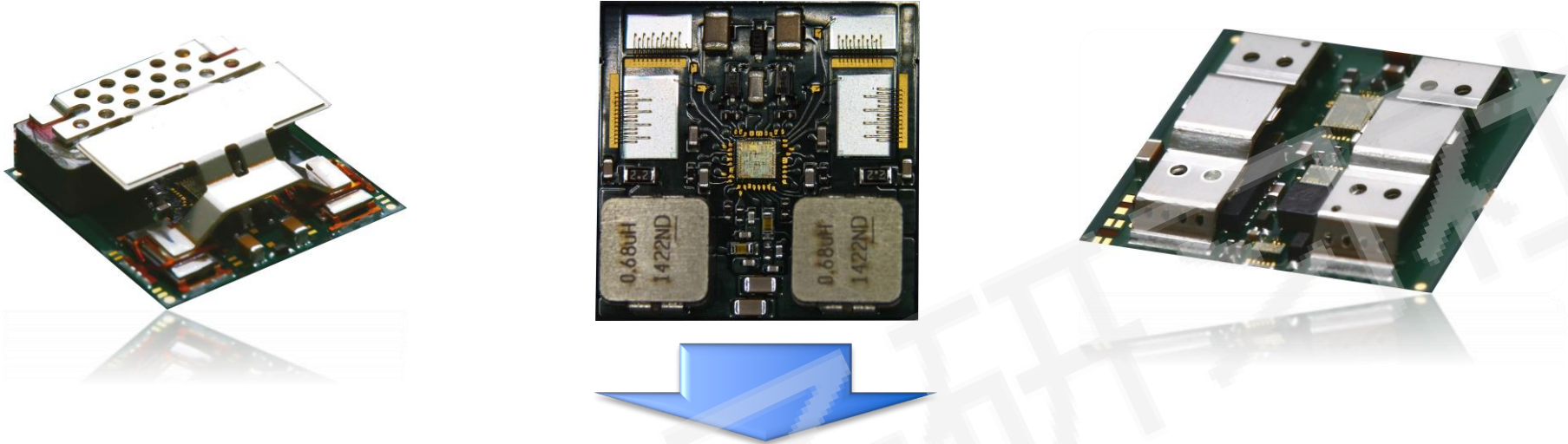
Dual-Output Converter: 1V/90A and 1.5V/30A with DrMOS



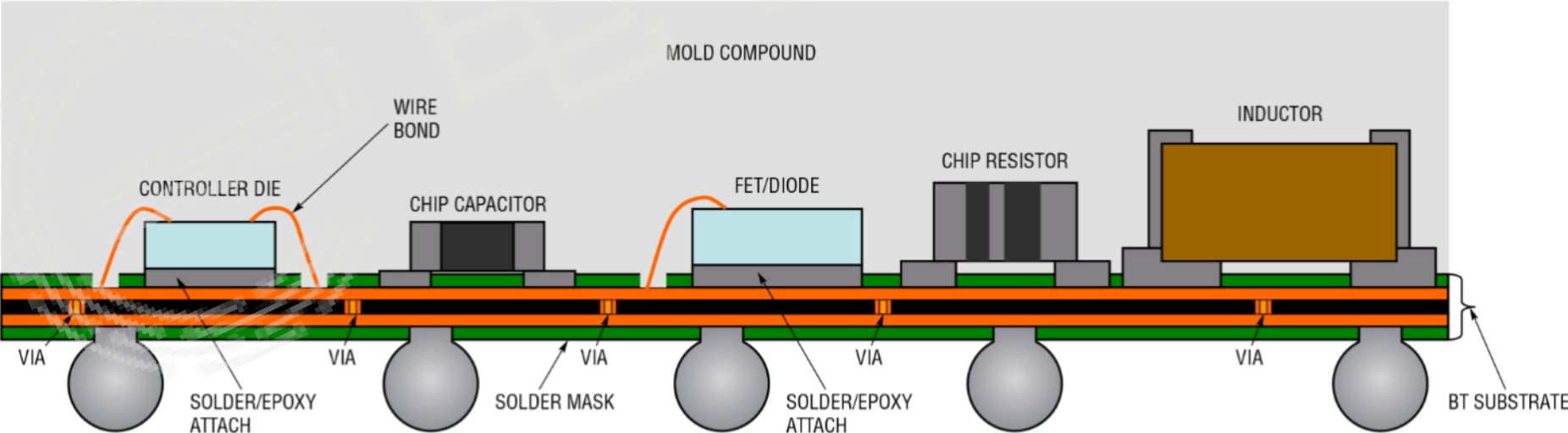
30x to 100x
reduced component count



μModule 内部构架



μModule™ BGA Package Construction
(Not To Scale)



电源模块发展趋势



6.25mm x 6.25mm x 3.87mm BGA (4626) 12A

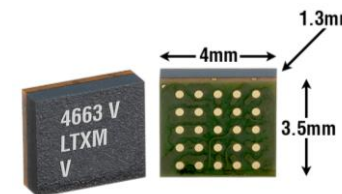
6.25mm x 6.25mm x 5.02mm BGA (4638) 15A

通用型

大功率



LTM4700
单路 100A 或
双路 50A
22mm x 15mm



LTM4663
1.5A TEC Controller
3.5mm x 4mm x 1.3mm



LTM4680
单路 60A 或
双路 30A
16mm x 16mm



LTM4678
单路 50A 或
双路 25A
16mm x 16mm



LTM4677
单路 36A 或
双路 18A
16mm x 16mm

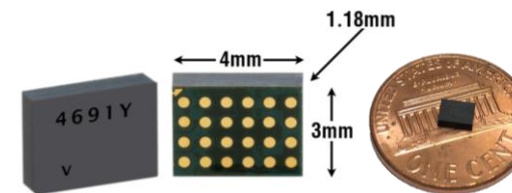


LTM4675
单路 18A 或
双路 9A
11.9mm x 16mm



LTM4676
单路 26A 或
双路 13A
16mm x 16mm

微型化



LTM4691 双路 2A
3mm x 4mm x 1.2mm

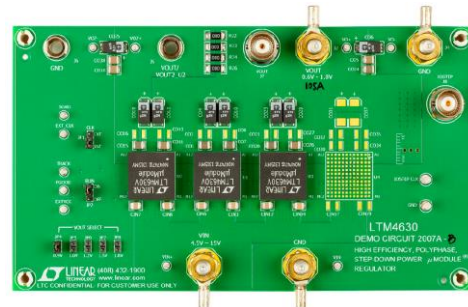
AI及数据中心处理器供电解决方案

CPU Core 0.8V @100A
供电解决方案



Year 2012

4x LTM4620



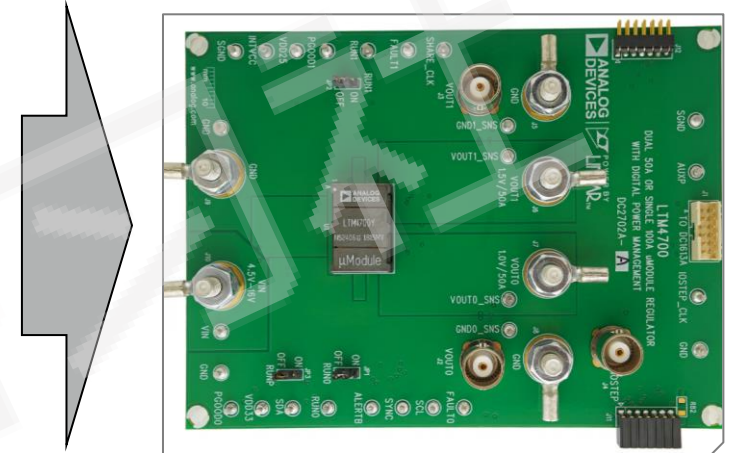
Year 2014

3x LTM4630



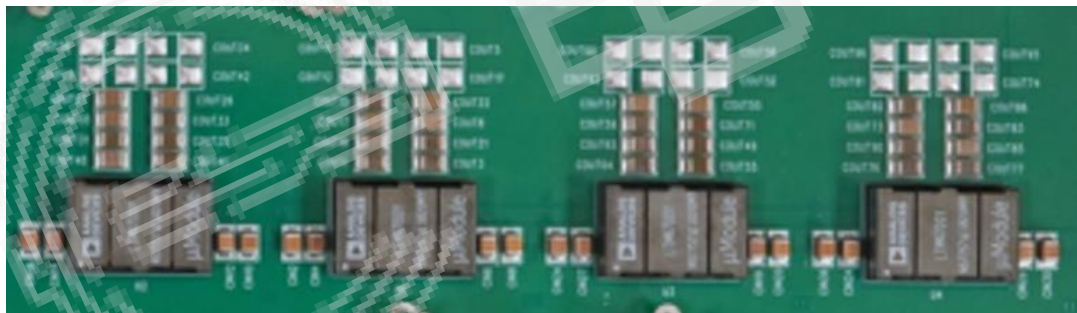
Year 2016

2x LTM4650



Year 2018

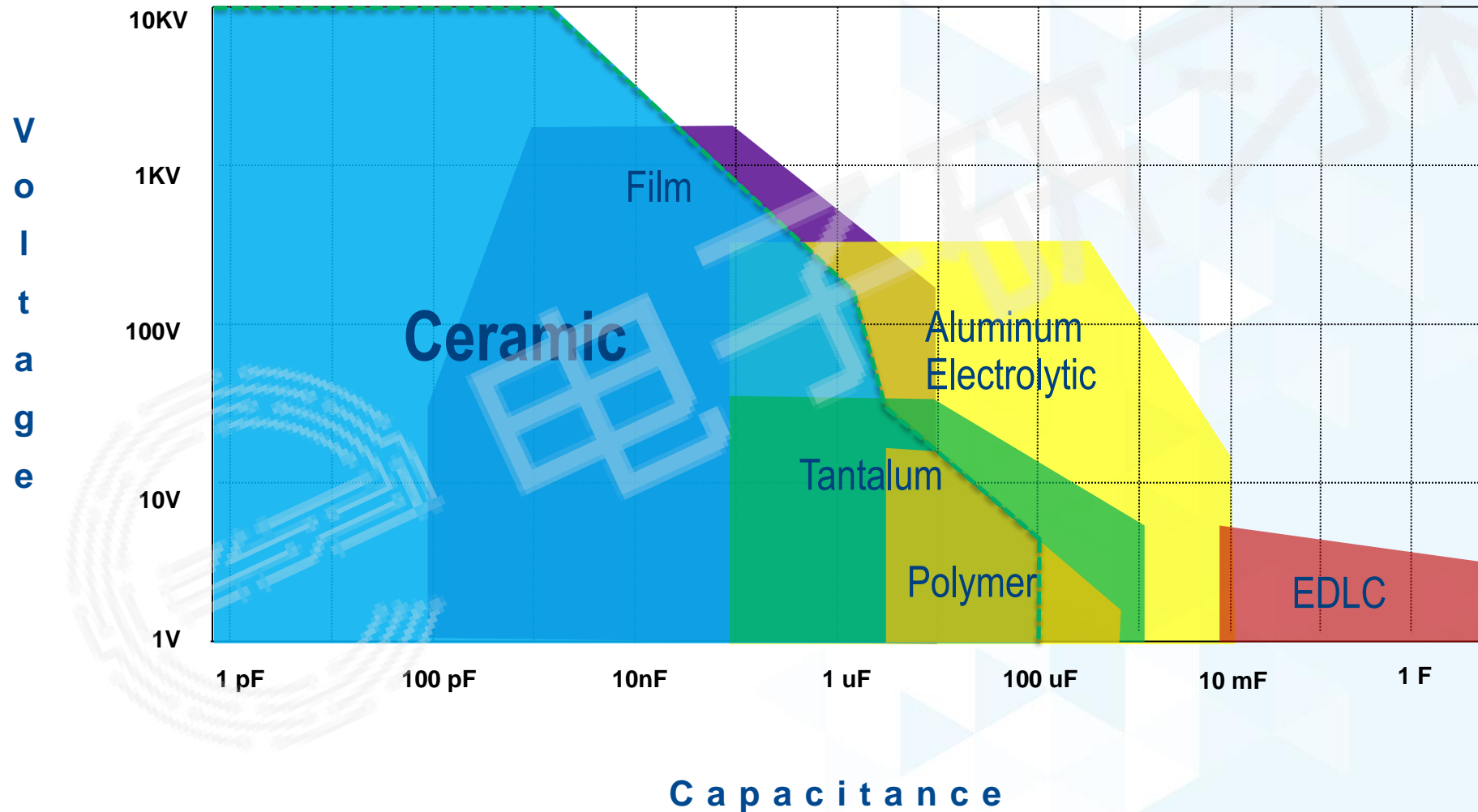
1x LTM4700



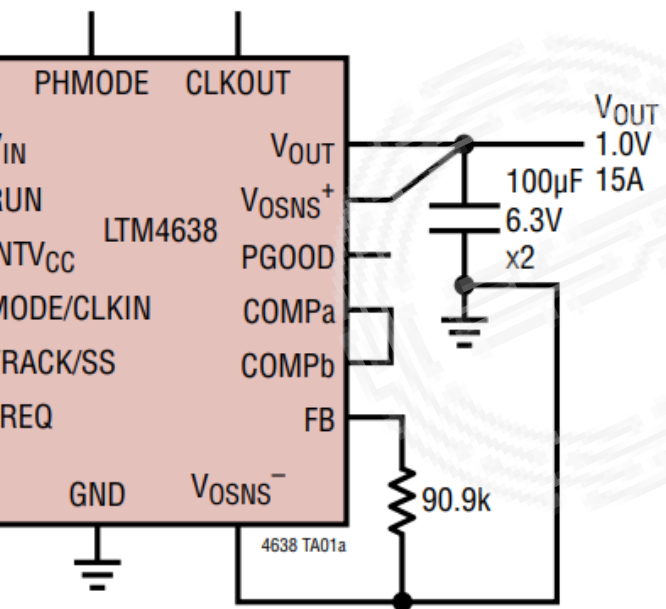
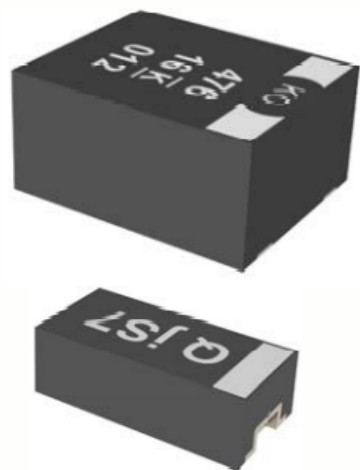
400A 4x LTM4700

- ▶ 100 A, >90% 效率
- ▶ PMBus总线
- ▶ 系统回读, 失效记录

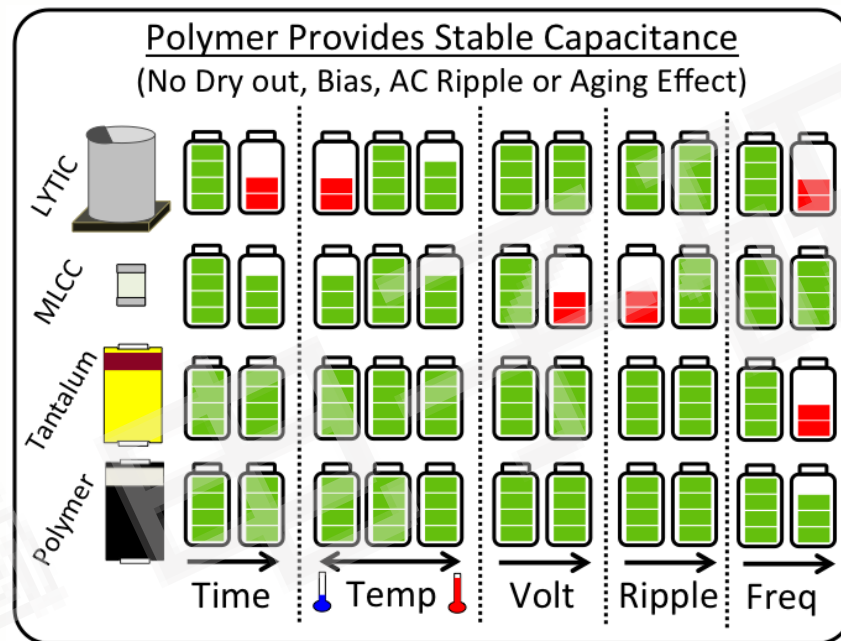
KEMET offers 95% of dielectric CAP solutions



需要100μF? – 得到 100μF!

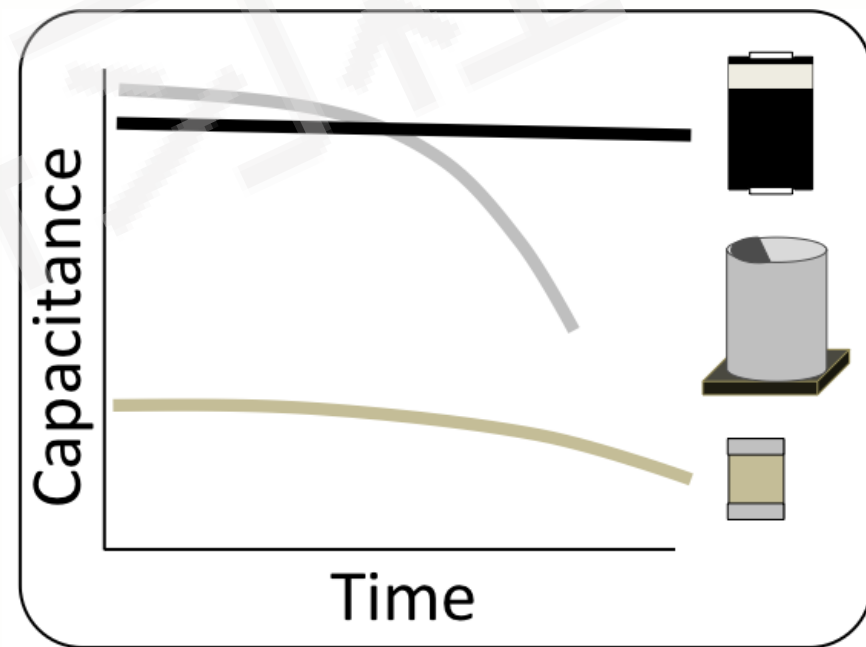


稳定的容值表现



高可靠性 (长寿命)
高稳定 (温度, 时间, 电压都无影响)

长寿命

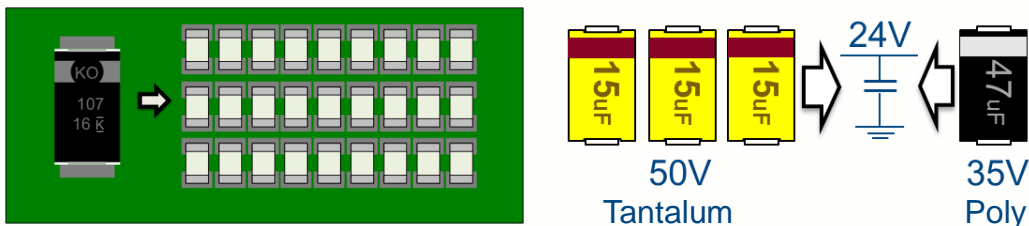


无电解液干涸问题
无老化问题

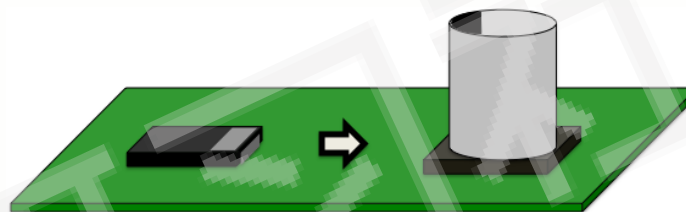
聚合物钽电容的优势



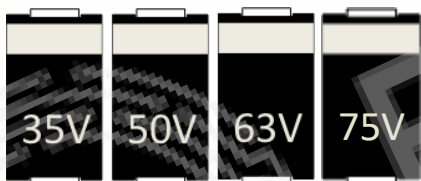
更高容值



更低高度



更高的应用电压范围

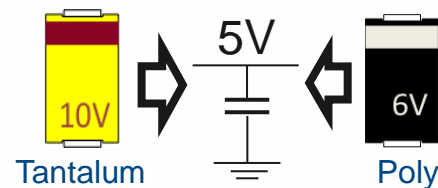


更安全的失效模式

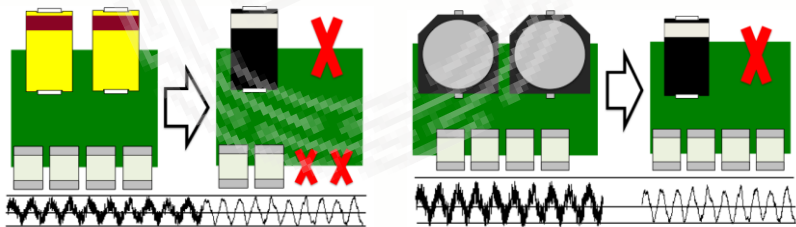


改善电压降额问题

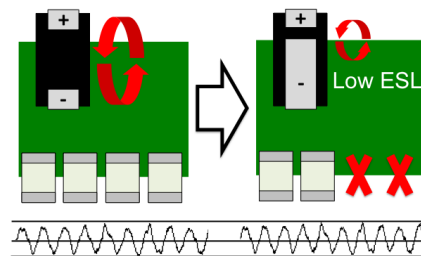
钽电容 = 50% 降额
聚合物钽电容 = 10-20%降额



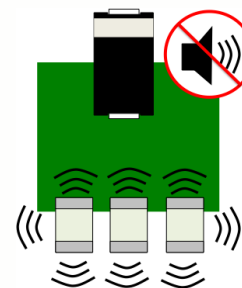
更低的ESR (降低单板使用量)



较低的ESL

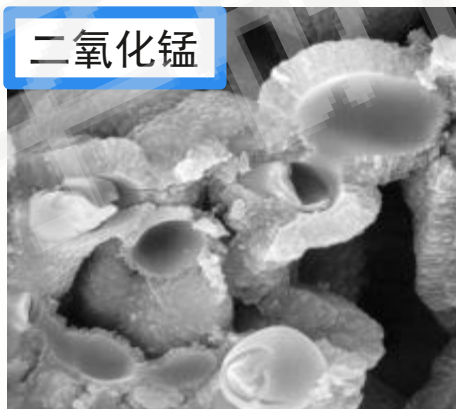
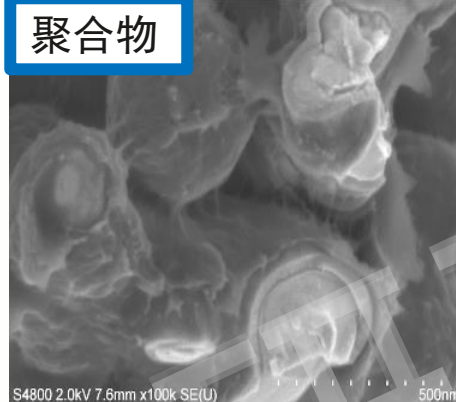


MLCC压电啸叫问题的终极解决方案



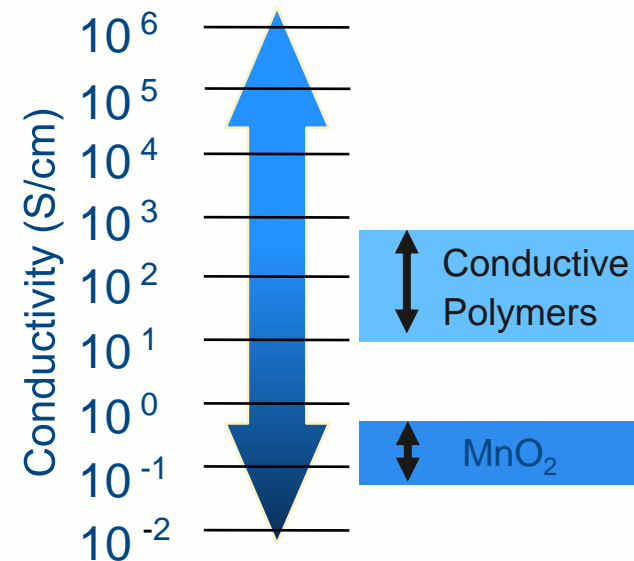
基本参数

类型	钽 (二氧化锰)	钽 (聚合物)
外观	黄色	黑色
额定电压(Vr)	4V~50V	2.5V~75V
应用电压(Va)	50%Vr	80%~90% Vr
工作温度	85~125~150~175~200°C	105~125°C (150°C, 2017)
容值范围	0.1~1500uF	10~1500uF
能量密度 (e.g 47uf, 35V)	7343-43	7343-15
等效串联电阻	Middle 10mohm~7ohm	Low 5~200mohm
工作频率	~100KHz	~10MHz
自愈特性	Yes	Yes
回流焊温度 (Peak Temp.)	260 °C	260 °C
最小尺寸	S(1206)	P(0805), 0603UD
最大尺寸	E(7360-38)	H(7360-20)
湿敏系数	1	3, 4
等效串联电感	1.0nH~2.7nH	130pH~2.7nH

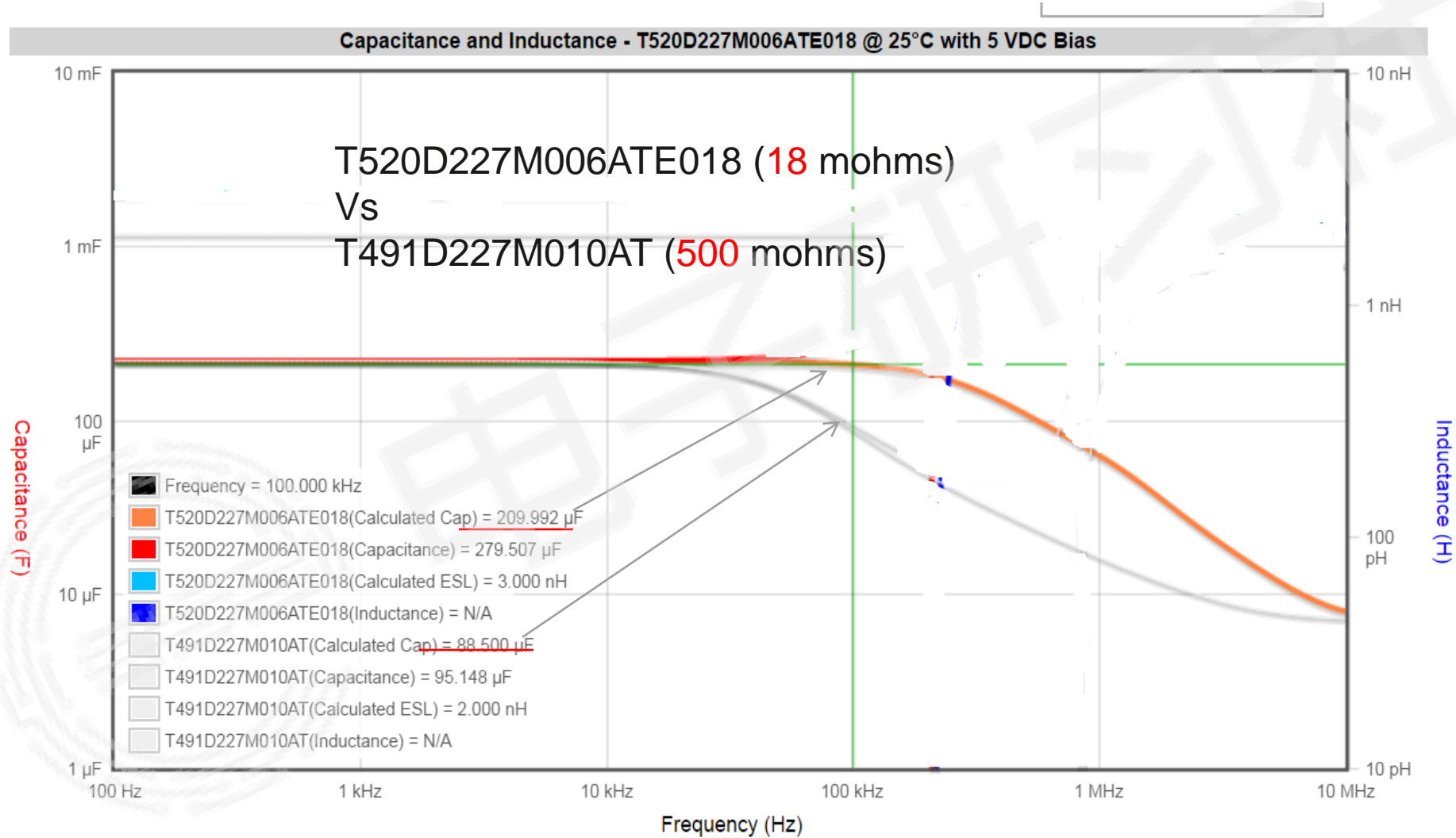


• 聚合物本质上是一种导电聚合物，柔软而有弹性，更小尺寸

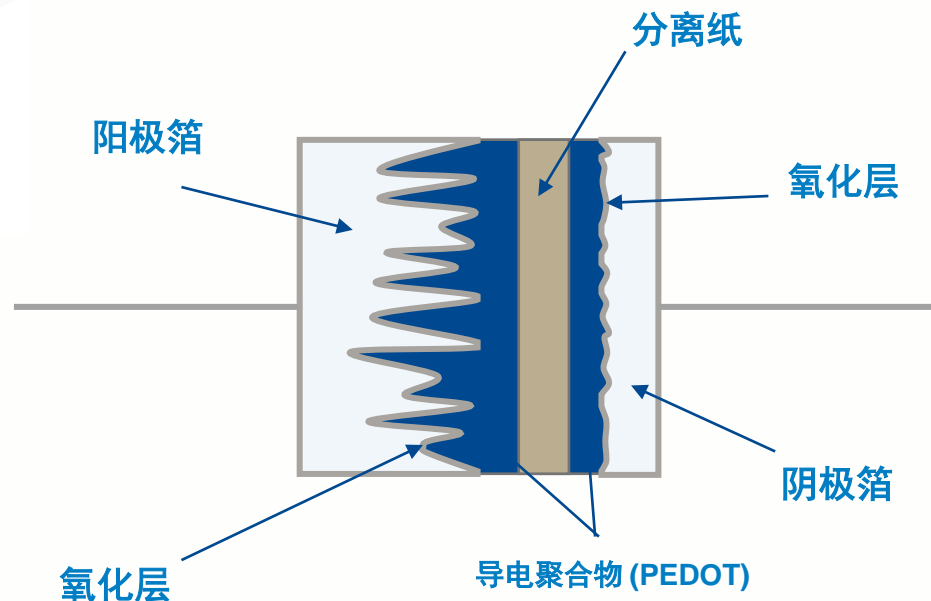
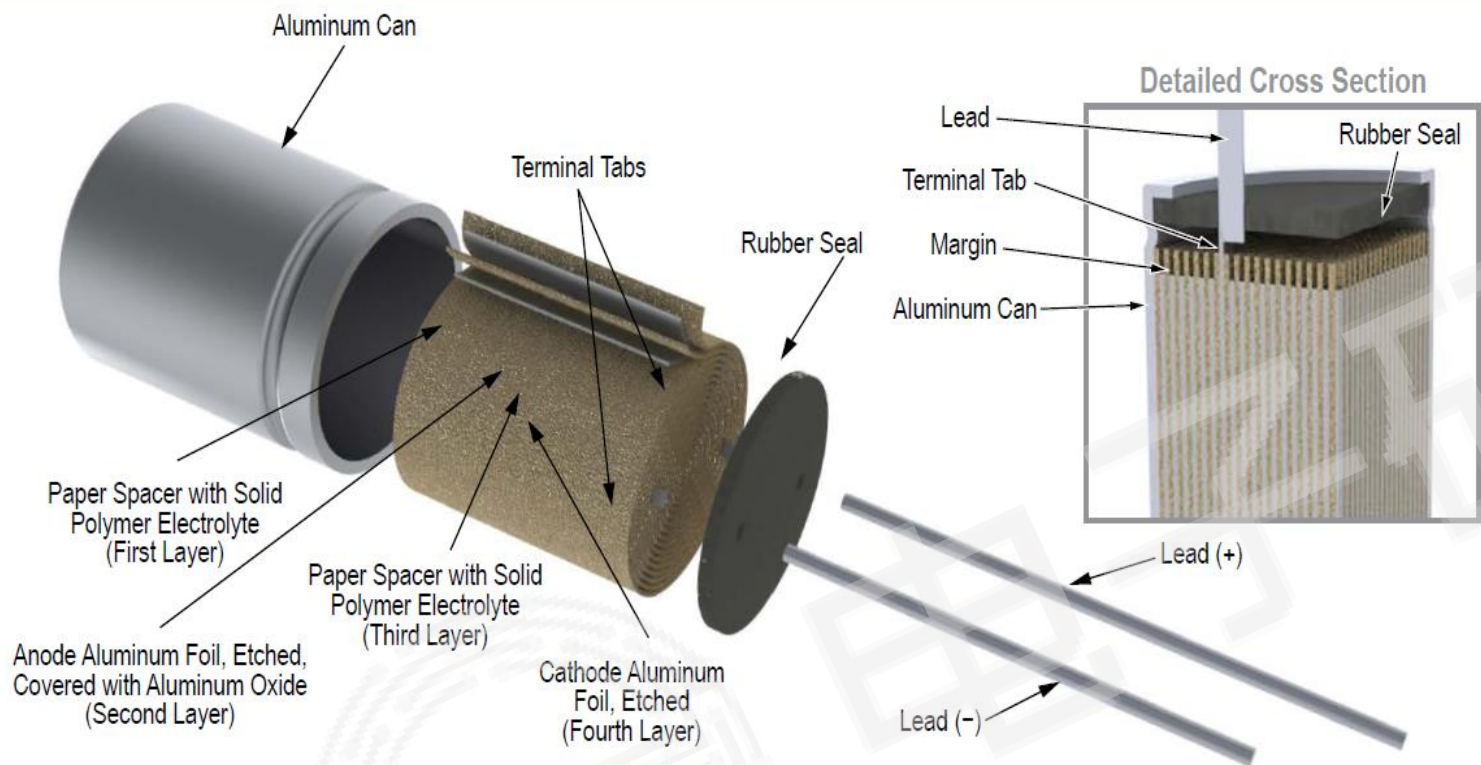
• 二氧化锰是一种氧化物，晶体状，颗粒较大



容值变化趋势

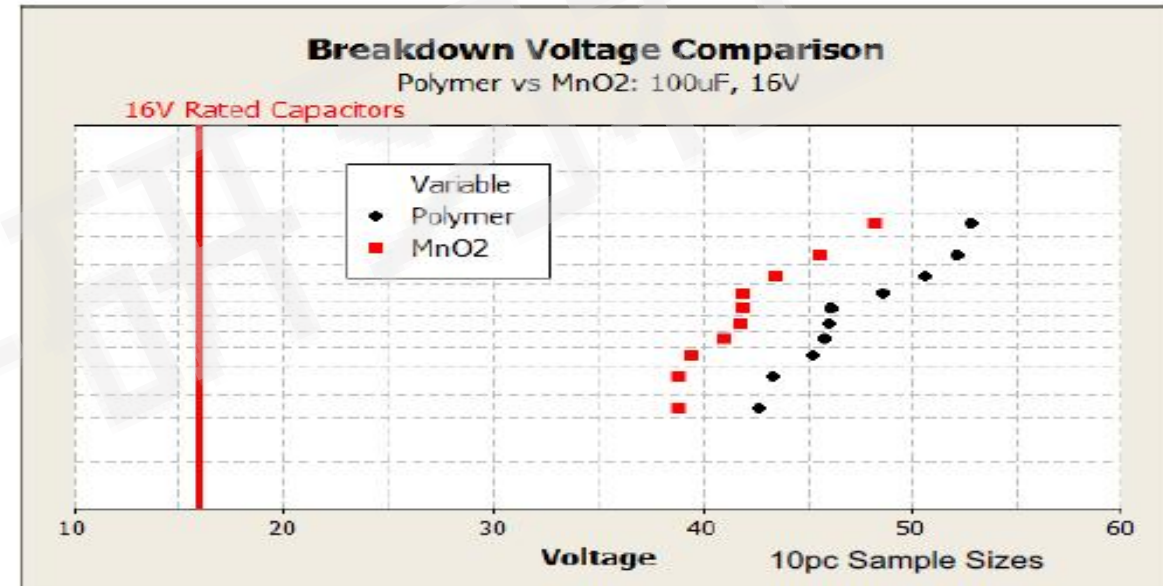
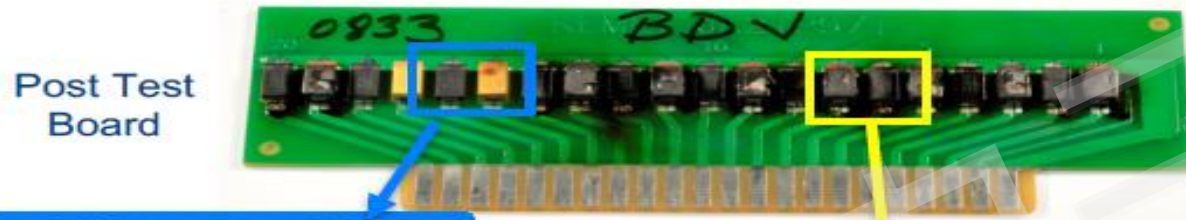
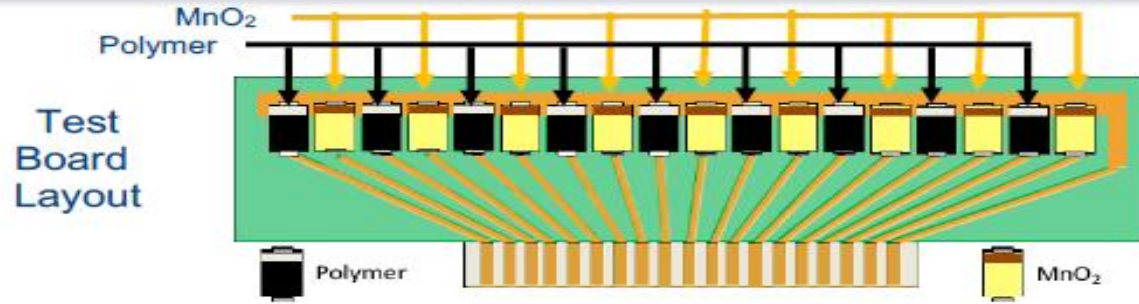


聚合物铝电容 – EO-CAP



Polymer Capacitors

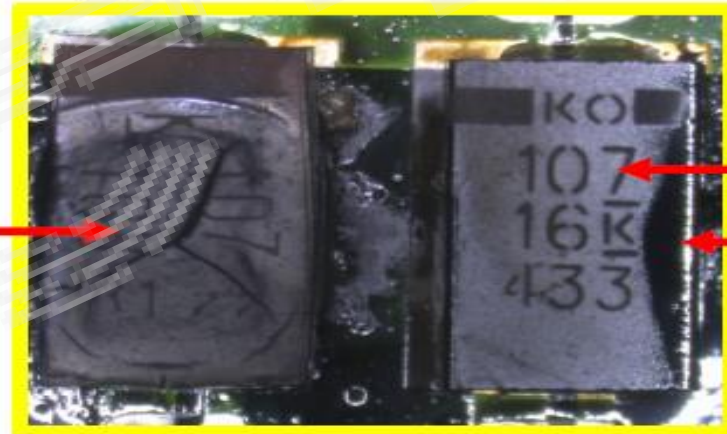
Breakdown Voltage Test: MnO₂ Cathode vs Polymer



External Damage
(Part was Yellow)

MnO₂
(Ignition)

Polymer
(No Ignition)



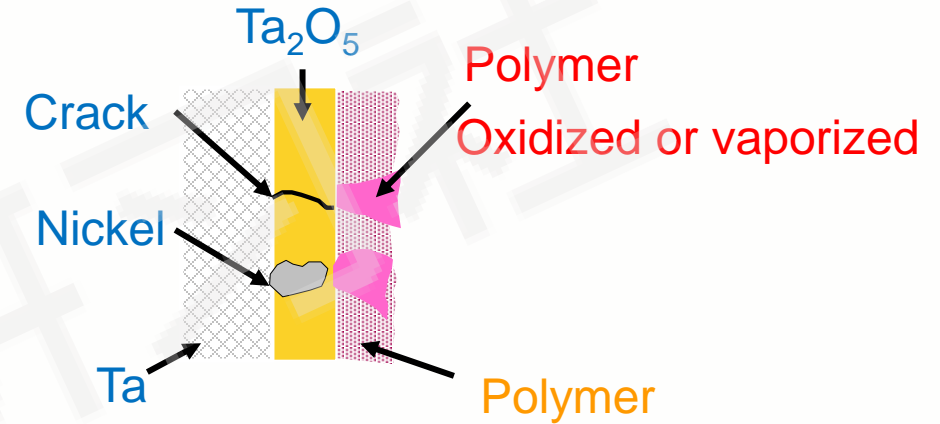
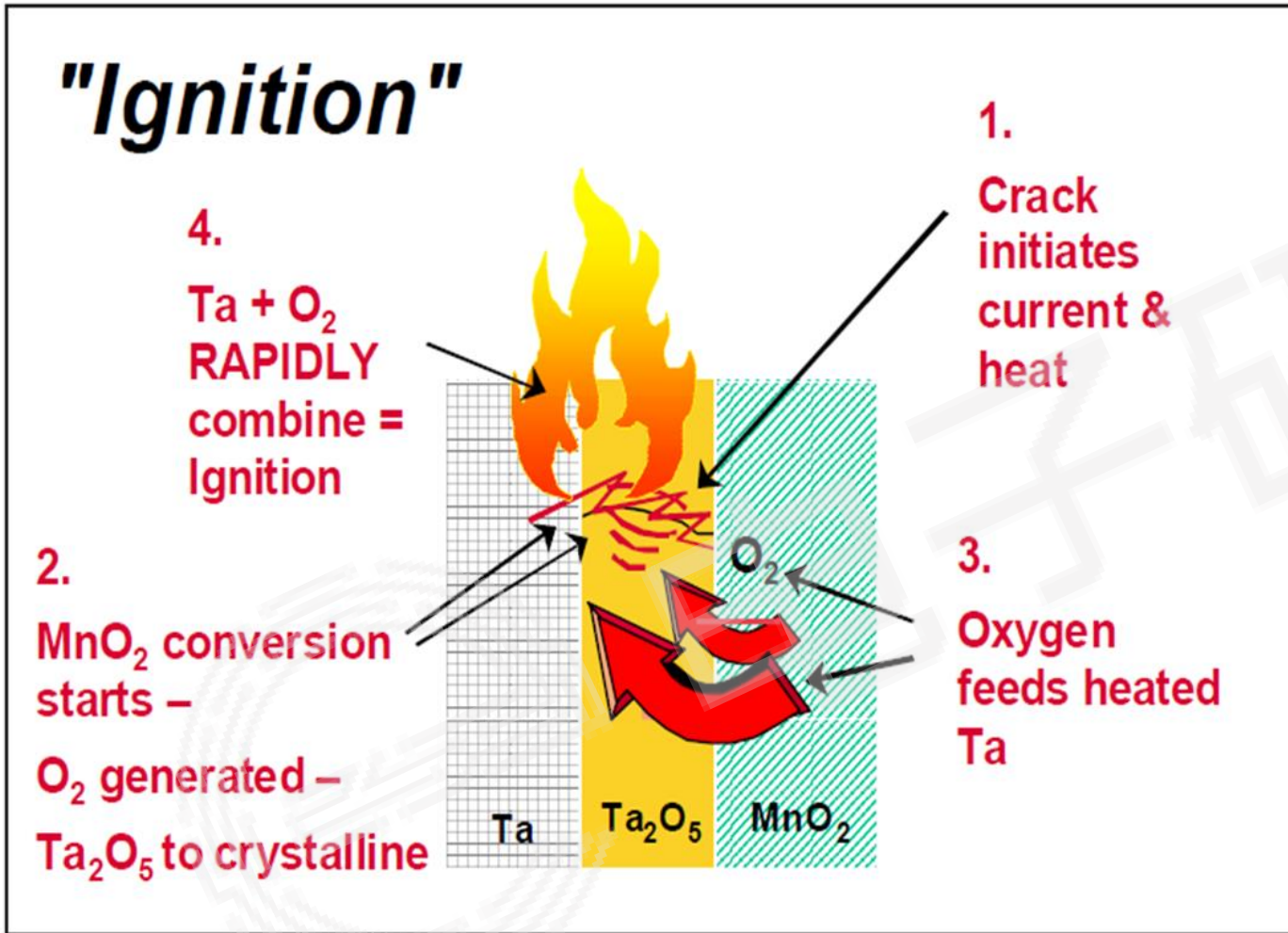
No External Damage

Surface residue
from neighboring
MnO₂ Failure

BDV Test Condition

- 2 Reflow Passes
- 85°C
- 3.3V/sec ramp
- 1.0 Amp
- No series resistance

为什么聚合物钽电容没有明火失效现象？



聚合物在高温下只会挥发掉或被氧化



燃烧是物体快速氧化，产生光和热的过程。

而燃烧是必需三种东西并存才能发生，分别是可燃物如燃料（fuel），助燃物如氧气（oxygen）及温度要达到燃点——

——热量（heat），称为燃烧三要素——**火三角**

产品路线图 - 汽车级聚合物产品



a YAGEO company

通讯 / 导航 / 工业 / 新汽车领域

500h Ur 85°C/85%RH

T591

严苛环境的解决方案

拓宽可提供产品范围 / 可评估的需求寿命时间

CVs 延展

T598



125°C

小型化

低外形

个位数的ESR

48V输入方案

可靠性

T599



150°C

<35V

>= 35V

可靠性

Txxx



175°C

Laboratory Material Settings

Prototype Samples

更丰富的容值 CV 选择
支持新需求开发

更丰富的容值 CV 选择
支持新需求开发

保持 R&D 活跃度

2017

2018

2019

2020

3216-12
47uF6V
22uF10V

2012-10
22uF6V

3528 -20
220uF6,3V

3216-12
47uF6V
22uF10V

3528 -20
220uF6,3V

2012-10
22uF6V

7343-20
330uF/2,5V
220uF4V

7343-20
470uF2,5V

7343-15
330uF2,5V

7343-20
220uF2,5V
9mOhm / 105°C

7343-31
470uF2,5V
9/6mOhm / 105°C

7343-31
470uF2,5V
9/6mOhm / 125°C

7343-43
10uF75V
15uF75V

7343-43
10uF75V
15uF75V

7343-43
10uF100V

7343-43
10uF100V

LV 125°C
/2000h

HV 125°C
/2000h

LV I 125°C
/4000h

LV II & HV I
125°C /4000h

HV II 125°C
/4000h

7343-31
22uF/35&50V
7343-43
33uF/35&50V

7343-43
33uF/35V

7343-31
22uF/35&50V
7343-43
33uF/50V

7343-43
10uF75V

7343-43
15uF75V

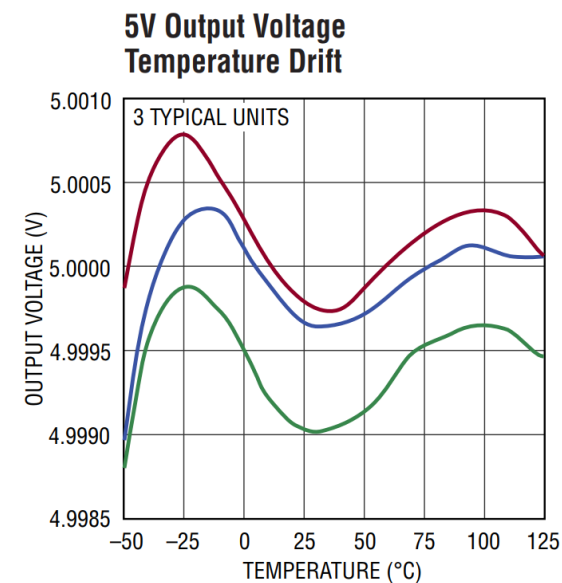
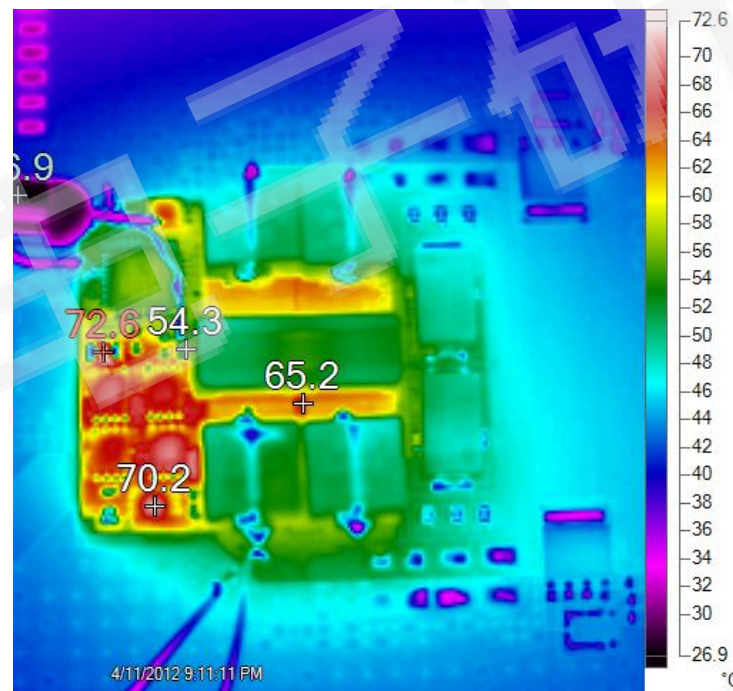
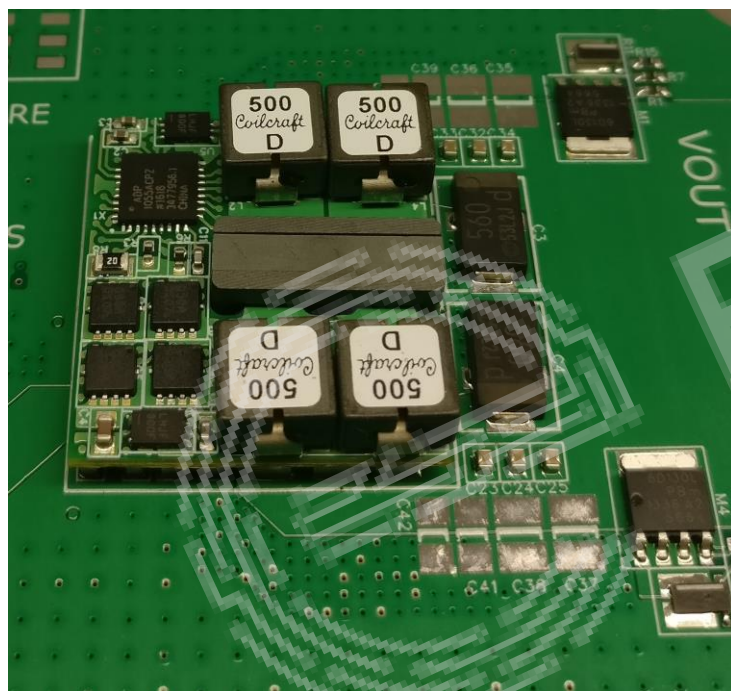
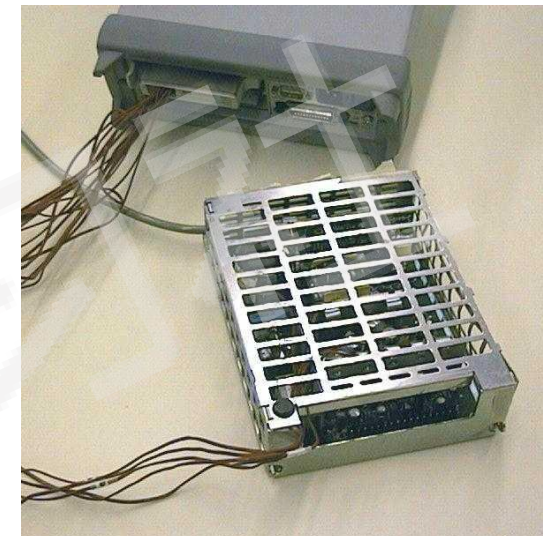
1000h / 150°C

150°C /2000h

电源效率的重要性

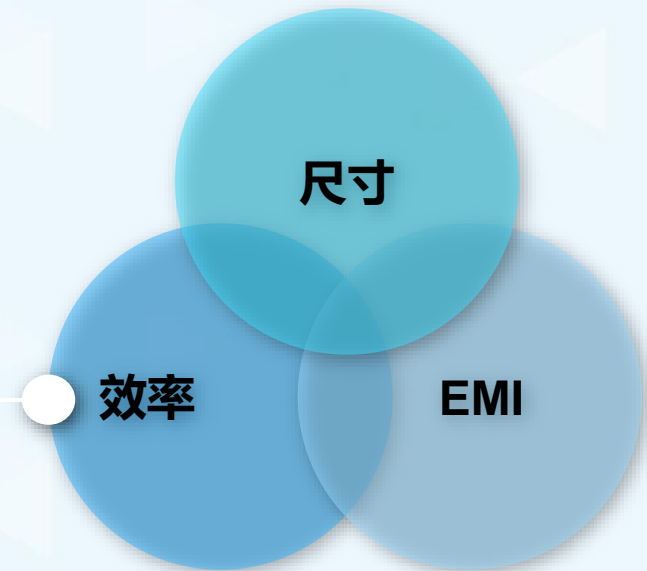
新技术带来的挑战之二：更高的效率

- 工业应用可靠性与电源效率
- 低效=更高温升=更低可靠性

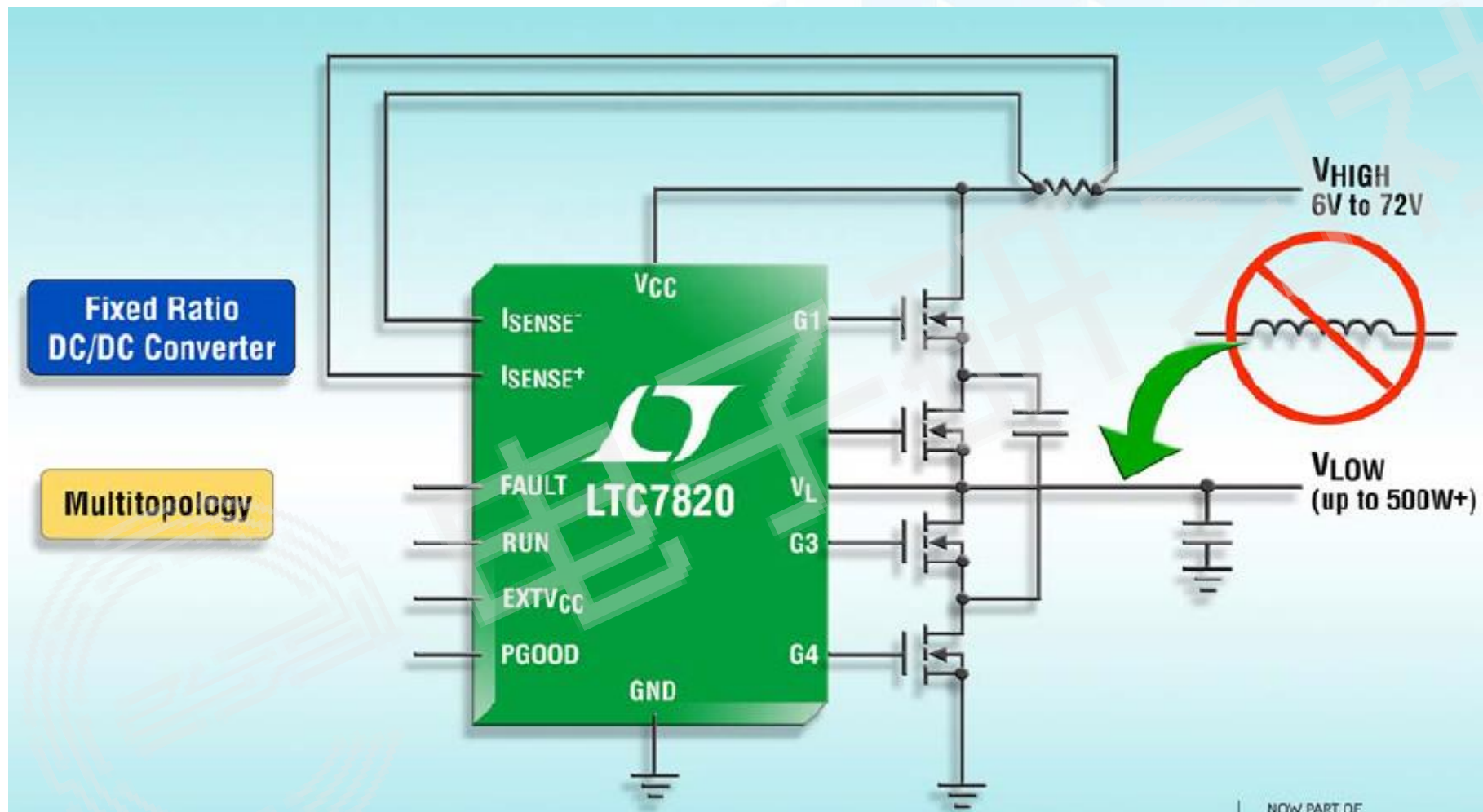


无需电感的高效开关电源 混合型开关电源

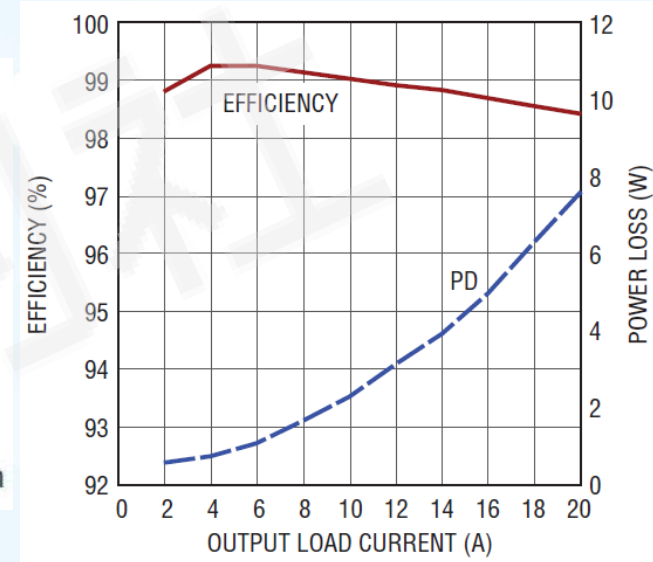
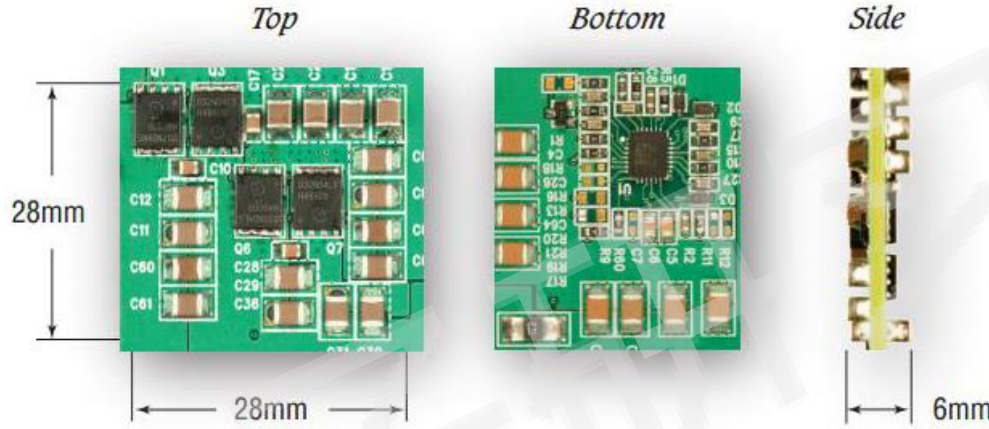
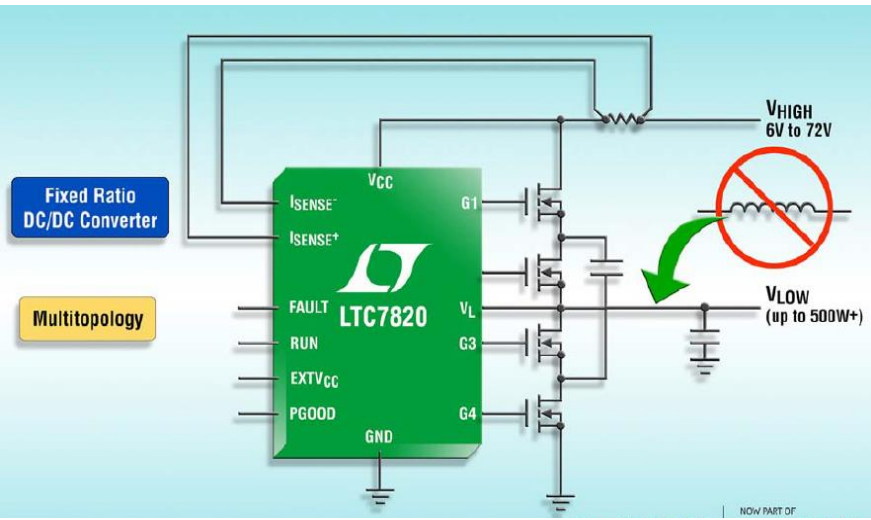
高效率电源有助于系统热功耗设计，提升系统稳定性



传统开关电源的效率损失与改进思路



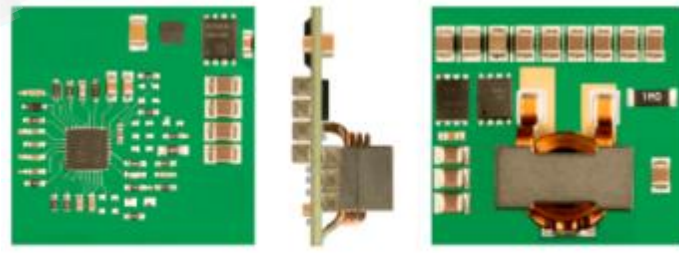
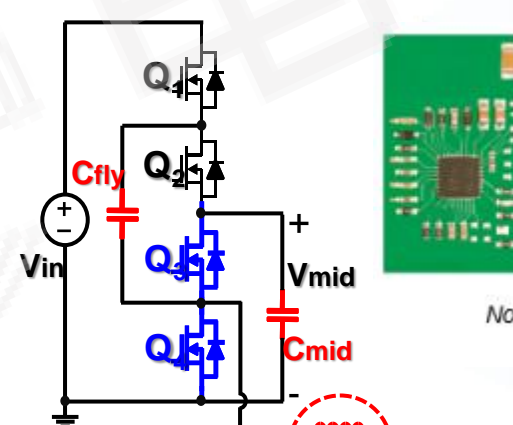
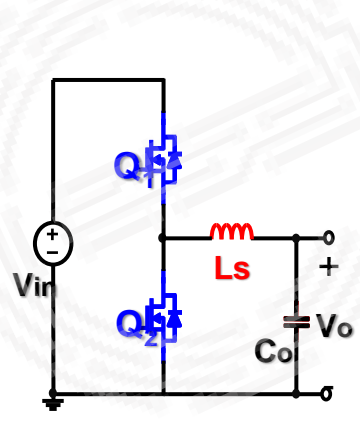
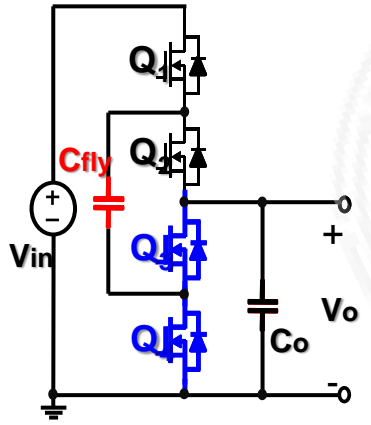
无电感及混合型高效率开关电源



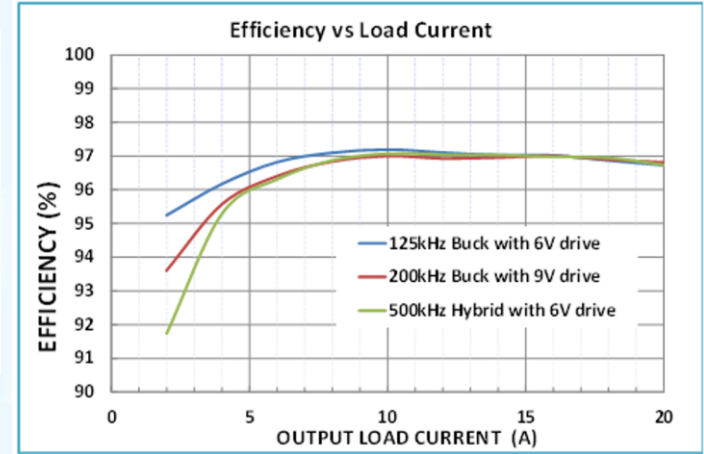
❖ 飞行电容

❖ 同步Buck

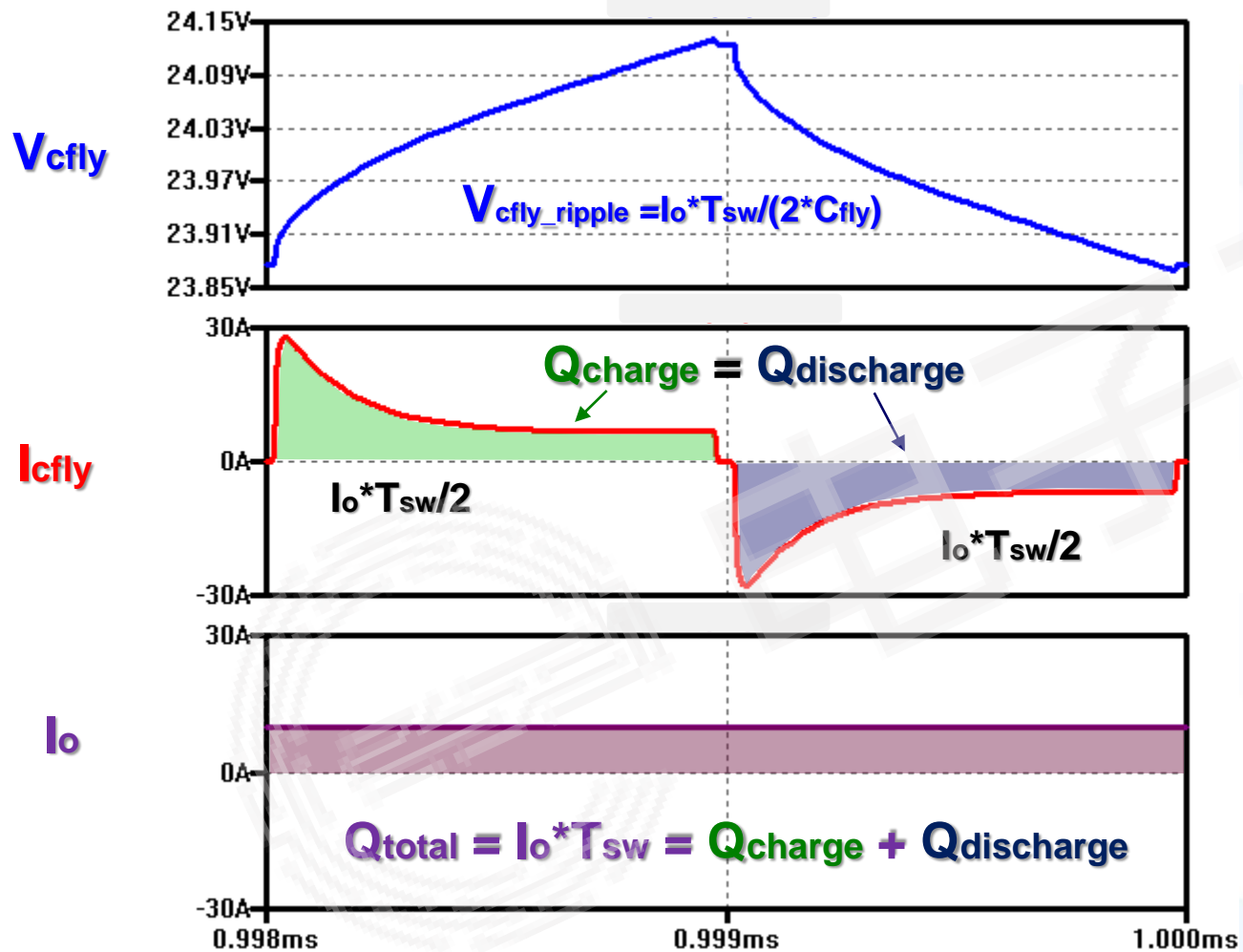
❖ 混合型电源变换器



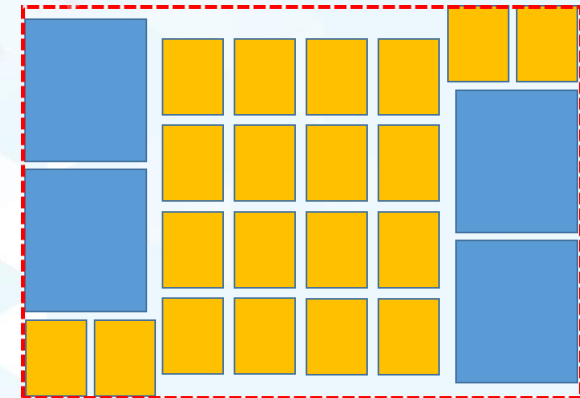
Non-Isolated Distributed Power Architecture Using LTC7821



至关重要的飞行电容性能



$V_{in} = 48V$, $V_o = 24V/20A$,
 $C_{fly} = 16 \times 10\mu F/50V/X7R/1210$
 $F_{sw} = 200kHz$, $Q_1 = BSC027N06LS5$,
 $Q_2 = Q_3 = Q_4 = BSC032N04LS$

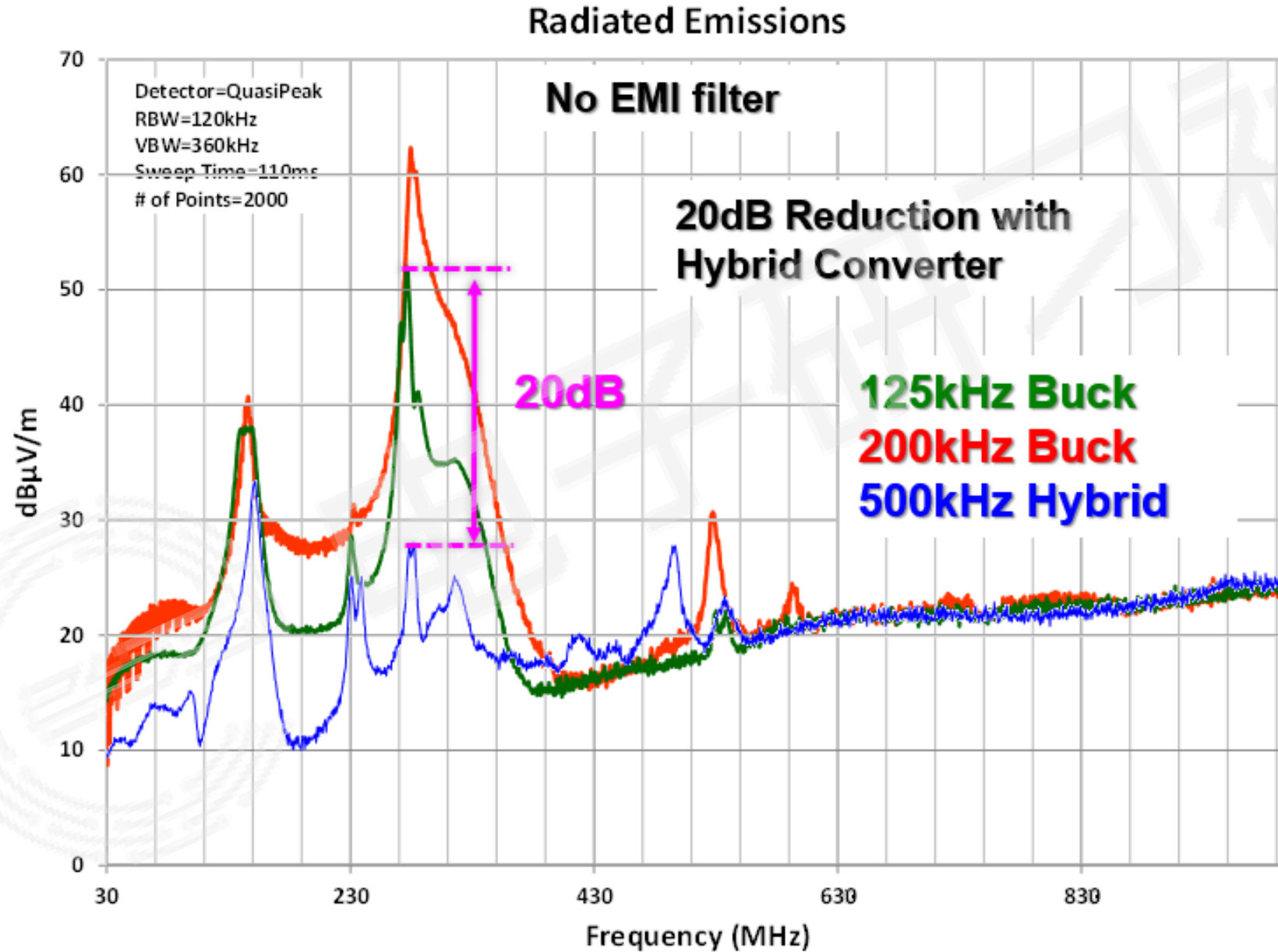


15mm x 13mm x 5mm

(0.59" x 0.51" x 0.2")

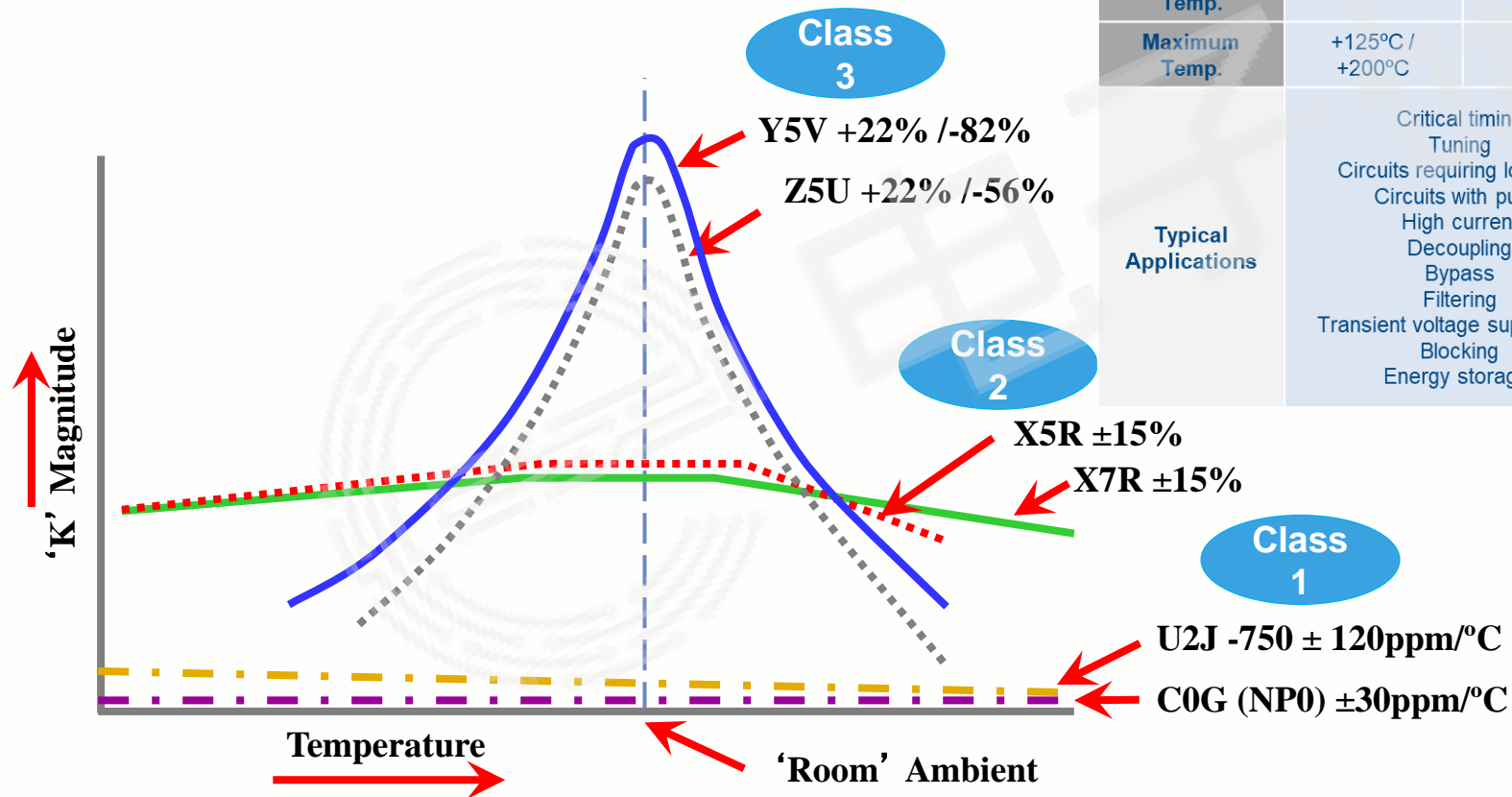
Power density: 4000W/inch³
(800W/inch²)

LTC7821 – EMI減少20dB



相对容值 vs. 环境温度 (TCC)

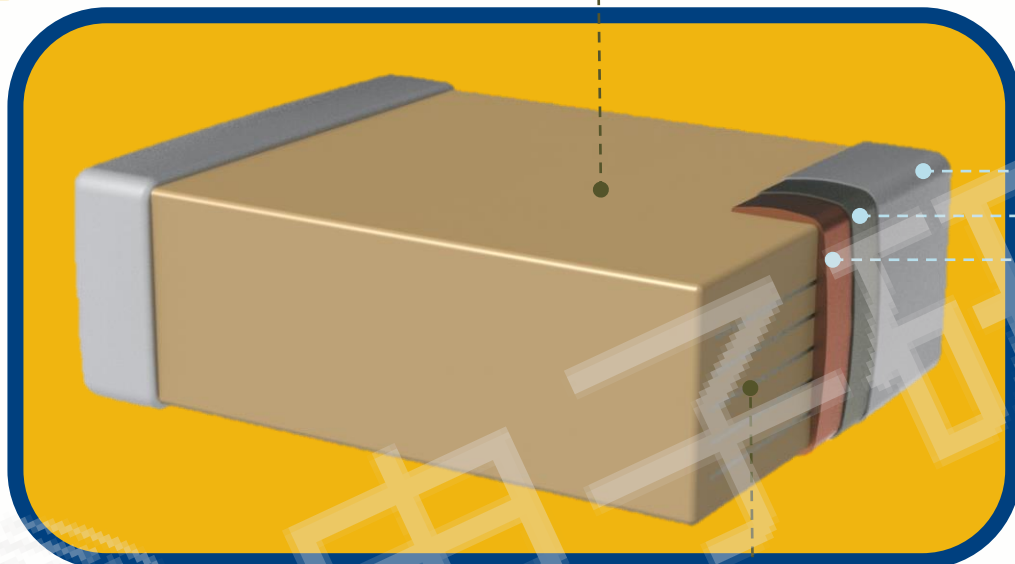
Dielectric Classification	CLASS I		CLASS II				CLASS III	
Temperature Coefficient	C0G	U2J	X7R	X5R	X8R	X8L	Z5U	Y5V
Capacitance Shift	±30ppm/°C	-750 ± 120ppm/°C	±15%	±15%	±15%	+15% / -40%	+22% / -56%	+22% / -82%
Technology	PME & BME	BME	PME & BME	BME	BME	BME	BME	BME
Minimum Temp.	-55°C	-55°C	-55°C	-55°C	-55°C	-55°C	+10°C	-30°C
Maximum Temp.	+125°C / +200°C	+125°C	+125°C / +175°C	+85°C	+150°C	+150°C	+85°C	+85°C
Typical Applications	Critical timing Tuning Circuits requiring low loss Circuits with pulse High current Decoupling Bypass Filtering Transient voltage suppression Blocking Energy storage.		Decoupling Bypass Filtering Transient voltage suppression.				Decoupling Bypass Filtering	



MLCC 种类

介质材料

Class	BME	PME
COG	•	•
U2J	•	
X8R	•	
X8L	•	
X7R	•	•
X5R	•	
Z5U	•	
Y5V	•	
BP	•	•
BX		•
BR		•

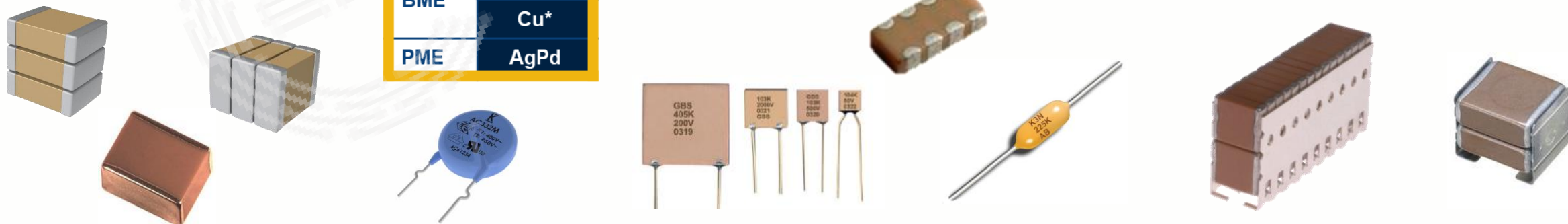


金属化端头材料

	External Electrodes	Barrier Layer	Finish
BME	Cu	Ni	(C) Sn - 100% (L) SnPb - 5% Pb min (E) Au - 1.97 - 11.8 μin (F) Au - 30 - 50 μin (G) Au - 100 μin min
BME Flex	Cu + Ag Epoxy	Ni	(C) Sn - 100% (L) SnPb - 5% Pb min
PME	Ag	Ni	(C) Sn - 100% (L) SnPb - 5% Pb min

内电极材料

BME	Ni
	Cu*
PME	AgPd



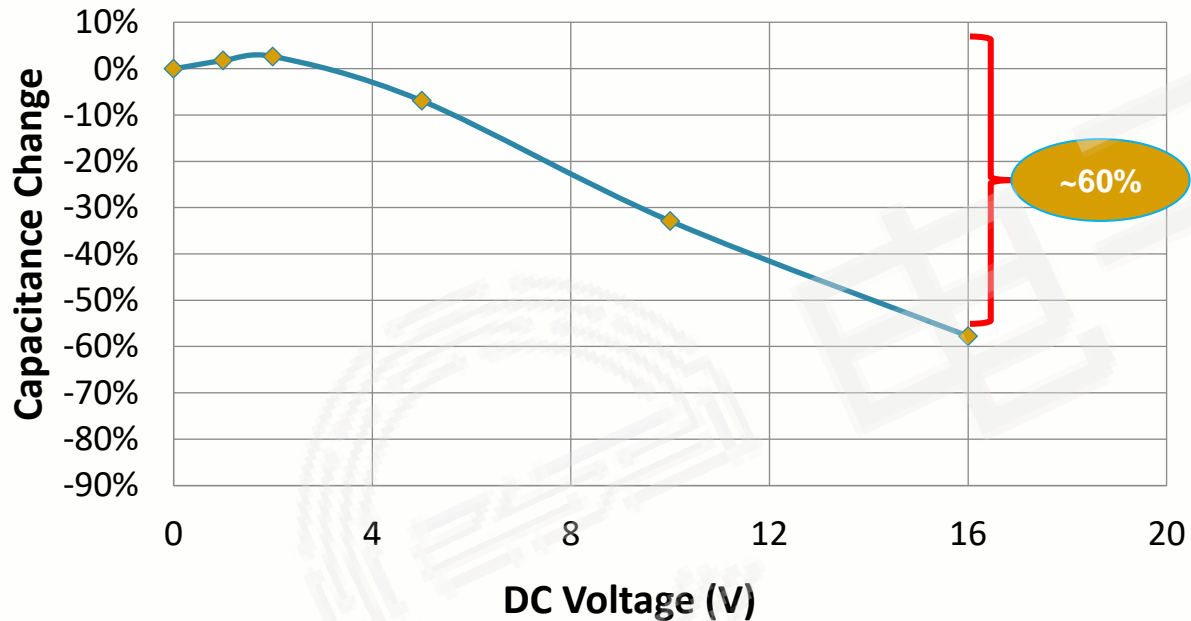
容值稳定性

直流偏压影响 – 2类介质 和三类介质 MLCC



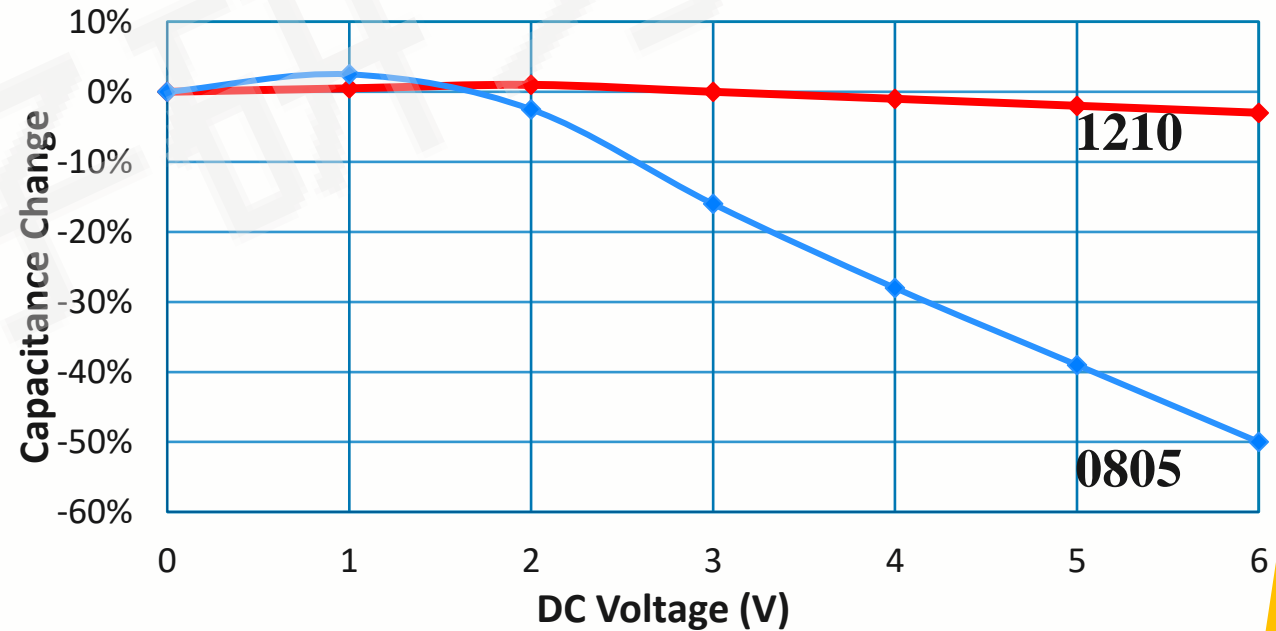
容值 vs. 直流电压

X7R 1206 10uF 16V

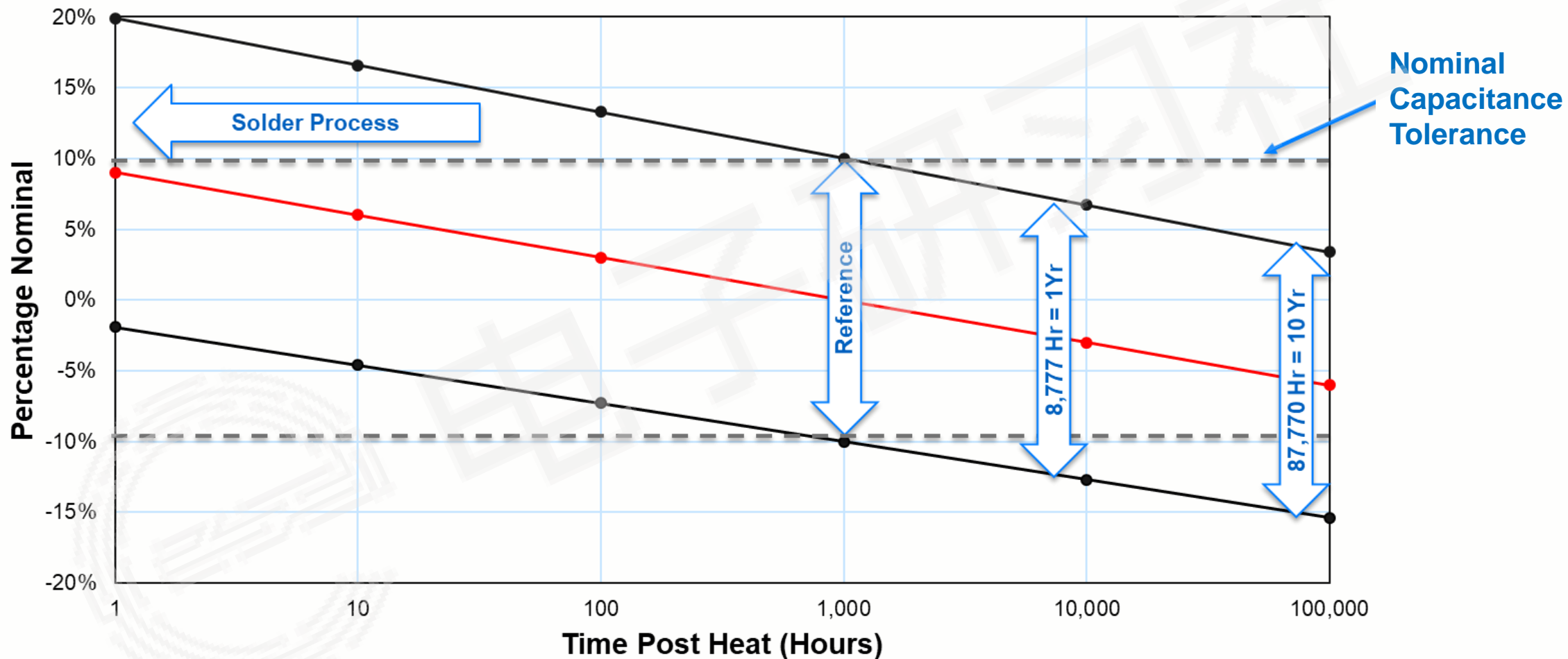


容值变化 vs. 直流偏压

1210 vs. 0805, X7R, 10uF, 6.3V



容值稳定性 vs. 时间 (二类介质老化问题)

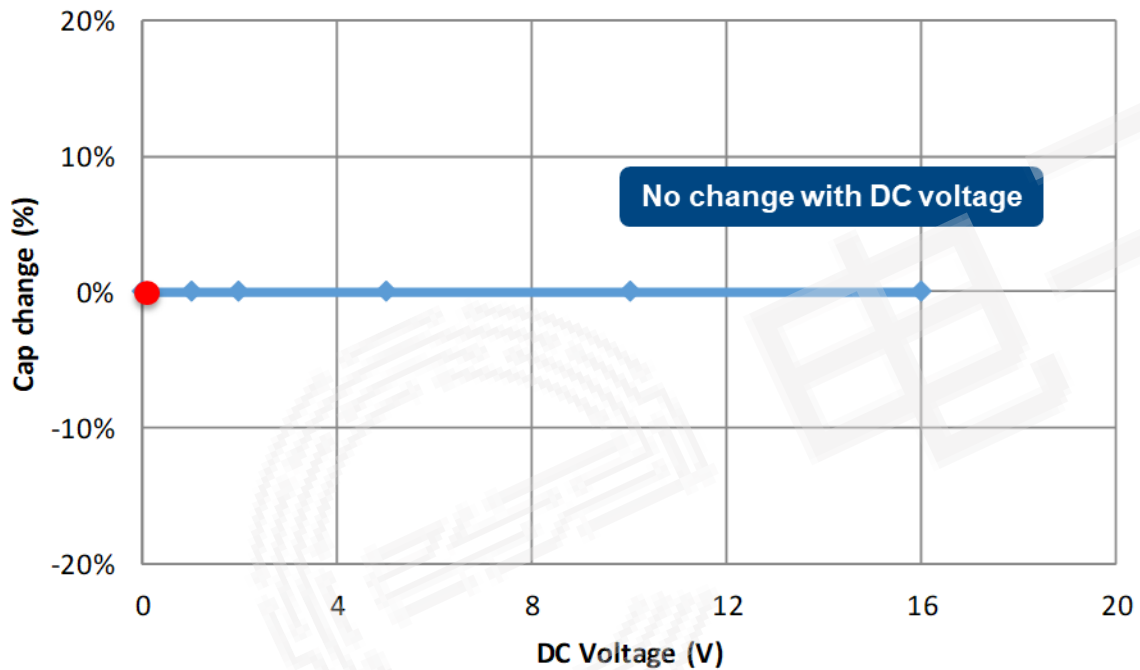


<https://ec.kemet.com/design-tools/aging-calculator-for-ceramics>

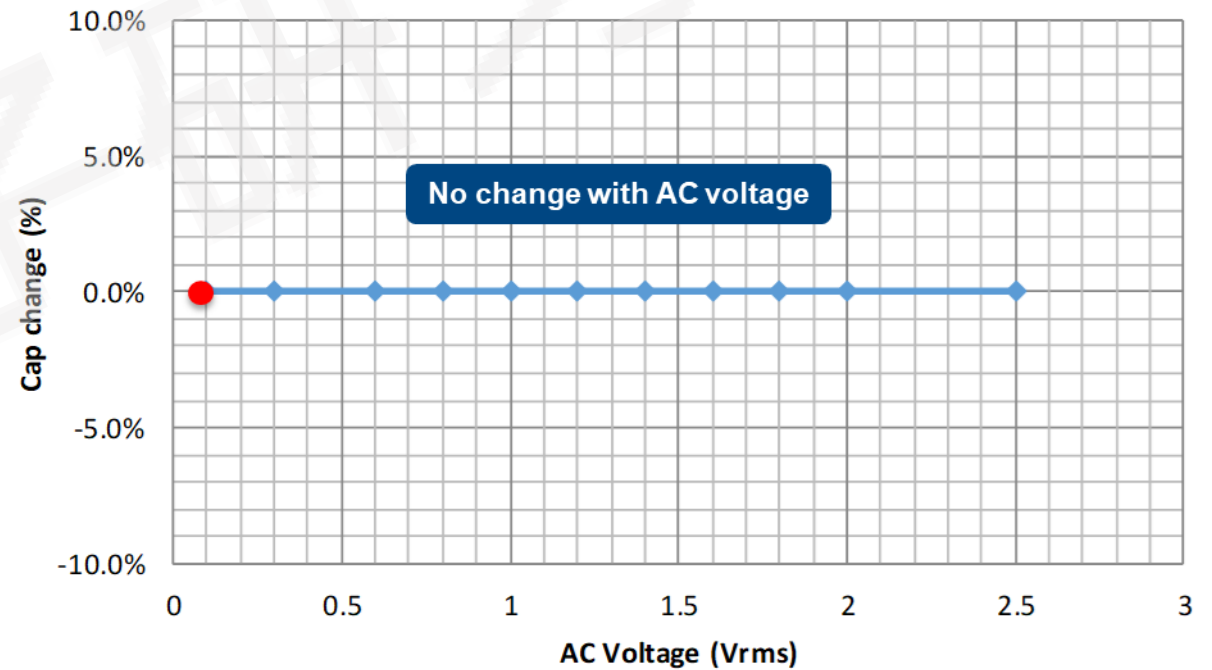
容值稳定性

一类介质随电压变化 - 极稳定, 无变化

Capacitance Change vs DC Voltage COG 1210 220nF 25V

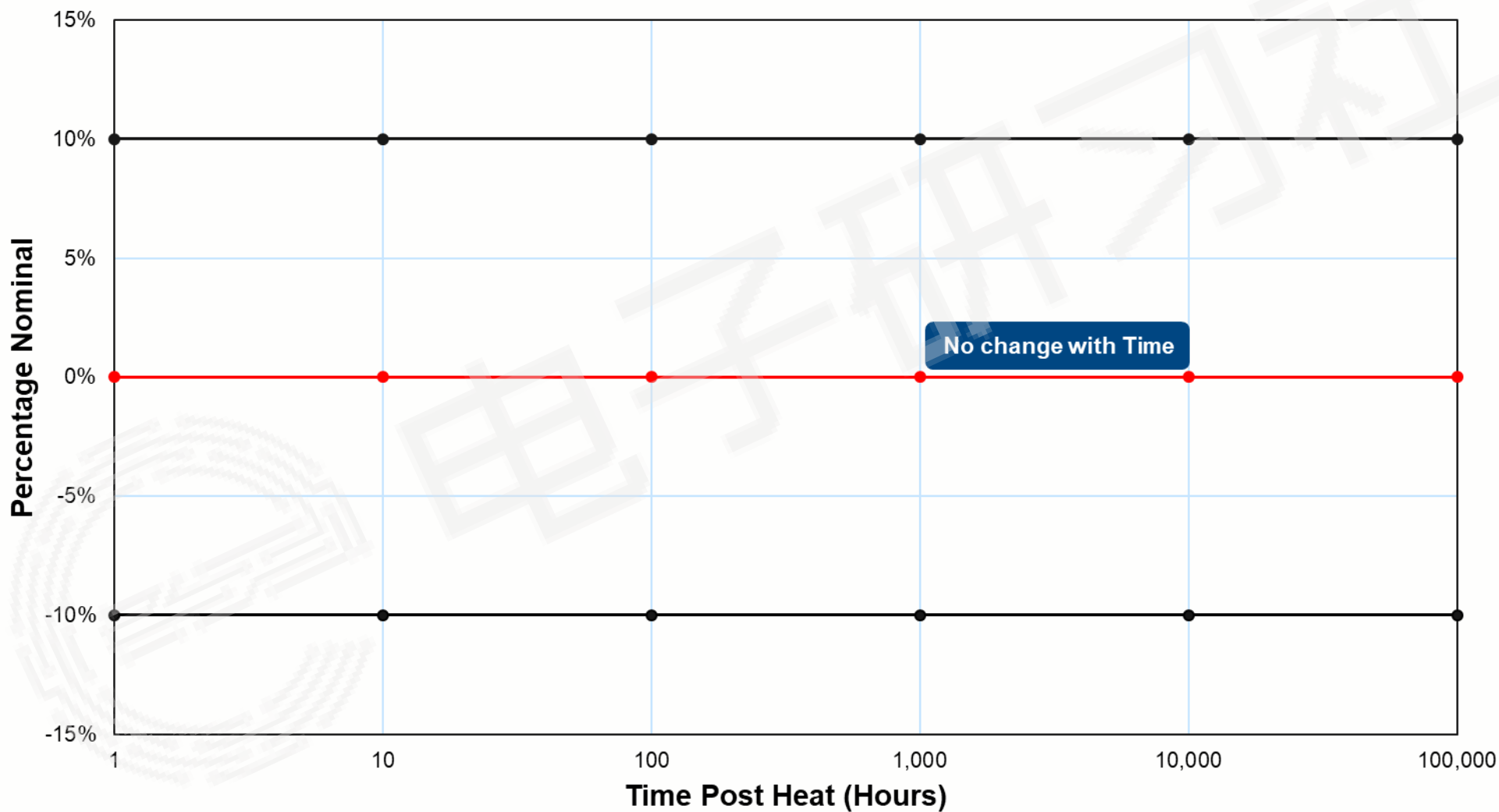


Capacitance Change vs AC Bias COG 1210 220nF 25V



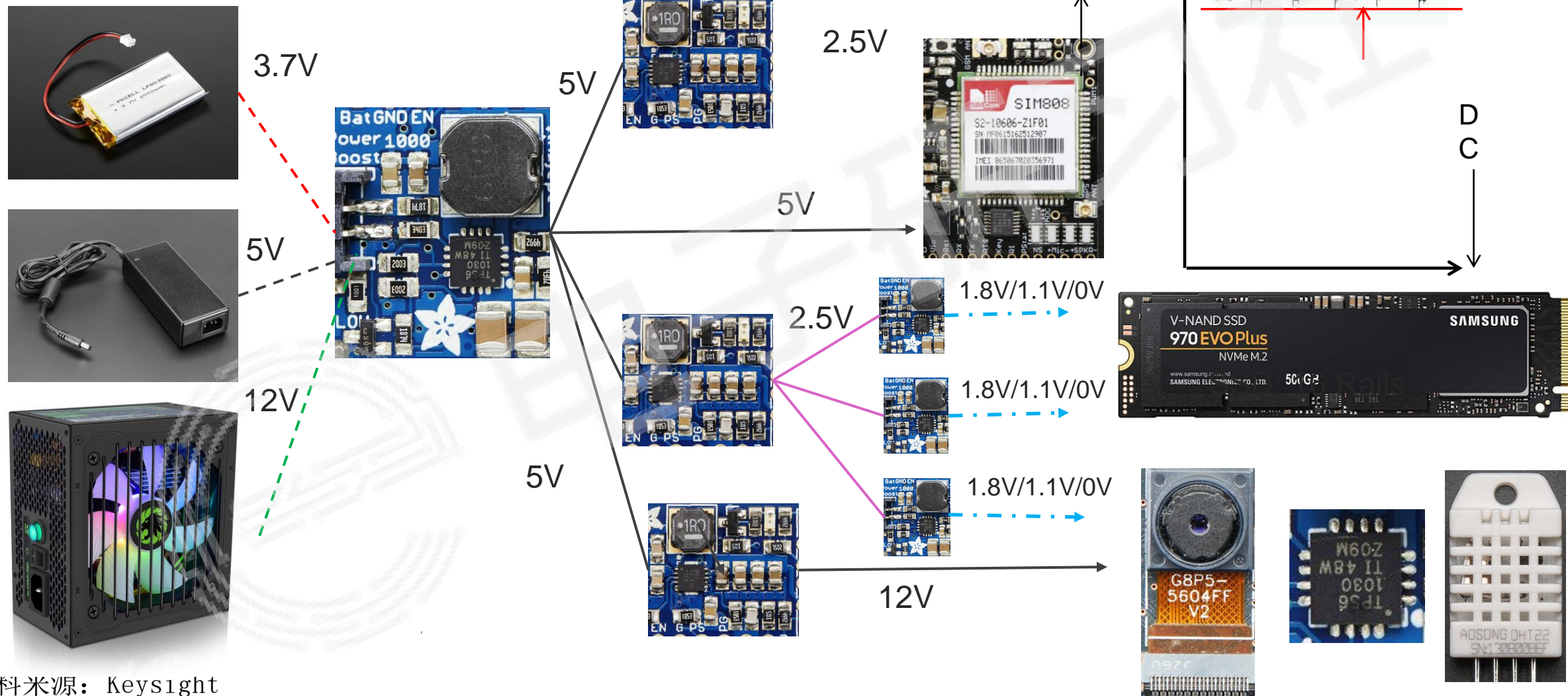
容值稳定性

一类介质随时间变化 – 无变化



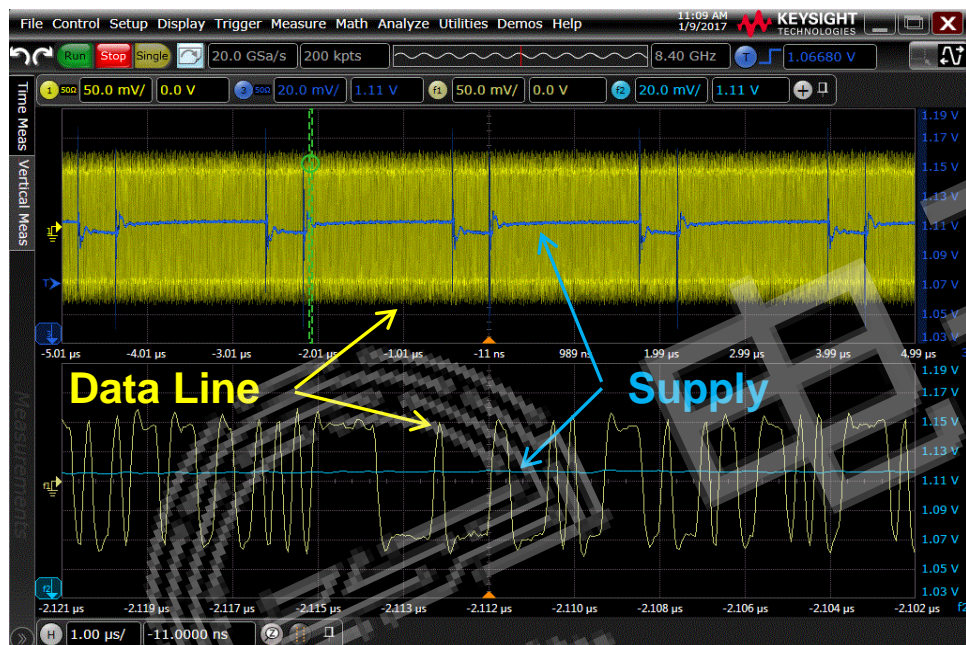
电源完整性问题

新技术带来的挑战之三：EMI和电源完整性

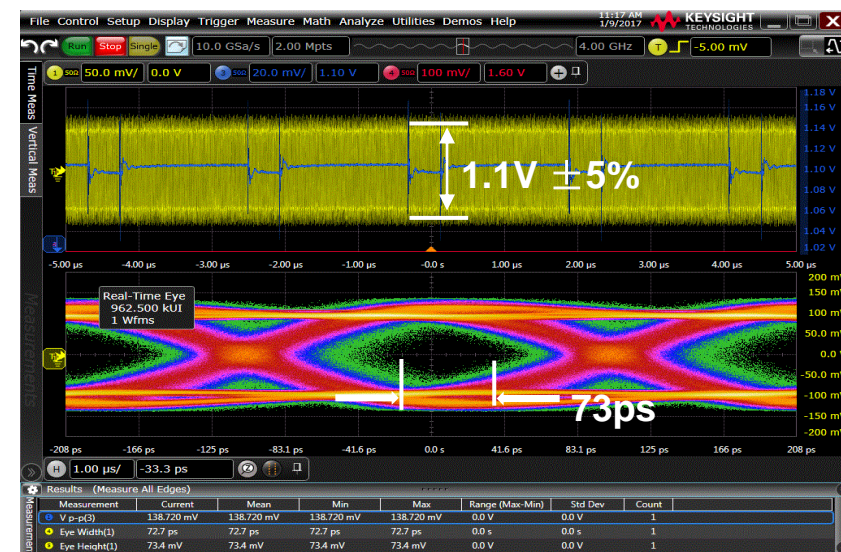
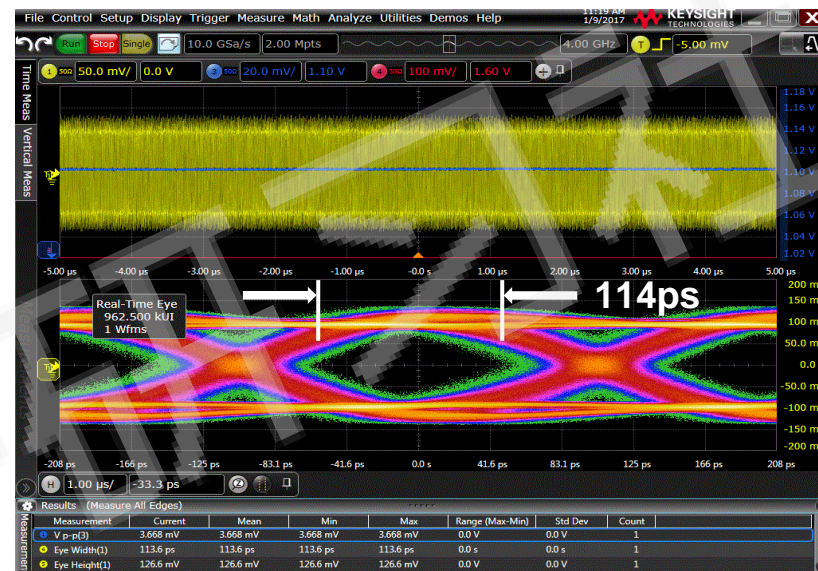


新技术带来的挑战之三：EMI和电源完整性噪声导致高速数字电路中明显恶化的眼图

1.10V Supply with 3mV_{pp} Noise



1.10V Supply with 115mV_{pp} Noise



新技术带来的挑战之三：EMI和电源完整性 医疗影像设备

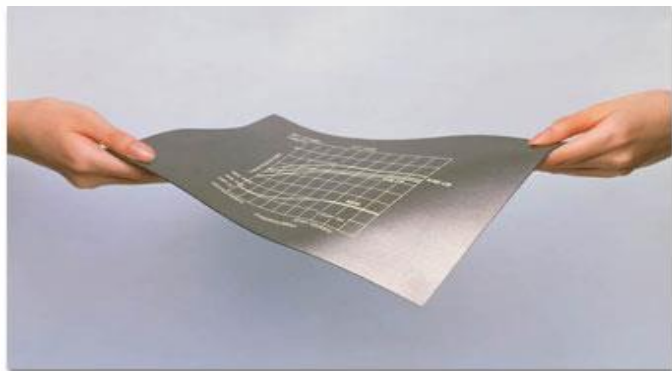


低噪声的环境至关重要 - 任何额外的电磁传导和辐射噪声，都可能影响成像的清晰度

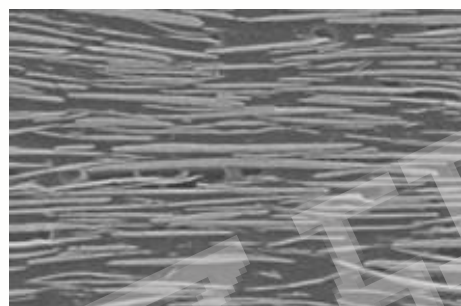
吸波材料的简易认知

KEMET

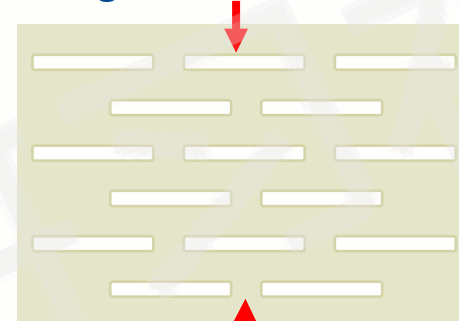
a YAGEO company



Cross-Section Structure of Flex Suppressor



Magnetic metal flakes



Polymer

右图并不是吸波材料的实际制造方法。由于，吸波材料与EMI磁环具有同样的吸收EMI干扰的能力，因此为方便理解，等效为右图。

EMI 磁环



Split



Break into pieces



Break into micron size

吸波材料



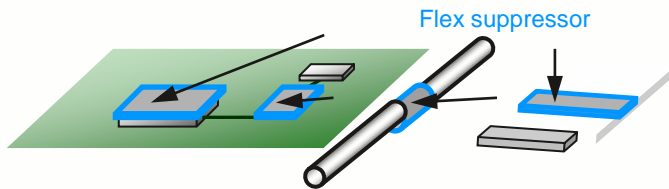
Make sheet by blending & dispersing magnetic powder in polymer

使用方法

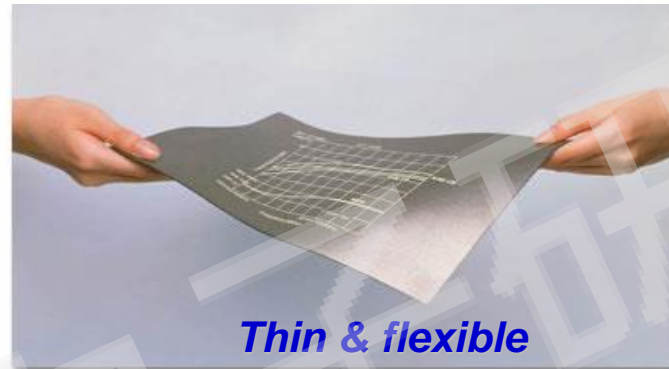
FLEX-SUPPRESSOR™

For EIM

Radiation (for EMI regulation)



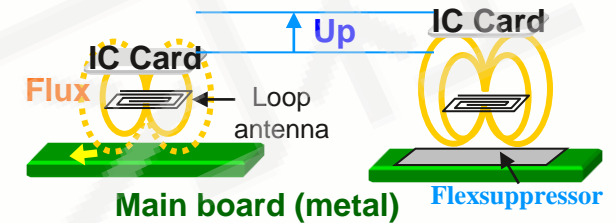
Suppression of radiation noise from CPU/GPU, signal line, cable etc.



Thin & flexible

For RFID

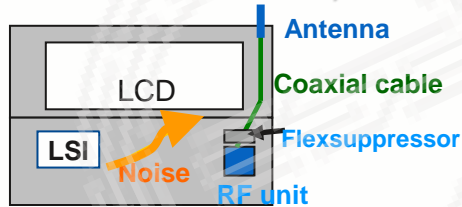
NFC (RFID etc)



NFC communication distance is enhanced by Flex-suppressor.

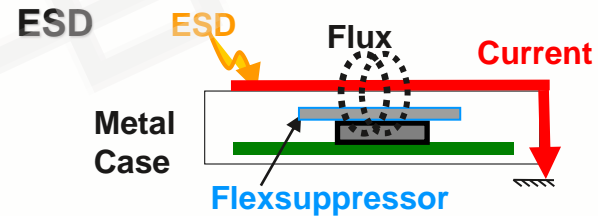
For Desence

Wi-Fi (for internal interference)



Internal noise is interfering to Wi-Fi receiving sensitivity. Flex-suppressor improves desense.

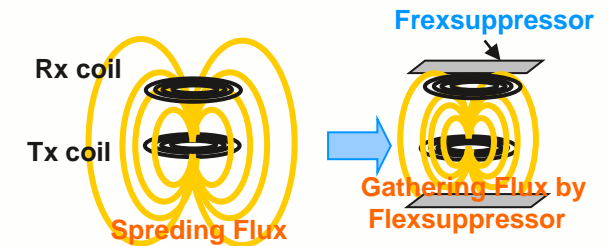
For ESD



Internal interference caused by ESD is a factor of false operation. Flex-suppressor improves this issue.

For Wireless charging

Wireless charging



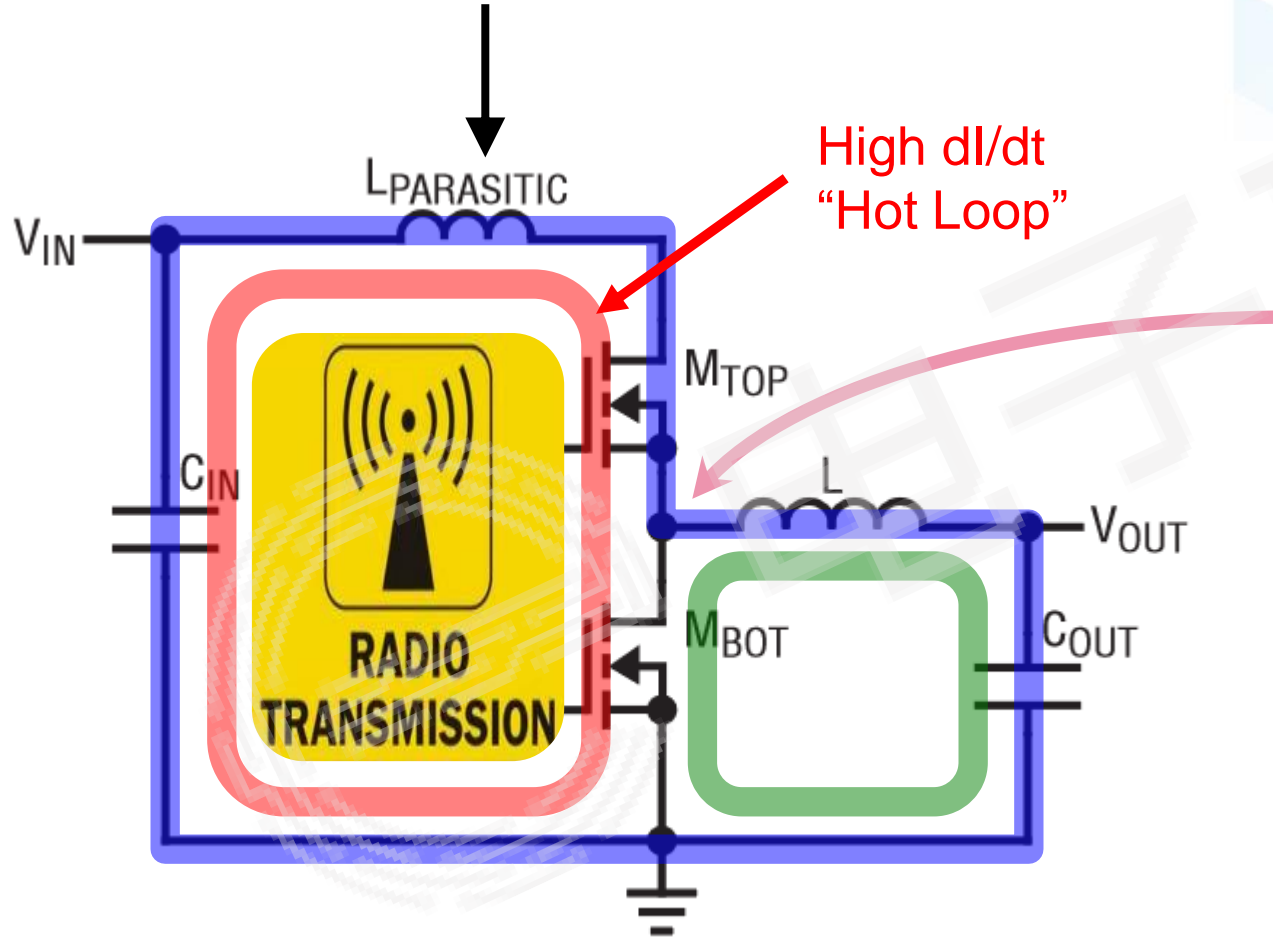
Conversion efficiency is improved by using Flex-suppressor

卓越的 EMI 开关电源技术 Silent Switcher 降压型稳压器

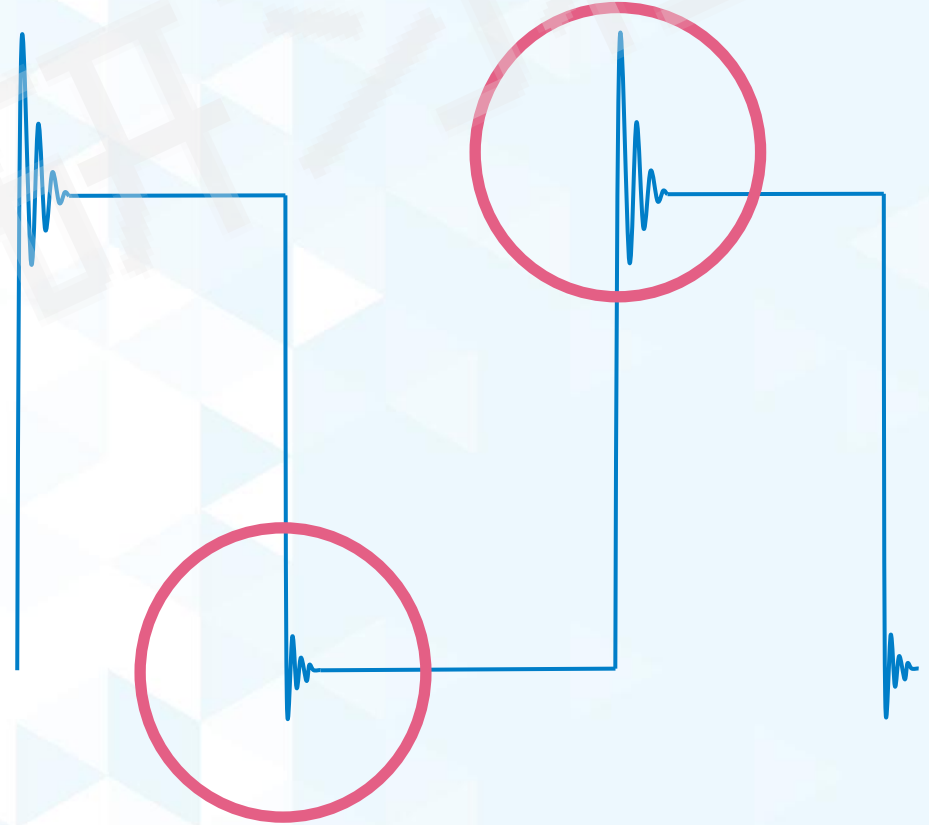
传统同步降压电路必然出现的问题

极高 di/dt 电流在开关电源回路中产生EMI

铜线、键合线、电容器的ESL电感和场效应晶体管内部金属引起的寄生电感

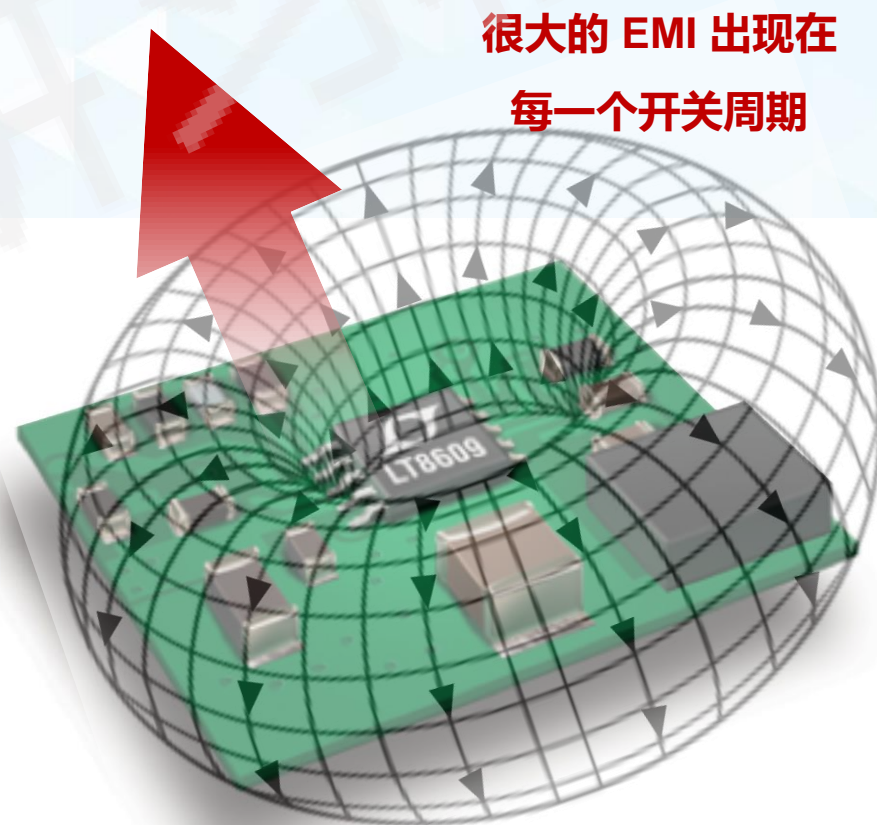
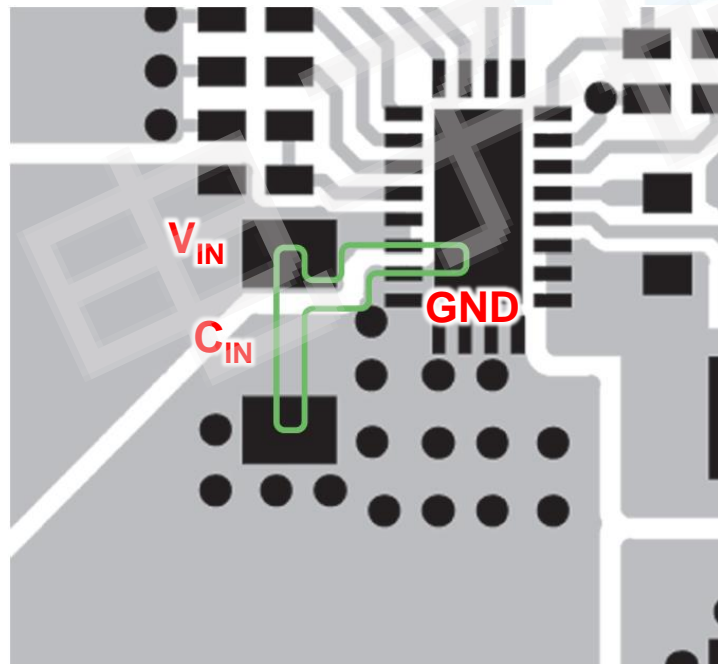
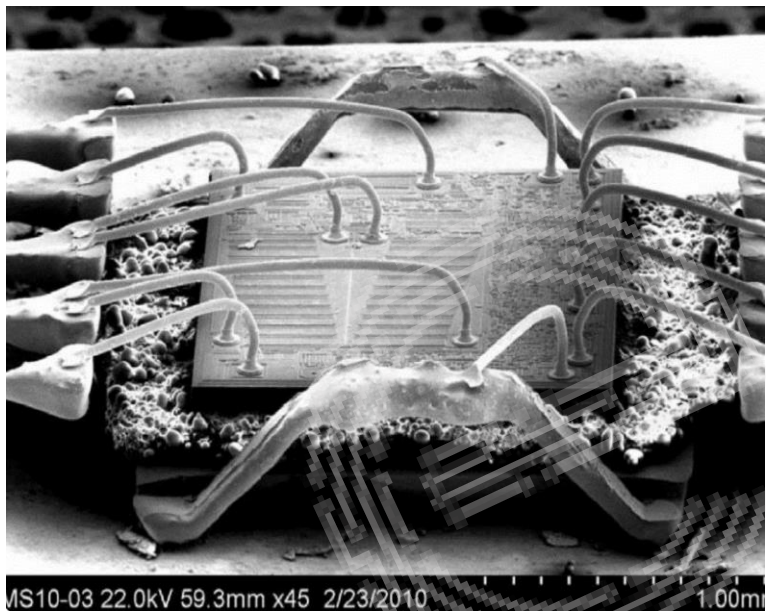


开关边缘过多的振铃会引起传导噪音和辐射



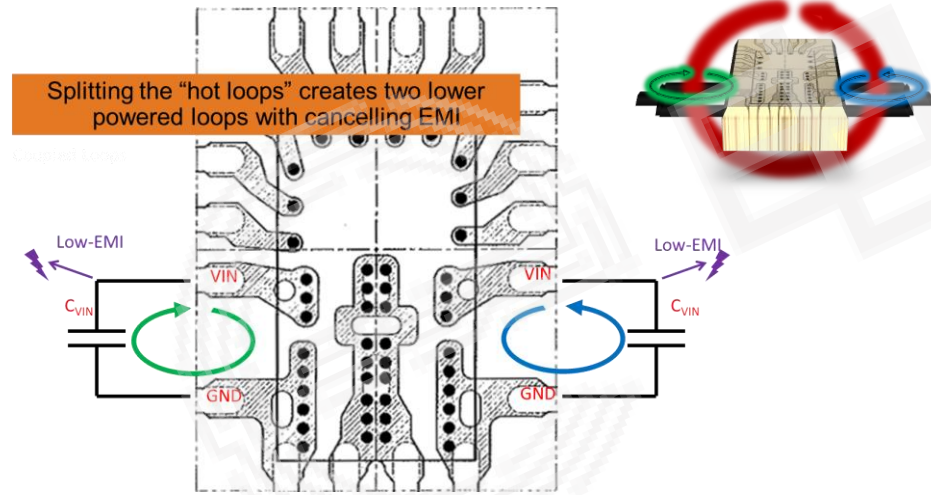
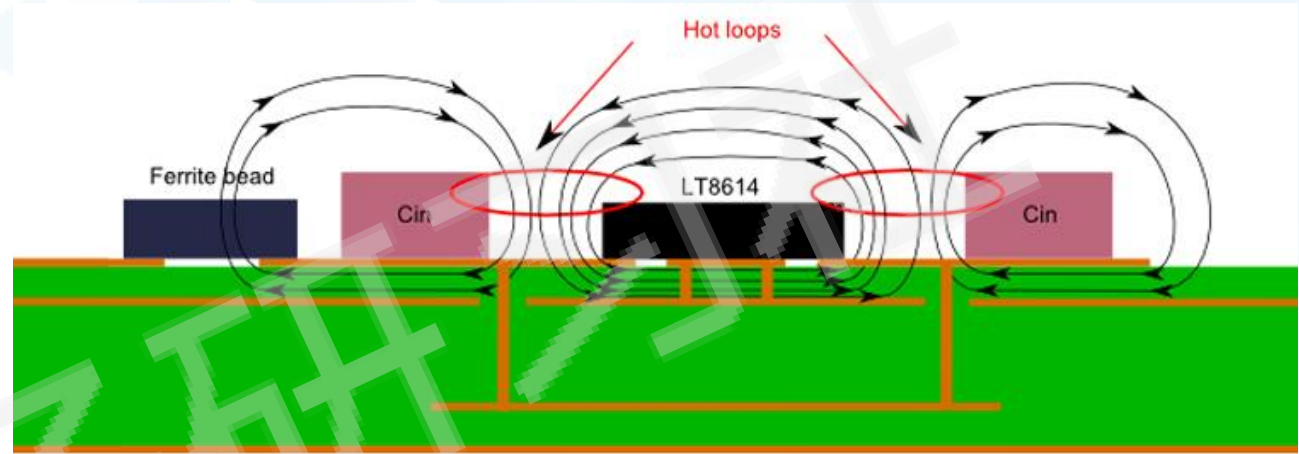
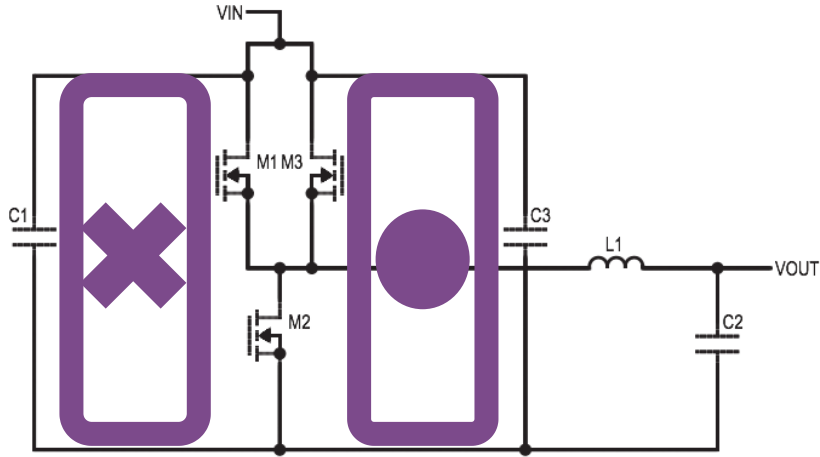
最小化dI/dt回路

- ▶ 对于内置MOSFET的开关电源,最好的方法是放置低ESL输入电容尽可能接近VIN和GND
- ▶ 采用与热回路距离最小的实心GND平面是减少电磁干扰最有效的方法之一



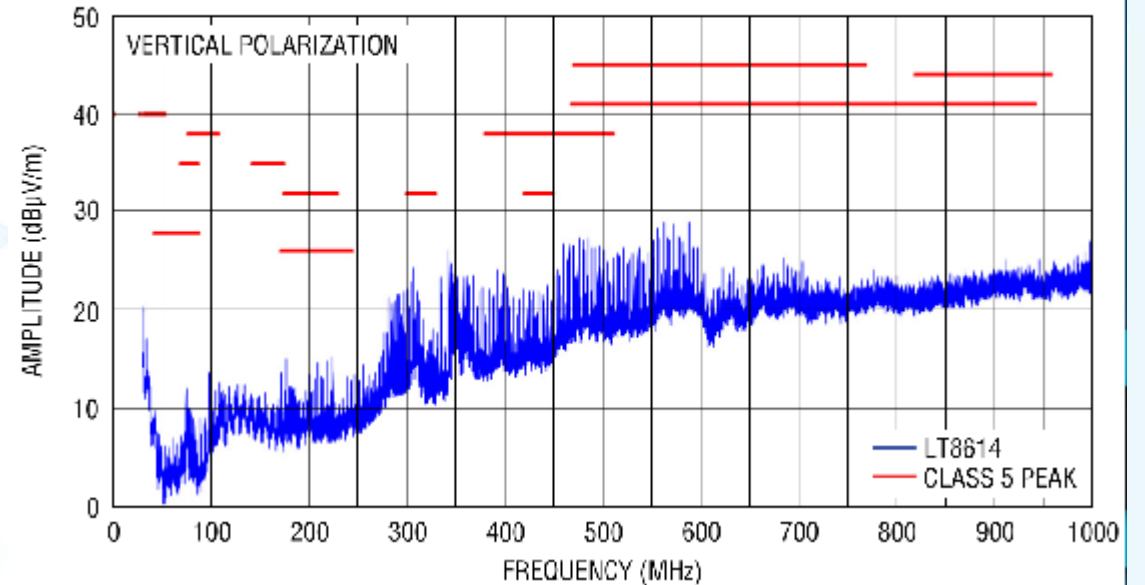
Silent Swither 1

创新 - Silent Switcher 1 如何降低磁场辐射



- ◆ 两个大电流回路相互抵消磁场，几乎就像把磁场封闭在一个金属盒子里。

Radiated EMI Performance (CISPR25 Radiated Emission Test with Class 5 Peak Limits)



创新 - Silent Switcher 1 如何消减开关振铃

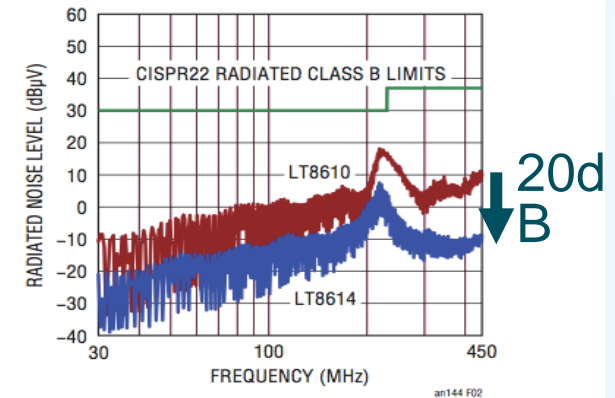
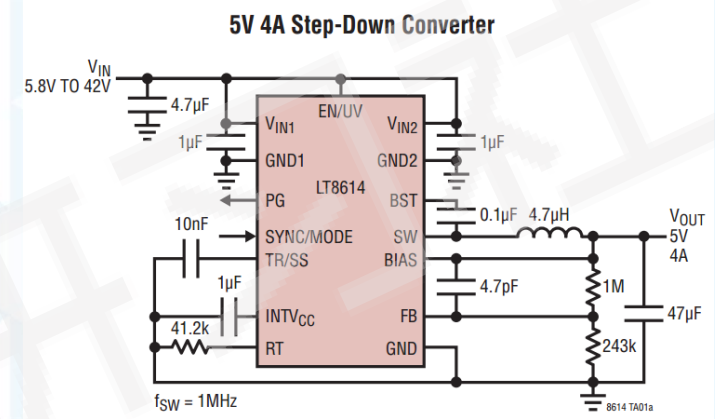
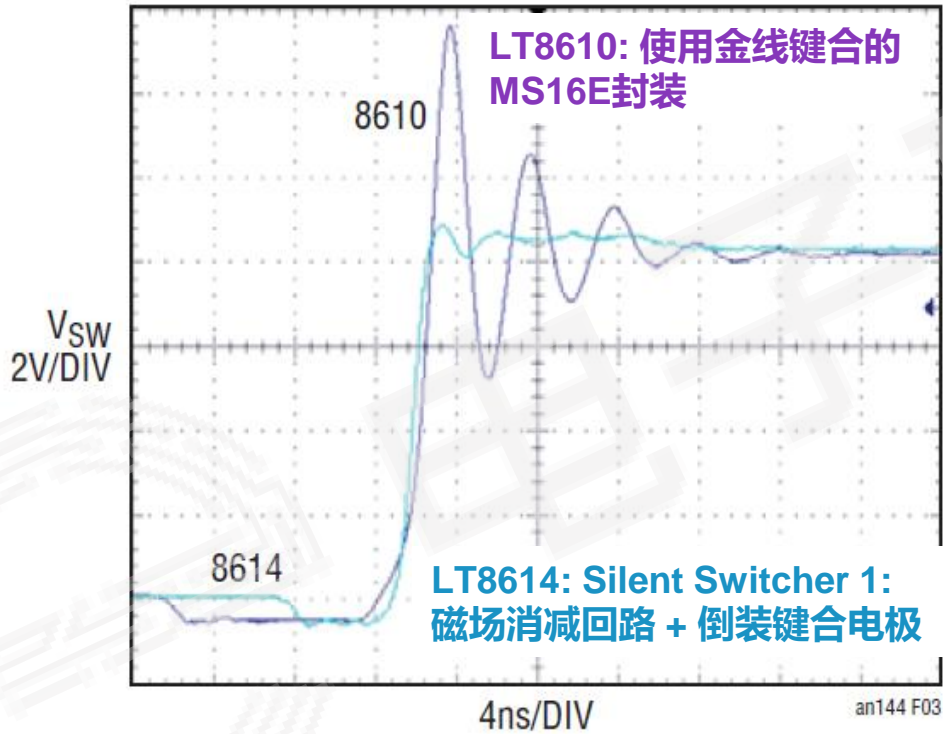
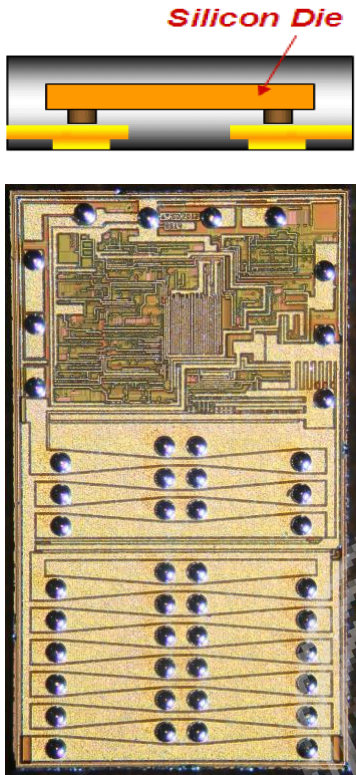
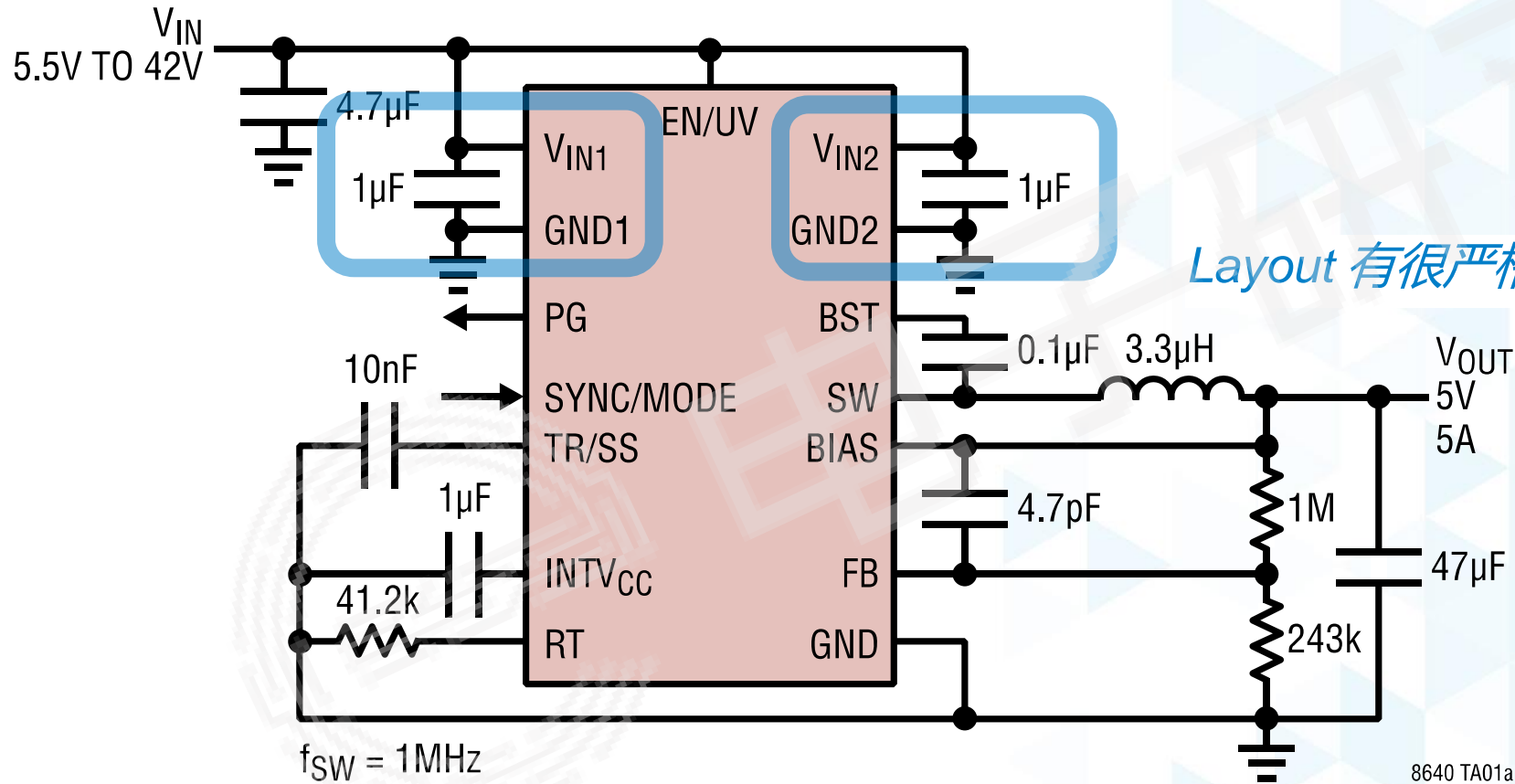


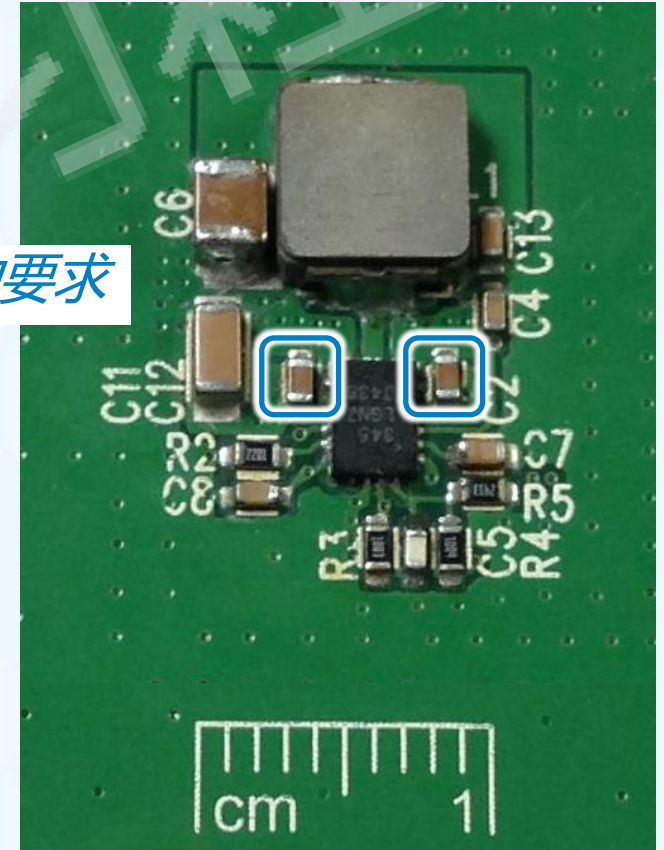
Figure 2. LT8610 and LT8614 700kHz 14V to 3.3V 2A Radiated EMI in GTEM Corrected for OATS

Silent Switcher 1 – 构建理想的di/dt回路

5V 5A Step-Down Converter



Layout 有很严格的要求

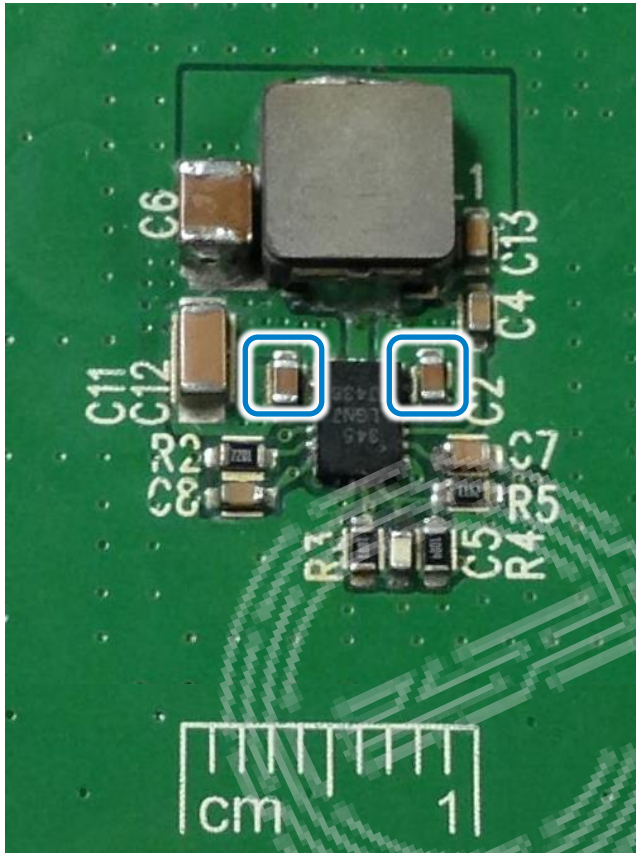


Silent Switther 2

创新 - Silent Switcher 2

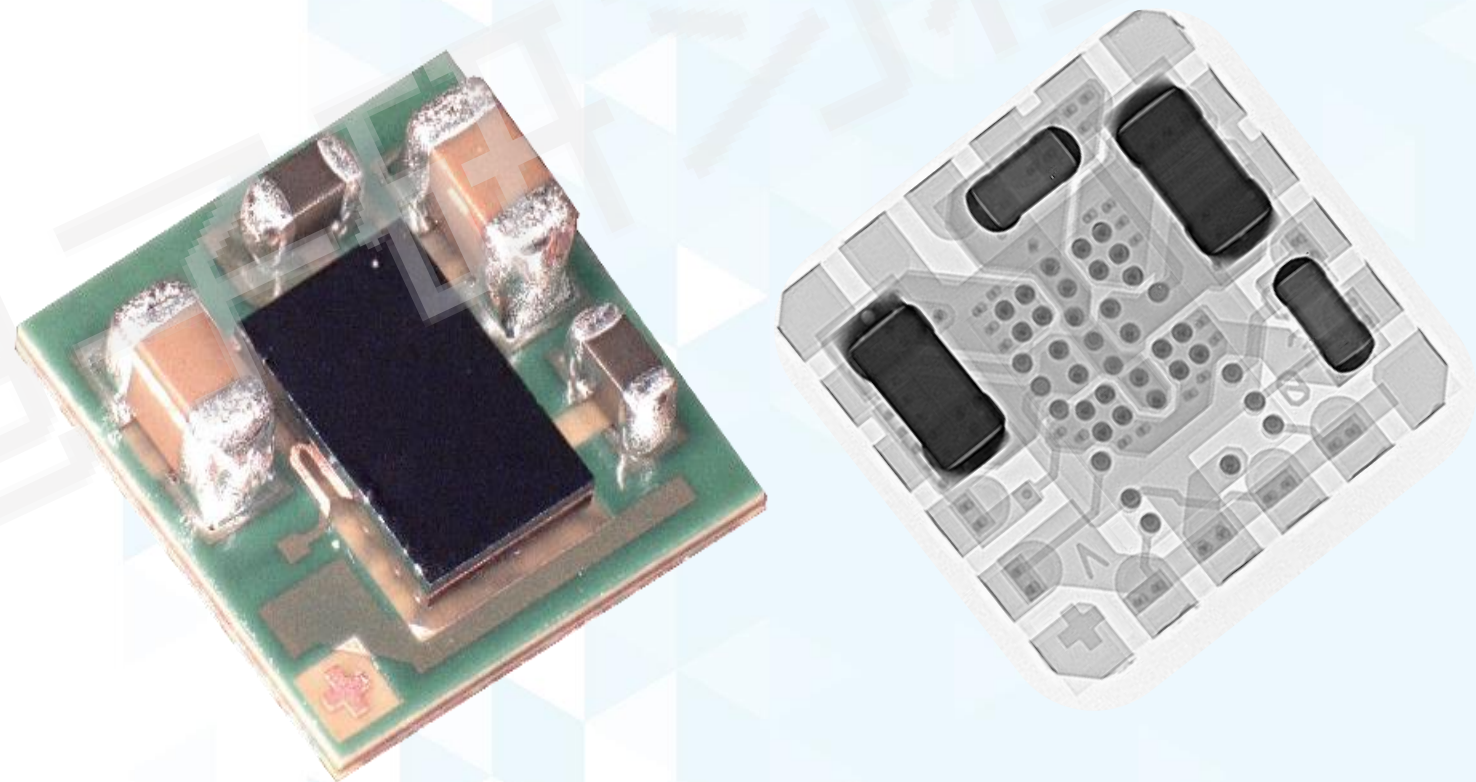
Silent Switcher 1

布局与走线的局限性很大



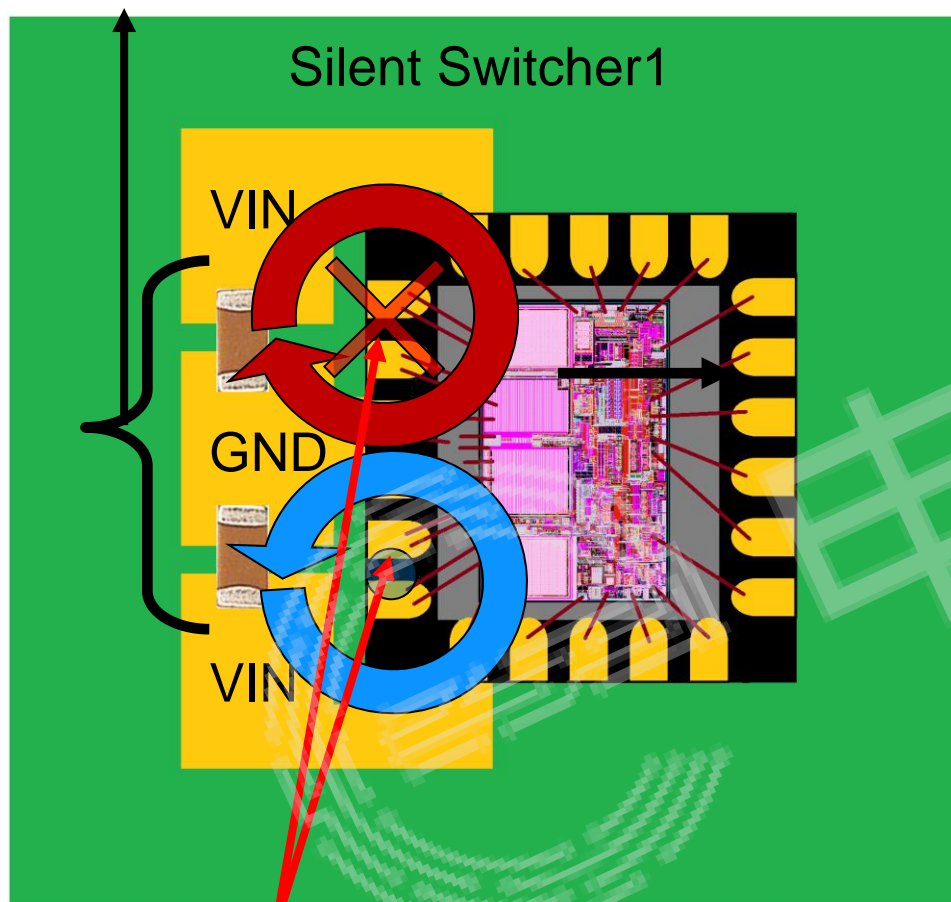
Silent Switcher 2

倒装芯片及内置电容



Silent Switcher 2 构建在芯片内核之上的磁场消除回路

双局部旁路电容器安装在靠近PCB IC封装的地方。

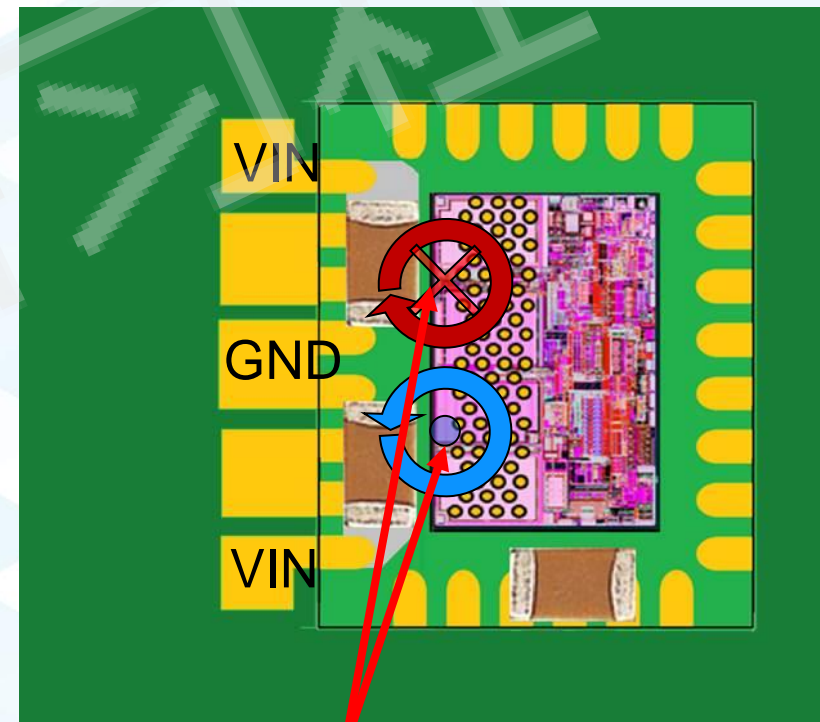


磁回路直径= 0.5cm

Silent Switcher 2



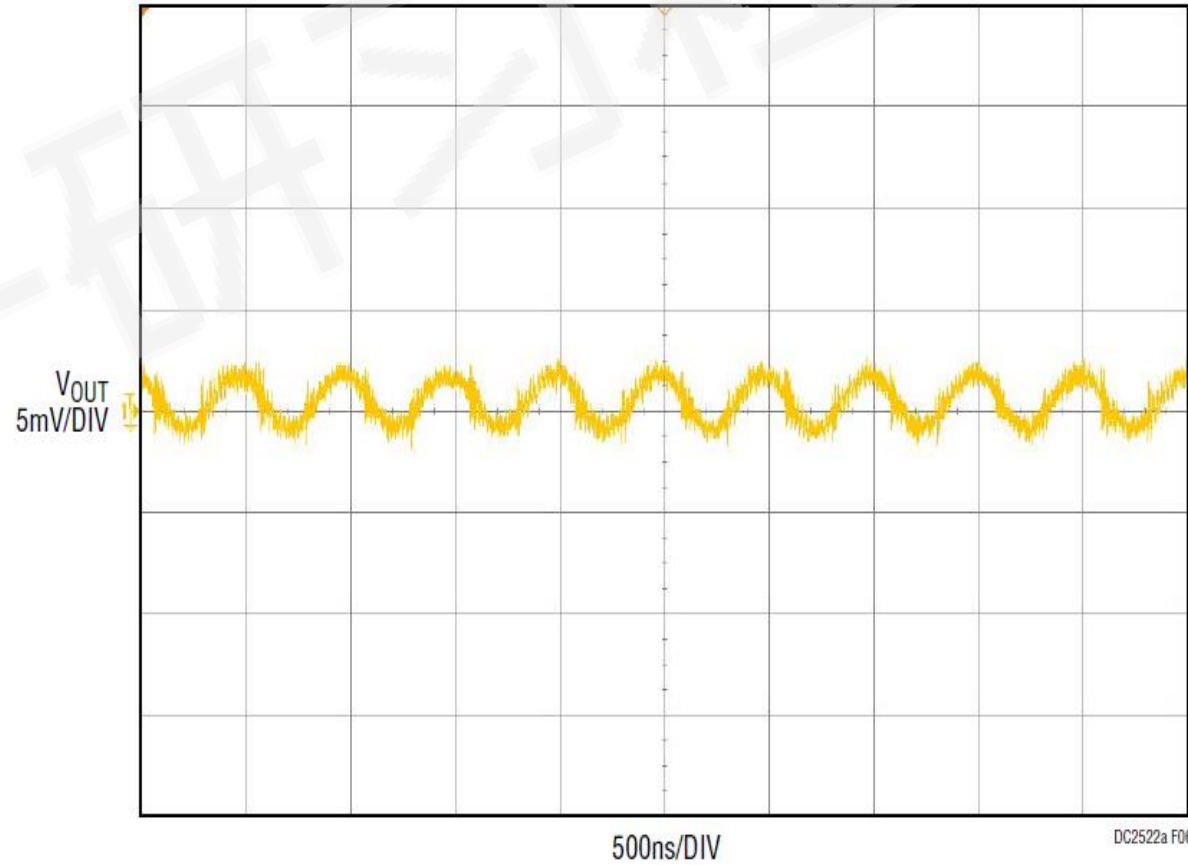
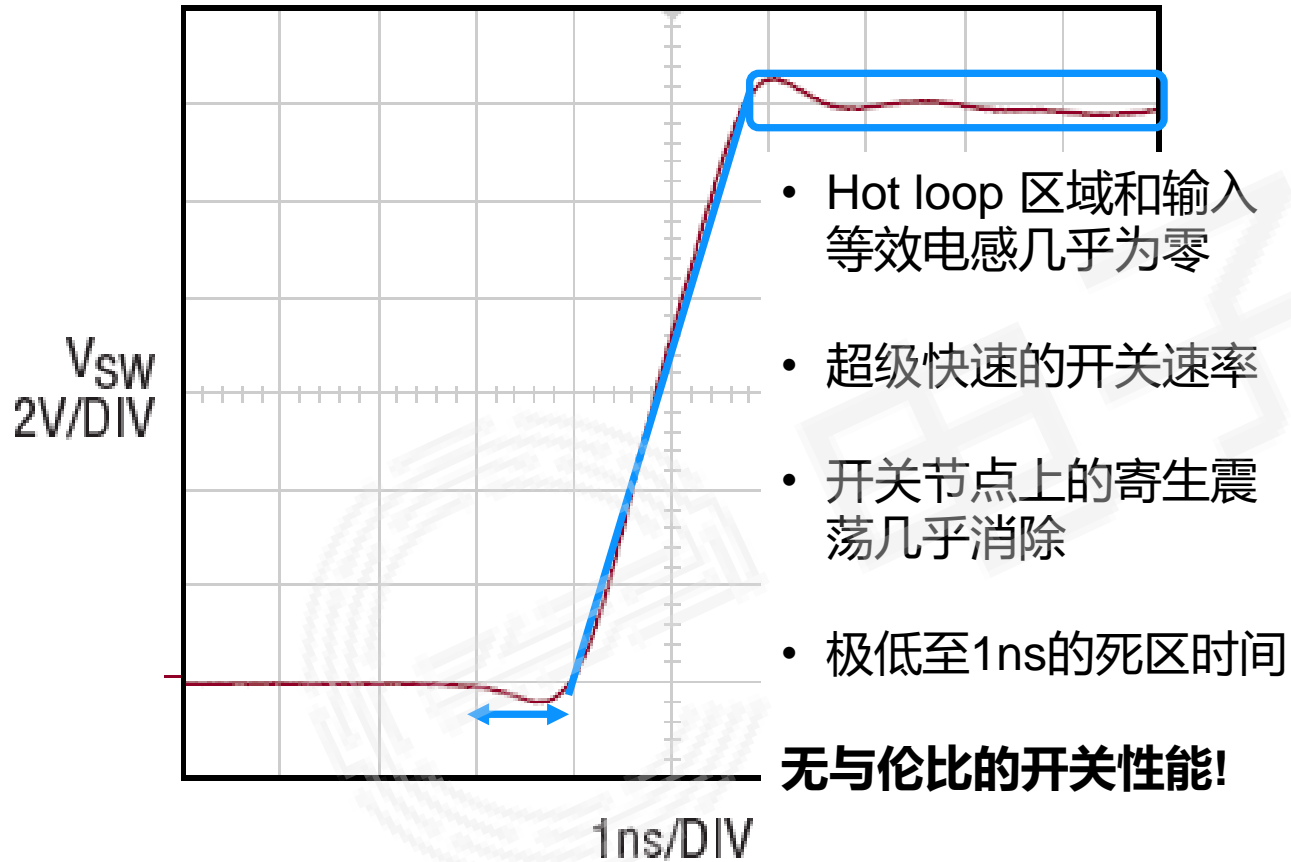
所有的di/dt 仅存在于芯片封装中: PCB设计更容易



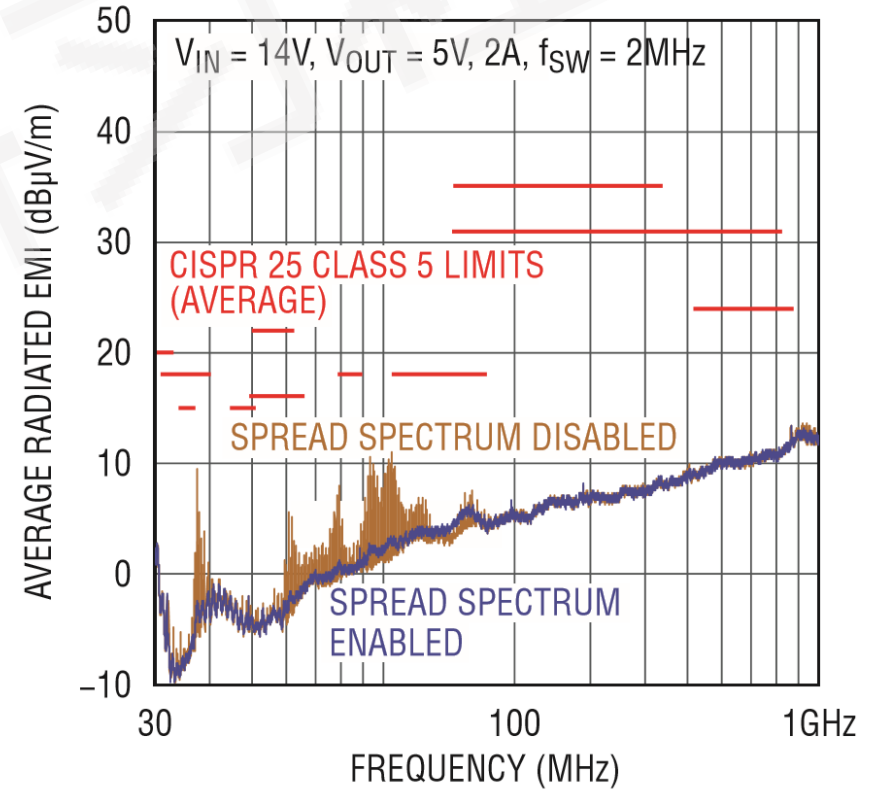
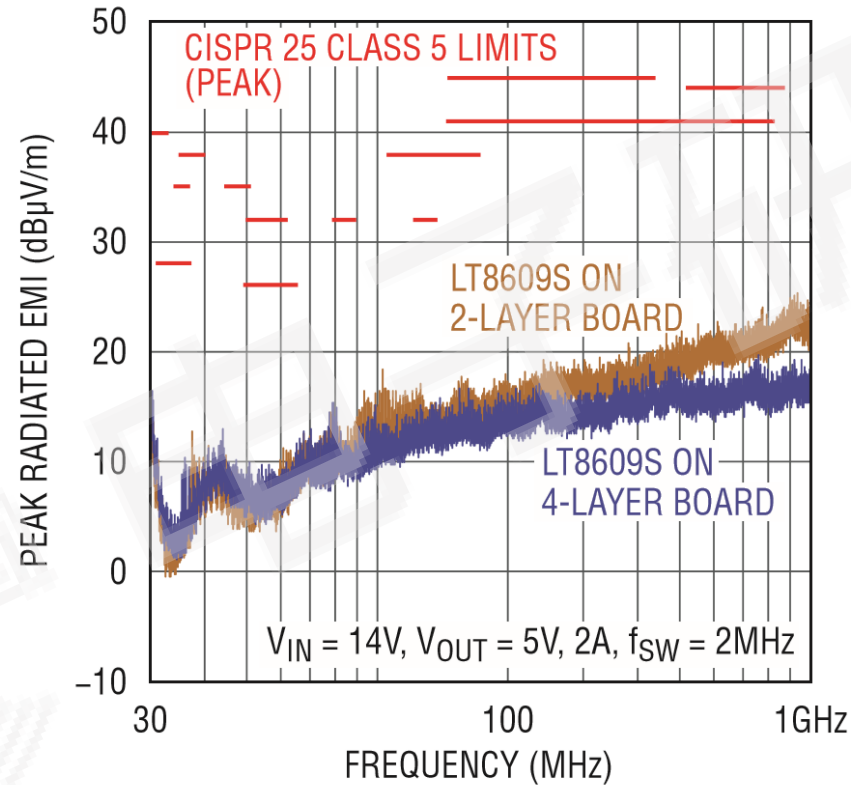
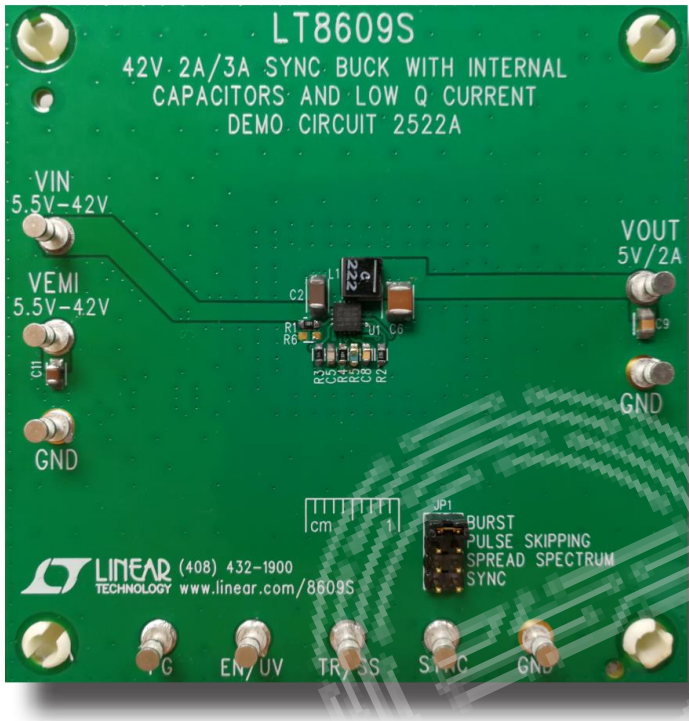
磁回路直径= 0.1cm

创新 - Silent Switcher 2

没有PWM转换斜率的限制，低电磁干扰得以实现！ 同时开创极低电源纹波新纪元！



Silent Switcher 2 – 卓越的 EMI 测试结果Its



Silent Switcher Efficiency

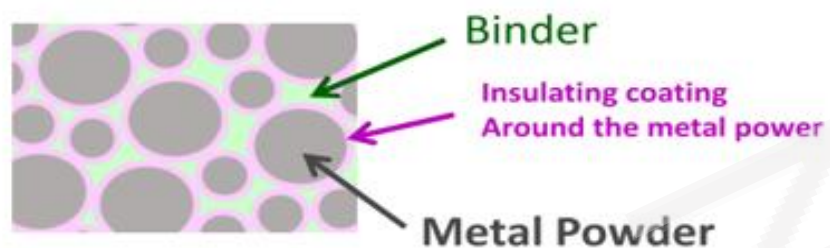
DEVICE	# OF OUTPUTS	V _{IN} RANGE	OUTPUT CURRENT	PEAK EFFICEINCY AT 2MHz, 12V TO 5V	I _Q	FEATURES	PACKAGES
LT8650S	2	3V – 42V	4A + 4A on both channels or 6A on either channel	94.60%	6.2μA	Silent Switcher 2	6mm x 4mm x 0.95mm LQFN
LT8645S	1	3.4V – 65V	8A	94%	2.5μA	Silent Switcher 2	6mm x 4mm x 0.95mm LQFN
LT8643S	1	3.4V – 42V	6A continuous 7A peak	95%	120μA	Silent Switcher 2, external compensation	4mm x 4mm x 0.94mm LQFN
LT8640S	1	3.4V – 42V	6A continuous 7A peak	95%	2.5μA	Silent Switcher 2	4mm x 4mm x 0.94mm LQFN
LT8609S	1	3V – 42V	2A continuous 3A peak	93%	2.5μA	Silent Switcher 2	3mm x 3mm x 0.94mm LQFN
LT8640 LT8640-1	1	3.4V – 42V	5A continuous 7A peak	95%	2.5μA	Silent Switcher, LT8640 pulse skipping, LT8640-1 forced continuous	3mm x 4mm QFN-18
LT8641	1	3V – 65V	3.5A continuous 5A peak	94%	2.5μA	Silent Switcher	3mm x 4mm QFN-18
LT8614	1	3.4V – 42V	4A	94%	2.5μA	Silent Switcher. Low ripple Burst Mode operation	3mm x 4mm QFN-18

金属化一体成型电感结构

KEMET

a YAGEO company

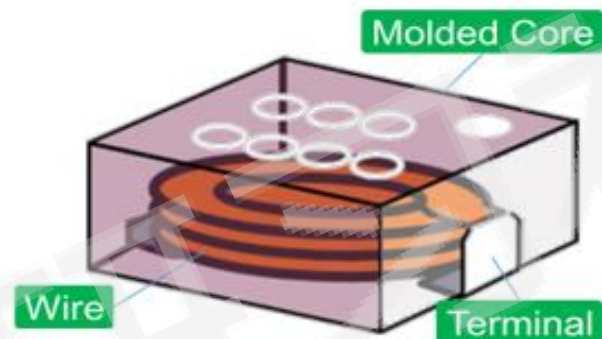
- The **core** is a sintered powder of magnetic *metal-composite*.



- The **wire** is a coil surrounding that core, attached to terminals.

Copper Coil

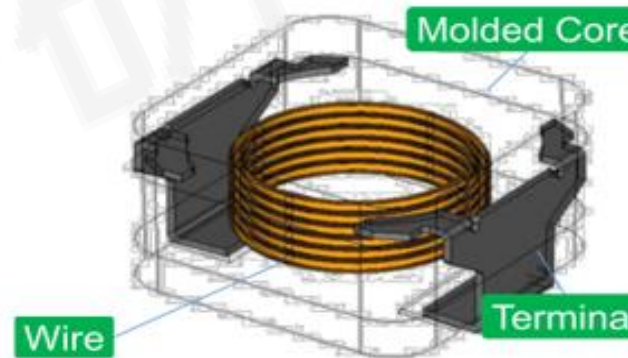
Metal Composite



MPC series

Flat Wire

Large Current
Low DCR



MPLC series

Round Wire

Large Inductance

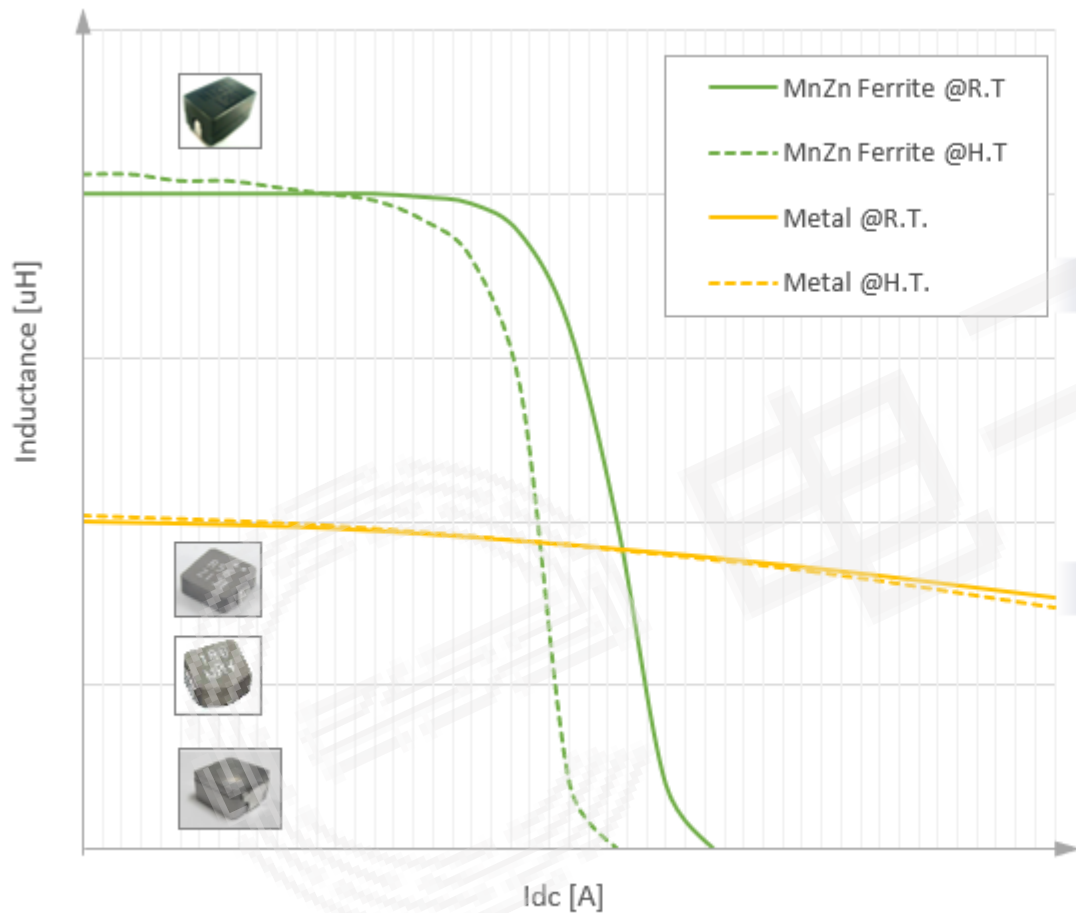
Metal Composite Advantages

- Low acoustic noise
- High Saturation Flux Density
- Stable Inductance for thermal

More inductance in a smaller package

铁氧体和金属化一体成型电感的比较

饱和特性



Advantage on the Ferrite

1. Higher inductance with high permeability
2. Stable inductance in the right range

High L and Low DCR capability

Advantage on the Metal composite

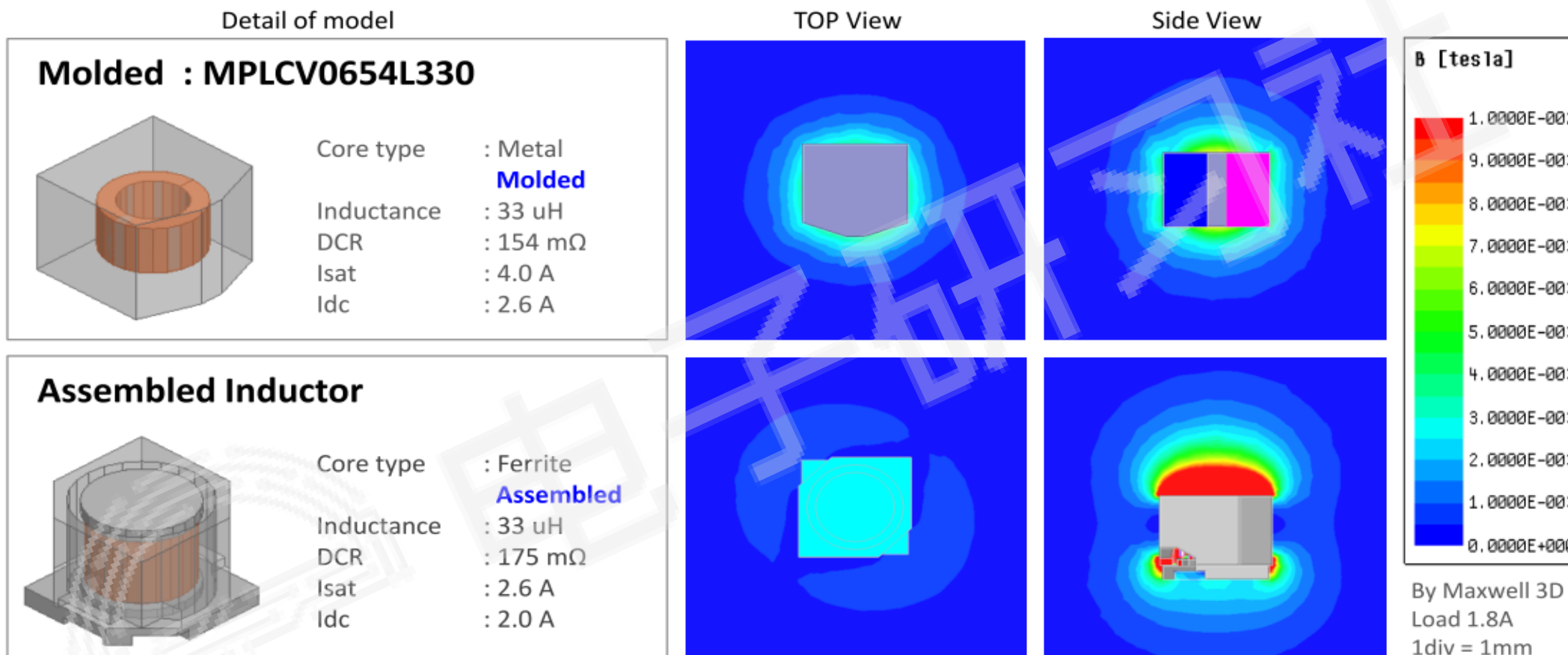
1. Very slow saturation
2. Very stable saturation for the thermal

Good for Auto app especially

较好的EMI 与噪声特性表现

KEMET

a YAGEO company

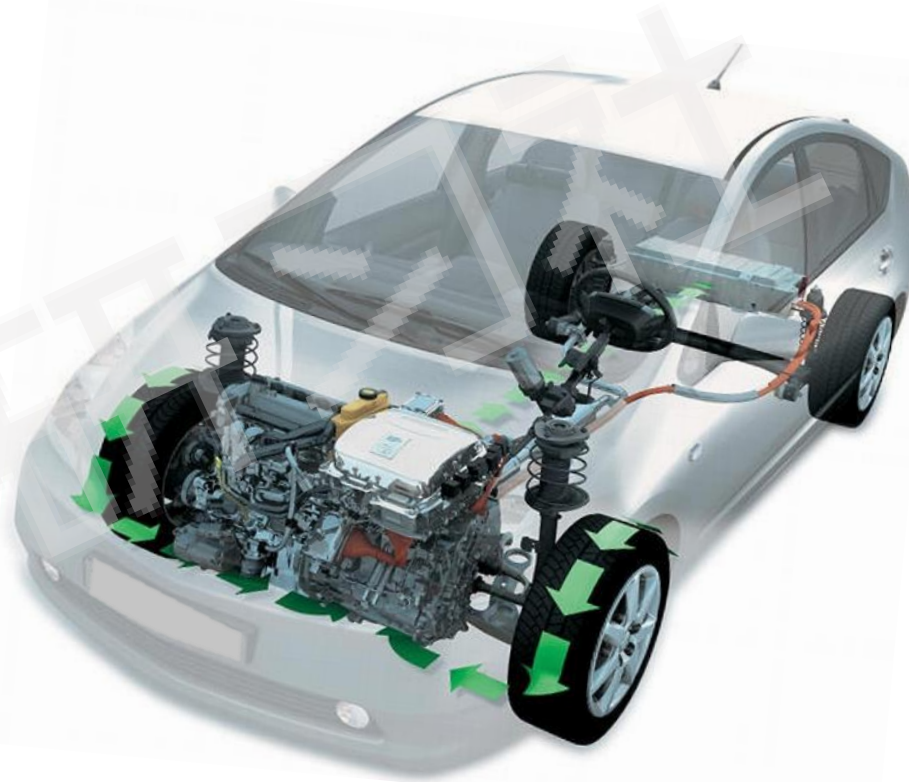


Molded type is better for magnetic flux leaking than assembled type.

The ferrite inductor has some aperture since it's assembled type typically.
Magnetic Flux leaks from aperture.

品质 & 可靠性

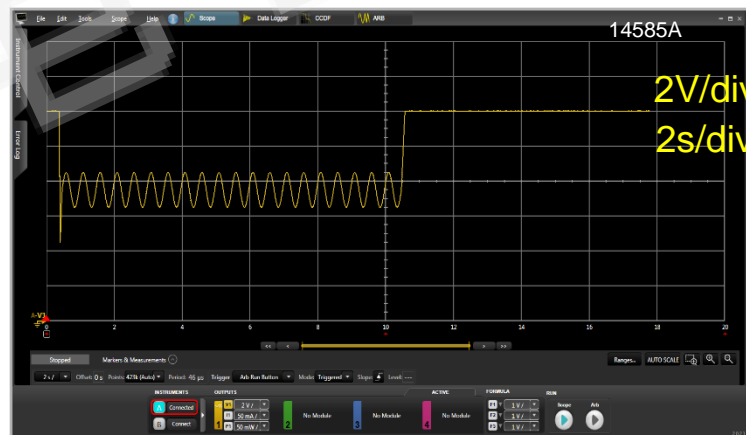
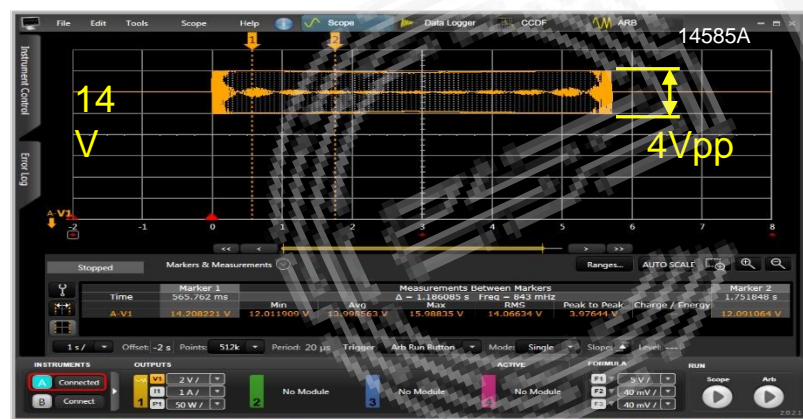
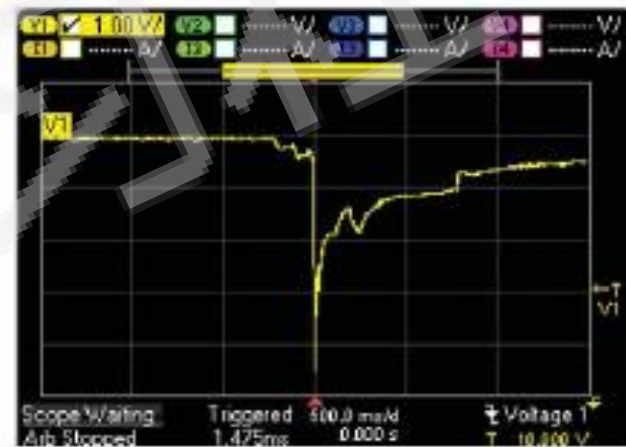
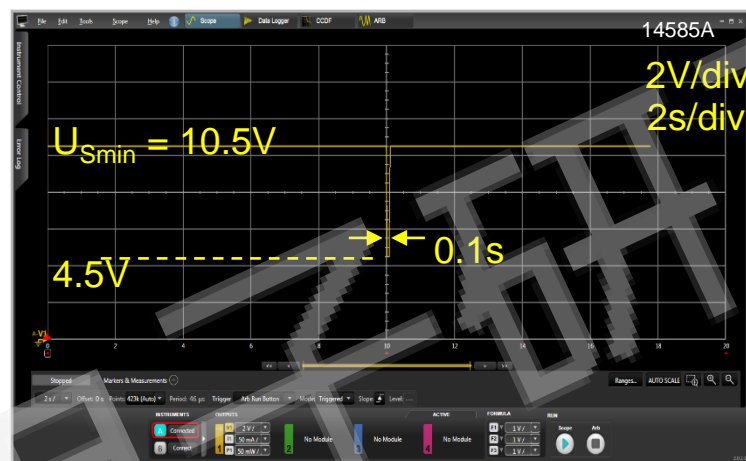
新技术带来的挑战之四：绝不妥协的可靠性



2020+

- 车联网信息处理、自动驾驶、主动安全系统
- 车载娱乐系统
- 使用直流电机/发电机的再生制动和子系统
- 机械子系统，如 **ABS** 和动力转向

新技术带来的挑战之四：绝不妥协的可靠性 最“任性”的供电系统

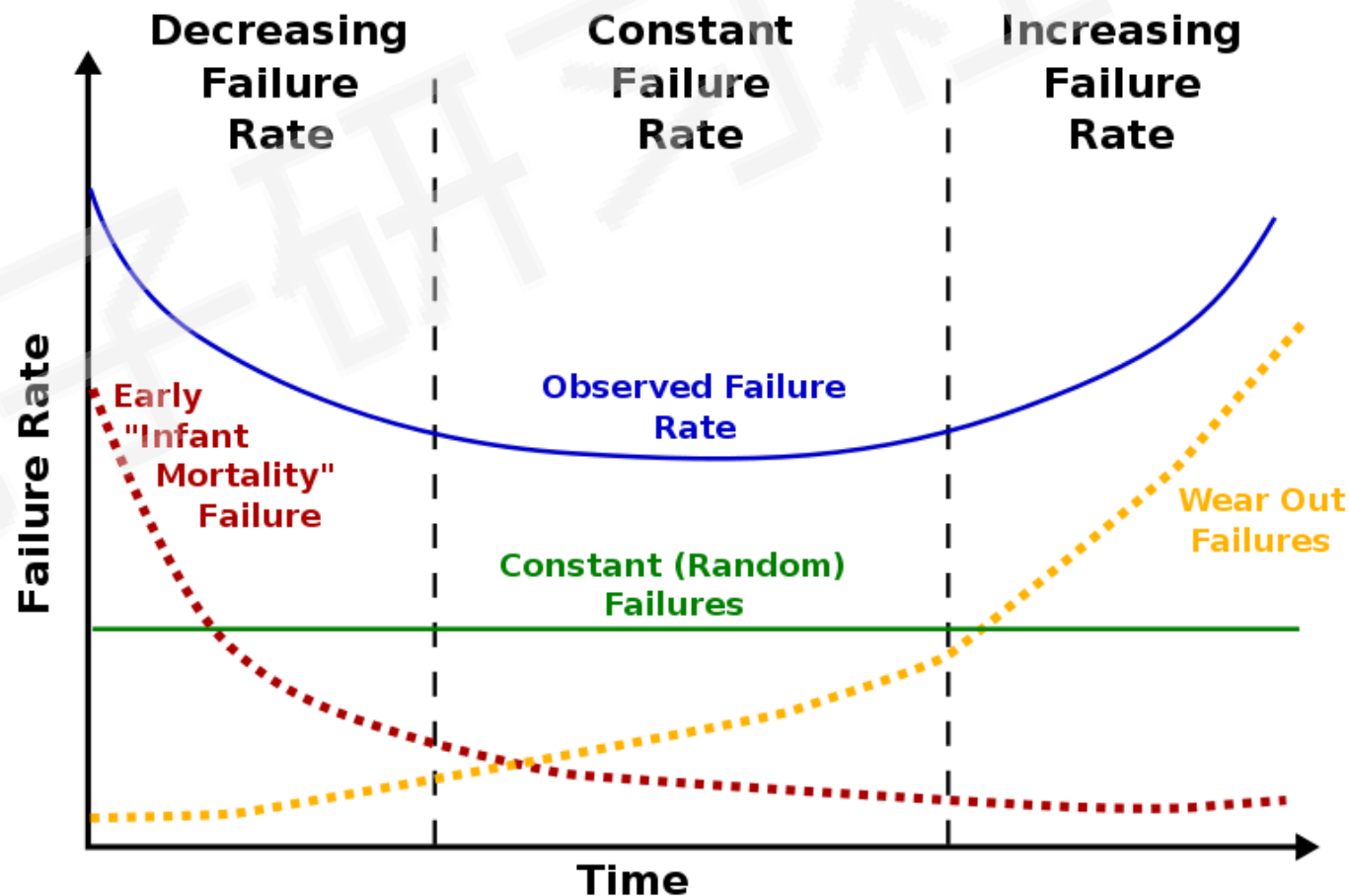


新技术带来的挑战之四：绝不妥协的可靠性 最任性的工作环境稳定



为什么品质和可靠性如此重要！

- ▶ 短期 (早期) 看品质
 - 生产制造出厂无失效
- ▶ 长期 (后期) 看可靠性
 - 在产品的生命周期内没有故障



品质与可靠性的区别？

▶ 品质

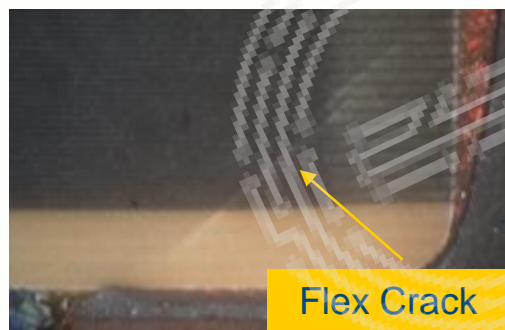
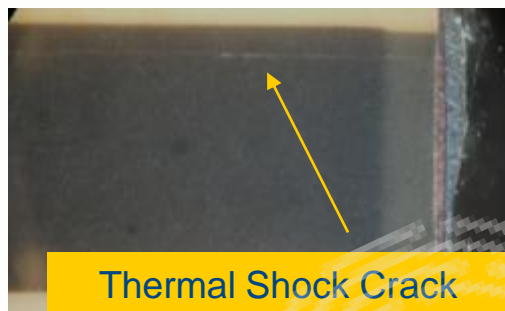
- 定义为“**0使用时长**”失效率
 - 基于产品内在特性的运行失效率
- 衡量单位为 **PPM** (每百万片失效率)

▶ 可靠性

- 定义为基于长期使用的“**本质的失效率**”
 - 在给定的时间、使用情况和环境中，设备将在定义的特性内继续执行的概率
- 衡量单位为 **FITS** (在每十亿运行小时的器件失效数)

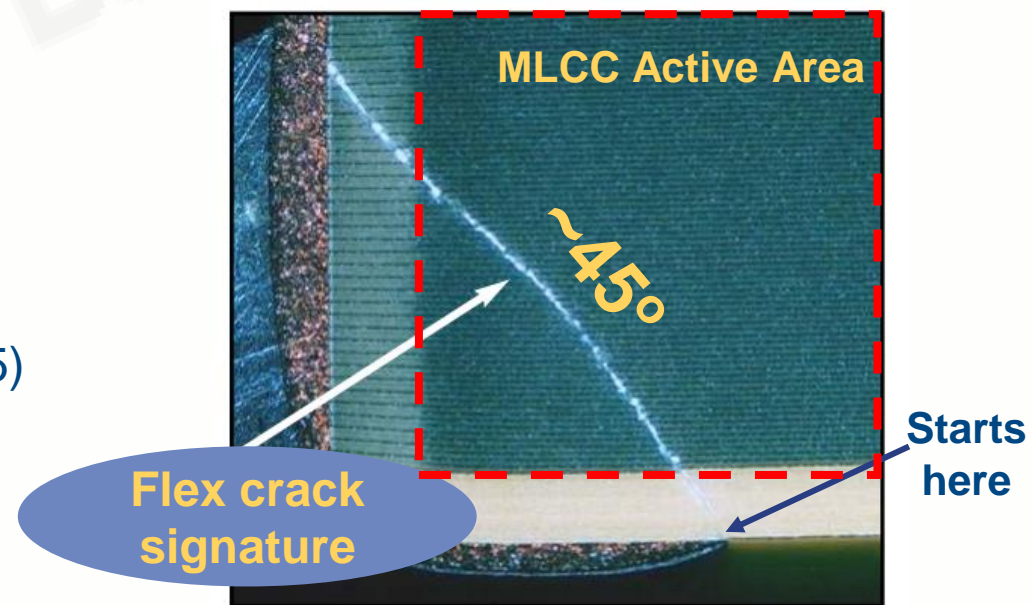
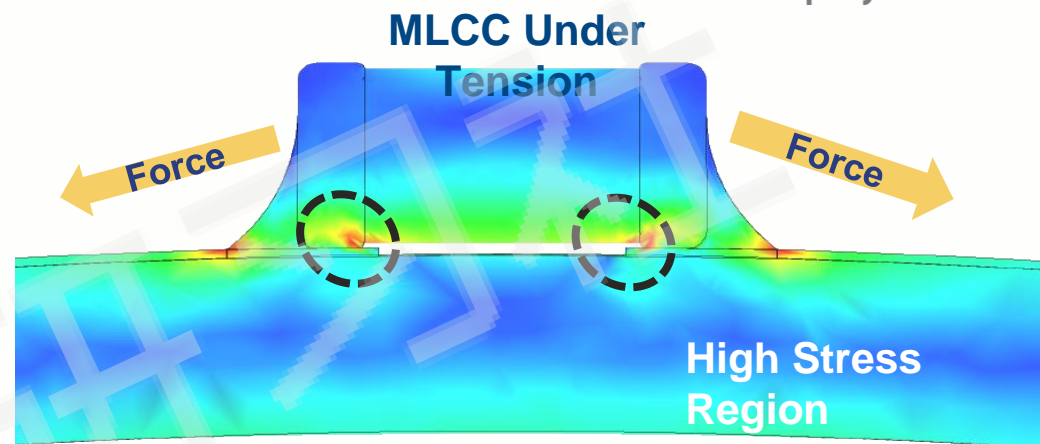
注意：器件的使用不得超过器件设计的极限条件或固有功能

MLCC断裂特征



MLCC 断裂的主要成因：

- 机械损坏
 - 不正确的拾放
- 热冲击 (平行裂纹)
 - 极端温度循环
 - 手焊
- 弯曲或扭曲变形
 - 焊接后
 - 通常是大尺寸MLCC (>0805)

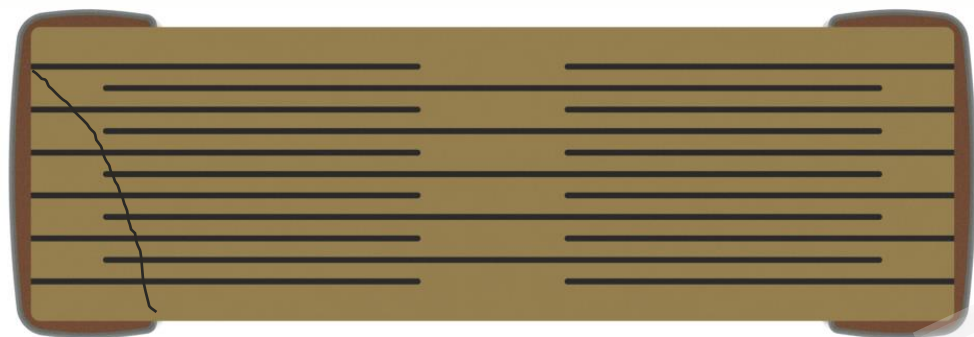


MLCC 缓解风险方案1

基础级保护 L1

KEMET
a YAGEO company

浮电极结构



优点

- 串联结构设计
- 开路失效

缺点

- 同样尺寸的最大容值降低了



开路失效模式结构

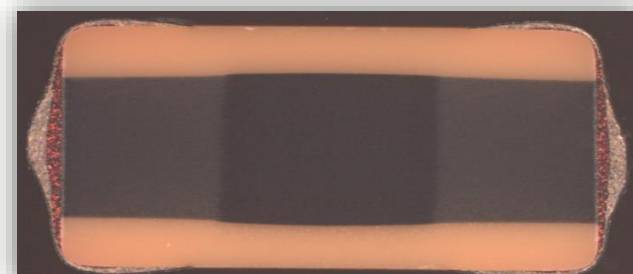


优点

- 开裂点不会影响到电容有效区域
- 开路失效

缺点

- 同样尺寸的最大容值降低了



MLCC 缓解风险方案2

中级保护 L2

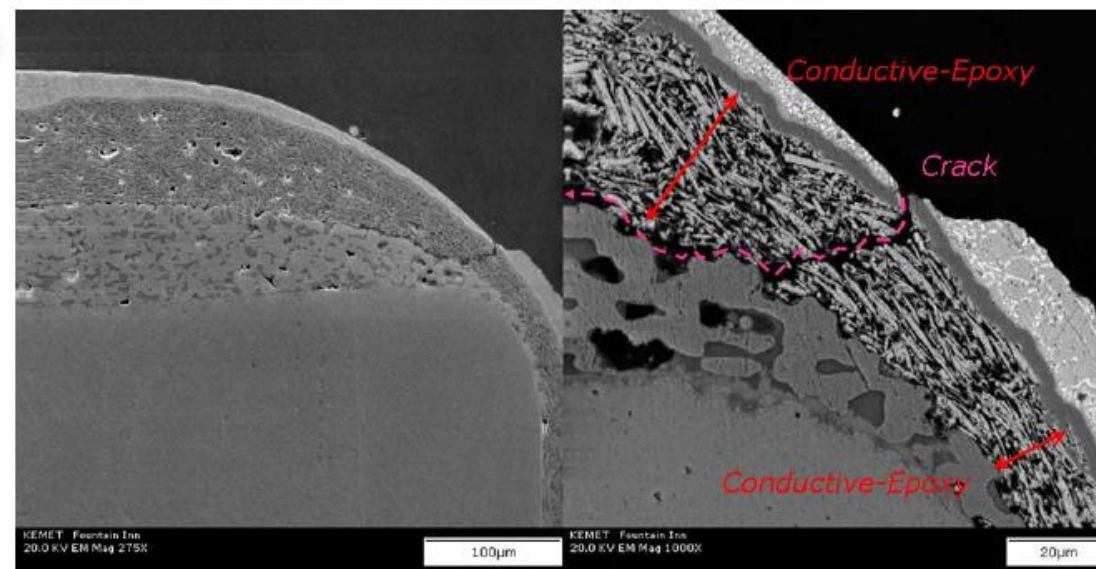
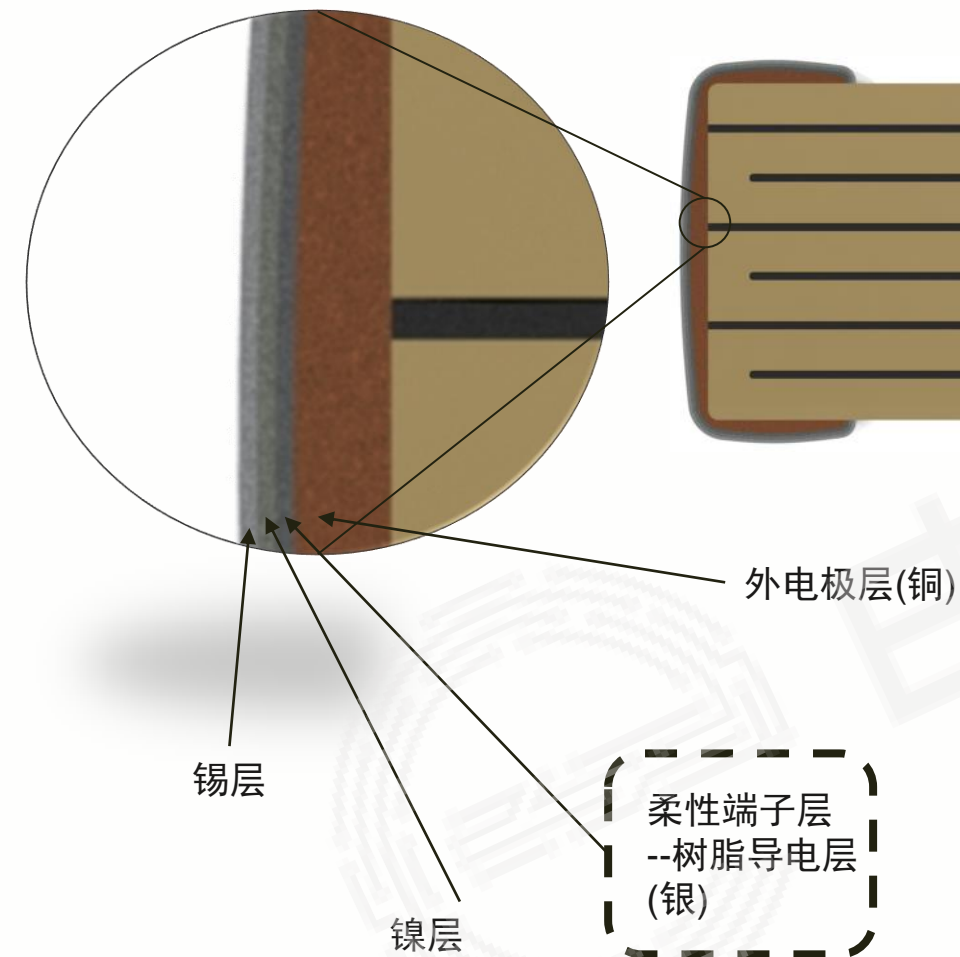
柔性端子 (FT-CAP)

优点

- 增强了端子柔性
- 高容积效率

缺点

- 短路失效模式

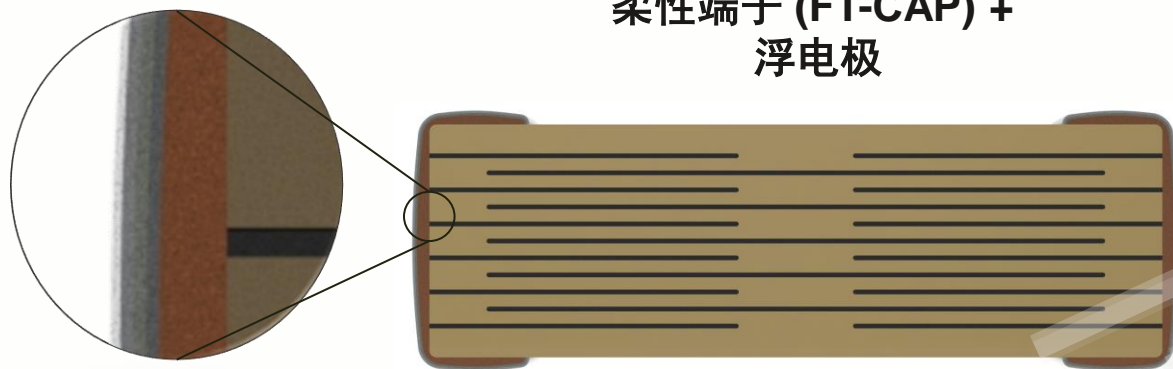


MLCC 缓解风险方案3

高级保护 L3

KEMET
a YAGEO company

柔性端子 (FT-CAP) +
浮电极



柔性端子 (FT-CAP) +
开路失效模式



优点

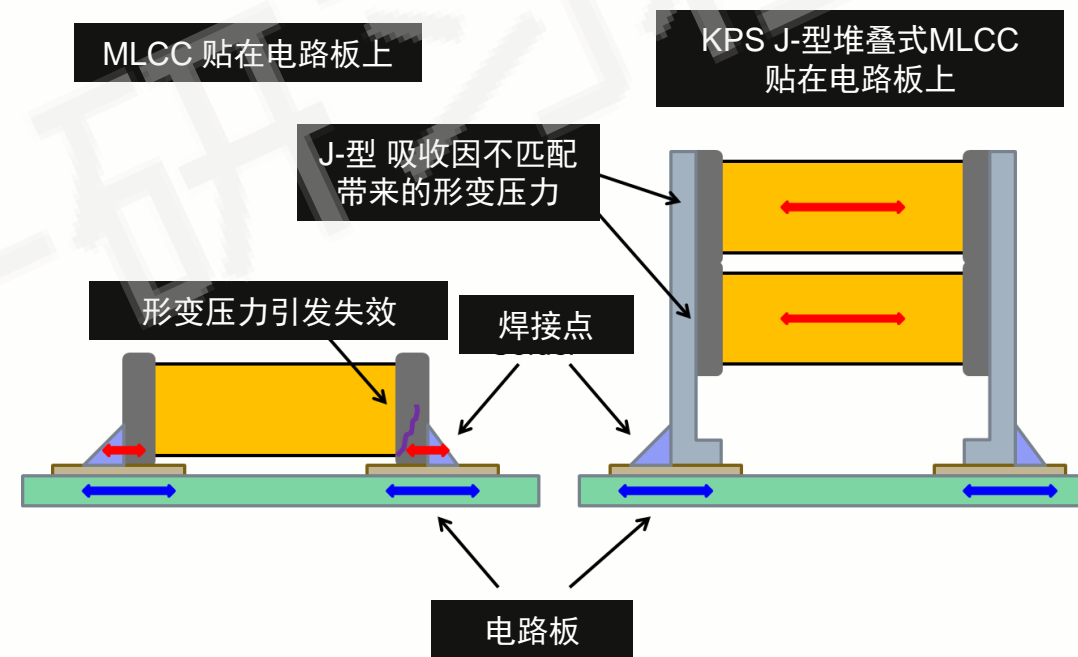
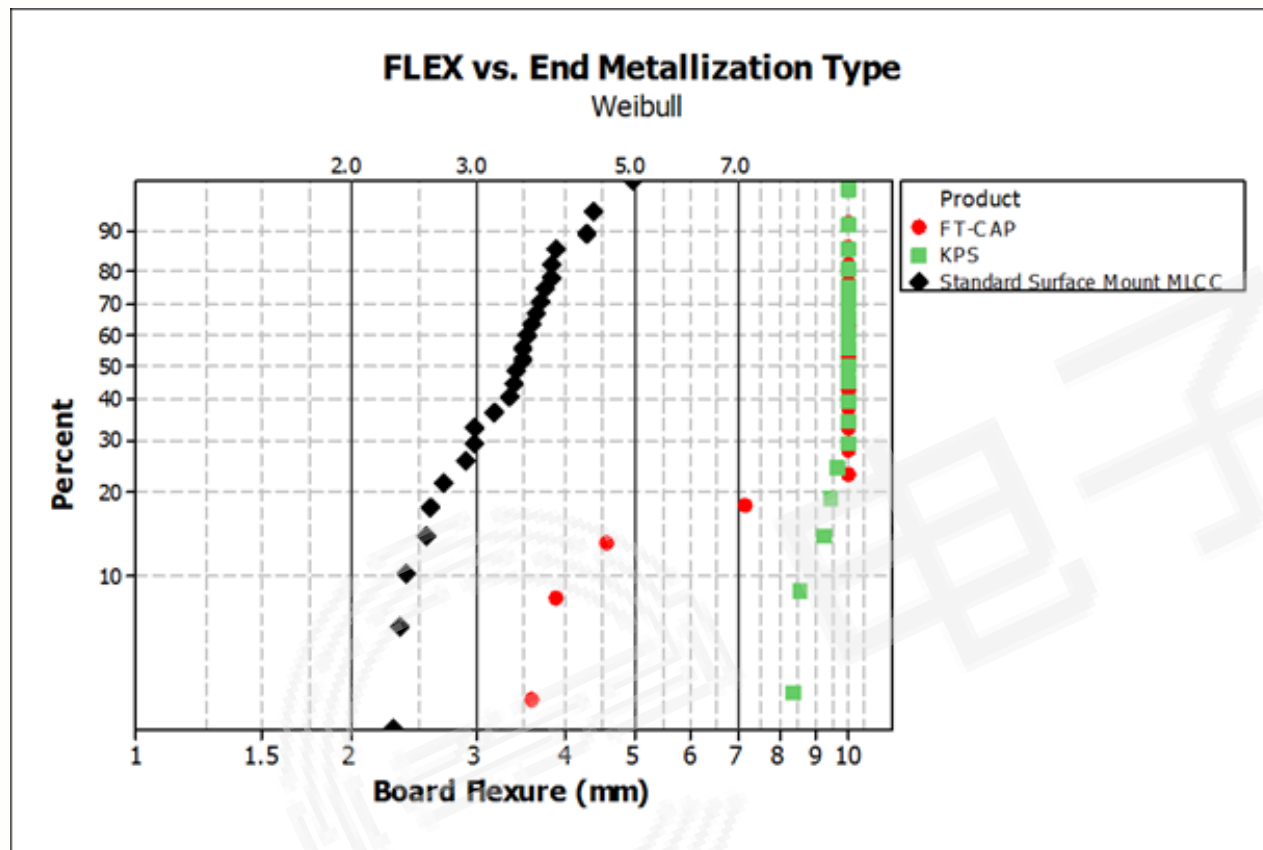
- 增强了端子柔性
- 浮电极设计
- 开路失效模式

缺点

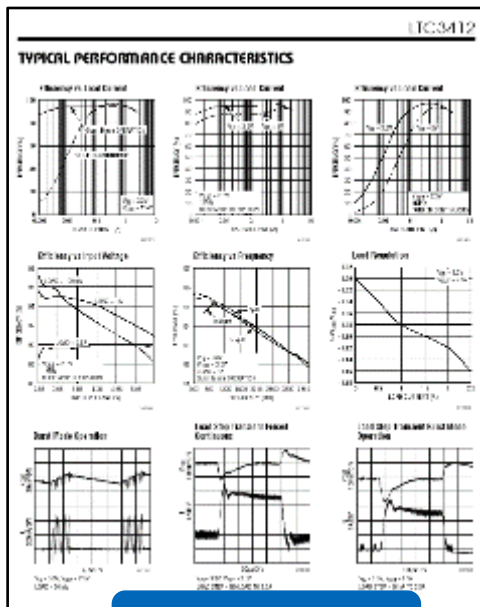
- 同样尺寸的最大容值降低了

板弯测试- KPS J型堆叠式MLCC 10mm测试 (10 μ F 2220 MLCC)

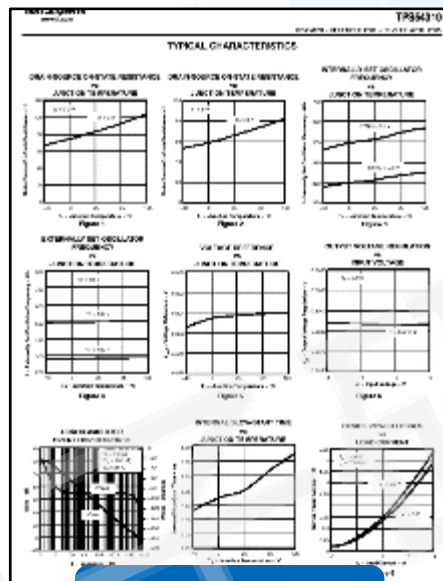
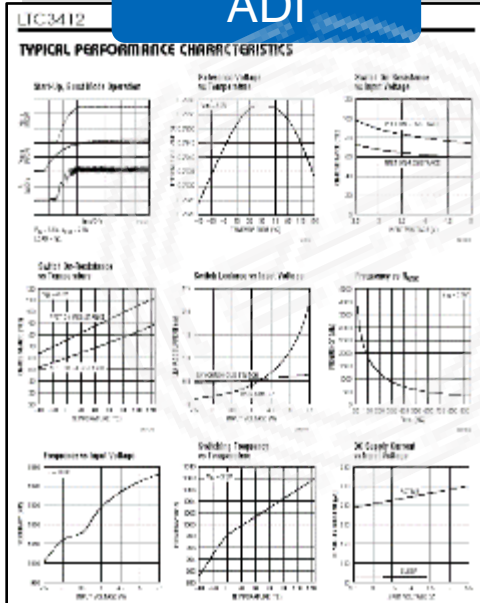
最高级保护 L4 – 利用J型引脚明显提升MLCC抗板弯能力



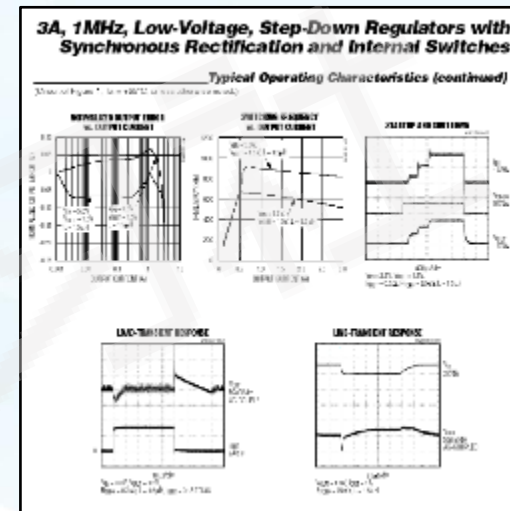
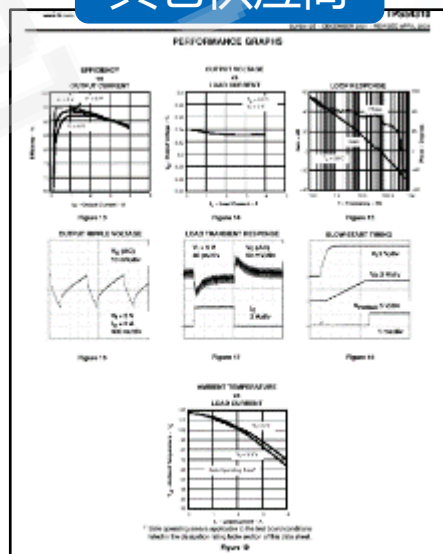
详尽的各工况数据是品质与可靠性的保障



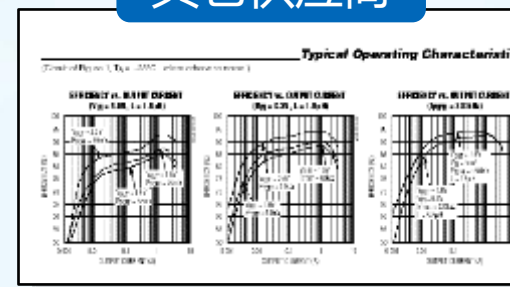
ADI



其它供应商



其它供应商



基于测试保障的可靠性 VS 设计保证的理论可靠性

Features

LTC3803

- ◆ Low 20µA Quiescent Current
- ◆ +3.5V to +30V Wide Input Voltage Range, +45V Tolerant
- ◆ Operates Through Cold-Crank Conditions
- ◆ Low-Dropout Voltage of 280mV at 200mA
- ◆ Up to 200mA Output Current Capability
- ◆ Stable Operation with Tiny 4.7µF Output Capacitor

◆ User-

+3.

+1.

Re

◆ Open

◆ Fixed

◆ High-

◆ Therm

◆ Oper

◆ Autor

200mA, Automotive Quiescent Current,

ELECTRICAL CHARACTERISTICS (

($V_{IN} = V_{ENABLE} = +14V$, $C_{TIMEOUT} = OPEN$, $C_{IN} = 1\mu F$, $V_{OUT} = 10V$, unless otherwise noted, $T_A = T_C = T_D = T_E = T_F = 25^\circ C$, unless otherwise noted. Typical values are $T_A = +25^\circ C$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SETOV INPUT (TRI-MODE)						
SETOV Input Leakage Current		SET = HIGH, $V_{SETOV} = 5V$ or SET = GND, $V_{SETOV} = 5V$		1		µA
SETOV Low-Level Input Voltage	$V_{ILSETOV}$	SET = GND, $V_{SETOV} < V_{ILSETOV}$ or places device in +3.3V fixed output-voltage mode			0.4	V
SETOV High-Level Input Voltage	$V_{IHSETOV}$	SET = GND, $V_{SETOV} > V_{IHSETOV}$ or places device in +5V fixed output-voltage mode	$V_{OUT} - 0.4$			V

Note 2: Production tested at $T_A = +25^\circ C$. Overtemperature limits are guaranteed by design.

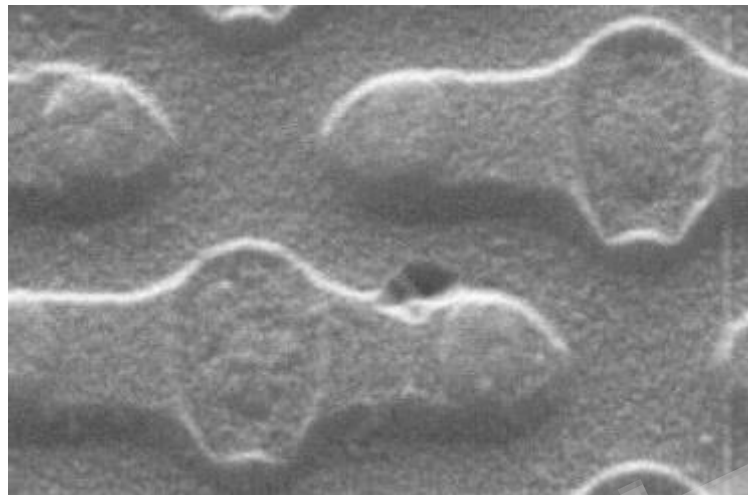
ELECTRICAL CHARACTERISTICS

junction temperature range, otherwise specifications are at $T_A = 25^\circ C$.

The ● denotes the specifications which apply over the full operating junction temperature range, otherwise specifications are at $T_A = 25^\circ C$. $V_{CC} = 8V$, unless otherwise noted. (Note 2)

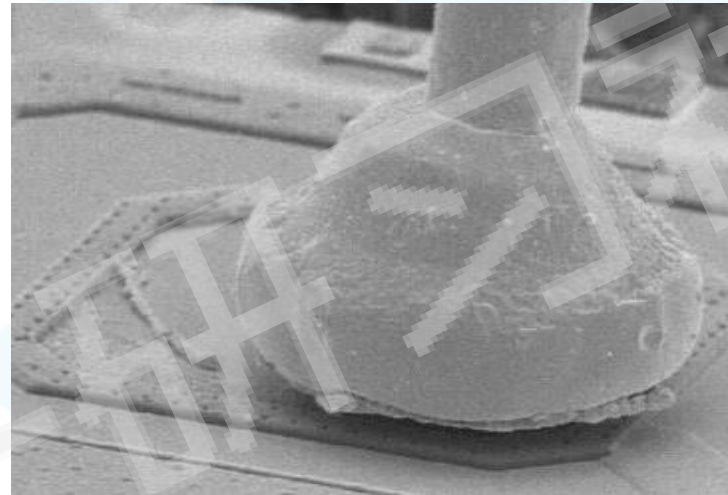
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$V_{CLAMP1mA}$	V_{CC} Shunt Regulator Voltage at 1mA	$I_{CC} = 1mA$, $V_{ITH/RUN} = 0V$ LTC3803E LTC3803H, LTC3803I LTC3803MP	● ● ●	8.3 8.3 8	9.4 9.4 9.4	10.3 10.5 10.5	V V V
$V_{CLAMP25mA}$	V_{CC} Shunt Regulator Voltage at 25mA	$I_{CC} = 25mA$, $V_{ITH/RUN} = 0V$ LTC3803E LTC3803H, LTC3803I LTC3803MP	● ● ●	8.4 8.4 8.1	9.5 9.5 9.5	10.5 10.7 10.7	V V V
V_{MARGIN}	$V_{CLAMP1mA} - V_{TURNON}$ Margin	LTC3803E LTC3803H, LTC3803I, LTC3803MP	● ●	0.05 0.03	0.6 0.6		V V

器件失效如何产生



▶ 硅片相关的失效:

- 热应力敏感性
- 电压应力敏感性
- 颗粒污染
- 晶格缺陷
- ...



▶ 封装相关的失效

- 热应力
- 机械应力
- 湿敏导致的失效
- ...

ADI 品质及可靠性管理流程

▶ QR²

- 居于光谱干涉方法的二次筛选，超越ICT的品质及可靠性保障
- 每周批量生产监控计划
- 抽样每个包装类型、生产数量、装配工厂和测试工厂的日期代码

管理部门会认真对待出现的故障，一旦发生，整批次全检再出厂

▶ 长期可靠性的审核

- 真实应用批量器件加速老化测试，用于故障时间(拟合)计算估算

每月有超过10万片芯片 用于可靠性测试!

ADI 电源器件失效率

- ▶ **0.08 FITS** (每10亿小时 0.08 片失效)
 - 故障率居于 +55°C, 60%置信水平
 - 高温工作寿命测试样品数量: 322,306
 - 总体失效数量: 8 pcs

ACCELERATED HIGH TEMPERATURE OPERATION LIFE (HTOL) TEST RESULT	
FIT Rate	0.08
Numbers of Total Failures	8
Total HTOL Sample Size from Q105 to Q415	322,306
Equivalent Device Hours at 55°C	113,358,618,880

The End

