

# PD多口充电器应用介绍

## TEA2016/7+TEA2095

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2022年5月



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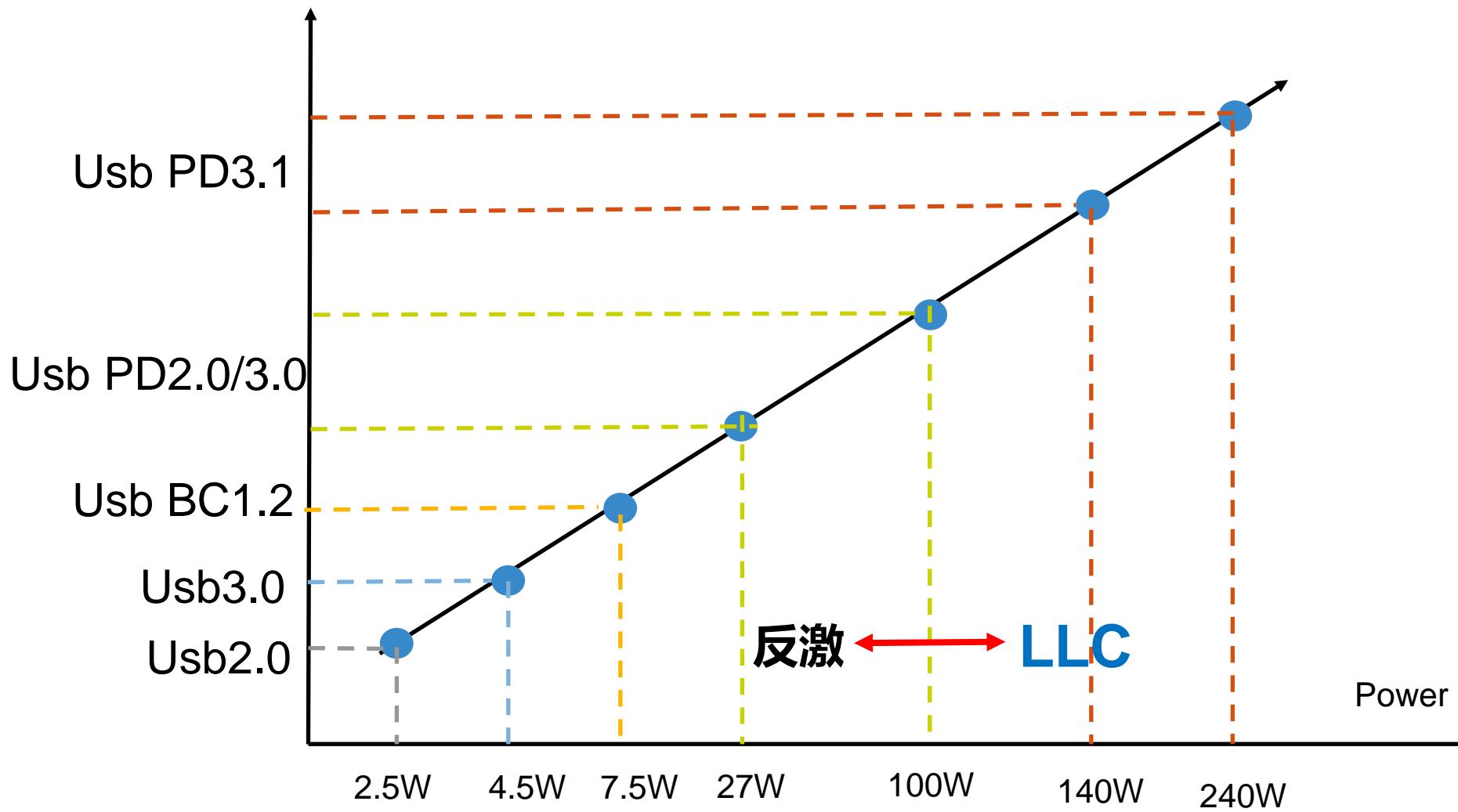
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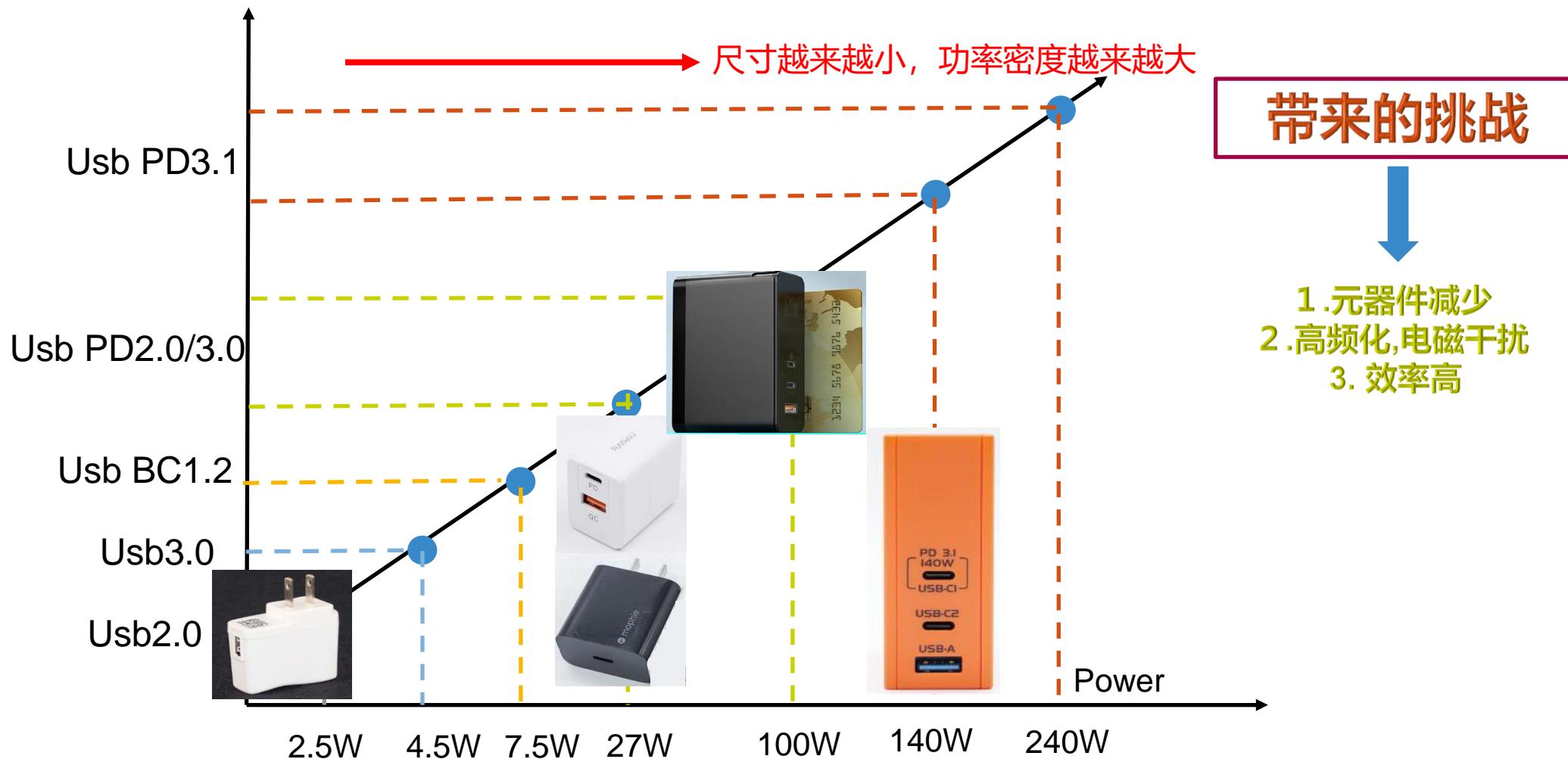
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- 充电器发展历程
- TEA2016/7 关键功能
- TEA2016/7详细功能的介绍
- TEA2095 同步整流功能介绍
- TEA2016/7 应用的介绍

# USB充电器发展历程



# USB充电器发展历程



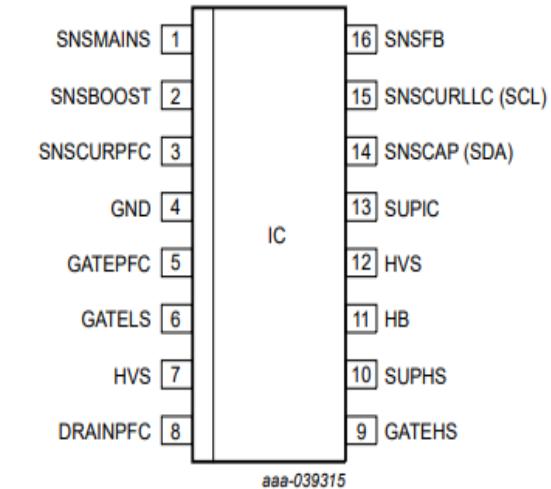
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# TEA2016/7 关键的功能介绍

## 关键功能：

- ✓ 封装SO-16,很多功能是软件设定，外部原件极少, 软件设定同时方便开发设计。
- ✓ PFC 和 LLC 的最高频率可以通过软件设定, TE2016 PFC最高可以500kHz, TEA2017最高可以到250kHz, LLC最高可以1MHz, 可以大大提高PCB尺寸
- ✓ PFC有谷底检查, 可以工作准谐振模式, LLC 实现零电压开通, 可以大大提高整体效率。
  
- ✓ 具有输入欠压和过压保护
- ✓ PFC第二级过压保护
- ✓ TEA2016 PFC工作模式 DCM/QR
- ✓ TEA2017 PFC 工作模式 DCM/QR/**CCM**
- ✓ X-cap 放电功能
- ✓ 待机功耗可以满足<75mW 以下
- ✓ 可以支持DC输入
- ✓ TEA2017 PF在高低可以达到0.98以上, THD可以10%以内

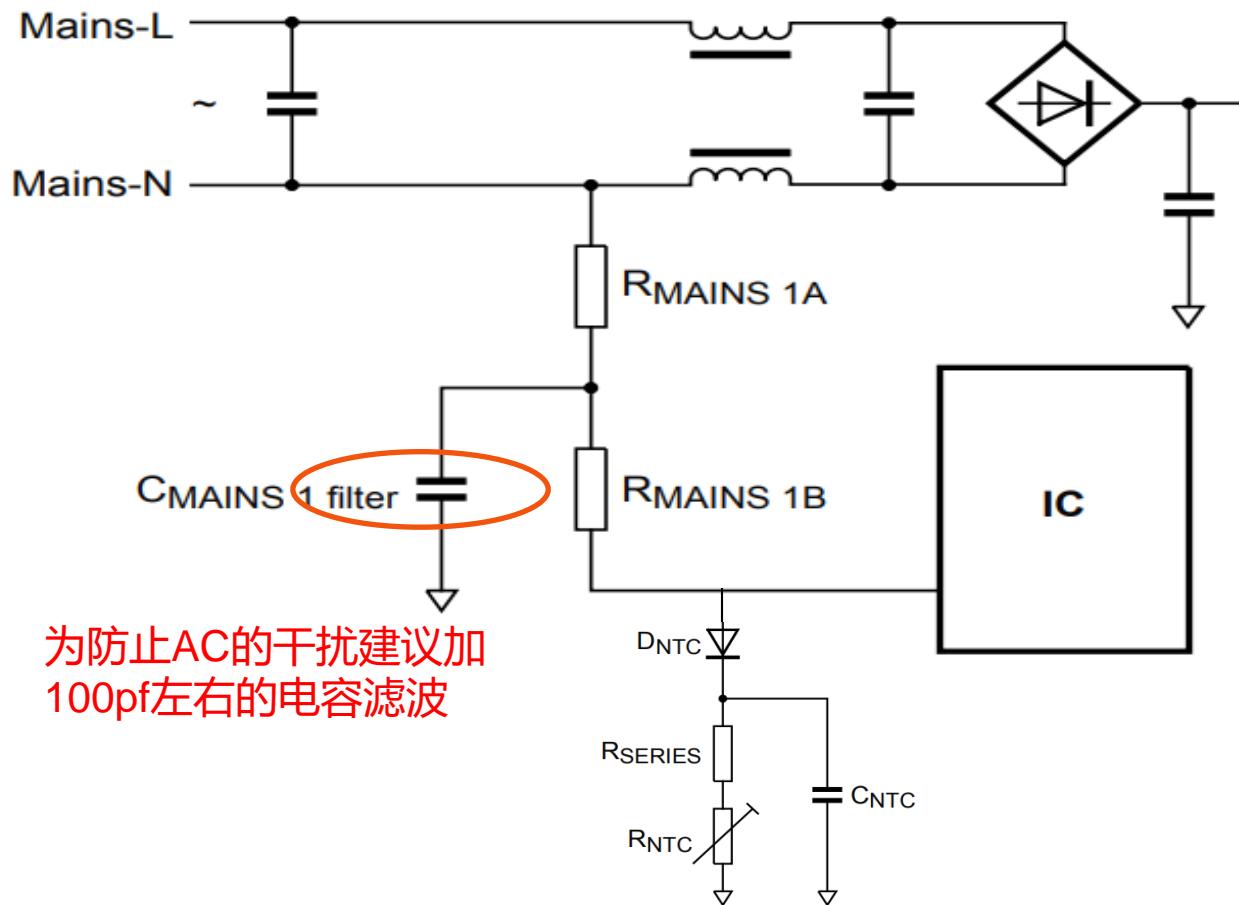


# 多口PD充电器方案介绍

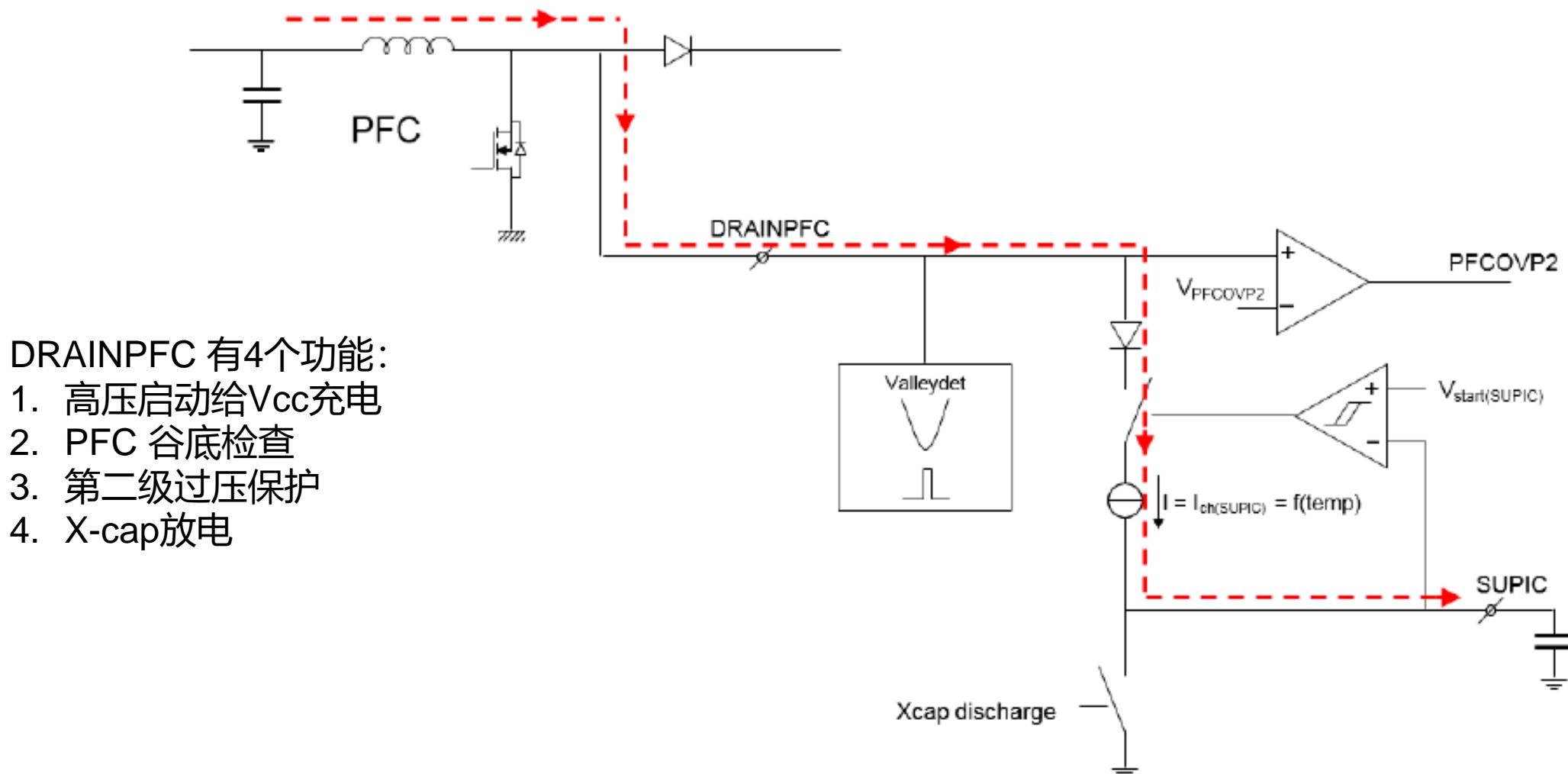
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# TEA2016/7 Snsmain功能

1. 输入高低压的功率补充
2. 输入开启(brown in) 和 欠压 (brown out) 功能
3. 外部的过温保护。
4. 快速开关解锁死功能

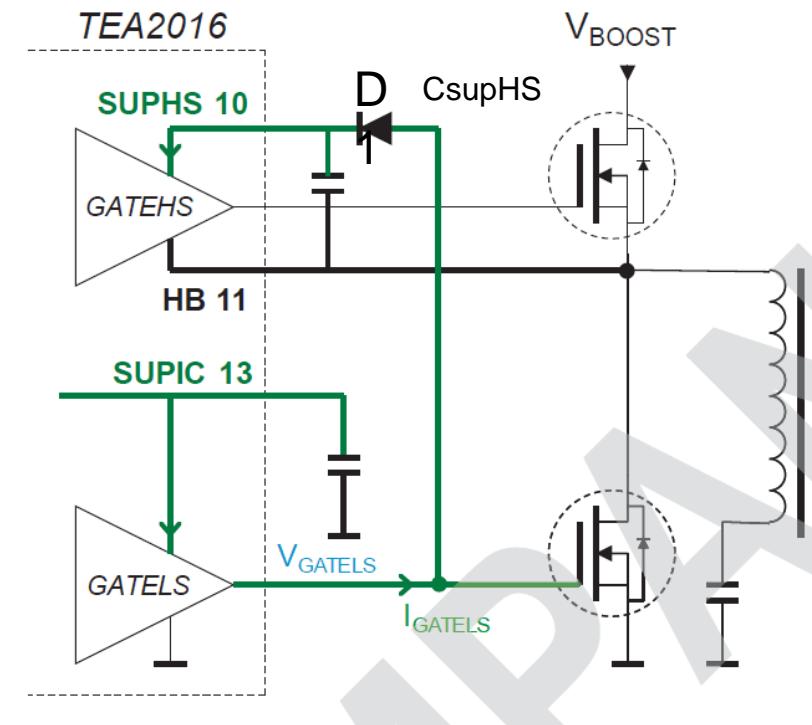


# TEA2016/7 Drainpfc功能

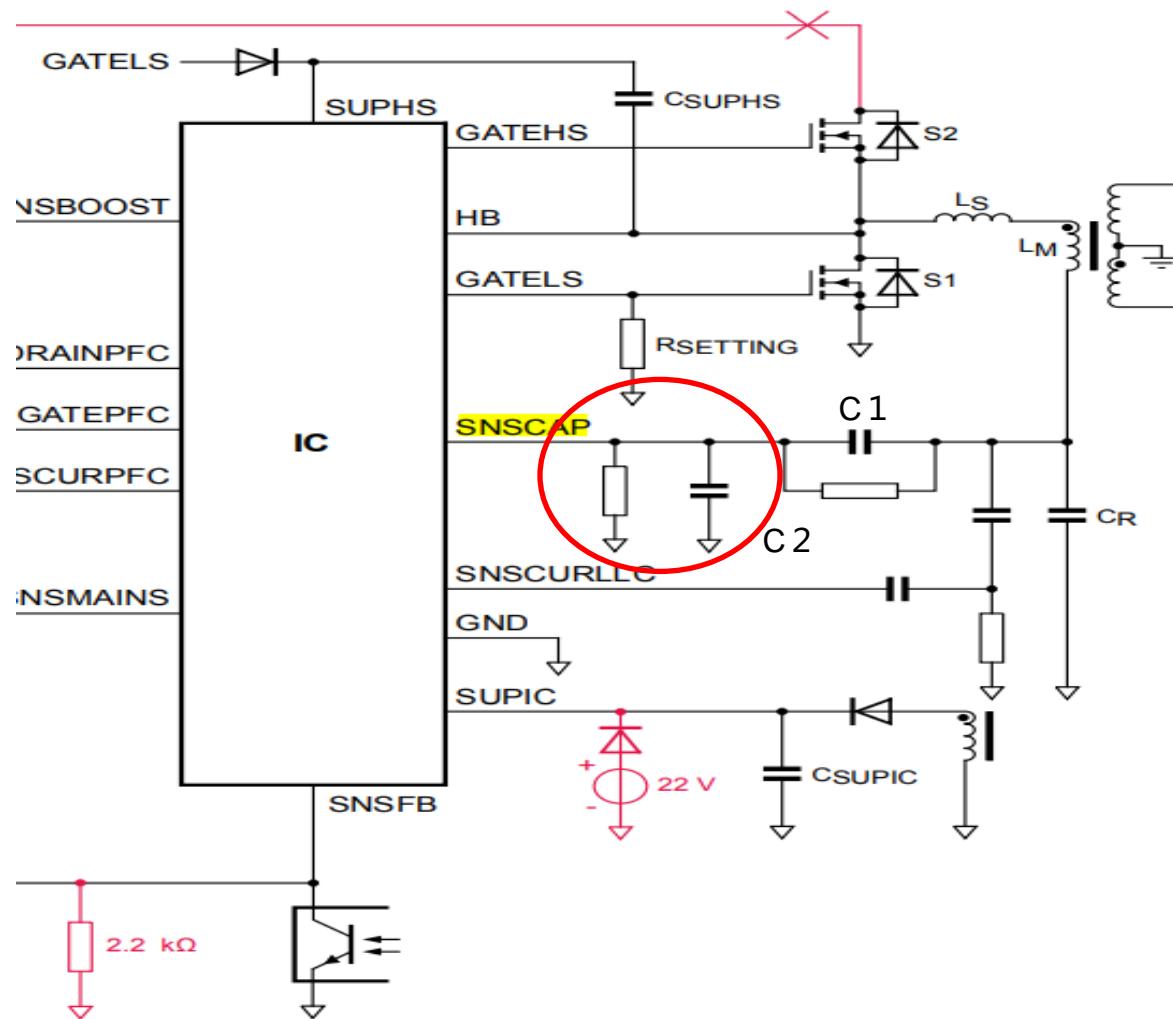


# TEA2016/7 SUPHS供电

1. SUPHS 供电来自LLC下管驱动,不需要通过Vcc加线性稳压来供电.
2. SUPHS自身有过压和欠压保护.



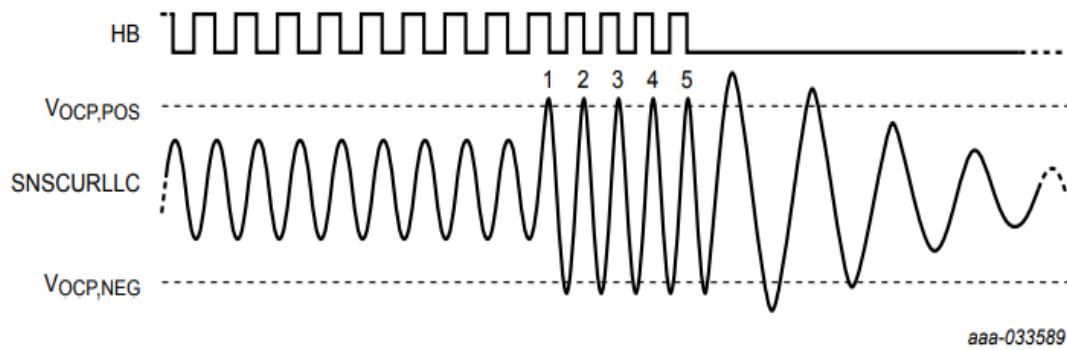
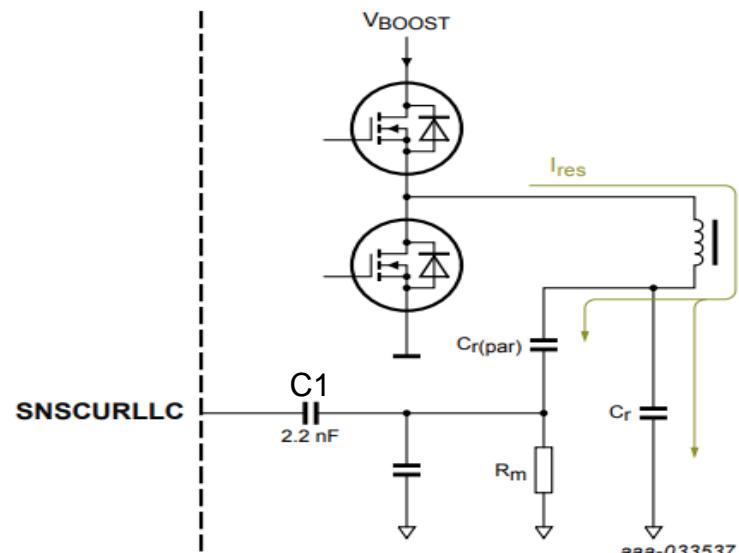
# TEA2016/7 SNSCAP功能



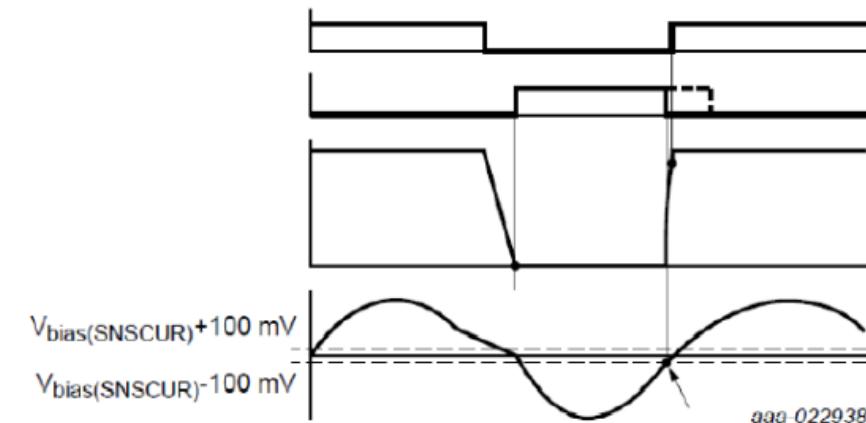
1. 输出电压稳定的调整

2. 输出过功率的调整，只需  
调整C2的电容大小，保护时  
间比较长。

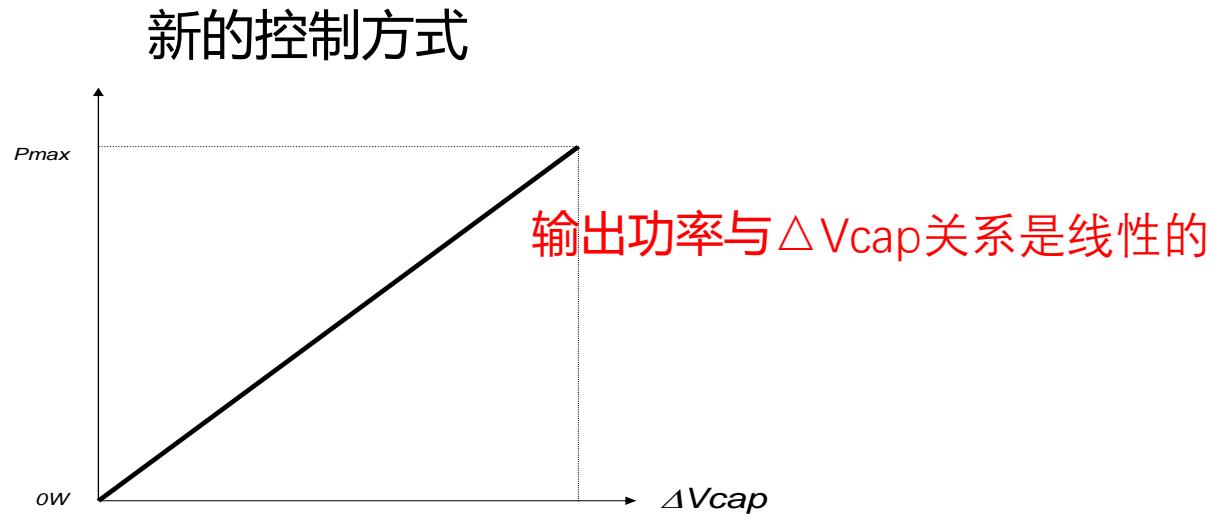
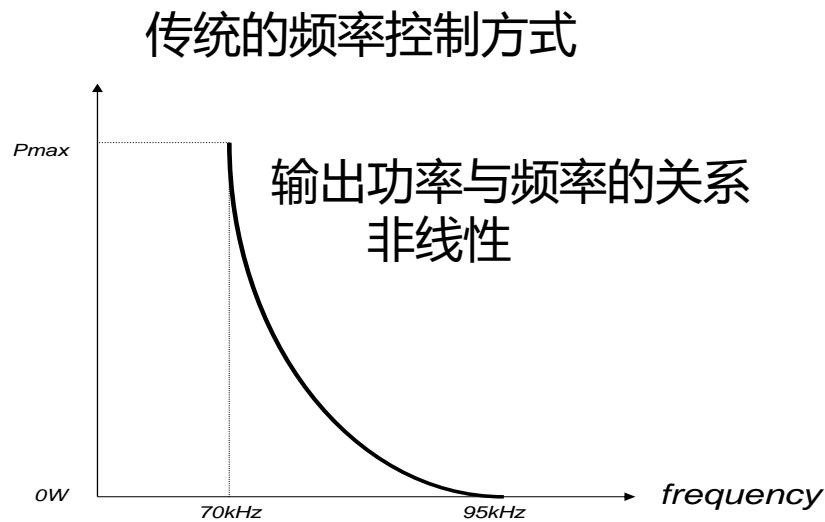
# TEA2016/7 SNSCURLLC功能



1. 输出短路时候保护,保护时间比较短
- 2 .谐振电路的容性保护。
3. C1建议2.2nf, 短路保护和容性保护调整Rm



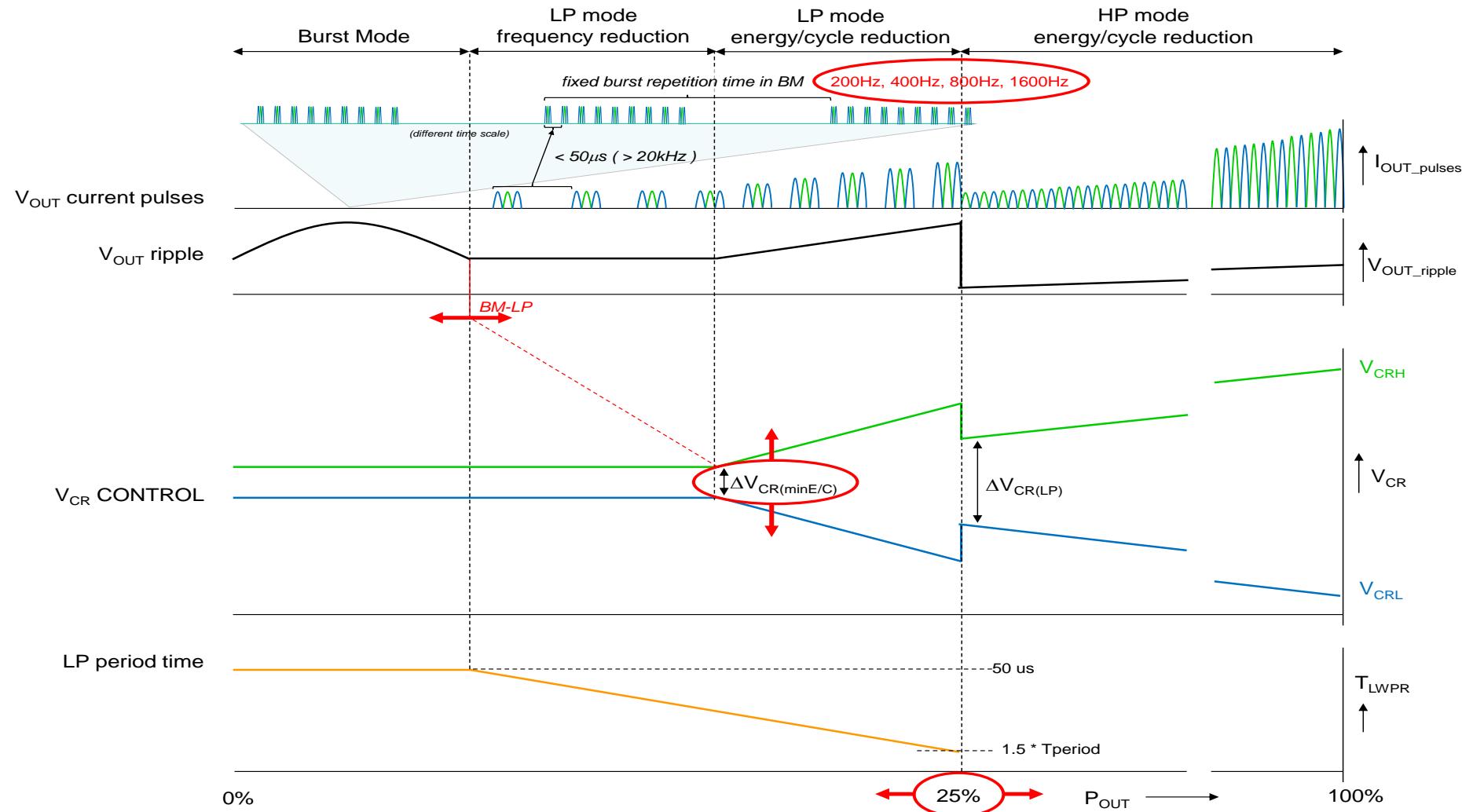
# TEA2016/2017 LLC控制方式



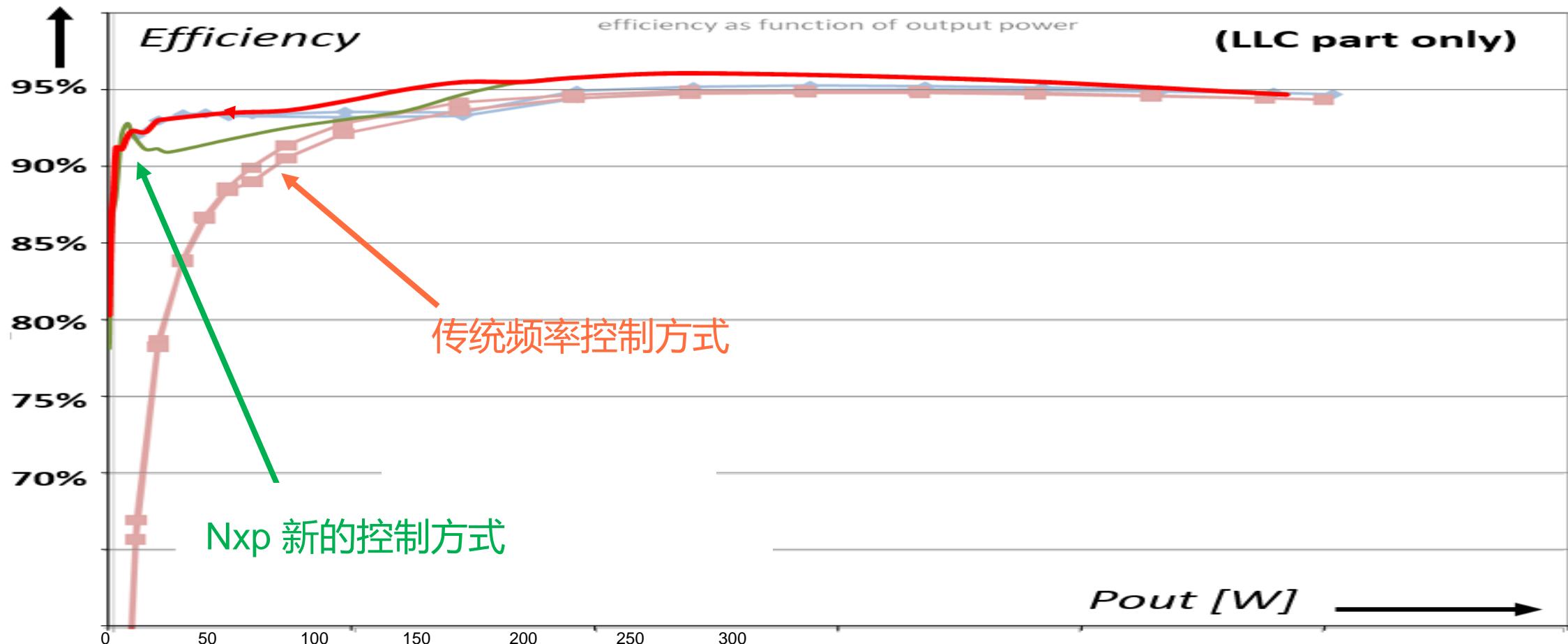
用这种方式控制的好处?

- ◆ 线性的控制方式让功率控制变得更加容易，可以很精准控制BM,LP, HP 进退出点。
- ◆ 非非常好的动态响应速度。

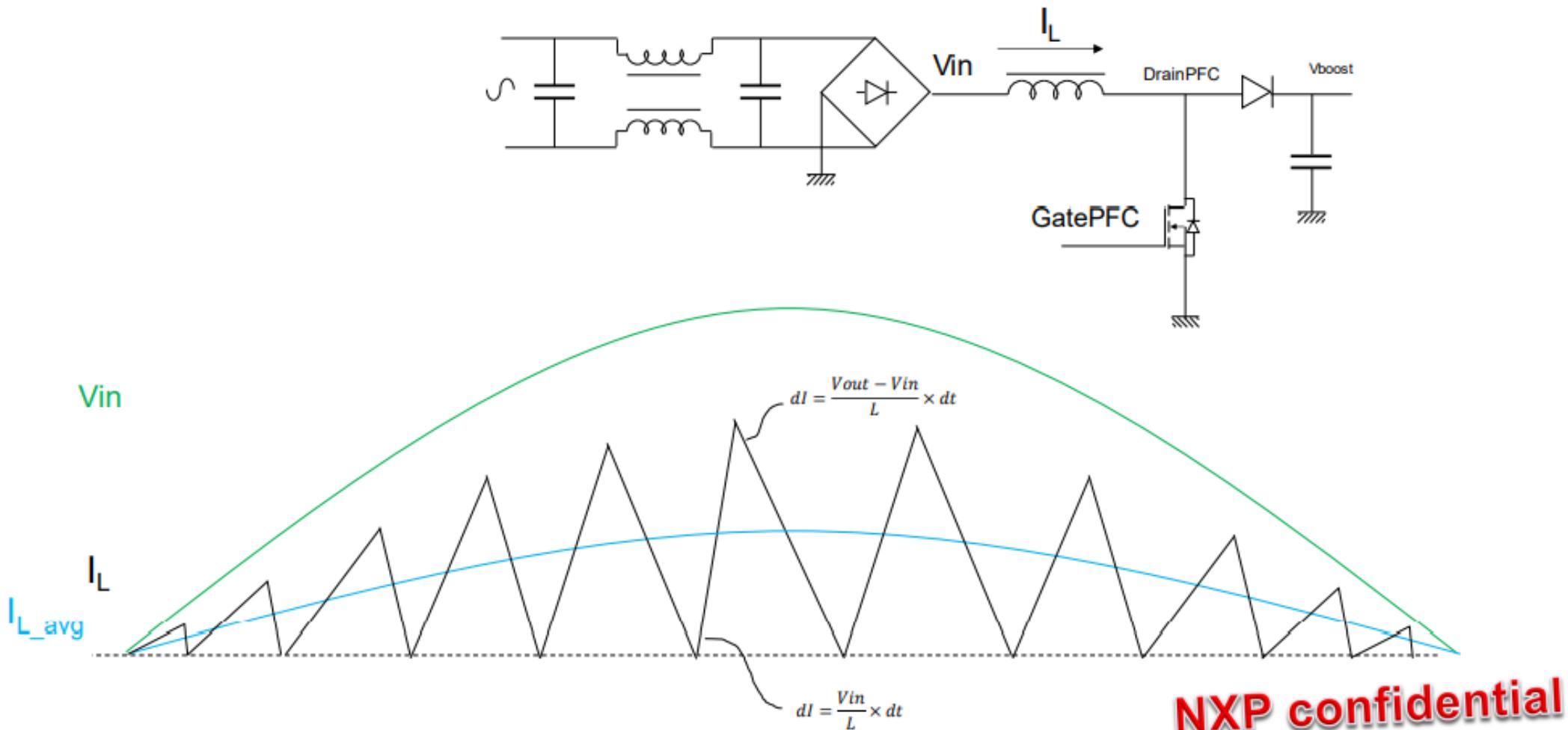
# LLC工作的三种模式



# LLC相比传统控制提升效率

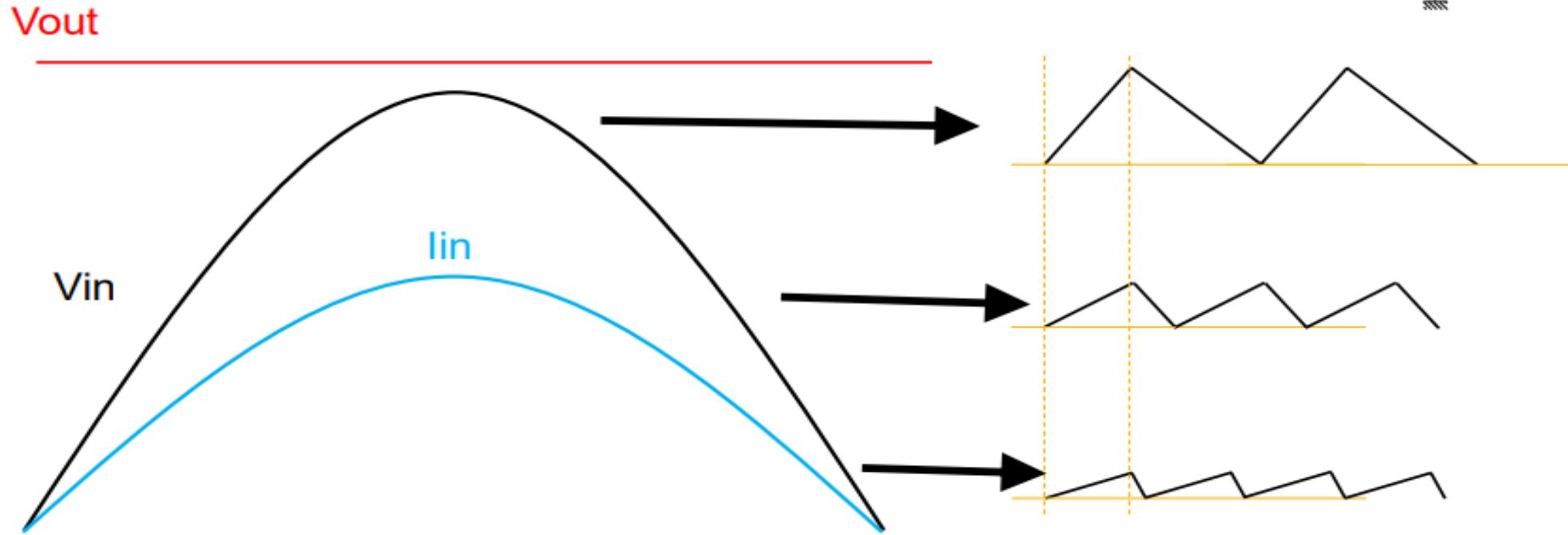
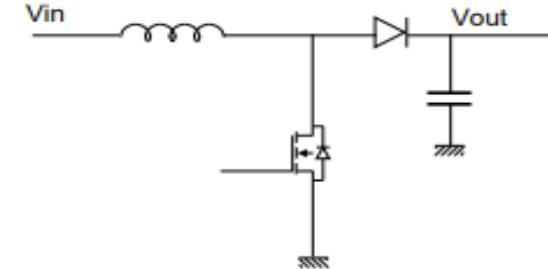


# TEA2016 功率因数校正

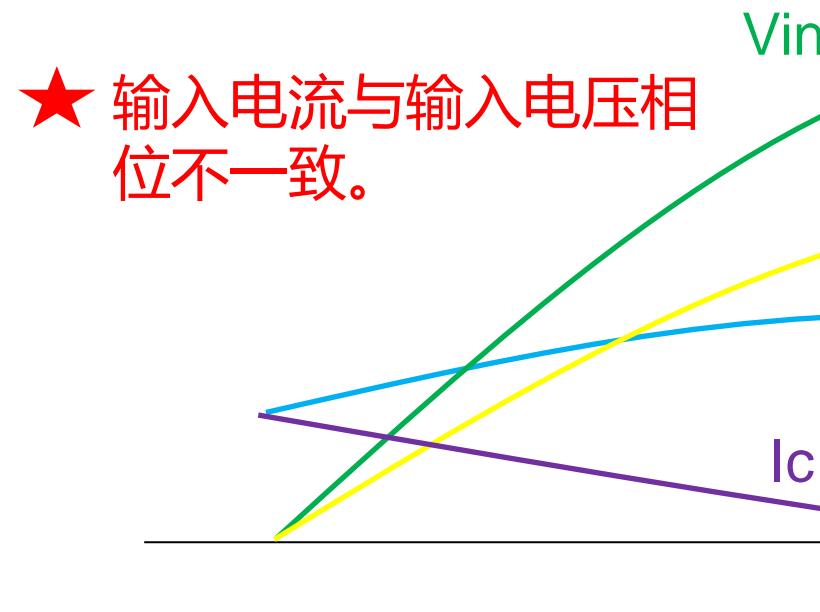
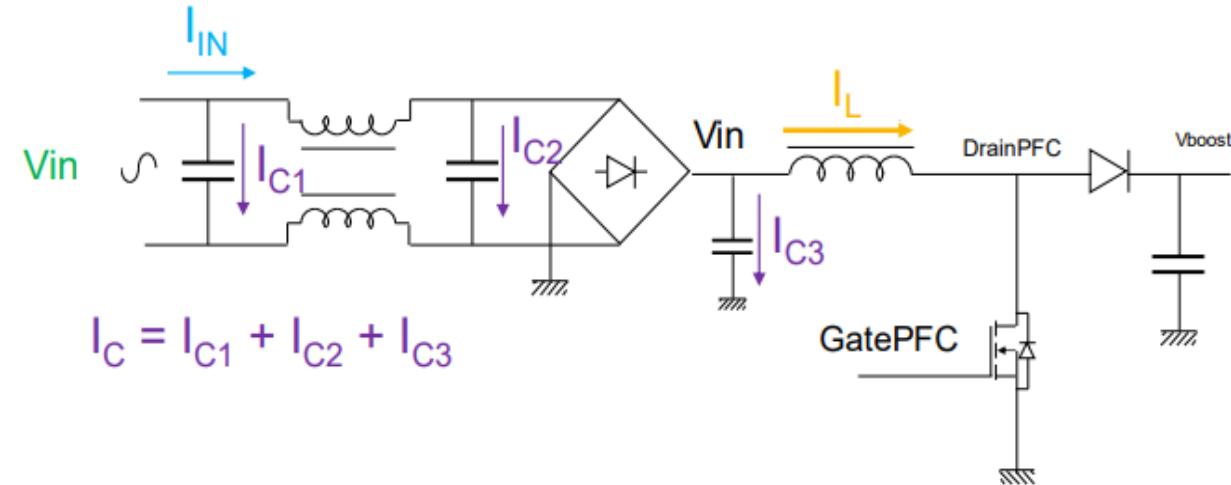


# TEA2016 功率因数校正

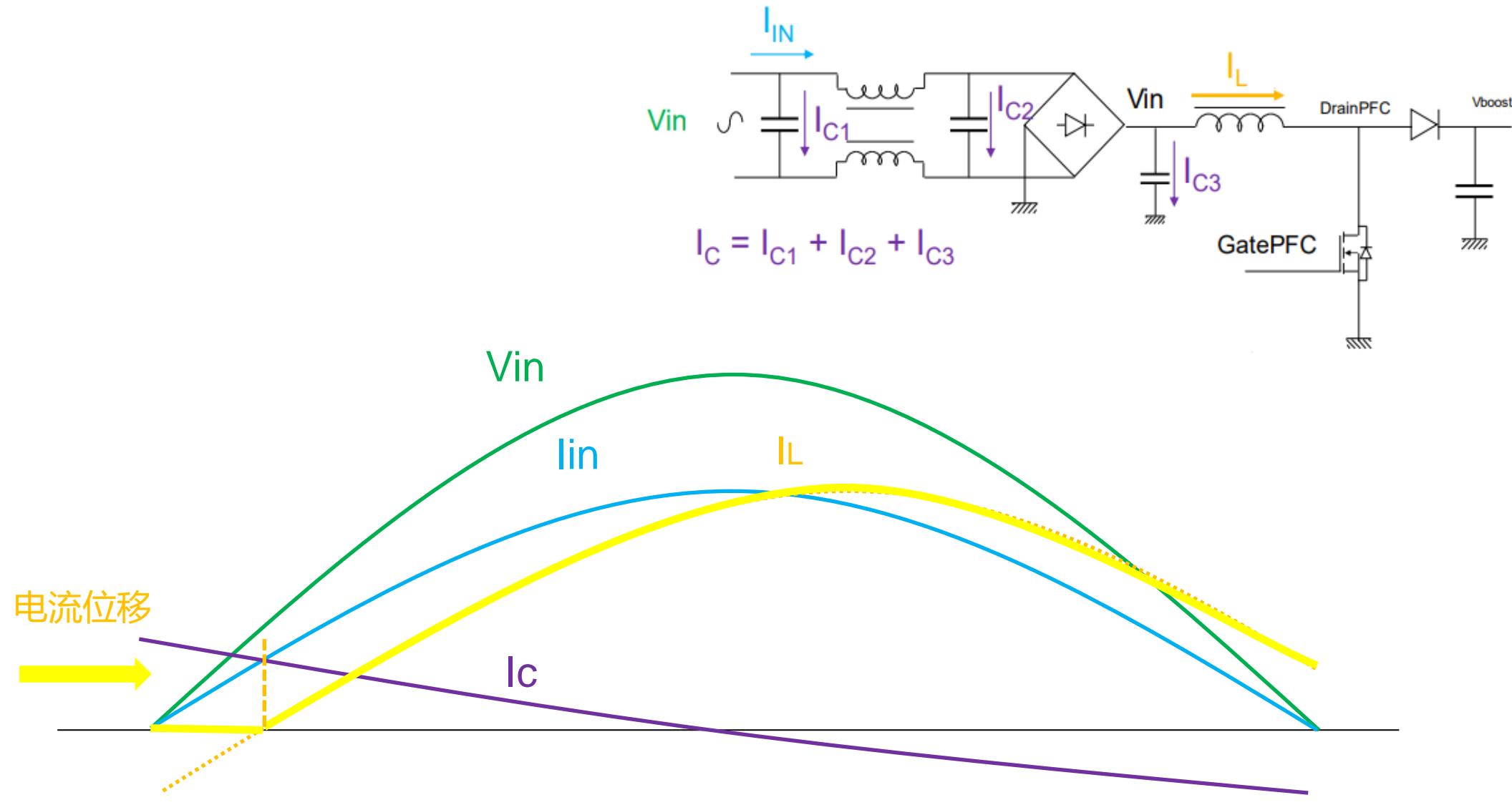
$$\frac{dI}{dt} = \frac{Ul}{L}$$



# TEA2017 功率因数校正

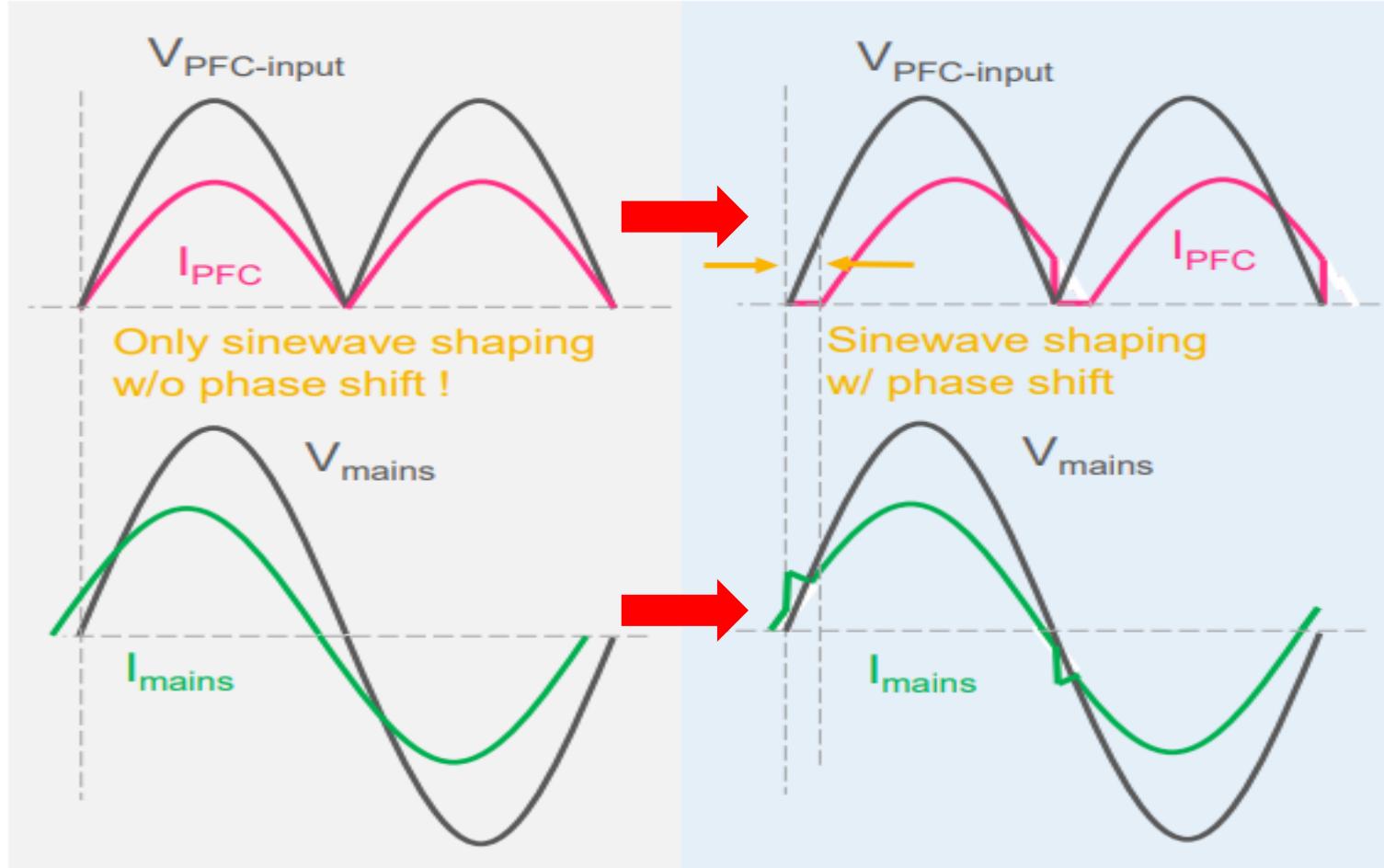


# TEA2017 功率因数校正

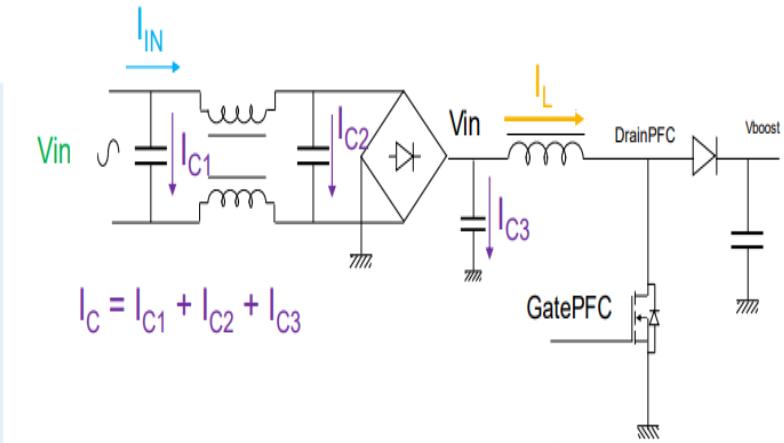


# 测试结果

没有相位的结果

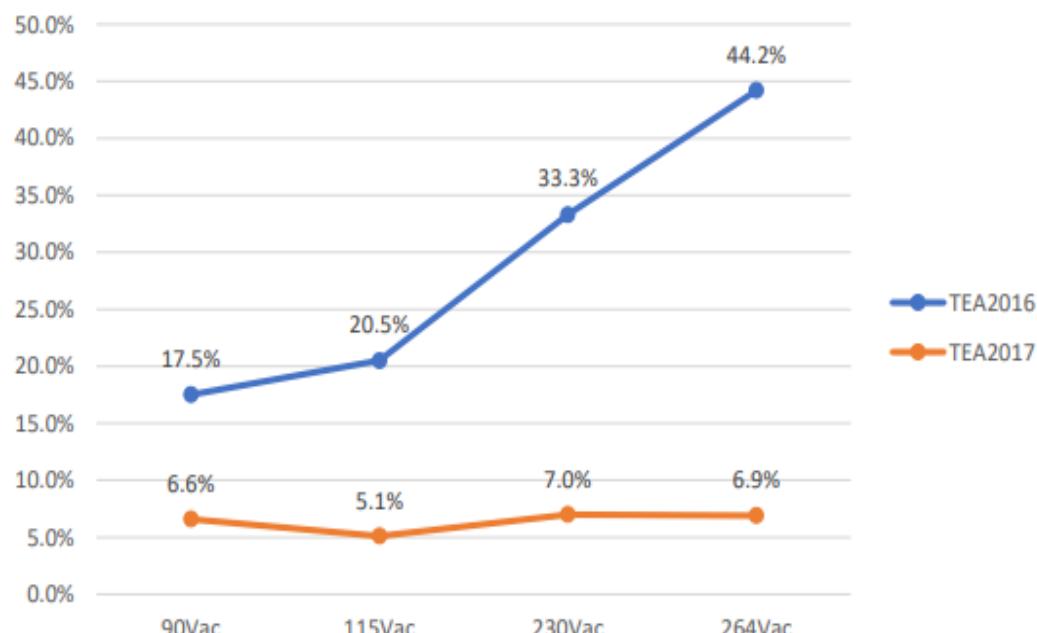


有相位的结果



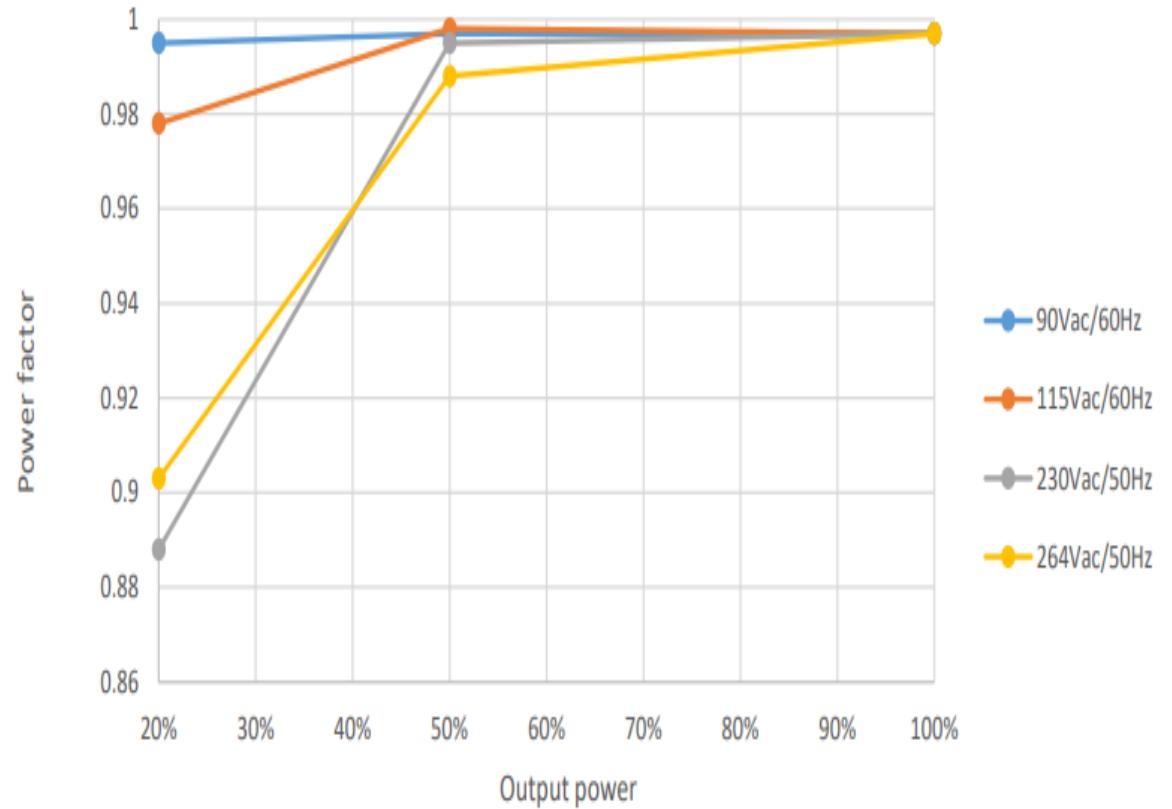
# PF和THD测试结果比较

TEA2016和TEA2017 THD结果比较

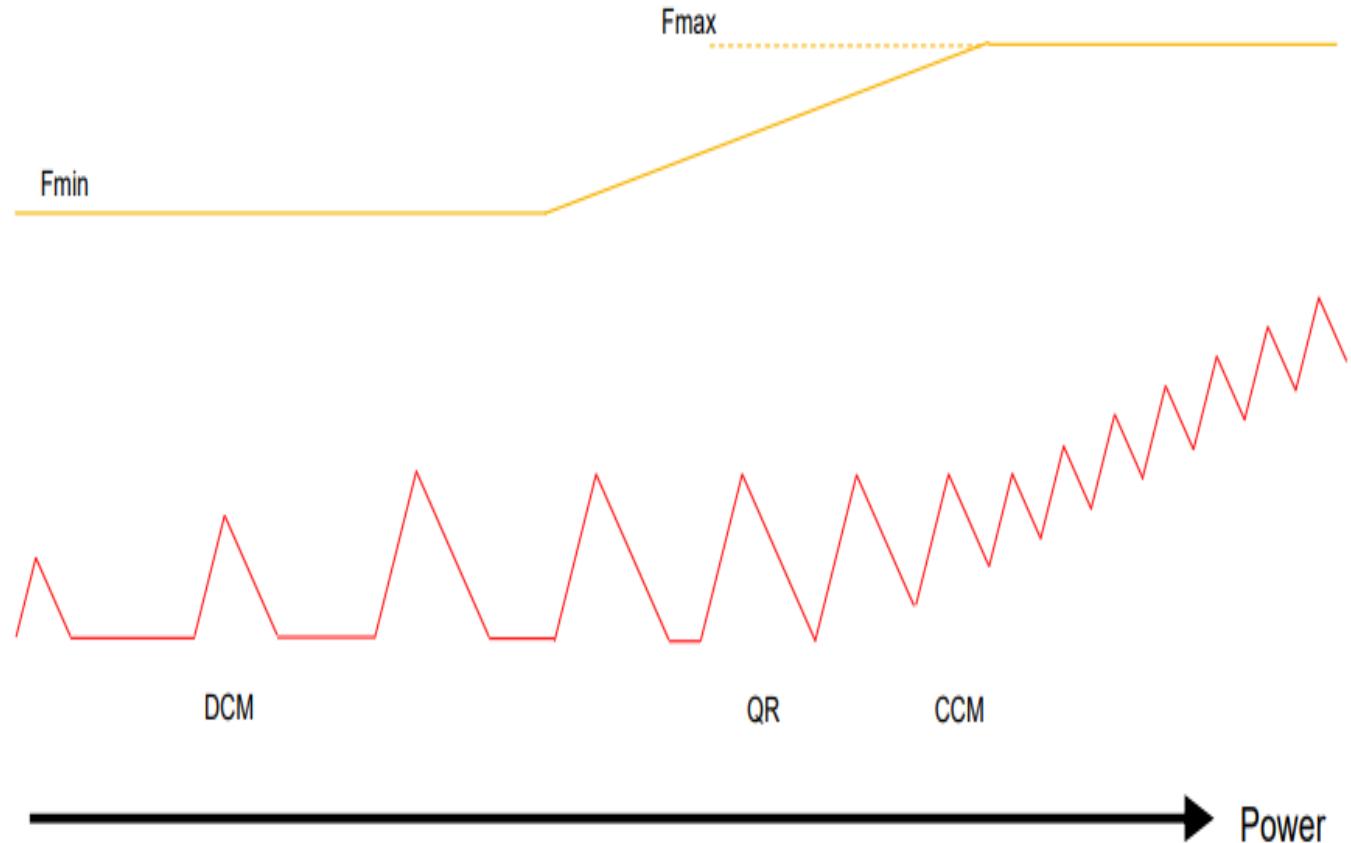


• Test result at half load condition

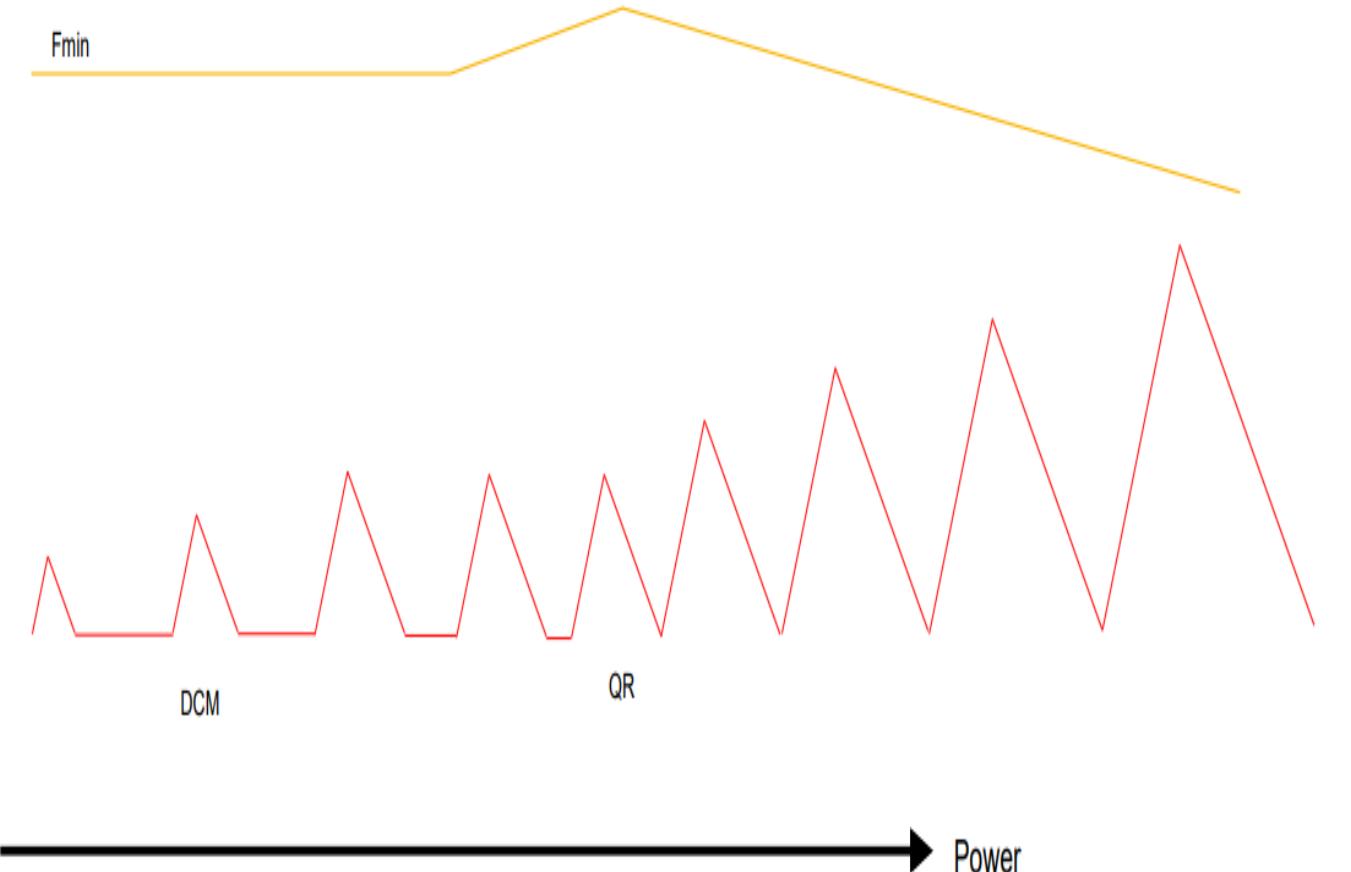
TEA2017 PF 结果



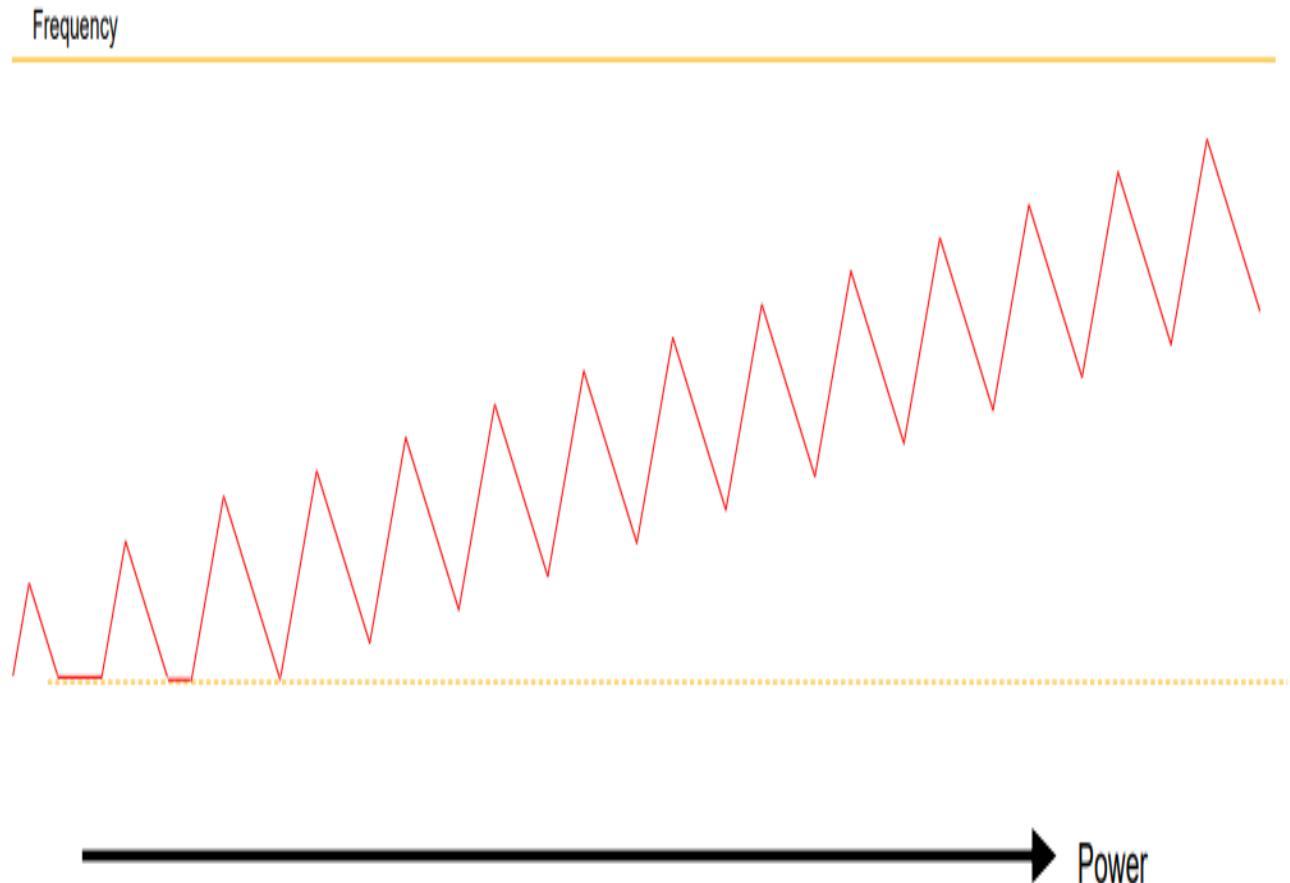
# TEA2017 PFC 多种工作模式: DCM/QR/CCM



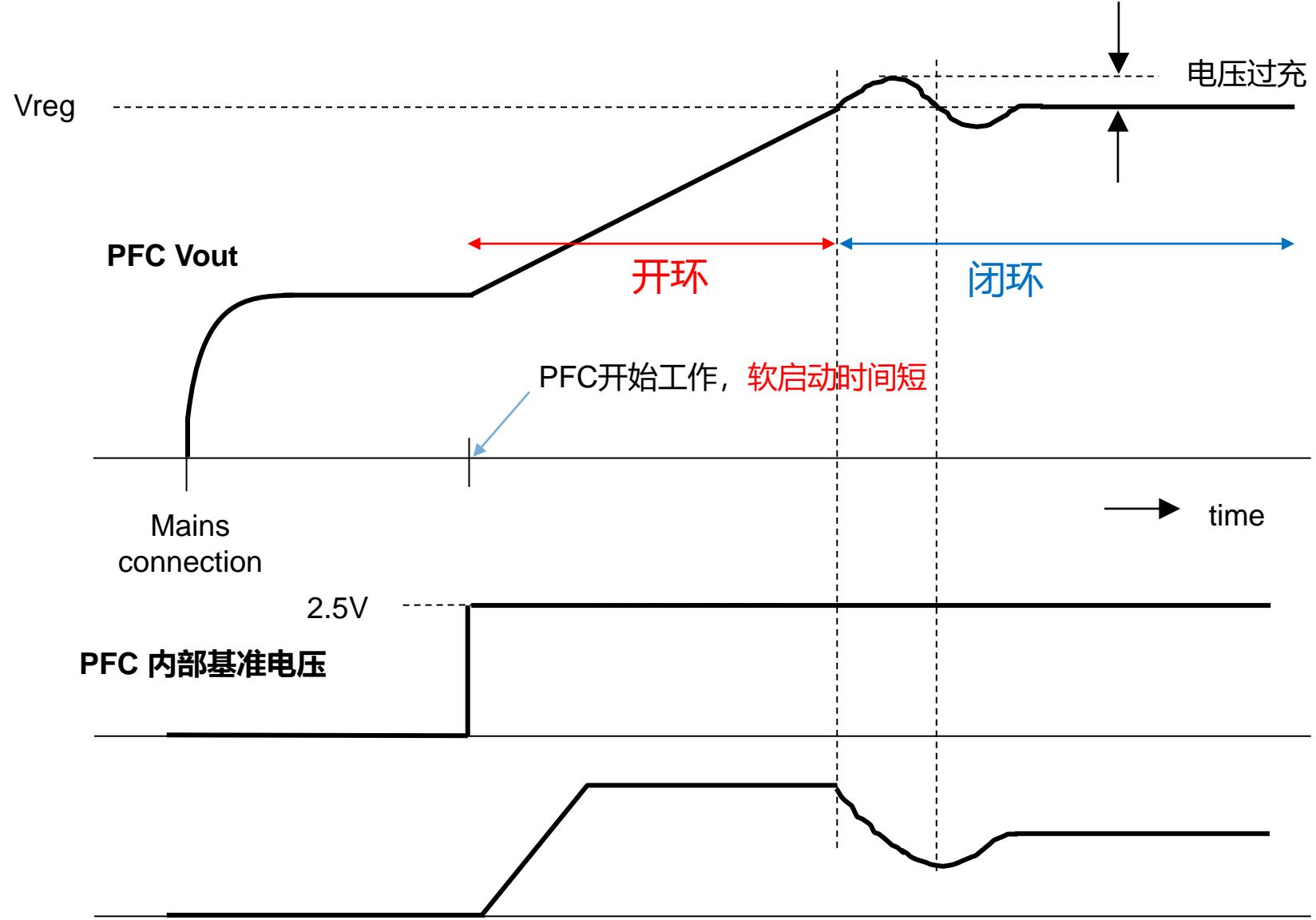
# TEA2017 PFC 多种工作模式: DC/QR



# TEA2017 PFC 多种工作模式: CCM



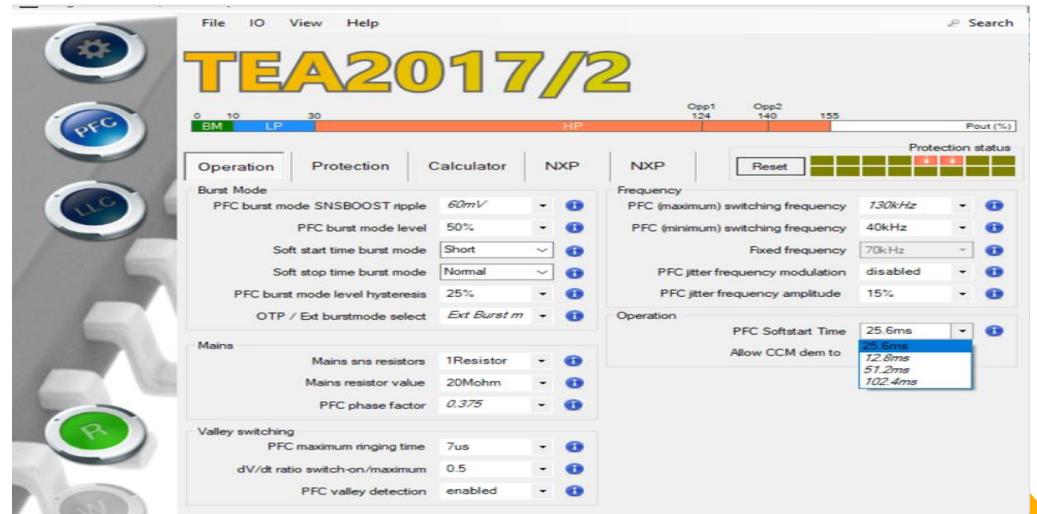
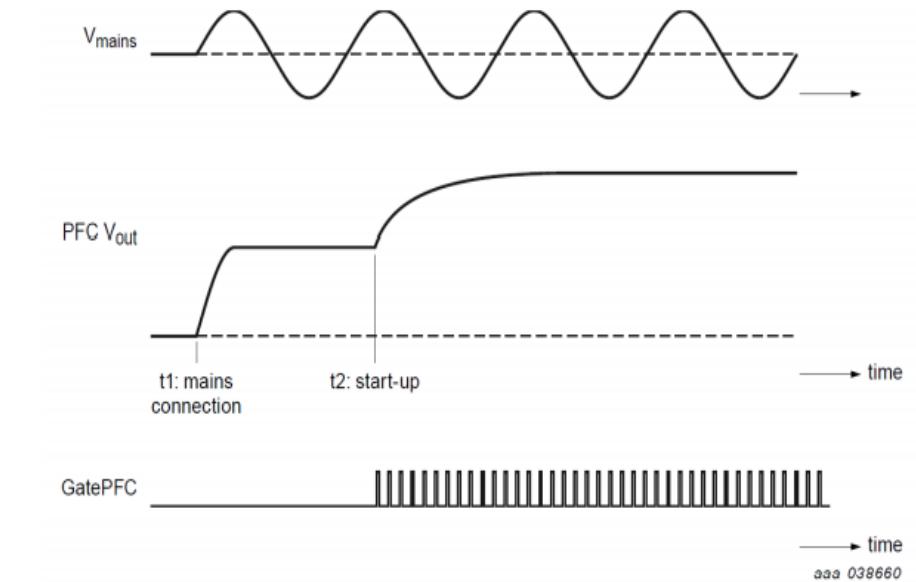
# TEA2016 PFC 工作\_开机



# TEA2017 PFC 工作\_开机

## 1. 软件可以设定比较长的软启动时间：

- 可以减少PFC电感开机时候电流
- 可以减小开机时候的噪声
- 可以减小PFC输出电压的过充现象。



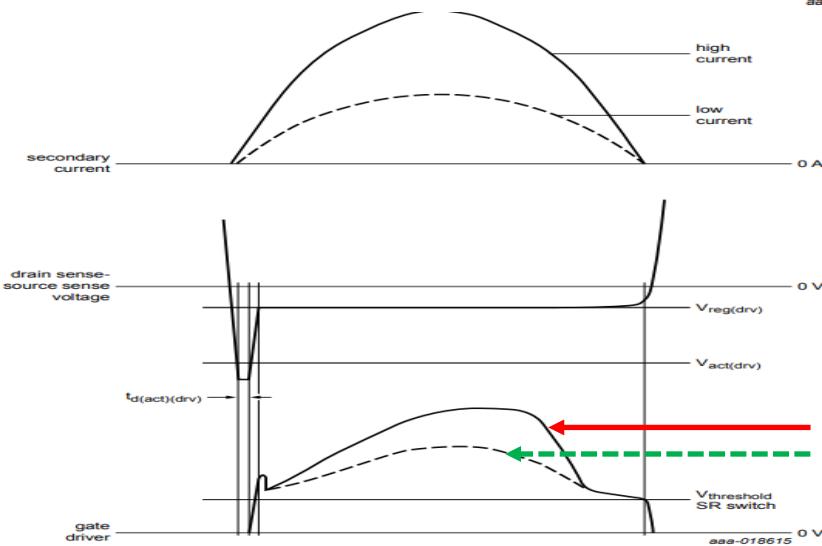
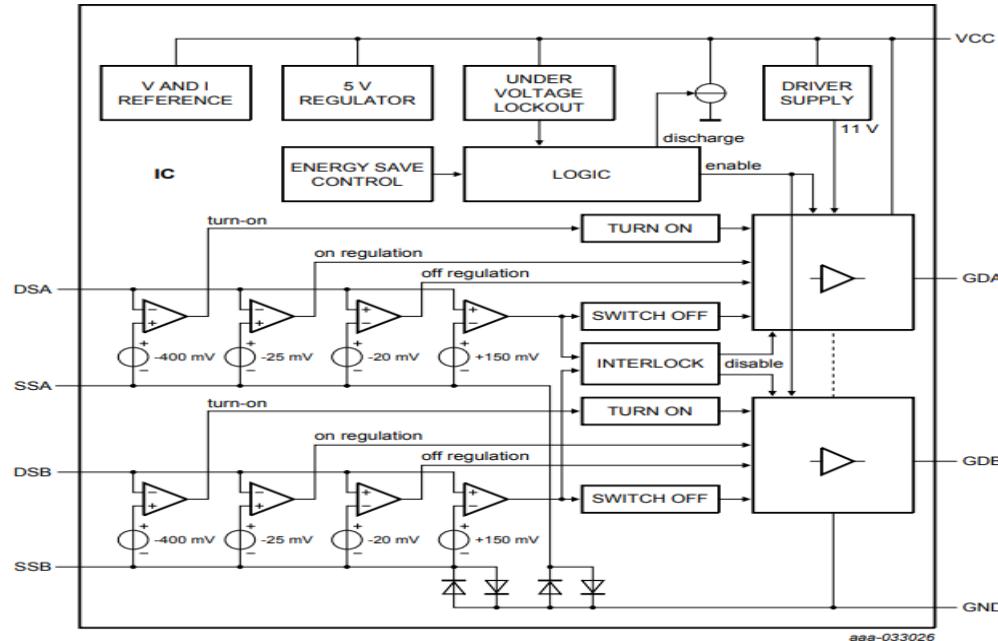
# TEA2016 与 TEA2017的差异

	TEA2016	TEA2017	注释
PFC部分			
PFC 工作方式	固定导通时间	平均电流	
PFC 工作模式	断续和临界模式	三种工作模式可以选择： 1.断续, 临界, 连续 2 断续, 临界 3 .连续	TEA2017可以应用在更高的功率
PF/THD 实现方式	固定导通时间	平均电流和相位移的方式	TEA2017可以得到更好的PF和THD
工作频率	限定最高频率	频率控制方式	TEA2017轻载效率可以更好。
频率抖动	没有	有	改善EMI
PFC软启动	固定的软起动时间。	软起的时间可以选择	TEA2017可以更好的解决开机电压过充的问题。

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- TEA2016/7 应用的介绍

# TEA2095



## (1) TEA2095 特性:

- 1, DSA,DSB 耐压120V,
- 2, Vcc工作电压非常宽: 4.5V~38V
- 3, 驱动自适应, 可以提升轻载效率

**(2) TEA2095工作原理,采样流过MOSFET的工作电流,也就是 $V_{ds}$ 的压降。**

开通过程:

1.  $V_{ds}$ 电压小于-400mV给IC一个 $V_{gs}$ 可以开通的一个条件
2. 当 $V_{ds}$ 电压小于-25mV, IC可以提高驱动电压, 从而降低 $R_{ds}$ , 来维持 $V_{ds}$ 的电压在-25mV.

关断过程:

1. 当流过MOSFET电流减小时, 并大于-20mV的时候, IC会降低驱动电压, 从而提高 $R_{ds}$ , 保持 $V_{ds}$ 的电压在-20mV.
2.  $V_{ds}$ 电压大于150mV的时候, 驱动会立即关断。

电流大的时候, 驱动电压高,  
电流小的时候, 驱动电压低, 可以提  
升轻载效率

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# 150W 氮化镓演示板

输入规格: 90Vac~264V

输出规格: 21.5V, 150W

功率密度: 1.91W/厘米<sup>3</sup>

PCB尺寸: 6.5cm\*5.5cm\*2.2cm

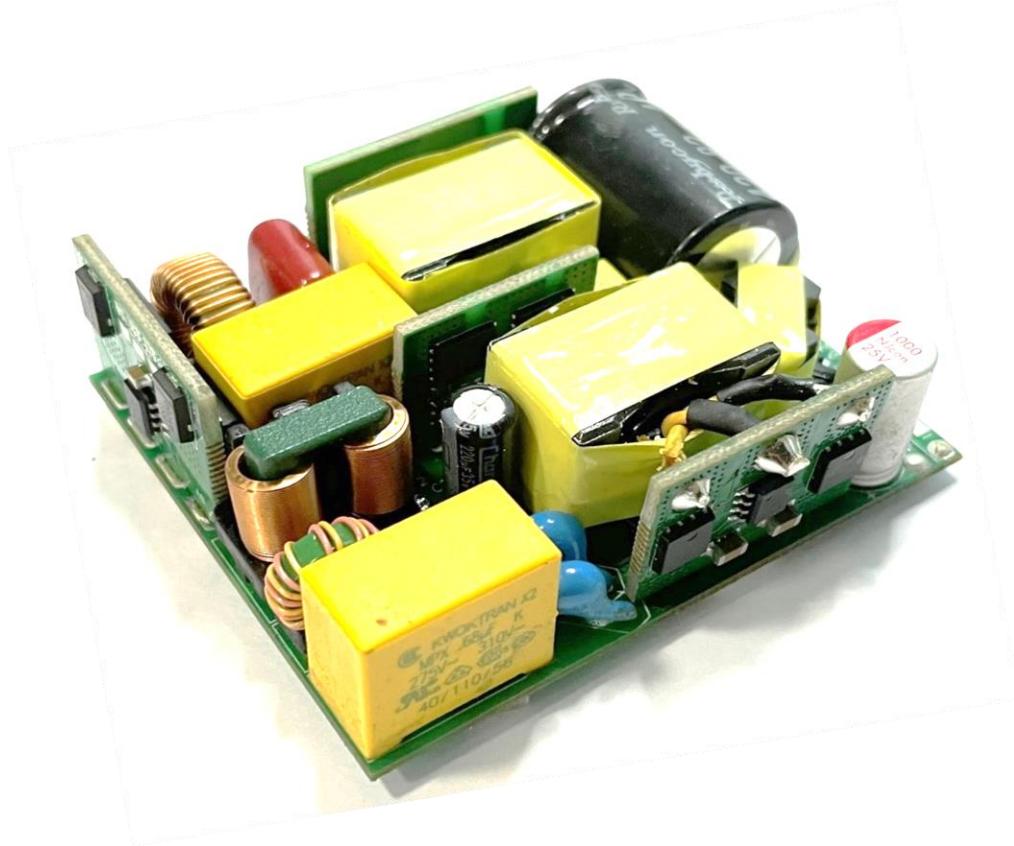
工作频率: PFC@200kHz

LLC@250KHz

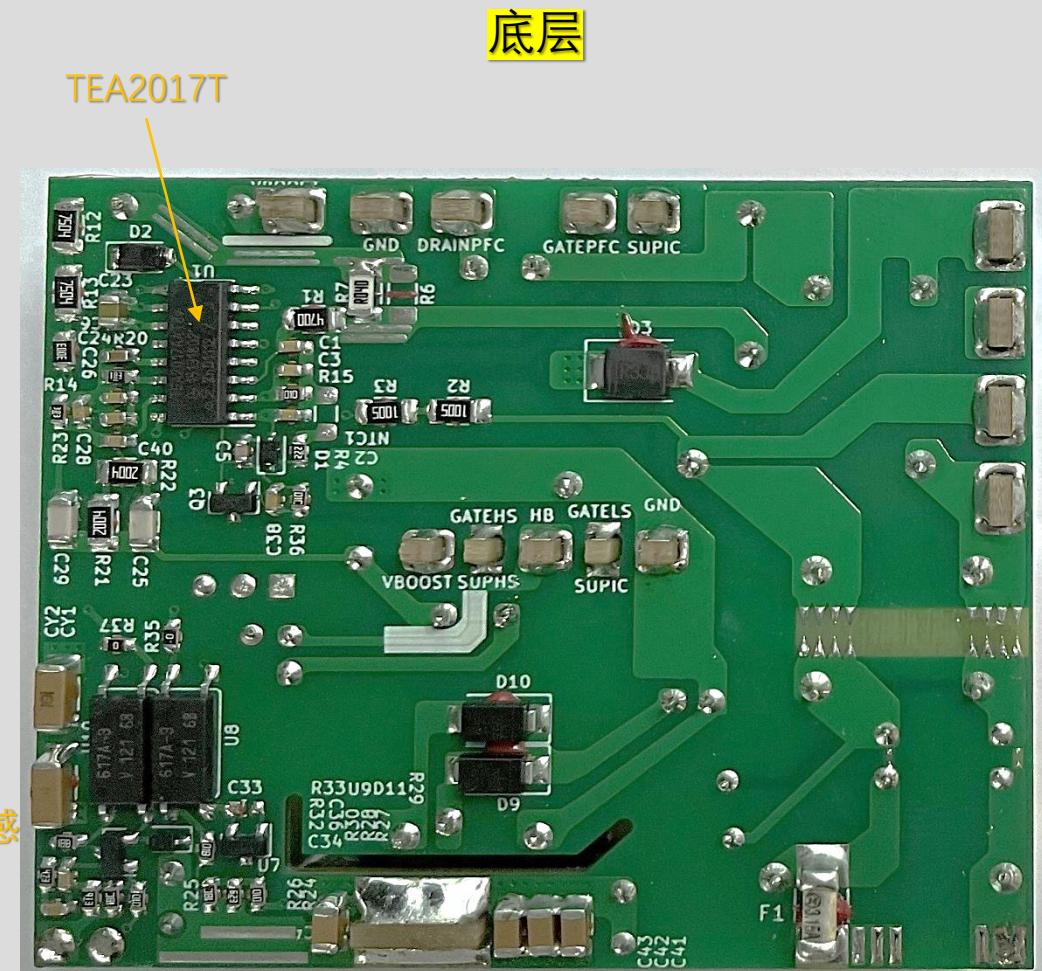
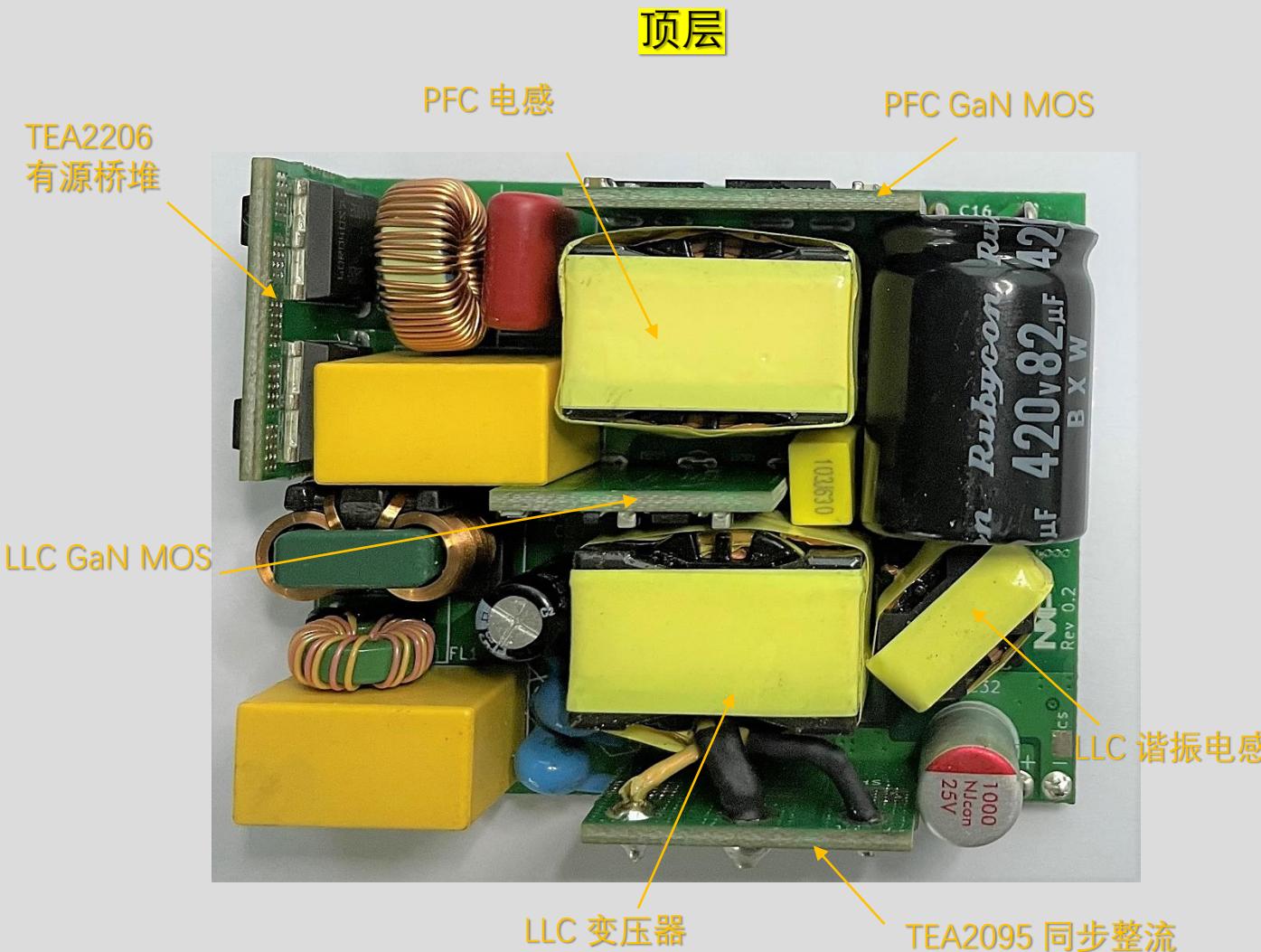
应用nxp产品: TEA2017 SO16 PFC+LLC

TEA2206 SO8 有源桥堆

TEA2095 SO8 同步整流

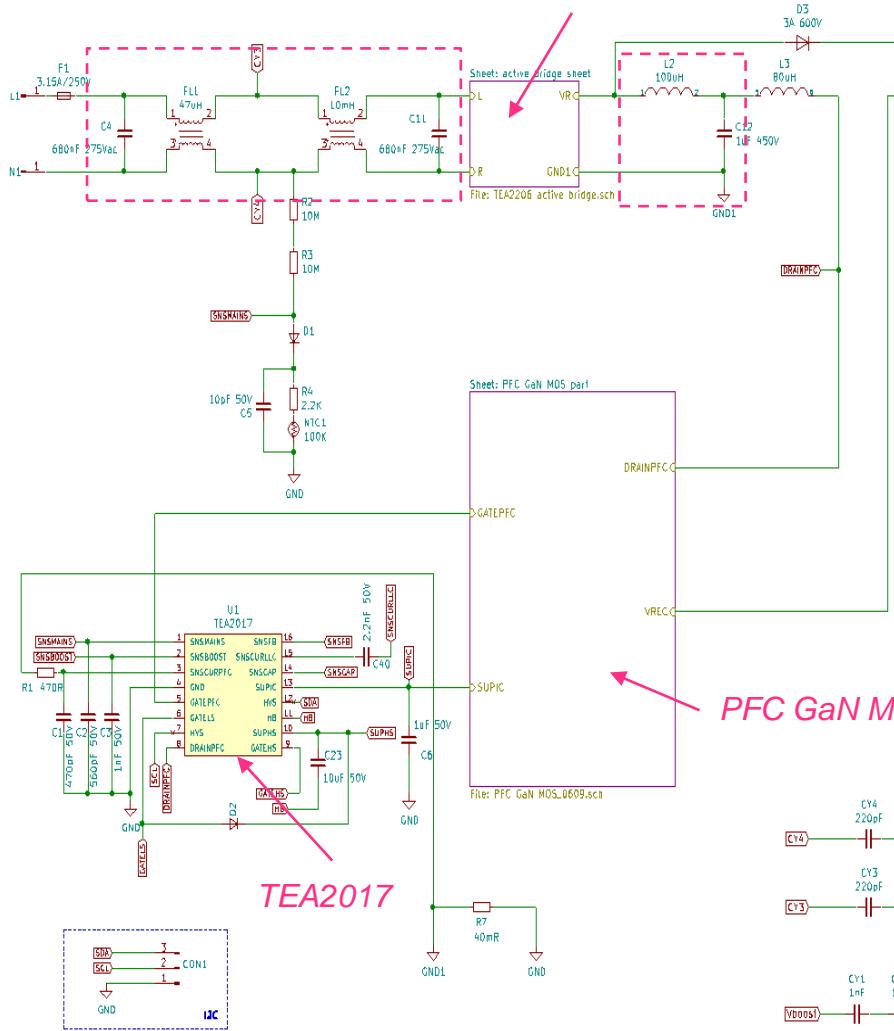


# 150W 氮化镓演示板



# 150W 氮化镓原理图

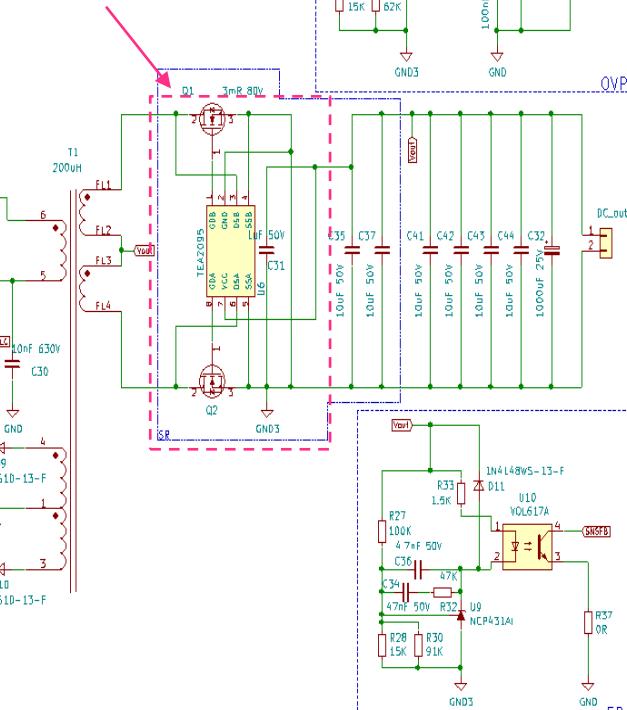
TEA2206有源桥堆



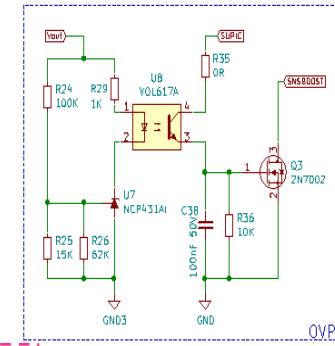
LLC two GaN MOS



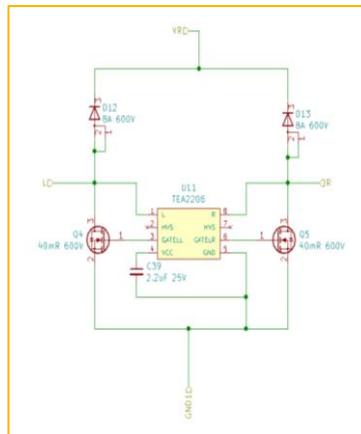
TEA2095同步整流



外部OVP

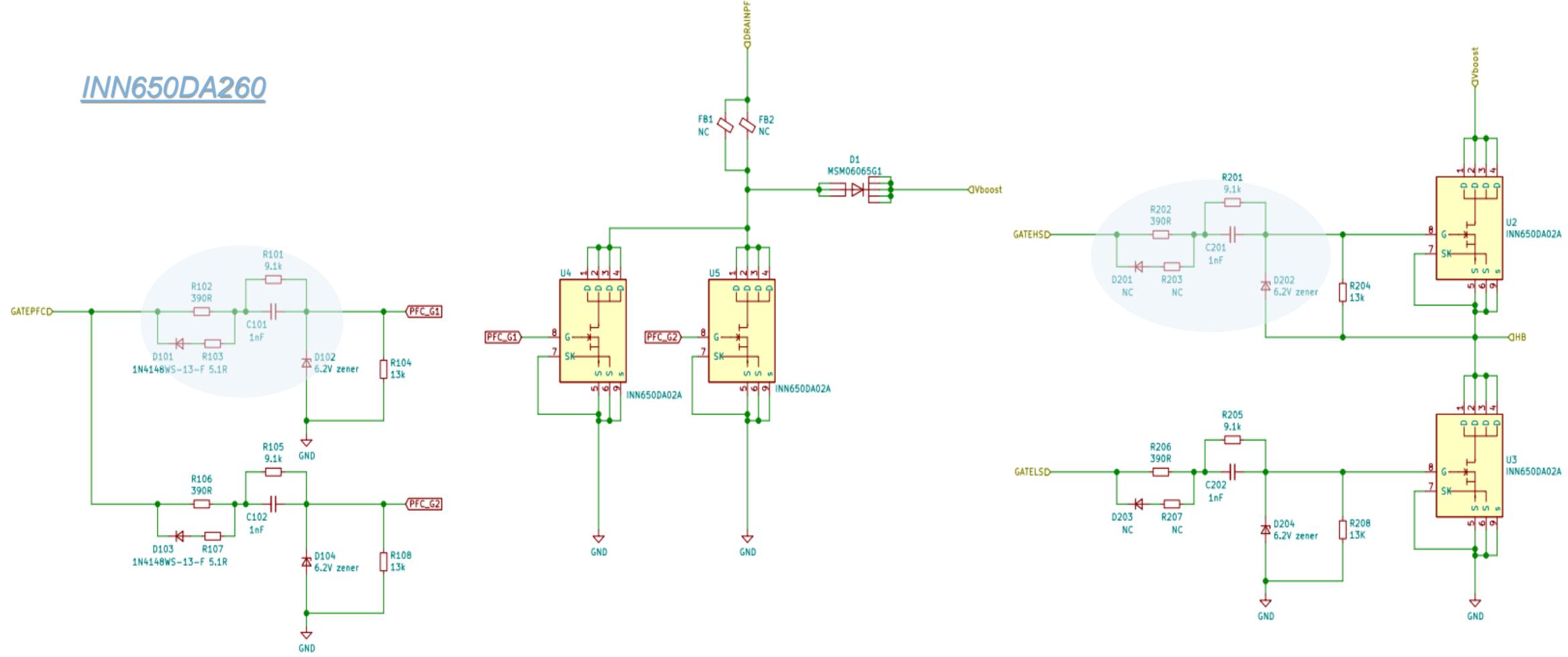


TEA2206有源桥堆



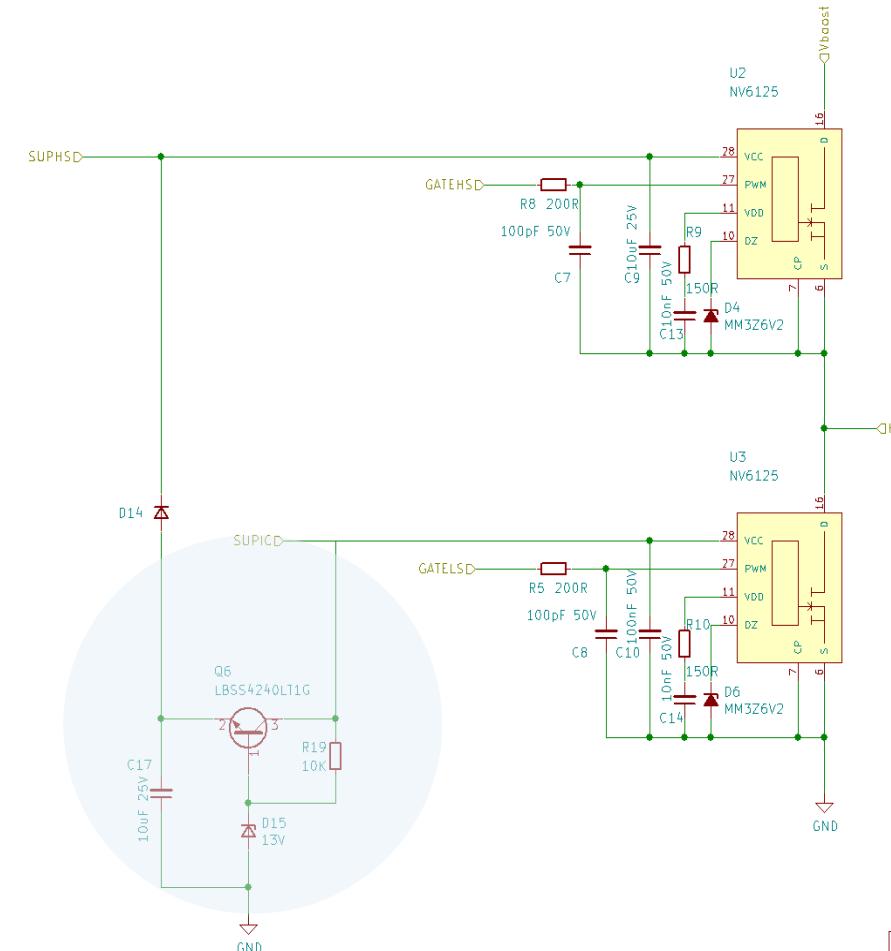
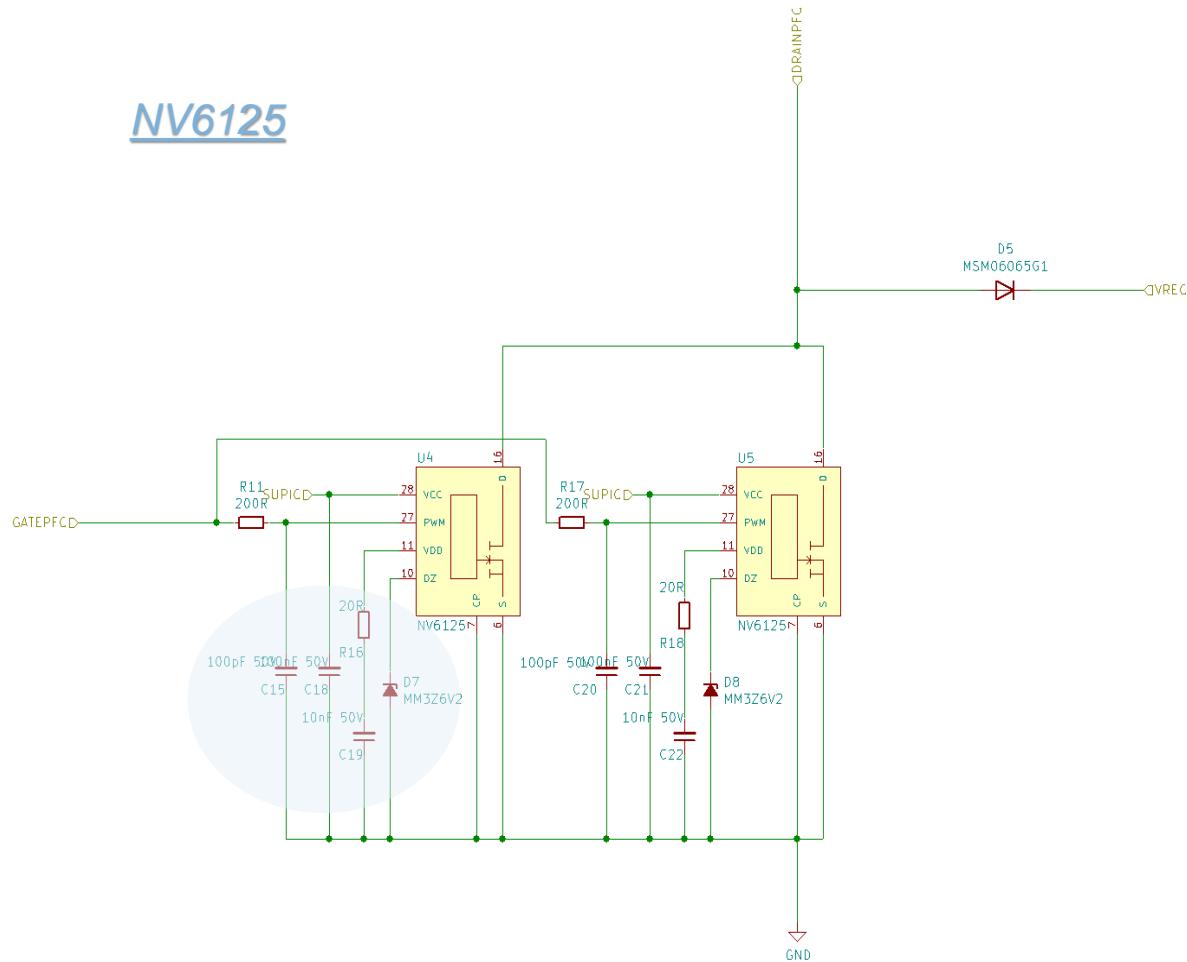
# 150W 氮化镓驱动线路

## INN650DA260



# 150W 氮化镓驱动线路

NV6125



需要外部加LDO,防止在BM模式下  
SUPHS供电不足。

# 150W 氮化镓设计的差异

	Navitas, NV6125	Innoscience, INN650DA260A	平面MOSFET
TEA2017 VCC	$C_{SUPIC} = 220\mu F$ $C_{SUPHS} = 10\mu F$ LDO for SUPHS	$C_{SUPIC} = 100\mu F$ $C_{SUPHS} = 1\mu F$ No ext. LDO	$C_{SUPIC} = 47\mu F$ $C_{SUPHS} = 330nF$ No ext. LDO

# 150W 氮化镓设计的MTP设定

## PFC部分

Frequency		
PFC maximum switching frequency	200kHz	i
PFC minimum switching frequency	80kHz	i

Application values		
L (uH)	300	Value for PFC inductor
Cout (uF)	390	Value for Boost elcap
Pout_max (W)	750	Maximum PFC output power
Vout (V)	410	PFC output voltage
Vmains_min (V)	75	Minimum mains voltage
Rsense (mΩ)	12	Recommended 9mΩ
Rsense over L (Ω / H)	40	Only for reference

Loop stability		
PFC mode	DCM/QR	i
PFC current scaler	2.013	i Recommended: 2.013
PFC current gain	10	i Recommended: 250
PFC gain	0.375	i Recommended: 0.562

## LLC部分

Startup		
LLC soft-start speed	7X	i
Maximum (start-up) frequency	200kHz	i
LLC soft-start current limit	0.75V	i
LLC converter	enabled	i

# 150W 氮化镓设计计算工具

## PFC部分

**NXP**

### LLC Resonant Converter Design Tool

- PFC + LLC: TEA2017, Active Bridge Rectifier: TEA2208/TEA2209/TEA2206, SR: TEA1995/TEA2095

**PFC Design**

- Step 1. Input Spec.
- Step 2. Output Cap.
- Step 3. Boost Inductor
- Step 4. Sense Resistor
- Step 5. MOSFET & Diode
- Step 6. Bridge Rectifier
- Step 7. Input Filter Etc.
- Step 8. Control & Misc.

Note: "User Input" is for users to enter typical design or component parameter. "Default" is recommended typical parameter or calculation result:

#### 1. Input Requirements

##### 1.1. Input

	User Input	Default	Unit
Min AC line voltage (Vac_min)	90	90	Vrms
Nominal low AC line voltage (Vac_low)	110	110	Vrms
Nominal high AC line voltage (Vac_high)	230	230	Vrms
Max AC line voltage (Vac_max)	264	264	Vrms
Min AC line frequency	47	47	Hz
Max ambient temperature	50	50	C
Nominal output power (Pout)	150	240	W
Peak output power (Pout_peak)	232.5	232.5	W
Nominal output voltage	400	400	V
Minimum output voltage	300	300	V
Efficiency of LLC	95.0	95	%
Efficiency of PFC	95.0	95	%
Brown-in voltage	70	70	V
Estimated total output capacitance of PFC MOSFET	130	130	pF
PFC input power at nominal Pout		157.9	W
Brown-out voltage	60.9	60.9	V
PFC mode of operation	DCM/QR	DCM/QR/CCM	

Default parameter = DCM/QR/CCM

#### 2. PFC Output Capacitor

	Default	Unit	
Peak to Peak Output Ripple Voltage	16	16	V

D105  
BD101  
D106

## LLC部分

**LLC Design:**

- Step 1. In/Out Spec.
- Step 2. Ini. Settings
- Step 3. Power Train
- Step 4. LLC MOSFET
- Step 5. TEA2017 Rel.
- Step 6. Output Cap
- Step 7. Output
- Step 8. Compensation

Note: "User Input" is for users to enter typical design or component parameter. "Default" is recommended typical parameter or calculation result:

#### 1. Input/Output Specifications

##### 1.1. Input Specifications

	User Input	Default	Unit
Min AC line voltage	90	90	Vrms
Max AC line voltage	264	264	Vrms
Max ambient temperature	50	50	C
Min PFC output voltage for hold-up time	300.0	300	V
Min PFC regulated output voltage (Min VBOOST)	392.0	392	V
Typ PFC regulated output voltage (Typ VBOOST)	400.0	400	V
Max PFC regulated output voltage (Max VBOOST)	408.0	408	V
Max PFC output OVP voltage (OVP VBOOST)	427.2	427.2	V

PFC + ABR      LLC + SR

##### 1.2. Output Specifications

	User Input	Default	Unit
Nominal output voltage (Vo)	12	12	V
Max nominal output current (Io)	20	20	A
Max nominal output power		240.0	W
Over power output current	25	25	A
Over Power output power		300	W
CV regulation tolerance (+/-)	3	3	%
Max output voltage ripple (+/-)	3	3	%
Max output peak-to-peak ripple (+/-)		360	mV
Peak transient voltage deviation at load release ( $\Delta V_o/V_o$ )	5	5	%
Output over voltage protection (OVP) ratio	125	125	%
Max output voltage (at OVP)		15	V

Peak-to-peak ripple       $\Delta V_o/V_o$        $\Delta V_o/V_o$   
Io

##### 1.3. Output Rectifier Design Concept

	User Input	Default	Unit
Rectifier winding type	Center tap		
Bridge type			

# 150W 氮化镓软起动波形：

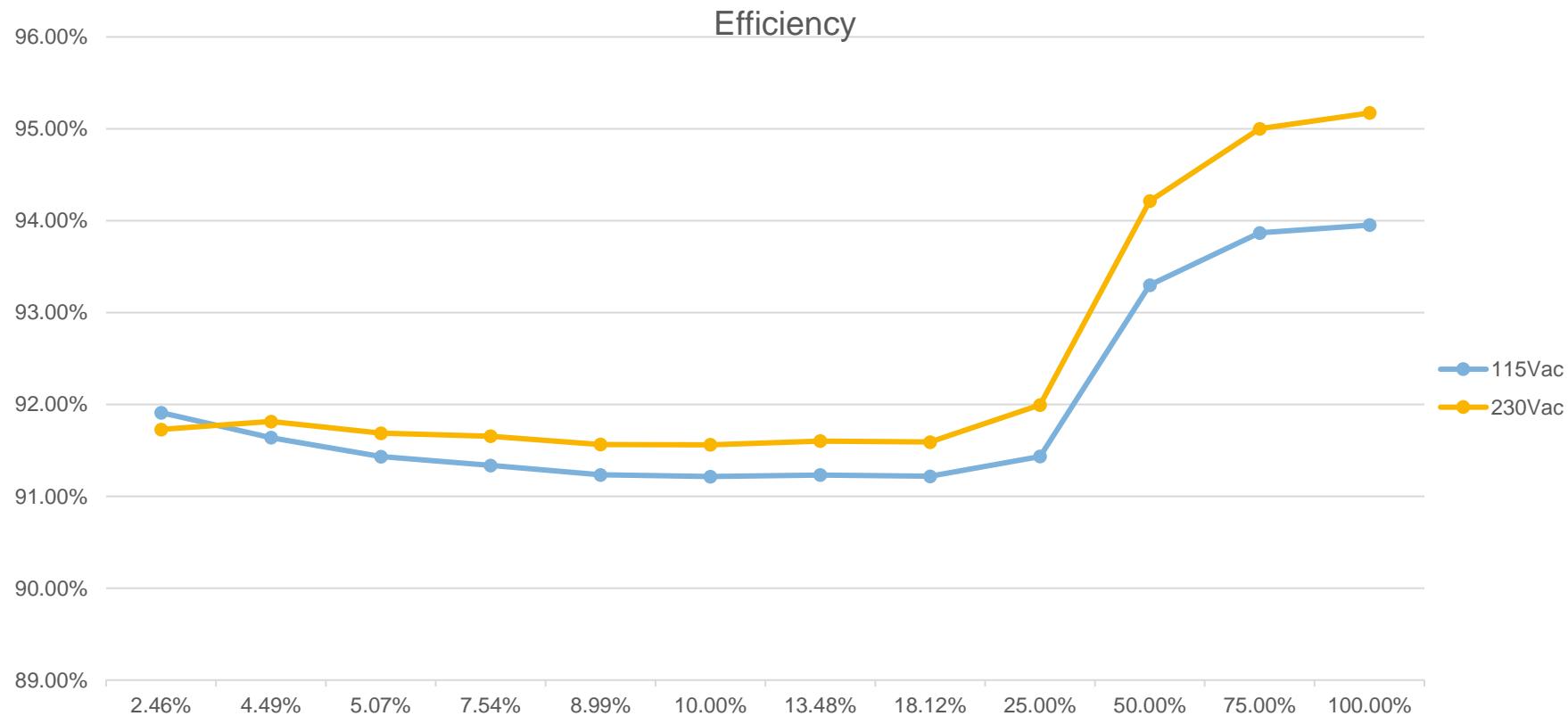


I<sub>cr</sub>最大3.78A@700K



I<sub>cr</sub>最大4.81A@450K

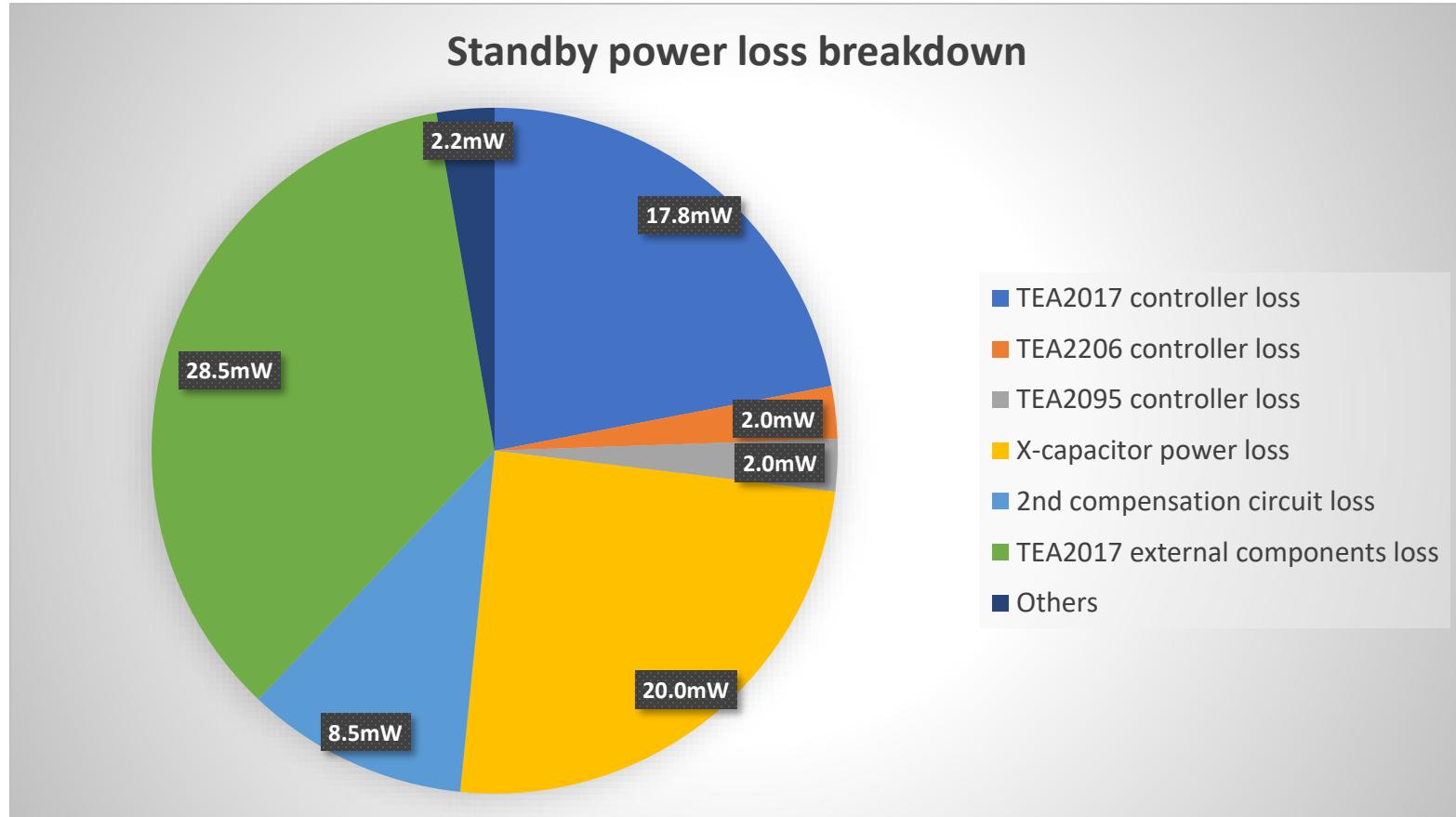
# 150W 氮化镓效率



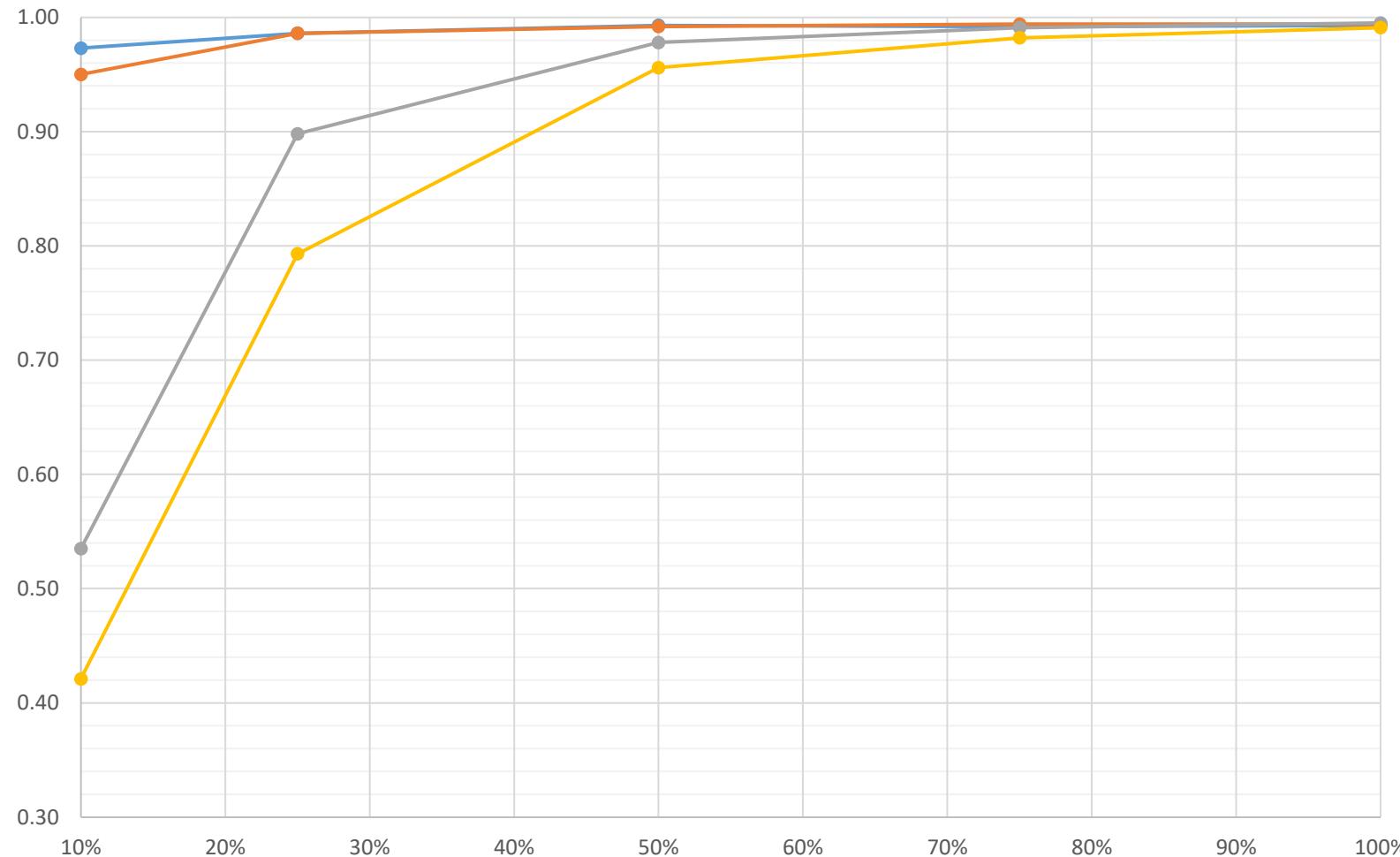
2.46%	4.49%	5.07%	7.54%	8.99%	10%	13.48%	18.12%
5V*0.75A	9V*0.75A	5V*1.5A	5V*2.25A	9V*1.5A	5V*3A	9V*2.25A	9V*3A

# 150W 氮化镓待机功耗

230Vac输入测试待机总共损耗 81 mW



# 150W 氮化镓PF



# 140W 氮化镓演示板

输入规格: 90Vac~264V

输出规格: 28.5V, 140W

功率密度: 1.83W/厘米<sup>3</sup>

PCB尺寸: 6.5cm\*5.5cm\*2.2cm

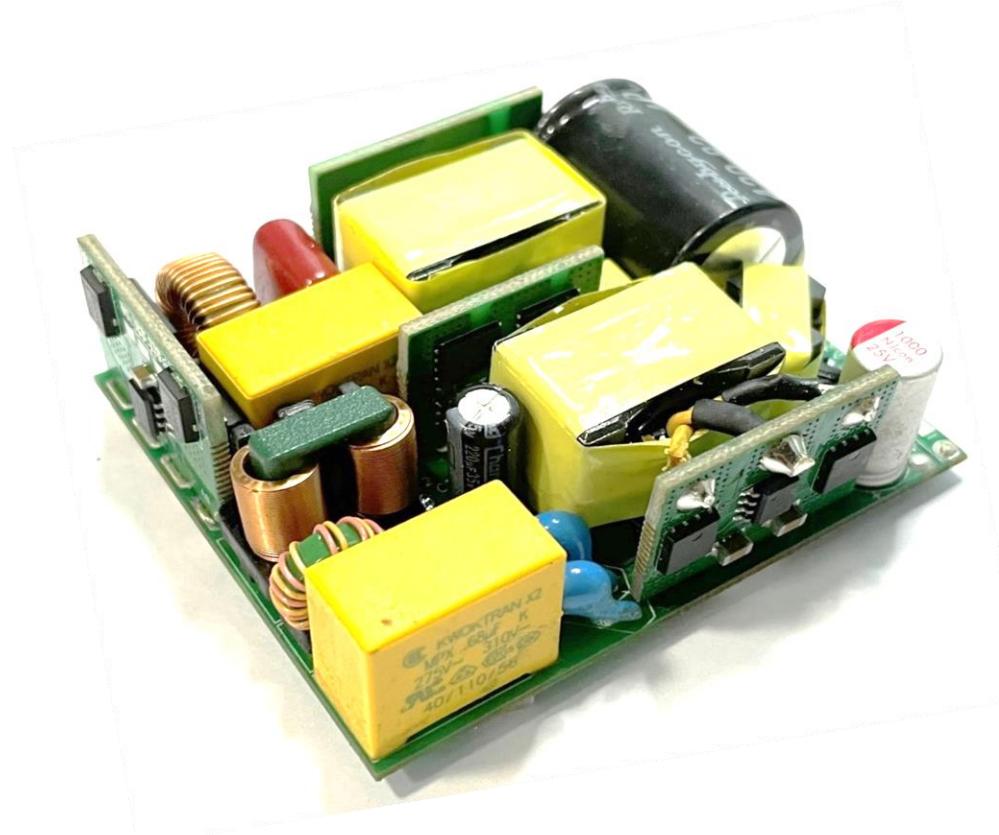
工作频率: PFC@200kHz  
LLC@250KHz

应用nxp产品: TEA2017 SO16 PFC+LLC

TEA2206 SO8 有源桥堆

TEA2098 SO8 同步整流

满载效率 : 94.3% at 115Vac,  
95.3% at 230Vac



# 140W 氮化镓演示板 Vs 150W 氮化镓演示板

	<b>28.5V/140W</b> <i>All GaN solution (PFC/LLC/SR)</i>	<b>21.5V/150W</b> <i>GaN (PFC/LLC), SR (MOSFET)</i>
<i>SR drive temperature</i>	~85 °C / TEA2098T	~118 °C/ TEA2095T
<i>SR switch temperature</i>	~84°C / INN150LA070A (7mohm)	~100°C/ SFS06R03GF (3mohm)
<i>Output ripple</i>	396mV <sub>max</sub>	270mV <sub>max</sub>
<i>LLC switching frequency</i>	~250KHz	~250KHz
<i>Solution efficiency</i>	95.33% / 230Vac	95.34% / 230Vac
<i>Standby power loss</i>	96mW	89mW

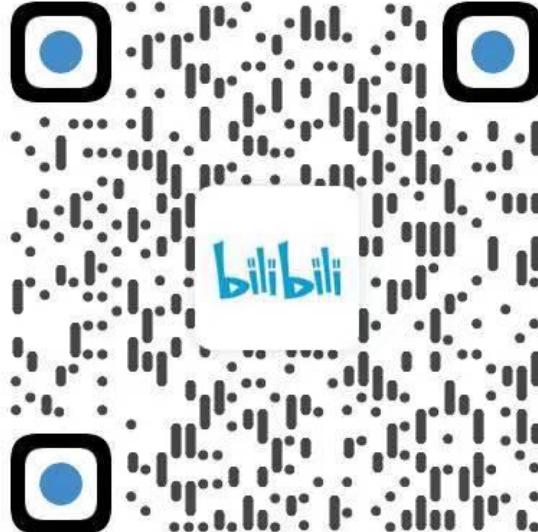
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# TECHNOLOGY SHOWROOM

## JOURNEYS BY DESIRED ENGAGEMENT

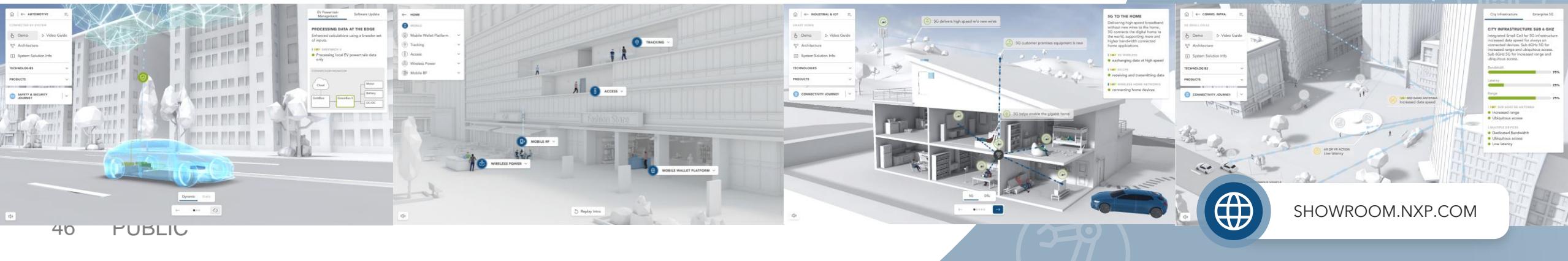
Self-guided tour  
Live-streaming at set times  
Guided tours

## JOURNEYS BY DESIRED FOCUS

Edge & AI/ML  
Safety & Security  
Connectivity  
Analog

## 40+ VIRTUAL DEMOS

Focus on system solutions  
Set up along NXP verticals





# Q & A



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FOR A SMARTER WORLD**



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