MPS新的中大功率ACDC电源方案分享

Nov 2021

丁连锋

ACDC电源产品应用领域

<100W

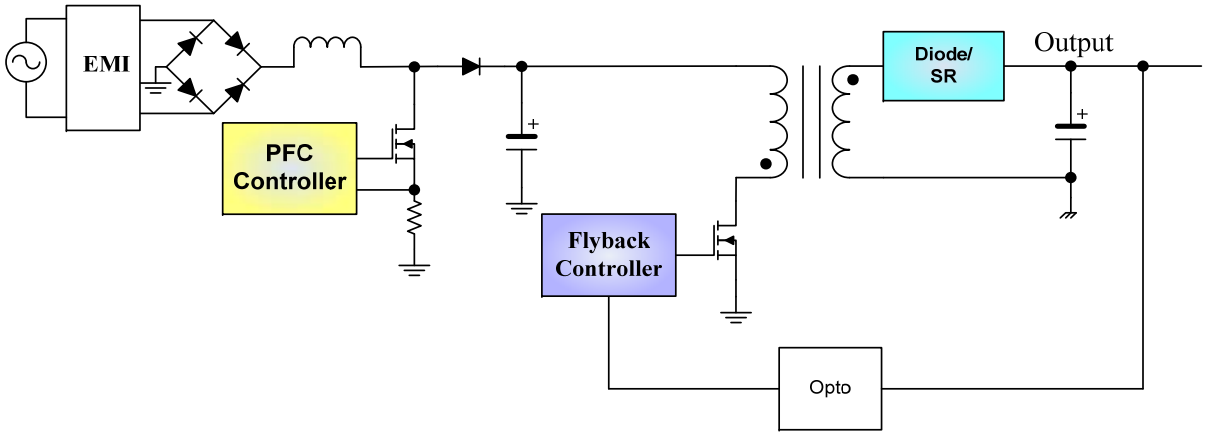
>100W

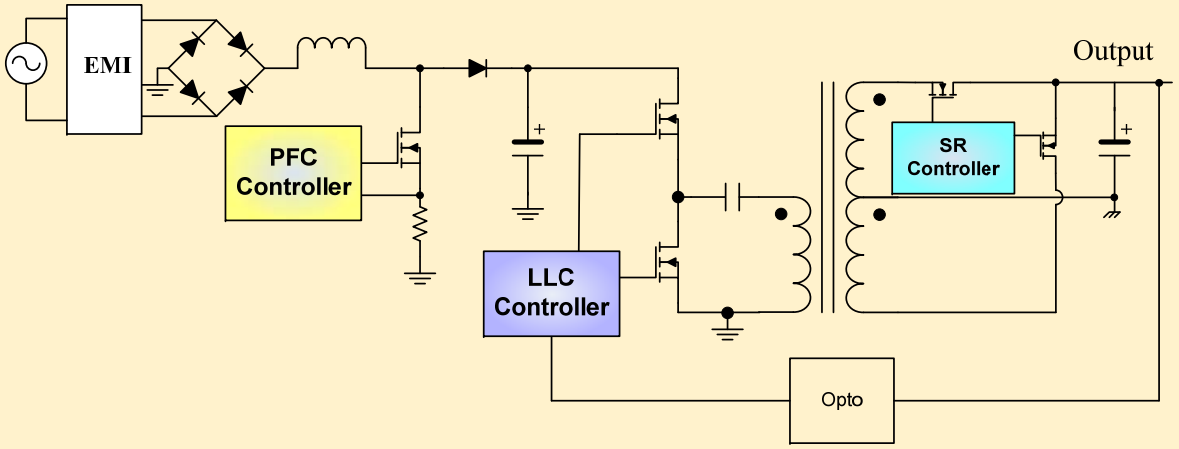
ACDC电源产品的要求

- 高效
- 高功率密度
- 有竞争力的BOM
- 高可靠性
- 无电磁兼容问题

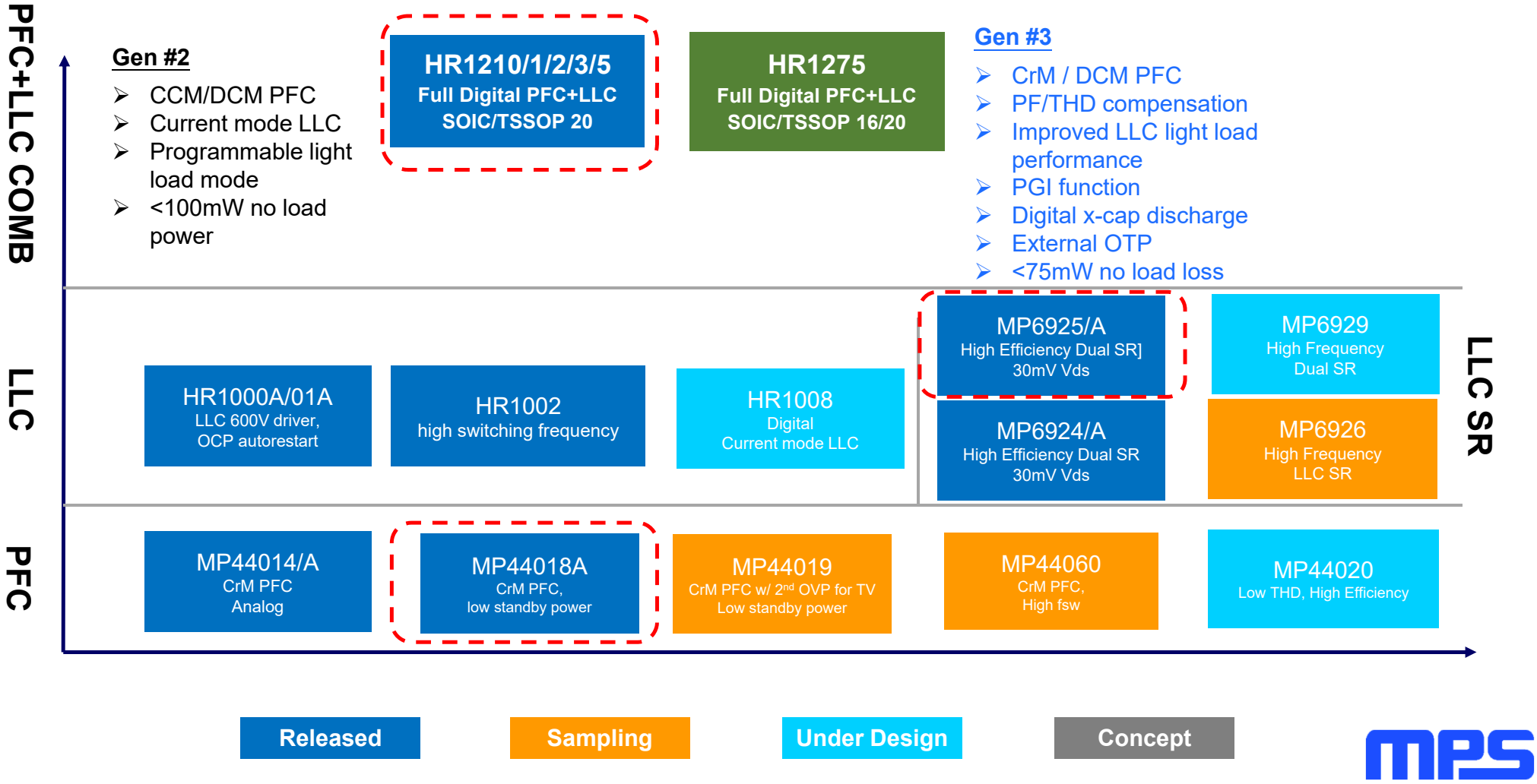
中大功率ACDC电源方案

Power>75W, 电源方案都需要加PFC
比较常见的电源方案：
PFC+Flyback （<150W）
PFC+LLC (>100W)



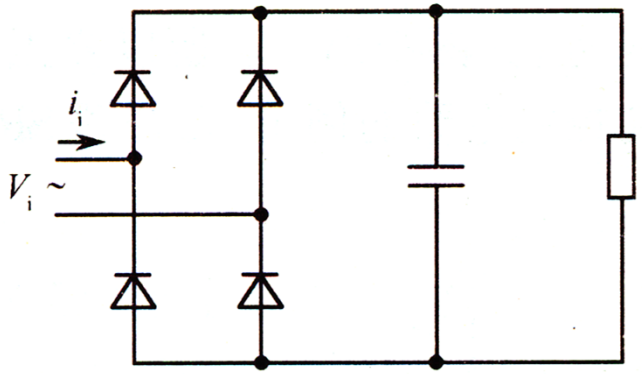


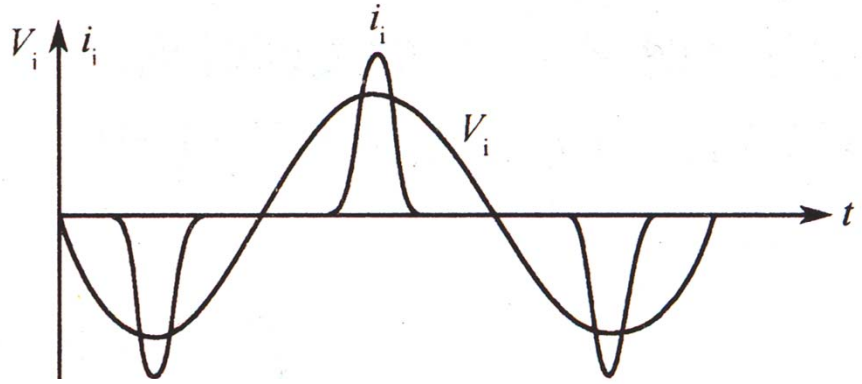
MPS 中大功率ACDC电源方案



高性能的PFC方案

PFC的目的





$$PF = \frac{P_{有功}}{P_{视在}} = \frac{V_{1rms} \times I_{1rms} \cos\varphi}{V_{rms} \times I_{rms}} = \frac{I_{1rms} \cos\varphi}{I_{rms}} = \gamma \cos\varphi$$

γ基波因数 cosφ基波功率因数

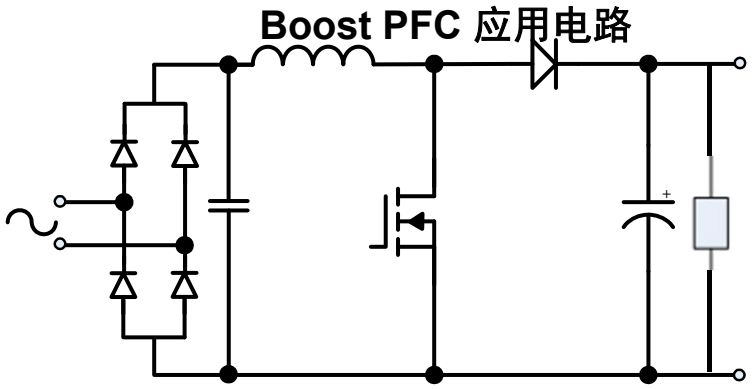
$$\gamma = \frac{I_{1rms}}{I_{rms}} = \frac{I_{1rms}}{\sqrt{\sum_{1}^{n} I_{krms}^{\ 2}}} = \frac{1}{\sqrt{1+\mathrm{THD}^2}}$$

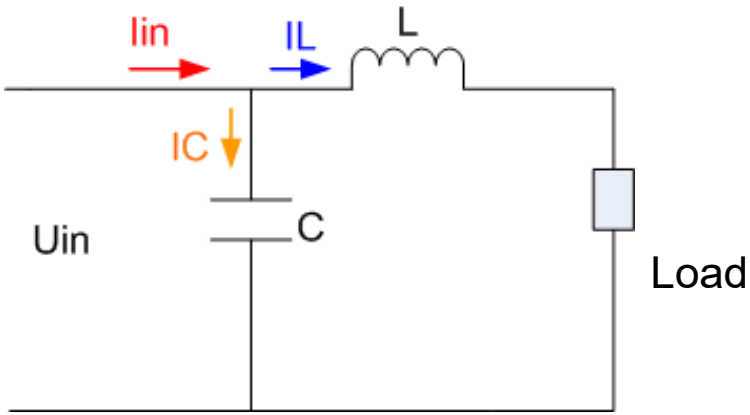
➢ **PF=1**

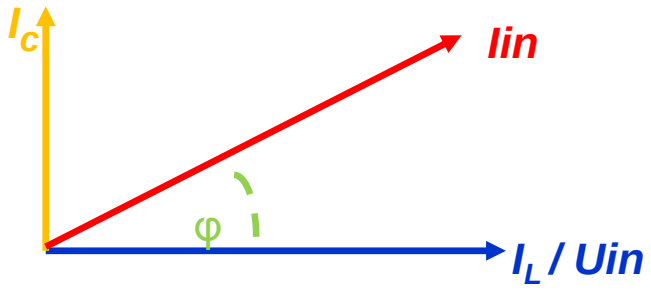
1. 将输入电流波形尽量校正成正弦波形，减少谐波失真　　γ=1　　--------》　THD=0

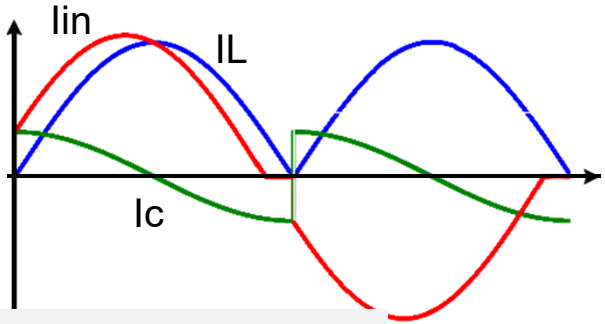
2. 输入电流和输入电压尽量同相位　　cosφ=1

影响有源功率因数校正的参数









➢ 改善PF

$$\cos\varphi = \frac{Pin/Uin}{\sqrt{(\mathrm{Pin}/\mathrm{Uin})^2 + (Uin \times \omega C)^2}}$$

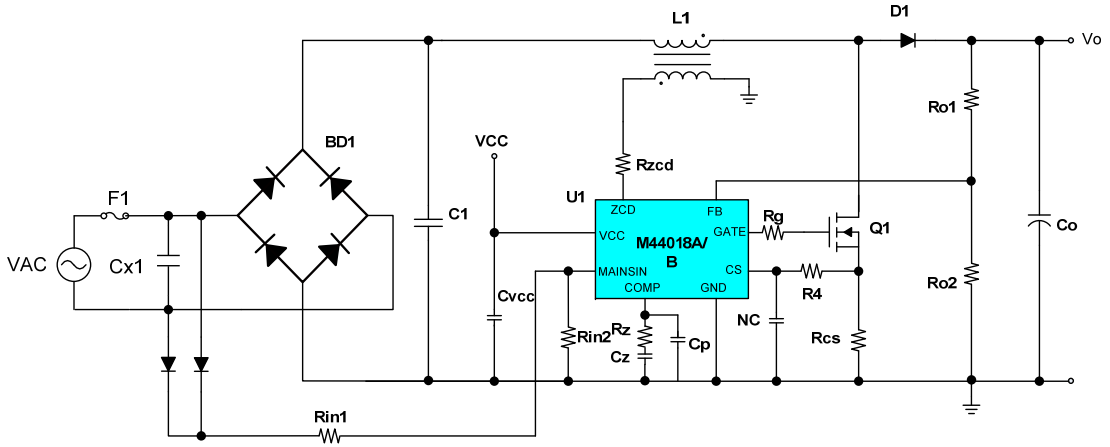
1. 减小THD --------> 优化输入电流波形
2. 减小相位差 --------> 减小输入电容或者补偿容性电流

MP44018-A

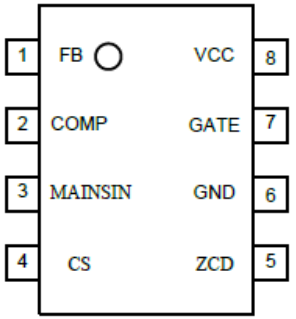
特点

- **CrM/DCM控制方式**
- **超低的待机功耗 <30mW**
- **快速的动态响应**
- 谷底开通减小开关损耗
- 轻载降频减小开关损耗
- 待机模式下供电电流非常低
- 工作在打突发模式下软开关以及软关断技术可以减小噪声
- 线电压补偿可以实现很好线电压跳变及相同的过载保护点
- THD优化
- 全面的保护（欠压保护、过呀保护，过流保护，输入欠压保护，FB开路以及短路保护）

典型应用电路



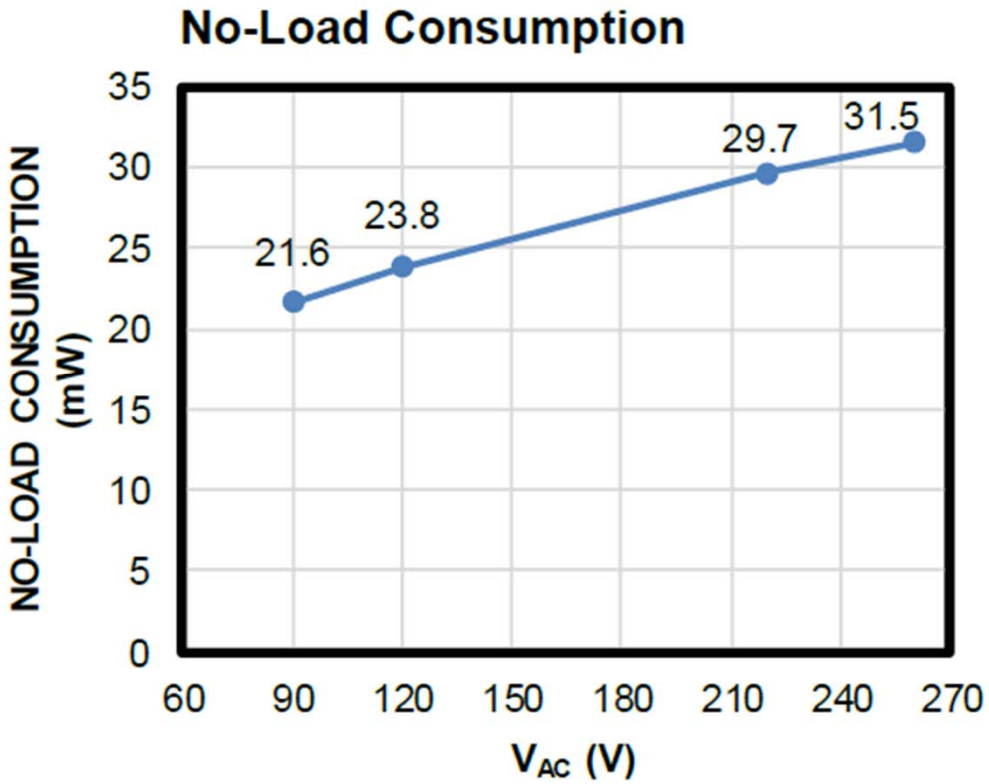
TOP VIEW



SOIC-8封装

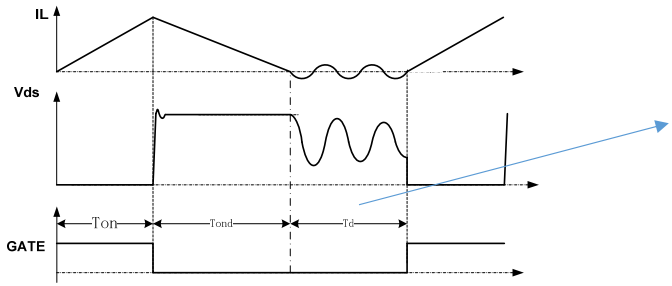
MP44018-A 空载损耗

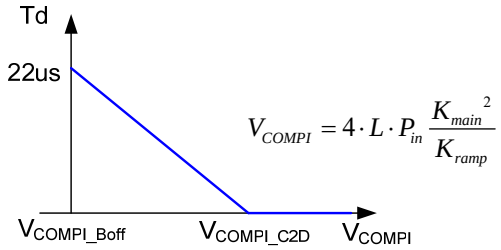
Vin=85-265VAC Vout=400V



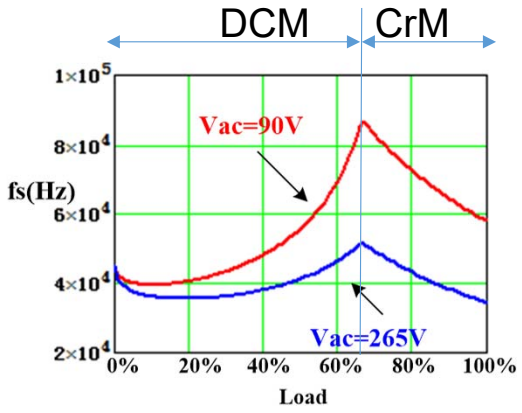
MP44018-A 空载损耗

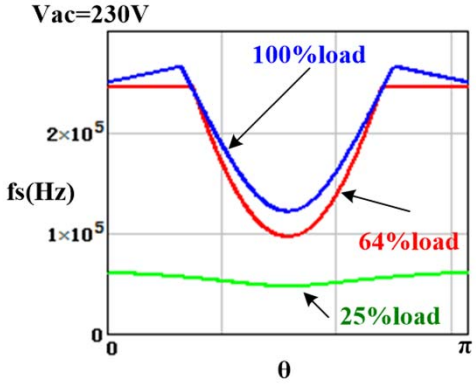
1) 在重载，MP44018-A工作在临界导通模式，此时主要是导通损耗
2) 随着负载变轻，开关损耗渐渐占据主导，MP44018A通过死区延伸技术由临界导通模式切换到断续模式
3) 不管是在临界还是在断续，MP44018-A都是谷底导通来降低开关损耗



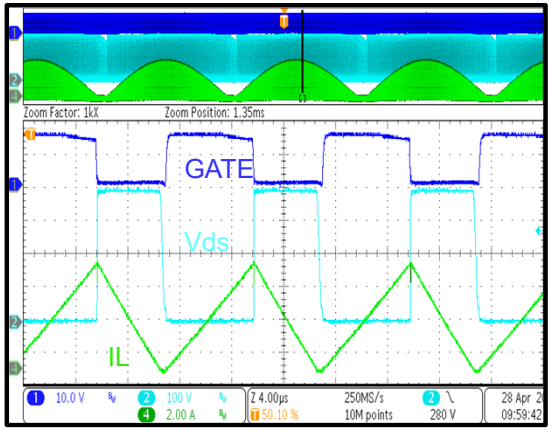


$$V_{COMPI} = 4 \cdot L \cdot P_{in} \frac{K_{main}^{\ 2}}{K_{ramp}}$$

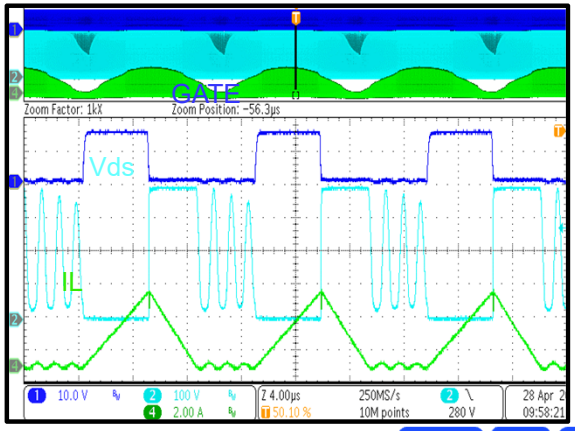




100%负载



50%负载



MP44018-A 优越的动态性能

传统PFC的带宽在10Hz以下，抑制工频纹波，减小电感电流的THD。但是动态响应比较差。

主电路补偿

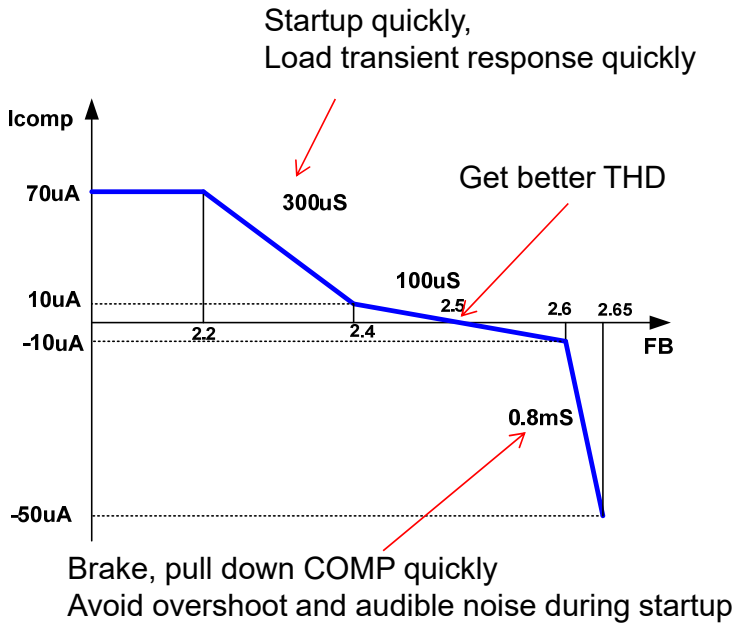
$$\begin{cases} P_{in} = \dfrac{V_{ac}^{\ 2}}{2L} \cdot T_{on} \\ T_{on} = C_{ramp} \dfrac{V_{comp}}{i_{ramp}} \end{cases}$$

$$i_{ramp} = kV_{ac}^{\ 2}$$

MP44018 contains a square of Vac compensation circuit.

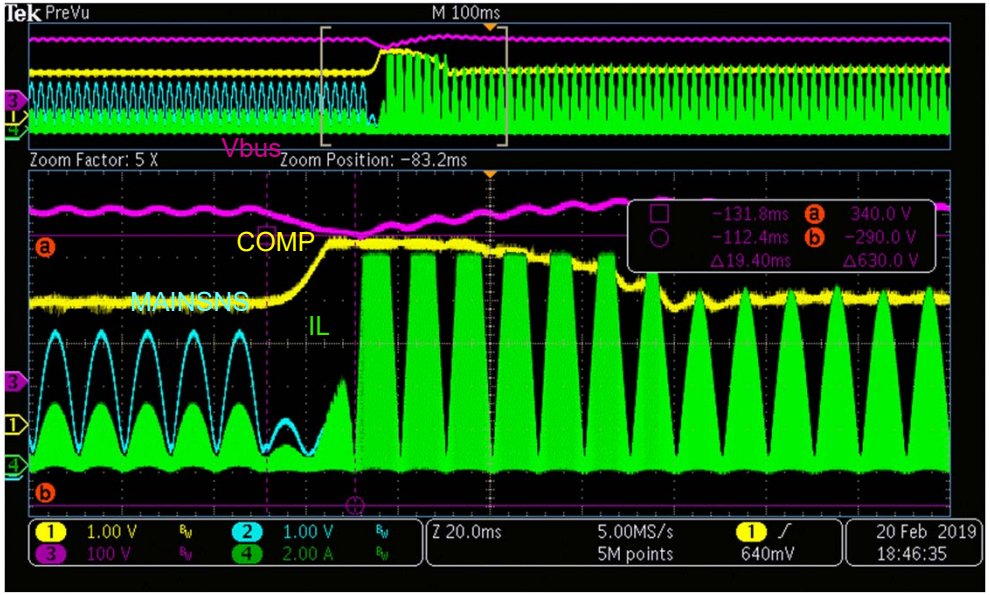
$$\Rightarrow \quad P_{in} = \frac{V_{ac}^{\ 2}}{2L} \cdot C_{ramp} \frac{V_{comp}}{kV_{ac}^{\ 2}}$$

非线性增益设计



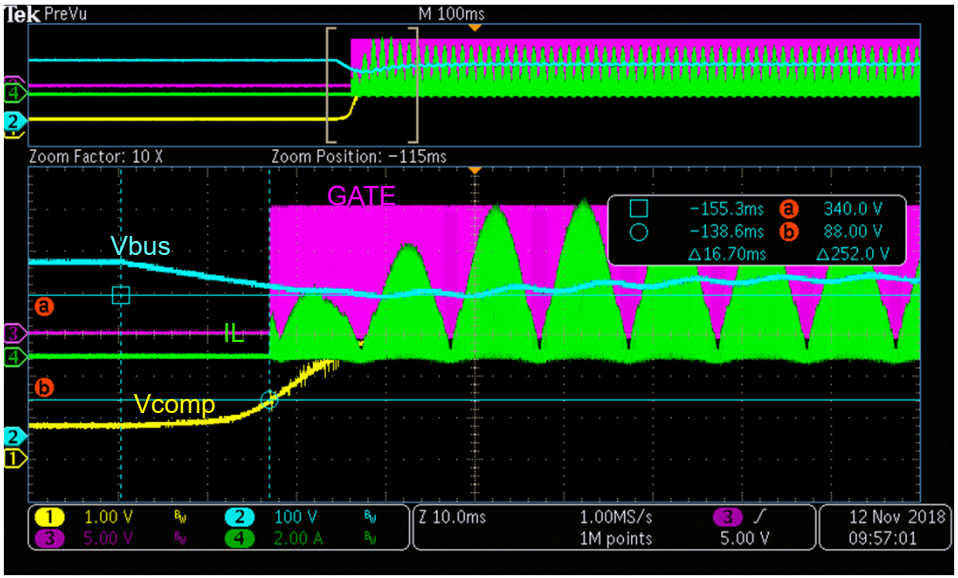
MP44018-A输入线性跳变和负载跳变

输入电压跳变
260VAC→90VAC/满载



Vbus min=340V

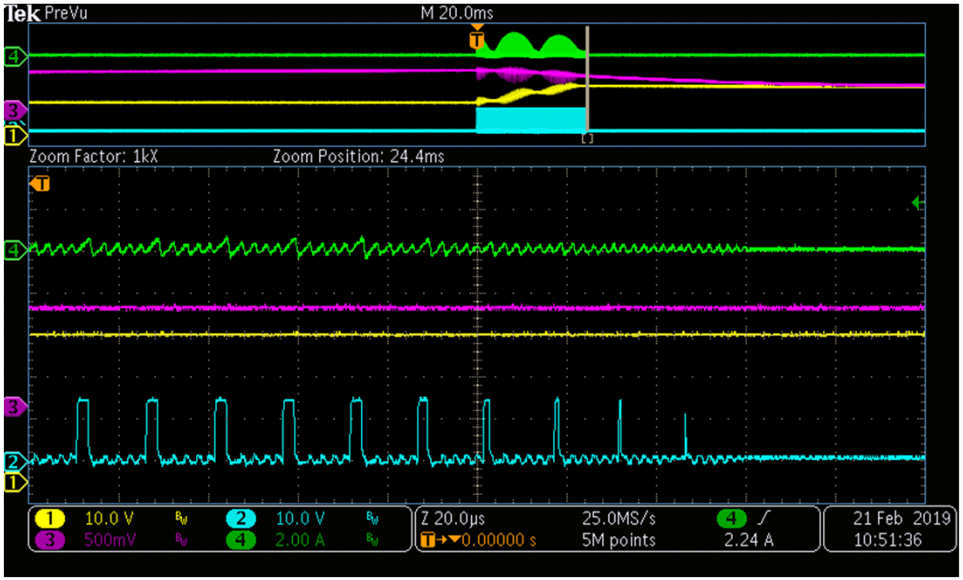
负载跳变
空载→ 满载



Vbus min=340V

MP44018-A 较小的噪音

MP44018-A工作在轻载



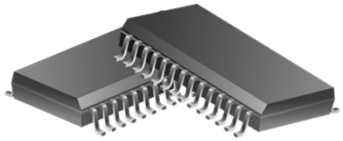
✓ **Burst模式下MP44018-A有软启动和软关断功能，这样可以避免电感电流突变，避免了噪音。**

数字型PFC+LLC COMB方案

HR12xx –Family Tree, up to 1kW

HR120x

Digital PFC + Analog LLC
SOIC/TSSOP 28



Voltage mode LLC
CCM/DCM PFC
<150mW No load Power

HR121x

Full Digital PFC + LLC
SOIC/TSSOP 20

Current Mode LLC
Improved Light Load Performance
＜100mW No Load Power

HR122x

Full Digital PFC + LLC
SOIC/TSSOP 20

Next Gen, Coming Soon…..

2016 2018 2020 2021

Released Sampling Design

HR1211 – 数字型PFC+LLC 2合1的控制器

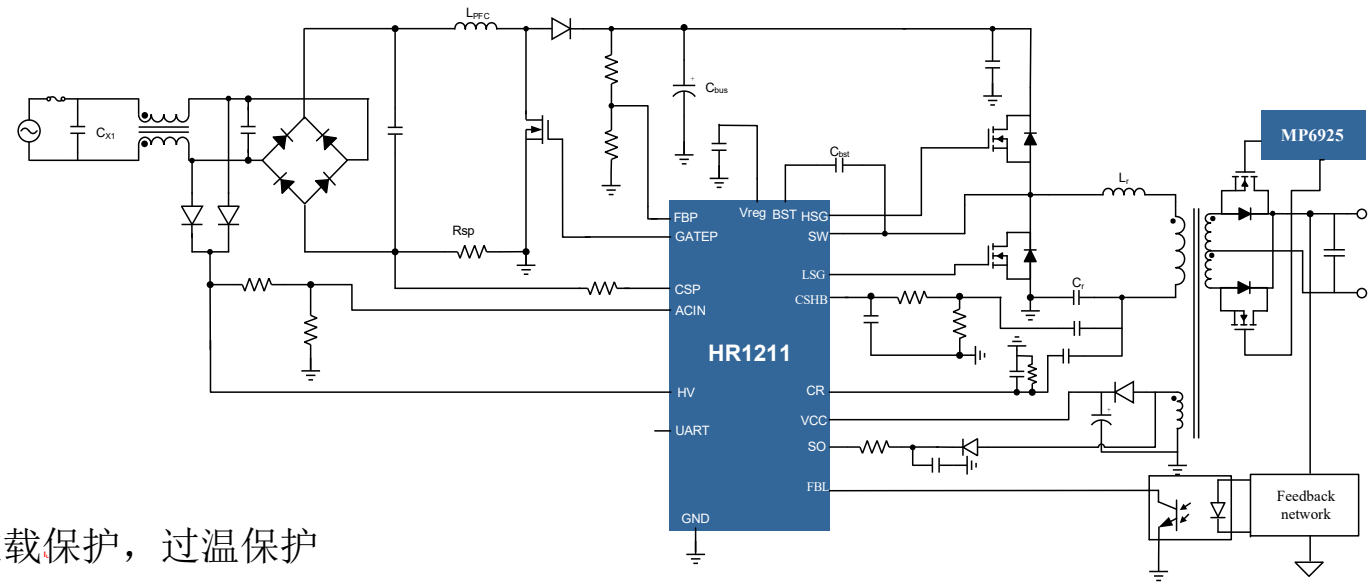
主要特点

系统概述

通过GUI进行数字可编程控制

- <100mW 待机功耗
- 轻载有较高的效率
  - > 80%@ 5W, > 65%@0.5W
- 全面的保护

  欠压保护，过压保护，过流保护，过载保护，过温保护



PFC部分

- 高压启动以及集成X-cap放电
- CCM和DCM多模式控制
- PF补偿，PF容易获得>0.9 在10%负载
- 两级数字环路补偿

LLC部分

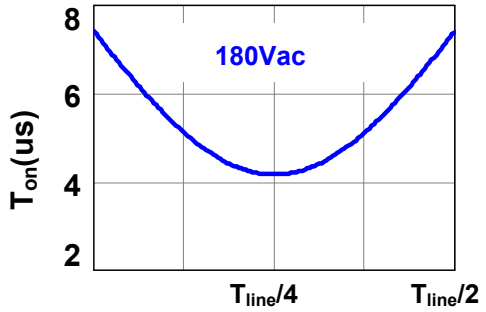
- 集成600V半桥驱动
- 电流模式控制
- 专有的突发和跳变工作模式
- 可变死区和容性保护

HR1211 – 数字型PFC+LLC 2合1的控制器

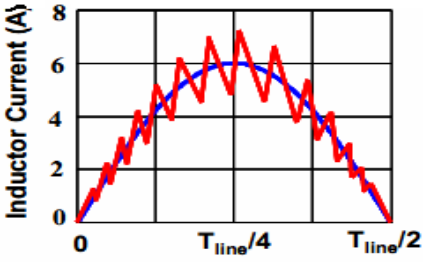
控制原理:

$$T_{ON}(t) = \frac{V_{out} - V_{in}(t)}{V_{out}}$$

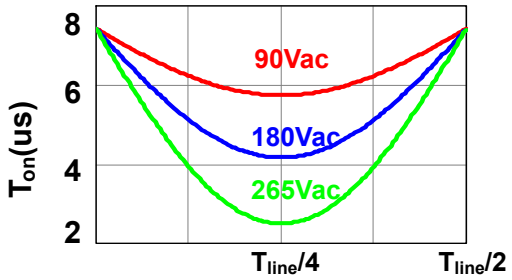
T_{on} vs Load



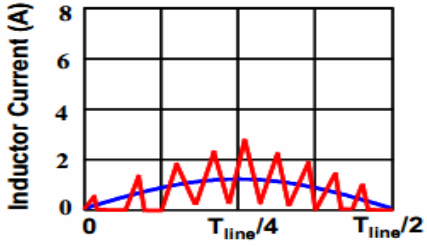
Full Load CCM



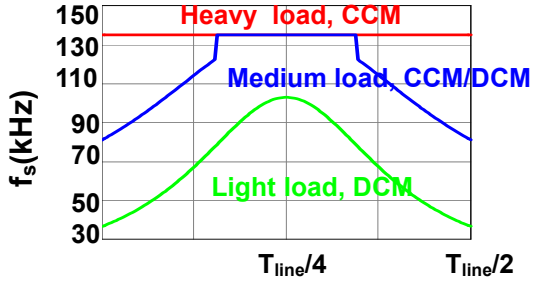
T_{on} vs V_{in}



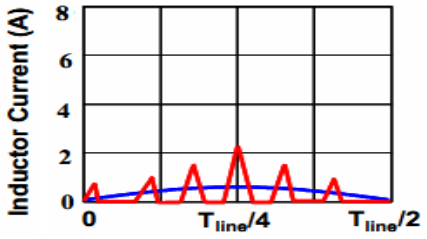
Medium Load CCM/DCM



f_s vs (V_{in}or Load)

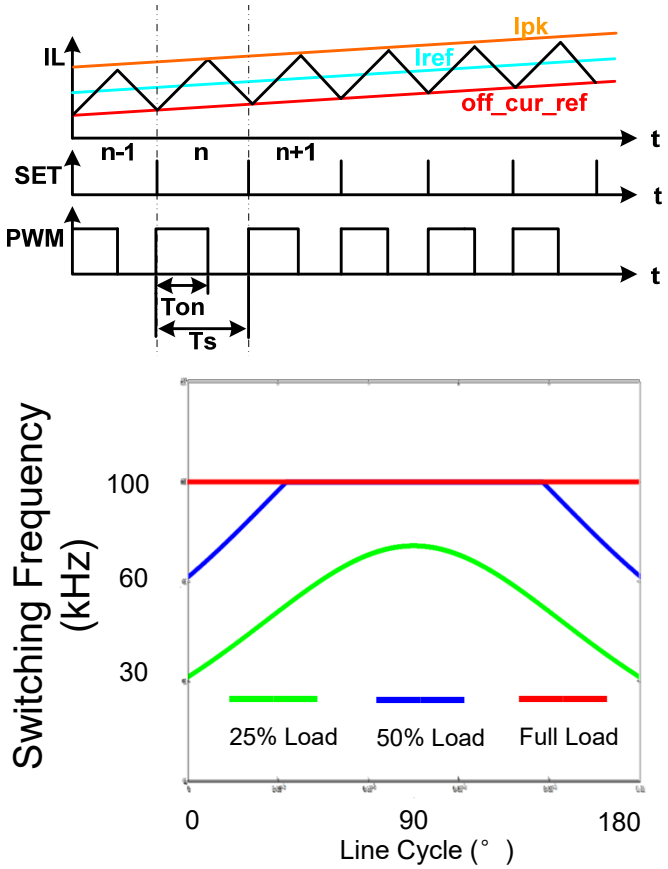


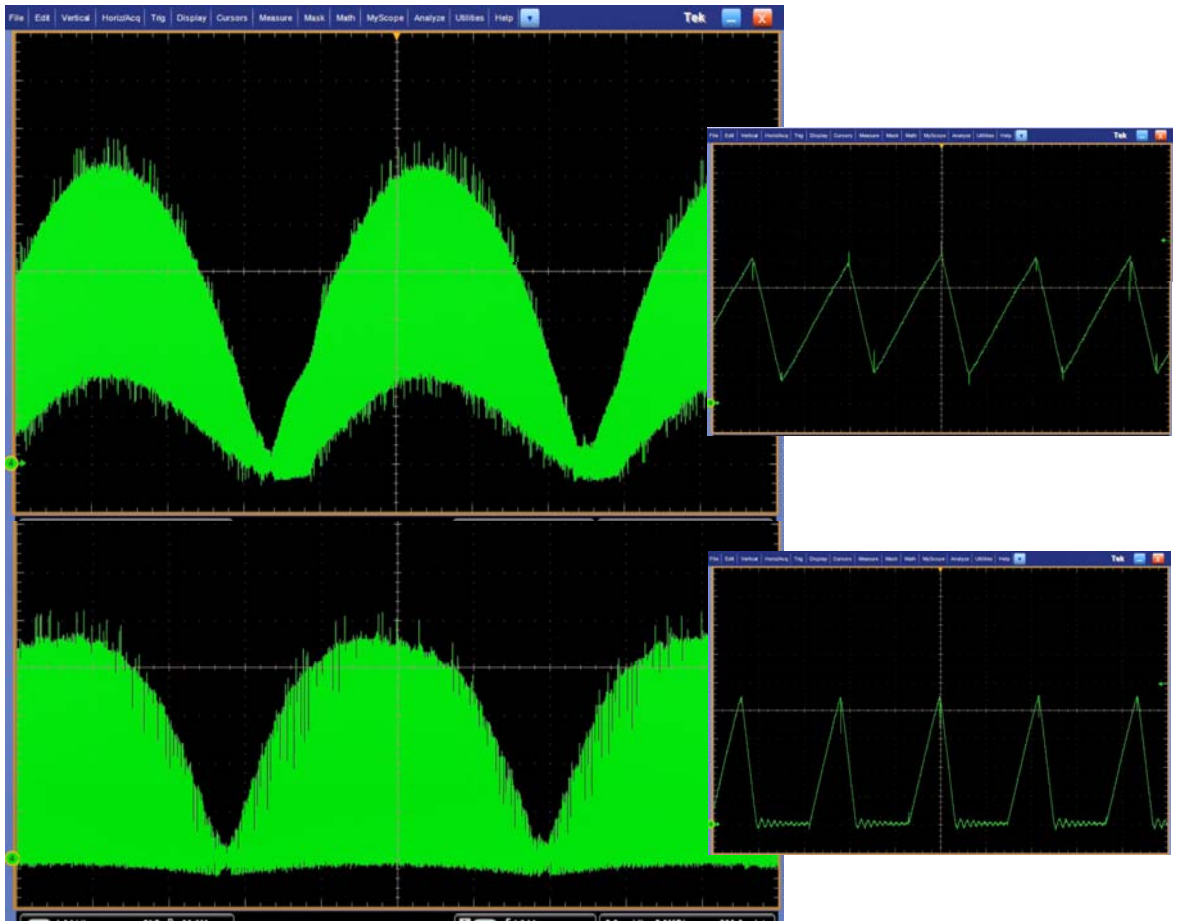
Light Load DCM



HR1211 – 数字型PFC+LLC 2合1的控制器

CCM&DCM PFC Control

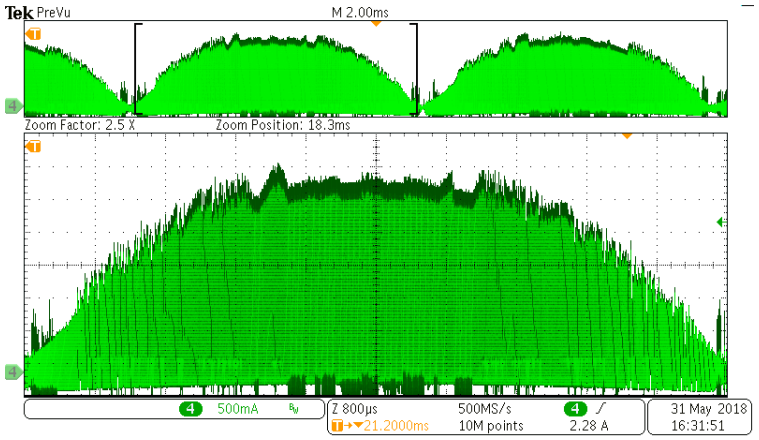


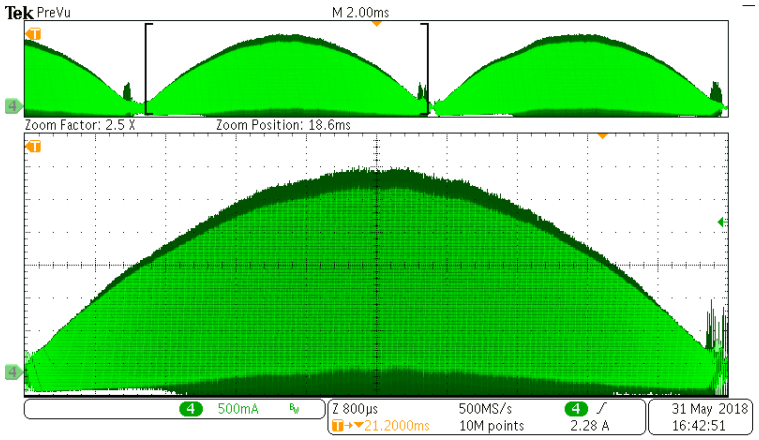


HR1211 – 数字型PFC+LLC 2合1的控制器

电流采样的数字滤波

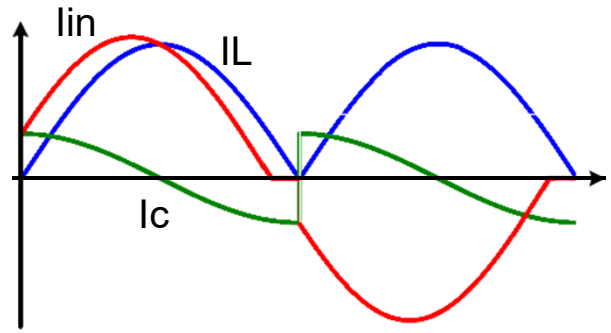
csp filter:	ON	td filter:	ON
csp filter stage:	1st stage	td filter stage:	1st stage
1st csp filter cross freq set:	15	1st td filter cross freq set:	9
2nd csp filter cross freq set:	15	2nd td filter cross freq set:	15



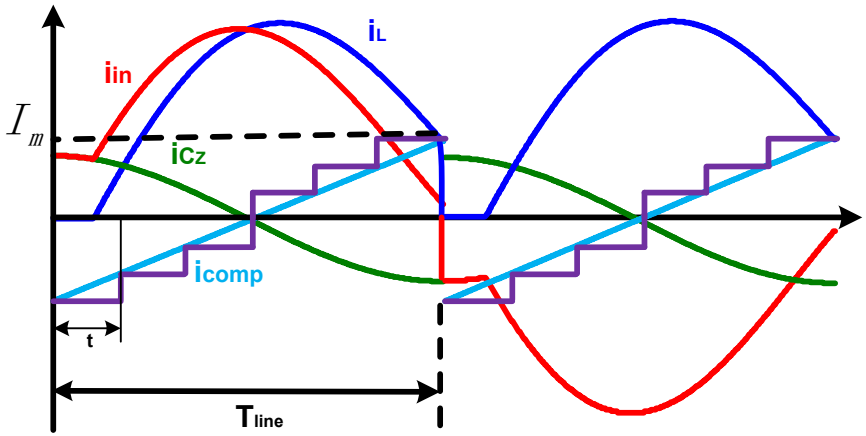


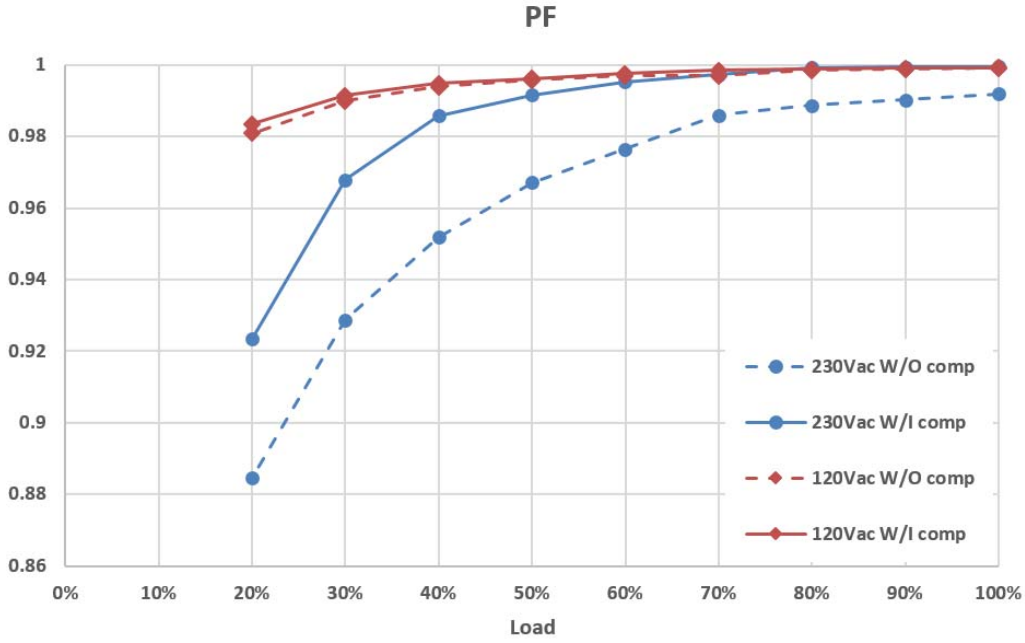
HR121x – Digital PFC+ LLC Combo Controller

PF补偿



$$\cos\varphi = \frac{Pin/Uin}{\sqrt{(\mathrm{Pin}/\mathrm{Uin})^2 + (Uin \times \omega C)^2}}$$



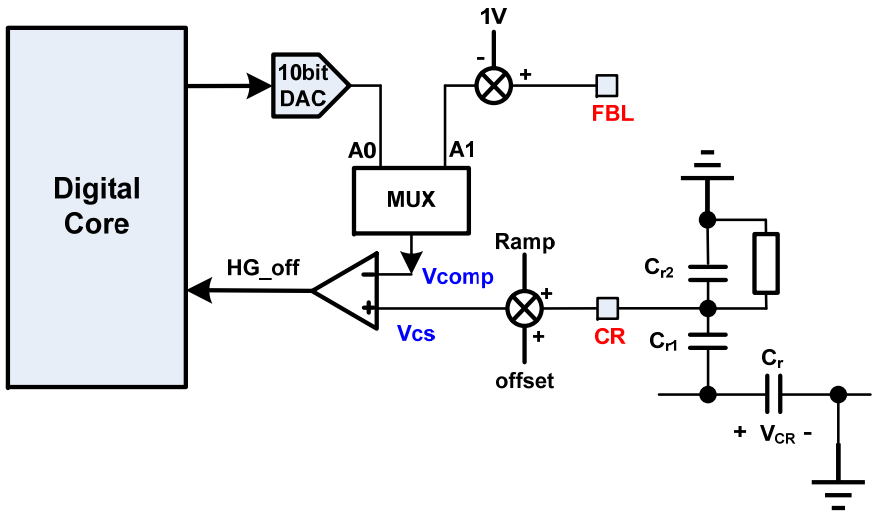


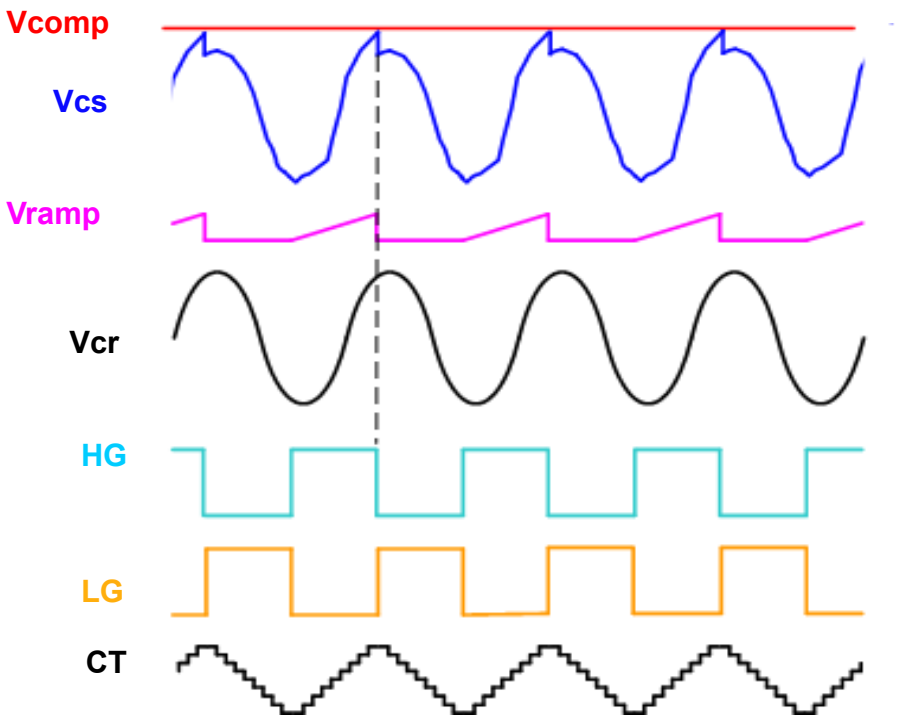
PF Compensation: ON

	VIN-R1	VIN-R2	VIN-R3	VIN-R4
Input Voltage (Vrms) :	85	150	220	265
Input Frequency (Hz):	60	60	50	50
Cap Compensation (%Cin):	30	50	80	100

HR121x – Digital PFC+ LLC Combo Controller

电流模式LLC控制

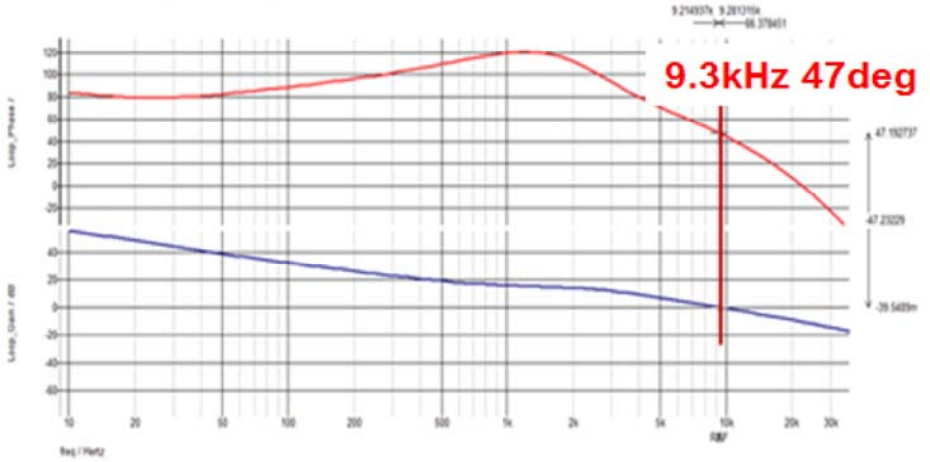




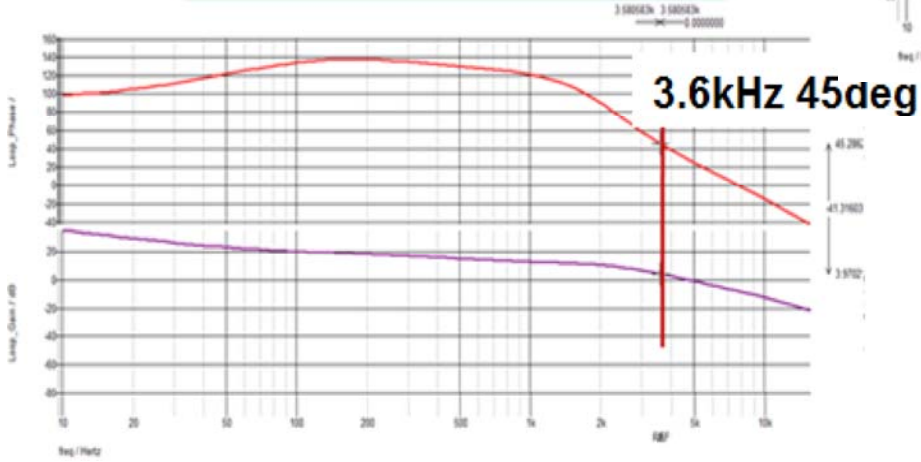
HR121x – Digital PFC+ LLC Combo Controller

Current Mode LLC Control

LLC_Current Mode Control

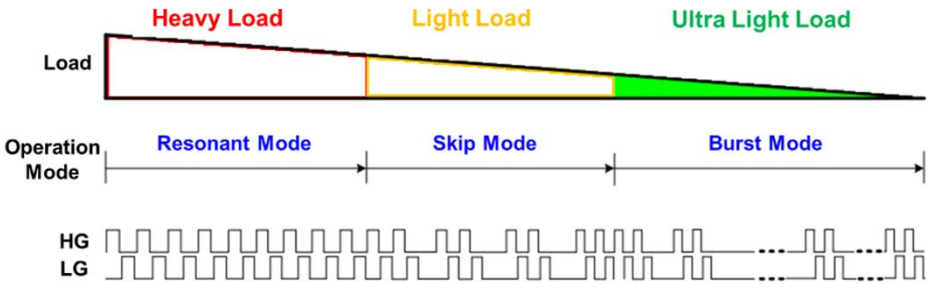


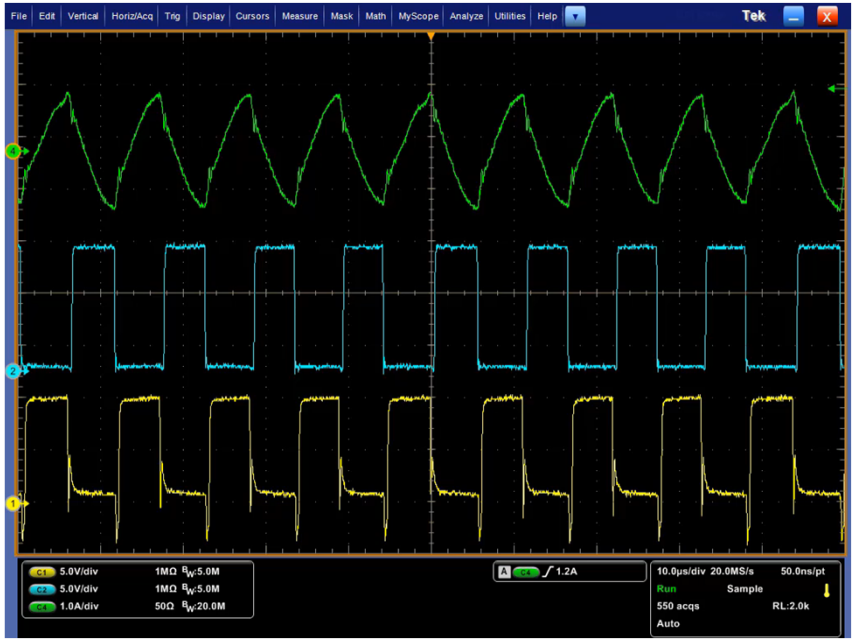
LLC_Voltage Mode Control



HR121x – Digital PFC+ LLC Combo Controller

Skip and Burst Modes for Light Load

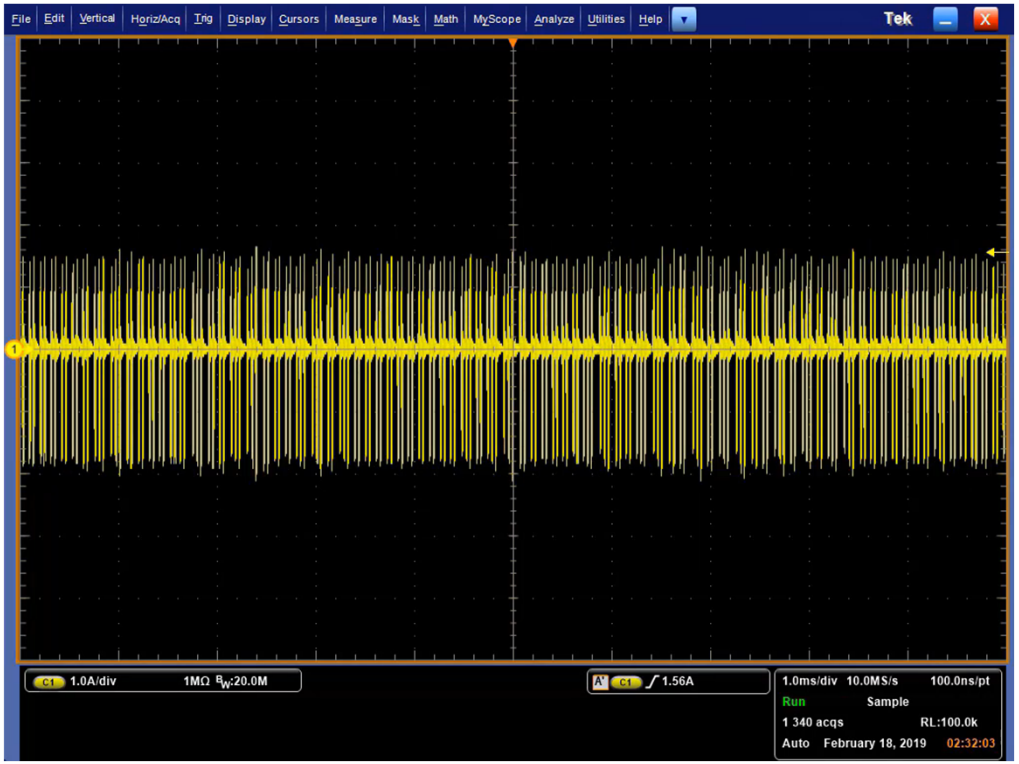




HR121x – Digital PFC+ LLC Combo Controller

Burst Frequency Control

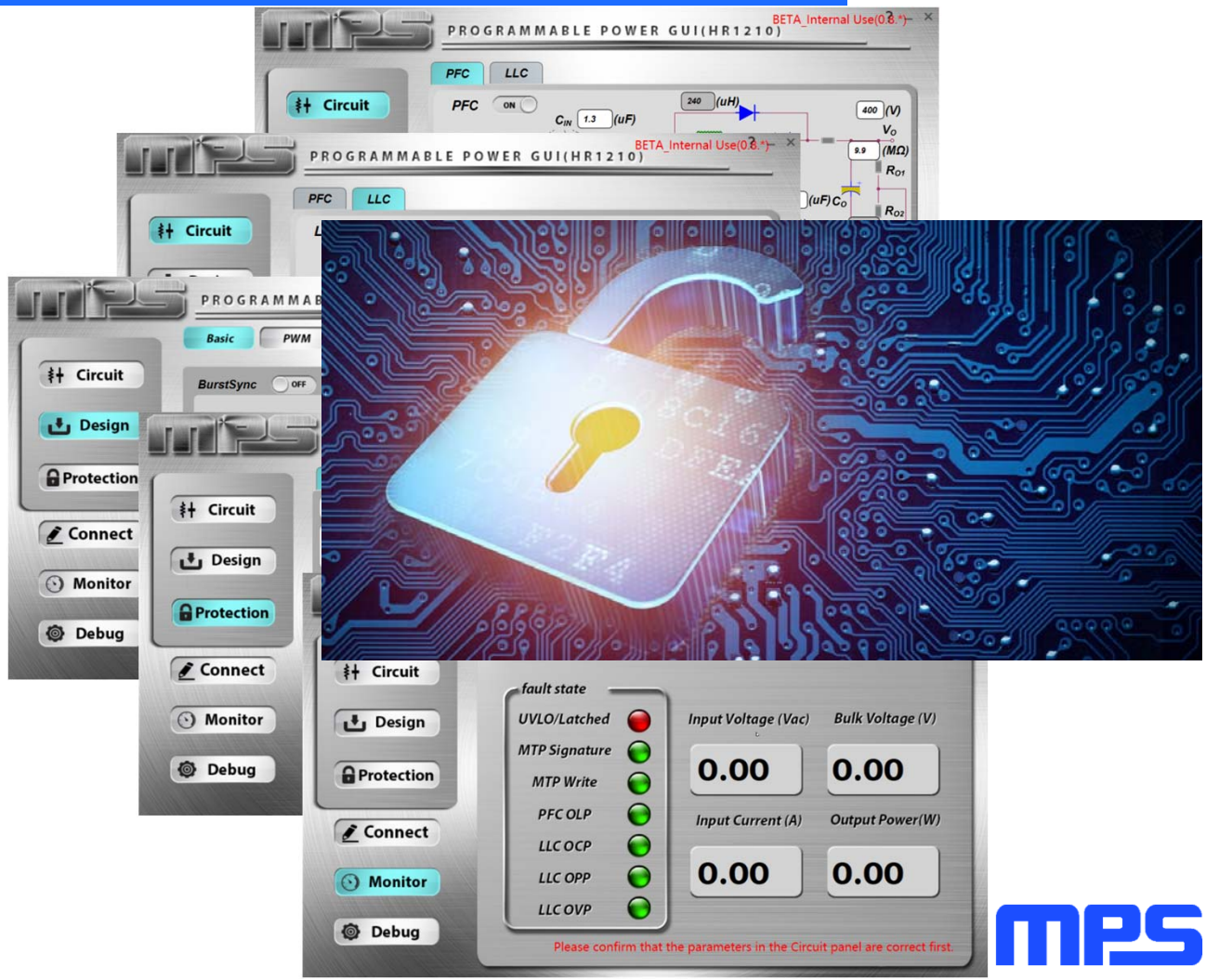
Burst mode		
Burst mode in level(FBL):	0.4	(V)
Burst mode in level(VComp):	0.18	(V)
Burst mode hysteresis:	0.1	(V)
Burst frequency control:	ON	
Max Burst frequency:	800	Hz
Min Burst frequency:	375	Hz
Burst frequency blanking period:	3	



HR121x – Digital PFC+ LLC Combo Controller

数字好处

- 通过GUI可以进行丰富的配置
- 可在任何阶段配置，从研发到成品专利保护



HR12xx Families Based Products

85W Laptop Adaptor

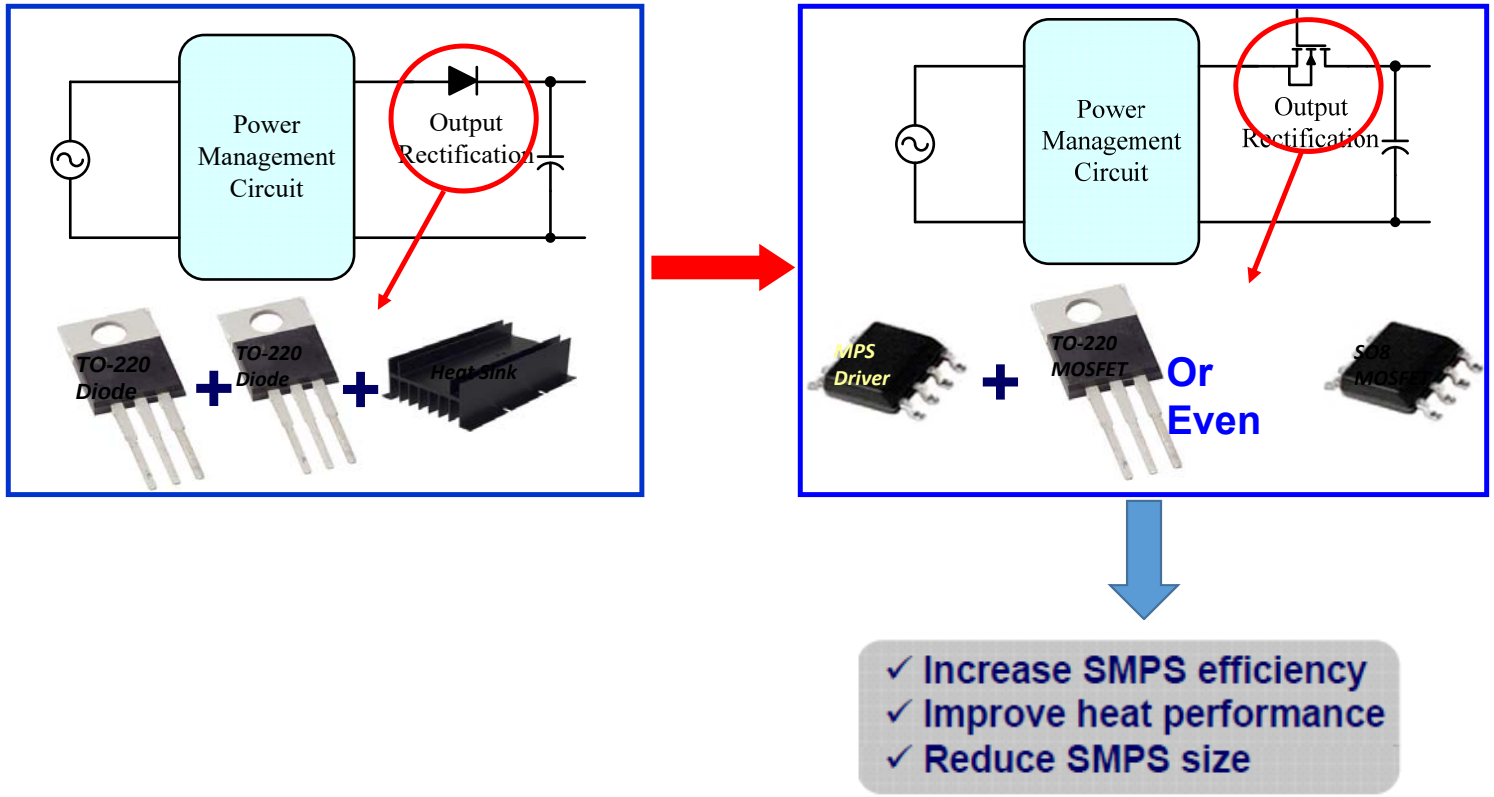
100W PD Adapter

460W Desktop Power

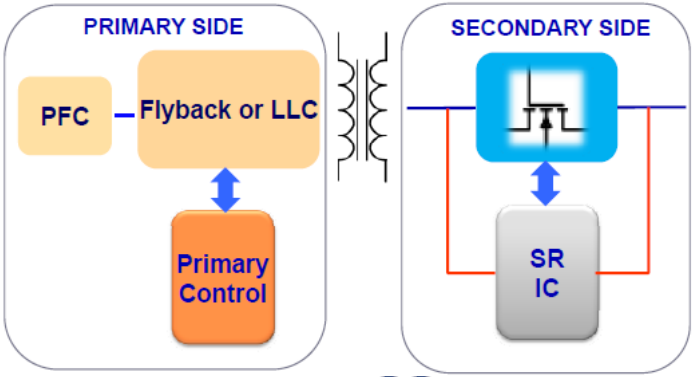
570W Server Power

高性能、高可靠的同步整流方案

应用场景-低压大电流输出



同步整流的实现方式



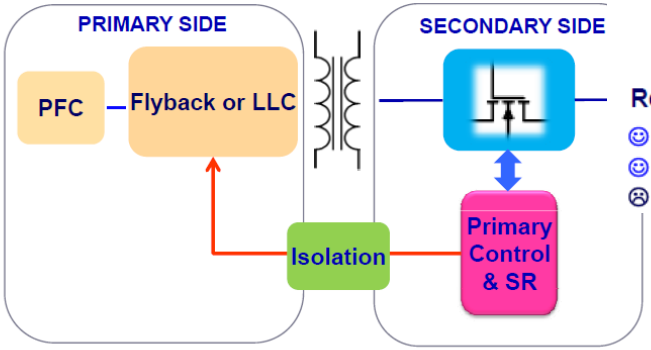
Rely on secondary side:

☺ Simple structure

☺ Low cost

☹ Driving speed critical

Good design flexibility
Widely used

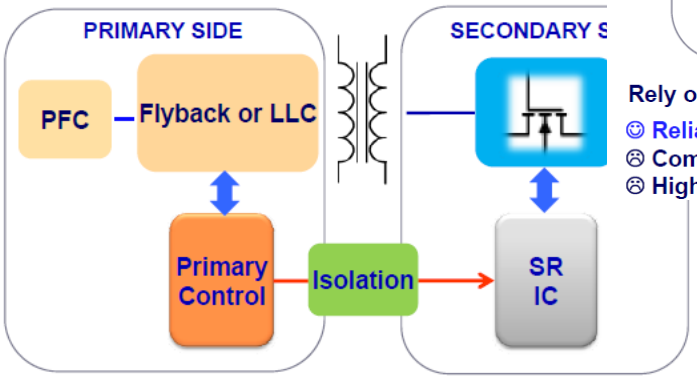


Rely on secondary side:

☺ Reliable SR control

☹ Complicated structure

☹ High cost



Rely on primary side:

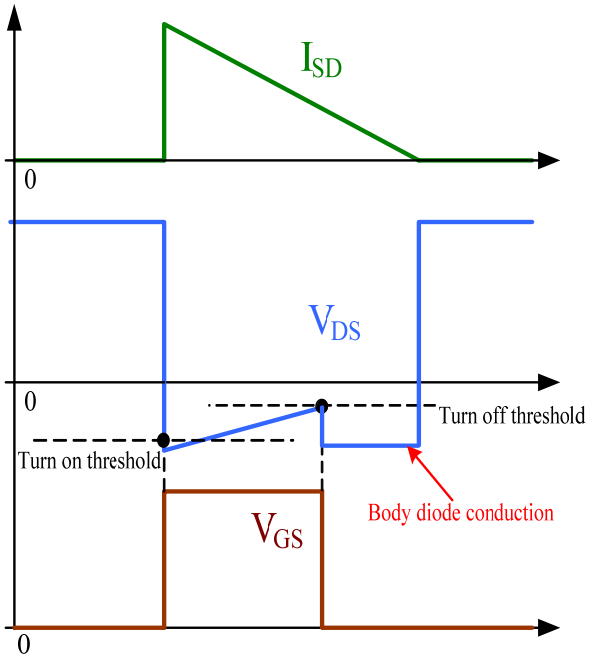
☹ Driving speed critical

☹ Complicated structure

☹ High cost

同步整流的控制方式

1



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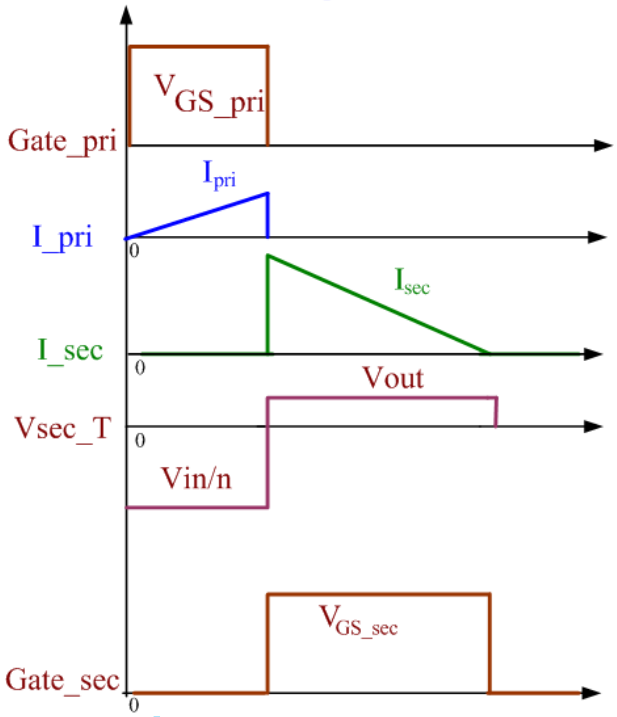
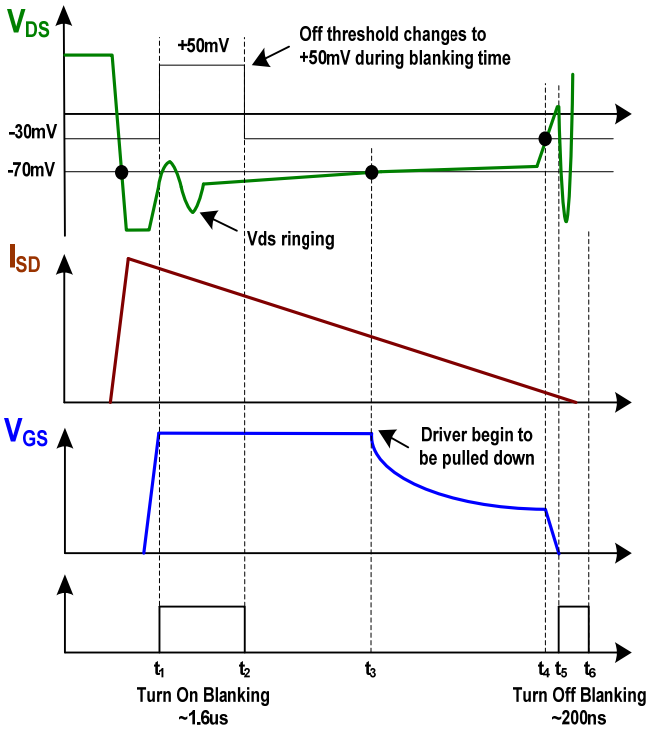
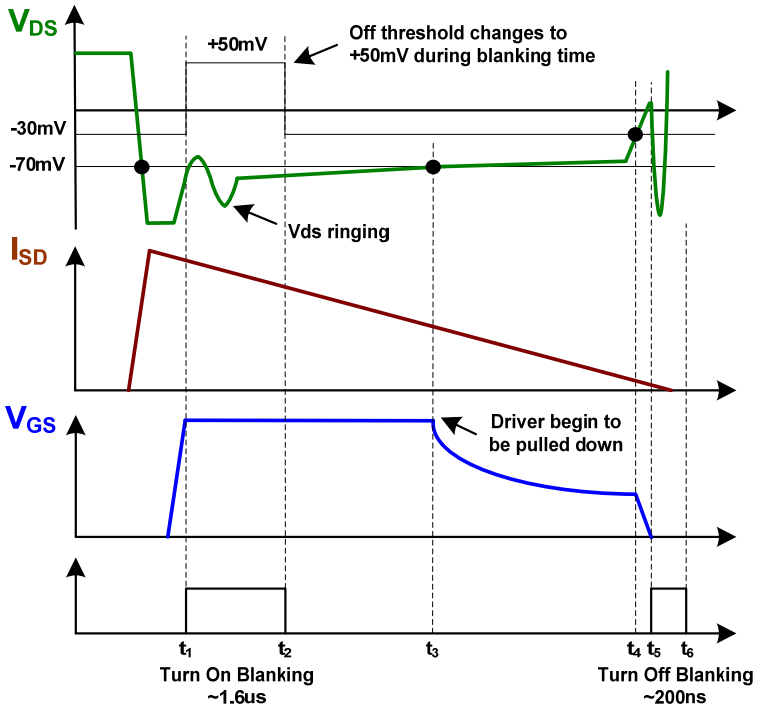


Vin/n×Ton=Vout×T

3



MPS SR工作原理



t1: MPS SR通过采样Vds电压，一旦检测到Vds电压小于-70mV, 就会开通MOS

t1-t2: 为了避免由于震荡引起的误关断，SR有个最小的导通时间

t2-t3: Vds小于-70mV, 驱动电压一直维持在最大值

t3-t4: 一旦Vds电压大于-70mV,驱动电压开始调制从而使得Vds保持在-70mV附近

t4-t5: Vds一旦 碰到关断阈值，驱动就会关断

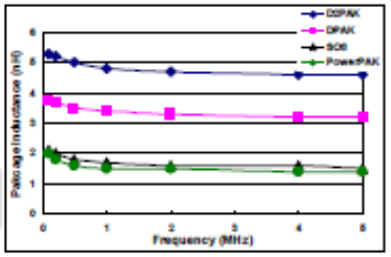
t5-t6: 200ns最小的关断时间

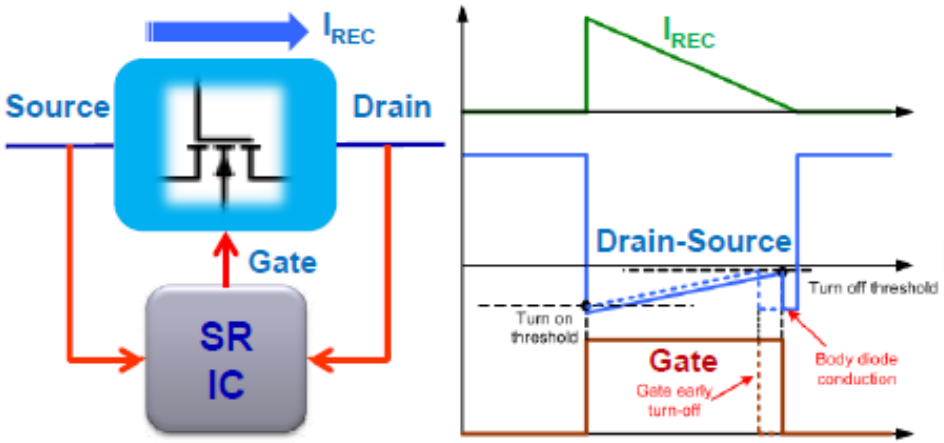
SR应用常见遇到的问题

MOSFET

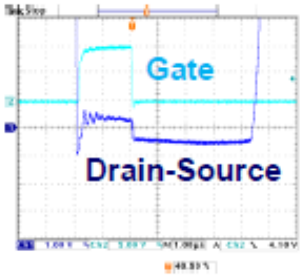
R_{DSon}

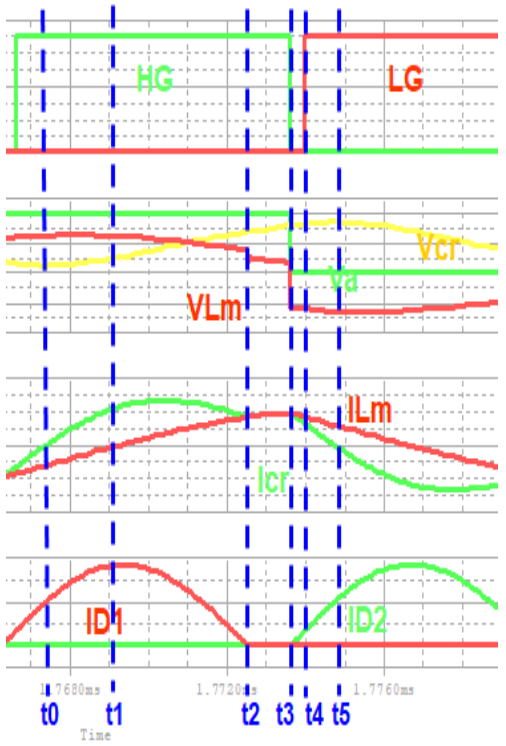
Package inductance





$$V_{Drain-Source} = -I_{REC} \cdot R_{DSon} + L_{package} \cdot \frac{dI_{REC}}{dt}$$

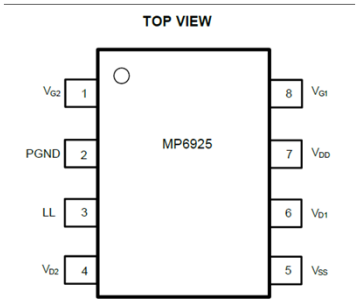




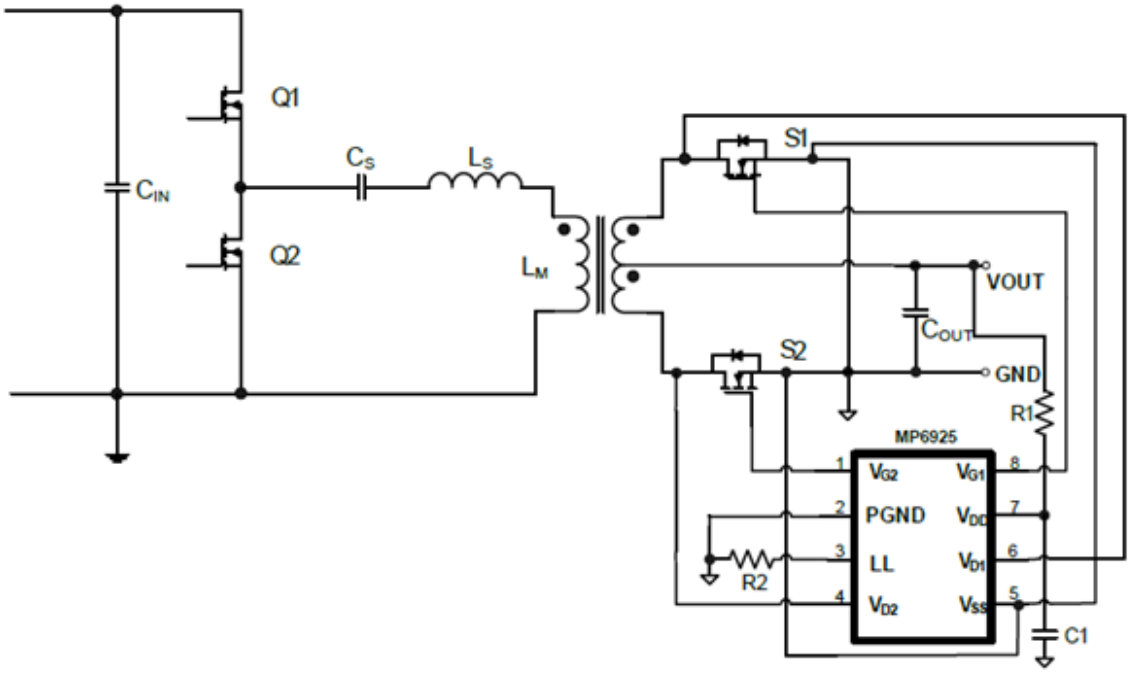
MP6925 – LLC 同步整流

特点

- **快速关断, 总延时35ns**
- 宽电压工作范围（4.2-35V）
- **175μA 低静态工作电流**
- 支持CCM, DCM 和CRM
- 兼容能源之星

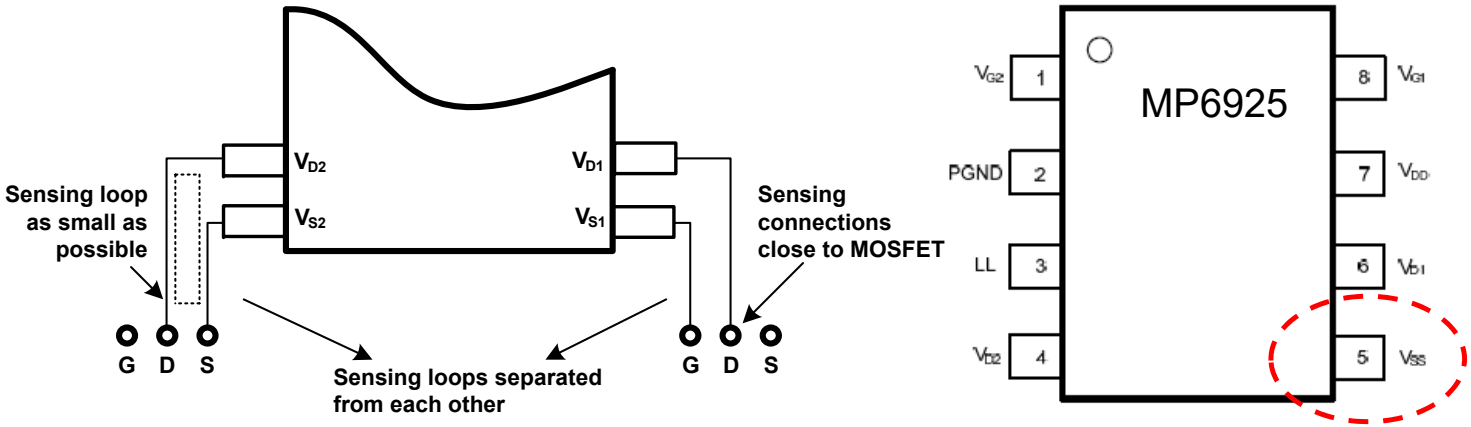


Available in an SOIC-8 Package



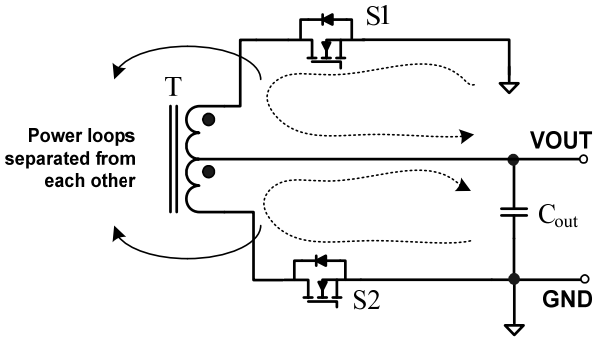
应用场景-布板的注意事项

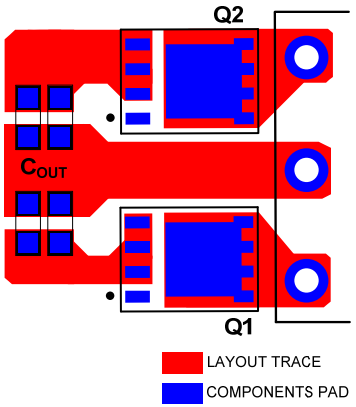
Sensing for V_D/V_{SS}



- ✓ VD/VSS采样必须尽量靠近MOS
- ✓保持两个MOS的采样通道独立，以及回路尽可能小
- ✓ SR芯片一定要放在功率回路外面，防止被干扰

应用场景-布板的注意事项





系统回路

✓尽可能减小功率回路，

谢谢

MPS Nanjing Sales

丁连锋

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