

高功率密度快充平台

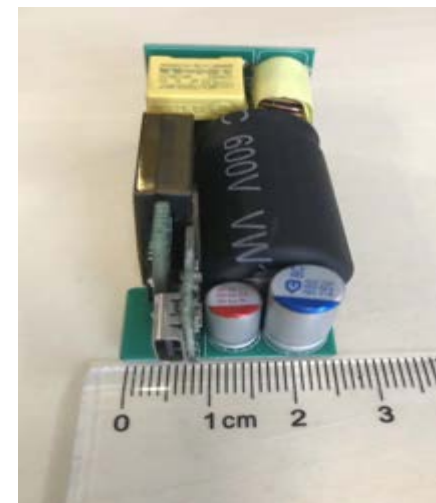
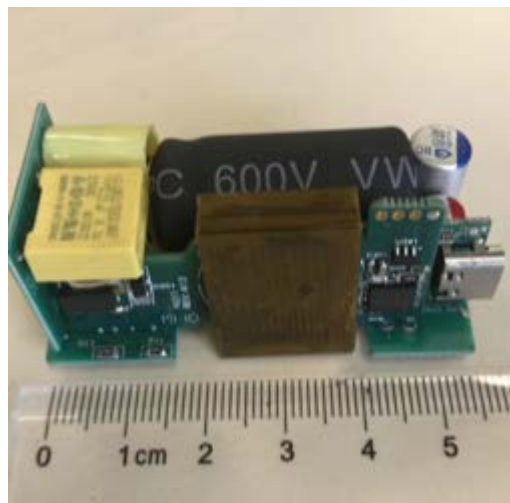


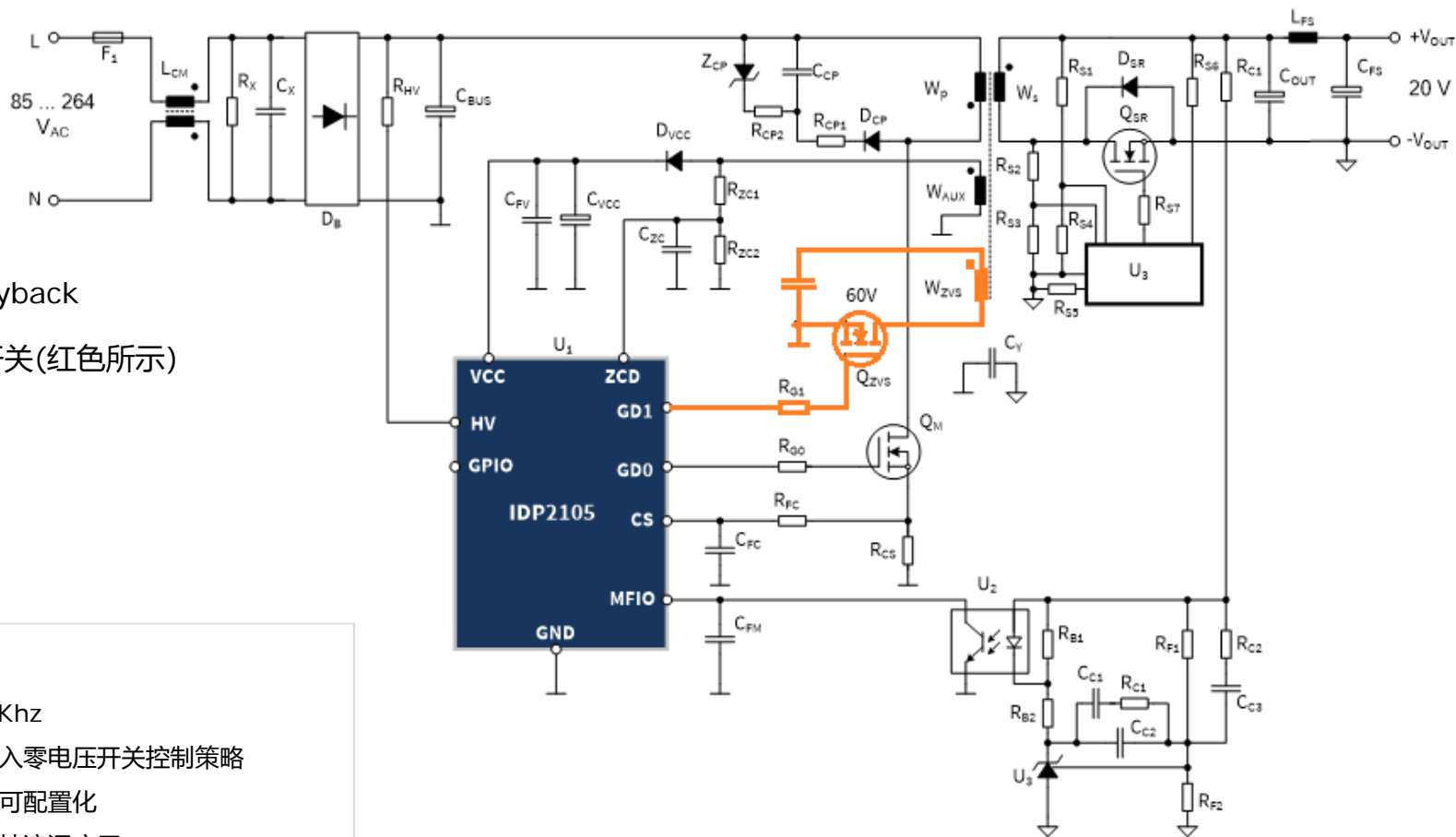
Agenda

- 1 基于XDP21061快充数字平台的45W演示板介绍
- 2 基于英飞凌第五代准谐振平台的18W演示板介绍
- 3 基于IPD2303A快充数字平台的介绍100W演示板介绍

这是什么？

- USB PD 充电器
- PCBA功率密度 (28W/In³)
- 采用平面变压器
- 效率: 92%

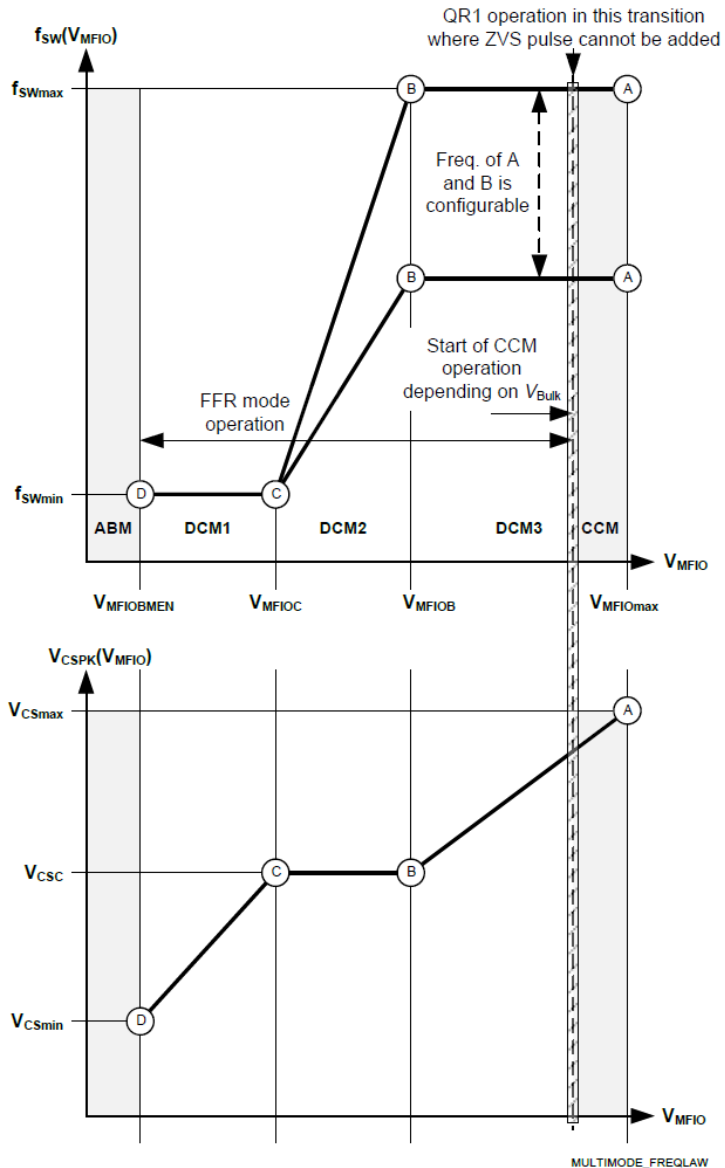




- 基于传统QR Flyback
- 增加ZVS辅助开关(红色所示)
- 高频工作
- 数字控制

主要特点

- 开关频率高达140Khz
- 工作于高频以及引入零电压开关控制策略
- 多模式控制, 参数可配置化
- 双过流点保护可支持浪涌应用
- 过压保护可配置自动重启或锁住模式
- 出色的突发模式可消除音频噪声
- 可配置过温保护点



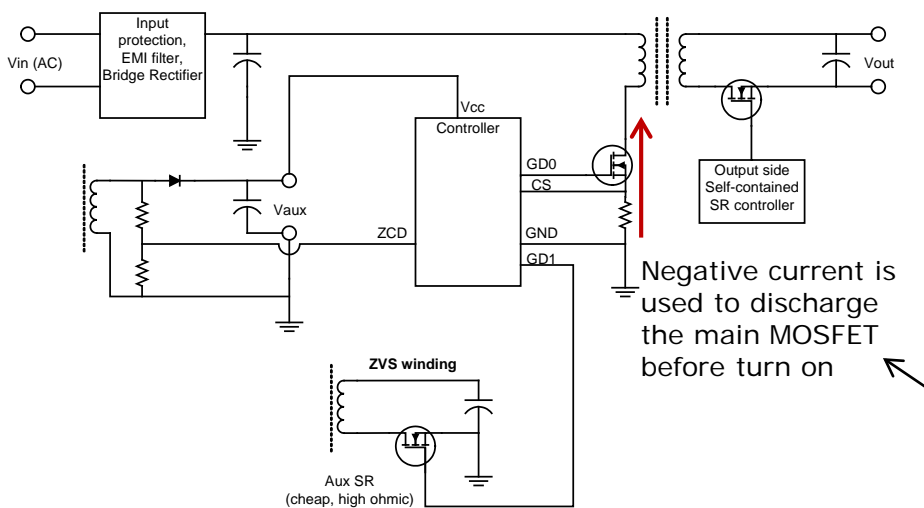
- 类定频工作，最大140kHz
 - 全电压满载频率较高，变化小（如20kHz）
 - 优化变压器选择，更合适小型化

- 工作频率曲线可调，轻载降频
 - 改善轻载效率，平均效率
 - 改善待机性能

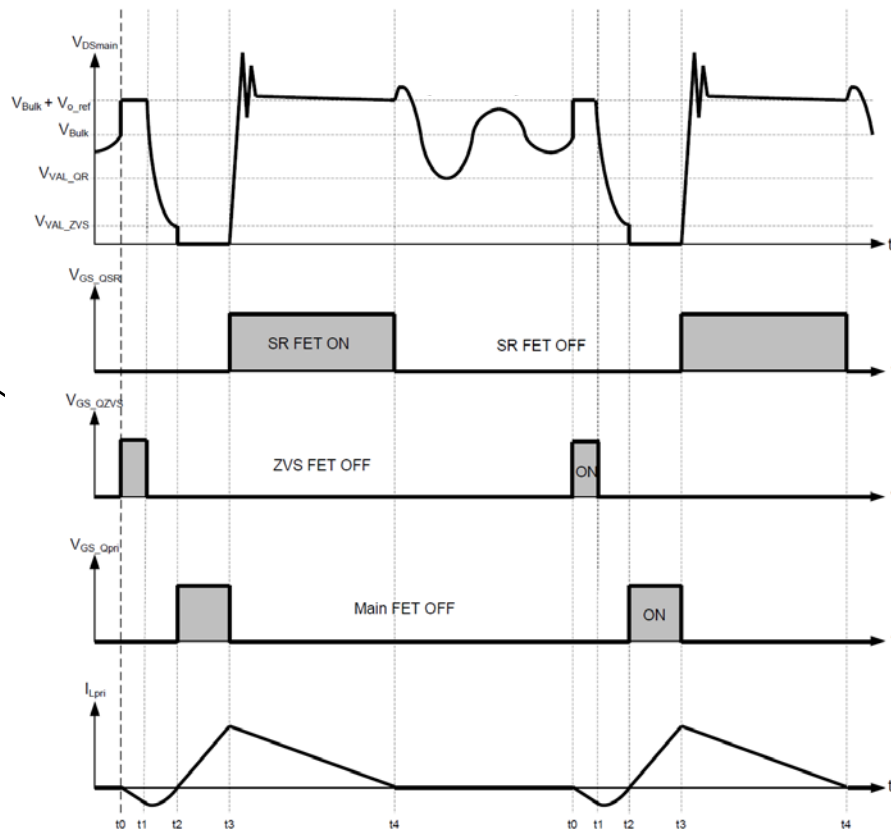
- 支持CCM工作
 - 支持峰值功率

强制ZVS

典型应用框图



工作波形



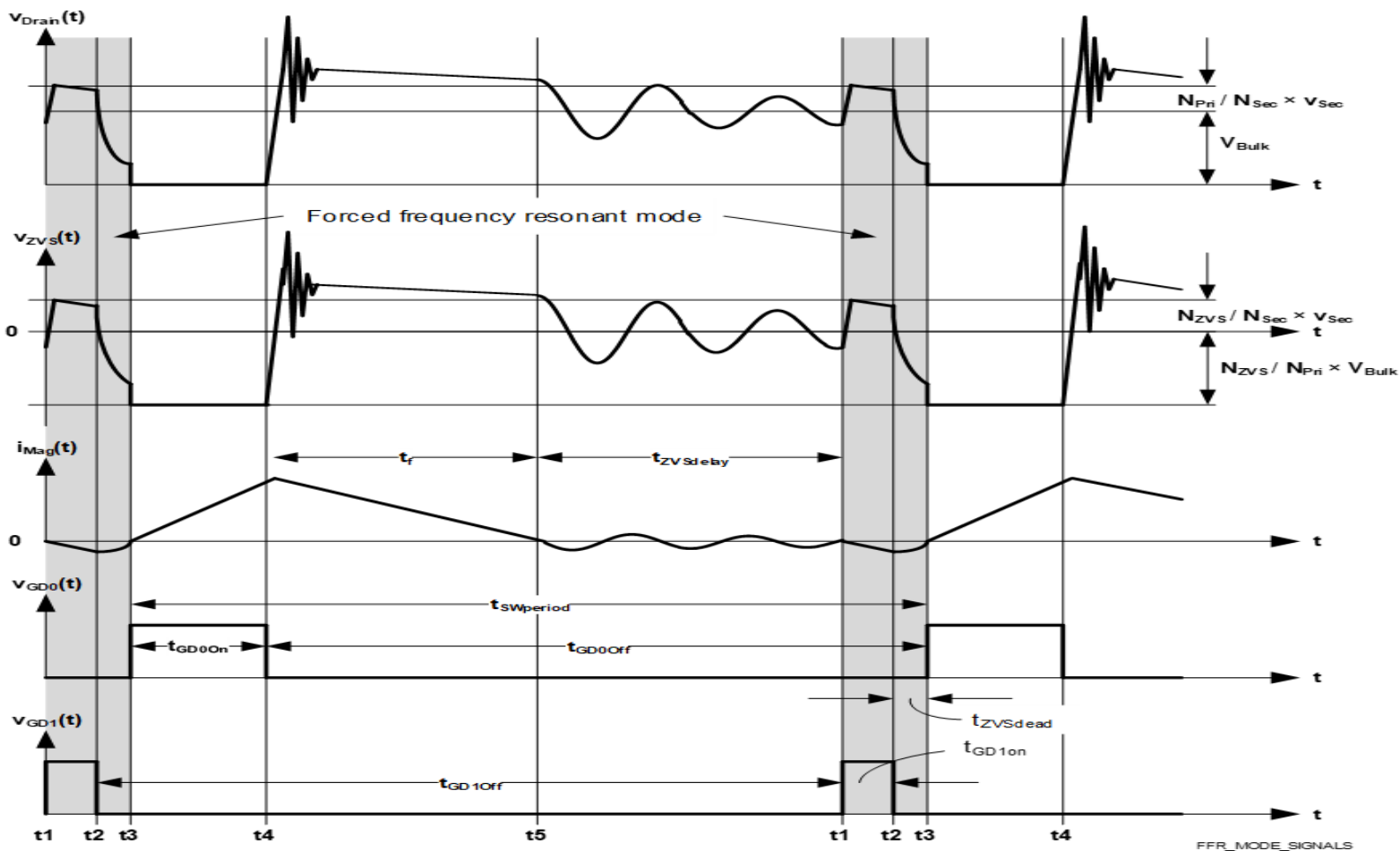
❖ ZVS脉冲宽度: $ZVS_{ton} \sim \sqrt{L_p * C_{eqv}} * \frac{V_{bulk} + N_{pa} * V_{zvs}}{N_{pa} * V_{zvs}}$

❖ 谷底延时时间: $T_{delay} = \frac{\pi}{2} * \sqrt{L_p * C_{eqv}}$

❖ ZVS脉冲在下列情况不会发生

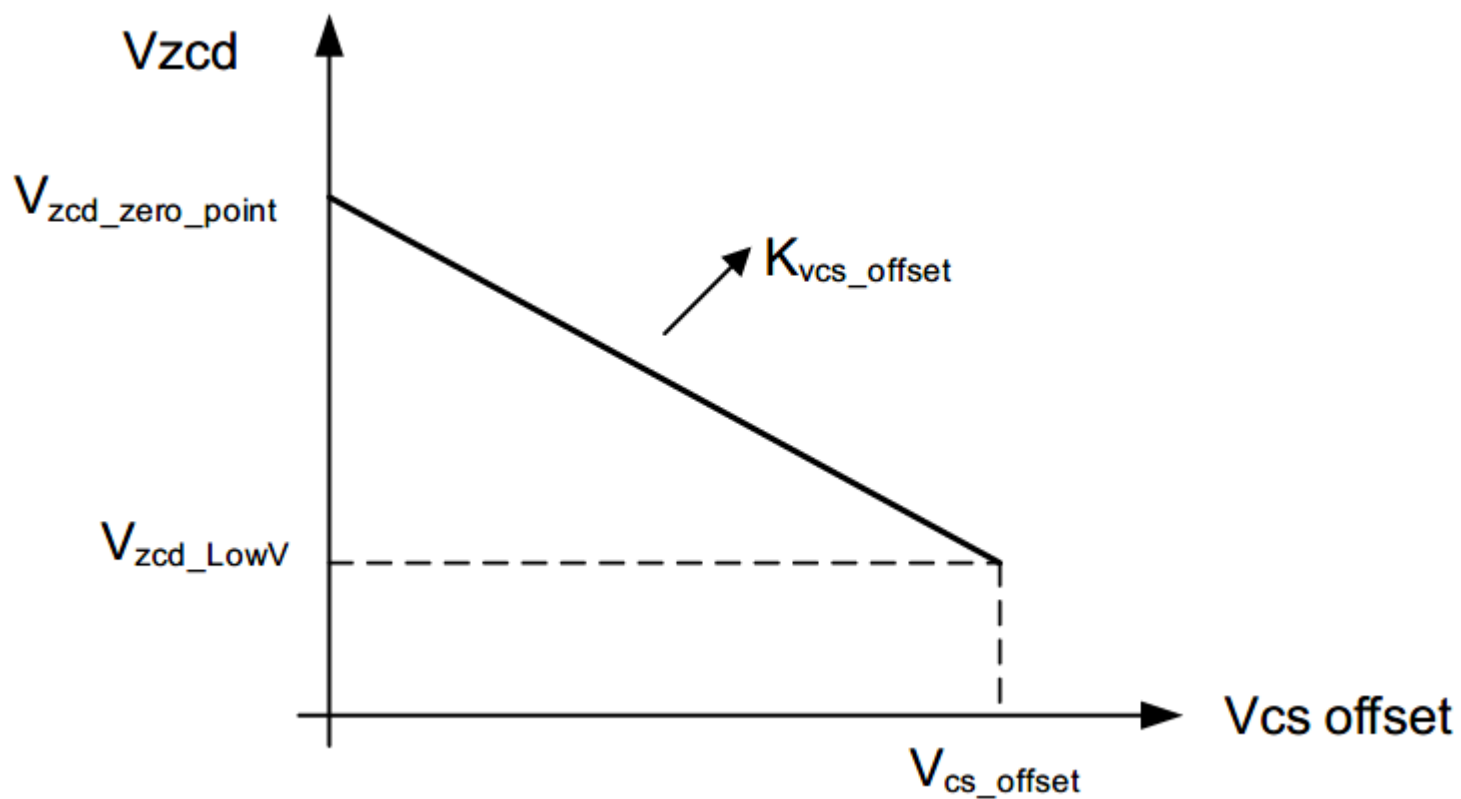
- 检测不到过零点。
- 能检测到过零点，但是剩余时间不足。

ZVS 原理说明



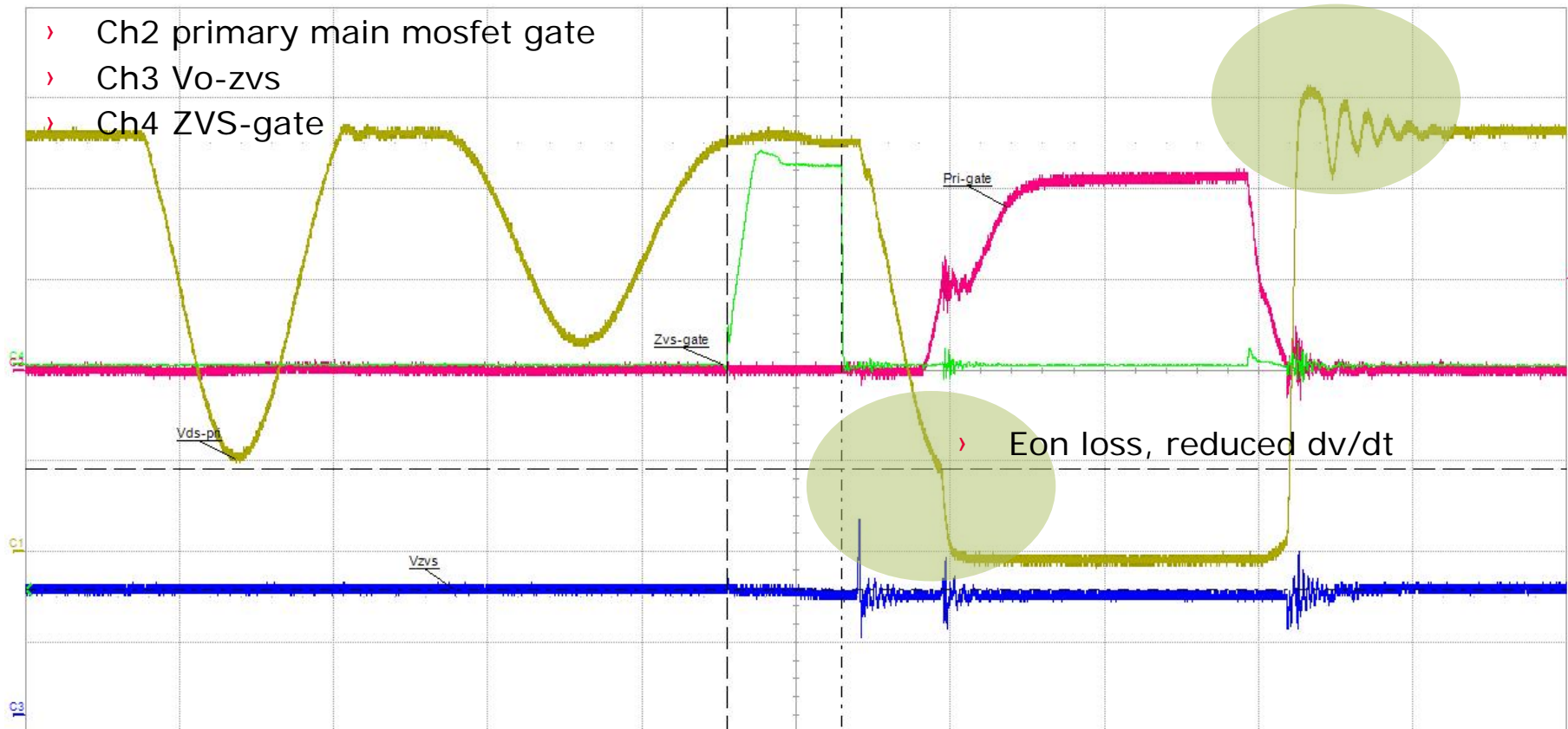
自适应功率补偿

V_{zcd} 电压越低 K_{vcs_offset} 补偿越大, 输出功率越小



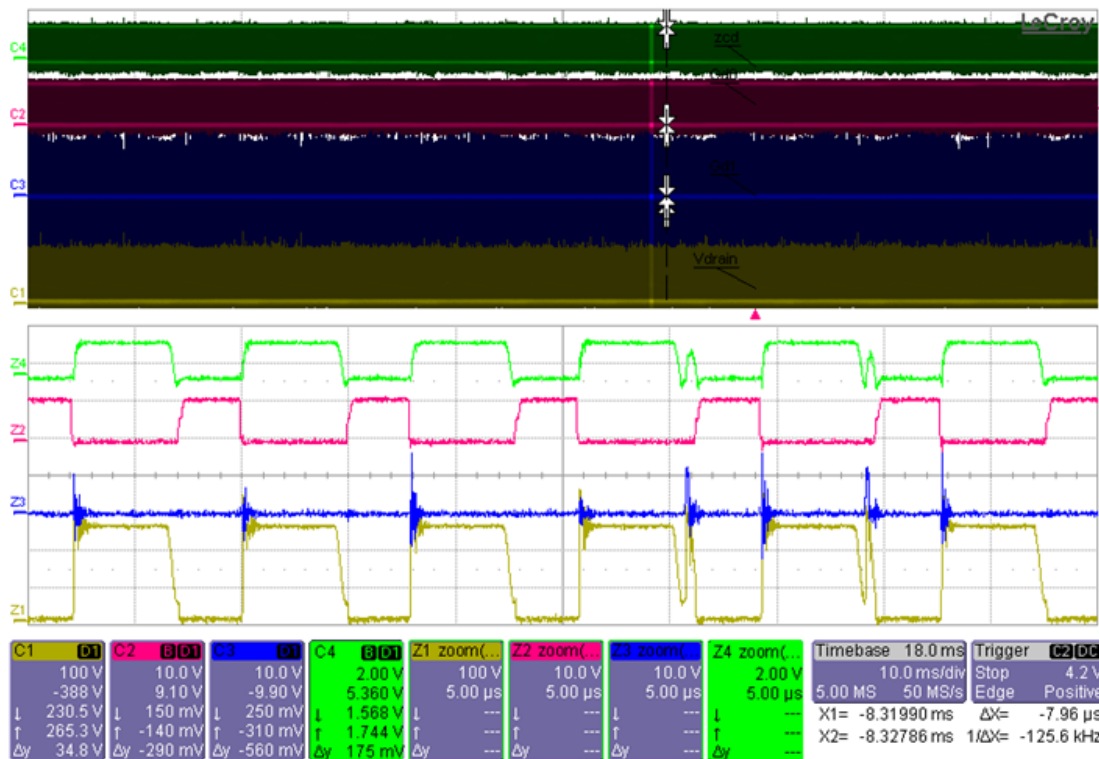
实际效果@360Vdc 2.5A

- › Ch1 Vds
- › Ch2 primary main mosfet gate
- › Ch3 Vo-zvs
- › Ch4 ZVS-gate
- › Snubber loss



Measure value status	P1:width(C4) 335.084 ns	P2:freq@lv(C4) ---	P3:width(C2) 912.713 ns	P4:---	P5:---	P6:---	P7:---	P8:---																				
C1 BwL DCTM 100 V/div -200.0 V ---- -42 V ---- 91 V Δy 133 V	C2 BwL DCTM 5.00 V/div 0.00 V ofst ---- -12.10 V ---- -5.45 V Δy 6.65 V	C3 BwL DCTM 5.00 V/div -19.05 V ---- 6.95 V ---- 13.60 V Δy 6.65 V	C4 FLT DCTM 5.00 V/div 300 mV ---- -12.40 V ---- -5.75 V Δy 6.65 V	<table border="1"> <tr> <td>Tbase</td> <td>1.50 μs</td> <td>Trigger</td> <td>C2 [DC]</td> </tr> <tr> <td></td> <td>500 ns/div</td> <td>Stop</td> <td>5.05 V</td> </tr> <tr> <td></td> <td>50 kS</td> <td>Edge</td> <td>Neg</td> </tr> <tr> <td>X1=</td> <td>-1.3540 μs</td> <td>ΔX=</td> <td>-370.5 ns</td> </tr> <tr> <td>X2=</td> <td>-1.7245 μs</td> <td>1/ΔX=</td> <td>-2.6991 MHz</td> </tr> </table>					Tbase	1.50 μs	Trigger	C2 [DC]		500 ns/div	Stop	5.05 V		50 kS	Edge	Neg	X1=	-1.3540 μs	ΔX=	-370.5 ns	X2=	-1.7245 μs	1/ΔX=	-2.6991 MHz
Tbase	1.50 μs	Trigger	C2 [DC]																									
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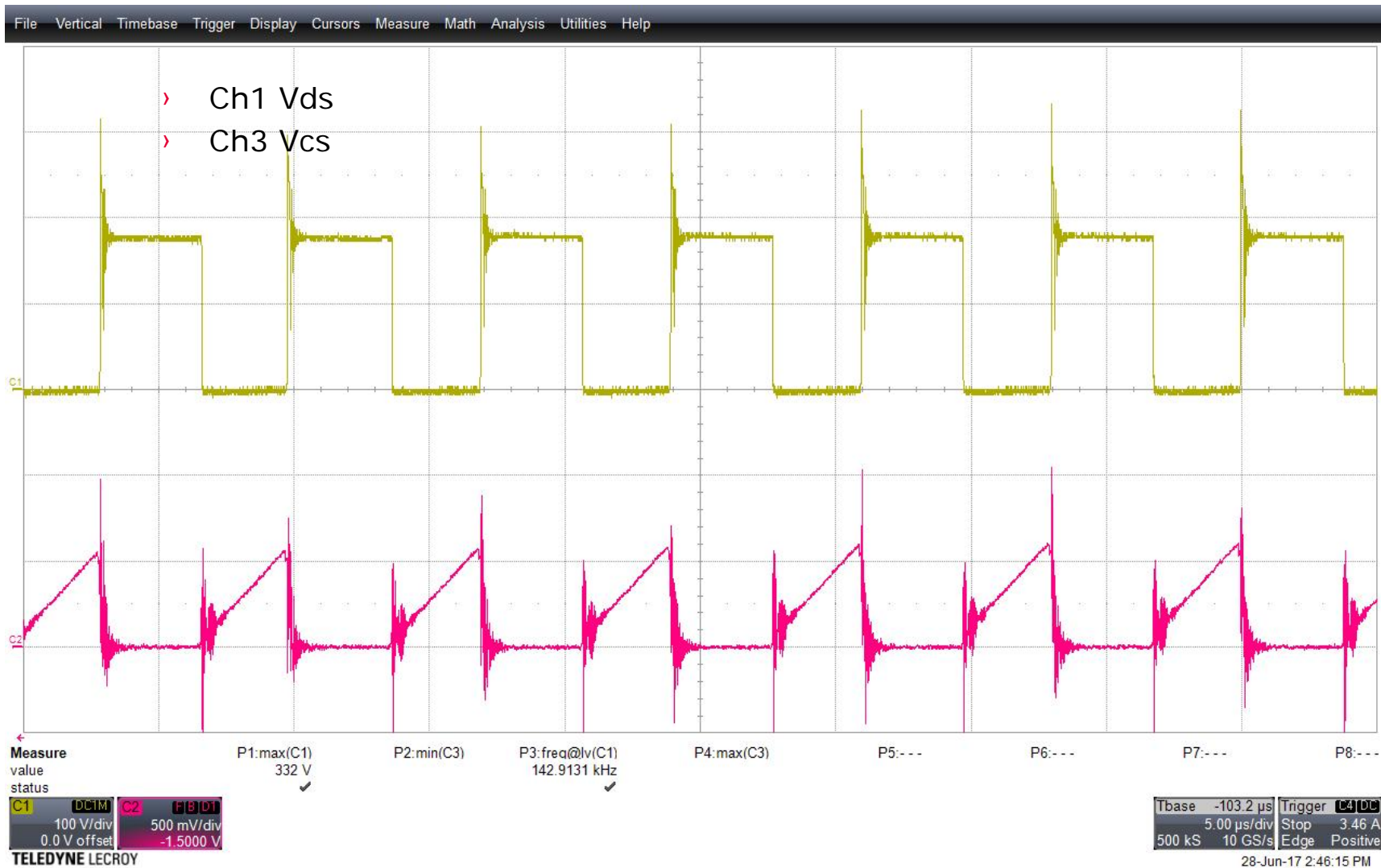
多工作模式-准谐振模式



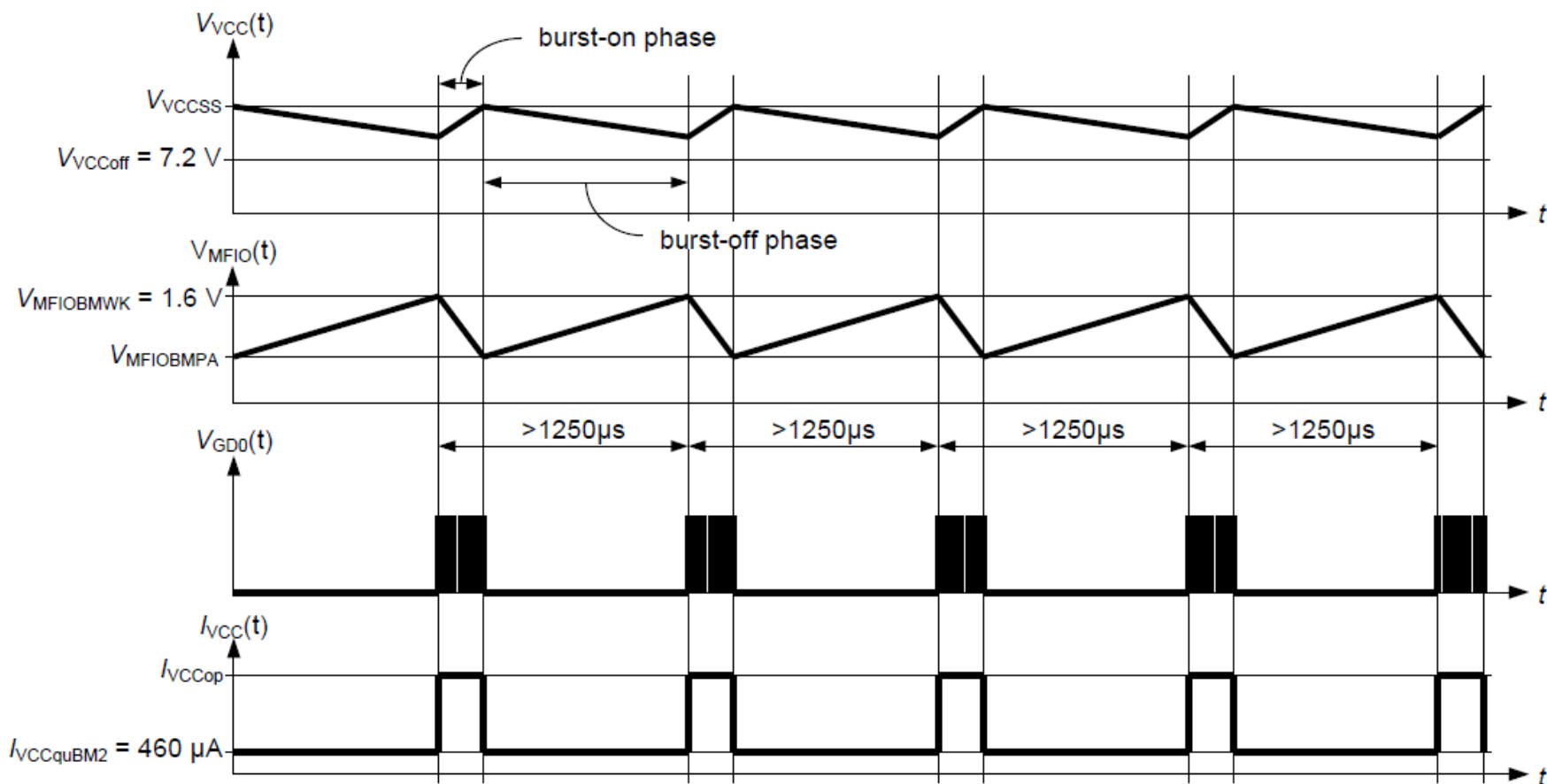
QR switching waveform @ V_{in} = 90Vac 3.25A load ,Ch1 Vds,Ch2,main_gate,Ch3,ZVS_gate,Ch4 ZCD

连续工作模式 90Vac/60Hz, 20V/4.5A

CCM support



安静的突发工作模式



- ❖ 当 MFIO电压小于0.4V时，IC会进入突发模式。
- ❖ 突发频率 30kHz, $V_{cs} = 0.2\text{V}$
- ❖ 当 MFIO电压大于2V时，IC会离开突发模式
- ❖ Burst pause level is 1.0V, burst on depends on two conditions, timer $>1250\mu\text{s}$ (configurable) and $V_{mfio} > 1.6\text{V}$

保护功能小结

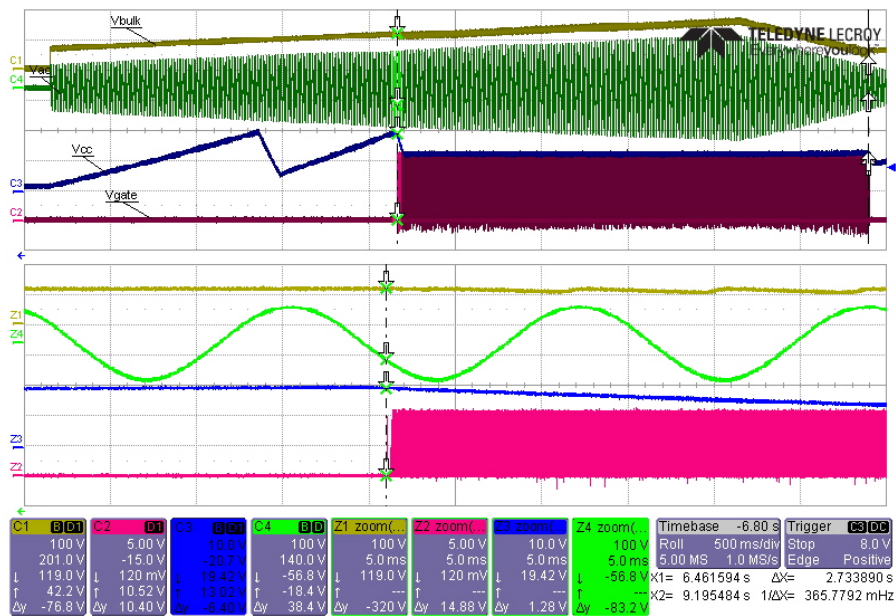
Table 7 Protection Features

Protection Feature	Symbol	Reaction
VCC Under-Voltage lockout	UVOFF	Deactivate IC
Brown-In Protection (when Brown-in conditions not met)	BIP	Block switching
Brown-Out Protection	BOP	Stop switching
Over-Current Protection level 1	OCP1	CbC limit
Over-current protection level 2 (< 35 μ s)	OCP2	Auto-restart
High input at CS pin (> 200 μ s)	CShigh	Auto-restart
Short Circuit Protection at CS pin	CSSCP	Auto-restart
MFIO pin High	MFIOH	Auto-restart
Internal Over-Temperature Protection	IntOTP	Auto-restart
Primary side output Over-Voltage Protection	VoutOVP	Auto-restart / Latch mode
Over Load Protection	OLP	Auto-restart
Peak Power Protection	PPP	Auto-restart

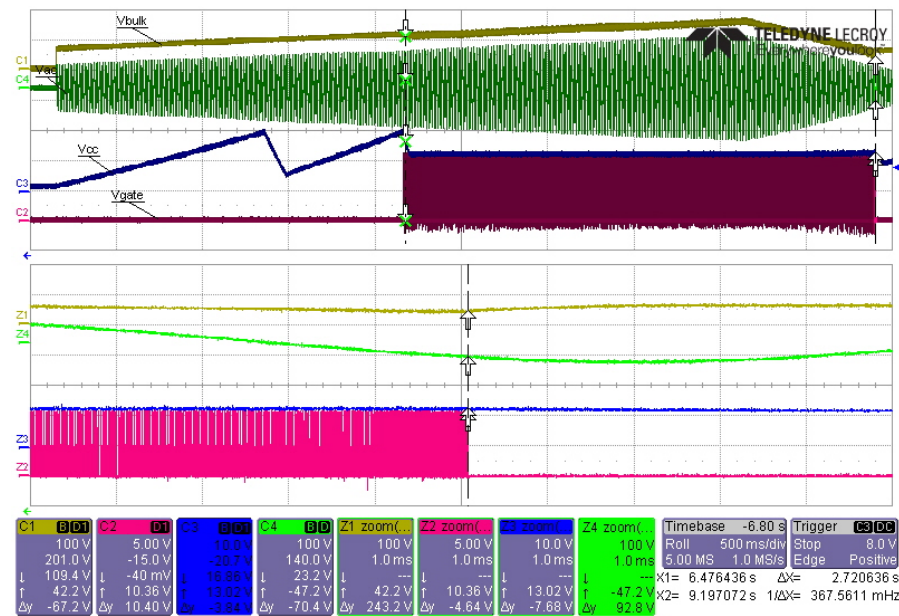
- ❖ Brown in threshold for $V_{cc}=15V$
- ❖ Brown in threshold , $I_{hv_BI}=1.15mA$
 - ❖ $V_{bulk_BI} = I_{hv_BI} * (R_{hv} + 0.75 + 0.94)$
 - ❖ Using $R_{hv}=100kohm$, leads to $V_{bulk_BI}=117Vdc \sim 83Vac$
- ❖ Brown out threshold,
 - ❖ $V_{brownout} = I_{hvbo} * R_{hv} + I_{hvbo} * 0.99 = 0.443mA * (100kohm + 0.99kohm) = 44.7Vdc$
- ❖ R_{hv} also influence V_{bulk} detection accuracy and startup current, so we don't suggest to change this value , the recommended value is 100Kohm
- ❖ Since V_{bulk} is used to set brown in/out value, so brown in AC level is not load dependent, but brown out (AC voltage) is load dependent

Brown In/Out at 1A loading

› BI=119Vdc



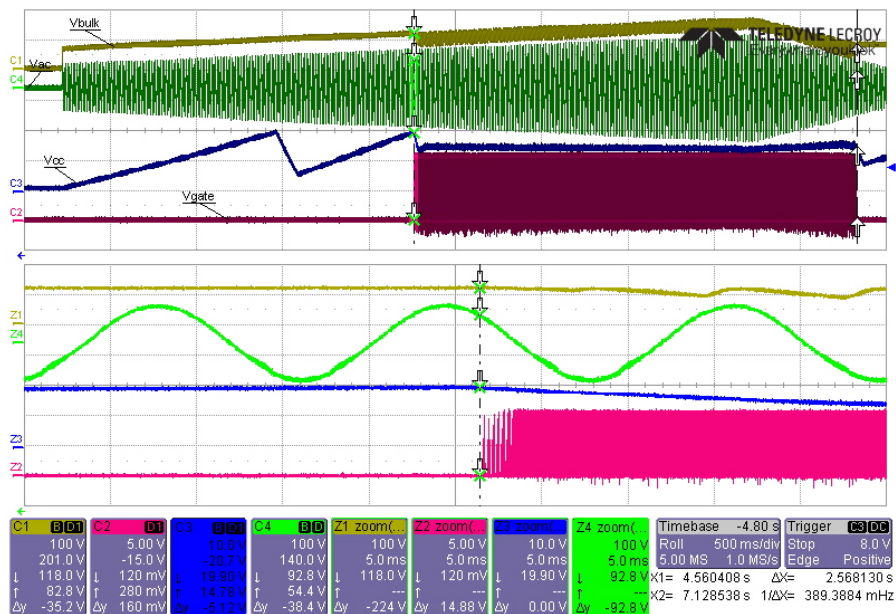
› BO=42Vdc



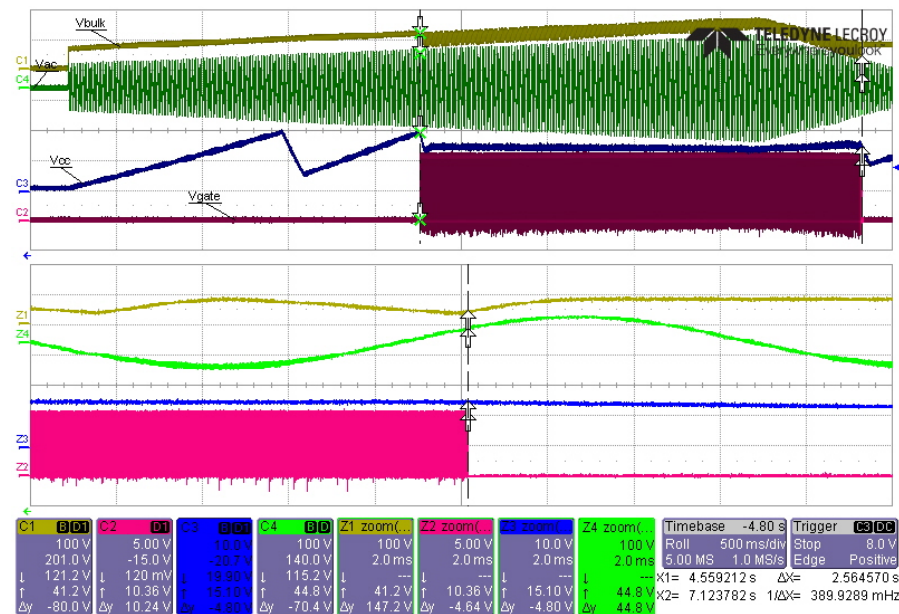
› Ch1 Vbulk ,Ch2 gate,Ch3 Vcc, Ch4 Vin_ac

Brown In/Out at 3.2A loading

› BI=118Vdc

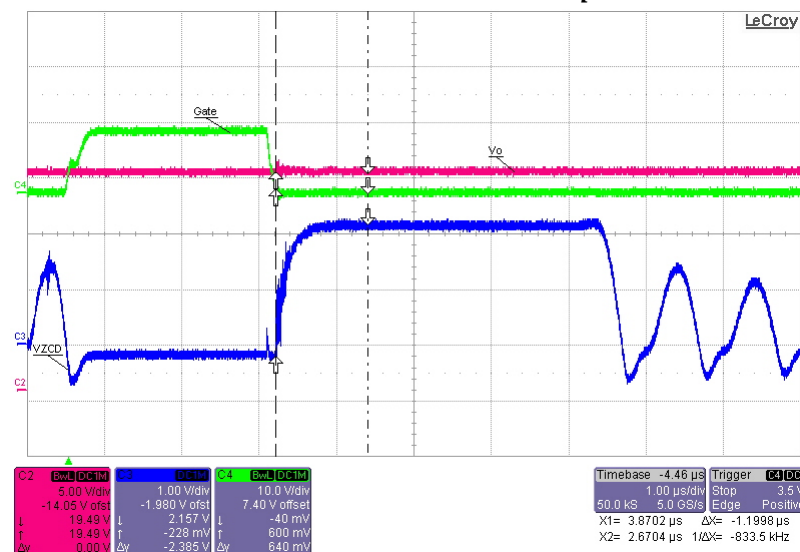
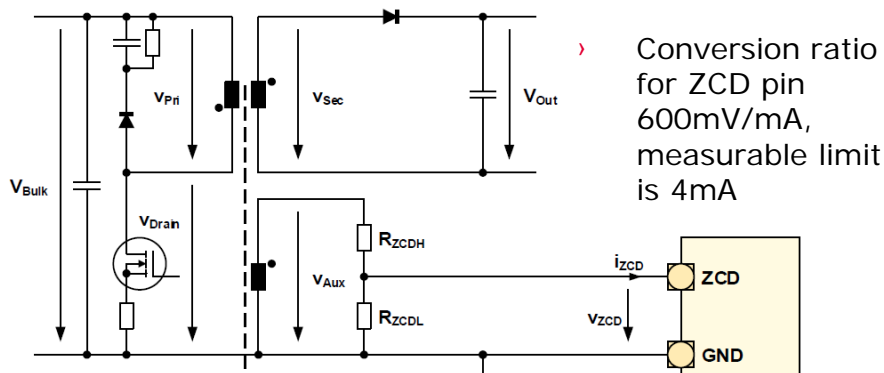


› BO=41Vdc



过压保护

- ❖ Protection is through aux winding voltage after $\sim 1.2\mu s$ when ZCD is high
- ❖ $V_{zcd_ovp} = 2.26V$ (dig value $(2.26V - 1.2V) * 1.5/2.4 * 255 = 0XA9$)
- ❖ $V_{zcd} = \frac{R_{zcdl}}{R_{zcdh} + R_{zcdl}} * (V_o + V_{diode})$ when MOSFET is OFF
- ❖ $i_{zcd} = (V_{aux} - V_{clamp}) / R_{zcdh}$ When MOSFET is ON, $V_{aux} = \frac{N_{aux}}{N_{pri}} * V_{bulk}$



45W 实测性能

设计规格

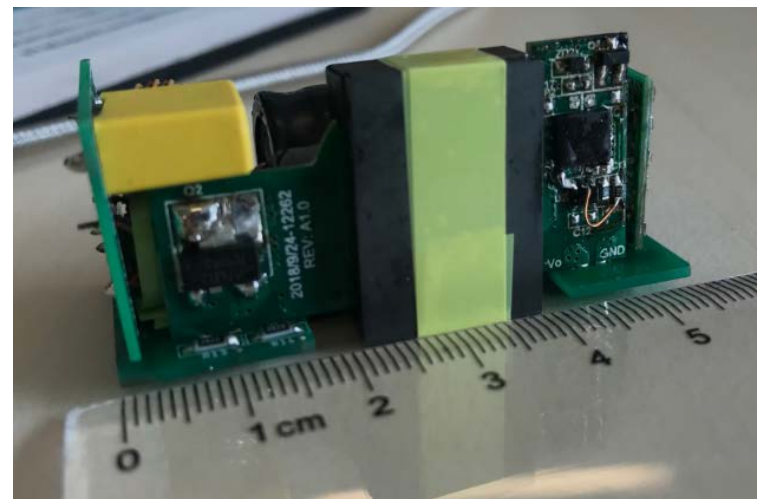
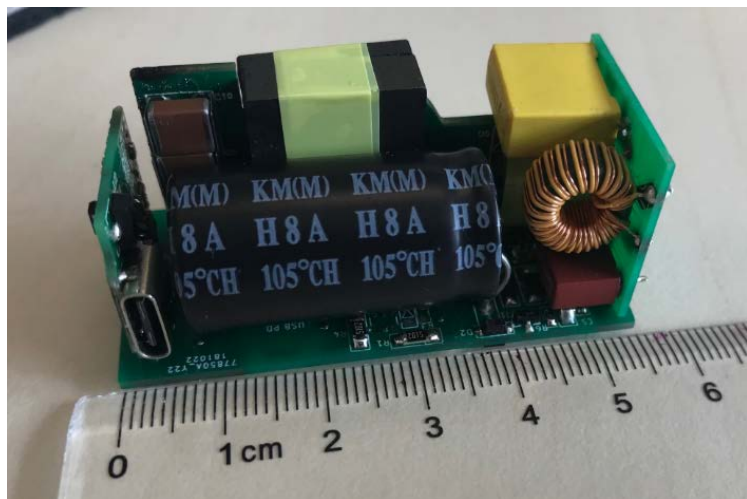
Description	Specification
Input voltage	90Vac~265Vac
Input frequency	50/60Hz
Output voltage	5V 9V 12V 15V 20V
Output current	2.25A
Output power	45W
No-load Power Consumption Limit (EC CoC Version 5 Tier 2)	<50mW
Minimum Four Point Average Efficiency in Active mode (25%, 50%, 75% & 100%) (EC CoC Version 5 Tier 2)	>88% at 115Vac & >88% at 230Vac
Minimum Efficiency in Active mode at 10% (EC CoC Version 5 Tier 2)	
Form factor case size (L x W x H)	(55 x 26 x 25) mm ³

Max Eff. Up to 92%

英飞凌关键器件

Functionality	Part name	Number of pcs
Primary PWM controller	XDPS21061	1
Primary HV MOSFET	IPN70R360P7	1
Secondary Synchronous Rectifier MOSFET	BSC0805LS	1
ZVS MOSFET	BSL606SN	1

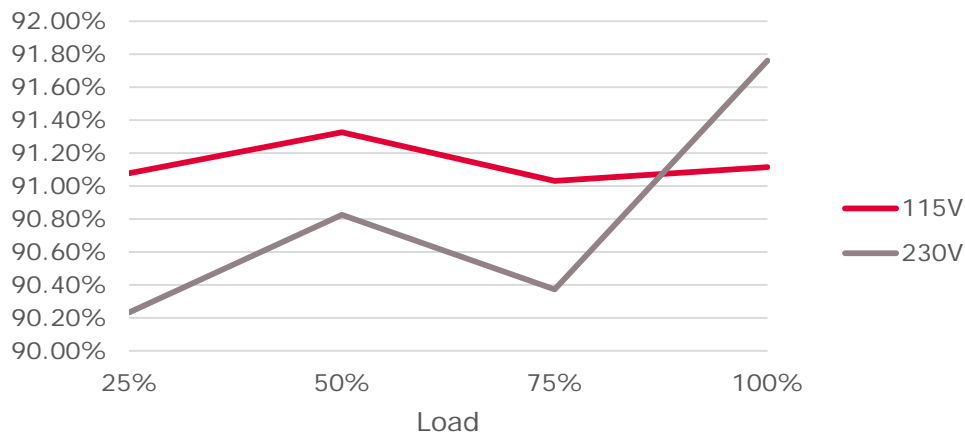
实物照片



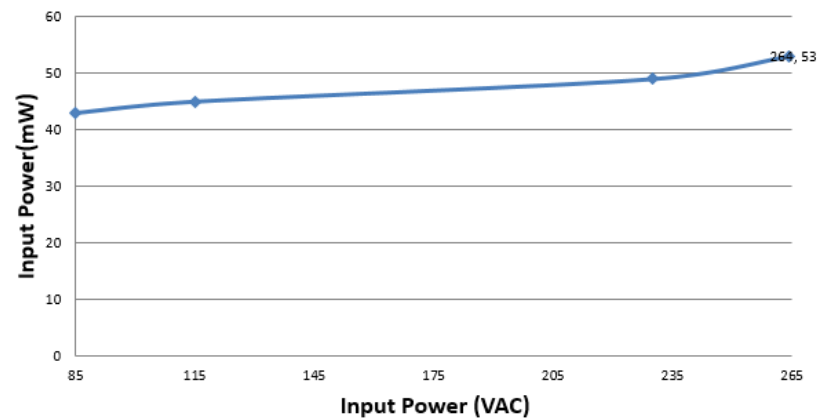
- › PCB Size L55mm*W26mm*H25mm

效率测试

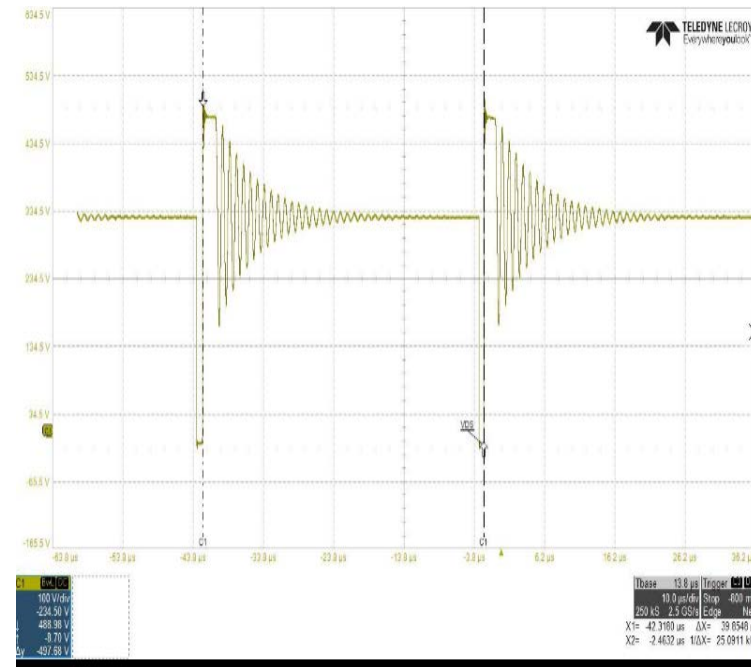
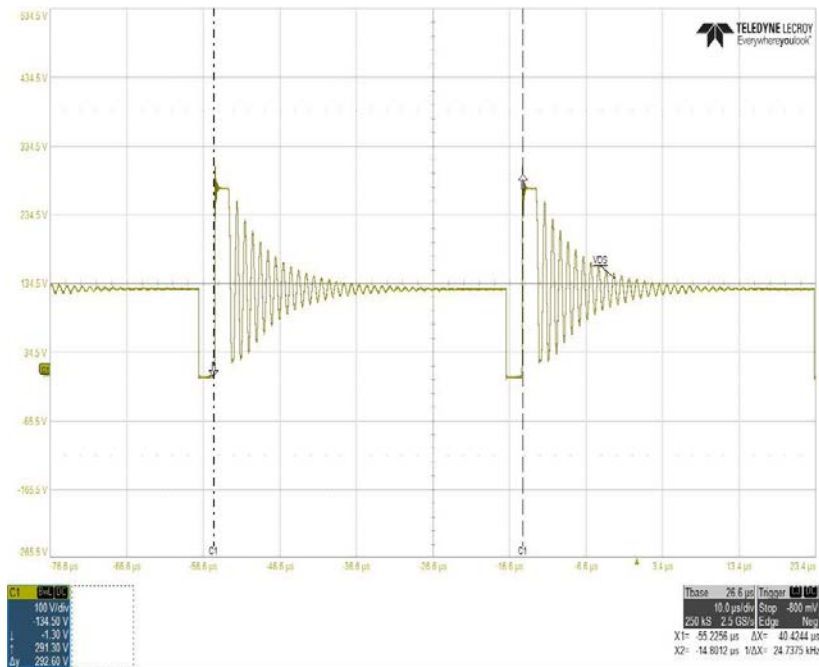
20V



Standby Power @ no-load versus AC Line Input Voltage

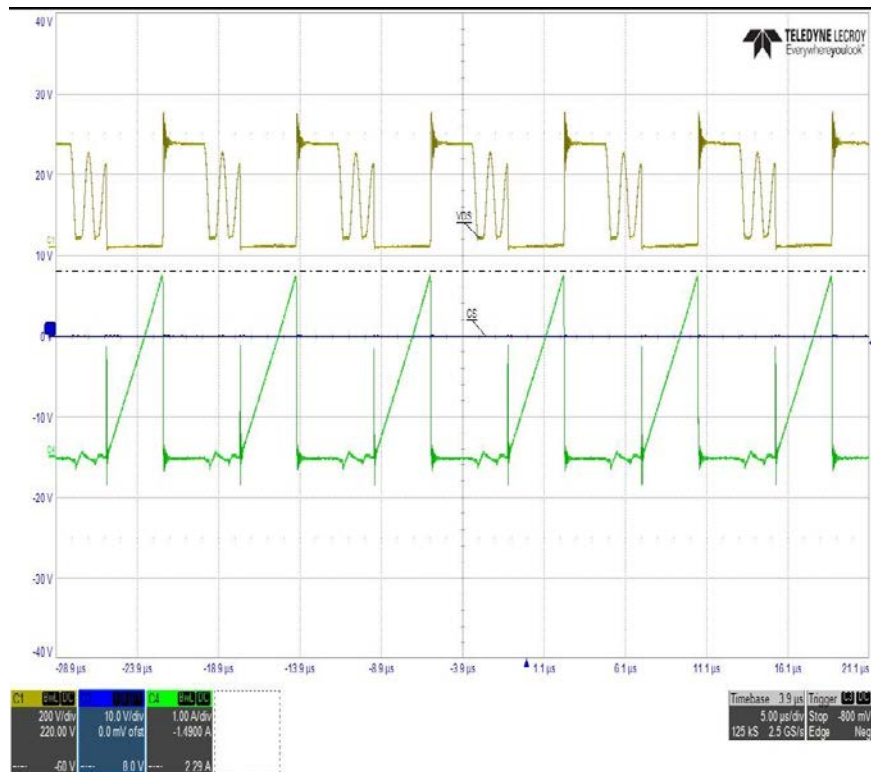


轻载波形



90Vac Full load, switching frequency is 24.7kHz and 264Vac Full load is 25kHz

变压器的磁通密度



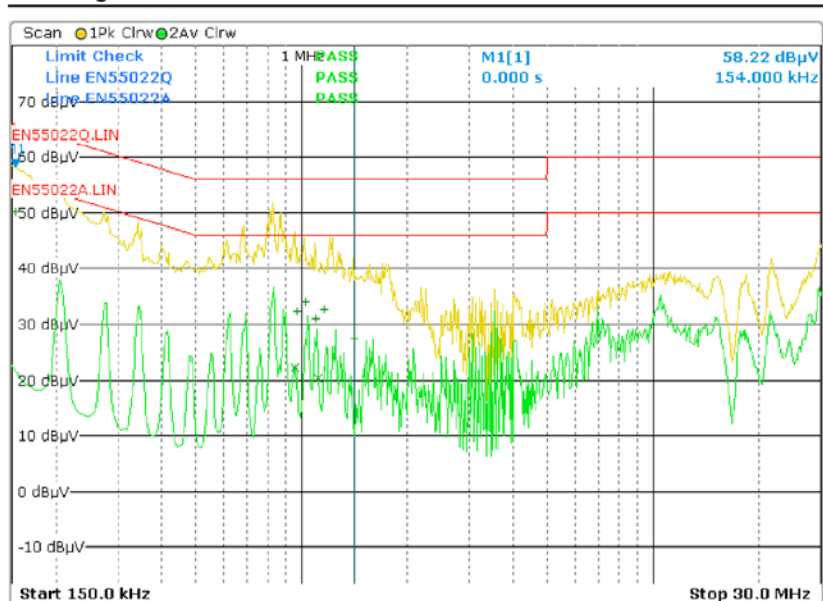
- › **I_{pk} is monitored at 90Vac and output 20V/2.25A IPK is 2.29A**

$$B_{\max} = \frac{L_p * I_{pk}}{N P * A_e} = \frac{0.15 * 2.29}{12 * 89} = 0.32T$$

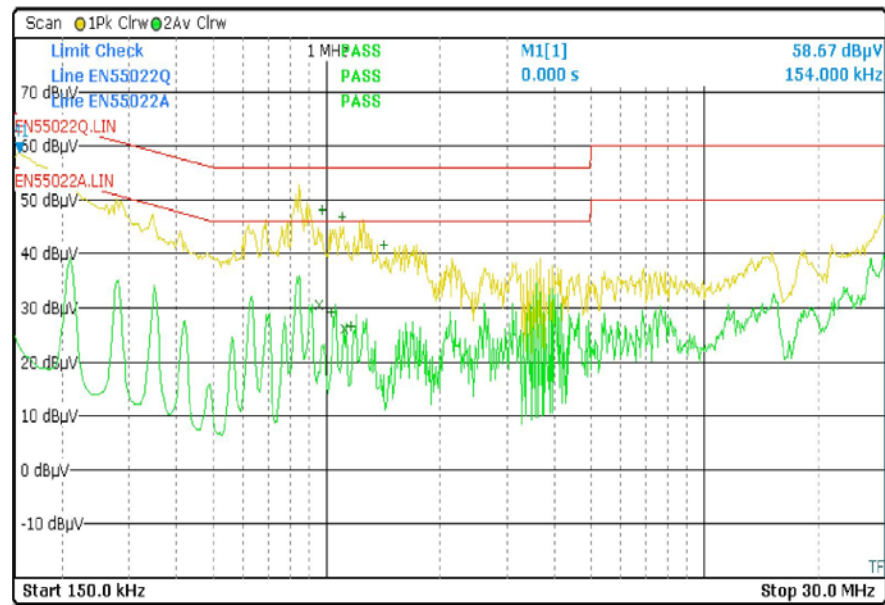
$$B_{\max} = 0.32T (\text{Tesla})$$

传导 EMI

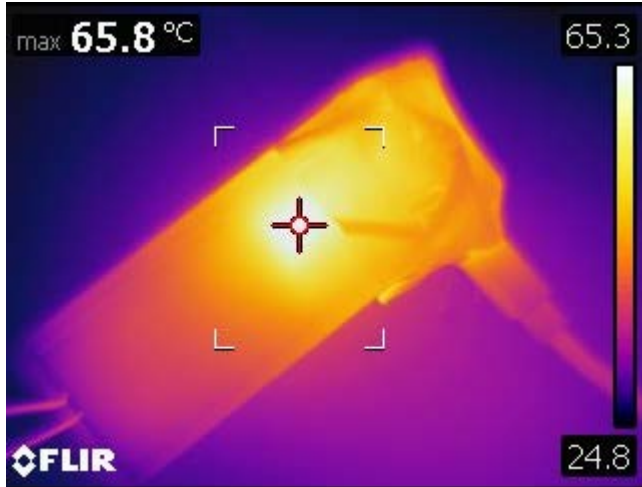
Scan Diagram



Conducted EMI Maximum steady state load at 230Vac 50Hz (N line)

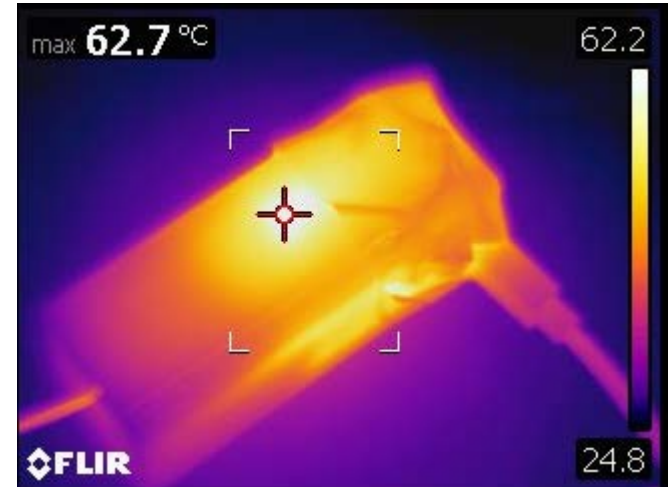


Conducted EMI Maximum steady state load at 230Vac 50Hz (L line)



Test condition: output 20V/2.25A

Max.65.8°C at 115Vac

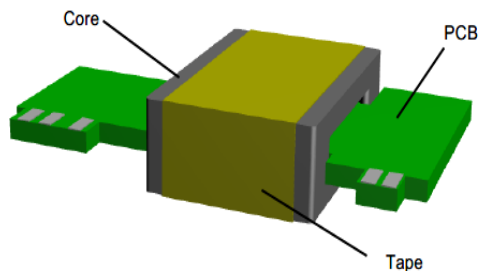


Test condition: output 20V/2.25A

Max.62.7°C at 230Vac

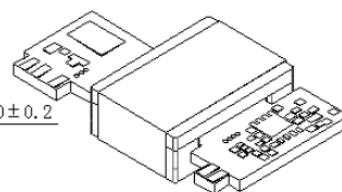
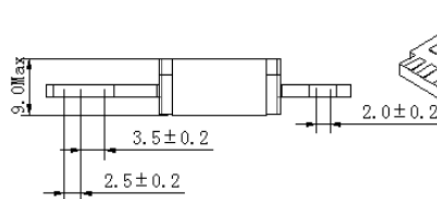
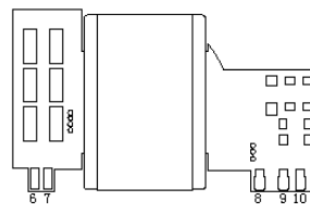
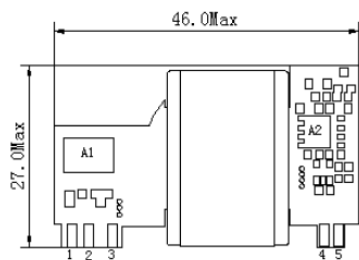
平面变压器

1. Structure and Material

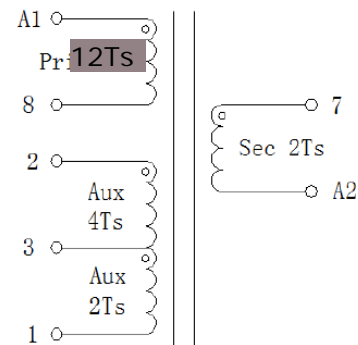


No.	Part Name	Material Name
①	PCB	FR-4
②	Core	Mn-Zn Ferrite
③	Tape	Mylar tape

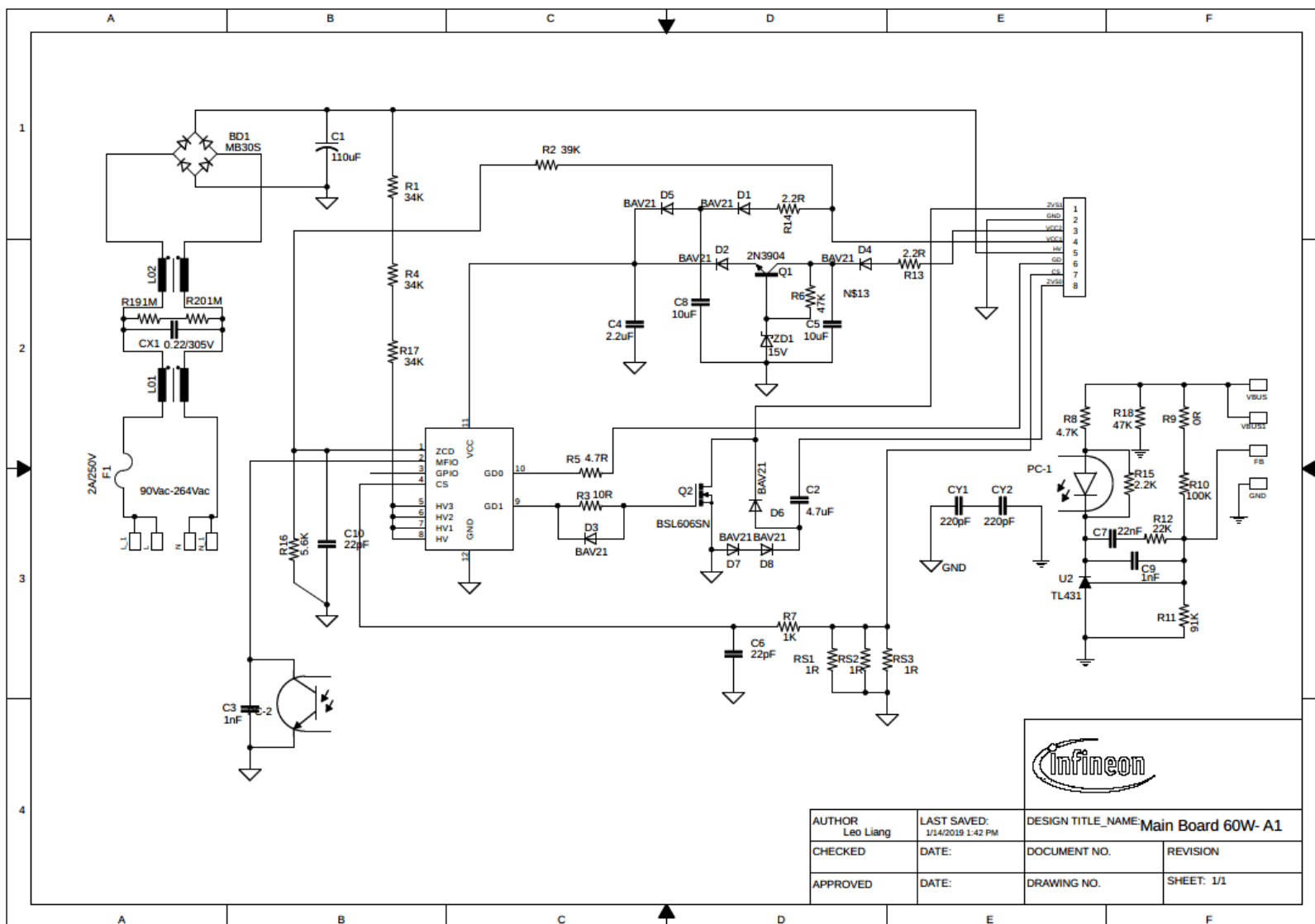
2. Shape and Dimensions (unit:mm)



Equivalent Circuit

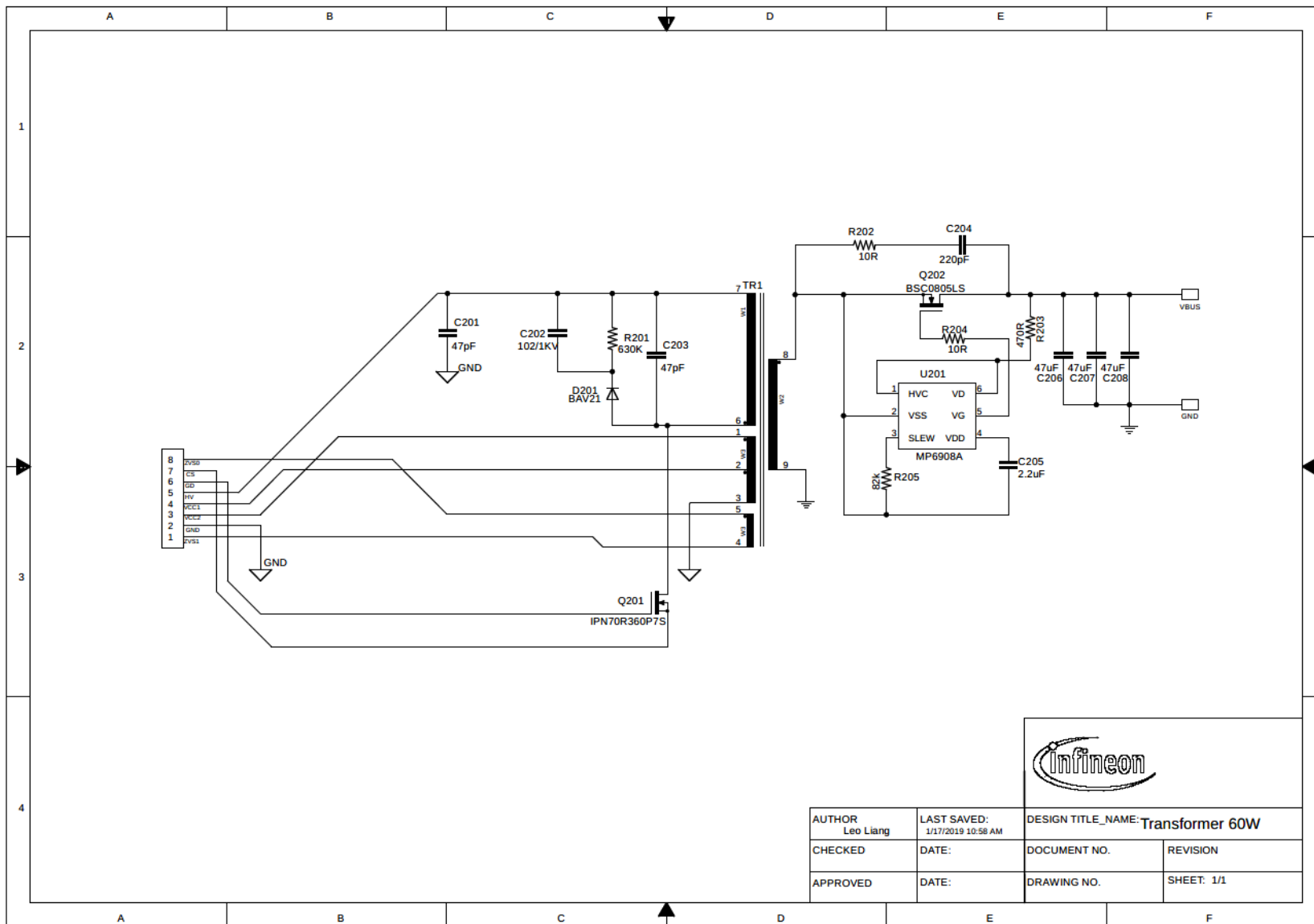


Schematic



AUTHOR Leo Liang	LAST SAVED: 1/14/2019 1:42 PM	DESIGN TITLE_NAME: Main Board 60W-A1	
CHECKED	DATE:	DOCUMENT NO.	REVISION
APPROVED	DATE:	DRAWING NO.	SHEET: 1/1

变压器板原理图



AUTHOR Leo Liang	LAST SAVED: 1/17/2019 10:58 AM	DESIGN TITLE_NAME: Transformer 60W	
CHECKED	DATE:	DOCUMENT NO.	REVISION
APPROVED	DATE:	DRAWING NO.	SHEET: 1/1

可配置的参数列表

Table 9 Configurable Parameters

Parameter Symbol	Parameter Description	Pin	Default	Range	Unit
P_EFF	Converter efficiency	-	0.9	0.8 ~ 1	-
R_CS	Current sense resistor	CS	0.138	-	Ω
k_PDC	Propagation delay compensation factor	-	9472	2300-23000	-
K_PDC_OFFSET	Propagation delay compensation offset	-	0	0-15	-
t_CSLEB	Leading edge blanking time	CS	269	120 ~ 400	nS
t_ZVSdead	Deadtime between Gd0 and Gd1	GD1	221	100 ~ 400	nS
k_ZVSON	On-time factor for Gd1	GD1	4096	0 ~ 9192	-
TJ_OTP		-	117	40 ~ 150	$^{\circ}\text{C}$
t_IPP_LVL1		-	80	0 ~ 400	mS
L_IPP_LVL1		-	70	0-120	W
t_IPP_LVL2		-	45	1 ~ 300	mS
L_IPP_LVL2		-	95	0-120	W
t_PeakPower		-	5	1 ~ 300	mS
EN_IPP_LVL1_LVL2		-	Enabled	Enabled or Disabled	-
EN_PeakPower		-	Enabled	Enabled or Disabled	-
Response_OVP		ZCD	Auto-Restart	Auto-Restart or Latch	-
Vcs_Burst		CS	0.2	0.2 ~ 0.4	V
Freq_Burst		GD0	30	30 ~ 140	kHz
v_Burst_Pause		MFIO	1	0.8 ~ 1.5	V
v_Burst_Exit		MFIO	2.1	1.8 ~ 2.2	V
t_Reentry_Burst		MFIO	1.25	0 ~ 2	mS
t_Quiet_Burst		MFIO	1.25	1.4	mS
Freq_Low_Max	Maximum frequency	GD0	140	25-140	kHz
k_Slope_Divp	Slope drop rate for slope compensation	CS	56	0-100	-

› Page 22 IDP2105_Design guide_1.0_03-Jul-17.pdf

灵活无编程参数配置

- 电脑-接口界面-IC
- 可视化界面
- RAM模拟调试模式
- OTP多次刷写
- 3Pin UART接口 (VCC,Data,GND)

Configuration file: IDP2105_Demo_65W_with_assistant_rev05.csv, Project name: Example, Firmware version: 0xF001

Name	Value	Unit
Hardware Configuration		
P_EFF	90	%
R_CS	0.138	ohm
Control Feature		
k_PDC	9472	
k_PDC_OFFSET	0	
t_CSLEB	269	ns
t_ZVSdead	221	ns
k_ZVson	4096	
Protection		
T_JOTP	117	degreeC
t_IPP_LVL1	80	ms
L_IPP_LVL1	70	W
t_IPP_LVL2	45	ms
L_IPP_LVL2	95	W
t_PeakPower	5	ms
EN_IPP_LVL1_LVL2	Enabled	
EN_PeakPower	Enabled	
Response_OVP	Auto-Restart	
Burst Configuration		
Frequency Law		
Slope Compensation		

Parameter description

Explanatory image



XDPS21061总结

- **功率密度**
 - 提高频率，高低压频率平衡
 - 采用平面变压器
- **效率提高**
 - 强制频率谐振（辅助管）
 - 安静待机低功耗
- **EMI 性能**
 - 高低压频率平衡
 - 采用平面变压器
 - 驱动电流可调
- **全面保护**
 - 自适应输出功率限制
 - 温度管理
 - 保护功能启用，保护动作
- **易于设计**
 - 工作状态容易理解的ZVS
 - 可软件优化
 - 可多次修改参数，无需更改硬件

Agenda

- 1 基于XDP21061快充数字平台的45W演示板介绍
- 2 基于英飞凌第五代准谐振平台的18W演示板介绍
- 3 基于IPD2303A快充数字平台的介绍100W演示板介绍

18W设计规格

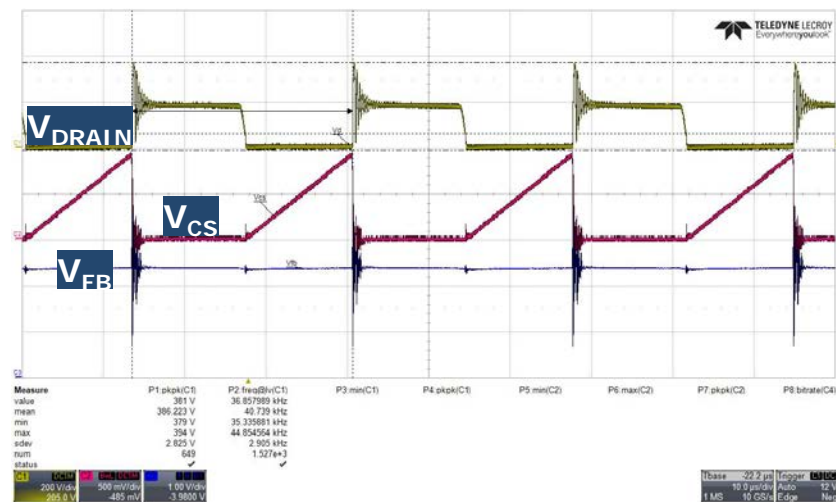
Description	Specification
Input voltage	90Vac~265Vac
Input frequency	50/60Hz
Output voltage	5V 9V
Output current	5V/3A 9V/2A
Output power	18W
No-load Power Consumption Limit (EC CoC Version 5 Tier 2)	<50mW
Minimum Four Point Average Efficiency in Active mode (25%, 50%, 75% & 100%) (EC CoC Version 5 Tier 2)	Meet EC CoC version 5 Tier 2
Minimum Efficiency in Active mode at 10% (EC CoC Version 5 Tier 2)	
Form factor case size (L x W x H)	(42*37*18) mm ³

英飞凌关键器件

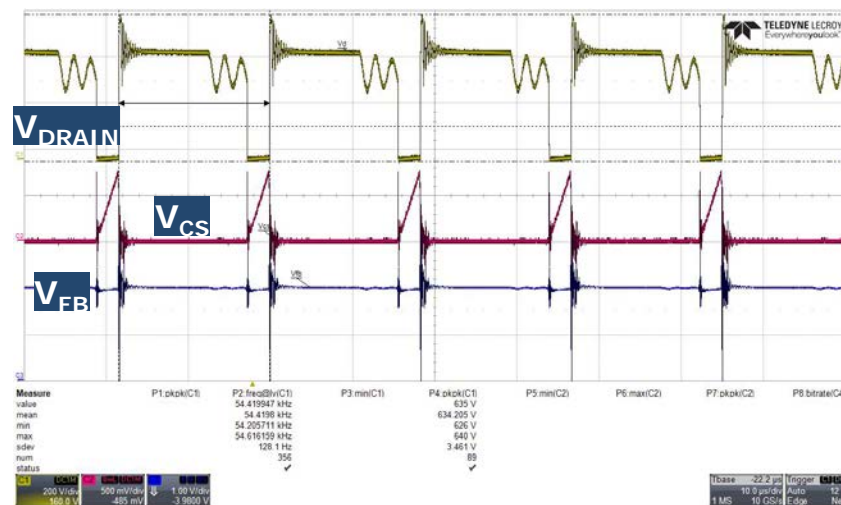
Functionality	Part name	Number of pcs
Primary PWM controller	ICE5QSAG	1
Primary HV MOSFET	IPN70R1K4P7S	1
Secondary Synchronous Rectifier MOSFET	BSZ0704LS	1
SR IC	IR1161	1

谷底检测

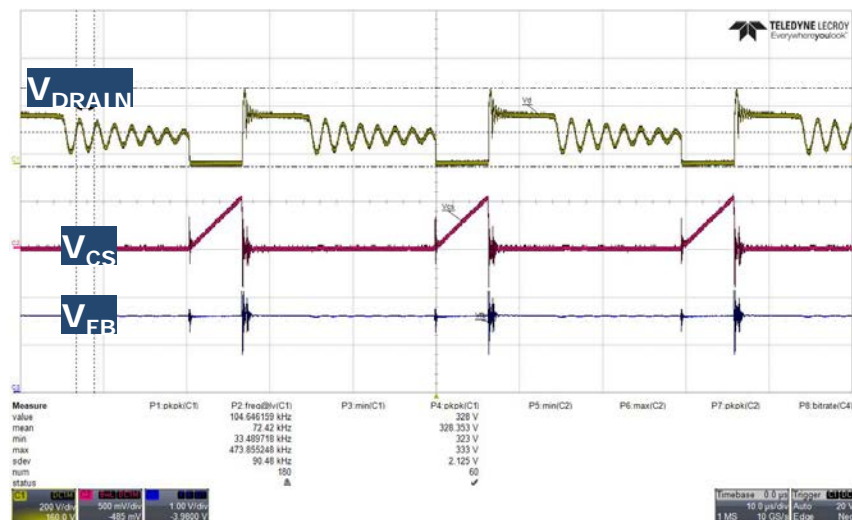
Vin=85Vac / Full-load / ZC=1



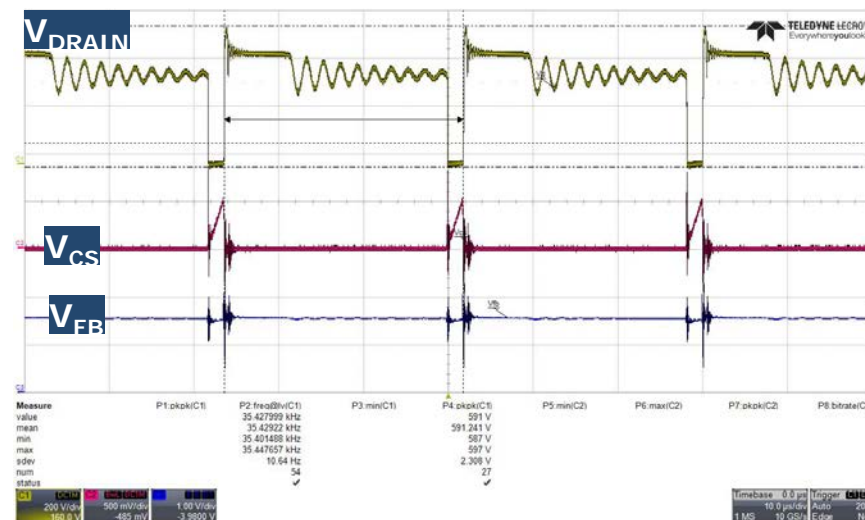
Vin=300Vac / Full-load / ZC=3



Vin=85Vac / 20% Load / ZC=8

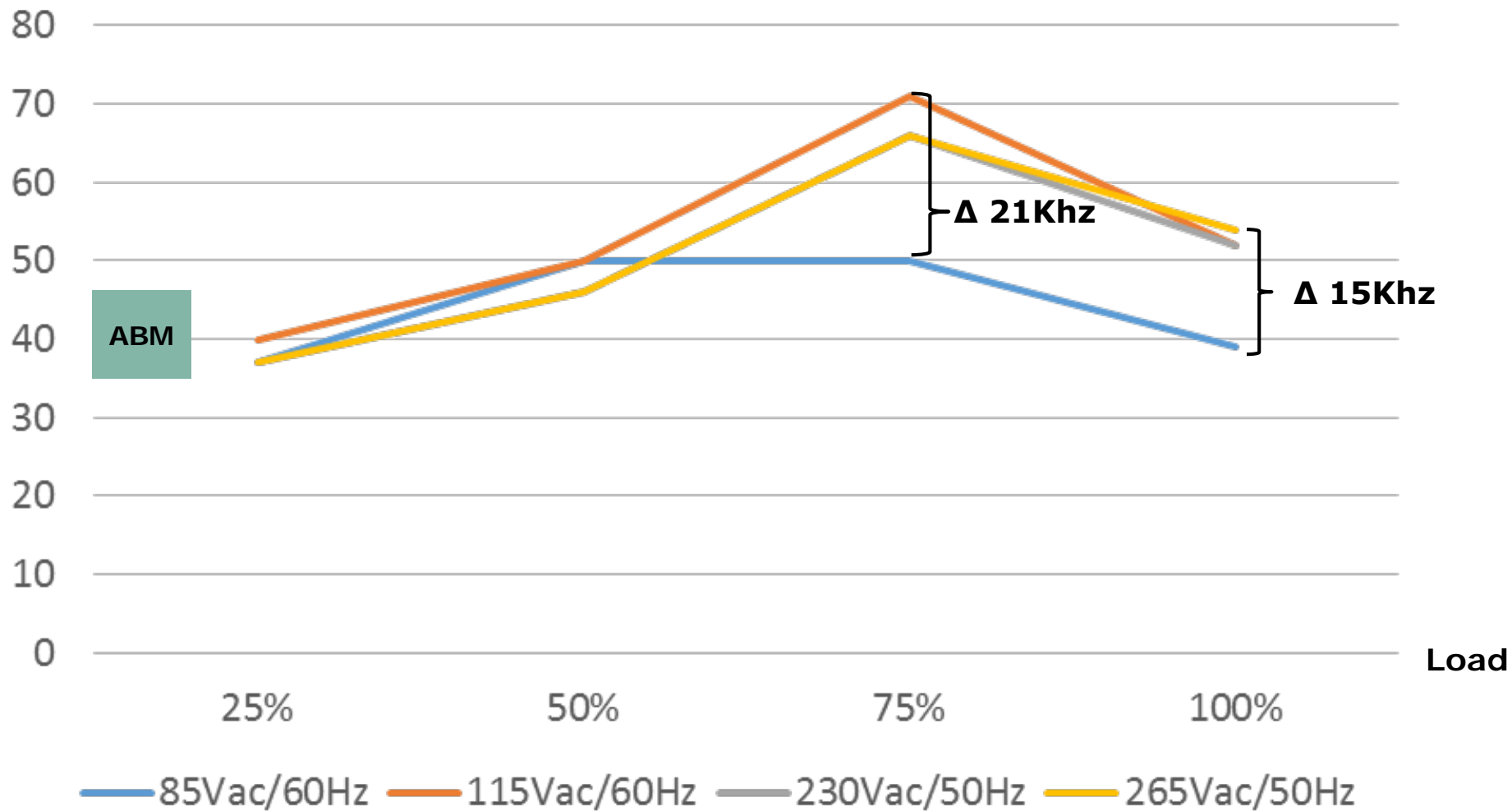


Vin=300Vac / 20% Load / ZC=10

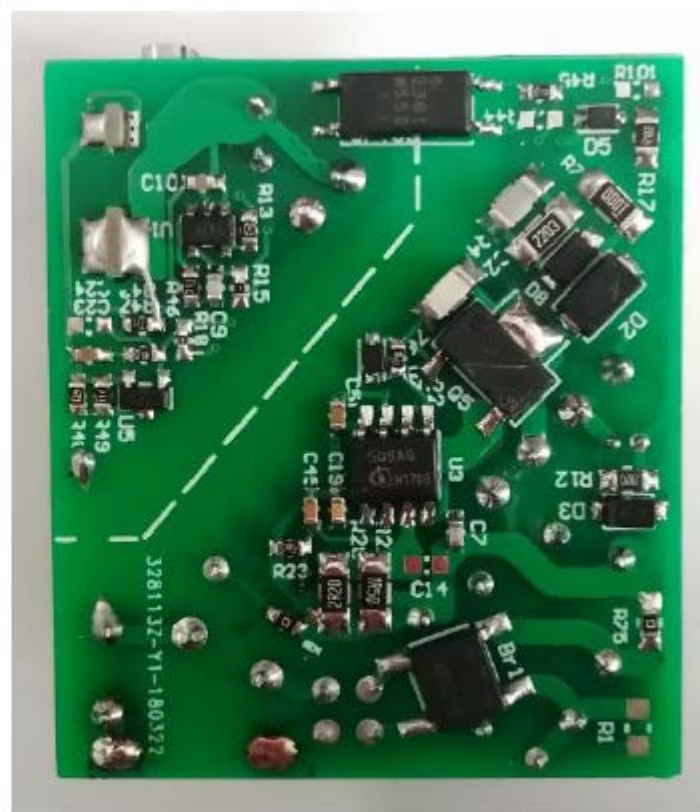


开关频率

Fsw (Khz)

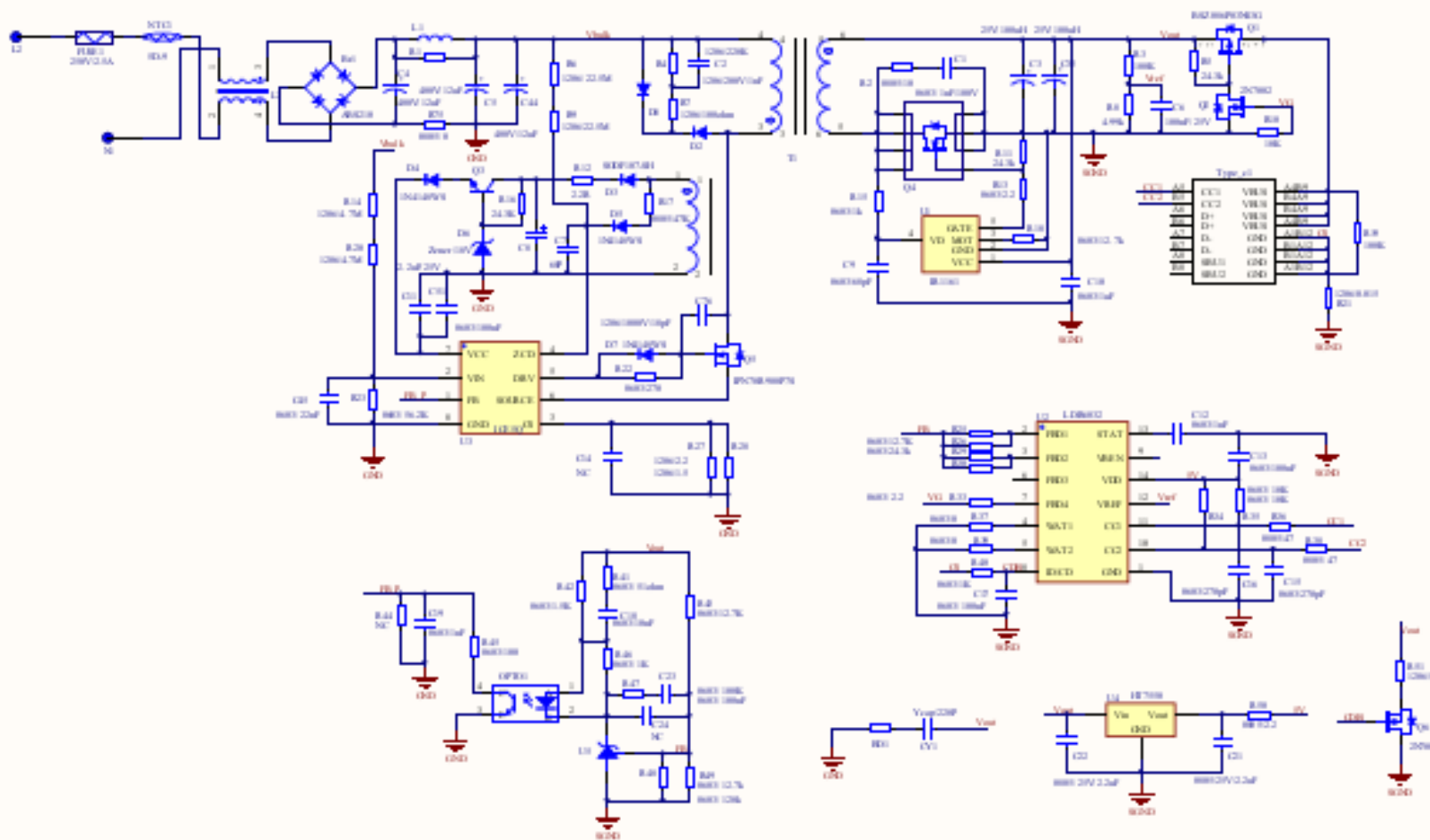


18W USB PD solution



PCB 板尺寸 42mm*37mm

原理图



Agenda

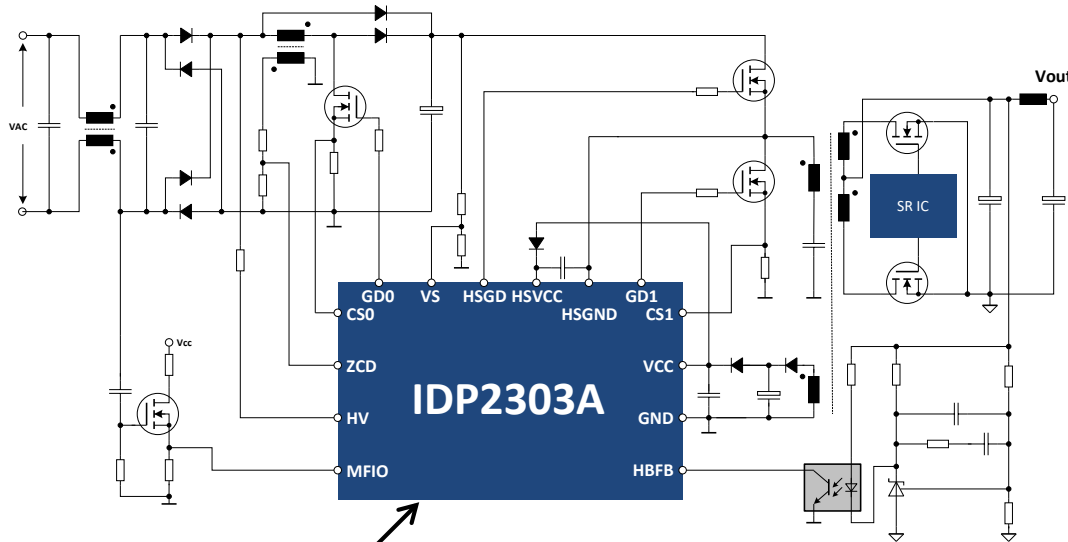
- 1 基于XDP21061快充数字平台的45W演示板介绍
- 2 基于英飞凌第五代准谐振平台的18W演示板介绍
- 3 基于IPD2303A快充数字平台的介绍100W演示板介绍

IDP2303A for **non-AUX** adapter

Digital Multi-Mode PFC + LLC Combo IC



Non-AUX adapter

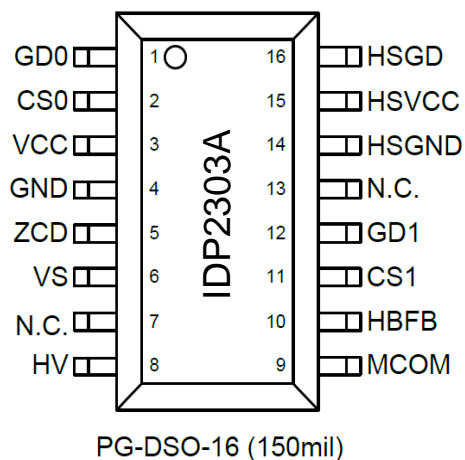


Eliminating the auxiliary power supply

Product Highlights

- › Digital CrCM PFC+LLC combo IC with integrated drivers and 600V depletion cell designed for minimum system cost
- › Robust floating driver based on coreless transformer technology
- › **Less external BOM** count to **enable small form factor** design
- › Supports Non-Aux operation with lowest standby performance by means of advanced Burst Mode and active X-cap discharge function
 - › Operation **w/o PS-On signal**
- › Configurable multi-mode PFC for optimized efficiency curve
- › Configurable and comprehensive protections for PFC/LLC/IC temp
- › Selectable protection mode: Auto-restart or latch mode

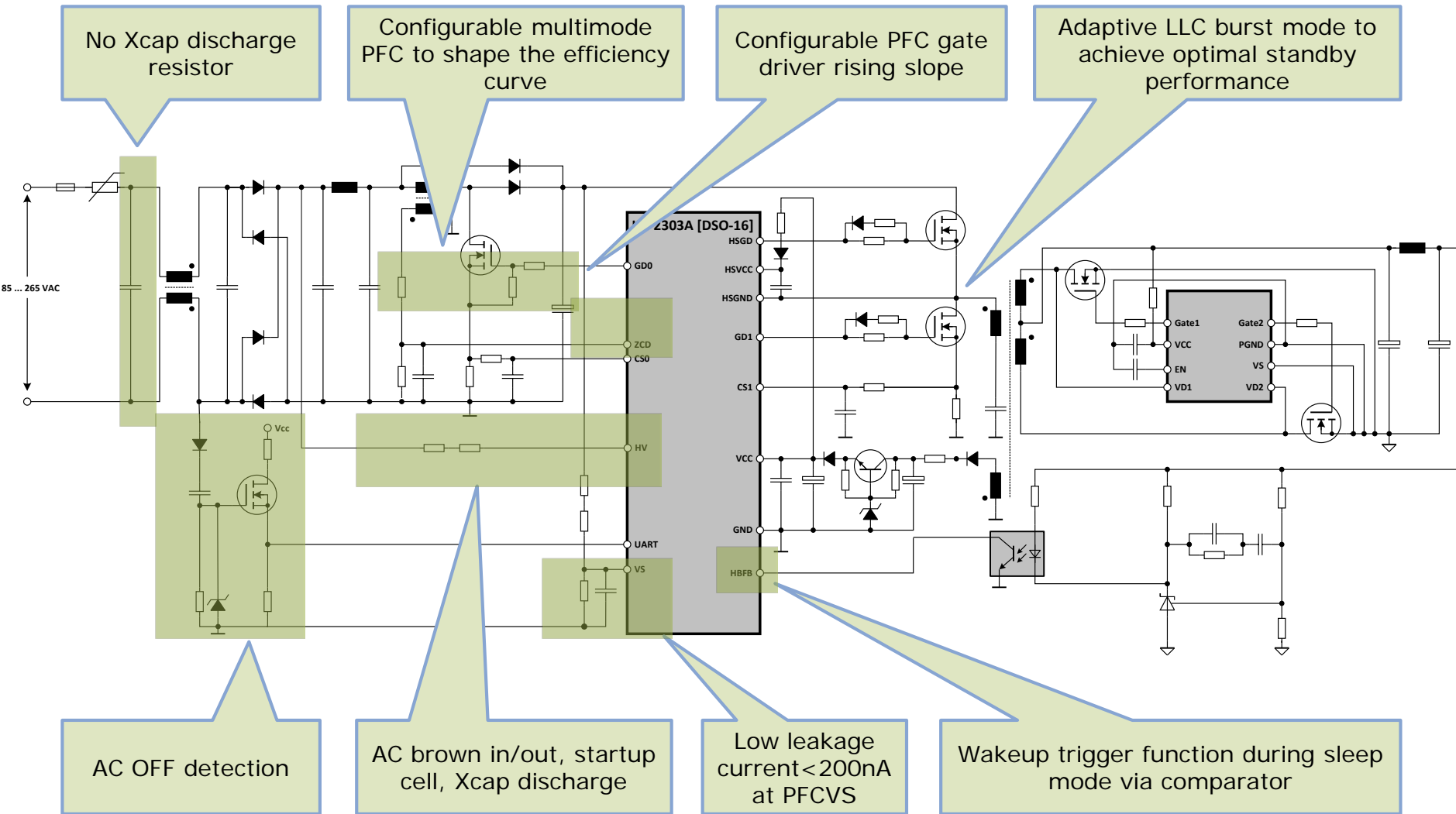
IDP2303A Package & Pin Layout



DSO-16

Pin	Symbol	Function
1	GD0	PFC gate driver
2	CS0	PFC current sense
3	VCC	Positive voltage supply
4	GND	IC low-side chip ground
5	ZCD	PFC zero crossing detection
6	VS	PFC voltage sensing
7	N.C.	Not connected for creepage distance
8	HV	High voltage input
9	MFIO	Multi-function and UART communication
10	HBFB	Half bridge feedback
11	CS1	Half bridge low-side current sense
12	GD1	Half bridge low-side gate driver
13	N.C.	Not connected for creepage distance
14	HSGND	High-side ground
15	HSVCC	High-side VCC
16	HSGD	High-side floating gate driver

IDP2303A in non-AUX adapter typical application and key features



100W IDP2303A Demo Board for Adapter

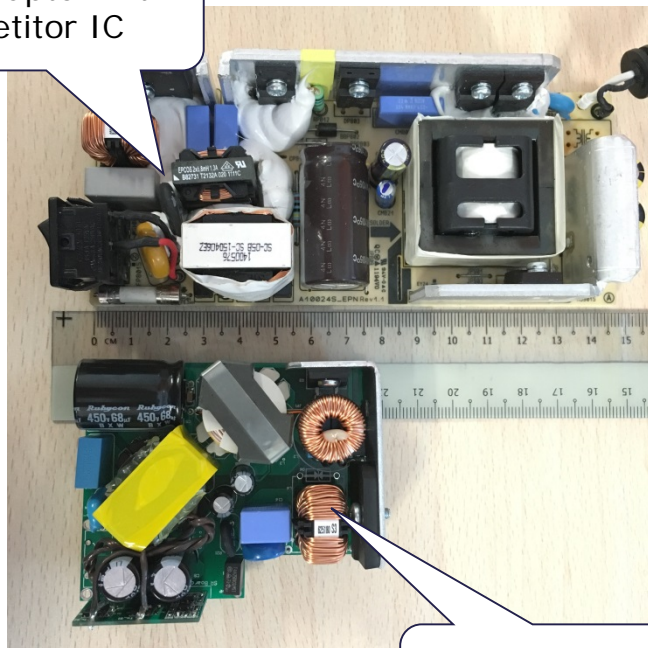
Specification:

- › Input: 90 ~ 264Vac
- › Output: 19V, 5.27A_max
- › Standby: 270mW @152mW load

Highlights:

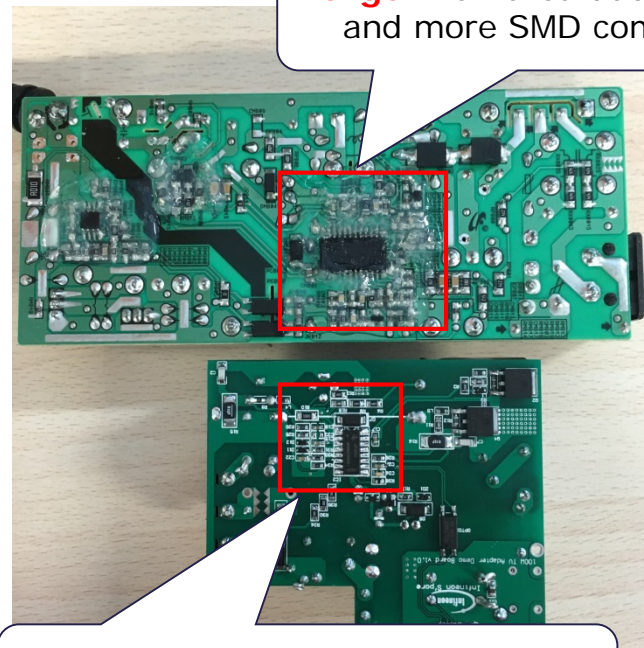
- › Simple application design
- › Low standby power
- › Low output ripple of 1%
- › Power density: 10W/inch³

100W Adapter with competitor IC



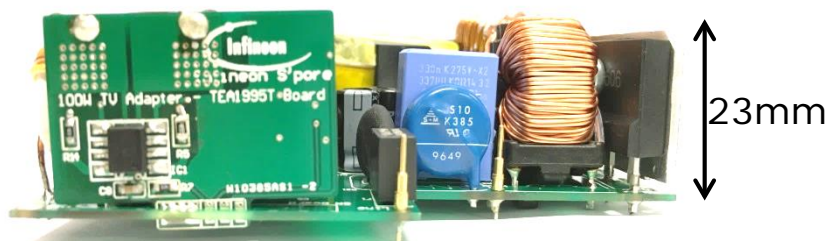
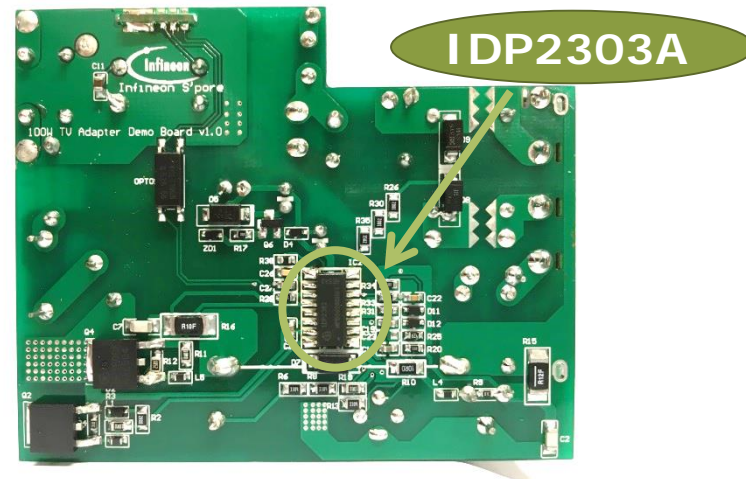
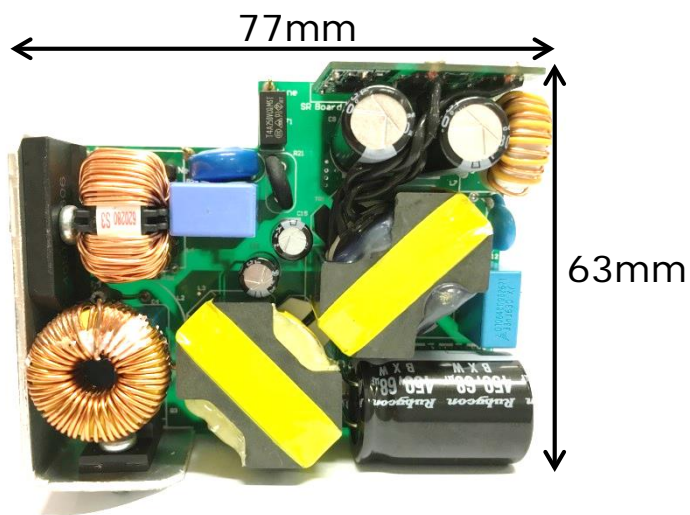
100W Adapter with **IDP2303A**

Larger PCB area due to DSO-20 and more SMD components



Smaller PCB area thanks to small DSO-16 & fewer SMD components

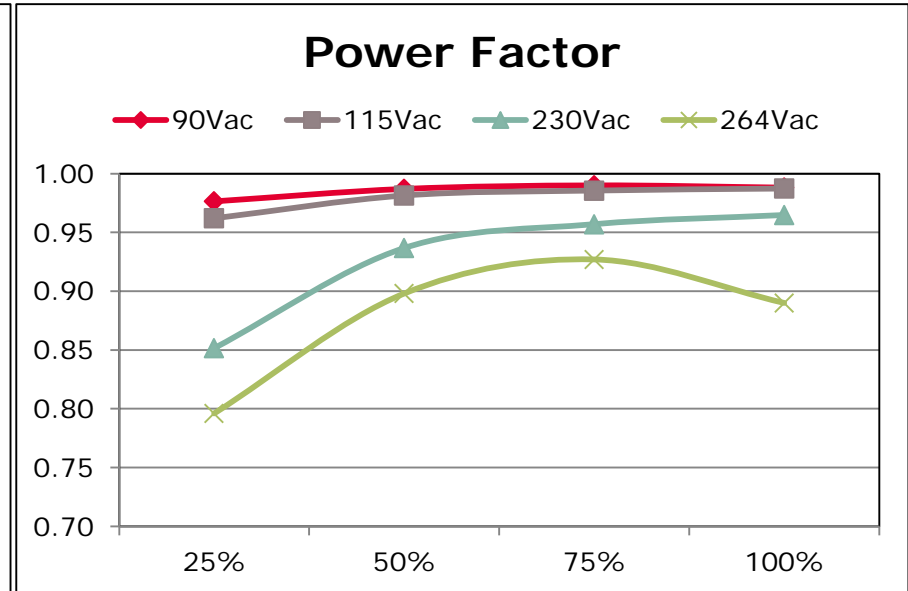
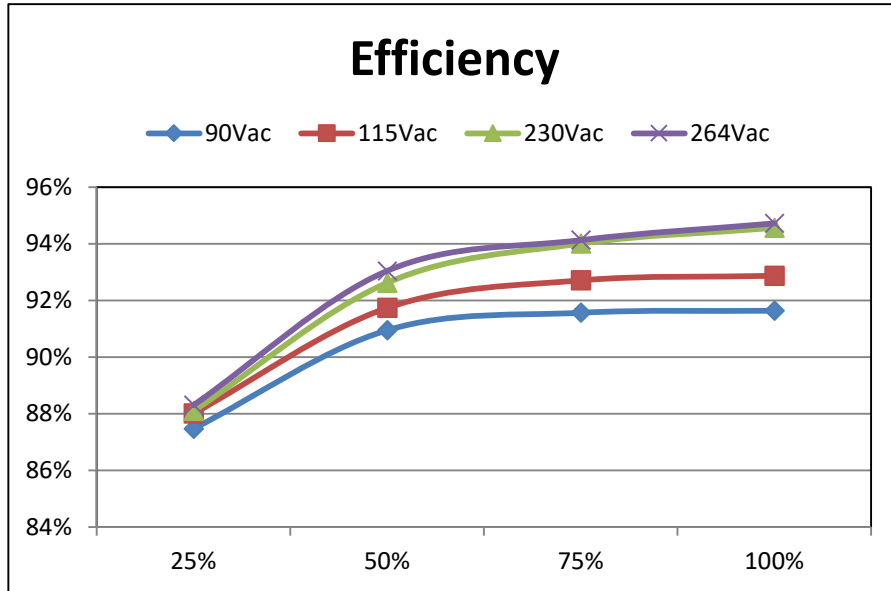
100W IDP2303A Demo Board for Adapter



Inductor Dimensioning

- › PFC
 - L_m : 270uH,
Core size: RM10; Turn ratio: 66:7
- › LLC
 - Resonant Tank : L_{m_450uH} / L_{r_50uH}
@ 100kHz, 1Vrms, C_r_{33nF}
 - Core size: RM10; Turn ratio: 32:3:3:3

100W IDP2303A Demo Board for Adapter Efficiency, PF and standby power consumption



Standby Power Consumption

Burst start/Nor/stop frequency	130/90/130khz
Standby spec (230Vac, 19V/8mA)	< 270mW
Measurement at 230Vac	264mW
Measurement at 110Vac	251mW
Standby spec (230Vac, 19V/0mA)	< 170mW
Measurement at 230Vac	86mW
Measurement at 110Vac	70mW

100W 测试结果

System specification	Test results
Efficiency > 88.3%	Pass: > 90.4%
Power density > 8W/inch ³	Pass: 10W/inch ³
Start up time	Pass: < 670ms
Standby power consumption	Pass: <270mW @ Po=152mW 70mW @ Po=0mW (110Vac)
Over voltage protection (<33V)	Pass: trigger at 25V
Output ripple / noise < 190mV	Pass: 86mV @ no load
EMI conduction margin > 6dBm	3dBm margin
Hold up time > 16ms	Pass: 16ms
Dynamic load response < 1V	Pass: 0.64V



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