概述

UCS165XS 是一款最新的 PWM IC，利用混合操作模式（PWM/PFM/Burst）达到高效率，满足六级能效标准。其具有高压启动功能，方便客户满足待机效率的六级能效设计。超低启动电流（<5uA），超低静态电流（0.8mA）。具备欠压保护（UVP）、过压保护（OVP），VCC 嵌位、过载保护（OLP）过温度保护（OTP）、过电流保护（OCP）。

性能特点

- 高压启动技术
- 内置功率管
- 极低启动电流（<5uA）
- 混合操作模式
  - 重载低输入电压 CCM 中 PWM 工作
  - 中载 DCM 中 PWM 工作
  - 轻载 DCM 中 PFM 工作
  - 待机 Burst Mode 工作
- 中重载开关频率 65kHz
- 具有 5mS 软启动
- 动态过电流保护 OCP
- VCC 欠电压保护（8V OVP）
- VCC 过电压保护（26V OVP）
- VCC 嵌位（32V/10mA）
- 过载保护（OLP/ 88mS Blanking）
- IC 内部过温度保护（150℃ OTP）
- 自主 IP 抖频技术抑制 EMI
- 自主 IP 软驱动技术抑制 EMI

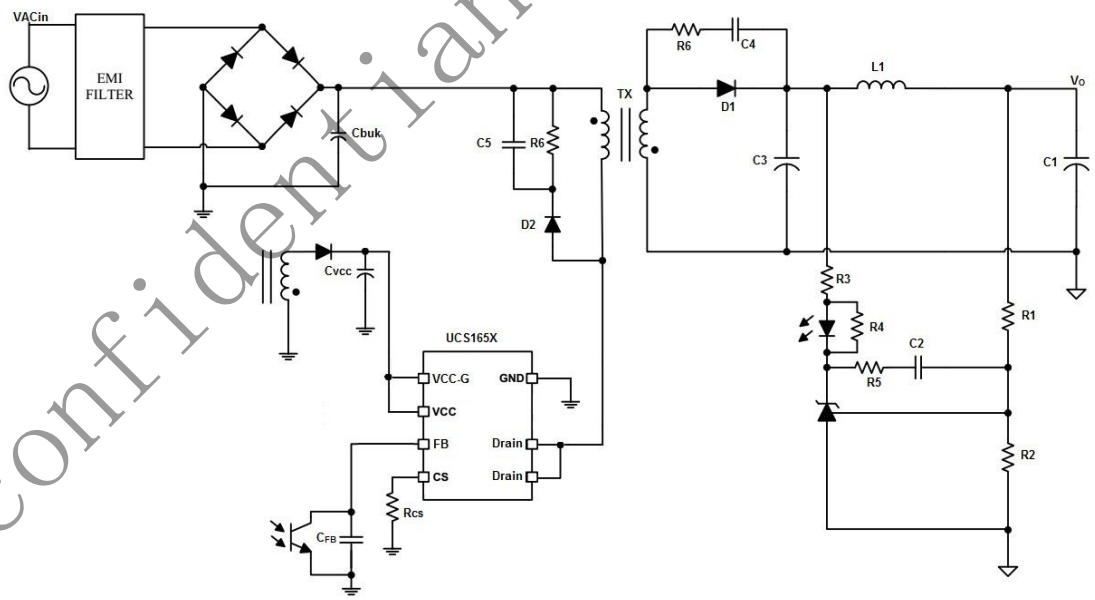


图 1 典型应用图

UCS165XS 内部功能方框图

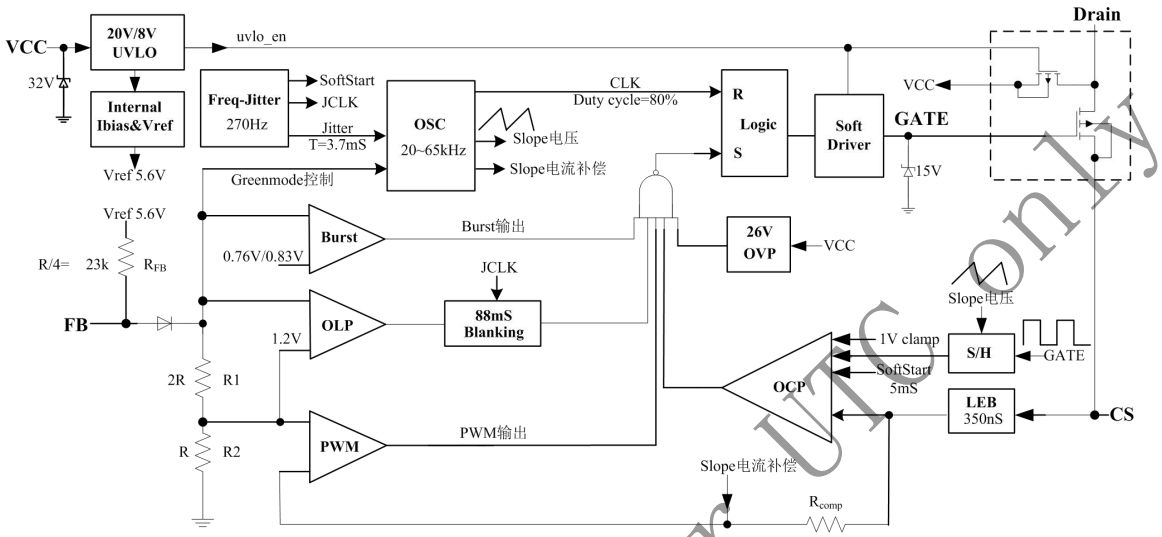


图 2 内部功能框图

目录

UCS165XS 系列内部功能说明

■ **VCC 脚位**

1、启动电路和欠压停止工作

UCS165XS 有非常低的启动电流（<5uA）和较低的起始电压，并且内含高压启动开关，与常规 PWM IC 相比，可最大限度地减少外部电路之启动功耗损失，同时又能保障启动速度最快，对 VCC 脚位电容值的上限限制极低。由内部高压启动开关通过功率管 Drain 提供起始电流对 VCC 电容充电，当 VCC 电压达到工作点（VCCon）20V 时，IC 开始工作，再由变压器辅助绕组线路对 VCC 电容进行充电。如果 VCC 电压低于欠压工作点 8V，就会关闭输出电路减少工作电流。欠压工作点起到迟滞作用，可让启动电容器有充分的能量供应 IC。

启动电容建议选用电解电容（供电）和 SMD 陶瓷电容（高频滤波）并联配套使用，启动电容可选 2.2~10uF 的电容，SMD 陶瓷选用 100nF。欠压锁定迟滞曲线如图 3 所示。

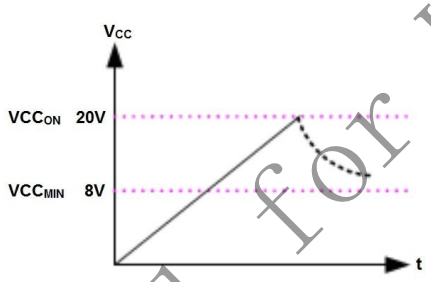


图 3 UVLO 曲线

2、过电压保护（OVP）

为保护功率 MOSFET 不受损坏，IC 在 VCC 脚位增加过电压保护功能。当 VCC 电压高于 26V 时，gate 信号立即停止 ON/OFF，功率管关闭，动作如图 4 所示。VCC 过压保护功能是自动恢复重启的保护。一旦 OVP 发生，功率管关闭，如果过电压解除，系统将在下一次上电后恢复正常工作。

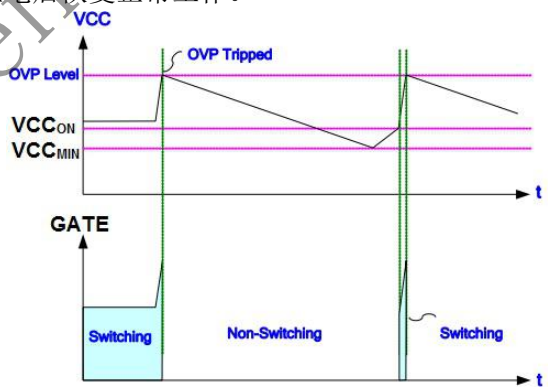


图 4 OVP 曲线

3、VCC 电容值与待机功耗关系说明

待机时辅助线圈对 VCC 电容充电电流较小，IC 静态功耗没有太大变化，因此导致待机进入 burst mode 后，VCC 电容电压会在 OFF time 中容易触碰 VCC_{MIN}，发生 VCC 自动重启误动作。为了避免上述误动作发生，推荐 VCC 电容尽量不要采用过低值，VCC 电容值越大，待机功耗越低。客户不必担心 VCC 电容偏高导致系统启动时间过长问题，因为 IC 本身含有高压启动开关，具有大电流恒流充电特性。

4、VCC 脚位增加一高频滤波电容

建议 VCC 脚位旁边并联一个高频滤波电容（例如 100nF MLCC），增加 IC 工作稳定性，避免高频干扰。

5、高压启动开关控制

VCC 电容的启动，传统开关电源控制器都是外接启动电阻对 IC 的 VCC 脚位电容充电启动，UCS165XS 系列责使用内含高压启动开关从功率管 drain 脚位抽取线输入电流进行恒流启动，启动恒定电流约为 600uA，其优点是无论线输入电压高低，充电电流恒定，避免了传统开关电源系统外接电阻启动在低输入线电压条件下的启动电流极低的尴尬，因此 UCS165XS 系列启动速度极快，对高值电容限制低。

■ VCC-G 脚位

UCS165XS 有一个 VCC-G 脚位，其为 driver 驱动上管的 drain，通过在 VCC-G 与 VCC 脚位之间串接电阻 R_G，可以调节降低 driver 上驱动能力，RGD 推荐范围：51~1000。只有极特殊的设计会使用到此功能，因此，通常情况下 VCC-G 与 VCC 是短接的。

■ CS 脚位

1、电流检测比较器

UCS165XS 的 CS 脚位是用来检测流过变压器初级侧也就是 MOSFET 源极的电流，当输出发生过电流的情况时，CS 脚位检测 Sense 电阻 Rcs 的电压达到设定值，会立即关闭功率管，对电路进行保护，若是输出短路或者开关机时，检测到 GATE 脉宽大于 7.7uS，CS 检测电压达到 1V 时，会关闭功率管，若 GATE 脉宽小于 7.7uS 时，CS 检测电压阈值自动按照 GATE 脉宽等比例修正缩小，零 GATE 脉宽对应的 CS 检测电压阈值为 0.72V，避免高压输入输出短路时功率管源漏压差 Vds 过高。

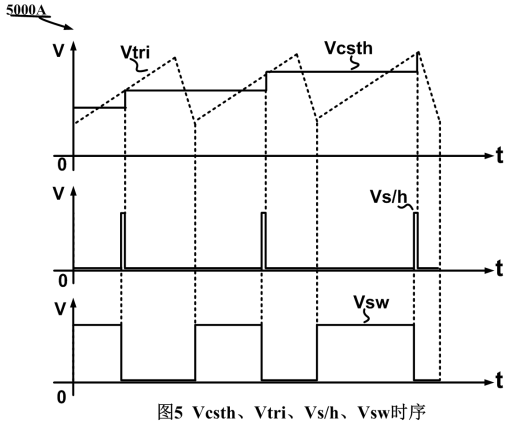


图5 Vcsth、Vtri、Vs/h、Vsw时序

OCP 点线电压补偿方式，采用 CS 阈值跟随占空比正比例增长方式实现；（此控制已申请为专利）：

Vth_ocp=Vcsth 为 OCP 阈值，

Vs/h 为采样保持窗口控制信号，

Vtri 为 OSC 的电压三角波，

Vsw 为驱动 GATE 输出。

输入线电压越高 duty 越小，Vcsth 越小，功率越低，从而达到 OCP 点高低压的一致性；0.72V（Duty=0%）≦Vcsth≦1V（voltage clamped，Duty≧50%）；

最大极限负載時，Vth_ocp 限制 Vcs，工作频率为最大频率 65kHz；

重载及中等載时，FB 電壓限制 Vcs，工作模式为 PWM 模式，工作频率为最大频率 65kHz；

輕載時，FB 電壓限制 Vcs，工作模式为 PFM 模式，工作频率随 VFB 降低而降低，最低频率为 20~30kHz；

待机时，FB 電壓限制 Vcs，工作模式为 burst 模式，工作频率为最小频率 20~30kHz。如下圖：

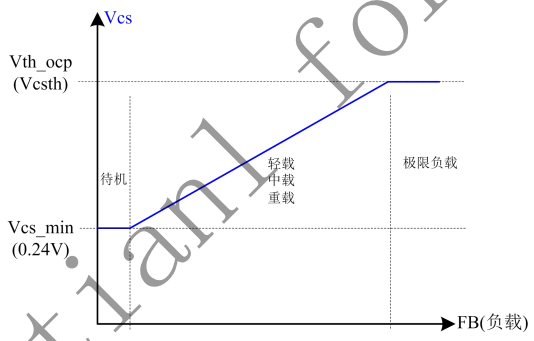


圖 6 CS 峰值電流與負載關係

SENSE 与 FB 脚位电压关系：Vcs=（VFB-0.62V）/3；

此處最小 CS 值 0.24V 是：Vcs_min=0.24V=（VFB_IN-0.62V）/3=（1.35-0.62V）/3;

2、前沿消隐屏蔽（Leading-Edge Blanking）避免误触发

功率管导通瞬间，会有一个不可避免的导通尖波发生在检测电阻上，其会导致功率管误关闭。UCS165XS 内建了 350nS 屏蔽时间可以避开此导通尖波。

3、峰值电流与原边电感、输出输入功率关系

如圖 2 所示，CS 峰值電流被 FB 電壓調製。當負載由重變輕時，CS 峰值電流也從 Max 值逐漸減小。

選擇滿載開關頻率為 Fsw。(65KHz)

由輸入功率公式計算初級電感量：

$$L_m = \frac{(V_{DC}^{\min} \cdot D_{\max})^2}{2P_{in} f_s K_{RF}} \quad (1)$$

$$I_{ds}^{peak} = I_{EDC} + \frac{\Delta I}{2} \quad (2)$$

$$I_{EDC} = \frac{P_{in}}{V_{DC}^{\min} \cdot D_{\max}}$$

$$\Delta I = \frac{V_{DC}^{\min} D_{\max}}{L_m f_s} \quad (3)$$

上式應有一個平方。

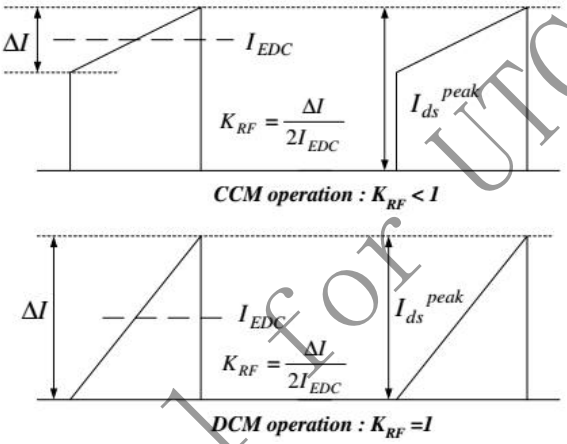


圖 7 CCM 和 DCM 工作中 CS 峰值電流與 K_{RF} 關係

K_{RF} 为原边电流纹波系数，DCM 中 K_{RF}=1，CCM 中通常 K_{RF}=0.3~0.5，这里取 D=0.5，

Po 可由系統的輸出電壓，輸出電流計算。Dmax 為初級側的最大占空比（取 0.5），VDCmin 為整流後的最低直流電壓。

推薦最大 Dmax≤50%，VDC_min=120V，效率值η和 Pin_max 为预先设定值，則可以計算出初級電感。之後可得到峰值電流 Ipk。

系統工作於 DCM 模式的系統：

Lp=（120*0.5）*（120*0.5）/（2*Pin*65）=27.69/Pin（mH）

对于工作于 CCM 模式的系统：

Lp=（120*0.5）*（120*0.5）/（2*Pin*65*0.5）=55.38/Pin（mH）

$$Pin = \frac{1}{2} * Lp * Fsw * Ipk^2$$

之后可以得到 Ipk

根据初级输入最低电压 Vin=120V 和次级输出电压 Vo+Vbe 的比值計算得到 Nps。

$$n = \frac{N_p}{N_{s1}} = \frac{V_{RO}}{V_{o1} + V_{F1}}$$

$$V_{RO}=\frac{D_{max}}{1-D_{max}}\cdot V_{DC}^{min}$$

$V_{RO}=V_{DCmin}=120V$，n=120/（Vo1+0.7V），Vo1 为次级整流后输出电压；

$$V_{ds}^{nom}=\sqrt{2}V_{line}^{max}+V_{RO}$$

根据上公式得功率 MOS 管的最低漏极耐压要求，Vds_min=373.3V+120/（Vo1+0.7V）

■ FB 脚位

1、FB 脚电容的设定

FB 為光耦输出端，在 IC 内部接上拉电阻 R_{FB}=23kohm 到内部电源 5.6V。由于 FB 为补偿脚位，因此建议补偿电容采用 X7R 系列，以便抑制容值温漂产生的影响问题。FB 脚位补偿电容有利于环路稳定。**I_{FB_Short}=240uA(传统 IC 中 I_{FB_Short} 为 1mA，C_{FB}=2.2~10nF)**

	最小	最大	单位
FB 接地电容 C_{FB}	0.47	2.2	nF

2、混合模式控制

UCS165XS 系列为混合模式控制器，IC 的开关频率及运行模式取决于 FB 脚位电压。V_{FB} 其值反映負載的大小，負載越重，其值越大。下图为 FB 脚位电压、负载、开关频率的关系。

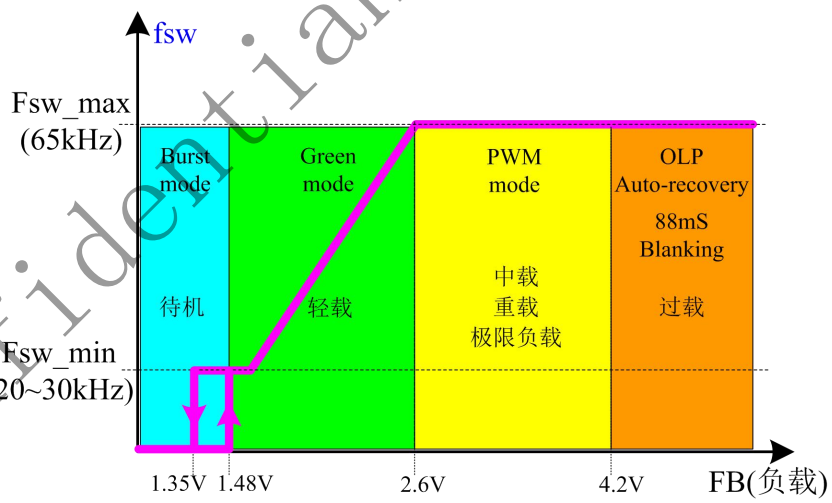


圖 8 FB 脚位电压與負載、开关频率關係

- ❖ 起始階段：IC 上电完毕后後，Vout=0，CS 為 0， 起始頻率 65kHz，PWM 开始工作， CS 由 Softstart 啟動，FB 为开路电压 5.2V。
- ❖ Vout 上升階段：晶片經過 Softstart 期間，CS 峰值电压和 GATE 占空比由 Softstart 电压

限制。软启动 Phase 结束后，若 Vout 未达到输出设定值 Vo，则 IC 以最大占空比继续上电直至上电完毕，V_{FB} 降低进入正常环路调节电压范围 1.35~4.2V；软启动 Phase 期间，若 Vout 达到输出设定值 Vo，则 V_{FB} 降低进入正常环路调节电压范围 1.35~4.2V，环路 PWM 由 V_{FB} 控制直至上电完毕，；

- ❖ 重載和中载：FB 调整芯片工作在 PWM mode 里，FB 值調整 CS 值。
- ❖ 輕載：FB 调整芯片工作在 Green mode 里，并調整 Tsw 和 CS 值。
- ❖ 待机：FB 调整芯片工作在 Burst mode 里，并控制 CS 值。并以最小频率工作。

以上為整個晶片的工作過程。

3、开路保护

UCS165XS 系列有开路保护功能，内部电路可以检测 FB 脚位电压，当 FB 脚位电压高于开路保护电压阈值 4.2V 并持续设定的时间后，关断驱动管停止系统动作，直到 VCC 下电后再重新启动才能恢复动作，请见图 8 所示。

■ Drain 脚位

Drain 脚位为内部功率管和高压启动开关管的漏极。

在 IC 的 VCC 脚位上电过程中，内部高压启动开关管通过 Drain 脚位对 VCC 脚位电容充电，VCC 上电到 VCCon 后，内部高压启动开关关闭，停止对 VCC 脚位电容充电，启动过程结束。IC 内部所有功能块开始工作，之后的时间里 Drain 脚位仅受内部功率管控制。

■ 保护功能说明

保护功能	触发条件	延时时间	保护模式
OLP	V_{FB}>4.2V	IC 启动后 88mS IC 启动时 93mS	Auto-recovery
VCC OVP	V_{CC}>26V	8~24uS	Auto-recovery
OTP	t >150℃	8~24uS	Auto-recovery

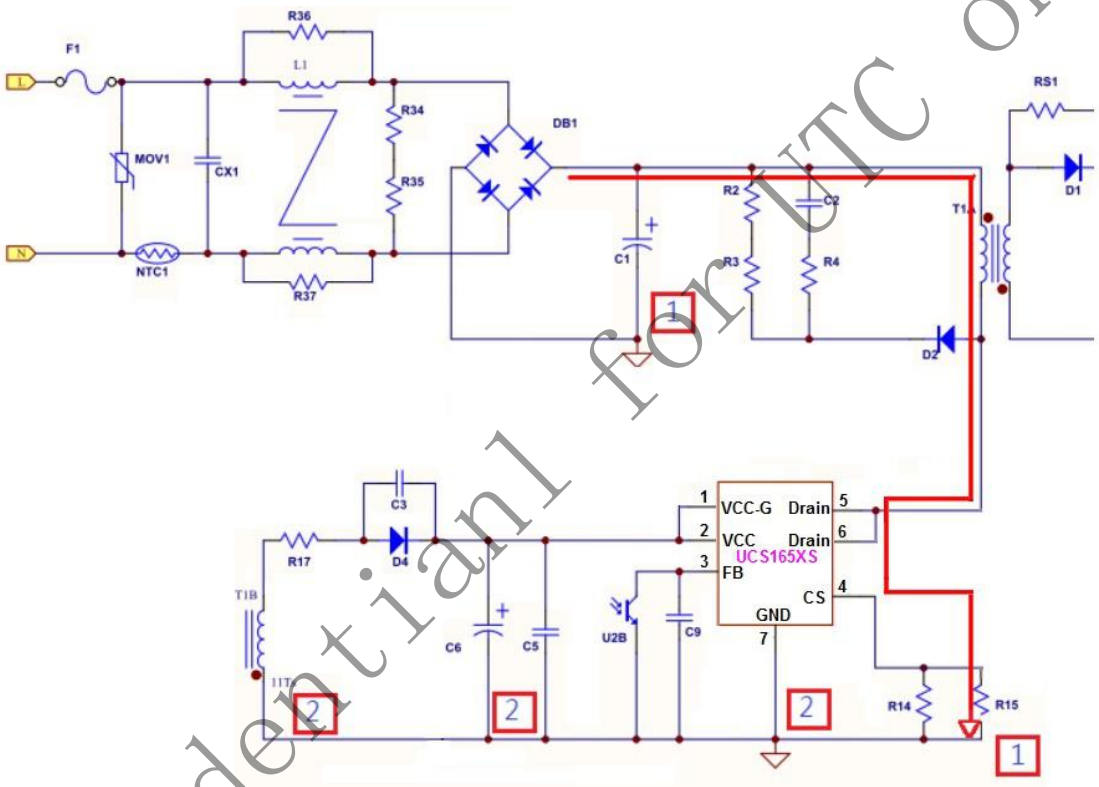
■ **电路板线路布局注意事项**

1、电路初级侧主回路由 C1 正端→变压器→MOSFET→R14、R15→C1 地端，此为电路中最大开关干扰源，此回路元器件尽量靠近以缩短路径线长及回路面积，并远离小信号回路以及 UCS165XS 本体，且接地 1 之间的连接线路需要保持最短并且最宽原则。

2、C5、C6 应靠近 UCS165XS GND 脚位以及 VCC 脚位，且接地 2 各点需要靠近 UCS165XS GND 脚位。

3、接地 2 经由 C1 接地 1 连接。

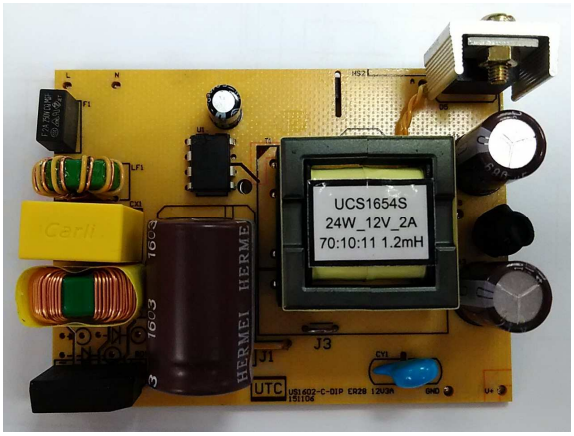
4、IC 周边元器件尽量靠近 UCS165XS 本体。



UNISONIC TECHNOLOGIES CO., LTD

24W Module Using UCS1654SG

UCS1654SG 24W / 12V_ 2A Demo Board Manual



Key features:

●AC Input Full Range 90Vac~264Vac

●DC Output 12Vdc / 2A

●Average Efficiency
>86.2% (meet level 6)

●No load Power
<100mW@230Vac (meet level 6)

●OCP/OVP/OLP/SCP Protection

Revision History

Revise Date	Version	Reason/Issue	Remark
2018/3/20	B		S6003 P025 UGRA 01

Contents Index

1. Module Specification

1.1. Input Characteristics

● AC input voltage range	90Vac ~ 264Vac
● AC input voltage rating	100Vac ~ 240Vac
● AC input frequency range	47Hz ~ 63Hz
● Input current	620mA (rms)max. @ 90Vac/60Hz

1.2. Output Characteristics

● Output Voltage	12V
● Output Tolerance	< ±5%
● Min. load current	0A
● Max. load current	2A

1.3. Performance Specifications

● Maximum Output Power	24W
● Standby Power	<100mW@230Vac (meet level 6)
● Average Efficiency	>86.2% (meet level 6)
● Line Regulation	<0.15%
● Ripple & Noise	< 120mV

1.4. Protection Function

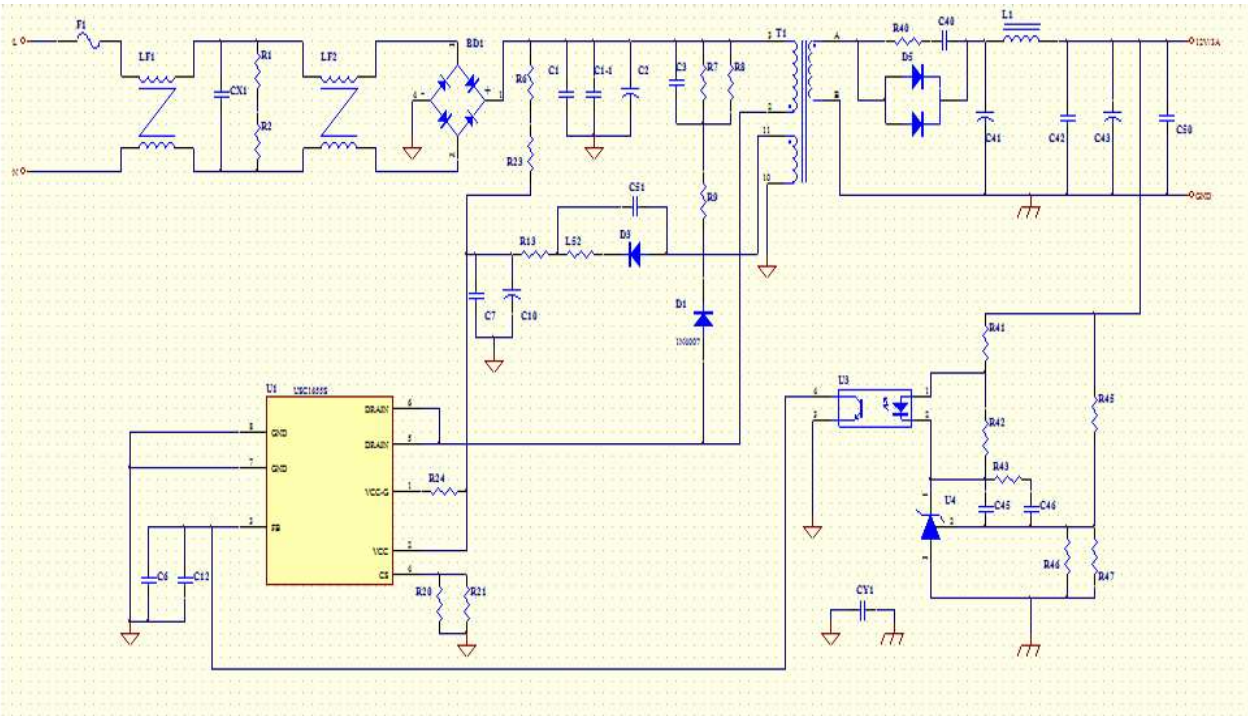
● Short Circuit Protection	Shut down and auto recovery
● Over Voltage Protection	Shut down and auto recovery
● Over Load Protection	Shut down and auto recovery

1.5. Environment

● Operation Temperature	0℃ to 40 ℃
● Operation Humidity	20% to 90% R.H
● Storage Temperature	-40℃ to 60 ℃
● Storage Humidity	0% to 90% R.H

2. Module Information

2.1. Schematic

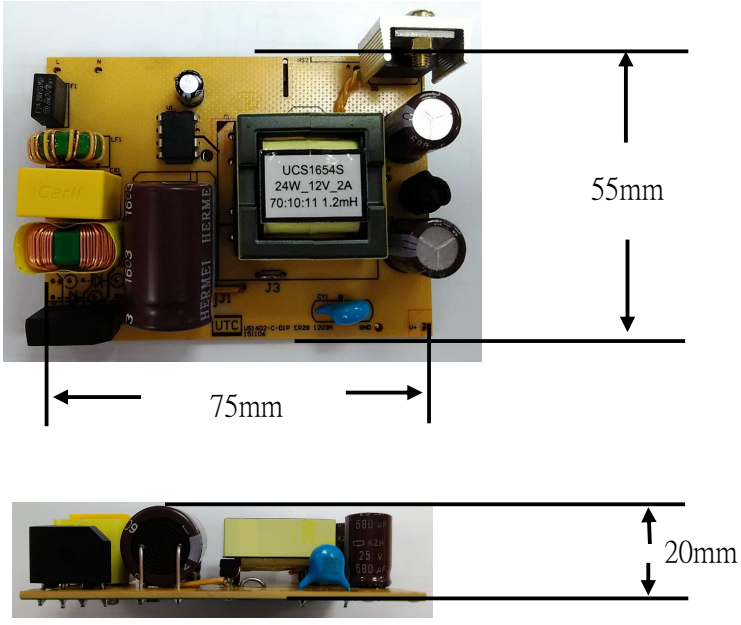


2.2. BOM

1	BD1	KBP208, 2A_800V	1
2	C1,C1-1	Capacitor, chip 10nF/1KV, NPO, SMD1206	2
3	C2	Capacitor, aluminum electrolytic, 47uF/400V, 105℃,±20% HER-MEI BL TYPE	1
4	C3	Capacitor, chip, 1nF/1KV, NPO, SMD1206	1
5	C6,C12	Capacitor, chip, 1nF/50V, X7R, SMD 0805	2
6	C7	Capacitor, chip, 0.1uF/50V, X7R, SMD 1206	1
7	C10	Capacitor, aluminum electrolytic,10uF/50V; 105℃,±20%	1
8	C40	Capacitor,chip, 220pF/1KV, NPO, SMD 1206	1
9	C41	Capacitor, aluminum electrolytic 680uF/16V,105℃,±20% HER-MEI LSR TYPE	1
10	C43	Capacitor, aluminum electrolytic 680uF/16V,105℃,±20% HER-MEI LSR TYPE	1
11	C45	Capacitor, chip, 10nF/50V, X7R, SMD 0603	1
12	C46	Capacitor,chip, 0.22uF/25V, X7R, SMD 0603	1
13	CX1	Capacitor, X2, 0.33uF/275VAC, 105℃ ,±20%	1
14	CY1	Capacitor, Y1, 1000pF/400V, 105℃,±20%	1
15	D1	Diode ,standard recovery, S1M, 1.0A/1000V SMA	1
16	D3	Diode ,fast recovery, BAV20WG ,1A/200V SOD-123	1
17	D5	Diode, dual Schottky, MGBR20V100CG, 20A/100V,TO-220	1
18	F1	1.0A / 250V MST TIME-LAG RADIAL LEAD F1 MICROFUSE 方型 (功得)	1

19	LF1	choke 320uH MIN 10Ts Φ0.5*1P 2UEW-B T12*6*4C JPZ1K	1
20	LF2	choke 8.7mH MIN 56Ts φ0.45*1P 2UEW-B T14*9*5C JPH-10F	1
21	T1	Transformer, EFD-25, L=1.2mH	1
22	R1,R2	Resistor, chip,1.5M, 1/4W,±1%, SMD 1206	2
23	J1,J3	Jump wire φ0.8	2
24	R7,R8	Resistor, chip,1M, 1/4W,±1%, SMD 1206	2
25	R9,R24,J2	Resistor, chip,0Ω, 1/4W,±1%, SMD 1206	3
26	R13	Resistor, chip,1Ω, 1/4W,±1%, SMD 1206	1
27	R20,R21	Resistor, chip, 1.8Ω, 1/4W,±1%, SMD 1206	2
28	R40	Resistor, chip, 120Ω, 1/4W,±1%, SMD 1206	1
29	R41	Resistor, chip, 510Ω, 1/10W,±1%, SMD 0603	1
30	R42	Resistor, chip, 2.2K, 1/10W,±1%, SMD 0603	1
31	R43	Resistor, chip, 680Ω, 1/10W,±1%, SMD 0603	1
32	R45	Resistor, chip, 39K, 1/10W,±1%, SMD 0603	1
33	R47	Resistor, chip, 10K, 1/10W,±1%, SMD 0603	1
34	L1	R core, 0.5uH	1
35	L52	Resistor, chip,0Ω, 1/8W,±1%, SMD 0805	1
36	U1	IC,CURRENT MODE PWM controller, UTC UCS1654SG, DIP-7	1
37	U3	IC, Opto-Coupler, LTV-357-T-C , SMD , LITE-ON	1
38	U4	IC, TL431 2.495V +-0.5% SOT-23	1
39	HS2	HEAT-SINK For D5	1
40	No Component	R6,R23,R46,C42,C50,C51	6
		: The Yellow color block means the parts that UTC can provide.	

2.3. Open frame Module Snapshot



2.4. Transformer Design

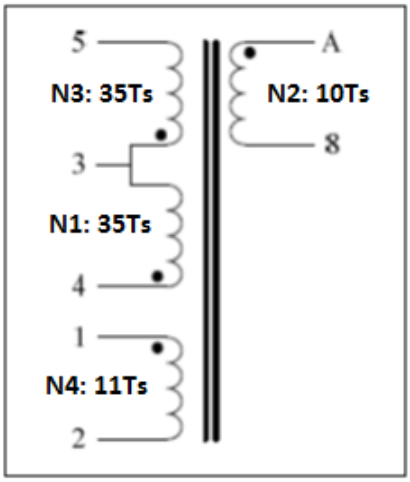
2.4.1. Transformer Specification

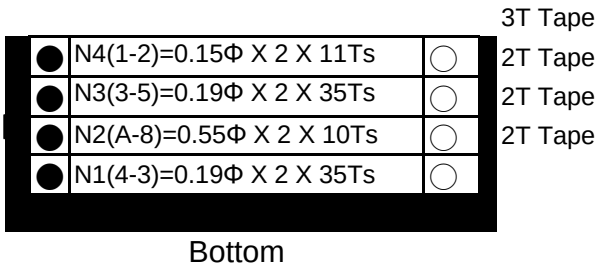
1) Bobbin: EFD-25

2) Core material : PC40 (TDK) or equivalent.

Lm: 1.2mH,±10% (65KHz)

2.4.2. Transformer Diagram





Transformer Winding Data

Layer No.	Winding	Material	Start	Turns	Finish
1	N1	0.19ΦX2 2 UEW	4	35	3
2	Tape	Tape		2	
3	N2	Triple Insulated Wire 0.55ΦX2	A	10	8
4	Tape	Tape		2	
5	N3	0.19ΦX2 2 UEW	3	35	5
6	Tape	Tape		2	
7	N4	0.19ΦX2 2 UEW	1	11	2
8	Tape	Tape		3	

※ N4: 0.19ΦX2 2 UEW 11Ts center Tight winding

3. Performance Evaluation

This document presented here is to describe the open frame Module performance.

The Summarized Result :

Item	Test result
1. Input Characteristics	
Input Current (90V/60Hz, full load)	565mA
Standby Power at No Load (230Vac/50Hz)	60mW(level 6<100mW)
Averaged Efficiency (@115/230Vac, 25%~100% Load ,On PCB End)	90.43% Meet level 6 >86.2% @115VAC 90.61% Meet level 6 >86.2% @230VAC
2. Output characteristics	
Output Tolerance	<5%
Line Regulation	≒0.15%
Ripple & Nnoise	<90mV
Overshoot	≦5%
Ripple of DynamicTest	≦5%
3. Protection	
Short Circuit Protection	Shut Down and Auto Recovery
Over Voltage Protection	Shut Down and Auto Recovery
Over Load Protection	Shut Down and Auto Recovery

Test Equipment:

Item	Vendor	Model No:
1.AC Source	Chroma	61602
2.Digital Power meter	Chroma	66202
3.Electronic Load	Chroma	63102
4.Digital Oscilloscope	Tektronics	DPO3014
5.Multi-meter	Keithley	2000
6.Thermal meter	Opex	PT-3S

3.1. Input Characteristics

3.1.1 Full Load Efficiency :

Table 1 Full Load Efficiency :

Input	Irms(mA)	Pin(W)	Vo(V)	Io(A)	Eff(%)
90Vac/60Hz	565	27.718	12.283	2	88.63
115Vac/60Hz	479	27.372	12.285		89.76
230Vac/50Hz	323	27.126	12.287		90.59
264Vac/50Hz	295	27.184	12.287		90.40

3.1.2 Efficiency:

BVO : PCB side measured 12V output. B.Eff :PCB side measured Efficiency.

*Table 3 Efficiency(**Test On PCB END**) :*

Input Voltage	25%(0.5A)			50%(1A)		
	Pi(W)	B.Vo(V)	B.Eff(%)	Pi(W)	B.Vo(V)	B.Eff(%)
115Vac/60Hz	6.765	12.298	90.89	13.552	12.294	90.72
230Vac/50Hz	6.801	12.299	90.42	13.558	12.295	90.68
Input Voltage	75%(1.5A)			100%(2A)		
	Pi(W)	B.Vo(V)	B.Eff(%)	Pi(W)	B.Vo(V)	B.Eff(%)
115Vac/60Hz	20.409	12.29	90.33	27.373	12.285	89.76
230Vac/50Hz	20.315	12.291	90.75	27.126	12.287	90.59

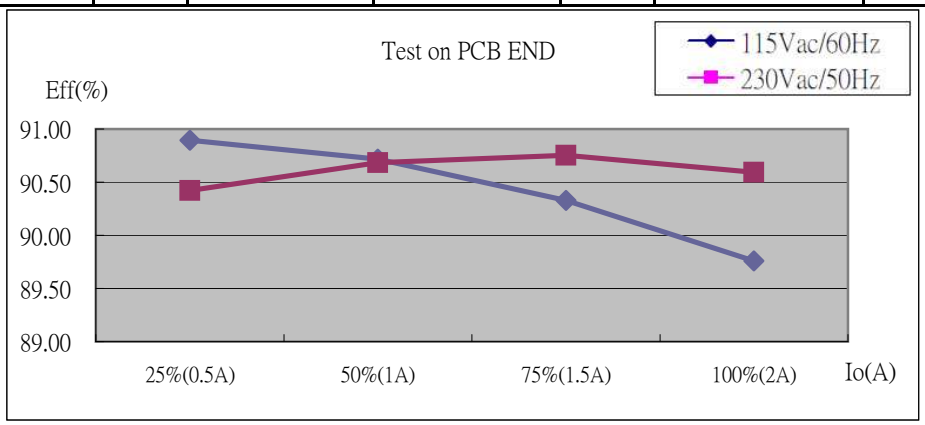


Fig.1 Efficiency VS Load

Table 4 Average Efficiency (PCB End) :

Input Voltage	Average	Remark	Result
	B.Aver. Eff.(%)		
115Vac/60Hz	90.42	level 6 >86.2%	**PASS**
230Vac/60Hz	90.61		**PASS**

3.1.3 Standby power

3.1.3.1

Table 5 Standby PowerTest Data

Input Voltage	Stand by power			
	Pin(mW)	Vo(V)	Remark	Result
90Vac/60Hz	30.00	12.303	level 6 <75mW	**PASS**
115Vac/60Hz	31.00	12.303		
230Vac/50Hz	50.00	12.303		
240Vac/50Hz	60.00	12.304		
264Vac/50Hz	83.00	12.304		

Input Voltage	Light Load		
	Pin(mW)	Io(mA)	Remark
90Vac/60Hz	153.00	10	For Reference
90Vac/60Hz	294.00	20	
90Vac/60Hz	436.00	30	
90Vac/60Hz	578.00	40	
90Vac/60Hz	715.00	50	
115Vac/60Hz	152.00	10	
115Vac/60Hz	293.00	20	
115Vac/60Hz	434.00	30	
115Vac/60Hz	573.00	40	
115Vac/60Hz	712.00	50	
230Vac/50Hz	177.00	10	
230Vac/50Hz	315.00	20	
230Vac/50Hz	456.00	30	
230Vac/50Hz	596.00	40	
230Vac/50Hz	749.00	50	
264Vac/50Hz	197.00	10	
264Vac/50Hz	342.00	20	
264Vac/50Hz	474.00	30	
264Vac/50Hz	614.00	40	
264Vac/50Hz	756.00	50	

3.2 Output Characteristics

3.2.1 Line Regulation & Load Regulation

Table 6 Line Regulation & Load Regulation

Input Voltage	Load			Load Regulation%	Remark	Result
	No Load (V)	Half Load	Full Load			
90Vac/60Hz	12.303	12.29	12.283	0.16		**PASS**
115Vac/60Hz	12.303	12.29	12.285	0.15		
Line Regulation%	0%	0.00%	0.00%			
Input Voltage	Load			Load Regulation%	Remark	Result
	No Load (V)	Half Load	Full Load			
230Vac/50Hz	12.303	12.30	12.285	0.15		**PASS**
264Vac/50Hz	12.304	12.30	12.287	0.14		
Line Regulation%	0%	0.00%	0.00%			

3.2.2 Ripple & Noise

Table 8 Ripple & Noise

Input Voltage	Ripple & Noise(mV)				Remark	Result
	No. Load		Full Load			
90Vac/60Hz	13.20	Fig 4	35.20	Fig 5		PASS
115Vac/60Hz	12.00	—	29.60	—		PASS
230Vac/50Hz	14.00	—	29.20	—		PASS
264Vac/50Hz	15.20	Fig 6	25.20	Fig 7		PASS

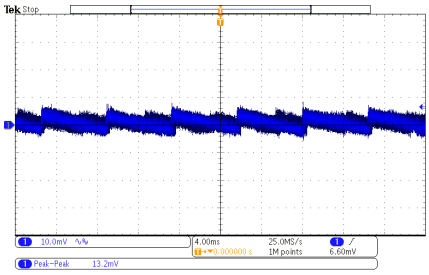


Fig.4 90Vac/60Hz@ No Load

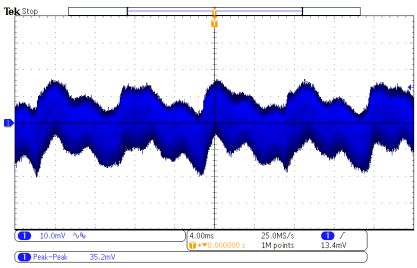


Fig.5 90Vac/60Hz@Full Load

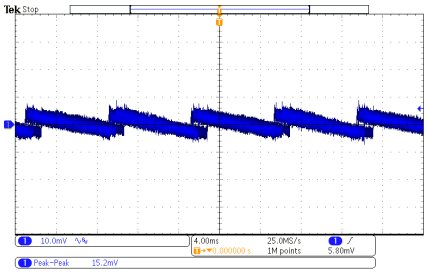


Fig.6 264Vac/50Hz@ No Loac

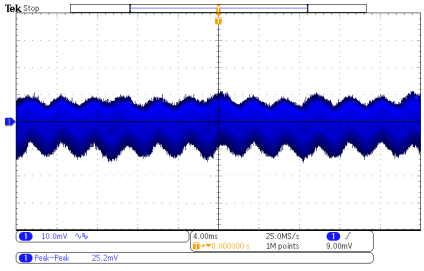


Fig.7 264Vac/50Hz@Full Load

3.2.3 Overshoot

AC Power switch ON for overshoot, and switch OFF for undershoot

Table 9 Overshoot

Input Voltage	Load Condition	Over shoot / Under shoot	Data (%)	Remark
90Vac/60Hz	Full Load	Overshoot	1.961	Fig.9
		Undershoot	1.961	Fig. 11
	No Load	Overshoot	1.961	Fig. 8
		Undershoot	—	—
264Vac/50Hz	Full Load	OverShoot	1.961	Fig.10
		Undershoot	1.961	Fig.12

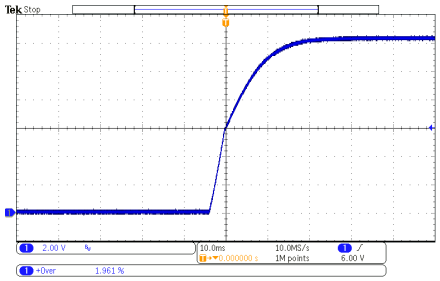


Fig.8 90Vac / 60Hz, Overshoot @ No Load

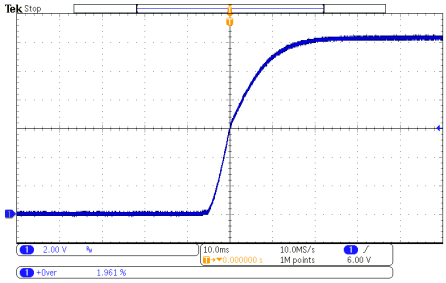


Fig.9 90Vac / 60Hz, Overshoot @ Full Load

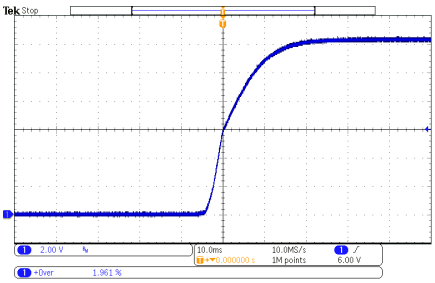


Fig.10 264Vac / 50Hz, Overshoot @ Full Load

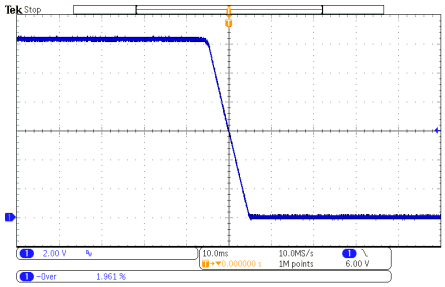


Fig.11 90Vac/60Hz,Under shoot @ Full Load

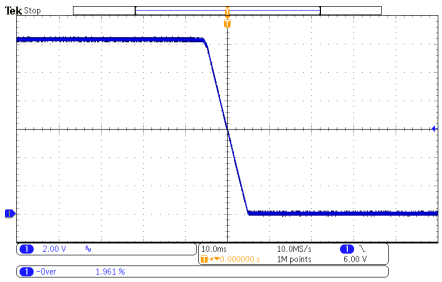


Fig.12 264Vac/50Hz, Undershoot @ Full Load

3.2.4 Dynamic Test

The High Level ;Low level switching time is set to 50ms each.

Table 10 Dynamic Test

Input Voltage	Output (V)	Io(A):Low-High	Remark
90Vac/60Hz	12.1V~12.5V	0-1	Fig.13
90Vac/60Hz	12.1V~12.5V	1-2	Fig.14
264Vac/50Hz	12.1V~12.5V	0-1	Fig.15
264Vac/50Hz	12.1V~12.5V	1-2	Fig.16

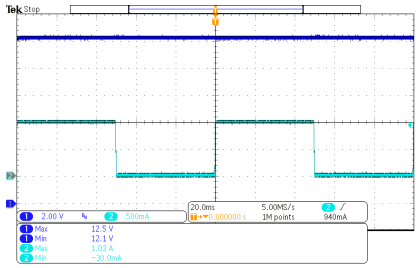


Fig. 13 90Vac / 60Hz Dynamic Test

CH2 Current Probe Waveform (0A-1A)

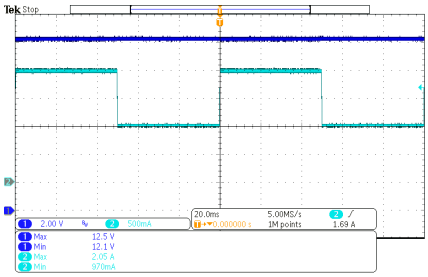


Fig. 14 90Vac / 60Hz Dynamic Test

CH2 Current Probe Waveform(1A-2A)

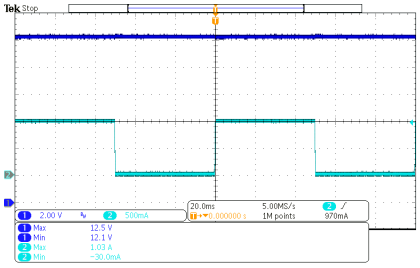


Fig. 15 264Vac / 50Hz Dynamic Test

CH2 Current Probe Waveform(0A-1A)

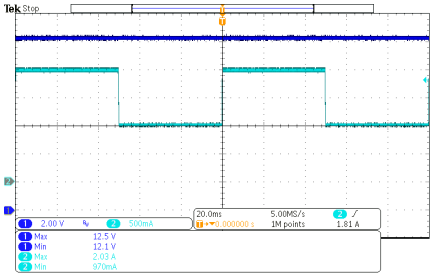


Fig. 16 264Vac / 50Hz Dynamic Test

CH2 Current Probe Waveform(1A-2A)

3.2.5 Time Sequence

Table 11 Time Sequence (Test at full load)

Item	Input Voltage	Meas. Data	Remark	Result
Turn on Delay Time	90Vac/60Hz	269ms	Fig. 15	**Ref**
	180Vac/50Hz	271ms	Fig. 16	**Ref**
Hold-UpTime	100Vac/60Hz	9.8ms	Fig. 17	**Ref**
	240Vac/50Hz	92ms	Fig. 18	**Ref**
Rise Time	100Vac/60Hz	13.69ms	Fig. 19	**Ref**
	240Vac/50Hz	13.39ms	Fig. 20	**Ref**
Falling Time	100Vac/60Hz	7.671ms	Fig. 21	**Ref**
	240Vac/50Hz	7.660ms	Fig. 22	**Ref**

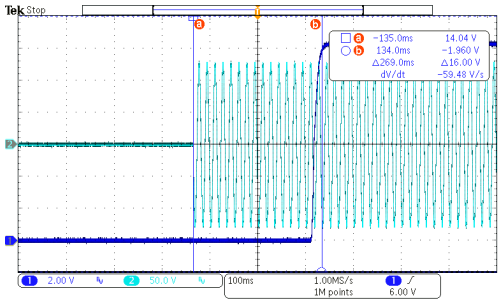


Fig. 15 90Vac/60Hz, Full Load Turn-on Delay Time
CH1=Vout, CH2=AC Input

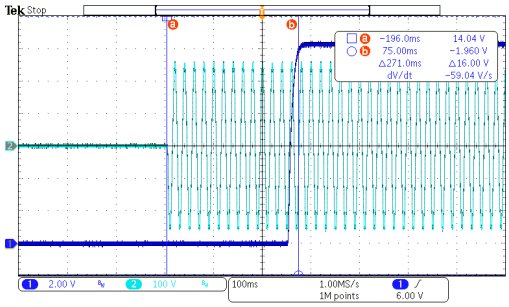


Fig. 16 180Vac/50Hz, Full load Turn-on Delay Time
CH1=Vout, CH2=AC Input

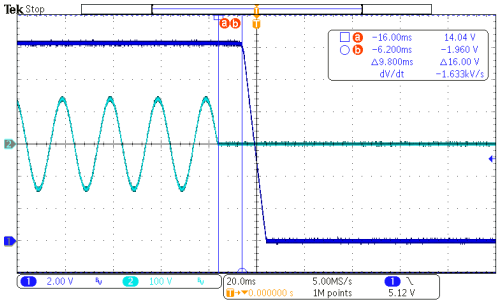


Fig. 17 100Vac / 60Hz, Full Load Hold-UpTime
CH2=AC Input, CH1=Vout

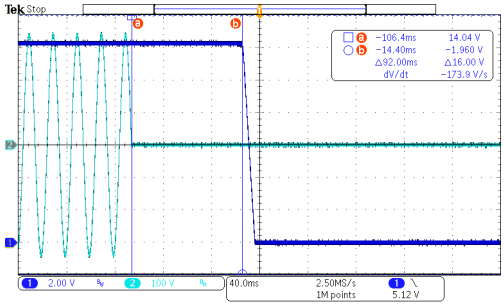


Fig.18 240Vac / 50Hz,Full Load Hold-Up Time
CH2=AC Input, CH1=Vout

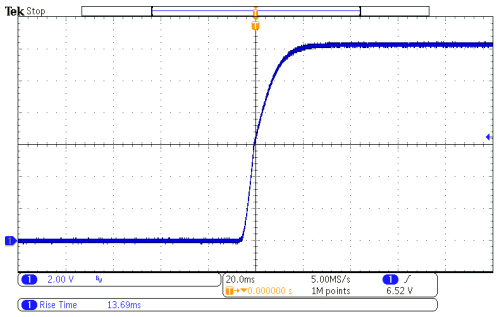


Fig. 19 100Vac/60Hz,Full Load Rising Time

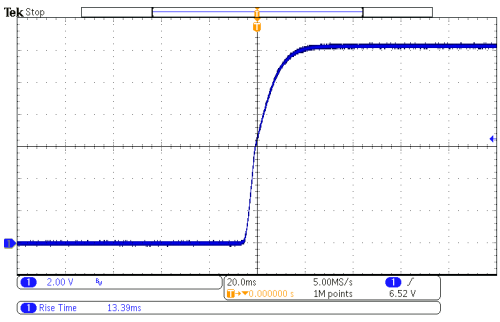


Fig.20 240Vac/50Hz,Full load Rising Time

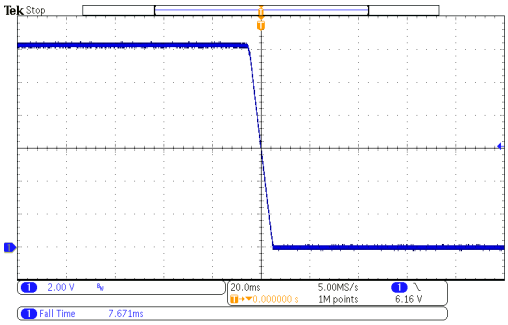


Fig. 21 100Vac/60Hz Full load FallingTime

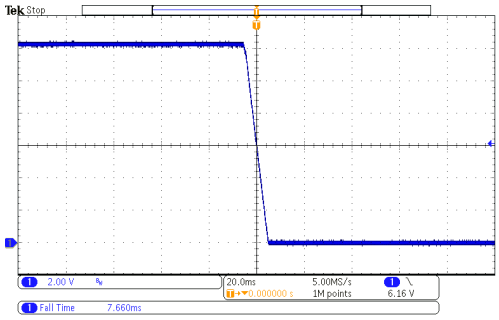


Fig. 22 240Vac/50Hz Full load Falling Time

3.3 Protection

3.3.1 Short Circuit Protection

When short the output voltage ,and no parts are damaged.Once Short Circuit condition is removed and the power should recover automatically .

Table 12 Short Circuit Protection

Input Voltage	Protection Mode	Result
90Vac/60Hz	Auto Recovery	PASS
264Vac/50Hz	Auto Recovery	PASS

3.3.2. Over Voltage Protection (OVP)

When Over Voltage Protectioncondition is removed and the power automatically recover

Table 13 OVP

Input Voltage	Protection Mode	Vcc	Remark	Test condition
115Vac/60Hz	Auto Recovery	26.4V	Fig. 23	U3(Pin1-Pin2) to short
230Vac/50Hz	Auto Recovery	26.4V	Fig. 24	

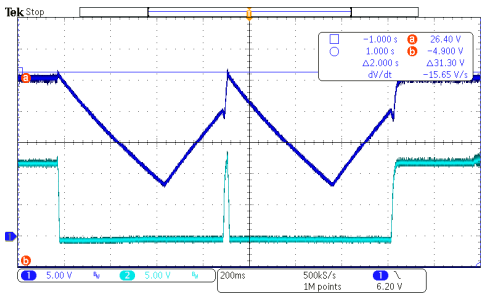


Fig 23. 115Vac/60Hz OVP (Full Load)
CH1: Vcc CH2: Vo

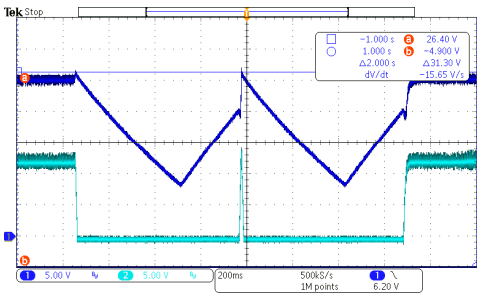


Fig 24 230Vac/50Hz OVP (Full load)
CH1: Vcc CH2: Vo

3.3.3 Over load Protection

When over load condition is removed and the power automatically recover.

3.3.3.1 Over load Protection

Table 14 OLP

Input Voltage	OLP(A)	%	Remark
90Vac/60Hz	2.52	126	
115Vac/60Hz	2.79	139.5	
180Vac/50Hz	2.82	141	
230Vac/50Hz	2.92	146	
264Vac/50Hz	2.91	145.5	

3.3.4 Thermal Testing

90Vin Burn in 2hrs, 115V、230V、264Vin Burn in 1hr @openframe.

Table 15 Thermal Testing

Input Voltage	AMB	U1(℃)	T1 Wire(℃)	T1 core(℃)	D5(℃)
90Vac/60Hz	25℃	70	50	46	74
115Vac/60Hz		62	52	47	76
230Vac/50Hz		59	53	53	81
264Vac/50Hz		60	56	55	82

4. Other Important Waveforms

4.1.1. Waveform from Top to Bottom :Vds;Vcc;Vfb@90Vac/60Hz, No Load

Measuring Data:Vds=229Vmax;Vcc=21.8V;Vfb=2.12V; Frequency: 18.73KHz(burst mode)

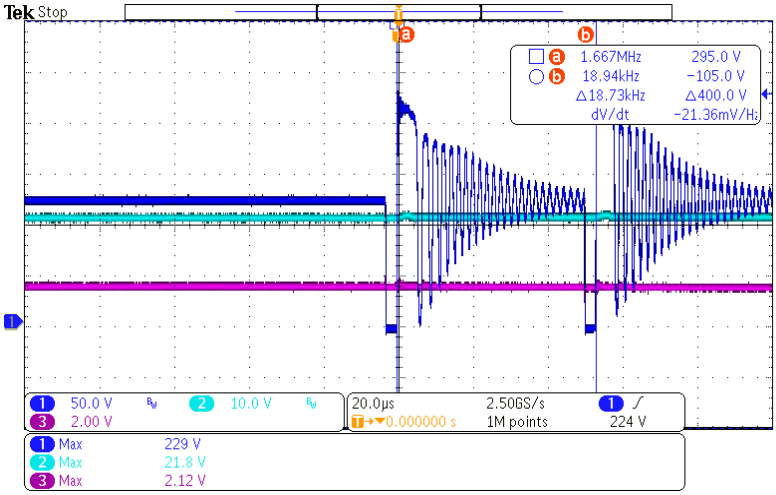


Fig.25 Vds;Vcc;Vfb @90Vac/60Hz, No Load

4.1.2. Waveform from Top to Bottom :Vds;Vcc;Vfb @90Vac/60Hz,Full Load

Measuring Data:Vds=267Vmax; Vcc=26.2V;Vfb=4.60V; Frequency: 62.66KHz

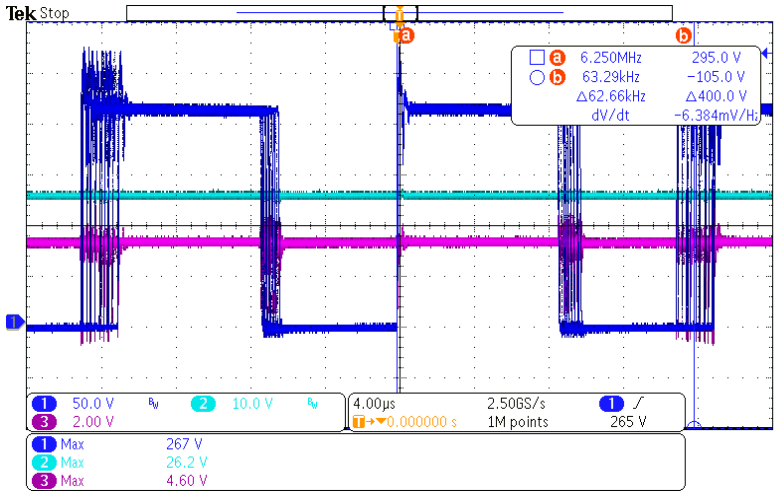


Fig. 26 Vds;Vcc;Vfb @90Vac/60Hz,Full Load

4.1.3. Waveform from Top to Bottom :Vds;Vcc;Vfb@264Vac/50Hz,No Load

Measuring Data:Vds=486Vmax;Vcc=21.8V;Vfb=2.52V; Frequency: 19.01KHz(burst mode)

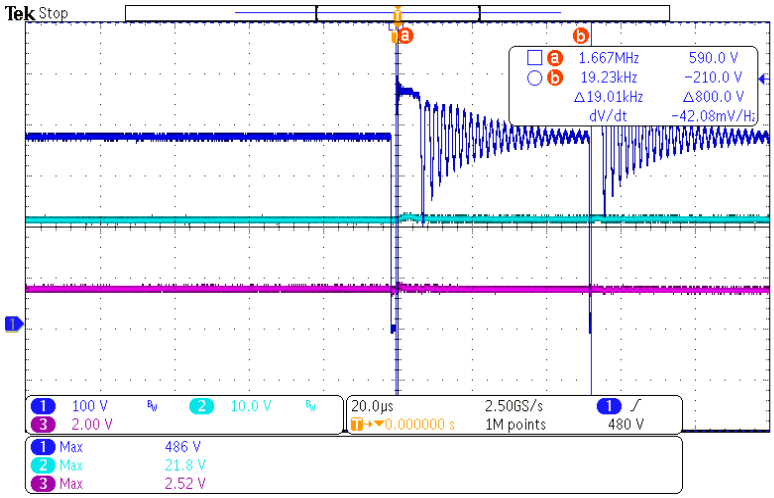


Fig.27 Vds;Vcc;Vfb 264Vac/50Hz, No load .

4.1.4 Waveform fromTop to Bottom :Vds;Vcc;Vfb@ 264Vac/50Hz, Full Load

Measuring Data:Vds=514Vmax;Vcc=25.4V;Vfb=3.96V; Frequency: 62.50KHz

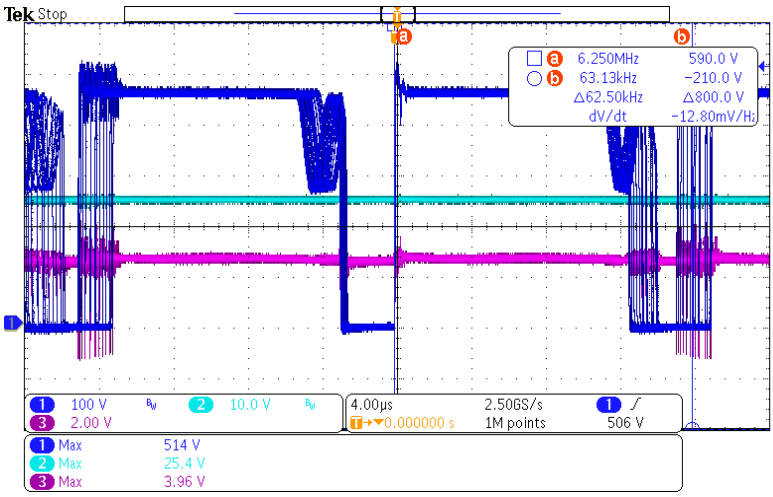


Fig.29 Vds;Vcc;Vfb 264Vac/50Hz, Full Load

4.2. Waveform at Full Load, Operating Start / Normal / Output Short to Ground

Table 26 Measuring Data at Full Load, Operating Start/ Normal / Output Short Test.

Test Item	Input voltage	U1,Vds(Max)	D5(Max)	Remark
Start at full load	264V/50HZ	510V	68V	Fig 30
Normal at full load	264V/50HZ	506V	67.2V	Fig 31
Short at full load	264V/50HZ	442V	61.6V	Fig 32

4.2.1. Start up at Full Load Waveform from Top to Bottom :U1,Vds(Max);D5,(Max)

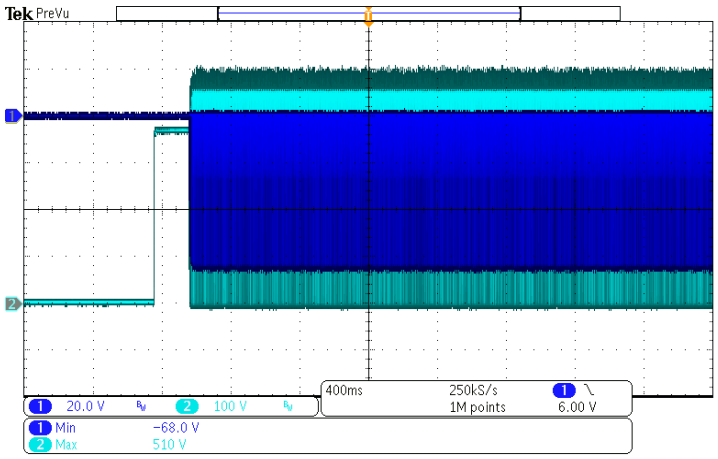


Fig.30 264Vac / 50Hz,Start up at Full load. U1,Vds(Max);D5,(Max)

4.2.2. Normal Full Load Waveform from Top to Bottom :U1,Vds(Max);D5,(Max)

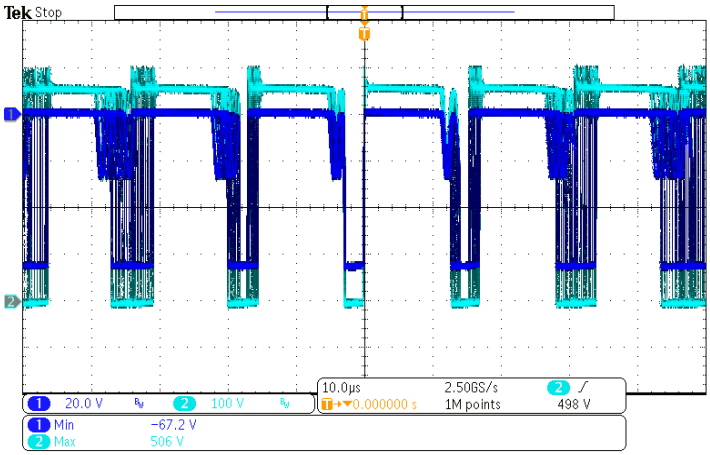


Fig.31 264Vac / 50Hz,Normal Full Load. U1,Vds(Max);D5,(Max)

4.2.3 Output Short to Ground Waveform from Top to Bottom :U1,Vds(Max);D5,(Max)

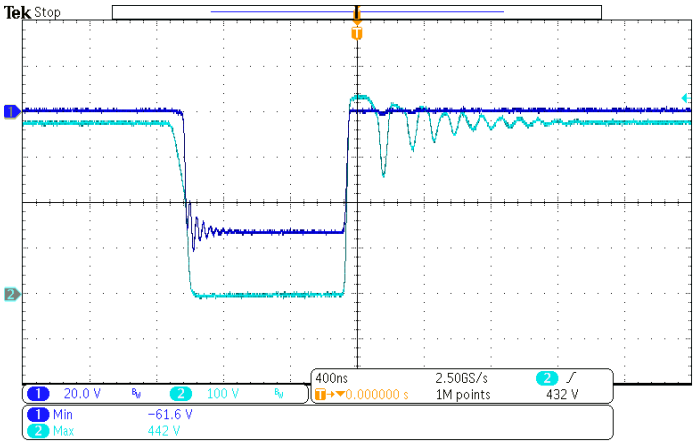
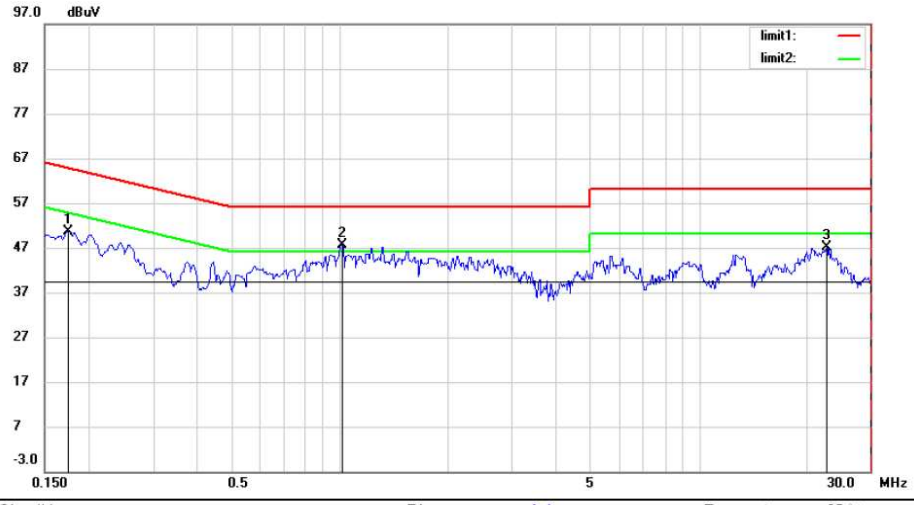


Fig.32 264Vac / 50Hz, Output Short to Ground at Full Load. U1,Vds(Max);D5,(Max)

5. Conduction

5.1 Conduction

5.1.1 input 110VAC/60HZ Line



Site Site #1 Phase: L1 Temperature: 25 ℃

Limit: EN55022 Class B Conduction(QP) Power: AC 110V/60Hz Humidity: 54 %

EUT:

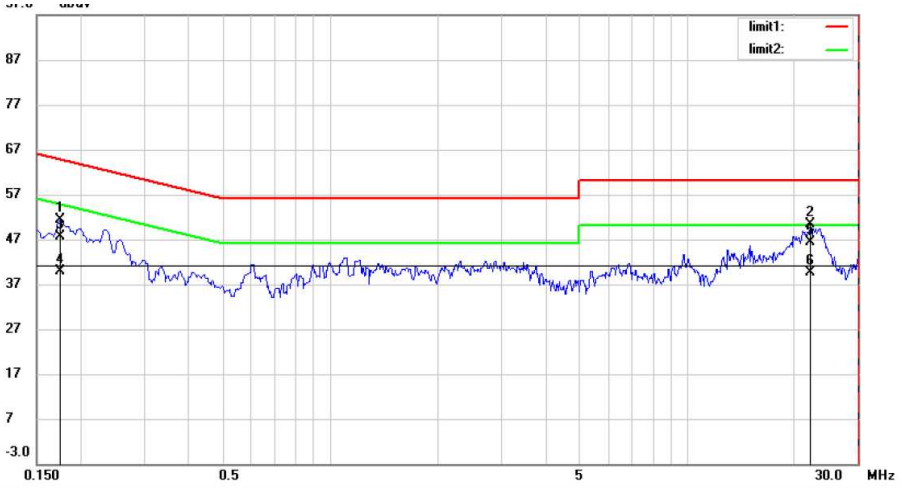
M/N:

Mode:

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		
		(MHz)	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1		0.1751	48.80	1.79	50.59	64.71	-14.12	peak	
2	*	1.0185	35.88	11.74	47.62	56.00	-8.38	peak	
3		22.6087	30.41	16.70	47.11	60.00	-12.89	peak	
4		0.1751	46.01	1.79	47.80	64.71	-16.91	QP	
5		0.1751	38.31	1.79	40.10	54.71	-14.61	AVG	
6		1.0185	31.06	11.74	42.80	56.00	-13.20	QP	
7		1.0185	19.06	11.74	30.80	46.00	-15.20	AVG	
8		22.6087	26.60	16.70	43.30	60.00	-16.70	QP	
9		22.6087	19.70	16.70	36.40	50.00	-13.60	AVG	

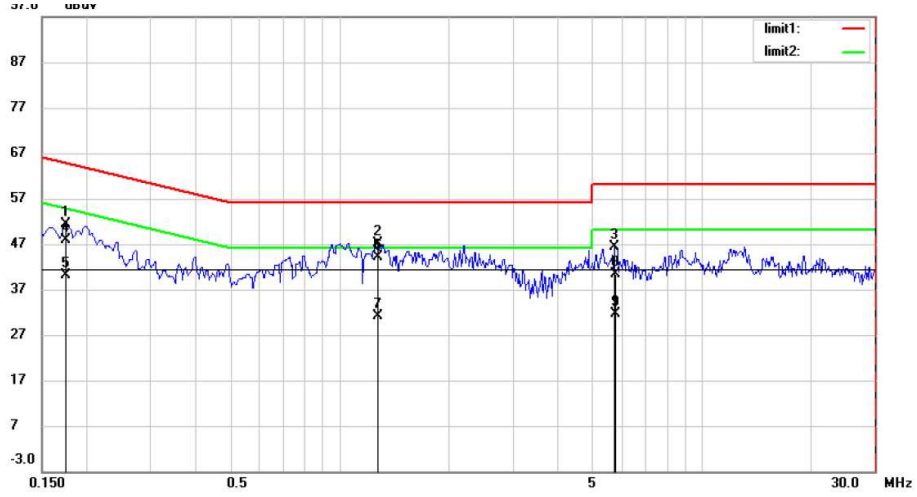
5.1.2 input 110VAC/60HZ Neutral



Site Site #1 Phase: N Temperature: 25 ℃
Limit: EN55022 Class B Conduction(QP) Power: AC 110V/60Hz Humidity: 54 %
EUT:
M/N:
Mode:
Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		
		(MHz)	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1		0.1751	49.48	1.79	51.27	64.71	-13.44	peak	
2	*	22.0109	33.53	16.71	50.24	60.00	-9.76	peak	
3		0.1751	45.91	1.79	47.70	64.71	-17.01	QP	
4		0.1751	38.11	1.79	39.90	54.71	-14.81	AVG	
5		22.0109	29.69	16.71	46.40	60.00	-13.60	QP	
6		22.0109	22.89	16.71	39.60	50.00	-10.40	AVG	

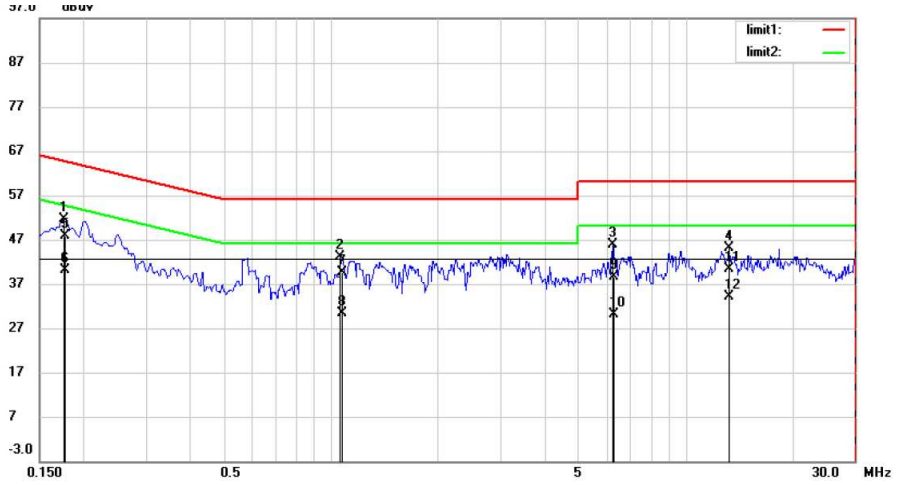
5.1.3 input 220VAC/60HZ Line



Site Site #1 Phase: *L1* Temperature: 25 ℃
Limit: EN55022 Class B Conduction(QP) Power: AC 230V/50Hz Humidity: 54 %
EUT:
M/N:
Mode:
Note:

No.	Mk.	Freq. (MHz)	Reading Level dBuV	Correct Factor dB	Measure-ment dBuV	Limit dBuV	Over dB	Detector	Comment
1		0.1751	49.63	1.79	51.42	64.71	-13.29	peak	
2	*	1.2728	35.77	11.33	47.10	56.00	-8.90	peak	
3		5.7609	35.35	11.11	46.46	60.00	-13.54	peak	
4		0.1751	46.11	1.79	47.90	64.71	-16.81	QP	
5		0.1751	38.21	1.79	40.00	54.71	-14.71	AVG	
6		1.2728	32.87	11.33	44.20	56.00	-11.80	QP	
7		1.2728	19.67	11.33	31.00	46.00	-15.00	AVG	
8		5.7609	29.19	11.11	40.30	60.00	-19.70	QP	
9		5.7609	20.59	11.11	31.70	50.00	-18.30	AVG	

5.1.4 input 220VAC/60HZ Neutral



Site Site #1 Phase: N Temperature: 25 ℃
Limit: EN55022 Class B Conduction(QP) Power: AC 230V/50Hz Humidity: 54 %
EUT:
M/N:
Mode:
Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		
		(MHz)	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1	*	0.1759	49.89	1.79	51.68	64.68	-13.00	peak	
2		1.0674	31.34	11.66	43.00	56.00	-13.00	peak	
3		6.2500	33.68	12.10	45.78	60.00	-14.22	peak	
4		13.2609	35.30	9.90	45.20	60.00	-14.80	peak	
5		0.1759	46.01	1.79	47.80	64.68	-16.88	QP	
6		0.1759	38.21	1.79	40.00	54.68	-14.68	AVG	
7		1.0674	27.84	11.66	39.50	56.00	-16.50	QP	
8		1.0674	18.74	11.66	30.40	46.00	-15.60	AVG	
9		6.2500	26.50	12.10	38.60	60.00	-21.40	QP	
10		6.2500	18.10	12.10	30.20	50.00	-19.80	AVG	
11		13.2609	30.50	9.90	40.40	60.00	-19.60	QP	
12		13.2609	24.10	9.90	34.00	50.00	-16.00	AVG	